

Proceedings of Conference on Technologies for Future Cities



Organized by

**Mahatma Education Society's
PILLAI COLLEGE OF ENGINEERING
NEW - PANVEL**

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Proceedings of Conference on Technologies for Future Cities

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Mahatma Education Society's

Pillai College of Engineering

Dr. K. M. Vasudevan Pillai Campus
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Editors

Satishkumar L. Varma, Richa S. Agrawal and Avinash R. Vaidya

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Editors

Preface

I am happy to present the Proceedings of the conference on “**Technologies for Future Cities 2021 (CTFC 2021)**” that was held at Pillai College of Engineering, New Panvel, Navi Mumbai during October 08 – 09, 2021 (www.futurecities.mes.ac.in). The conference is 2nd in the series; the first one was held in January 08 – 09, 2019. The conference consisted of invited talks and contributed papers covering six tracks, namely, (i) Software technologies (ii) Hardware technologies (iii) Systems for future cities (iv) Materials for future cities (v) Healthcare for future cities and (vi) Policies and Governance for future cities. About 150 scientists and engineers attended the conference.

The conference was inaugurated by Dr. R. K. Shevgaonkar (Prof. Emeritus, Department of Electrical Engineering, IIT Bombay) and Prof. Pradipta Banerjee (Department of Civil IIT Bombay) delivered the keynote address. Dr Sandeep M. Joshi (Principal, Pillai College of Engineering) welcomed the participants and the dignitaries and gave introductory remarks. The plenary talks were delivered by experts from several different disciplines. The list of speakers includes Dr. Sanjay Oak (Kaushlya Hospital Trust, Thane, and Chairman of Task force for COVID-19 in Maharashtra), Dr. Sanjay N. Talbar (SGGSIE&T, Nanded), Dr. Saurabh Mehta (Vidyalankar Institute of Technology, Mumbai), Dr Priam Pillai (COO, Mahatma Education Society), Dr. Milind Kulkarni (Prachi Services Inc., Mumbai), Veerle Vandeginste (Katholieke Universiteit, Leuven), Dr Sandeep M Joshi (Principal, PCE) and Dr. Padmaja Joshi (C-DAC, Mumbai). Except two talks, all talks were held in physical mode. This way, there were lot of discussions.

The contributed papers were presented both in oral and poster sessions. The other attraction of the conference was the Panel Discussions, where the panelists were largely from the industry. The panelists were G. Udaybhaskar (Reliance Industries), Vijay Kulkarni (Shapoorji Pallonji Infrastructure-Retired), Bhupendra Bhate (Larson & Toubro - Retired), B Ramaswamy (OPJS University), Satyanarayana Bheesette (TIFR) and Anupama Karanam (CIDCO, Maharashtra).

We had received 267 contributed papers, out of which 110 were presented at the conference; 85 were presented in oral sessions and 25 were presented in poster sessions. Eight papers, out of above 110 papers, were selected for best paper award; one corresponding to each track and one corresponding to each of the two poster sessions. The proceeding of the conference is published by Mahatma Education Society, Mumbai with an authorized ISSN number. It contains abstracts all plenary talks and contributed papers. In addition to that, proceedings contain 32 full papers where authors have transferred copyrights to the publisher, namely, MES.

I am very much grateful to the management of Mahatma Education Society (MES), the esteemed members of the International and National Advisory Committees for their advice and guidance. I would like to thank AICTE, Ministry of Education, Government of India for financial support. I would like to thank the Computer Society of India (Mumbai Chapter), National Environment Engineering Research Institute, Nagpur. I would also like to thank all the referees, track coordinators and track chairs of various sessions who helped us in maintaining the high standard of the conference. The conference organization owes its success to the efforts of our colleagues in the organizing committee, and many other individuals, especially the staff of Pillai College of Engineering, and other institutes of Mahatma Education Society. In particular, I express gratitude to Dr. P S Goyal, Dr. Avinash R. Vaidya, Dr. Richa Agrawal and Dr. Satishkumar Varma who were members of the core committee. I also thank MES for publishing the proceeding. I also acknowledge the untiring efforts of Dr. Satishkumar Varma, Dr. Richa Agarwal and Dr. Avinash R. Vaidya and their colleagues for editing the proceedings.

Dr. Sandeep M. Joshi

Convener CTFC 2021 and
Principal, Pillai College of Engineering,
New Panvel-410206, India.

About Pillai College of Engineering

Pillai College of Engineering (Erstwhile Pillai Institute of Information Technology until April 2016), established in 1999 under the patronage of Dr. K. M. Vasudevan Pillai, is a reputed engineering college in Navi Mumbai. It is affiliated to the University of Mumbai, approved by All India Council for Technical Education (AICTE), New Delhi and is recognized by the Government of Maharashtra. PCE is approved Research Centre of Mumbai University, which offers PhD degrees in Mechanical Engineering, Computer Engineering and Information Technology. The institute is NAAC accredited with A+ grade by NAAC and three of its departments have been accredited by NBA. The institute has achieved rank in ARIIA Band “Performer” all over India. The institute is selected one among the very few Institutes all over India as Mentor IIC institution to guide new IICs. The institute strives to provide state of the art facilities conducive to effective teaching-learning, research and consultancy. It further takes every effort in inculcating in the minds of students the respect for the environment. Faculty of PCE is very active in R & D and has completed projects for government agencies such as DST, BRNS, ICSSR and UGC. PCE has also undertaken and completed urbanization studies for the UN office project on ‘Urban Expansion’ in collaboration with New York University and continues to provide consultancy in similar fields to Tata Consultancy Engineering (TCE) and CIDCO.

About Conference

Cities in developing countries are rapidly expanding, and it is expected that about 65% of the world population would be living in cities by 2050. Unfortunately, the expansion is unplanned and disorganized which leads to inequitable distribution of public services, unaffordable housing, lack of sufficient streets and roads and insufficient open spaces. Scientists and engineers, world over, are looking for technological solutions to the problems, such as, unorganized traffic, unenforced traffic rules, poor quality public transport and parking facilities, deficiencies in water supply, air and water pollution, etc. Pillai College of Engineering has taken a timely lead and has started a series of conferences on “Technologies for Future Cities”. The first conference in the series was held during Jan.08-09, 2019. The conference was a great success. There were about a dozen invited talks followed by a Panel Discussion. About 250 scientists and engineers attended the conference. The present conference is the 2nd in the series. The conference consisted of, both, contributory papers and invited talks. The full details of the conference are available on www.futurecities.mes.ac.in.

About Panvel, Navi Mumbai

Panvel is an old town in Raigad District of Maharashtra and is famous for its heritage of lakes, temples, nearby sanctuary and forts. Panvel Municipal Corporation is the first Municipal Corporation of Raigad. The authority of City and Industrial Development Corporation (CIDCO) has been the backbone in the development of Panvel. The town is situated on the outskirts of Mumbai and is all set to become the new transportation hub of Maharashtra serving the major trade and passenger routes by road, rail and air. It is reachable from Mumbai railway stations by local train and by taxi from Mumbai airport. Depending on the starting point, the travel time varies but, generally, does not exceed 90 minutes.

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Program Schedule

Day 1: 8th October 2021

Time	Activity	Speaker/Session
8.30 - 9.45	Registration Breakfast	Main reception area Canteen
9.30 - 10.45	Inauguration Function <i>Venue: Main Auditorium 7th Floor</i>	9.30: Welcome 9.40: Address by Chief Guest Dr. R K Shevgaonkar (Professor Emeritus, IIT Bombay) <i>Inaugural Address</i> 10.05: Keynote Address by Dr. Pradipta Banerji (Professor, IIT Bombay) <i>Future Cities: A Case for Urban Observatories in India</i>
10.45 - 11.00	Tea Break	
11.00 - 11.30	Plenary Talks <i>Venue: Main Auditorium 7th Floor</i>	Talk 1: Dr. Sanjay Oak (Ex-Vice Chancellor, Padmashree Dr. D. Y. Patil Vidyapeeth) <i>Emerging Technologies in Future Healthcare</i>
11.30 - 12:00		Talk 2: Dr. Saurabh Mehta (Chief Academic Officer and Professor, Vidyalankar Institute of Technology, Mumbai) <i>IoE: The Next Generation Technology for Future Cities</i>
12.00 - 13.30	Contributed Oral Papers <i>Venue: Room G 502 Room G 503 Room G 504 Room G 402 Room G 403</i>	Session A - ST [Paper ID: 4, 67, 87, 119, 124, 145, 248] Session B - HT [Paper ID: 90, 190, 198, 203, 263] Session C - SY [Paper ID: 36, 105, 106, 137, 187, 234] Session D - MT [Paper ID: 98, 212, 226, 227, 252] Session E - PG [Paper ID: 202]
13.30 - 15.00	Lunch & Poster Session <i>Venue: Ground Floor</i>	All conference tracks mixed [Paper ID: 39, 64, 65, 74, 79, 80, 104, 115, 134, 135, 138, 169, 173, 186, 205, 237]
15.00 - 15.30	Plenary Talk <i>Venue: Main Auditorium 7th Floor</i>	Talk 3: Dr. S. N. Talbar (Professor, SGGSI&T, Nanded) <i>Brain Tumor Segmentation and Analysis</i>
15.30 - 16.00		Talk 4: Dr. Sandeep M. Joshi (Principal, PCE New Panvel) <i>Combining Solar PV and Thermal</i>
16.00 - 16.15	Tea Break	
16.15 - 17.45	Contributed Oral Papers <i>Venue: Room G 502</i>	Session F - ST [Paper ID: 69, 91, 97, 122, 126, 147, 150] Session G - ST [Paper ID: 27, 78, 103, 129, 131, 146] Session H - ST/SY [Paper ID: 1, 7, 112, 151, 161, 157, 200, 230, 247] Session I - HT/PG/MT/HC [Paper ID: 159, 264, 149, 113, 166, 204, 93, 139]

Day 2: 9th October 2021

9:00 – 10:00	Registration Breakfast	Main reception area Canteen
09.30 - 10.30	Contributed Oral Papers <i>Venue: Room G 502 Room G 503</i>	Session J - HT [Paper ID: 37, 130, 132, 167] Session K - MT [Paper ID: 192, 222]
10.45 - 11.15	Plenary Talks <i>Venue: Main Auditorium 7th Floor</i>	Talk 5: Dr. Milind Kulkarni (Director, Prachi Services Inc., Mumbai) <i>Solid Waste Management in Future Cities</i>
11.15 - 11.45		Talk 6: Dr. Priam Pillai (COO, Mahatma Education Society) <i>Studying Cities at the Urban Expansion Observatory</i>
11:45 -12:00	Tea Break	
12.00 - 13.30	Contributed Oral Papers <i>Venue: Room G 502 Room G 503 Room G 504 Room G 402</i>	Session L - ST [Paper ID: 85, 123, 196, 233, 249, 260, 266] Session M - HT [Paper ID: 45, 86, 88, 261, 228] Session N - SY [Paper ID: 95, 114, 154, 189, 242, 243, 267] Session O - HC [Paper ID: 21, 84, 99, 108, 136, 177, 209, 246]
13.30 - 15.00	Lunch & Poster Session <i>Venue: Ground Floor</i>	All conference tracks mixed [Paper ID: 92, 100, 109, 110, 120, 125, 127, 133, 201, 206, 224, 236, 241, 254]
15.00 - 15.30	Plenary Talks <i>Venue: Main Auditorium 7th Floor</i>	Talk 7: Dr. Padmaja Joshi (Senior Director C-DAC, Mumbai) <i>Future Cities and The Role of Blockchain</i>
15.30 - 16.00		Talk 8: Dr. Veerle Vandeginste (Professor, Department of Materials Engineering, KU Leuven) - Online Session <i>Advanced materials for smart buildings</i>
16.00 - 16.15	Tea Break	
16.15 - 17.15	Panel Discussion <i>Venue: Main Auditorium 7th Floor</i>	Topic: Impact of Technologies on Future Cities Shri G. Udayabhaskar, Dr. Satyanarayana Bheesette, Dr. B. Ramaswamy, Dr. Priam Pillai, Dr. Milind Kulkarni, Dr. Vijay Kulkarni, Shri Bhupendra Bhate, Ms. Anupama Karanam, Dr. P. S. Goyal
17.15 - 17.45	Best Paper Award Distribution and Valedictory Function <i>Venue: Main Auditorium 7th Floor</i>	Chief Guest: Dr B Ramaswamy (Vice-Chancellor, OPJS University)

Tracks

- **ST** - Software Technologies
- **HT** - Hardware Technologies
- **SY** - Systems for Future Cities
- **MT** - Materials for Future Cities
- **PG** - Policies and Governance for Future Cities
- **HC** - Health Care for Future Cities

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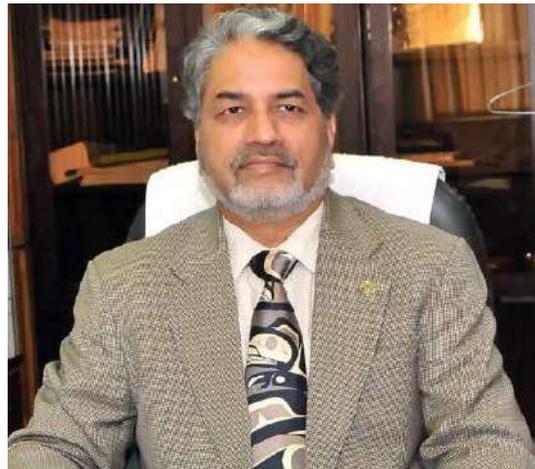
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PLENARY TALKS

Dr. R. K. Shevgaonkar
(Professor, Emeritus, IIT Bombay)



Profile of the Speaker:

Dr. R. K. Shevgaonkar has been a Professor at Department of Electrical Engineering, IIT Bombay since 1990 and is presently Professor (emeritus). He has a rich experience in science and technology and administration of institutes of higher education. He has worked as Vice Chancellor of University of Pune (2010- 2011), Director of IIT Delhi (2011- 2015) and Vice Chancellor of Bennett University (2018-2021). He had been visiting professor in several universities in USA and Europe also. He is known world over for his scientific contributions. Prof. Shevgaonkar's teaching and research areas include Strategic Planning, Optical Communication, Image Processing, and Computational Electromagnetics. He played a key role in commissioning one of the world's largest Decameter Wave Telescopes at Indian Institute of Astrophysics and Raman Research Institute, Bangalore. At his alma mater IIT Bombay, he played a visionary role in setting up a Centre to generate and disseminate the video and web lectures from experts in IIT. He also helped found Centre for Distance Engineering Education. Prof. Shevgaonkar's has received several awards, including IEEE Undergraduate Teaching Award (2011), Headline Today's Education Leadership Award (2012), and Devang Mehta Business School Award (2010).

Title of the Talk:

Abstract of the Talk:

Dr. Pradipta Banerji
(Professor, IIT Bombay)



Profile of the Speaker:

Professor Pradipta Banerji is a Professor of Civil Engineering and Centre for Urban Science and Engineering at IIT Bombay, in which he is a former Head. He is also a former Director of IIT Roorkee. He has more than 38 years of academic and research experience, including supervision of more than 70 postgraduate and doctoral candidates. He has more than 100 publications to his name. He has a B. Tech degree from IIT Delhi, and MS and PhD degrees from UC, Berkeley. He has many prestigious teaching and research awards. He has also delivered some of the most prestigious National Lectures in India and Keynote Lectures in International Conferences. He is a member, fellow, chair of several committees and professional societies across the world. He has developed many popular courses for working professionals in the field of structural engineering and urban sustainability. He has been on the Board of several companies in the past 15 years. He has been a short term consultant to the World Bank Group for developing innovative academic and research programs in STEM at high schools and universities in Sub-Saharan Africa. He is known internationally for innovative developments on bridge asset management and disaster resilience. Recently, he has focused on sustainable habitat and quality of life issues in Urban India.

Title of the Talk: Future Cities: A Case for Urban Observatories in India

Abstract of the Talk: The Smart Cities Mission of the Ministry of Housing and Urban Affairs was identified as a program to introduce technology in the management of Indian cities. However, the implementation has not realized in full measure the transformation that was expected in city management. Significantly, many of the cities used the funds to develop a Command and Control Centre that was supposed to be used to manage all the city services in a top down approach. However, again not much improvement has been visible to the citizens in the delivery of services in these Smart cities except for certain cosmetic changes in parts of the cities. An approach that involves an Urban Observatory concept is proposed here for ensuring sustainable future cities. This approach uses data collection that is managed by the city as well as local ward/citizen level. Of course, the type of data and the security of the data are both very important. The data should include energy consumption and generation, air quality, weather, noise levels, water quality and quantity, waste quantity (both solid and waste water), traffic in various roads and intersections, parking availability at locality level. Obviously, collection of the data requires an innovative approach that involves city government and local management/citizens and requires development and deployment of sensors at the local/citizen level and multi-level data collection. The future implementation of the 5G network in India could provide a platform for this data collection. However, the current CC Centre also envisions data collection at a city level. However, data collection alone cannot provide improvement of services to citizens. Analysis of the data and involvement of the data analysis in decision-making is imperative for improvement of services and ensuring that the entire process can be monetized and provide a sustainable future city.

Dr. Sanjay Oak
(Ex-Vice Chancellor, Padmashree Dr. D. Y. Patil Vidyapeeth)



Profile of the Speaker:

Dr. Sanjay Oak is a renowned Paediatric surgeon of nearly 37 years of clinical standing in the faculty. He has a rich experience of health sector administration of nearly 16 years. Sanjay Oak joined Government Medical College, Miraj in 1977 and held a very illustrious academic career winning several awards and Distinctions in Pharmacology, Forensic Medicine and General Surgery. He did Masters in General Surgery and subsequently his Masters in Pediatric Surgery. He was awarded Hon. FRCS by Royal College of Surgeons Of Edinburgh. He has published more than 250 scientific papers in pediatric surgery and laparoscopic surgery in children in journals of international repute and has also contributed in health administration and university education. He has written 51 books in Marathi and English. He has been a very sought after a columnist in Sunday Loksatta for 7 years. He has been a prolific orator and has been a mentor and a role model for several young medical students. He has been awarded Dr. B.C. Roy National award in the year 2005.

Title of the Talk: Emerging Technologies in Future Healthcare

Abstract of the Talk:

Dr. Saurabh Mehta
(CAO and Professor, Vidyalankar Institute of Technology, Mumbai)



Profile of the Speaker:

Dr. Saurabh Mehta is the Chief Academic Officer at Vidyalankar Institute of Technology and a Professor at the Department of Electronics and Telecommunication Engineering. As CAO, he is actively involved in the designing of curricula, implementing academic planning and policies, introducing modern pedagogical tools and teaching methodologies. He explores ways to collaborate and integrate academia and industry and facilitates training programs for academia so that students and faculty will gain useful exposure to the professional world. He puts in efforts to bring innovation in education, research programs, and human resource development. Currently he is serving as secretary of IEEE Bombay Section.

Title of the Talk: IoE: The Next Generation Technology for Future Cities

Abstract of the Talk: IT 4.0 revolution has put us on the door of the ubiquitous arena where the Internet of Everything (IoE) is the keystone technology to future cities. In this talk, we will discuss the use cases, challenges, and opportunities of IoT/E Technology.

Dr. S. N. Talbar
(Professor, SGGS Institute of Engineering and Technology, Nanded)



Profile of the Speaker:

Dr. Sanjay Talbar is a Professor in the Department of Electronics and Telecommunication Engineering, at Shri Guru Gobind Singhji Institute of Engineering and Technology, Nanded, MS, India since 2001. He has also worked as a Professor and Head at Dr. Babasaheb Ambedkar Technological University, Lonere-Raigad from July 2002-May 2004. He has received B.E. (Electronics Engineering) and M.E.(Electronics Engineering) degrees from SGGS Institute of Technology, Nanded, India in 1985 and 1990 respectively. He obtained his PhD (Electronics and Computer Engineering) from SRTM University, Nanded, India in 2000. He received the National level “**AICTE Visvesvaraya Best Teacher Award 2021**”, “Young Scientist Award” by URSI, Italy in 2003 and “**Best Teacher Award**” from SRTMU, Nanded in 2018. He has guided about 90+ students for dissertation at ME/M. Tech. and supervised 24 students for Ph.D and additional research scholars are working towards their Ph.D. He has published 10 books, about 212 papers in reputed/indexed Journals and Conferences. He has shouldered various responsibilities as a Head, Dean (Planning), Dean (Students Affair) and Registrar at SGGSIET Nanded. He is a member of various professional bodies like, IEEE, Fellow of IETE, Life member of Indian Society for Technical Education (ISTE), and Association of Medical Physicists of India. His research interest includes Image processing, Computer Vision, Medical Image Analysis, Applications of Deep Learning in computer vision and Embedded System Design.

Title of the Talk: Brain Tumor Segmentation and Analysis

Abstract of the Talk: Among various diseases, cancer has become a big threat to human being globally. About 15.0 million new cancer cases will be diagnosed leading to 12.0 million deaths. According to the study of World Health Organization (WHO) there are more than 100 types of brain tumors out of which glial tumors are most life threatening and cancerous. Amongst variety of imaging modalities MRI is preferred because of non-invasive and good soft tissue contrast for imaging brain tumors. Accurate Segmentation of brain tumor tissue from Brain MR images is of profound importance in many clinical applications such as surgical planning and image guided interventions. Manual segmentation of brain MR images is time consuming and error prone. Although researchers are actively working on segmentation of brain tumors, there is no winning theory which will indeed help the clinicians in hospitals. This presents an unmet need for automated segmentation methods. This talk mainly focuses on two aspects of the brain tumor analysis. Development of deep learning (AI) based brain tumor segmentation approaches and radiomic feature analysis on the segmented tumor for prediction Overall Survival (OS) and gene mutation status. The proposed methods are evaluated on publically available Brain Tumor Segmentation (BraTs) Challenge dataset and local dataset from Tata Memorial Hospital, Mumbai. A supervised Deep Convolution Neural Network (CNN) based 3D U-Net architecture is proposed. We also performed radiomic feature analysis on segmented tumor to predict the OS in days.

Dr. Sandeep M. Joshi
(Principal, Pillai College of Engineering, New Panvel)



Profile of the Speaker:

Dr Sandeep M Joshi has completed PhD in Mechanical Engineering from Indian Institute of Technology Bombay, Powai Mumbai. He received M. Tech in Mechanical with Thermal & Fluids Engineering from Dr. BATU Lonere and B.E in Mechanical Engineering from Dr BAMU, Aurangabad and Diploma in Mechanical Engineering, GPD, Dhule. He has over 25 years of academic experience. He is currently working as Principal at Pillai College of Engineering (Autonomus), New Panvel, affiliated to University of Mumbai. With 1 Indian patent on Solar Air Heater, 2 more patents are under the process of submission namely Solar Dryer and Drying Cabinet, he has published 25 papers in International Journals of well repute and 15 papers in peer reviewed international conferences. He delivered many Seminars/Invited Lectures/Talks for Students as well as teachers on various topics like, Solar Energy Utilization, Basics of Heat Transfer, Excellence in Teaching, Project Based Learning, Good Report Writing, Research methodology, IPR and Patenting, Outcome Based Learning, Use of ICT in Teaching and learning etc. He is an associate member of core group on Research and Development Projects initiated by BRNS, DAE for the subject Heat and Mass Transfer and also coordinated project from institute side for Industry Education Partnership Cell, IEPC, of Maharashtra Economic Development Council, Maharashtra Entrepreneur Development Cell, MEDC. He is a member, BoS in Mechanical Engineering, UoM from October 2015 to June 2018. He has been invited by BoS Mechanical Engineering, UoMumbai for framing the scheme and structure of UG Credit Based Semester Grading System, CBSGS, and Syllabus 2012. He is also a core Member of Syllabus Committee for setting up CBSGS (Credit Based Semester Grading System) 2012 and CBCGS (Choice Based Credit and Grading System) 2016 syllabus of BE Mechanical Engineering, Automobile Engineering, ME with Thermal Engineering, Heat Power Engineering and Energy Systems and Management.

Title of the Talk: Combining Solar PV and Thermal

Abstract of the Talk: Availability and Limitations of solar energy and its utilization in Indian context. This talk tries to promote the smart utilization of solar energy as thermal as well as photovoltaic utilities. Also the limitations and advantages of both the utilizes are discussed. To overcome the limitations and best use the advantages, the possibilities regarding combining solar PV and Thermal are also discussed. The opportunities, advantages and feasibility of combining solar PV and Thermal are discussed and the results of preliminary experiments on combining solar PV and thermal are also presented.

Dr. Milind Kulkarni
(Director, Prachi Services Inc., Mumbai)



Profile of the Speaker:

Dr. Milind Kulkarni has done his B.E. (Civil) from Walchand College of Engineering, Sangli, M.E. (Civil) – Env. Engg. from VJTI Mumbai and PhD from IIT Bombay. He has received various scholarships such as Middle School, High School, National Merit, GATE and QIP throughout his academic career. He has 34 years of rich academic, research and consultancy experience as Lecturer, Asst. Professor, Professor, Director and Group Director in Engineering Institutes. He has worked for Paramount Pollution Control. His fields of expertise are water treatment, wastewater treatment, air pollution and solid waste management. He is guiding organizations in achieving zero Solid Waste objective as stipulated by Municipal Corporation of Greater Mumbai (MCGM). He has served as expert for National Board for Accreditation of All India Council for Technical Education (AICTE). Presently he is nominated as Margdarshak by AICTE. He has undertaken consultancy and research assignments for prestigious national and international organizations like Godrej, Indian Oil, Somaiya Group, BMC, GIZ, Government of Maharashtra, Georgia University US and others. He has received substantial grants from Government of India for undertaking research in the area of Source Apportionment of Personal Exposure to Air Pollution in Mumbai. He has published more than 32 papers in international and national journals and conferences and has been invited as resource person in the area of Environmental Engineering by prestigious national and international bodies. He has been on the editorial boards of national and international journals. He has been examiner for research work in IIT Bombay, Pune University and Shivaji University. He is approved PhD guide of Mumbai University for Civil and Environmental Engineering and has been member of selection committees. He was invited as speaker by prestigious international organizations such as Desert Research Institute, Reno, California State University, Northridge, University of Memphis, US, University of Massachusetts, Lowell and World Bank. He chaired session at the World Engineering Education Forum, Dubai, UAE. He has visited leading international Universities and Higher Education institutes such as Harvard University, University of California, Berkeley, Purdue University, University of Massachusetts, Lowell, Manchester Metropolitan University, Siemens Technical Academy, Berlin. His work is published in leading newspapers like Times of India, Loksatta, Maharashtra Times. He was interviewed on TV. He has visited countries like US, UK, Germany, Argentina, UAE and Australia for presenting papers, forging collaborations and delivering lectures. At present, he is working as Director, Prachi Services Inc, Mumbai which provides Services in Environmental Engineering & Management. Recently he is awarded for his

contributions in Swacch Mumbai and Swacch Bharat Abhiyan by BMC and Chief Minister of Maharashtra.

Title of the Talk: Solid Waste Management in Future Cities

Abstract of the Talk: Solid Waste Management has been a major challenge for the cities across the globe. In India, Swachh Bharat Mission was launched in the year 2014 by Prime Minister Shri Narendra Modi and Solid Waste Management Rules came into force from 2016. As per these Rules, Segregation of Solid Waste at the source in categories like Dry, Wet and Domestic Hazardous is mandatory. It is expected that Dry Waste will be recycled and Wet Waste will be treated by Composting or Bio-Methanation. Many cities like Indore, Navi Mumbai have made significant progress in Solid Waste Management. But the challenges persist. Across the world cities like Singapore have realised the importance of Circular Economy and have accepted the model of Segregation at Source and Recycling of Dry Waste. Earlier Singapore was treating all the Solid Waste by incineration technology which was generating considering air pollution and against the principles of circular economy and sustainable development.

Though many cities have achieved progress in solid waste management, considerable work is yet to be done. In Mumbai, the Solid Waste dumped to landfill sites has been reduced from 9500 MT/day to 6000 MT/day. There is scope to reduce this quantity further so that the issues like environmental pollution, release of greenhouse gases responsible for global warming and climate change can be substantially resolved. Due to climate change, instances of flooding and resultant damage to life and property are consistently increasing in India. Recently released report of IPCC has predicted that Mumbai, which is the commercial capital of India, will be the worst affected city due to climate change and the sea levels will significantly rise from 40 cm to 60 cm. Hence we should adopt new technologies for our future cities so as to prevent the damages due to adverse impacts of climate change. This paper will present the strategies and technologies which should be adopted for the solid waste management of future cities. Information and Communication Technology (ICT) can be used to tackle the complex issues of segregation of solid waste, monitoring the collection and transport of solid waste and managing the data generated related to solid waste. Technologies for Decentralised Solid Waste Management which can be practiced at Residential Complexes, College Campuses will be discussed. Extended Producer's Responsibility (EPR) is not yet integrated in the Solid Waste Management and it is very much essential for Circular Economy of future cities. This paper showcases some success stories in this regard and also discusses how technology and engineering management can be used for solid waste management of future cities as envisaged by policy makers and for circular economy and to achieve Sustainable Development Goals as stipulated by UN.

Dr. Priam Pillai
(COO, Mahatma Education Society)



Profile of the Speaker:

Dr. Priam Pillai is an Associate Professor (Mechanical) at Pillai College of Engineering, New Panvel and is also the Chief Operating Officer of Mahatma Education (MES). He is PhD from MIT (USA). He has developed several novel instruments for material testing. His research interests also include applications of GIS and remote sensing for development of maps that can be used for Urban planning. He is the founding partner of the Urban Expansion Observatory, a joint research initiative in Geospatial technologies between Mahatma Education Society and New York University. He is Director of Valectus Pvt Limited, a geospatial analytics company that specializes in providing geospatial solutions to small and medium businesses as well as government agencies. The company was the winner of the Maharashtra State Innovation Society's start-up award in 2020. He has started many new initiatives at MES including launch of Pillai Center of Innovation and Entrepreneurship, Google Apps for Education in the all (48) MES institutions, founded the Urban Expansion Observatory, numerous Industry-Institute Interactions, development and adaptation of open-source software and technologies for education and many others. Dr. Pillai is the winner of numerous awards from the US government as well as private organizations. He was awarded the Gore Award for innovation by the Institute of Soldier Nanotechnologies sponsored by the US Army, the National Science Foundation Graduate Research Fellow Award, the UC Berkeley Materials Science and Engineering Department Citation. In 2010, he received an outstanding service award for assisting the Boston police department and district attorney's office in the use of thermal cameras in their investigations.

Title of the Talk: Studying Cities at the Urban Expansion Observatory

Abstract of the Talk:

Dr. Padmaja Joshi
(Senior Director C-DAC, Mumbai)



Profile of the Speaker:

Dr. Padmaja Joshi is currently working as Senior Director at C-DAC, Mumbai. She has total work experience of 29 years including her Ph.D. work. She has completed her Ph.D. in “Coupling and Cohesion Analysis of Object Oriented Programs for Refactoring” under the guidance of Prof. Rushikesh Joshi from IIT Bombay. She was an active member in the standard development committee at national level on Enterprise Architecture for e-Governance (IndEA). She also has contributed a chapter on security in this standard. She is also a member Software systems and applications for E-Governance and E-Business Infrastructure, Strategy and planning committee for Blockchain Technology, Data Anonymization subcommittee of e-Governance standards, IEEE subcommittee for “Digital Identity” standards. She has authored many research papers in international journals and conferences. She is currently involved in national level projects on Mobile Seva Appstore, Unified Blockchain Framework, e-Pramaan: An authentication framework and on projects like mVoting. Her areas of interest include blockchain technology, e-authentication, e-governance, object oriented technology, mobile cloud computing, data anonymization and cyber security.

Title of the Talk: Future Cities and The Role of Blockchain

Abstract of the Talk: Currently blockchain has shown its applicability in various applications like cryptocurrency, supply chain management, education etc. This distributed ledger technology helps build trust layer to the applications. Will this technology be useful in future cities?

Dr. Veerle Vandeginste
(KU Leuven, Campus Bruges, Department of Materials Engineering, Bruges, Belgium)



Profile of the Speaker:

Dr Veerle Vandeginste is an Associate Professor in Materials Engineering. Her research focuses on interfacial engineering for sustainable functional materials, in particular energy related, namely carbon capture, utilization and storage, smart coatings for better energy efficiency, and energy storage (electrode/electrolyte interfaces) and harvesting. She is an expert in physicochemical processes at material interfaces, linked with material behaviour, with 20 years of experience in natural materials (geo-energy), and more recent expertise in synthetic materials (chemical, electrical, renewable energy). She aims to narrow the gap between academia and industry, to accelerate knowledge transfer, bringing innovations from the laboratory into the large scale industry.

Title of the Talk: Advanced materials for smart buildings

Abstract of the Talk: Global warming and occurrences of climate extremes have already started to take human lives, in particular by heat-related illnesses [1]. The construction industry plays a major role in greenhouse gas emissions, with the cement industry generating about 7% of global CO₂ emissions [2], and buildings consuming about 40% of the world's energy [3]. Significant efforts are thus required to use renewable resources more efficiently and to develop buildings with sustainable, recycled or advanced materials [4]. There is thus a trend and evolution from (i) zero-energy building, with very high energy performance, and (ii) green buildings, with lower environmental impact, towards (iii) smart buildings with building management systems and which have a very high energy and environmental efficiency and intelligent interaction with the environment and the users. In the last decades, the advances in nanotechnology have paved the way for the development of nanomaterials with new or enhanced properties, which can contribute to improvements in the energy and environmental efficiency in buildings [5]. Developments have been achieved for a range of building materials, such as concrete with the use of nanocomposites and nanocoatings [6]. Advanced materials to improve insulation and thermoregulation in buildings include silica aerogel [7], phase-change materials [8], thermal reflective surfaces [9], self-cleaning glazing [10] and several types of dynamic glazing [11]. Silica aerogel is a nanoporous insulating material with very low density, made through dehydration of a colloidal gel by a gaseous component. The very low thermal conductivity of this material can be explained by the Knudsen effect. Phase change materials absorb or release heat to the environment by the latent heat associated with the solid/liquid phase change at a certain temperature. Self-cleaning glazing can have either superhydrophobic surfaces or superhydrophilic photocatalytic surfaces. In terms of dynamic glazing, these can be passive, for example

photochromic or thermochromic, or active, such as electrochromic or with polymer dispersed liquid crystals. Moreover, efforts are also focused on renewable energy for buildings through, for example, the development of advanced photovoltaic glazing [12]. To bring these innovative advanced building materials more into the market, several challenges still need to be overcome, such as the cost, information and knowledge transfer, and nanoparticle-related health concerns.

References

- (1) De Troeyer, K.; Bauwelinck, M.; Aerts, R.; Profer, D.; Berckmans, J.; Delcloo, A.; Hamdi, R.; Van Schaebybroeck, B.; Hooyberghs, H.; Lauwaet, D.; et al. Heat related mortality in the two largest Belgian urban areas: A time series analysis. *Environmental Research* 2020, 188. DOI: 10.1016/j.envres.2020.109848.
- (2) Benhelal, E.; Zahedi, G.; Shamsaei, E.; Bahadori, A. Global strategies and potentials to curb CO₂ emissions in cement industry. *Journal of Cleaner Production* 2013, 51, 142-161. DOI: 10.1016/j.jclepro.2012.10.049.
- (3) Perez-Lombard, L.; Ortiz, J.; Pout, C. A review on buildings energy consumption information. *Energy and Buildings* 2008, 40 (3), 394-398. DOI: 10.1016/j.enbuild.2007.03.007.
- (4) Shaikh, P. H.; Nor, N. B.; Nallagownden, P.; Elamvazuthi, I.; Ibrahim, T. A review on optimized control systems for building energy and comfort management of smart sustainable buildings. *Renewable & Sustainable Energy Reviews* 2014, 34, 409-429. DOI: 10.1016/j.rser.2014.03.027.
- (5) Singh, L. P.; Dhaka, R. K.; Ali, D.; Tyagi, I.; Sharma, U.; Banavath, S. N. Remediation of noxious pollutants using nano-titania-based photocatalytic construction materials: a review. *Environmental Science and Pollution Research* 2021, 28 (26), 34087-34107. DOI: 10.1007/s11356-021-14189-7.
- (6) Norhasri, M. S. M.; Hamidah, M. S.; Fadzil, A. M. Applications of using nano material in concrete: A review. *Construction and Building Materials* 2017, 133, 91-97. DOI: 10.1016/j.conbuildmat.2016.12.005.
- (7) Karamikamkar, S.; Naguib, H. E.; Park, C. B. Advances in precursor system for silica-based aerogel production toward improved mechanical properties, customized morphology, and multifunctionality: A review. *Advances in Colloid and Interface Science* 2020, 276. DOI: 10.1016/j.cis.2020.102101.
- (8) Kuznik, F.; David, D.; Johannes, K.; Roux, J. J. A review on phase change materials integrated in building walls. *Renewable & Sustainable Energy Reviews* 2011, 15 (1), 379-391. DOI: 10.1016/j.rser.2010.08.019.
- (9) Lee, S. W.; Lim, C. H.; Bin Salleh, E. I. Reflective thermal insulation systems in building: A review on radiant barrier and reflective insulation. *Renewable & Sustainable Energy Reviews* 2016, 65, 643-661. DOI: 10.1016/j.rser.2016.07.002.
- (10) Midtdal, K.; Jelle, B. P. Self-cleaning glazing products: A state-of-the-art review and future research pathways. *Solar Energy Materials and Solar Cells* 2013, 109, 126-141. DOI: 10.1016/j.solmat.2012.09.034.
- (11) Casini, M. Active dynamic windows for buildings: A review. *Renewable Energy* 2018, 119, 923-934. DOI: 10.1016/j.renene.2017.12.049.
- (12) Singh, D.; Chaudhary, R.; Karthick, A. Review on the progress of building-applied/integrated photovoltaic system. *Environmental Science and Pollution Research* 2021, 28 (35), 47689-47724. DOI: 10.1007/s11356-021-15349-5.

FULL PAPERS

Non-Repudiation with the help of A.I

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Abstract—Wrongdoing conception in surveillance videos is more challenging than detection. This work introduces the design of an accurate, lightweight and fast variance understanding neural network. AI capabilities can improve the way current security solutions are working today. It is projected that there will be need for security in area of AI to overcome issues like securing AI training data, training pipelines and ML models, also how AI modelled applications can be operated through negotiating with them. How can AI be leveraged to enhance security of critical infrastructure in the landscape of critical information which may contain large amount of critical business data. Now a day's state sponsored attacks are growing on an alarming rate, due to which government and private organization are more vigilant in protecting critical infrastructure. This can be achieved by creating business application which will solve the headache of securing critical information for NCIIPC. (National Critical Information Infrastructure protection centre) and various other such governing bodies. This can be simulating in high end laptop with Intel Core i5 – 9th Generation processor, 6 GB NVIDIA GPU GTX 1660 Ti, which has high FPS which we think will work more smoothly with MTCNN model to detect and recognize the face. Also, at various stages authentication function and alert function will work on top of recognition function. This application will prevent the user to enter into critical infrastructure and prevent wrong doing post validating itself through fake ID Card and also will help in achieving nonrepudiation.

Keywords—AI, ML, NCIIPC, MTCNN, Security, IoT, ID Card, Data-Theft, PII, SPDI (key words)

I. INTRODUCTION

Quick conception (detect and classify) of low-possibility abnormal (e.g., violent or illegal) events in surveillance videos are huge [1], [2], especially on resource-limited terminal or edge devices. Now a day's various devices complemented this on high end machine with 6 GB NVIDIA GeForce GTX Ti Graphic card, Intel i5 9th Gen processor, 8 GB RAM.

We are trying to provide a business application where business can be rest assure about intruder having fake/spoof ID card entering into their critical infrastructure once this solution is implemented. Our main goal is to develop an application which will have more than 95% accuracy along with faster processing which will recognize and detect the image so that it can be compared with database to take appropriate decision. There are lot of challenges in implementing this solution as on a daily basis hiring and firing are done in an organization, also while hiring most of the employees don't have their recent photo to share with organization so that they can print that on employee's ID card, so database will not be having most recent photo of an employee. To compare the face of employee with his already shared image is bit difficult as over the time lot many features get change, some may get glass with increase in their eyesight, some may get rid of it by operating.

deployed and monitored, various solution being purchased and being deployed to protect critical infrastructure of private or government organization. Among various works, a typical solution is to detect anomaly behavior such as destroying or harmful activity inside critical area. Rather than having detective control there should be preventive control so as to percentage of damage control can be minimized. All the motion detection solution monitors and extracts motion signal in a video stream, such as color, texture and optical flow [3], [4]. Other approaches use mixtures of probabilistic principal components on sparse dictionary [5], k-Nearest Neighbors [1], as well as Gaussian regression [6] etc. Nonetheless, Multi-Task Cascaded Convolution Neural Networks (MTCNN) detects facial landmarks and faces from images. It is one of the most accurate tool today. It consists of 3 neural networks (P-Net, R-Net and O-Net) connected in cascade. Facenet which is deep neural network used for mining sceneries from an person's face. FaceNet take an image of the person's face as input and gives output in form of vector, it gives 128 number vectors as an output which represent the most important features of a face. Vector which contains person's face in form of numbers is called as embedding. Why embedding? Because all the important information of person's face from an image is embedded into this vector.

The business solution whichever it may be with any algorithm or methodology it should ensure certain parameters like performance providing faster output along with high result accuracy. To achieve this, the framework should be light weight in term of processing and time complexity should be low. To achieve all this multi-threaded environment should be used. We have used MTCNN and facenet for face recognition. We have im

Organization needs to understand that insider threats aren't just their employees but their contractors, vendors, that come in and work for you. Arguably the most difficult to deal with is insider threat.

II. LITERATURE SURVEY

In this section we will be discussing the related work and contributions done towards creating applications for object detection and video surveillance. Viola and Jones face detection algorithm [7] brought an evolution in the field of Machine Learning and is distinguished by three key contributions which was significant one. The First key contribution is "Integral Image" which allows the sceneries used by the detector to be calculated very rapidly. The other key stimulus is, based on AdaBoost, which selects a small number of critical visual sceneries from a larger set and yields really efficient classifiers and the third key participation is a method for amalgamation progressively more complex classifiers in a "cascade" which allows background sections of the image to be rapidly remove while processing more computation on actual object like

regions. In one of the paper authors trained 38-layer cascaded classifier for detection of frontal faces. They published each classifier in cascade was trained with 4916 training faces and their straight flipped versions (totalling 9832 faces) and 10,000 non-face sub-windows using the Adaboost training technique. While the detector runs at 15 frames per second [7] making it appropriate for real-time applications.

But when used against 30 real life scenarios, the Viola-Jones face detector gets affected with multi-view discrepancies and radiance changes, causing the accuracy to drop significantly. Using Histogram of Orientated Gradient (HOG) in this case turn out to be a great auxiliary, as it is usually invariant to global vivacity changes and is capable of catching logical possessions of faces that are hard to capture with Haar-like features. Contrasting the Haar features, the HOG feature space is comparatively small. Hence, an idea to advance detection rate is to quickly extract HOG features and train a very modest SVM classifier and use in amalgamation as a Cascade classifier. Author trained this method with 1239 of the photos as constructive training samples, together with their left-right reflections together it is 2478 photos in total. A fixed set of 12180 patches tested arbitrarily from 1218 person-free training images provided the initial rejections. The method is then re-trained using the bigger set [8] [9]

The problem definition of object detection is to regulate where objects are positioned in a given photo that is object localization is the motive and which group each object belongs to this means object classification we want to do. So, the channel of old-style object detection models can be largely alienated into three steps: useful region selection, feature mining and classification. Deep learning has become really popular in industrial as well as among educational institute. Their triumph results from training a large convolutional neural network (CNN) on 1.2 million labeled images together with a few techniques including but not limited to [10], ReLU operation [12] and 'dropout' regularization [11]

Face observation is a vital portion of the human skill in building system and is a usual job for humans, while building a similar computer system is still an on-going research area. The early work on face recognition can be traced back at least to the 1950s in mindset [Bruner and Tagiuri 1954] and to the 1960s in the engineering creation [Bledsoe 1964]. Some of the initial studies include work on facial presence of views by Darwin [1972] (see also Ekman [1998]) and on facial profile-based biometrics by Galton [1888]). But research on automatic machine salutation of faces actually started in the 1970s [Kelly 1970] and after the influential work of Kanade [1973]. Over the past 30 years extensive study has been conducted by psychophysicists, neuroscientists, and engineers on various features of face recognition by various humans and machines.[2] As per literature review done there are various classifier for face detection but to achieve greater accuracy and on dealing with large dataset, we have to use deep learning e.g CNN or MTCNN models.

Author anticipated a system or rather a desktop-based application using OpenCV libraries, built on linux OS system and deep-learning algorithms[13]. This system will start video recording as soon as movement is recognized. As video recording munches huge data and they need more

time to search in the pre-recorded files. An AI based desktop application which is intended and established in order to start recording only if a person or a human face is identified. As this will improve systems proficiency in terms of dropping the storage need for saving recordings, and reducing the processing and searching time in the recordings. This application has 2 discovery modes, human face identification and human body identification. The system has been verified and appraised by various assessors and organizations that use surveillance systems, and survey and talks were conducted. Based on the assessment results, it can be inferred how much this system is an important application to the target group [14].

Numbers of writings are available on the applications of Hidden Markov Models (HMMs) for the design recognition. The practical applications of HMMs are in speech recognition, computational biology, biomedical signal interpretation, image classification and segmentation, online world recognition, etc. There are four basic parts involved in the HMM: namely states, initial state distribution, state transition matrix, and state observation matrix. A state represents a property or condition that an HMM might have at a particular time. Initial state distribution indicates each state probability of an HMM at the time of starting the exhibiting procedure of an event. The state transition environment represents the probabilities among the states. The observation environment contains the observation probabilities from each state. Once the architecture of an HMM is defined with the four essential components, training of the HMM is required. In practice, there are some well-established training algorithms available to automatically optimize the parameters of the HMM. The Baum-Welch [3] training procedure is a standard algorithm which uses the Maximum Likelihood Estimation (MLE) criterion.

III. OVERVIEW SCENARIO OF CURRENT PROBLEM

There are solutions to monitor and serve tracking of ID card access, Human face recognition, detection and motion monitoring, but there are no such systems which can integrate and correlate each other's activities, these systems when adding AI capabilities can produce highly unexplored great results compare to existing individual system. As there are no existing business solution which can overcome data theft related problems, currently what so ever solution available in the market all are detective rather than preventive solution. There are some challenges likewise how these systems connected over network will share information, coordinate and work hand in hand real time to detect and prevent the attack that to real time. With IoT in place to some extent these challenges can be addressed, integrating all these systems to work together with Internet connected devices will be connected through IoT framework. But to compute data generated by these devices will be huge and to work on huge data will be challenging. Also, there are other few challenges which we can forecast are network latency, device compatibility, cost of device, single point of failure, geographically located, cost of performance, different vendor systems, sharing and compatibility and many more challenges to this business application.

IV. PROPOSED SOLUTION TO THE CURRENT PROBLEM

For attack related to data mentioned above how AI-IoT enabled business application can help to overcome this problem? Let us illustrate with an example Consider there is a business application which is connected to RFID end terminal, CCTV camera inside critical infrastructure (let us consider Stock exchange server room), now when employee tries to enter server room by tapping ID card at RFID terminal immediately that data will be shared to cctv camera installed inside server room through our business application. On this our business application with initiate a search for an image of an employee in organisation database whose RFID got tap on terminal, it will bring the image already strode against that employee id and will be ready to compare the feeds coming in from CCTV insider server room as depicts (Fig. 1). Another thread will be initiate which will detect face, probability and landmarks from frame. MTCNN will be used to get three things bounding Box, probability that it is face and landmarks. Once our program identifies these three things, we will capture that frame and will initiate the 3rd thread which will do the face comparison in NumPy array. On comparing our program will return the boolean value 0 for exact match and 1 for no match. 0 meaning match will allow the employee into server room and 1 means there is no such match with stored information in data base and hence trigger the alert as depicts (Fig. 1) which will help us detecting employee using fake card/duplicate ID card for an attack. This way we think we can create preventive control and can stop the attacker at very initial phase of an attack.

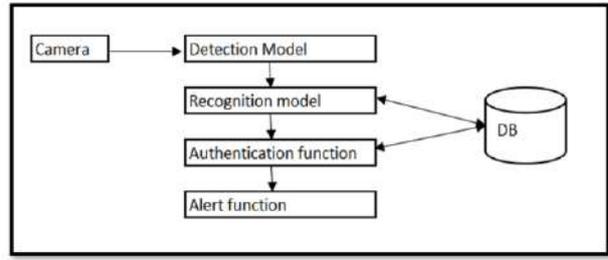


Fig. 2. Above diagram represents the architecture flow

As there are two ways to implement this solution is to deploy this application in actual organization’s server room where everything will be deployed from network to all the hardware. We will just need to connect it with our application but no corporates will allow to allow access to their critical infrastructure to 3rd party. So, we have decided to do this in simulation way that means we will be using high end laptop with NVIDIA GeForce GTX 1660 Ti 6 GB RAM, Processor with intel i5 9th Gen, 8 GB RAM, 144 HZ, 2 TD HDD with 256GB SSD. Along with the hardware components we have also used software components like: cv2, torch, numpy, facenet pytorch, MTCNN.

The Training method, each stage of MTCNN network is a multi-tasks network. The major tasks for each layer are face judgement, bounding box regression and feature location. Face judgement. The learning target is a bipartition problem. For each sample x_i , it uses cross-entropy loss function

$$L_i^{det} = -(Y_i^{det} \log(\pi) + (1-Y_i^{det})(1-\log(\pi))) \tag{1}$$

π is the probability that the face same x_i predicted by the MTCNN is a really face. Y_i^{det} stands for ground-truth $Y_i^{det} \in \{0,1\}$.

Bounding-Box Regression. For each candidate window, the offset (such as the top left coordinate, the height and the width) between it and the nearest ground-truth is predicted. The learning target is a regression problem. The loss function is the square loss function:

$$L_i^{box} = \|y_i^{box} - \hat{y}_i^{box}\|_2^2 \tag{2}$$

\hat{y}_i^{box} is the regressed target from the network. y_i^{box} is the ground-truth four-dimensional coordinate, including the top left coordinate, the height and the width. The property of the Bounding-Box contains many kinds of relevant labelled information, such as blur, expression, illumination, invalid, occlusion, pose.

Feature Location. It is similar with Bounding-Box Regression. The loss function is as following:

$$L_i^{landmark} = \|y_i^{landmark} - \hat{y}_i^{landmark}\|_2^2 \tag{3}$$

Likewise, $\hat{y}_i^{landmark}$ is the regressed feature coordinate from the network. $Y_i^{landmark}$ is the ground-truth containing five coordinates: two eyes, two corners of the mouth and the nose.

Multi-source Training. As the data set for training are different for the disparate tasks during the learning course, when doing one task of training, the loss of another task’s training should be zero. Thus, the combination loss function should be as follows:

$$\min \sum_{i=1}^N \sum_{j \in \{det, box, landmark\}} \alpha_j \beta_i^j L_i^j \tag{4}$$

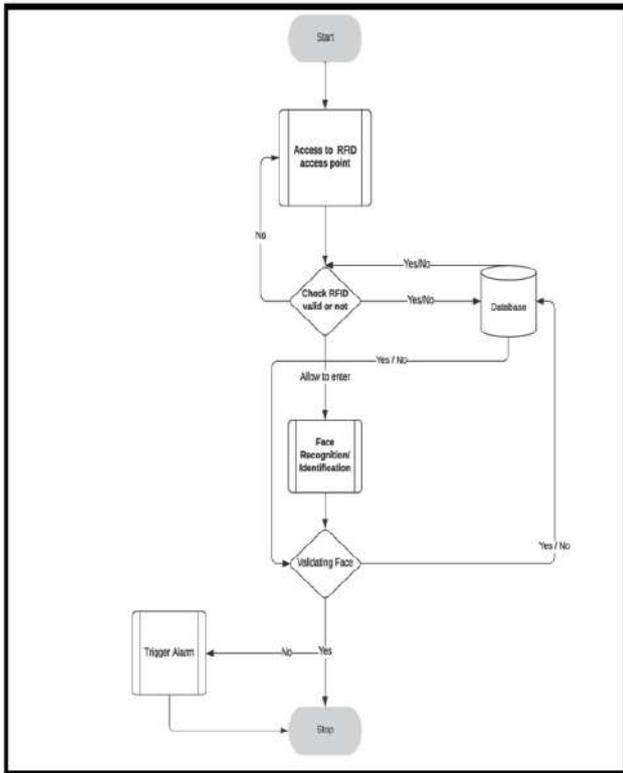


Fig.1. The above diagram depicts the Data Flow design step by step

We are planning to develop business application to the said problem that we have identified which will help in providing non-repudiation. For that we have proposed the architecture to which the development will be done considering it as a reference.

N stands for the quantity of the training samples a_j is the importance of each task. In P-net and R-net, $\alpha_{det} = 1$, $\alpha_{box} = 0.5$, $\alpha_{landmark} = 0.5$. While in O-net, for gaining higher precise face coordinates, the parameters are $\alpha_{det} = 1$, $\alpha_{box} = 0.5$, $\alpha_{landmark} = 1$. β_i^j is the indicator of the sample type, in this case, stochastic gradient decent (SGD) can be used naturally to train these CNNs.

V. RESULT AND OBSERVATION

We tried MTCNN, PyramidBox and DSFD algorithm with original images and resized images. We tried to observe results with CPU and GPU utilization along with computation time. In figure 3 we observed that for original image size 100%, MTCNN takes less CPU and GPU resources, when compared MTCNN with PyramidBox, MTCNN takes 94% less CPU computation time. And on comparing MTCNN with DSFD, MTCNN takes 97% less CPU computation time. And for GPU resource utilization we observed MTCNN is more efficient than PyramidBox and DSFD. In our observation we found that MTCNN takes 71% less GPU time compare to PyramidBox and 69% less when compared with DSFD.

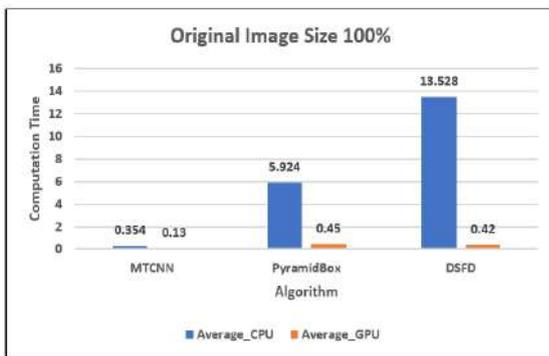


Fig.3. Above chart depicts the computation time taken by different algorithms when provided with same sized image

Similarly, we tried MTCNN, Pyramid Box and DSFD algorithm with resized images. We tried to observe results with CPU and GPU utilization along with computation time. In figure 4 we observed that for resized image 50%, MTCNN takes less CPU and GPU resources, when compared MTCNN with Pyramid Box, MTCNN takes 92% less CPU computation time. And on comparing MTCNN with DSFD, MTCNN takes 96% less CPU computation time. And for GPU resource utilization we observed MTCNN is more efficient than Pyramid Box and DSFD. In our observation we found that MTCNN takes 66% less GPU time compare to Pyramid Box and 63% less when compared with DSFD.

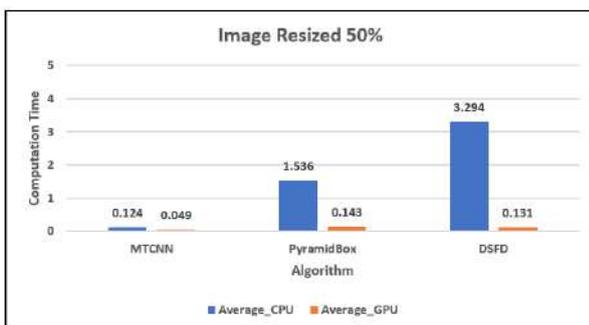


Fig. 4. Above chart depicts the computation time taken by different algorithms when provided with 50% resized image

VI. CONCLUSION

Initially we tried Haar cascade classifier for face recognition and we observe it is quite faster in recognizing face, however it failed when we obscure the partial face with finger or hand, we observed it failed to recognize the face. So, we tried using MTCNN where we observed it is slow compare to Haar, but Haar recognize frontal face while MTCNN was able to recognize tilt face too. We observe MTCNN has more accuracy in recognizing face over Haar cascade (Table I) Also, for our problem statement we really concern about accuracy than processing. And from the above result observation we found MTCNN to be more CPU and GPU efficient. Hence, we will be continuing our further work with MTCNN.

TABLE I CLASSIFIER COMPARISON DONE FOR VARIOUS FACE MOVEMENTS AND ALIGNMENTS

Sr. No	Comparing the models on Videos (Frame size 640X360)	HAAR	MTCNN
1	Different Angles of the face	50%	80%
2	Head Moving	60%	80%
3	Occlusion of Face	50%	70%
4	Different lightning Conditions	80%	60%

By proposing this concept, we want to enhance the existing authentication control with the help of AI for any critical infrastructure. If this concept used along with existing control, it will help system becoming more robust for authentication workflow. Also, while proposing this concept few things were kept in mind like OpenCV libraries open source and available freely, CCTV which are already been install are detective control and just to become compliant but by this concept we are trying to create preventive control that will be cost effective as well as easy to implement. In current scenario to enter into critical infrastructure one has to go through lots and lots of approvals from various governing body. As CCTV are mandatory for any critical infrastructure, we propose to integrate it with AI application which can detect and identify face base on input from RFID terminal and also will have action taking capabilities. With this we are concluding that our proposed concept can enhance the current process/system with the help of AI based application. In this model, accuracy, execution time, cost and client-trust parameters are considered simultaneously to yield a genuinely optimal and beneficial solution while improving usability experience. Human involvement will be less with all devices connected and having correlation capabilities. This business application will help in preventing various security and data related attacks and will avoid human error transaction etc.

REFERENCES

[1] M. U. K. Khan, H.-S. Park, and C.-M. Kyung, "Rejecting motion outliers for efficient crowd anomaly detection," *IEEE Transactions on Information Forensics and Security*, vol. 14, no. 2, pp. 541-556, 2019

[2] W. Sultani, C. Chen, and M. Shah, "Real-world anomaly detection in surveillance videos," *Center for Research in Computer Vision, University of Central Florida*, 2018.

- [3] M. Hasan, J. Choi, J. Neumann, A. K. Roy-Chowdhury, and L. S. Davis, "Learning temporal regularity in video sequences," in *IEEE Conference on Computer Vision and Pattern Recognition*, 2016, pp. 733–742.
- [4] E. Ricci, G. Zen, N. Sebe, and S. Messelodi, "A prototype learning framework using emd: Application to complex scenes analysis," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 35, no. 3, pp. 513–526, 2013.
- [5] C. Lu, J. Shi, and J. Jia, "Abnormal event detection at 150 fps in matlab," in *IEEE Conference on Computer Vision*, 2013, pp. 2720–2727.
- [6] K.-W. Cheng, Y.-T. Chen, and W.-H. Fang, "Video anomaly detection and localization using hierarchical feature representation and gaussian process regression," in *IEEE Conference on Computer Vision and Pattern Recognition*, 2015, pp. 2909–2917.
- [7] Paul Viola and Michael Jones, "Rapid Object Detection using a Boosted Cascade of Simple Features," in *Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the 2001 IEEE Computer Society Conference*, volume 1, pages 1– 511. IEEE, 2001.
- [8] N. Dalal, B. Triggs, "Histograms of oriented gradients for human detection," *CVPR*, pp. 886-893, Vol. 1, 2005.
- [9] Rekha N, Dr.M.Z.Kurian , "Face Detection in Real Time Based on HOG," *International Journal of Advanced Research in Computer Engineering and Technology (IJARCET)* Volume 3 Issue 4, April 2014.
- [10] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in *NIPS*, 2012.
- [11] V. Nair and G. E. Hinton, "Rectified linear units improve restricted boltzmann machines," in *ICML*, 2010.
- [12] Zhong-Qiu Zhao, Peng Zheng, Shou-tao Xu, and Xindong Wu, "Object Detection with Deep Learning: A Review," *Journal of Latex class files*, Vol. 14, No. 8, March 2017.
- [13] Alajrami, Eman, Hani Tabash, Yassir Singer, and M-T. El Astal. "On using AI-Based Human Identification in Improving Surveillance System Efficiency." In 2019 International Conference on Promising Electronic Technologies (ICPET), pp. 91-95. IEEE, 2019.
- [14] Aguilar, Wilbert G., Marco A. Luna, Julio F. Moya, Vanessa Abad, Hugo Ruiz, Humberto Parra, and Cecilio Angulo. "Pedestrian detection for UAVs using cascade classifiers and saliency maps." In International Work-Conference on Artificial Neural Networks, pp. 563-574. Springer, Cham, 2017.
- [15] Perdana, Octgi Ristya, Aris Tjahyanto, and Febriliyan Samopa. "Accuracy Comparison of Home Security Face Recognition Model in The Several Lighting Condition Using Some Kinect Produced Image." In 2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT), pp. 105-110. IEEE, 2021.
- [16] Egiazarov, Alexander, Fabio Massimo Zennaro, and Vasileios Mavroudis. "Firearm detection via convolutional neural networks: comparing a semantic segmentation model against end-to-end solutions." In 2020 IEEE International Conference on Big Data (Big Data), pp. 1796-1804. IEEE, 2020.

Distributed Workspace - Using Cloud Technology and Version Controlling

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Abstract— efficient management of stakeholders in any web project is need of the time. There are lots of stakeholders involved in a web project and managing everyone and everything becomes messy. To make the job easier there for platforms that facilitate distributed development. With this system, “Distributed Workspace”, features of existing applications have been integrated and more features have been appended to make development much easier. It is done by the algorithm which is based on microservice architecture. The application aims to provide better source code accessibility and version control. It automates project operations and other development tools all in one place. Mainly, it eliminated the overhead of downloading the project files to the local machine. All these make a platform where users can works, coordinate with each other and share their resources, bridging the communication gap in a more efficient manner than the existing applications.

Keywords— ERP, distributed workspace, developer workspace, Cloud computing, Live code editor, Version control.

I. INTRODUCTION

In today's world communication is a key to the success of any project. The work “Distributed Workspace” is based on the aspects of providing ways for better communication between project team members [1]. This is done using *distributed cloud servers* i.e. more than one server acting together to perform a large task in the system. In this system these distributed servers are Amazon’s EC2 instances. EC2 is a service that provides us to compute on virtual machine. These distributed servers communicate with each other using API and are connected in a network storage. This system uses an amazon storage service called the *EFS*, designed to provide scalable, elastic, concurrent and encrypted file storage. Every EC2 instance makes use of this file system.

The objective of this work is to develop a platform where resources & work of every developer can be viewed and shared by authorized co-workers. This platform which can be used in a website developing organization, where website resources can be bundled in one place [3].

This creates a workspace for every member in a project to view and use the resources for development. This workspace gives the developers the luxury to host their project within the same platform without the need to download the repository and run it on a local machine [3].

This system provides features like creating a roadmap, assigning task and contact members. An efficient algorithm and such added functionalities make this as a practical application.

II. RELATED WORKS

This section discusses the literature surveyed to build the idea of distributed workspace with unique features. It was identified that some existing workspaces use only cloud computing, only distributed computing or only version controlling. The idea proposed in this paper integrate these features and aims to overcome the drawbacks of these existing projects.

Microsoft Azure: Windows Azure platform offers a runtime execution environment for managed code to host and run scalable solutions. Each Windows Azure Compute instance is also a Virtual Machine (VM) instance created by the platform and only the number of instances is configured by the team hosting the application. Every VM instance runs an Azure agent to connect and interact with the Windows Azure fabric. Every VM has a local file system which can be utilized by the web/worker role instance during their lifetime, but once the VM instance is shut down, VM and local storage will go away. Azure maintains 3 different instances of every application on the cloud and the end-user will not be aware of which instance is serving the specific request. Hence persistent storage is required to support the application data and this can be met using the Windows Azure Storage Service. With geographically distributed canthers, Windows Azure Compute provides developers with the functionality to build, host and manage applications on the cloud. Application developers can connect to Windows Azure portal using Windows Live ID and choose a hosting account to host applications on the cloud and a storage account to store data or any relevant content on the cloud. Certain applications can use either the hosting or storage accounts or both. The accounts enable developers to host and deploy applications on the Windows Azure platform. Windows Azure presently supports three roles; web role instance, worker role and VM role.

Palantir: Coordinating distributed workspaces: By our observation Palantir not only requires the main user to have knowledge of their own set of work but it also requires the user to have knowledge about the changes done by his/her developer colleague.

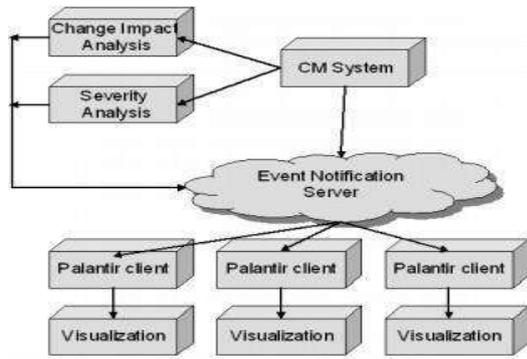


Fig. 1. Conceptual Architecture of Palantir.[6]

Palantir provides the developer with a graphical display. Specifically, Palantir allows developers to better coordinate their activities by providing each developer with a graphical display that shows the set of artifacts they are modifying, meta-data about those artifacts (e.g., artifact name, version number, author information, etc.), and the severity and impact of the modifications being made in parallel by other developers. Knowing this information allows developers to better assess the ongoing activities and accordingly coordinate their activities amongst each other.

The above figure displays the architecture used for the creation of Palantir. The main role of the Palantir Client is to intercept the severity and change impact events and translate them into an internal representation that is subsequently used by the visualization block. At a minimum, the visualization component will show which artifacts are being checked-out and checked-in and the severity and impact of each of the changes. In doing so, developers are presented with an increased level of awareness of other developers' activities. We intend to develop a range of visualizations from which each developer can choose the one they prefer. Each of these visualizations will be based on a different balance among the amount of information displayed, interface usability, and intrusiveness of the interface.

III. PROBLEM DEFINITION

Through the rigorous literature survey, it is observed that, in a typical distributed project work, where more number of people contribute, it is difficult to communicate with each other in a true manner [1]. The common problems encountered by any website developer are assigning sharing, tasks, hosting, having a progress report.

The work in this paper, aims to solve these problems by providing an environment where users can work in synchronism, controlled by a project administrator. The other objectives of this work is to provide flexible version control. While working on different technologies and modules, it may sometimes become necessary to revert back to the older versions of the modules. It is observed that this is extremely difficult in most of the existing workspace solutions because the current file is modified by multiple users simultaneously. [2].

The drawback of the systems which provide version control is that it mandates the entire project repository to be downloaded on the local machine making them less user friendly.

IV. METHODOLOGY

A. About the system

Distributed workspace is categorized in two parts, a) front end: It is the dashboard available for the admin, and b) the backend that handles the files and maintains version control. The front end dashboard interacts with the user/admin where they can edit files, add files, add employees, view their work etc. The backend consists of two servers, 'the php server' and the 'Linux powered got server'. All actions performed in frontend are received at the backend. The steps are as follows:

By referring to Fig. 2, the flow of the project can be understood. First any user would visit the website having information about us and how he/she could use the service. When a new user signs up, if it is a company, it will register itself and get a repository allocated with its company name on the server. If it is an employee, he would have to enter the unique company pin(known to the company admin only) to be registered into the company.

Once the user has signed up he/she would be prompted to sign in. On successful sign in, the website would open up either an admin dashboard, if sign in is performed through a company email id or to the user dashboard, if sign in is performed through an employee's email id.

In an admin's dashboard, the admin can add/Delete employees in his company and add projects and upload necessary files into the repository. The admin assigns a project manager whose role is to select required employees added in the company to his project and maintain the repository and maintain a To-Do list. In a user's dashboard, the user/employee can view his colleagues in the company he works, view projects assigned to him, keep a track of his works and tasks in the To-Do list and view files in the repository assigned to him and edit code using built-in code editor.

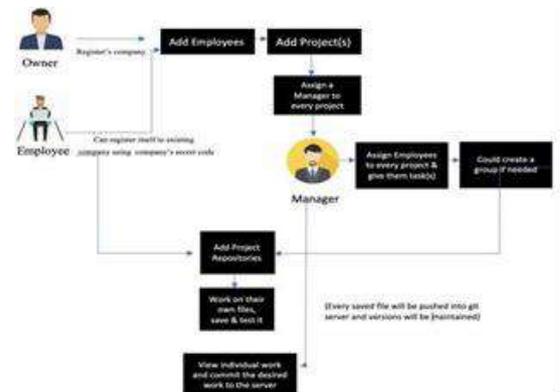


Fig. 2. Flow of Distributed Workspace

At the backend, it is mainly making use of two servers, one is the php server and other is the git server. While creating a project a git repository is created in the git server. Admin and manager are assigned with the developer (dev) branch and employees with their own branch named after their email id. When the user has to access the project files, a request is sent to the git server to load the files in the frontend. The editor will have a file structure column, which will be received from the server. It would only be the structure and not the files to save the server load. Once the employee selects a file, the request would be sent to the

'===== ' till '>>>>>>>>' (followed by the hash code of the incoming branch)'.
 Distributed workspace project simplify this task of identifying the conflict by separating the two files and highlighting the conflicted area in the files.

The task for identifying this conflict is simplified in the system where the conflict file is separated as two different original files and the conflicted area is highlighted.

Operation 6: Checkwork

Step 1: Send request to the checkwork server for creation of the other branch source code file on the EFS system.

Step 2: On the completion of the creation. Server will return a root key to the user.

Step 3: User can access the details form workdone. dwspace .tech/root_id

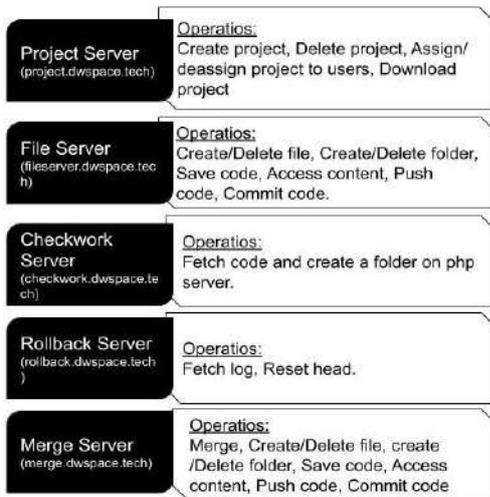


Fig. 6. Micro server and its operations

V. EXPERIMENTATIONS AND RESULTS

A) Application of the algorithm in the system

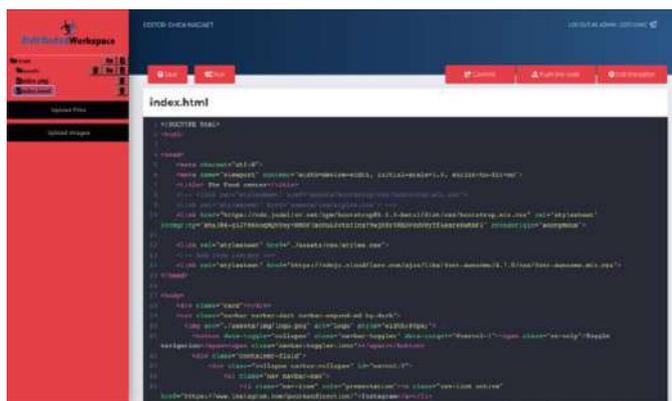


Fig. 7. Admin Editor

Fig. 7 shows the admin is assigned with a 'developer(dev)' branch. This branch is considered as a production branch where the code stored is the final expected output of the project. The dev branch has a default file structure which can be altered by creating a new file/folder or by uploading files/images from the local

machine. Every change done in the repository has to be committed with a commit message and should be pushed.

Fig. 8 shows the merge conflict page. As mentioned above, the developer (dev) branch is the ones whose code is considered as the final deployment version. As other employees are working on their respective assigned branches. At the end, the admin has to merge the code.

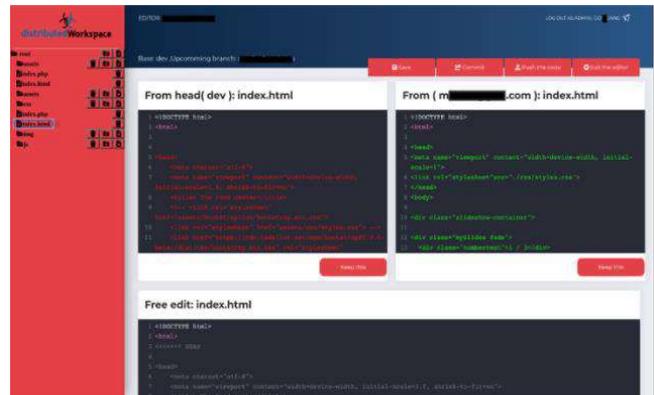


Fig 8. Handle Merge Conflict

During the merge process it is very much possible that a conflict might arise between the 'dev' branch and the employee branch. This is catered by this module, where the admin decides which code stays in the 'dev' branch. The code highlighted in red, depicts that this part is different from the other branch and here the conflict has arisen.

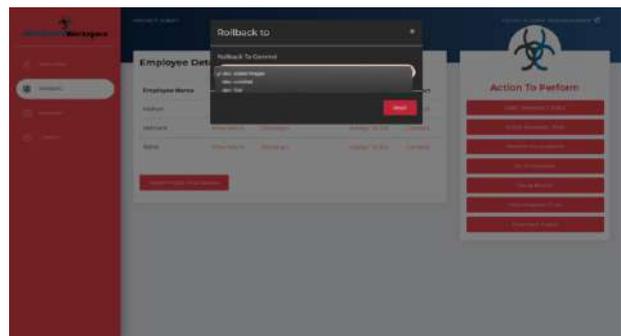


Fig 9. Rollback

Fig. 9 shows Rollback feature used in version control. It is possible that at some point the admin needs to retrieve the code with older version compared to current version code which user has committed recently. This can be done by clicking on it. the rollback button and selecting the commit message. All changes will be retrieved till the point where that selected commit was performed.

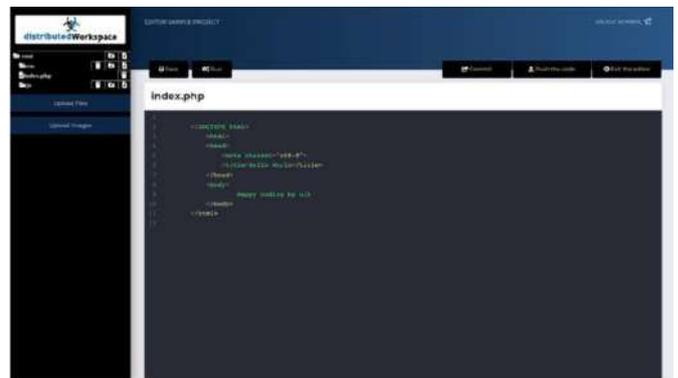


Fig 10. User Editor

Fig. 10 shows the user editor. It works similar to the admin editor. It displays the file allocated to the respective user branch. Any work performed, when just ‘saved’, is stored on the file server, once it is committed and pushed to the user repository, it is saved in the ‘git’ server.

B) Performance analysis

Although the current version of this system is built at the lowest level of hardware configuration, it has gained a very decent range of performance. This can be easily scaled up using vast service options from AWS and any other available cloud service providers at the time of deploying this project live for commercial use.

Table I shows the performance test results of important modules of this project and the time taken to perform it.

TABLE I APPLICATION PERFORMANCE ANALYSIS

Sr. no.	Module Name	Operation performed	Time taken (in sec)
1.	All CRUD Operations	Operations performed on the mySQL database like INSERT, UPDATE, DELETE.	<1
2.	Project creation	Git repository created on the Git server (installed on EC2).	3.78
3.	Editor loading	Fetching file hierarchy response from the server.	2.30
4.	Loading a file in the editor area	Fetch the file content from the hierarchy sent.	1
5.	Upload Image	Image is base64 format to the hierarchy selected.	2.1
6.	Save File	Content from file content is fetched and stored in the corresponding file hierarchy.	1.2
7.	Commit	All unsaved files are saved on the php server and a ‘git commit’ command is executed.	1.5
8.	Push	‘git push’ command is executed	2.3
9.	Load rollback logs	Logs of all the of the corresponding branch is requested	5
10.	Populate branches options during merge	Fetch all the branch name belonging to the corresponding project.	2.3
11.	Merge operation	Fetch base branch and the merge with in coming branch	4.5
12.	Download project	Fetch files from git server, store it in a folder, convert into zip and return this folder name in response.	3

Above performed task were carried out on branches which sized around 12MB. These numbers can vary depending on the size of the files. The git which could perform a merge of two 12 MB branches in 4 seconds could take even 10 minutes for a 100MB sized branch. Likewise, an image of 200 KB takes less than 2 seconds to be stored but an image of 8 MB could take more than 5 seconds. This depends upon the file size and the server capacity.

VI. FUTURE SCOPE

Distributed Workspace, while building aimed at eliminating the hardships taken by the members of a web project. The system is believed to overcome most of the problems that existed in the current system by providing the development means all at one place, in a user friendly fashion. Though, it is always said that everything has a margin of improvement in them. So while consistently

improving the existing features in this system, the system has impressive future scope as well.

As Distributed Workspace is capable of managing multiple projects, the system can provide a periodic *project report*, on the basis of which the admin could understand whether or not the given task is completed by the employees. The efficiency at which the project is being built can also be calculated. There is a vast scope of improvement in our editor. We can provide a number of *production tools and extensions for our editor* like, syntax checker, parenthesis highlighter, theme change, beautify tool, live share, auto completion, multiple cursor, etc. We could add *website templates* to make the work of developers easy, using the templates a lot of workload on the developers could be reduced. We can give the testers a dedicated area to *create test cases* and run the, for checking errors.

The features we provide to the public free of cost could be optimized and *customized according to the clients/companies requirements*, like providing an error detection system and also equipping the system with a compiler if need be. Another source of revenue can be providing *domain names* of their own company name, as the free one will have our domain name (dwspace.tech). We could also add *video conferencing* to the system so that communication is easier between the members and a more professional environment can be maintained.

VII. CONCLUSION

The main focus of our project was to overcome the drawbacks of existing systems and provide better communication, by providing the users with a workspace to communicate. We have tried to integrate practical features into the application which other applications may lack. Our algorithm makes distributed computing more efficient with the help of microservers, each assigned with an independent role. This can be seen in the application performance table, above in the report. The system has taken care of security aspects by giving a special privilege to the admin and controlled access/privileges to the employees. We are making a project environment that will be used for distributed product development on a rapid scale using agile project management. The project with its efficient algorithm has tried to be a better alternative and at the same time believe that there is more scope for improvement and make it a purposive application.

There are more applications like Github, Amazon Code Commit [9], BitBucket, Google Cloud Source Repositories [10], etc with similar concepts. However, this system is been inspired by these mentioned application's core concept of version control. This system has made maintaining the codes simpler for students or individuals, working in a small-scale project to use the system without worrying about the complications of version management. By providing a simple user interface and giving project management tools like roadmap, to-do, contact(chat), live-testing, etc., this system stand out from the other similar technologies in the market

REFERENCES

[1] Sutherland, Jeff, et al. "Distributed scrum: Agile project management with outsourced development teams." *2007 40th Annual Hawaii International Conference on System Sciences (HICSS'07)*. IEEE, 2007.

- [2] MacGregor, Steven Patrick. *Describing and supporting the distributed workspace: towards a prescriptive process for design teams*. Diss. University of Strathclyde, 2003.
- [3] Padhy, Rabi Prasad, Manas Ranjan Patra, and Suresh Chandra Satapathy. "Windows azure paas cloud: an overview." *International Journal of Computer Application* 2 (2012).
- [4] Daud, Nik Marsyahariani Nik, Nor Azila Awang Abu Bakar, and Hazlifah Mohd Rusli. "Implementing rapid application development (RAD) methodology in developing practical training application system." *2010 International Symposium on Information Technology*. Vol. 3. IEEE, 2010.
- [5] Zahariev, Alexander. "Google app engine." Helsinki University of Technology (2009): 1-5.
- [6] Sarma, Anita, and Andre Van Der Hoek. "Palantir: coordinating distributed workspaces." *Proceedings 26th Annual International Computer Software and Applications*. IEEE, 2002.
- [7] Wiil, Uffe Kock, and John J. Leggett. "Workspaces: the HyperDisco approach to Internet distribution." *Proceedings of the eighth ACM conference on Hypertext*. 1997.
- [8] Fernandez, Daniel J., and John D. Fernandez. "Agile project management—agilism versus traditional approaches." *Journal of Computer Information Systems* 49.2 (2008): 10-17.
- [9] Amazon Web Services, *Amazon CodeCommit Documentation*. July 09, 2015. Available: <https://docs.aws.amazon.com/codecommit/index.html>
- [10] [10] Google LLC, *Cloud Source Repositories | Documentation*. August 26, 2021. Available: <https://cloud.google.com/source-repositories>.

Survey on Ecommerce Store with Augmented Reality Features

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Abstract—The aim of this survey paper is to explore augmented reality as a technology and to study its implications in the e-commerce sector. The previous work in this field suggests that there is huge potential for improving e-commerce using augmented reality technology. Nowadays people use e-commerce websites on a daily basis to make their everyday purchases, and as Augmented reality is a relatively new domain we have tried to explore it more in this paper. The successful integration of augmented reality into retail space has the potential to completely change the way customers will interact with the e-commerce store in the future. Augmented reality in the field of retail eliminates the barriers of geography and capital by creating a virtual experience. The applications of augmented reality technology could potentially eliminate the problems in the current retail space, elevate customer service, and create a unique experience for customers tailored to their specific needs.

Keywords—3D modeling, augmented reality, e-commerce.

I. INTRODUCTION

Long gone are the days when technology was primitive in the field of e-commerce, nowadays technology is changing so rapidly that it is hard to keep a track of it, and with this ever-changing technology the modern retail business could grow to new heights. The only problem with e-commerce businesses is that right now it struggles with giving the customers the traditional experience of a brick and mortar shop where people can enter the shop, browse through various products, and interact with them. Now to solve this problem is where augmented reality(AR) and virtual reality(VR) technology shine, the use of these technologies in the e-commerce space will make it possible for businesses to showcase their products in 3D in the real environment. In order to redefine the shopping experience, we need to integrate e-commerce platforms with augmented reality technology as it will make the users visualize themselves using the products and at the same time will create a unique shopping experience for them. Now that we know how augmented reality will boost e-commerce business let us understand the working of augmented reality.

Augmented reality is generally categorized into two types:-

1. Marker-based: In this type, we need to have a marker and when this marker is recognized by the camera, we can see our digital 3D object or virtual object rendered on top of this marker.
2. Marker-less: In this type, as the name suggests, we do not require any marker or image for its working, but instead it detects the surface plane that is the floor and on top of the floor we can place 3D objects.

In order to experience augmented reality in our smartphone, our smartphone must be equipped with a camera sensor, GPS sensor, extremity sensor, and compass for navigation. Along with this smartphones must also have significant processing power.

II. LITERATURE SURVEY

According to Wikipedia's definition, "Augmented reality is a technology that superimposes computer generated images on a user's view of the real world, thus providing a composite view". We have redefined augmented reality in simple terms as the above definition is quite complicated to understand at first glance. The word augmented originates from the word document, which means to add something. So in augmented reality technology, we are augmenting something or adding something inside the real world. That is, we're adding computer-generated graphics or 3D objects inside the real world.

Now for using these computer-generated graphics you need to acquire a handheld device, for example, a smartphone or a heads-up display. We here first discuss a practical example for augmented reality and how it can be achieved with the help of other services. Tahirović, Talib, et.al. have discussed a new insight into this field through an example of the development of an augmented reality service for a furniture manufacturing company. They have developed a virtual catalog with the help of AR Designing technology and AR service for a furniture manufacturing company. This service comes under the product design phase because they needed to create 3D models of the products while designing the actual products. Later on, the modifications of 3D models can be done in order to integrate these models into an AR application [1].

Now moving ahead let us discuss various techniques that can be used for enhancing the shopping experience of the shoppers. E-commerce is becoming a crucial aspect of the modern-day enterprise but lacks a lot of critical capabilities. These drawbacks can be addressed with the help of Virtual and Augmented reality technologies, by integrating these technologies with E-commerce we can achieve real-time navigation in 3D in shopping malls [2]. Ashok Kumar P. et al. have discussed various shopping enhancements that can be made through mobile applications such as a personal assistant for shoppers with the help of AR. This application will be of great assistance to the shoppers as it will help them in navigating the desired product. For example, in a shopping mall, with the help of in-store GPS that uses INS, RFID, Wi-Fi, and AR image capturing technologies. This app will help shoppers to scan a single product or multiple products on a rack by using the camera on their smartphone and get all the necessary information about the products like the prices or the ongoing promotional offers. The shopping experience is really enhanced since it utilizes both the physical aspect of a brick and mortar store and the digital aspect of e-assistance in real-time This shopping assistance app also helps shoppers with in-store navigation to find the desired products from their shopping list, at the same time also saving their time from wandering around to find the desired product. Their research work concludes that most of the shopping purchases in the supermarket are impulse purchases and to improve the sale even a little assistance in shopping can help [3].

Now in order to get a better understanding of all the advancements in this ever-growing field of augmented reality, we got great help from a research paper by Roxo, Mafalda Teles, and Pedro Quelhas Brito in it they have reviewed the literature produced since 1997 in the field of augmented reality and have discussed all the advancement that has happened in the field of AR with respect to the fields of Business and Economics (B&E). They have highlighted and cross-analyzed the variables identified by researchers related to the intrinsic aspects of AR technology that guided the development of AR solutions. They observed that the next decade will be full of AR technological advancements and the main focus will be on wearable AR solutions [4].

Although augmented reality is really a trending technology there are two more technologies that have really great potential. They are virtual reality and mixed reality and to shed some light on this topic we got help from another paper by Qian Wang and Sheng Cao who have introduced the concept and basic principles of Augmented reality technology. They have also discussed analysis feasibility and development of applying Augmented reality technology in mobile E-commerce. This paper includes the difference between AR and VR and MR. They have mentioned the applications of Augmented reality in various fields in our daily life. They have also highlighted the advantages and disadvantages of Augmented Reality [5].

Augmented reality in the form of an app is what is going to drive the e-commerce business in the next decade and to discuss just that Egaji, Oche A., et. al. have presented a paper which discussed an app developed for bespoke jewelry solutions which use Augmented Reality features [6]. In this app, customers can design and review

rings without having to visit the jeweler’s shop. They can also communicate with the jewelers in real-time for specifications or changes. They can use the app to see how the 3D generated ring with the help of augmented reality will look on their finger. This app uses Google firebase to store data so that they have access to rings that are being requested at any time. Now to take it one level up, Jayananda, P. K. V., et. al. have a complete mobile application that utilizes AR core and Augmented Reality as their base technology for making positioning and navigation systems for their app. Besides this, in order to make their application more user-friendly, they have also used object detection with AR and remote shopping for handling customer shopping list databases and giving customers personalized recommendations based on that list [7].

A. Summary of Literature Survey

Title & Year	Summary	Drawbacks
Designing Augmented Reality services for E- business: A project management perspective 2018 [1]	This paper discusses Augmented reality as a service for a furniture manufacturing company and has brought some new insights into this field.	No One Can Buy During a Site Crash. Lack of security may affect the overall augmented reality principle.
Shopping using Virtual Reality and Augmented Reality 2019[2]	The goal of this paper is to enhance the shopping experience for the shoppers by discussing various techniques that can improve it.	Lack of privacy. Lack of shopping experience
Prospects of Augmented Reality in Physical Stores’s using Shopping Assistance App 2020[3]	This paper discusses the development of a personal assistant for the mobile application to enhance the shopping behavior of users.	No One Can Buy During a Site Crash
Augmented Reality Trends to the Field of Business and Economics: A Review of 20 years of Research 2018[4]	The objective of this study is to review the literature produced since 1997, i.e all the advancement that have happened in the field of Augmented Reality	Filling the gap between technical aspects of AR and their effect on the user Study is based on two databases: WOS and Scopus.
Application and Prospect of AR Technology in E-commerce 2017[5]	This paper introduces the concept and basic principles of Augmented reality technology, analysis feasibility and development of applying	To understand the inferences that might be drawn from AR applications in digital media
An Augmented Reality Application for Personalised Diamond Shopping 2017[6]	This paper discusses developing an Augmented Reality(AR) application for a jewelry shop.	Lack of privacy and Security
Augmented Reality Based Smart Supermarket System with Indoor Navigation using Beacon Technology 2018[7]	This paper discusses the effectiveness of AR technology in mobiles in the context of shopping and how it will improve the user experience.	GPS does not support indoor navigation. Less accuracy of localization method.

III. PROPOSED WORK

With the purpose of making life easy for customers we will develop an Augmented reality feature in our e-commerce website while further enhancing the shopping experience of customers. The detailed information of augmented reality and its implementation is given in this chapter.

To get started we first need to develop a website for our 3D models to be rendered in, and for this, we will use React which is a lightweight JavaScript library used in web development. To handle the backend of our website

we will use MongoDB which is a non-relational database and create few application programming interfaces(APIs) for storing information about our users on the database. With this, our website will be ready for displaying products in augmented reality. Now to make the augmented reality work inside a web browser is somewhat a mammoth task but we can accomplish this with the help of Google’s model-viewer API which helps in rendering the 3D models inside of a browser.

The system architecture is given in Figure 1. Each block is described in this Section.

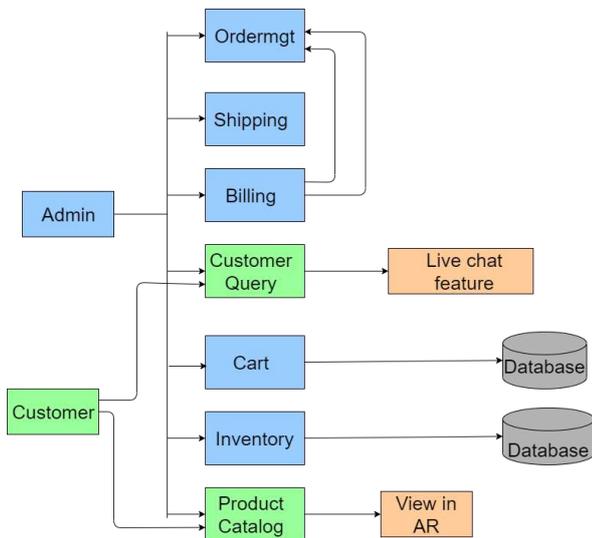


Fig 1. Proposed system architecture

A. Admin: An administrator evaluates e-commerce transactions and provides support to nearly all associate activities. They intend to monitor all product information, site issues and resolve them.

B. Customer: Just like admin, designing the website for the customer side will be a crucial part as that is what an end user will see. The UI for customers will be quite different from the administrator as they just need to see the products and not manage them.

C. Order Management: This process of keeping track of customer’s orders and handling the steps involved with fulfilling them is called order management. The process generally consists of accepting the order; picking, packing, and shipping the items mentioned in the order, and finally tracking them until they get delivered.

D. Shipping :

There are three things that need to be taken care of in the shipping process:

1. Product size and weight: will we be able to deliver the product of said weight and size.
2. Shipping destinations: Where are you shipping to — domestic or international?
3. Shipping options: What are the best shipping services or carriers for your unique needs?

E. Billing:

Billing can be handled easily with the help of any billingAPI and to name a few we can use Razorpay or Paypal API. With API integration, we are able to create an invoice for the orders. An Invoice is just a digital document made for customers which contains all the transaction details so that they can initiate payments, generally, an invoice contains information about the products ordered such as name, quantity, price, and so on.

F. Customer Queries:

Recent studies have shown that most of the customers want their queries to be resolved quickly so that they will give good feedback and will remain loyal customers[4].

Live chat makes it all pretty simple for communication on both sides. A customer is always a click away from getting the needed assistance. Live chat agents on another side can provide instant answers.

G. Live Chat feature:

During our literature survey, we found out that everyone tried to implement AR capabilities into their app but no one thought about making a feature to register user complaints.

With the aim of making the communication bi-directional between customers and customer care agents, we thought we would implement a live chat feature for our website. The main advantage of this feature will be that the customer care agent could speak with multiple customers at the same time.

Since this is a chatting feature, in order to further save time we could also pre-populate the message with the answers for frequently asked questions, with the help of this feature all the customer queries will be responded to quickly, which in turn will make the customer loyal to our website for getting good customer service.

H. Shopping cart:

Shopping carts are essential for any website because they make the transition from shopping to purchasing the items really easy for the customers.

A shopping cart acts as a digital basket, in which customers can review their products, see their price tags and quantity, and make the final decision of whether to make the final purchase or further add or delete the products from the cart

While designing the cart we should take care of three primary things:

1. It will store all the product information
2. It's a gateway for order and customer management

3.It displays the product data, site information, and categories for user display

I. Viewing products in AR:

This will be the most prominent feature of our app as the AR technology will completely enhance the shopping experience and to implement this we will use marker-based augmented reality. In this, the 3D model of the desired object is imposed on a marker, so when the user flashes his camera on the marker he will be able to view the model in real-time. The 3D modeling will be done with the help of Unity software.

IV. REQUIREMENT ANALYSIS

Since we are making a website to demonstrate augmented reality inside the browser, the main requirement for this project is getting the 3D models of products to be displayed on our website, and to make this happen we need a software called Unity for constructing these said models and googles model-viewer API for displaying the models inside browser, and to write all the code for this project we will use visual studio IDE.

A. Unity :

Unity is a cross-platform game engine developed by Unity Technologies, it was first released in June 2005. The engine has since been updated to support a variety of desktop, mobile, console and virtual reality platforms. This engine helps developers in building 3D models [8].

B. Visual Studio IDE :

Visual Studio IDE is a code editor which helps developers write the code in a more efficient way, it supports IntelliSense which is a code completion plug-in and also helps in code refactoring. There is an integrated debugger that works as a source-level debugger. And let's not forget its most important feature i.e. it supports source control systems which means that it can work with Git for collaborative development of projects [9].

V. CONCLUSION AND FUTURE SCOPE

The main aim of this paper was to identify various advancements in the field of augmented reality and its applications with respect to the e-commerce field and with all the literature discussed in this paper we can conclude that although the augmented reality is still in its nascent state, the coming decade will see a massive shift towards this technology and its integration with e-commerce platforms.

Now to develop the discussed website in the proposed work section and integrate it with Augmented Reality technology in order to display the 3D models inside web browsers will come under the future scope for this survey paper.

REFERENCES

- [1] Tahirović, Talib, Tamara Naumović, Lazar Živojinović, Zorica Bogdanović, and Marijana Despotović-Zrakić. "Designing augmented reality services for e-business: a project management perspective." *European Project Management Journal* 8, no. 2 (2018): 9-16.
- [2] Sejal Jain, Nishita Hada, Shubham Joshi, "Shopping using Virtual Reality and Augmented Reality", *International Journal of Advanced Science and Technology* Vol. 29, No. 04, (2020), pp. 7546 –7552
- [3] Ashok Kumar, Murugavel, R., "Prospects of Augmented Reality in Physical Store's using Shopping Assistance App", 9th World Engineering Education Forum, WEEF 2019
- [4] Roxo, Mafalda Teles, and Pedro Quelhas Brito. "Augmented reality trends to the field of business and economics: a review of 20 years of research." *Asian J Bus Res* 8.2 (2018): 94-117.
- [5] Cao, Sheng, and Qian Wang. "Application and Prospect of AR Technology in E-commerce." 2017 7th International Conference on Education, Management, Computer and Society (EMCS 2017). Atlantis Press, 2017.
- [6] Egaji, Oche A., et. al. "An Augmented Reality Application for Personalised Diamond Shopping." 2019 25th International Conference on Automation and Computing (ICAC). IEEE, 2019.
- [7] Jayananda, P. K. V., et. al. "Augmented Reality Based Smart Supermarket System with Indoor Navigation using Beacon Technology (Easy Shopping Android Mobile App)." 2018 IEEE International Conference on Information and Automation for Sustainability (ICIAFS). IEEE, 2018.
- [8] Wadhawan, Neha, and R. K. Arya. "Understanding E-commerce: A study with reference to competitive economy." *Journal of Critical Reviews* 7.8 (2020): 805-809.

Machine Learning based Speaker Verification of Voice Recording

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Abstract— Impersonators may synthesize speech to try to deceive voice verification systems. Hence it becomes difficult to tell the difference between genuine and forged content. It makes the study, research, and development of speaker verification systems important. With the use of machine learning techniques, efforts can be made to differentiate between genuine and fake voices. Considering that a suspect will not deliberately give sound recordings for preparation, our arrangement uses indirect features to prepare and approve a machine learning model utilizing neural networks (NN). A neural network, which is used as a classifier, contains several layers of nodes. These layers are connected. The first layer is the input layer, which receives the data as input. There is a single hidden layer that is responsible for the processing. The output from hidden layers is supplied to the output layer, which provides the output of prediction. The inputs of our framework are not specifically taken from sound recordings, but from a quantitative comparison between a match of recordings of the same speaker or distinctive speakers, utilizing a few messages. Wavelet coherence matrix between each combination of sound recordings was used for preparation and test. Neural Network (NN) is measured in terms of hidden neurons, learning rate, and the number of iterations. Our framework gives Accuracy of 87.8%, Precision of 88.7%, Recall of 83.5%, F1 score of 86%, and AUC of 94.5% as the best result for the number of iterations at 100, the number of hidden neurons at 150, and a learning rate of 0.0005.

Keywords: machine learning, neural network, genuine and fake voices, speaker verification

I. INTRODUCTION

In recent times, there has been a surge in the number of technologies that make use of speech. Personal digital assistants are used in various areas like the workplace, banking, marketing, healthcare, etc. The human voice is also an important aspect of biometrics. These are just a few of the existing applications of human speech. Similarly, there have also been increases in technologies that engender synthetic speech. This is the result of advancement in the field of deep learning. These synthetic utterances can prove to be a huge threat if misused. Since voice is a part of one's identity, its fake reproduction can put one's privacy and reputation at stake.

With great developments in the fields of AI-generated voices which sound like humans, there has also been a surge in crimes where synthesized speech is used to fool people to gain some advantages. This poses a great threat to the security of people. Innocent people might be accused of misconduct and offences which they haven't conducted. So,

speaker verification systems play an important role in decreasing these kinds of threats.

The main approaches in the area of speaker verification include making use of direct features like MFCC (Mel Frequency Cepstral Coefficient), VAD (Voice Activity Detection) for feature extraction, and neural networks as the classifier [1], [2]. Another approach makes use of neural networks for classification, and indirect features [3]. Here, indirect features mean that the classifier is trained on the values of wavelet coherence for a pair of audio recordings. This means that the method focuses on the comparison between a pair of audio recordings rather than direct features (like MFCC, VAD, etc.) of a single audio sample. Some proposals for speech recognition systems have used artificial neural networks [4], [5], [6], Hidden Markov Model, or Support Vector Machines [4]. Other systems which focus on singing voice extraction make use of robust principal component analysis [7] and Azimuth discrimination and resynthesis [8]. In recent developments, densely connected Time Delay Neural Networks (D-TDNN) and D-TDNN with a mechanism called statistics-and-selection have been implemented [9]. As shown in figure 1, fake sound recordings can be categorized as follows:

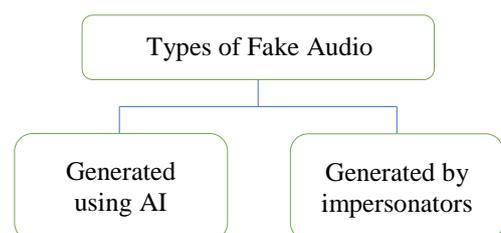


Fig. 1. Types of Fake Audio

- **Generated using AI** – This audio sounds like a human but is machine-generated in reality. It makes use of deep learning technologies, which allow a person to train a speech synthesizer with a target voice, creating a model to reproduce someone's voice with high fidelity.

- **Generated by Impersonators** – Impersonators are people who mimic someone to sound like them. Though this audio is human-generated, it is fake since it does not belong to the person whom it is made to sound like.

To differentiate fake audio of these types from genuine audio, properties, and features of audio need to be taken into consideration. Different features of audio are MFCC, pitch,

timbre, voice activity detection (VAD), volume, zero cross rate (ZCR). These features can be collectively matched in two signals using the wavelet coherence approach, a measure of similarity between two signals. This forms the base for speaker verification systems.

II. FEATURE EXTRACTION

The dataset contains 2250 rows and 3001 columns. The dataset has 50 different messages spoken by 2 speakers (s1 and s2), in 5 different intonations - normal (n), whisper (w), hoarse voice (h), fine voice (f), nasal (l). Number of instances where the speaker is same i.e., where output is 1 (ns1 vs ws1, ns1 vs hs1, ns1 vs fs1, ns1 vs ls1, ws1 vs hs1, ws1 vs fs1, ws1 vs ls1, ...) are $10 \times 50 \times 2 = 1000$. Similarly, number of instances where the speaker is different i.e., where output is 0 (ns1 vs ns2, ns1 vs ws2, ns1 vs hs2, ns1 vs fs2, ns1 vs ls2, ws1 vs ns2, ws1 vs ws2, ws1 vs hs2, ws1 vs fs2, ws1 vs ls2, ...) are $5 \times 5 \times 50 = 1250$. Hence, the total number of instances of audio recordings is $1250 + 1000 = 2250$. These are the rows of the dataset. Wavelet coherence values are computed at each pair of audio recordings for 3000 different intensities. These form the 3000 columns. Also, there is one output column in the dataset. Hence, the total number of columns in the dataset is 3001. [3]. The dataset contains values of wavelet coherence for each audio pair at the given intensity. For speaker acknowledgment purposes, ideal elements, for example, high variety in between speaker, low variety in intra-speaker, simple to assess, viable against camouflage and mimicry, strong against contortion and commotion, ought to be engaged for building up a vigorous speaker check framework. Relationships between vocal measures can be affected due to the acoustic microphone from which they are derived [10]. Different features (also called highlights) are separated for perceiving a speaker precisely which are referenced in the accompanying segment.

- Spectral features
- Source features
- Dynamic features
- Supra segmental features
- Significant level features

Actual qualities of the speech (also referred as discourse) source Actual qualities of the speech (also referred to as discourse) source which are addressed inside the transient span is called spectral. Time advancement of the spectral highlights indicates the dynamic highlights. Source highlights address glottal voice including vector. Supra-segmental highlights address examples of intonation, cadence, stress, prosody, and so forth that length over different portions. At last, symbolic kind of portrayal of discourse data are signified as significant level highlights.

Feature extraction is significant for the extraction of different data. In the first place, speech conveys a few highlights which are profoundly perplexing in nature. In speaker acknowledgment relationship perseveres among social and physiological trademark highlights of the speaker. Different other significant measures ought to likewise be considered before extricating features in unwanted commotion conditions whose impact should be limited. Feature extraction strategies should separate features by focusing on the accompanying boundaries

- Speaker length fluctuation
- Concentration on pantomime/mimicry
- Health issues that prompt varieties in voice
- Speech ought to happen much of the time and normally
- Focus on noise abrogation and bends

Wavelet coherence is a measure of the correlation between two signals, in the time-frequency domain. It is the degree to which two signals are similar. The wavelet coherence of two time series x and y is:

$$WC = \frac{|S(C_x^*(a,b)C_y(a,b))|^2}{S(|C_x(a,b)|^2)S(|C_y(a,b)|^2)} \quad (1)$$

$C_x(a, b)$ and $C_y(a, b)$ denote the continuous wavelet transforms of x and y at scales a and positions b. The superscript * is the complex conjugate and S is a smoothing operator in time and scale.

III. PRE-PROCESSING OF THE DATASET

After feature extraction, before putting the data as inputs to our neural networks, we perform some necessary processing on our data set. The completeness of rows and columns in our dataset is very important. Missing data in a training data set can reduce the fit/power of a model. Missing values can lead to a model being biased as we are not able to analyze the behavior and relationship with other variables in a correct manner. This stage is important as some algorithms are unable to deal with or work with missing data. Therefore, it is crucial to identify and mark the missing data. Once marked, a replacement can be prepared. Replacement of missing data means replacing it with either mean, median, or mode value. If needed we can replace it with entirely new data or we can completely remove the whole column if there are a great number of missing values. We can also infer values based on statistical methods.

We have used the 'Clean Missing Data' module and connected our dataset containing missing data. We chose all of the columns that held the missing data we wished to be changed. The property 'Minimum missing value ratio' has been set to 0. This means that even if there are only a few missing values or even a single missing value, they are cleaned. The 'Maximum Missing Value Ratio' has been set at 1. This indicates that even if all of the data in the column are missing, the missing values are cleared. We chose the 'Replace with Median' option for Cleaning Mode, which calculates the column median value and uses it as a replacement for any missing values in the column. The module provides a Cleaned dataset with the columns you provided and missing values handled as you specified. Columns not decided on for cleaning are also passed through.

IV. PROPOSED SYSTEM FOR SPEAKER VERIFICATION

The proposed approach for speaker verification of voice recording is mostly based on a machine learning method. Neural networks, in particular, are chosen. Layers of interconnected nodes make up a neural network. A perceptron is a type of node in a neural network that is similar to multiple linear regression. We read neural networks from left to right most of the time. The inputs are accepted by the first layer. The initial layer is followed by

an internal layer (sometimes known as a hidden layer). These levels are in charge of some processing, while the final layer comprises all possible outputs. The signal created by a couple of linear regressions is sent into the perceptron, which converts it into a nonlinear activation function. The proposed system for speaker verification has been illustrated in figure 2.

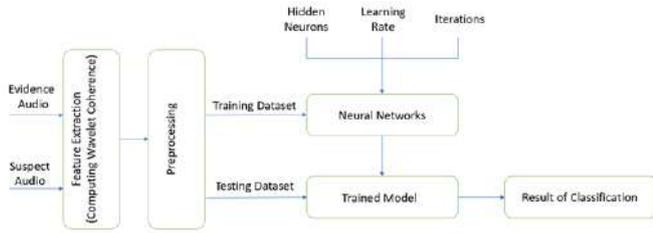


Fig. 2. Proposed System for Speaker Verification of voice recording

Reasons in the back of the usage of neural networks are as stated ahead in this paragraph. Firstly, the output of neural networks isn't always restricted to their input. Secondly, inputs are saved in their very own network and are now no longer in a database. So, the lack of records now no longer places any impact on our expected outcomes. Coming to the next point, these networks can examine and learn from past experiences and follow them while a comparable occasion arises. Even if a neuron isn't always responding or a bit of record is missing, the network can stumble on the fault and nonetheless produce the output. Moving ahead, neural networks can carry out more than one obligation in parallel without affecting device performance. And lastly, they can distinguish among subtle non-linear interdependencies and styles which other strategies of technical evaluation cannot. The model is trained and tested on different values of hyperparameters as shown in table 1.

TABLE I. VALUES OF HYPERPARAMETERS

Hidden Neurons	Learning Rate	Number of Iterations
50	0.0002	80
100	0.0005	100
150	0.001	200
200	0.002	
250	0.005	
300		
350		

V. MEASUREMENT PARAMETERS

To pick out the first-rate version of our skilled models, four measurement parameters had been selected. A parameter is a numerical quantity or characteristic of a populace that is estimated using facts collected from the populace. The first parameter or as we are saying evaluation metric is accuracy, which is the fraction of predictions our model receives accurately. The second assessment metric we have taken into consideration is precision, which evaluates the fraction of correctly categorized instances among the ones categorized as positive. Next being recall,

that's a metric that evaluates the number of accurate positive predictions constructed from all positive predictions that would have been made. And lastly, the F1 score, that's the weighted common of precision and recall. In general, F1 is preferable to accuracy, especially if the class distribution is uneven. If the costs of false positives and false negatives are comparable, accuracy performs admirably. If the value of false positives and false negatives differ significantly, it's best to look at each precision and recall separately.

In Table 2, TP stands for a class 1 identity that is suitable (positive). TN stands for a class zero identification that is suitable (negative). FP denotes data of class zero that can be classified into class 1. FN denotes records of class 1 that can be classified into class zero. Accuracy (A), Precision (P), Recall (R), and F1-score (F1) are determined using the preceding metrics, as shown in table 2.

TABLE II. PERFORMANCE EVALUATION MEASURES

METRIC	FORMULA
Accuracy (A)	$(TP+TN) / (TP+TN+FP+FN)$
Precision (P)	$TP / (TP+FP)$
Recall (R)	$TP / (TP+FN)$
F1 Score (F1)	$(2 * P * R) / (P + R)$

VI. SELECTION OF THE NN'S PARAMETERS

In this step, the neural networks are tested for different values of hyperparameters. Various metrics can be used to evaluate the performance of the system.

TABLE III. VALUES OF METRICS

Number of Learning Iterations	Learning Rate	Number of Hidden Neurons	A	P	R	F1
80	0.0002	50	0.84	0.835	0.802	0.819
80	0.0005	100	0.858	0.86	0.817	0.838
80	0.001	100	0.874	0.869	0.849	0.859
80	0.002	150	0.874	0.854	0.869	0.862
80	0.005	300	0.868	0.842	0.869	0.855
100	0.0002	250	0.861	0.865	0.82	0.842
100	0.0005	150	0.878	0.887	0.835	0.86
100	0.001	200	0.879	0.872	0.857	0.864
100	0.002	50	0.87	0.848	0.867	0.857
100	0.005	50	0.869	0.851	0.859	0.855
200	0.0002	200	0.864	0.855	0.842	0.848
200	0.0005	50	0.881	0.858	0.881	0.87
200	0.001	300	0.864	0.846	0.854	0.85
200	0.002	250	0.866	0.841	0.864	0.853
200	0.005	350	0.862	0.835	0.864	0.85

On setting different values of hyperparameters, the values at which the model gives the best results for the performance metrics must be selected. The hyperparameters for which the values are adjusted are the number of hidden neurons, learning rate, and the number of learning iterations.

In Table 3, a few of the results obtained on the values of hyperparameters mentioned in Table 1 are shown. It represents A, P, R and F1 values for corresponding values of hyperparameters.

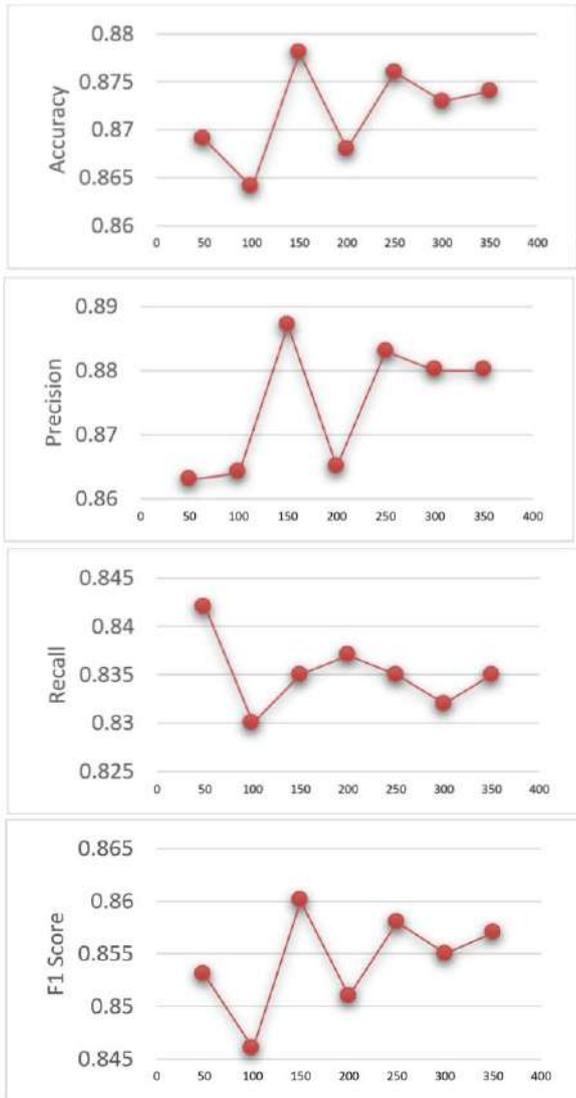


Fig. 3. Values of Accuracy (A), Precision (P), Recall (R), F1-Score (F1) with number of hidden neurons (X-axis) and values of performance metrics (Y-axis). Results have been plotted for the test set.

Figure 3 shows the values for different performance metrics when the learning rate is 0.0005, and the number of learning iterations 100. Table 3 and figure 3 present the values of A, P, R, and F1 for the hidden neuron values mentioned in Table 1. In Figure 3, it can be observed that the precision (P) and accuracy (A) give the best results when the number of neurons is 150. It can also be seen that F1-Score is highest for 150 hidden neurons. Therefore, this value appears to be the best for criterion of neurons. On testing the model for different values of learning rate and number of iterations, as specified in Table 1, it is observed

that the model performs the best when the number of iterations is 100 and the learning rate is 0.0005.

VII. FINAL PERFORMANCE

On adjusting the various hyperparameter values, the values on which the system provides the best results for performance metrics are selected. The system gives the best results when the number of hidden neurons is 150, the learning rate is 0.0005, and the number of iterations is 100. Table 4 shows the confusion matrix for the testing set on selected values of hyperparameters.

TABLE IV. CONFUSION MATRIX FOR TESTING SET

Real values	Predicted value	
	1	0
1	338	67
0	43	452

The obtained results are A=87.8%, P=88.7%, R=83.5% and F1-Score=86%.

According to the results obtained, the A and P values are quite high. This is desirable since this system has application in the forensic and criminal investigation domain. The system should not falsely convict an innocent person as a criminal. To ensure this, it is important to consider precision.

On comparing the results obtained from the proposed method and those of existing methods, we get to know that the proposed system outperforms the existing ones. The accuracy obtained in [1] by making use of direct features like MFCC, MFCC+ Spectral Subtraction, and MFCC+ Centroid are 50, 65.7, and 75.3. Whereas, the proposed system’s A and P have significantly higher values. Hence, the proposed method provides remarkable advantages over the existing ones.

VIII. CONCLUSION

As seen in this study, a system has been developed for speaker verification that considers intonations. In most of the methods used for speaker classification in the past, the audio of the suspect needs to be present in the training dataset. In the real world, suspect audio may not always be present while training the model. However, the method presented in this paper does not require the suspect audio to be present in the training dataset since it takes into consideration the wavelet coherence values of different intonations of the same as well as different speakers i.e., the indirect features are taken into consideration instead of the direct ones. This makes it possible to find the original speaker even if the evidence audio recording contains audio of the same speaker but in different intonation. The proposed system does not require a very large dataset. The classifier used is a two-class neural network and the best model has been chosen after evaluating the system on different values of hyperparameters. Future work can be done in this domain by trying to increase the number of hidden layers in the neural networks to improve performance. Other types of classifiers like Support Vector Machines or Bayesian classifiers can also be tried.

REFERENCES

- [1] Neha Chauhan And Mahesh Chandra, "Speaker recognition and verification using artificial neural networks", 22-24 March 2017.
- [2] Zhenhao Ge, Ananth N. Iyer, Srinath Chelvaraja, Ram Sundaram, Aravind Ganapathiraju, "Neural network based speaker classification and verification systems with enhanced features", Intelligent system conference 2017, 8 September 2017.
- [3] Angie Natalia Vasquez, Dora Mar'ia Ballesteros, Diego Renz, "Machine learning applied to speaker verification of fake audio recordings", 2019 XXII Symposium on Image, Signal Processing and Artificial Vision (STSIVA), 24-26 April 2019.
- [4] N. D. Londhe, IEEE Senior Member, M. K. Ahirwal, P. Lodha , "Machine learning paradigms for speech recognition of an indian dialect", 2016 International Conference on Communication and Signal Processing (ICCSP), 6-8 April 2016.
- [5] "Speech recognition based on convolutional neural networks", 2016 IEEE International Conference on Signal and Image Processing (ICSIP), 13-15 Aug. 2016.
- [6] Khon Kaen, "Speech recognition using deep learning department of computer engineering", Computers and Communications (ITC-CSCC), 23-26 June 2019.
- [7] Po-Sen Huang, Scott Deeann Chen, Paris Smaragdis, Mark Hasegawa-Johnson, "Singing separation from monaural recordings using robust principal component voice analysis", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 25-30 March 2012.
- [8] Stratis Sofianos, Aladdin Ariyaeinia, And Richard Polfreman, "Towards effective singing voice extraction from stereophonic recordings", 2010 IEEE International Conference on Acoustics, Speech and Signal Processing, 14-19 March 2010.
- [9] Ya-Qi Yu, Wu-Jun Li, "Densely Connected Time Delay Neural Network for Speaker Verification", INTERSPEECH 2020, Shanghai, China, October 25-29, 2020.
- [10] Daryush D. Mehta, Member, IEEE, Jarrad H. Van Stan, And Robert E. Hillman, "Relationships between vocal function measures derived from an acoustic microphone and a subglottal neck-surface accelerometer", IEEE/ACM Transactions on Audio, Speech, and Language Processing.

M-Lens an IOT Based Deep Learning Device

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Abstract—M-Lens is a hand-held device that automatically classifies defective parts even if the defects are novel and previously uncategorized. This allows inspection workers to quickly identify not only previously known defects with great accuracy but also novel defects by adding new/custom defects to the cloud-based defect repository and retraining the deep learning model on the server. The concept of transfer learning is used to enable a shorter training time. The device is made using off the shelf Raspberry Pi and camera extensions. This paper discusses the major features of implementation, working and analytical results of the final device.

Keywords — Transfer learning, Deep learning, Raspberry Pi, Cloud-based Training, Server, Handheld device.

I. INTRODUCTION

The purpose of the inspection is to reduce the defects in products while manufacturing or maintenance. Ideally, the aim is to produce zero-defect.

Currently, the inspection is done manually using either skilled workers trained in detecting optical surface anomaly or by devices designed for a specialized type of inspection (like Borescopes, Videoscopes, Ultrasonic, and Radiographic devices). Such devices have a very specific purpose and cannot be transferred to different types of inspection. Additionally, these devices are usually expensive and immobile.

These devices usually require specialized training to be used effectively. Even optical inspection requires years of experience to master. In current manufacturing industries practices, thousands of parts are produced at considerable expense before the detection of defects due to the unavailability of real-time analysis. These practices, consecutively, would lead to a significant loss for the manufacturing companies. Many defect detection devices available fail to provide a real-time classification of the defects.

However, in a dynamic environment where new and unclassified defects are the norm, an inspection device should be generic in implementation. Instead of retraining inspection workers with device training or optical training, such design allows novel defects to be quickly added to existing machines, thus reducing iteration time between the first instance of a new defect identified and the ability to detect and classify the defect in subsequent inspection cycle.

We compare the performance of the device based on the underlying hardware used, i.e. CPU or GPU based cloud server. We also compare the underlying training models used in cloud-based servers with primary emphasis on speed of retraining and accuracy.

II. BACKGROUND

Current defect detection devices do not provide real-time categorization at a reputable place correctly, labelled randomly selected. Some of these devices are ponderous and require specialized training. Handheld devices work on specialized principles whose application to general-purpose use is impractical. Visual inspection is exceptionally accurate but time-consuming. M-Lens provides real-time analysis by providing defect detection and categorization. It uses visual sensors to provide on par accuracy to traditional visual inspection with the added advantage of improved speed. Combining machine learning with image processing [9][10] the system seeks to overcome the long-standing issue of production defects which cost manufacturers a fortune, in defect waste, production reruns, and part redesigns. The approach has the potential to dramatically reduce manufacturing scrap by detecting production errors, instantly eliminating the propagation of defects along the production line.

III. LITERATURE REVIEW

A. AWS DeepLens

AWS deep lens uses an image classification algorithm, the device has a camera. The deep lens device is integrated with various amazon deep learning services. For example, let's consider a service in which the images are to train or validate any CNN model or import any pre-trained model SageMaker service is used. This SageMaker service works on supervised learning in which the image was taken in a deep lens and many related labels appear as per the trained model. The input format for SageMaker image classification algorithms is JPG or PNG format raw images or videos that are broken into numerous frames.

B. Google Glass

AdaBoost [27] has been used to construct a classifier that is used to select a small number of essential features. It provides a dynamic learning algorithm and has a distinct limit for performance in non-specialized environments.

The captured frames are sent to the server where further processing is performed, which enables it to detect predefined objects. The server uses OpenCV [15][17] to process the frames, and identify the objects in the frames. The identified object’s positions are calculated and returned to be displayed.

Research on FPGA (Field Programmable Gate Array) [11][12]. These are programmable semiconductor devices that can be programmed as per the functionality after being manufactured, it is a widely used electronic circuit in the industry. FPGA [16] has better security and can execute many programs at the same time. The drawback of this board is that it is costly compared to other microcontroller boards.

IV. IMPLEMENTATION

A. Architecture

As mentioned in Fig1 below, the M-Lens forwards the datasets defects in the form of images to the AWS cloud server. These images are used for training machine learning models on the cloud server as they provide faster training time compared to the limited resources of the device. The device receives the updated model from the server and using this updated model, M-Lens can detect and classify defects.

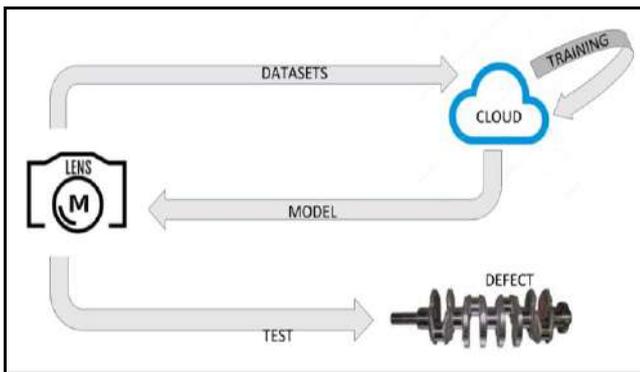


Fig. 1. M-Lens Architecture

B. Design



Fig. 2. The physical image of the M-Lens device

The handheld IoT device (Fig. 2) has a raspberry pi with a camera and a touch screen display connected to it and the R-Pi is connected to the intranet and a power bank for the power supply.

The device uses its primary input, images. During the training phase, the device extracts the features from the

training images to create a machine learning model. During the testing phase, we take new input images, extract their features and compare them to the extracted features from the training phase. Output to the M-Lens screen displays the percentage based on the graph. Thus, it stores the feature. During the training phase, the processing of target object images sets is done (from different views). First, it draws out the highlights from the training images of the defect dataset. In the next phase of testing, feature matching takes input from the training phase model. In testing, we use the image, select the feature and correspond it with the fundamental features. The percentage of correspondence is directed on the touch screen display.

C. Working

The project aims to create a system where a naive user can detect the defects of the manufacturing parts of any particular industry with minimum effort. The end-user will use this transportable device. A mediator server helps to interact with the device for training and indicating the defect. Following are the aspects of each system part. The device has two separate computational components: training and inference.

1) Input

The camera takes input images. Input image resolutions are 128px, 160px, 192px, or 224px. If higher resolution images are provided then the processing time to process the images increases but it gives better accuracy in the classification of the image. M-Lens screen shows the camera outputs to aid in acquiring a high-quality custom dataset.

2) Training

Initially, industry-specified images (JPG and PNG) of defects were used to train the device. Training of the images or building the knowledge about the defect from images is implemented on the cloud server. In deep learning [14] the data pre-processing step can be omitted and also the original data itself can be used for model training. Deep learning has complex and multi neural networks which hamper the defects that are seen in traditional machine learning methods [25].

Compared to cloud-based and GPU training, the cloud based training took three times more than GPU. The process of training must be required once.

Images used for training the device were of resolution about 240px to 480px. the training time for the higher quality images would take about 2-3 times more than the 240px image.

As the dataset quantity increases, for a particular classification increases, the accuracy of detecting the defect also increases. For transfer learning a smaller set of the dataset is also enough. Here, in table Fig. 3. the number of images used for training the device is mentioned.

Machinery Classifier	Cranks	37
	Defective Crank	25
Parts Classifier	Flaking	102
	Over-Fitting	66
Defect Classifier	Damaged Parts	40
	Holes	60

Fig. 3. Images used in the dataset for training

- 2) *Parts Classifier*: Flaking and Over-Fitting.
- 3) *Defect Classifier*: Damaged Parts and Holes
- 1) *Inference/Detection*

A camera is attached to M-lens for real-time analysis [13] to measure the faults of the part. The display screen has a real-time feed and a percentage indicating a measure of defect confidence. It sends the real-time feed to the cloud server where the trained models are used to detect and categorize the image into an appropriate classifier type. Categorizing the defect takes place on the cloud server, which eliminates the device to fall back and optimizes the process.

2) *Graphical User Interface*

The GUI [18] of M-Lens helps Quality Inspector with judging the defect and also knowing the status of the device.

D. *Transfer Learning*

Training a model from the beginning would take a huge amount of training images for each image and a lot of training time. To rapid up this process, we use transfer learning — a process where we take the weights of pre-trained models that trained on a vast amount of data. In DNNs, the network is initialized from a pre-trained network on a related task and having the same input and hidden layer sizes. M-Lens uses the MobileNet model, a convolutional neural network [22][23][24] as the base model. It is used to increase the detection accuracy, diminish the computing load and reduce the time required for training this algorithm, all of which are crucial characteristics of the device. It further trains the pre-trained MobileNet model on our custom datasets, thus adequately tuning the layers for specialized use.

E. *Training of Custom Data*

When the end-user that is inspector is evaluating often, he can come across a new defect or unknown defect or known defect but wrongly classified. In such cases, M-Lens the device takes images of the defect from different angles, in multiples of 30 or some other number which can be used for training the model. The images taken by the camera of the device are 240px JPEG format images. The inspector provides a label to this custom defect and forwards it to the server for training. The gadget installs the trained and updated model. Instantly, this current defect can be recognized and classified. It uses the model which has been trained to identify a wide variety of images. This application runs 500 training steps. Each step chooses 10 images at random from the training set, finds its bottlenecks from the cache, and feeds them into the final layer to get predictions. Comparison of predictions and actual labels are used to update the final layer's weights through a backpropagation method.

F. *Classifiers*

For M-Lens, the following classifiers types and their corresponding sample images were used:

- 1) *Machinery classifier*: Cranks and Defective Crank.

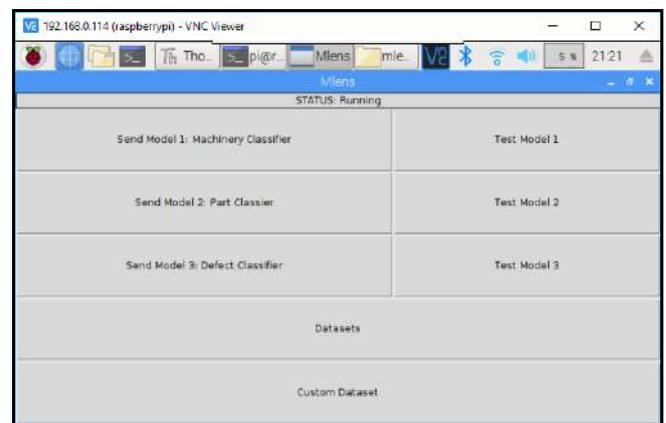


Fig. 4. M-Lens GUI

Following are the different elements of the GUI as stated in Fig. 4:

a) *Datasets*

As seen in Fig. 5 below, the datasets of defect images are shown along with image storage directory information. By clicking this the inspectors can have a look at the images on which the device is trained.

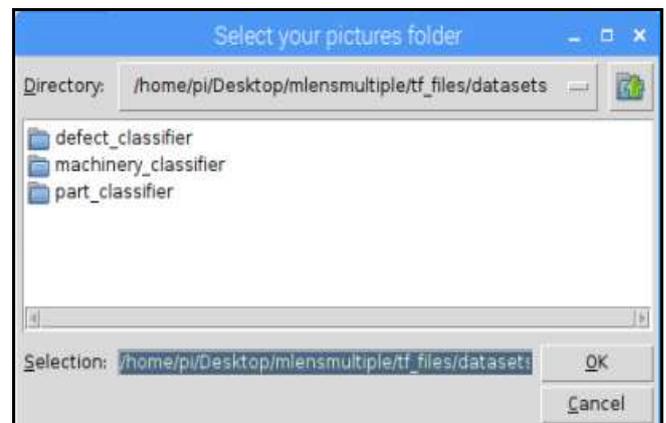


Fig. 5. Dataset Directory Information

b) *Custom Dataset*

This option displays a new window that shows the images. The snapshot (Fig. 6) button clicks 30 images (from

multiple angles). According to the requirement, the number of images clicked can be changed. The quality Inspector labels the defect and the device stores this information.

getting about 60-80%. As the dataset quantity increases, the accuracy of the detection also increases. The device displays the type of defect detected as seen in Fig. 10.



Fig. 6. Snapshot

3) Model Retrieval

The server receives the images for the selected class. During this phase, the device tells what status it is in a simple way it updates its status of working. Described below are the device statuses:

- a) *Running*: During this, the datasets are sent to the server for training (Fig. 7).
- b) *Datasets Received*: The server sends a message to the device that it has got all the datasets that are required for training (Fig. 8).
- c) *Retraining Model*: The server is retraining the model that is developing or evolving its knowledge about the defect from the sent datasets and sends the updated model to the device (Fig. 9).

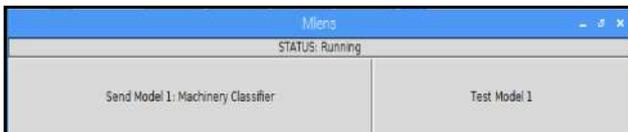


Fig. 7. Status: Running

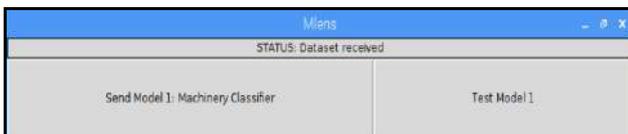


Fig. 8. Status: Dataset Received

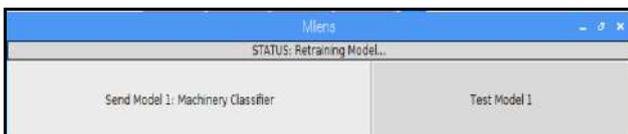


Fig. 9. Status: Retraining Model

4) Test Model

After receiving the updated model from the server, inference of the defect takes place that is judging the defect. The result is shown in percentage whether the image is faulty or not. the accuracy with the dataset we used we were

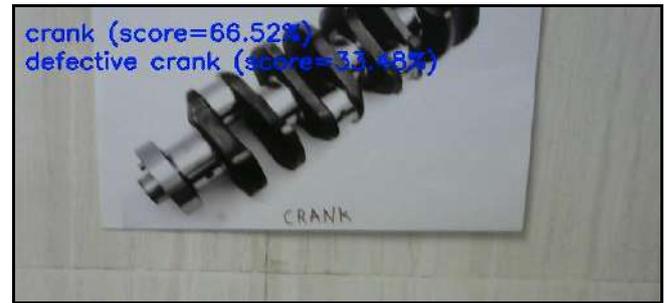


Fig. 10. M-Lens detection testing

5) Communication

Here the communication of Raspberry Pi with AWS server [21] is illustrated. When the “Send Model” button is clicked, it directs a POST request to the AWS server. This request contains the following parameters: URL address and the selected classifier details. Using the above-received URL, AWS sends a custom GET request to Raspberry Pi, in response, Raspberry Pi sends the corresponding image catalogue. On the AWS server, the application repeatedly requests the image URL, creates a same-named local file, and saves the data acquired from the URL into the local file. It further retrains the model that is developing the knowledge and sends a confirmation message back to Raspberry Pi. Now Raspberry Pi sends GET requests for definite model files. Thus, Raspberry Pi receives the required model files.

V. INTERFACING

A. Raspberry Pi

The Raspberry Pi [19] is a computer that uses a standard keyboard and mouse and requires a computer monitor or television as the display device. The Raspberry Pi 3, with a 4-core ARM processor, has a better performance compared to other lower version R-Pis’ like Raspberry Pi 1.

B. Camera

The Raspberry Pi Camera [19] Module v2 is a high-quality 8-megapixel image sensor custom designed add-on board for Raspberry Pi, featuring a fixed focus lens with 3280 x 2464 pixels.

VI. FUTURE SCOPE

The significance of this project has pertinence in the many scenarios [26], discussed below are some of them. M-Lens gives us a wide range of options in terms of future uses [8]. The use of deep learning is different, from object detection [1][2] in self-driving cars to disease detection in the medical world, deep learning has proved that it is capable of achieving human-level accuracy [4].

A. Industrial/Manufacturing Applications

In the manufacturing industry, it has to perform a continuous evaluation of the plant [7]. Employee performs a manual inspection of the machines and instruments used in the industry for manufacturing the things. So this manual

inspection thing can be replaced by having a customized handheld, portable, transportable device according to a type of industry.

B. Shipbuilding Industry

Inspection of ships is time-consuming process [6]. So by using MLens, the process will be automated. A defect recognition at the time of inspection saves time and improves the accuracy of defect categorization.

M-Lens future scope for improvement:

- A. Cloud training [5]
- B. Scalable [3]
- C. Portable
- D. Usability
- E. Edge Computing

VII. CONCLUSION

Perceiving the quality in the manufacturing stream is an erring and sluggish man-involved process and results in falsification. Detection of a faulty element at the end of the production line. Automated defect inspection utilizing vision and sensory hardware is now advantageous over manual inspection due to its accuracy, speed, relative ease of implementation, and the reduced costs.

Supervised learning is used in MLens deep learning devices, the class name is specified by the user. M-Lens is transportable, expandable to any type of industry, easy to use or understand, and productive about its cost device that operates on the edge. With the help of transfer learning the device develops its knowledge about the defects itself in the AWS cloud. Devoted equipment would lower latency and yield quicker output. Also, a commutable approach will ease the inclusion of new operations in the future.

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REFERENCES

- [1] Liming Wang, Jianbo Shi, Gang Song, and I-fan Shen- Object Detection Combining Recognition and Segmentation.
- [2] Joseph Redmon, Santosh Divvala, Ross Girshick, Ali Farhadi - You Only Look Once: Unified, Real-Time Object Detection – CVPR (2016).
- [3] Divya Patel, Pankaj Kumar Gautam - A Review Paper on Object Detection for Improve the Classification Accuracy and Robustness using different Techniques – IJCA (2015).
- [4] Omkar M. Parkhi, Andrea Vedaldi, C. V. Jawahar, Andrew Zisserman - The Truth About Cats and Dogs – ICCV (2011).
- [5] Egil Fykse- Performance Comparison of GPU, DSP, and FPGA implementations of image processing and computer vision algorithms in embedded systems.
- [6] Ashwin Deshpande-Object Recognition Using Large Datasets.
- [7] Yousef Al Ohali-Computer vision-based date fruit grading system.
- [8] Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng- Reading digits in natural images with unsupervised feature learning.
- [9] <https://www.fpga4student.com/2016/11/image-processing-on-fpga-verilog.html>.
- [10] https://www.researchgate.net/publication/228914467_Implementing_image_processing_algorithms_on_FPGAs
- [11] <https://numato.com/kb/learning-fpga-verilog-beginners-guide-part-1-introduction/>
- [12] <https://www.quora.com/What-is-better-to-use-in-image-processing-an-FPGA-or-a-Raspberry-Pi-board>
- [13] <https://codelabs.developers.google.com/codelabs/tensorflow-for-poets/#0>
- [14] <https://www.tensorflow.org/resources/libraries-extensions>
- [15] <https://docs.opencv.org/2.4/doc/tutorials/tutorials.html>
- [16] <https://store.digilentinc.com/pynq-z1-python-productivity-for-zynq-7000-arm-fpga-soc/>
- [17] <https://solarianprogrammer.com/2018/04/21/python-opencv-show-video-tkinter-window/>
- [18] <https://codereview.stackexchange.com/questions/171179/python-script-to-execute-a-command-using-paramiko-ssh>
- [19] <https://www.raspberrypi.org/documentation/hardware/>
- [20] <http://web.csulb.edu/~hill/ee400d/Technical%20Training%20Series/02%20Intro%20to%20Arduino.pdf>
- [21] <https://aws.amazon.com/api-gateway/api-management/>
- [22] Dua, M. (2019, June). Machine Learning Approach to IDS: A Comprehensive Review. In 2019 3rd International Conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 117-121). IEEE.
- [23] Dadrwal, A., Nehra, S., Khan, A. A., & Dua, M. (2018, April). Checkpoint Based Live Migration of Virtual Machine. In 2018 International Conference on Communication and Signal Processing (ICCSPP) (pp. 1083-1086). IEEE.
- [24] Singla, K., Dua, M., & Nanda, G. (2016, March). A language-based comparison of different similarity functions and classifiers using a web-based Bilingual Question Answering System developed using Machine Learning Approach. In Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies (p. 120). ACM.
- [25] T. Prakash, V. P. Singh, and S. R. Mohanty, "A Cyber-Attack Resilient Design of Wide-Area PSS Considering Practical Communication Constraints", IEEE Systems Journal, 2019.
- [26] T. Prakash, V. P. Singh, S. R. Mohanty, "A synchrophasor measurement-based wide-area power system stabilizer design for inter-area oscillation damping considering variable time-delays", International Journal of Electrical Power & Energy Systems, Vol. 105, pp. 131-141, 2018.
- [27] Taraghi, Babak & Babaei, Mahdi. (2015). Object detection using Google Glass. 97-102. 10.1109/ICOS.2015.7377285.

Web Indexing Through Hyperlinks

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Abstract— As the size of the Internet is growing rapidly, it has become important to search content faster and more accurately. Web indexing (or Internet indexing) refers to numerous methods for indexing the contents of a website or the web as a whole. Crawlers have bots that fetch new and recently changed websites, and then index them. The objective of this article is that the uniform resource locator (URL) will be crawled and indexing will be performed on the crawled data to display the results. The relevancy will be checked after the complete hierarchical scanning of the website. A modified version of the Depth First Search Algorithm is used to crawl all the hyperlinks along with the concept of APIs. These links are then approached via source code and its metadata like title/keywords, and outline is obtained. This is called indexing of the crawled data. This content is extremely essential for any sort of analyzer work to be carried on the Big Data obtained as a result of Web Crawling. Web indexing is especially utilized by search engines.

Keywords— *Hyperlinks, Web Crawling, Searching techniques, content-based ranking, Web Indexing*

I. INTRODUCTION

A web crawler is a kind of bot that is commonly used by search engines like Google and Bing. It copies web pages so it will be processed later by the search engine, which indexes the downloaded pages which enable users of the program to search out web pages quickly. They crawl [1] the web pages at those URLs first. As they crawl those web pages, they will locate hyperlinks to other URLs, and they incorporate those to the list of pages to crawl next. Given the enormous amount of web pages on the web that could be indexed for search, this process could go on incessantly. The hyperlink [2] is an electronic link providing direct access from one distinctively marked place in a hypermedia document to another to a different within the same or a different document. It creates a shortcut that jumps to a different location within the current workbook or opens a document stored on a network server, or the web.

Whenever a query is entered, the input query is crawled and the hyperlinks are indexed based on forwarding and inverted indexing for any search. After all the hyperlinks have been crawled and indexed the URLs are displayed to the user as final output along with their title, description, content-based score, usage-based score, and time spent on a particular link.



Figure 1. The flow

Figure 1 depicts the process and working of the search in a simple fashion. There are 3 steps i.e.: Crawling, Indexing, and displaying the search results.

The purpose of the discussion is to focus on crawling the links and regain all information related to them and to expedite easy processing for other uses. Firstly, the links are crawled from the specified uniform resource locator (URL) using a search algorithm along with APIs which allows for complete hierarchical scanning of corresponding web links. The links are then approached via the source code and its metadata like title/keywords, and outline is extracted. There exist tons of links related to each URL linked with the web. Since the number of pages on the web is extremely large, even the most important crawlers fall short of making an entire index. Hence search engines are bad at giving relevant search results. So, this article will target identifying the most effective method to crawl these links from the corresponding web URLs. It then builds a productive extraction to spot the metadata from each associated link. This could conglomerate the documents parallel to the corresponding title, keywords, and description.

The target is to propose a better method to crawl and index links related to the required URLs. Studying the recommendation techniques [3] and identifying their limitations is essential to suggest a hybrid approach that may overcome the drawbacks of existing methods.

In section-II, we discuss the background study with respect to web indexing through hyperlinks, section-III explains the proposed model, section-IV investigates the experimental evaluation and section-V presents the conclusion of the paper.

II. BACKGROUND STUDY

Formerly plenty of investigation is going on within the sector of web data extraction techniques [4]. In the coming times, tasks may be done to enhance the productivity of algorithms. Also, there is a scope for improving the accuracy and timeliness of the search engine. The work of the various crawling algorithms has been extended further to rise the accuracy and speed of web crawling [5]. A significant open issue for future work about the scalability of the system and the behaviour of its components. Constructing an efficacious web crawler to resolve different purposes isn't a challenging task, but selecting the correct strategies and constructing an efficient architecture will result in the execution of extremely smart web crawler applications. In this domain, various challenges within the area of hidden web data extraction and their possible solutions got to be understood.

R. Suganya Devi, et al [6] proposed that the links are crawled from the specified uniform resource locator (URL) using an enhanced variant of Depth First Search Algorithm (DFS) that allows complete hierarchical scanning of the similar web links. The access of links is done through the source code and then its metadata is obtained. This content is extremely important for any form of analyser work to be carried on Big Data obtained as a result of Web Crawling

Maria et al [7] proposed a framework that includes the constraints of existing methods. It actively obtains user-required web services by crawling among the different repositories. Usage of Google Custom Search API is done. The search is both functional level and interface-based and there's flexibility to feature more links to increase the requirements of user requests. Also, verification and validation checks are done to confirm the retrieved documents and are currently available for free.

An experimental performance analysis of web crawlers using single and multi-threaded web crawling and indexing algorithms for the appliance of smart web contents is proposed by Arvind K Sharma et al. The simulation work [8] addresses the key parameters for this single and other strategies, including harvest ratio and execution time. Performance metrics of harvest ratio, execution time, precision, recall, harmonic mean, and fallacy have been estimated for the corresponding crawling URL web pages. Mukherjee et al. presented a technique to find web knowledge for presenting web users with a more personalized web page. Their method [9] was to gather usage data from different users then find the similarities between all pairs of users. Experimental results generate correct suggestions that retrieve relevant documents for the user.

Few researchers also worked on the comparison of different crawlers [10] for features like robustness, scalability, politeness, etc. which can be extended to build an effective content mining crawler to satisfy future trends.

Agarwal and team have worked on algorithms for crawling of the web, indexing and the order of search results are determined by the ranking of pages, which uses the popularity of a web page as a ranking parameter for the ordering of the website according to the amount of traffic visiting these sites. The purpose is to provide a platform where the user can discover the searched content based on popularity.

Here a novel page ranking algorithm is put forward, named as User Preference-Based Page Ranking [11] which is robust in relevancy since it uses agents to see pages content relevancy and user behaviour is additionally considered while ranking the online pages. Hence User Preference-Based Page Ranking makes user's search result navigation simpler to seek out the required data [1].

III. PROPOSED MODEL

The system overview is presented in this Section. In the proposed system, the user enters an input URL. The URL is then processed and entered from the data sets, where the validity of the URL is checked. All the hyperlinks in the particular websites are stored into a stack. Using depth-first search algorithm each link is popped from the stack in crawled, till the stack gets empty. Check if you have already crawled the URLs and/or if you have seen the same content before. If not, add it to the index.

In general, hybrid recommender is system that combine multiple recommendation techniques together to attain synergy between them. The proposed architecture is shown in figure 2.

Log Files Analysis was carried out aside to remove unrelated records from the Log file. In an attempt to improve the productivity of usage-based retrieval algorithms by important

record only, Log file analysis consists of a sequence of processes such as data cleaning and user identification.

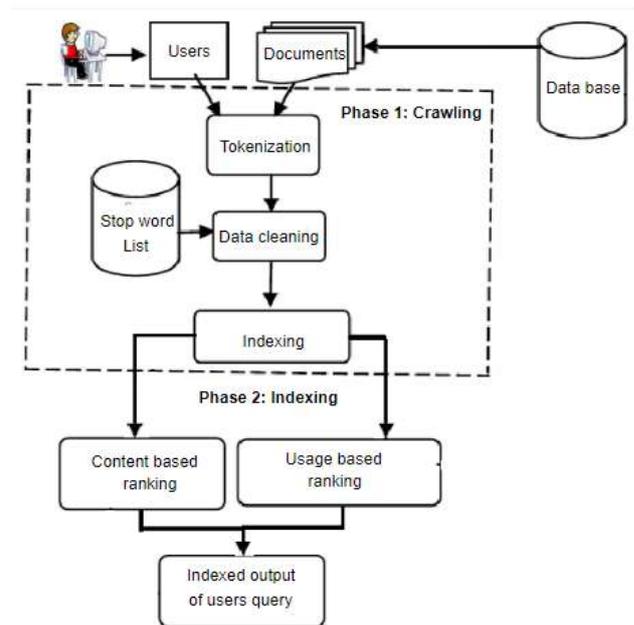


Figure 2. Proposed System for Web indexing

A. Modules Description:

This system works as shown in figure 3, which is in two phases such as crawling and indexing.

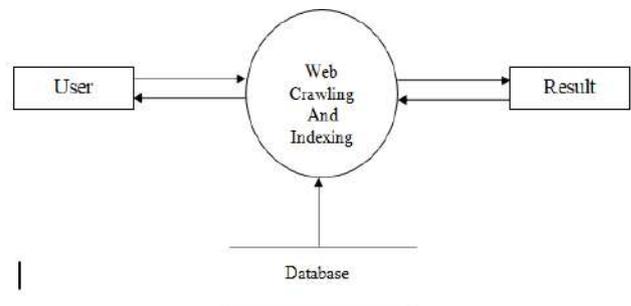


Figure 3: Data flow diagram

1. **Crawling:** To access the pages in a depth-first manner. Depth First Search Algorithm is adopted as it is one most productive strategies to crawl the web. Using this method, the crawled links are obtained in a sequential hyperlinks manner. The system uses the concept of metadata tag extraction to store the URL, title, keywords, and description in the database are used to crawl links from the web which has to be further processed for future use, thereby increasing the overload of the analyzer. It mainly concentrates on crawling the links and accessing all information linked with them to facilitate easy processing for other uses. The aim is to recommend a productive method to crawl followed by indexing the links associated with the specified URLs. Here tokenization is followed by breaking a stream of text up into words and keeping the words in a list called Word's List. The links are then accessed via the source code and its metadata like title, keywords, and description are

extracted. it's followed by data cleaning where useless words are far from the Word's List. This content is extremely important for any type of analyzer work to be carried on the big data obtained as a result of Web Crawling.

2. Indexing: As baseline Implementation, MapReduce was modelled from the beginning to produce the varied data structures involved in web search, including inverted indexes and also the web graph. Input to the mapper consists of document ids (keys) paired with the genuine content (values). Individual documents are manufactured in alongside by the mappers. First, each document is analyzed and dampened into its component terms. A graph within a graph is an "inset," not an "insert".

Two ranking techniques are used as a hybrid for indexing, such as

Content-based ranking: It is also referred to as cognitive filtering, recommends items based on a comparison between the content of the items and a user profile as shown in fig 4.

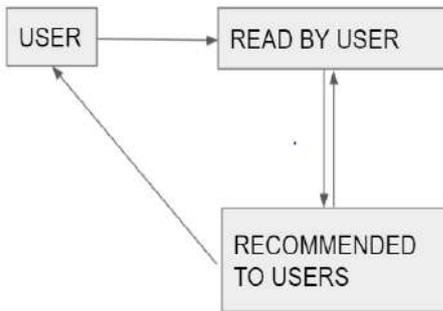


Figure 4: Content-based ranking

The content of every item is represented as a group of descriptors or terms, typically the words that occur in a document. The user profile is represented with an equivalent term and built up by analysing the content of items that are seen by the user.

The efficiency of a learning method does play a crucial role in the decision of which method to decide on. The most important aspect of efficiency is the computational complexity of the algorithm. The user's query is matched with the index terms to get the relevant documents to the query. Documents are then ranked using ranking algorithms in line with the foremost relevant to the user's query.

- **User-based ranking:** The goal of Recommendation algorithms is proposing "subsequent" pages to a user established on the current visit and the past users' navigational patterns. In almost all related algorithms, only the usage data is used to produce recommendations, whereas the structural properties of the Web graph are ignored.

But in this case, Web structure and using link analysis algorithms is also considered to improve the quality of recommendations. In this concept, we introduce UPR, an innovational tailor-made algorithm [12] that conjoin link analysis techniques and usage data for recommending and ranking of web pages to the end-user. Using the Web site's structure and its usage data, personalized navigational graph synopsis (prNG) is produced to use for applying UPR and create unique recommendations. Logfile analysis supports to execute of this task. Experimental results show that the accuracy of the recommendations is superior to pure usage-based approaches. Overall steps to execute are as shown in figure 5.

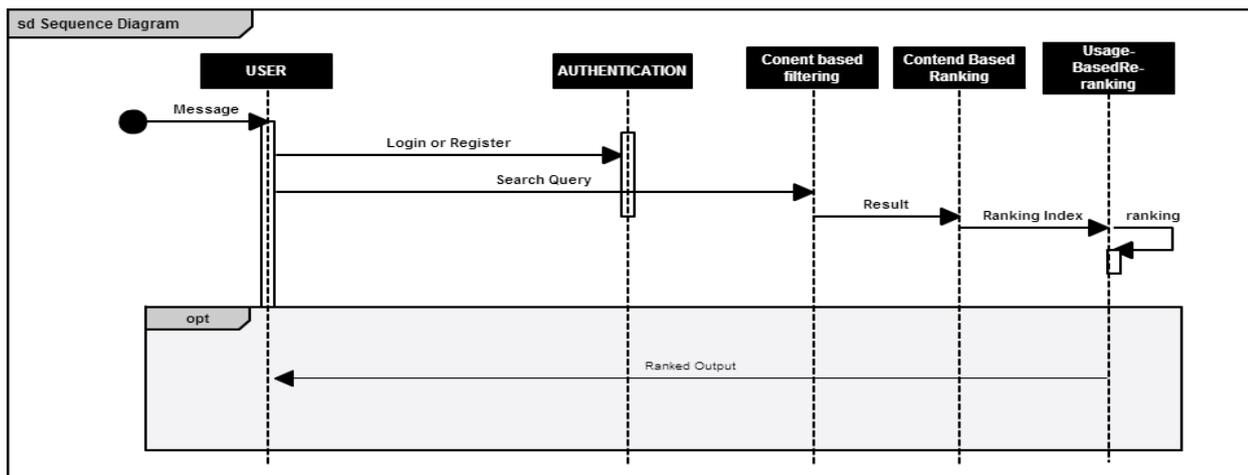


Figure 5: Sequence diagram

B. API:

It is used for any style of communication. It provides support for the HTTP/s protocol: URL Request/Response Headers, etc. The steps followed are:

1. User queries the system. The input is any word within the user's mind. The system matches the query word not only with the service interface but also with its methods.
2. The request goes to Google Custom Search Engine through Google Custom Search API.

3. The engine has been scaled to the specified links to crawl. It can be scaled at any time.
4. Engine crawls on all the links given and churns out the results.
5. Results produced aren't user understandable format. So, the system parses the results produced.
6. System uproots the WSDL files from the set of results.
7. Results are presented to the Client.
8. To check whether the service is obtainable at a given time, a validity check is performed.
9. Results are displayed and sent to the local database.

From the first technique, the client's way of crawling the websites is achieved. In this technique, it is said that the depth-first search algorithm is the ideal client approach for crawling. In the second technique, it is well described how to index the crawled pages or links. After crawling the websites all the hyperlinks from that site are gathered and are indexed accordingly. The third technique solves the problem with dynamic pages. The dynamic pages [13] are then indexed successfully. Using all these three techniques the output i.e.: the links stored in are displayed to the user. The objective of the present work is to concentrate on crawling and indexing the links by retrieving all information associated with them. Firstly, the links are crawled from the specified uniform resource locator (URL) using an enhanced version of the Depth First Search Algorithm. Using this complete hierarchical scanning [14] of corresponding hyperlinks is possible. These links are stored in a database and the indexing technique [15] is used for arranging or representing the gathered links. The baseline (Map Reduce) indexing technique [16,17] is used for displaying the query results which makes the output look simpler. Thus, by combining the crawling and indexing techniques our objective is successfully achieved.

IV. EXPERIMENT EVALUATION

The framework is modelled to erase every single redundant finding from the user and analyzer. An established URL is taken as input from the client by the system. It cycles the circle over a time of ten seconds. This permits the bot time to renew and enter unique pages, hence getting rid of overlapped and redundant pages.

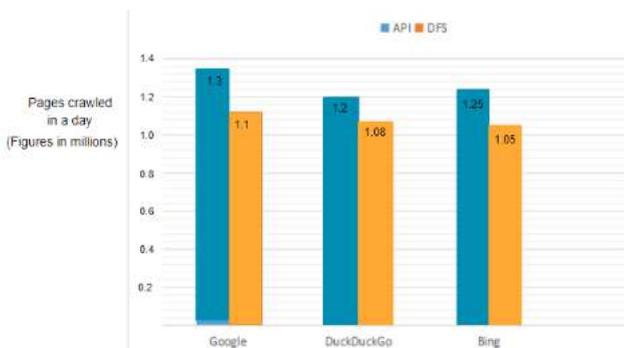


Figure 6: Performance of crawling

The above figure 6 compares the techniques used for crawling i.e.: Depth First Search and API's. This graph is a representation of performance achieved by making use of

API's and the Depth-first search algorithm. This graph shows the number of pages crawled by each technique in a day. API's clearly crawl more pages when compared to DFS for all three search engines.

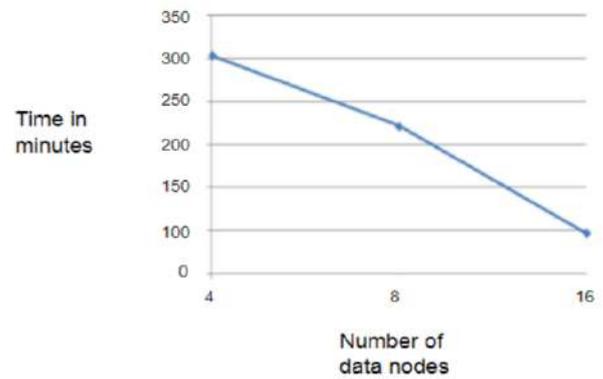


Figure 7: Indexing time graph

The graph in figure 7 represents the time required in minutes to index the data depending on the number of nodes. The graph is a clear indication of how the increase in the number of nodes reduces the time required to index the data.

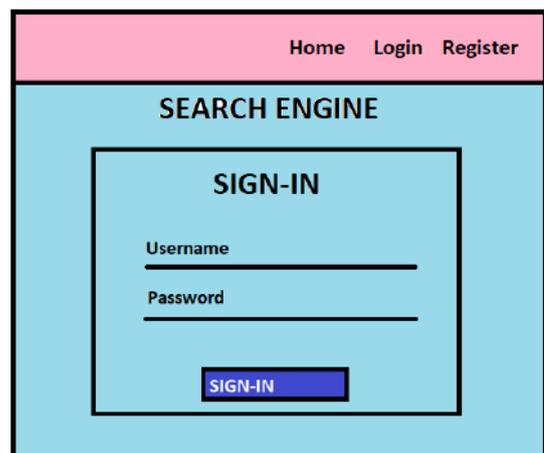


Figure 8: Login Page

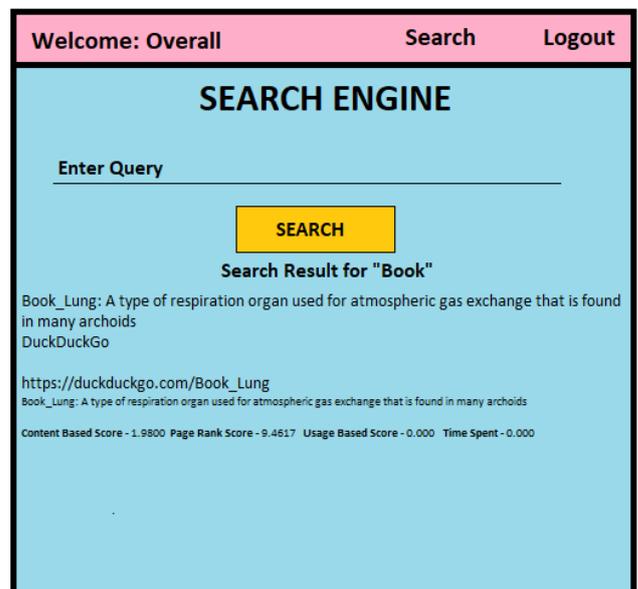


Figure 9: Search Results

This indicates that the system is able to handle larger data sets by having more resources. The above graph shows the results of indexing the data. The output is demonstrated with screen shots as shown in figure 8 and figure 9.

V. CONCLUSION

The envisioned system primarily focuses on building a database of pages and links from the World Wide Web. After an initial boost, it's observed that robust pages that are required to be crawled, occur with more probability since the total amount of pages rises. This shows that in real-time, the application which handles **tons** of data, the results are certain to reach utmost productivity, hence it is the most productive Web Crawling System. A bonus inclusion to this framework is its information integration with the concurrent meta tag extraction. It also focuses on re-crawling frequently changing web pages to keep the contents of the database current. In the future, this work can be extended to reduce the bandwidth requirement to generate this framework and make it approachable to the next level of links.

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REFERENCES

- [2] Castillo, Carlos. "Effective web crawling." *Acm sigir forum*. Vol. 39, No. 1. New York, NY, USA: Acm, 2005.
- [3] Raisi, Hossein, et al. "Hyperlink network analysis of a tourism destination." *Journal of Travel Research* 57.5 (2018): 671-686.
- [4] Suri, Sandeep, Arushi Gupta, and Kapil Sharma. "Comparative analysis of ranking algorithms used on web." *Annals of Emerging Technologies in Computing (AETiC)*, Print ISSN (2020): 2516-0281.
- [5] Martinez-Rodriguez, Jose L., Aidan Hogan, and Ivan Lopez-Arevalo. "Information extraction meets the semantic web: a survey." *Semantic Web* 11.2 (2020): 255-335.
- [6] Lee, Wang-chien, and Dik L. Lee. "Signature file methods for indexing object-oriented database systems." *Proc. ICIC*. Vol. 92. 1992.
- [7] Devi, R. Suganya, D. Manjula, and R. K. Siddharth. "An efficient approach for web indexing of big data through hyperlinks in web crawling." *The Scientific World Journal* 2015 (2015).
- [8] Allauddin, Maria, and Farooque Azam. "Service crawling using google custom search api." *International Journal of Computer Applications* 34.7 (2011): 2011.
- [9] Sharma, Arvind K., Vandana Shrivastava, and Harvir Singh. "Experimental performance analysis of web crawlers using single and Multi-Threaded web crawling and indexing algorithm for the application of smart web contents." *Materials Today: Proceedings* 37 (2021): 1403-1408.
- [10] Hajeer, Safaa I., et al. "An Efficient Hybrid Usage-based Ranking model for information retrieval systems & web search Engine." 2015 6th International Conference on Information and Communication Systems (ICICS). IEEE, 2015.
- [11] ThirugnanaSambanthan, K. "A new approach to Web Crawling—DHEKTS Crawler in comparison with various Crawlers." *Indian Journal of Science and Technology* 14.19 (2021): 1580-1586.
- [12] Agrawal, Nishchay, and Suman Pant. "Web Crawler for Ranking of Websites Based on Web Traffic and Page Views." *Proceedings of International Conference on Machine Intelligence and Data Science Applications*. Springer, Singapore, 2021.
- [13] Dohare, Mahendra Pratap Singh, Vinod Kumar, and Premnarayan Arya. "Efficient personalization and Recommendation Methods for Web Mining." *International Journal of Advanced Research in Computer Science* 2.5 (2011).
- [14] Singh, Jaitag. "Effective model and implementation of dynamic ranking in web pages." 2015 Fifth International Conference on Communication Systems and Network Technologies. IEEE, 2015.
- [15] Hardik, Vasa, Vasudevan Anirudh, and Palanisamy Balaji. "Link analysis of Wikipedia documents using mapreduce." 2015 IEEE International Conference on Information Reuse and Integration. IEEE, 2015.
- [16] Ganapathy, Apoorva, and Takudzwa Fadziso. "Intelligent Indexing and Sorting Management System—Automated Search Indexing and Sorting of Various Topics." *Engineering International* 8.2 (2020): 101-110.
- [17] Abdalla, Hemn Barzan, Awder Mohammed Ahmed, and Mustafa A. Al Sibahee. "Optimization driven mapreduce framework for indexing and retrieval of big data." *KSII Transactions on Internet and Information Systems (TIIS)* 14.5 (2020): 1886-1908.
- [18] Swati Mali, Dr. B.B Meshram, Implementation of multiuser personal web crawler, In CSI 6th Int. Conf. on SE(CONSEG), IEEE Conf. Publication, 2012.

Regression Analysis for Crop Yield Prediction using Machine Learning

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Abstract—Agriculture is a big part of the Indian economy. Lot of crops have been affected by global climate change in India which leads to unpredictable yields. This makes it important to put a system in place that could get accurate estimates of yields in particular conditions, allowing farmers to optimize their produce. Machine learning algorithms can be used to predict crop yield under different climatic scenarios. Developing better ways to predict crop productivity in different climatic conditions could help farmers in making better decisions in choosing which crops to grow. The goal of this paper is to predict crop yield using basic parameters. Three machine learning algorithms – Support Vector Regression (SVR), Random Forest Regression (RFR) and XGBoost Regression - are applied, for crops namely, Rice, Maize, Sugarcane, Chickpea, Pigeonpea, Wheat, Sesamum. Proposed algorithms are evaluated using standard evaluation metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and R Squared (R^2) Score were used. The results of all the algorithms are analyzed and also discusses performances proposed algorithm.

Keywords—Support Vector Regression, Random Forest Regression, XGBoost Regression, Crop Yield Prediction.

I. INTRODUCTION

The constant changes in the climate have directly affected the yields of various crops. The discrepancies in the yields of crops threaten the food resources and give rise to uncertainty in the lives of farmers. In India, agriculture is a big part of the rural life which accounts for a huge chunk of the population. These farmers have to survive under the current economic situations. The decisions they make regarding the crops they should grow, whether they should pivot to a different crop or stick with the crop they already grow, can make a big difference in their incomes. The constant variations in the climate creates difficult situations for farmers to decide how to be more productive to determine food security problems.

Crop yield estimation can be improved by using the statistical data of past year's yields and other important factors such as soil and weather data [3]. To supplement this, some more factors that are typical to a particular region, like soil type can be used. The predictions are made for Rice, Maize, Sugarcane, Chickpea, Pigeonpea, Wheat, Sesamum using yield of past years in particular districts, the average

rainfall and temperature of those districts, the soil conditions of the district and some other important factors.

This paper studies the application of machine learning algorithms for the prediction of yield of various crops and the reasons behind the obtained results.

II. BACKGROUND

A. Regression Analysis

Regression analysis is a method of determining the amount of impact variables have on a topic of interest. Performing regression analysis allows one to determine which factors impact the results the most and which factors have negligible impact, and how these factors might influence each other.

Regression analysis studies the connection between a dependent (target) and independent variables (predictors).

- 1) Dependent Variable: This is the primary factor that the model is trying to predict.
- 2) Independent Variables: These are the factors that have to be studied to determine the amount of impact they have on the dependent variable.

Regression analysis is an important method that can be used for analyzing the data. A curve is fitted to the data points in a way that the differences between the distances of data points from the curve is reduced optimally. Regression analysis allows comparing the effects of variables measured on different scales, like the effect of rainfall and the average temperature on the yield of a crop, thus helping data analysts to evaluate the best variables to build predictive models.

B. Literature Review

Predicting the yield of crops could provide farmers with crucial decisions. An accurate result could tell the farmers what crop to grow and how much yield they can expect. There have previously been a few attempts made to solve this problem. This section reviews some of these works and focuses on the factors that these works have considered.

The below table studies the factors considered for predicting the yield of crops in various papers and compares them with this paper –

TABLE I RELATED WORK

Attributes	Papers			
	<i>Proposed System</i>	<i>Somvanshi, P., Mishra, B.N., 2015</i>	<i>Crane-Droesch, A., 2018</i>	<i>Gandhi, N., Armstrong, L., 2016.</i>
Yield	☑			
Rainfall	☑		☑	
Precipitation	☑	☑		☑
Temperature	☑	☑	☑	☑
Soil Type	☑	☑	☑	☑
Nitrogen	☑			
Phosphorous	☑	☑		
Potassium	☑	☑		
pH		☑		
Humidity		☑	☑	

While analyzing the retrieved publications, the factors considered for predicting were reviewed carefully to compare with this paper. Khwaja Osama, Bhartendu Nath Mishra and Pallavi Somvanshi [4] performed a study wherein emphasis was placed on biological factors like nutrigenomics and biomechanical engineering. They considered factors like temperature, soil type and precipitation and used different machine learning algorithms to study their applications in plant biology. Andrew Crane-Droesch [5] focuses mainly on the climate’s impact on the production of corn yield in the US Midwest. This study takes into consideration the temperature, rainfall and the soil type and gives a prediction of crop yields. It explains the negative impacts of climate change on corn yield. Niketa Gandhi and Leisa Armstrong’s [6] work studies the impact of climate, soil type and hydrology on the yield of rice crop in kharif season. They use metrics like RMSE, MAE, RAE (relative absolute error) and RRSE (root relative square error) to evaluate their results. These existing works studied some of the factors that affect the yield of a crop. Some works focused solely on the climate change impacting the yield, while some dived deep into the biological factors and the soil’s impact on the yield. This paper combines all these factors - the weather changes, rainfall, precipitation, type of soil present, the nutrients and their percentages in the soil - giving a more accurate estimation of the yield. Three different machine learning models have also been used, compared and evaluated using various metrics.

III. METHODOLOGY

Machine learning algorithms are suitable if faster results are required, as they are quicker to train and require much less computational power. Also, a considerable amount of computational cost is required for the optimization of connection weights in a network with many training samples. Since the dataset is not large enough it is not efficient to spend so much for these algorithms, so this system was built using machine learning models. Further a deep neural network that has been trained and tested for one category of samples may not work when generalized to different testing samples. Due to these factors, machine learning algorithms were preferred over deep learning models.

The reason for taking up crop yield prediction as a regression problem is to get the estimate of the yield of a given crop, a quantity needed to be predicted. A problem becomes a regression problem if the target variable is a continuous value. As a result, regression techniques are used instead of classification techniques. The next section explains regression in machine learning.

A. Regression in Machine Learning

Regression in terms of machine learning is a statistical approach to understand the relationship between a dependent variable and independent variable which has one or multiple independent variables. Regression helps us understand how the value of the dependent variable corresponding to the independent variable changes when other independent variables remain constant. This process helps in the prediction of many continuous values such as weight, price, etc. We chose SVR, RFR and XGBoost Regression. SVR is effective in cases where we have a high number of dimensions like we do in our dataset and it performs well in such higher dimensional spaces. RFR is used because it reduces overfitting in decision trees and helps to improve the accuracy and it automates the missing values present in the data. XGBoost is designed to handle missing data with its in-build features and performs well on small to medium sized datasets.

1) Support Vector Regression (SVR)

“SVM develops a collection of one or more hyper-planes in a high-dimensional space [7] . This can be used for classification, regression. An acceptable separation is obtained by the hyper-plane which has the largest distance to the nearest training data points of any class, as the generalization error of the classifier decreases with increase in margin”. A regression model estimates a continuous-valued multivariate function. The approach used in SVM can be extended to decode regression problems, which is called Support Vector Regression (SVR). SVR keeps the important attributes from SVM [8]. It attempts to find a curve suitable to the data points. Support vectors help in discovering the nearest match between the data points and the actual function that is denoted by them. When the distance between the support vectors to the regressed curve is maximized, the curve is closest to the actual curve. The prediction model by SVR relies on a part of the training data because the cost function established by the model will be extremely close to the training data of the model prediction threshold, the regression estimation can be formulated into a function inference problem given below training set [9].

$S = \{(x_1, x_2), (x_2, x_2), (x_l, x_l)\}$, $x_i \in X \subseteq R^n$ is the input variable, $y_i \in Y \subseteq R$ is the predicted value, l gives the number of training samples. Regression function is given as:

$$f(x) = \sum_{i=1}^l (\alpha_i - \alpha_i^*)k(x_i, x) + b$$

In the above formula, $k(x_i, x)$ is the kernel function; b represents the bias term; α_i and α_i^* are Lagrangian operators.

2) Random Forest Regression (RFR)

Decision trees build regression or classification models in the shape of a tree. They break down the data into subsets and at the same time a new decision tree, based on the original one, is gradually developed. End result is a tree

which has decision nodes and leaf nodes. A decision node has greater than or equal to two branches, each of them represent values for the properties tested. Leaf nodes represent decisions on a particular numerical target. The decision node that is at the top in a tree corresponds to the best predictor, called the root node. For every decision tree, the importance of a node is calculated by using Gini Importance[10]:

$$ni_j = w_j C_j - w_{left(j)} C_{left(j)} - w_{right(j)} C_{right(j)}$$

Where, ni_j is the importance of node j , w_j is weighted number of samples reaching node j , C_j is the impurity value of node j . $left(j)$ is child node obtained from left split on node j and $right(j)$ is child node obtained from right split on node j

Each feature's importance has to be calculated. It can be done as follows :

$$fi_i = \frac{\sum_{j: \text{node } j \text{ splits on feature } i} ni_j}{\sum_{k \in \text{all nodes}} ni_k}$$

Where, fi_i is the importance of feature i , ni_j is the importance of node j

By dividing the sum of all feature importance values, these can be normalized between 0 and 1.

$$normfi_i = \frac{fi_i}{\sum_{j \in \text{all features}} fi_j}$$

The concluding feature importance is the mean over all the trees. This can be done by:

$$RFfi_i = \frac{\sum_{j \in \text{all trees}} normfi_{ij}}{T}$$

Where, $RFfi_i$ = feature i 's importance calculated from all trees in the Random Forest model, $normfi_{ij}$ = the normalized feature importance for i in tree j and T = total number of trees.

3) XGBoost Regression

The XGBoost library builds upon the pre-existing gradient boosting decision tree algorithm. The Gradient Boosting machines combine the decision trees in the beginning whereas, RFR combines them in the end. To correct the errors made by the existing models, an ensemble technique called boosting is used. A sequential process is followed to add the models until no further improvements are possible. Here gradient boosting approach is followed wherein the latest models that are created, predict the mistakes or errors made by the previous models, then these predictions are added together and a final prediction is made. This approach is called gradient boosting as it follows a gradient descent algorithm to reduce the loss when new models are added together.

For building a powerful supervised regression model, XGBoost approach is used. Loss function and regularization term are included in the objective function. The difference between actual and predicted values are obtained from it. This tells how far away the model is from the original values. Widely used loss function in XGBoost for regression is 'reg:linear'[12] and for binary classification is 'reg:logistics'.

The following tableII illustrates the advantages and disadvantages of the models used for crops yield prediction used in this paper.

B. Evaluation Metrics

It is essential to obtain the accuracy of the model on the training data and is equally important to have an approximate result on new data given to the model. Evaluation metrics are therefore important as they evaluate the model on different parameters and help us to better optimize the performance by fine tuning the hyperparameters. For this paper, we have considered three traditional evaluation metrics used for regression problems which are Root Mean Squared Error (RMSE), R Squared Score and Mean Absolute Error (MAE).

TABLE II ADVANTAGES & DISADVANTAGES OF MODELS USED FOR CROP YIELD PREDICTION

	SVR	RFR	XGBoost
Advantages	Performs well in cases where no. of dimensions are high and it is memory efficient as it uses a part of training set	Missing values present in the dataset are automated by the model	It has built-in features which are designed to handle the missing data
	It is adaptable to various kernel functions, customization is possible	Overfitting done in decision trees is reduced here which helps in further improving the accuracy	Provides good results with small to medium sized datasets
Disadvantages	For probability estimates calculation, expensive fivefold cross validation is used	Requires resources and computational power as it combines numerous outputs after building several trees	The limitation of xgboost is, like any other tree based model, it overfits if the model is not stopped early.
	To avoid overfitting when no. of features is greater than no. of samples, to choose regularization terms and kernel functions is difficult	Training time is high because it many decision trees are required to combine and determine the class	Training time for larger dataset is significantly high

1) Root Mean Squared Error (RMSE)

For accurately measuring the errors made by the model while predicting any quantitative data, Root Mean Square Error i.e. RMSE values are calculated [13].

$$RMSE = \sqrt{\frac{1}{n} \sum_{j=1}^n (y_j - \hat{y}_j)^2}$$

Where, n is the number of data points, y_j indicates the values that are observed (true values) and \hat{y}_j represents the values that are fitted or predicted.

Normalised RMSE facilitates comparison between two models. Basically, the closer Normalised RMSE is to 0, the better the model performs. Normalised RMSE = RMSE / (Max.Value - Min.Value)

2) R Squared Score

R^2 Scores are used to compute how well the values predicted fit the model which is calculated using the equation given below [13]:

$$R^2 = 1 - \frac{SS_{regression}}{SS_{total}}$$

where, $SS_{regression}$ indicates the summation of squares of the regression result, and SS_{total} indicates the complete sum of those squares.

3) Mean Absolute Error (MAE)

This error function calculates mean square error, which is a risk metric that associates to the value that is expected of the squared error or loss. If \hat{y}_i is value predicted for the i -th sample and y_i corresponds to the original or true value, the MSLE i.e mean squared logarithmic error calculated for $n_{samples}$ is computed using the following formula

$$MSLE(y, \hat{y}) = \frac{1}{n_{samples}} \sum_{i=0}^{n_{samples}-1} (\log_e(1 + y_i) - \log_e(1 + \hat{y}))^2$$

When targets have exponential growth, this metric is widely used.

IV. PROPOSED ARCHITECTURE

A. Dataset Used

The data was taken from Tata-Cornell Institute. The datasets for Temperature, Rainfall, Precipitation, Type of soil and its nutrient content were merged with crop yield data for the chosen crops. Above attributes were taken for the years from 2000 to 2016 for hundreds of districts from 20 states of India.

B. Proposed System For Crop Yield Prediction

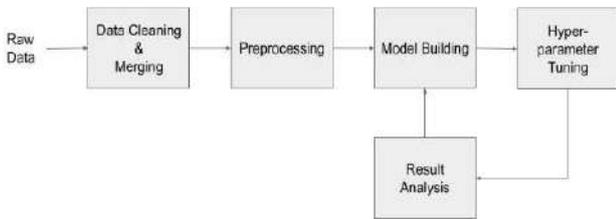


Fig. 1: General Architecture for Crop Yield Prediction

As the data was collected from various sources, the data had to be cleaned and made suitable to input into the machine learning algorithms. The data was first merged and the missing values were appropriately filled. The data was then normalized as the range of values in different columns is very large. This normalized data is suitable to be fed into the machine learning algorithms. The parameters of the algorithm best suited to the dataset are selected and the model is tuned with those parameters and then the model is evaluated.

Various parameters that could potentially affect the yield of a crop were considered and their data was obtained from various sources. This data was then required to be merged into a standalone dataset. The missing values in the dataset were filled using appropriate data mining techniques, outliers in the data were analyzed and removed and the noisy data points were excluded to fix structural errors in the dataset. Further, values were normalized between 0 and 1 to ensure a common scale throughout the columns.

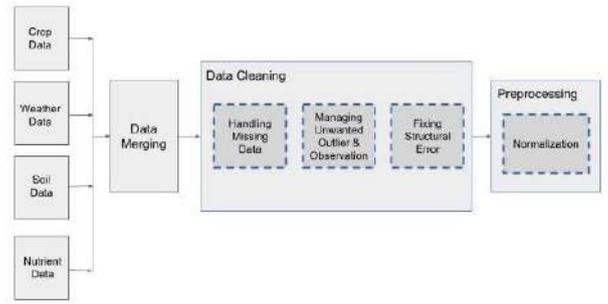


Fig 2: Data Preparation for Crop Yield Prediction

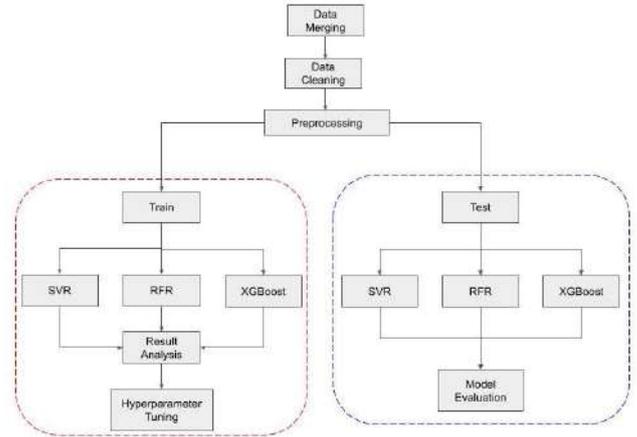


Fig. 3: Proposed Architecture for Crop Yield Prediction

Below are the steps followed for cleaning and preprocessing raw data from different sources to gain the final data ready for applying machine learning models.

Step 1: Acquiring precipitation and rainfall monthly records of several districts from 2000 to 2016 using the government records.

Step 2: Determining the annual mean for precipitation and rainfall for each district from 2000 to 2016.

Step 3: Acquiring the yield for the following crops: rice, wheat, maize, chickpea, pigeonpea, sesamum, sugarcane for each district.

Step 4: Acquired the monthly minimum and maximum temperatures for all years, calculated annual minimum and maximum temperatures and took the mean of minimum and maximum annual temperatures.

Step 5: Acquiring district wise soil type along with nutrient contents of the soil. The major three contents are Nitrogen (N), Potassium (K) and Phosphate (P) in the form of Percent share in NPK, Nitrogen, Phosphate and Potassium per hectare of Gross Cropped Area (GCA) (Kg per ha).

Step 6: These raw datasets were then integrated into a single sheet in Microsoft Excel which had the following columns SR. No, District Code, Year, State Code, State Name, District Name, Rice Yield, Wheat Yield, Maize Yield, Chickpea Yield, Pigeonpea Yield, Sesamum Yield, Sugarcane Yield, Annual Rainfall, Soil Type, Annual Precipitation, Annual Temperature, Nitrogen, Phosphate and Potassium. To apply the data mining techniques, dataset was prepared by omitting the redundant columns such as Serial No., names of the states, state codes and district codes.

Step 7: Rows with values that were 0s and -1s were filled with the district mean of that parameter. Districts having more missing data for more than 5 years were excluded like Bombay, Chennai, etc.

Step 8: Categorical variables like District Name and Soil Type were encoded using OneHotEncoder. The year column was transformed as (current year - given year) to make it an conducive input parameter for the model.

Step 9: With these steps, a fully cleaned and merged dataset was acquired which was then stored in a CSV file for the further procedures of data mining.

After the merging, cleaning and preprocessing of the data, the final dataset is then fed into machine learning algorithms. The dataset is then split into two different sets - train set containing 80% of the data and test set containing the remaining 20%. The train set is fed into the selected machine learning algorithms and the fit of the models is analysed. The parameters of the models were tweaked and the parameters best suited to the given dataset are obtained. The model is then fitted again using these parameters. Test data is then trained on these models using the selected parameters and are then evaluated using various evaluation metrics.

V. IMPLEMENTATION

Various libraries were used for the implementation of this paper. Some of them are explained below.

- 1) Scikitlearn - This library provides machine learning models for classification & regression. It also provides the metrics to evaluate the performance of these machine learning models. It encapsulates all the traditional machine learning models and the sklearn API provides detailed documentation about the parameters that can be tuned in order to improve the performance of these models.
- 2) Seaborn - A library built on top of matplotlib. It helps to find trends and correlations in data. The plots drawn using seaborn are easier on the eye.
- 3) XGBoost - An efficient & flexible library. It works under the Gradient Boosting framework and provides an optimized solution that solves many data science problems accurately and quickly. The Python module of this library uses DMatrix as its internal data structure which makes it optimized for both memory and training speed efficiency.

For implementation of this paper, we made use of CoCalc. It is a virtual online workspace for collaboration and research. For the environment we chose Python 3 (python v3.9.6) and set up a Jupyter Kernel in CoCalc for execution of the models. During the implementation of the training phase, for all the 7 crops, on an average, SVR took 2.35s, RFR took 0.13s and XGBoost Regression took 2.07s. For all the cases, Random Forest Regression proved to be the fastest in the training of the model, followed by XGBoost Regression and Support Vector Regression.

VI. RESULT

Yield of crops is directly related to a few factors. These factors show a high correlation with the yield of a crop. The following scatter plots compare some of these factors with the yield of the corresponding crop. It can be concluded from these plots that wherever a thick concentration of data points is observed, it indicates the optimum value of that factor for the yield of the corresponding crop.

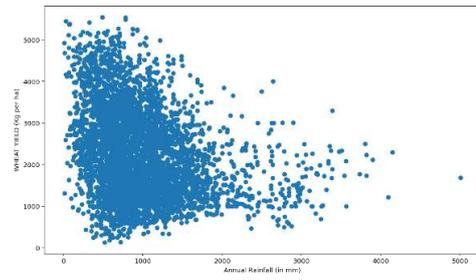


Fig. 4: Annual Rainfall vs Wheat Yield (Kg/ha)

It becomes clear that an annual average rainfall between 500mm to 1500mm is optimum for Wheat yield.

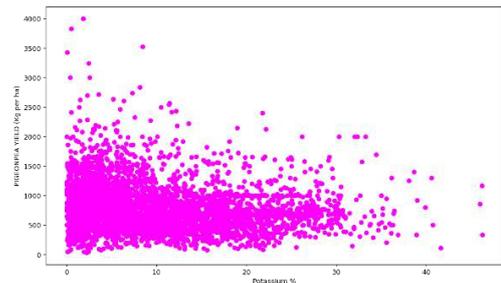


Fig. 5: Potassium % in NPK vs Pigeonpea Yield (Kg/ha)

It could be concluded that the share of Potassium in NPK should ideally be less than 25% for optimum Pigeonpea yield.

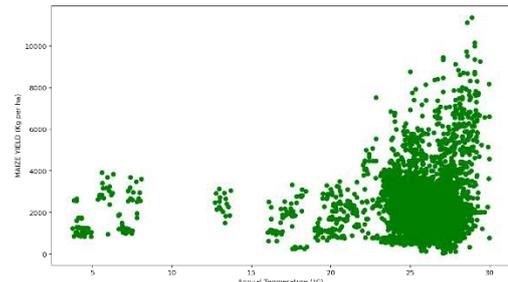


Fig. 6: Annual Temperature vs Maize Yield (Kg/ha)

It can be inferred that Maize Yield is more consistent when the average annual temperature ranges from 24°C to 28°C.

This paper has applied three different machine learning models to predict the yields of crops. These machine learning models need to be evaluated in order to understand the accuracies of these models. The following charts show the R^2 scores, MAE and RMSE for each of the seven crops for the given models.

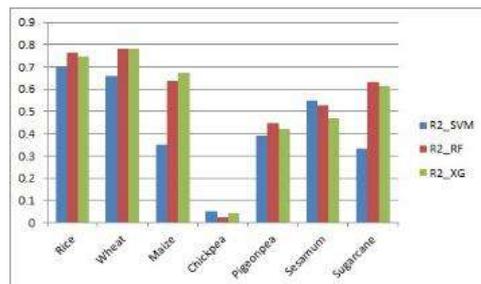


Fig. 7: R^2 Score comparison of all crops for all models

The above figure compares the R^2 Score values for each of the three models for all the crops considered.

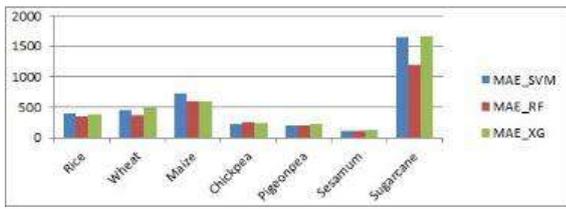


Fig. 8: MAE comparison of all crops for all models

This figure compares the Mean Absolute Error values for each of the three models for all the crops considered.

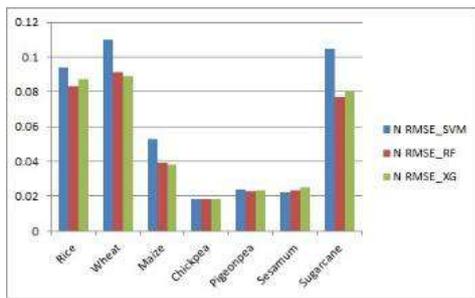


Fig. 9: RMSE comparison of all crops for all models

The above figure compares the Root Mean Squared Error values for each of the three models for all the crops.

TABLE III COMPARISON OF MODEL PERFORMANCE

Evaluation Metric	SVR	RFR	XGBoost
R^2 Score	0.70	0.78	0.78
MAE	110.44	117.43	127.06
RMSE	0.09	0.01	0.02

An efficient model has R^2 scores closer to 1 and MAE and Normalized RMSE scores closer to 0 [14]. Considering this, it can be seen from the above table that the RFR model outperforms the SVR and XGBoost Regressor.

VII. CONCLUSION

Based on soil type, nutrients of the soil and weather data, the proposed system predicts the yields of different crops [15]. This model uses three different machine learning algorithms, namely, SVR, RFR and XGBoost Regression. We performed regression analysis on these algorithms and found that RFR performed best on our dataset which was of small to medium size and contained noisy data points as well. XGBoost performed better than SVR, but was unable to outperform RFR while evaluating.

VIII. FUTURE SCOPE

The dataset used has been put together from various sources as there was no dataset available which took into consideration all the different parameters that are considered in this paper for prediction. If a dataset with these parameters becomes available in the future, robustness of the algorithms used for this system can be checked.

Further research can be done by including the harvest prices which could not be included in the input parameters due to unavailability of such data. Farmers will benefit from this research if they can find out which crop yields maximum profit.

IX. REFERENCES

- [1] N. Suresh et al., "Crop Yield Prediction Using Random Forest Algorithm," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021, pp. 279-282, doi: 10.1109/ICACCS51430.2021.9441871
- [2] M. Kavita and P. Mathur, "Crop Yield Estimation in India Using Machine Learning," 2020 IEEE 5th International Conference on Computing Communication and Automation (ICCCA), 2020, pp. 220-224, doi: 10.1109/ICCCA49541.2020.9250915.
- [3] N. Gandhi, L. J. Armstrong, O. Petkar and A. K. Tripathy, "Rice crop yield prediction in India using support vector machines," 2016 13th International Joint Conference on Computer Science and Software Engineering (JCSSE), 2016, pp. 1-5, doi: 10.1109/JCSSE.2016.7748856.
- [4] Osama K., Mishra B.N., Somvanshi P. (2015) Machine Learning Techniques in Plant Biology. In: Barh D., Khan M., Davies E. (eds) PlantOmics: The Omics of Plant Science. Springer, New Delhi. https://doi.org/10.1007/978-81-322-2172-2_26
- [5] Andrew Crane-Droesch, "Machine learning methods for crop yield prediction and climate change impact assessment in agriculture", 2018 Environ. Res. Lett. 13 114003
- [6] N. Gandhi and L. Armstrong, "Applying data mining techniques to predict yield of rice in humid subtropical climatic zone of India," 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), 2016, pp. 1901-1906.
- [7] J. Bao. "Multi-features Based Arrhythmia Diagnosis Algorithm Using Xgboost," 2020 International Conference on Computing and Data Science (CDS), 2020, pp. 454-457, doi: 10.1109/CDS49703.2020.00095.
- [8] G. Gupta and N. Rathee, "Performance comparison of Support Vector Regression and Relevance Vector Regression for facial expression recognition," 2015 International Conference on Soft Computing Techniques and Implementations (ICSCTI), 2015, pp. 1-6, doi: 10.1109/ICSCTI.2015.7489548.
- [9] J. Wu, X. Chen, Y. Wei and H. Huang, "Prediction of Grain Output in Anhui Province Based on Machine Learning," 2021 IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE), 2021, pp. 1088-1092, doi: 10.1109/ICBAIE52039.2021.9390000.
- [10] R. Medar, V. S. Rajpurohit and S. Shweta, "Crop Yield Prediction using Machine Learning Techniques," 2019 IEEE 5th International Conference for Convergence in Technology (I2CT), 2019, pp. 1-5, doi: 10.1109/I2CT45611.2019.9033611.
- [11] Chen, T. & Guestrin, C., 2016. XGBoost: A Scalable Tree Boosting System. In Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. KDD '16. New York, NY, USA: ACM, pp. 785-794. Available at: <http://doi.acm.org/10.1145/2939672.2939785>.
- [12] L. Sun, "Application and Improvement of Xgboost Algorithm Based on Multiple Parameter Optimization Strategy," 2020 5th International Conference on Mechanical, Control and Computer Engineering (ICMCC), 2020, pp. 1822-1825, doi: 10.1109/ICMCC51767.2020.00400.
- [13] Stephen Gbenga Fashoto, , Elliot Mbunge, , Gabriel Ogunleye and Johan Van den Burg, "Implementation of Machine Learning for Predicting Maize Crop Yields using Multiple Linear Regression and Backward Elimination", 2021 Malaysian Journal of Computing.
- [14] M. S. Acharya, A. Armaan and A. S. Antony, "A Comparison of Regression Models for Prediction of Graduate Admissions," 2019 International Conference on Computational Intelligence in Data Science (ICCIDS), 2019, pp. 1-5, doi: 10.1109/ICCIDS.2019.8862140.
- [15] A. Nagaraju, M. A. Kumar reddy, C. Venugopal reddy and R. Mohandas, "Multifactor Analysis to Predict Best Crop using Xg-Boost Algorithm," 2021 5th International Conference on Trends in Electronics and Informatics (ICOEI), 2021, pp. 155-163, doi: 10.1109/ICOEI51242.2021.9452918.

Code-Mixed Sentiment Analysis for Multi-Lingual [HI-EN] Social Media Text

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Abstract—India has a great diversity of languages. People use English and colloquial languages to put forward their ideas and views on social media platforms like Twitter and Facebook which has given rise to code mixed text. Sometimes, emoticons are used along with text to express the emotions and to indicate sarcasm. Analyzing this complex multilingual code-mixed text becomes an enormous challenge for researchers who work in the domain of Text Analytics. The research work regarding sentiment analysis of code-mixed text and negation handling has been done separately and there has been no cumulative model to do the same. The proposed research work will use a hybrid approach, consisting of Lexicon based methodology and Deep Learning and Machine Learning algorithms to identify the sentiments from multilingual code-mixed text from social media for the language pair: English-Hindi.

Keywords—Code Mixed Text, Social Media Text, Natural Language Processing, Sentiment Analysis, Lexicon Approach, Supervised and Unsupervised Learning.

I. INTRODUCTION

Natural Language Processing or NLP is a field in the study of languages where computers interpret the language used by humans, i.e., natural language. The input to the machine can be either in speech or in text format and the task of the machine would be to comprehend the input and generate appropriate output. Natural language processing has two main approaches: using Lexicon approach and using Machine Learning. Lexicon Approach involves various methods to break sentences into tokens, then try to understand the meaning of the tokens with the help of various approaches. Machine Learning approach involves feature extraction of POS, bigrams etc. and training the model with the dataset.

Code-mixing is the mixing of two or more languages or language varieties in a single sentence. It is a type of script in which both native and English are written in Roman script. People mainly use Code-Mixed text on social media to assert their opinions or to put forward their ideas in an effective and an easier way. In a country having linguistic diversity like India, analyzing such scripts is a huge challenge in the field of NLP for detecting sentiment, sarcasm, irony etc. Additionally, wide use of emoticons in today's time calls for

including them in such analysis procedures. An example of code mixed text is as follows:

Air Pollution level in Delhi doubled within hours on Sunday due to use of#firecrackers to celebrate #Dussehra2020!!!! I think its STUPIDITY to grt levels....kephle firecrackers jalao, and agle din air pollution pebaatein aur protest karo. Extraña!!

Humeinhaq nahi hai complain karneka if we burn crackers. Log bohooooohypocritic hai.

U knw Delhi is the only city where u hve to step inside 2 get sm fresh air 😊😊😊.

Politicians ko air pollution ke issue ko address karna chahiye but voapne "IMP" kaamomein busy hai 😊😊😊😊😊.

A hybrid model approach is proposed which consists of lexicon and machine learning algorithms to analyze sentiments effectively and to provide more accurate results in production as compared to the existing systems. Also, emoticon and abbreviation analysis are included in the course of pre-processing the text.

II. RELATED WORKS

One of the earliest works on code mix text was started by Sharma et al. [1] proposed a model that does word-level language identification in the code- mix script of Hindi and English, automatic transliteration of Romanized English language words and judge the sentiment of the script as positive or negative. These authors also worked on additional parts in language identification, figuring out ambiguous words and recognizing sounds. Also, A. Nagvenkar et al. [2], mainly worked on in which 'sense' a word is used in Hindi and English by defining Cross Lingual Word Semantic (CLWS) similarity as a task to find the semantic similarity between two words across languages. They presented a system that computes CLWS similarity between two languages: source (English) and scarce (Hindi). Additionally, D Singh et al. [3], contributed in the field of NLP majorly when they proposed detecting Multiword Expressions for Hindi Language using Word Embeddings and WordNet-based features. Focussing on identifying the co-occurrence of the two words using word bags, they concluded the research

that the WordNet-based approaches performs better than Word Embedding based approaches.

Use of attention mechanisms was proposed by Y. Lal et al. [17] using two Bi-LSTM models called Collective and Specific Encoders. This method worked well with compound sentences, which was a drawback with the normal LSTM approach, with a good accuracy. D. Gupta et al. [5] worked on code-mixed data from Government portals. Cosine similarity and CNN Models were used to analyze sentiments. B. M. Badr et al. [4] inferred that POS tags improve classification performance when they are attached to the unigrams. Also, skip gram features are capable of capturing informative sentiment terms than bigram features. K. Ravi et al. [6] recommended using k-fold cross validation for improving the accuracy and increasing the number of classes of classification. Also, they M. Zhang et al. [7] developed a DNN Model for sarcasm detection. They inferred that DNN improves accuracy for sarcasm detection with different error distributions compared with discrete manual features.

P. V. Veena et al. [8] used trigram and 5-gram for classification purposes which produced an accuracy of 93%. Importance of preprocessing of input text is emphasized for improving accuracy. A. Pravalika et al. [9] used a hybrid system consisting of lexicon-based approach and machine learning approach for sentiment analysis. Trie data structure is used for English and Hindi Dictionaries. Importance of including emoticons in the process of polarity checking is highlighted by P. Yadav et al. [10]. Factors affecting sentiment analysis and pros of feature selection techniques are to be considered before proceeding with the implementation. S. Ghosh et al. [11] extended the preprocessing step by expanding the abbreviations. Also, many new methods like counting multiple repetitions of a character in a word, counting the number of switchings done between languages and counting the number of uppercase words were employed in a bid to increase the accuracy of the model. S. Swami et al. [13] worked on EN-HI code-mixed dataset of tweets to check for presence of sarcasm and irony by annotating a token with a language tag. Supervised classification system was developed using Random Forest classifiers for word n-grams and performing 10-fold cross validation and achieved an average F-score of 78.4. Also, P. Mishra et al. [14] for identifying the sentence level sentiment polarity of the code-mixed dataset on HI-EN and BN-EN. Voting Classifier for BN-EN and SVM with (2,6) char n-grams. Shalini K et al. [15] on BEN-EN, HI-EN corpus and considered data from Facebook comments in KAN-EN. They experimented with distributed representation of text through Doc2Vec, Fasttext, CNN and Bi-LSTM models where Fasttext representation outperformed for all 3 datasets. A new clustering algorithm from R. Singh et al. [12] used the similarity function between two vectors to resolve various occurrences of a particular word because of change in spelling, thereby improving accuracy of sentiment analysis and POS Tagging.

Attention based deep learning technique was used in S. Mukherjee et al. [16] which does fusion of character and word feature to develop a robust classifier for code-mixed text of Hindi-English. Here a single sentence of a sequence of 200 characters and also space characters. A.Saini [18] implemented Rule-based technique using the ML model GradientBoostingRegressor model which is an ensemble

model and uses decision trees internally. Three different datasets with 6 classes were considered and gave good accuracy for the datasets.

So far, the following gaps have been identified. Firstly, language identification is difficult due to Word Sense Ambiguity of code mix text. Additionally, emoticons were rarely used for sentiment analysis. In some papers, deep learning models have fared better, while in some cases, the same type of models have fared lower than expectations. Also, conflict of opinion results in misclassification of text. Uppercase and repeating characters theoretically hold sentiment values, but this was not seen during tests. Finally, handling Scriptio Continua text, i.e. handling texts in which constraint on maximum number of characters is mentioned, where users tend to combine words to fit more text.

III. CODE MIX SENTIMENT ANALYSIS [HI-EN]

In order to achieve better domain results, ML based techniques and the Lexicon Based approach are combined to build Hybrid domain systems to inherit advantages and eliminate disadvantages.

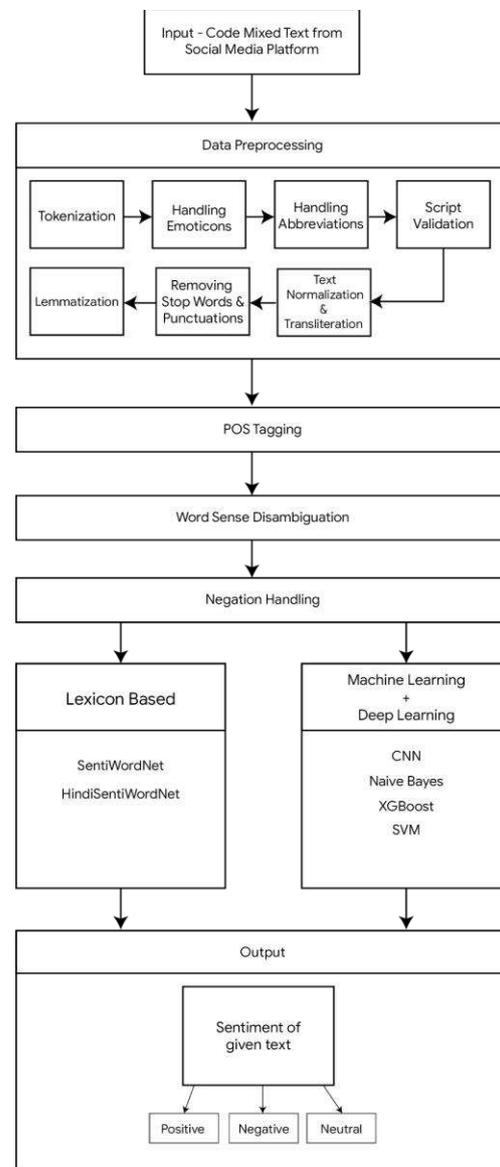


Fig. 1 Proposed Architecture

A. Data Preprocessing

First process is tokenization. This process breaks the sentences into tokens (words). Script Validation process involves checking whether the input is in the language under consideration, i.e. whether the script is valid to be analyzed (here, English-Hindi). After that, text normalization and transliteration is performed. Language identification is done in this step. The English words are tagged as /E and Hindi words are tagged as /H. Transliteration process converts the script from one language to another. Here, we are transliterating HINDI into ENGLISH. A dictionary is used to convert all instances of the abbreviations present, to its long form. Stop words are those words which are frequently used (a, an, the, etc.) in the documents. These words do not contribute to sentiment value in a sentence. Punctuations from the tokenized words are removed. Handling Emojis is done by considering only a certain emojis of the entire set, as only a few express sentiments. Lemmatization reduces the word to its root form such that the reduced word is an existing word.

B. POS Tagging

POS (part-of-speech) tagger marks up a word in a corpus to its corresponding part of a speech tag based on its context and definition. There are different techniques for POS Tagging like Rule-Based Methods, Transformation Based, Stochastic based. Single best tag is given to every word.

C. Word Sense Disambiguation

Word Sense Disambiguation is the solution to ambiguity which arises due to different meanings of words in different contexts which are spelled the same.

D. Negation Handling

Polarity of the sentence or words are inverted by negation words. Negation handling is an automatic way of determining the scope of negation. Examples of negation words include not, no, never, cannot, shouldn't, wouldn't, etc. 'Not' is considered for English and 'नहीं' and 'न' for Hindi. Forward negation was performed for 'not' and 'न' and backward negation for 'नहीं'.

E. Hybrid Technology

In this approach, Lexicon based methods using SentiWordNet and Hindi SentiWordNet are used along with Machine Learning methods using classifiers and Neural Networks.

- 1) *Lexicon based methods*: They work with the SentiWordNet database consisting of a token and the sentiment value of that token. SentiWordNet is a database or a lexical resource for determining the sentiment of a particular word. It contains the words in a language along with its part of speech, polarity meaning whether the word is positive, negative or neutral. Additionally, the word's synonyms and glossary are present. For each word, an associated positive score and negative score is attached, along with its POS tag.
- 2) *Machine Learning based methods*: They recognize mathematical patterns from data and use that

knowledge to classify sentiments accurately.

Bag of words model (BoW) is a representation of text that describes the occurrence of words within a document.

TF-IDF is a short form of Term Frequency – Inverse Document Frequency. It consists of two parts, Term Frequency which gives an idea how often a given word comes up within a document and Inverse Document Frequency that scales down words that comes up frequently across documents. The scores highlight words that are distinct (contain useful information) in a given document.

Machine Learning Models:

Support Vector Machine (SVM): Each data item in the dataset is plotted in an N-dimensional space, where N is the number of features in the data. In the next step, optimal hyperplane is found to separate the data. SVM can mainly perform binary classification.

Naive Bayes Classifier: Naive Bayes classifier is a family of classification algorithms based on Bayes' Theorem of Probability. It assumes every feature is independent and is a probabilistic model.

XGBoost: XGBoost is an ensemble Machine Learning algorithm based decision-tree classifier that uses a gradient boosting framework and is designed for speed and performance. Structured or tabular datasets are dominated by XGBoost on classification and regression predictive modelling problems.

Deep Learning Models:

Convolutional Neural Networks: ConvNets used in classifying a sentence into a set of predefined classes by considering n-grams.

IV. EXPERIMENTAL ANALYSIS

A. Dataset Used

The dataset for supervised learning algorithms for the machine learning approach would consist of Twitter tweets and their sentiments. The dataset is obtained from Semeval 2020 competition for Task 9. There are 14000 tweets for training and additional 3000 for validation.

For Pure Language Analysis, we referred datasets from Kaggle. The datasets consisted of movie reviews given on IMDb. For English, there are 40000 reviews. Similarly for Hindi, there are 900 annotated reviews. The dataset contains tweets in Hinglish format with sentiment annotations as Positive, Neutral and Negative, which have been annotated by Language Experts.

B. Evaluation Metrics

An essential part of analysing the performance of the model on the code mix text is its evaluation. Generally, evaluation for the classification problems is done using the following evaluation metrics: Precision, Recall and Accuracy.

$$\text{Precision} = \frac{TP}{TP+FP} \quad (1)$$

TABLE I PRECISION FOR ALL APPROACHES

Precision in %	Lexicon based approach	Machine Learning & Deep Learning based approach			
		Naive-Bayes	SVM	XGBoost	CNN
Pure English	88	88%	85	79.7	87.71
Pure Hindi	84	61	55	55.02	70.55
Codemix	60	59	58	61.4	56.25

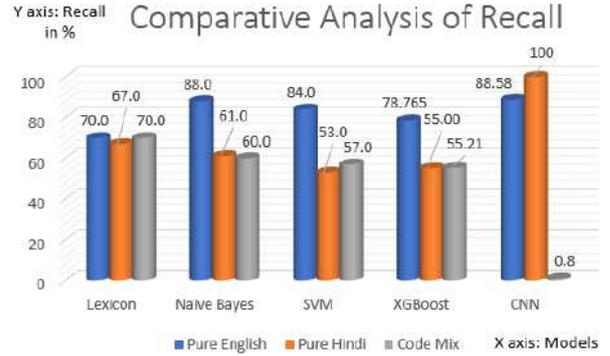


Fig. 3. Comparative Analysis of Recall

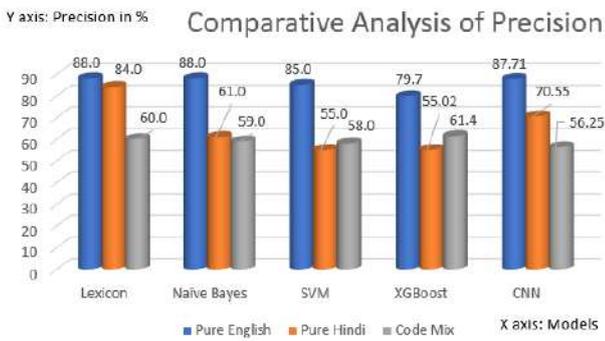


Fig.2. Comparative Analysis of Precision

$$\text{Recall} = \frac{TP}{TP+FN} \quad (2)$$

TABLE II RECALL FOR ALL APPROACHES

Recall in %	Lexicon based approach	Machine Learning & Deep Learning based approach			
		Naive-Bayes	SVM	XG Boost	CNN
Pure English	70	88	84	78.76	88.58
Pure Hindi	67	61	53	55	100
Codemix	70	60	57	55.21	0.8

$$\text{Accuracy} = \frac{TP + TN}{TP+TN+FP+FN} \quad (3)$$

TABLE III ACCURACY FOR ALL APPROACHES

Accuracy (%)	Lexicon based approach	Machine Learning & Deep Learning based approach			
		Naive-Bayes	SVM	XG Boost	CNN
Pure English	70	88.4	84.5	78.9	88.02
Pure Hindi	80	61.11	52.78	56.25	36.11
Codemix	70	59.86	56.73	56.04	37.51

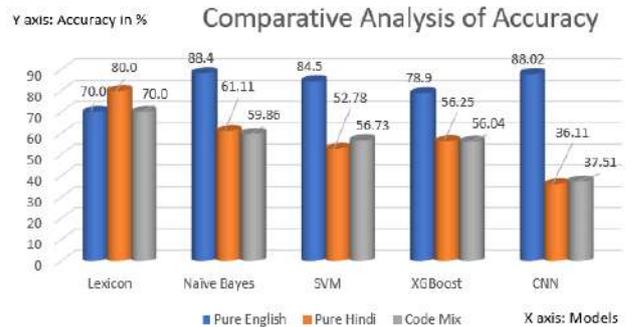


Fig. 4. Comparative Analysis of Accuracy

C. Result Analysis

In order to evaluate the proposed system, experiments were conducted on the above mentioned dataset using two approaches: Lexicon based approach and Machine learning

approach. SVM, Naive-Bayes, XGBoost and CNN models were used in ML techniques.

For Lexicon based, accuracy for Pure English, Pure Hindi and Code mixed text was 70%, 80% and 70% respectively. While in Machine Learning, for Code mixed text, Pure English as well as for Pure Hindi, Naive-Bayes performed better than other models with an accuracy of 59.86%, 88% and 61% respectively.

CNN model was used for Deep Learning model and it performed well on Pure English with an accuracy of 88.58% whereas for Code mixed text we achieved an accuracy of 37.51%. For Pure Hindi accuracy was 36.11%.

V. CONCLUSIONS

The previous works related to code-mixed sentiment analysis were studied thoroughly and analysed for further improvements. Proposed architecture seeks to eliminate those shortcomings using a hybrid approach. The hybrid approach consists of two methods - Lexicon and ML based methods. The performance measures like precision and recall are used for evaluation.

A robust emoticon and abbreviation library are considered for better results. This proved to be beneficial for the Lexicon Model. Negation handling also provided satisfactory results.

The algorithm's performance can be improved by using an extensive corpus with correct annotation of classes.

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REFERENCES

- [1] Sharma, P. Srinivas and R C. Balabantaray, "Sentiment Analysis of Code – Mix Script", in *International Conference on Computing and Network Communications (CoCoNet'15)*, Trivandrum, India, 2015, pp. 530-534.
- [2] A. Nagvenkar, J. Pawar, P. Bhattacharyya, "Let Sense Bags Do Talking: Cross Lingual Word Semantic Similarity for English and Hindi", in *Proceedings of the 12th International Conference on Natural Language Processing (2015)*, Trivandrum, India, 2015, pp. 79–83.
- [3] D. Singh, S. Bhingardive, K. Patel and P. Bhattacharyya. "Detection of Multiword Expressions for Hindi Language using Word Embeddings and WordNet-based Features", in *Proceedings of the 12th International Conference on Natural Language Processing (2015)*, Trivandrum, India, 2015, pp. 295–302.
- [4] B. M. Badr and S. S. Fati "Using Skipgrams, Bigrams, and Part of Speech Features for Sentiment Classification of Twitter Messages", in *Proceedings of the 12th International Conference on Natural Language Processing*, Trivandrum, India, 2015, pp. 268–275.
- [5] D. Gupta, A. Lamba, A. Ekbal and P. Bhattacharyya, "Opinion Mining in a Code-Mixed Environment: A Case Study with Government Portals", in *Proceedings of the 13th International Conference on Natural Language Processing*, Varanasi, India, 2016, pp. 249 - 258.
- [6] K. Ravi and R. Vadlamani "Sentiment classification of Hinglish text" , in *3rd International Conference on Recent Advances in Information Technology (RAIT)*, Dhanbad, India, 2016, pp. 641-645.
- [7] M. Zhang "Tweet Sarcasm Detection Using Deep Neural Network", in *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*, Osaka, Japan, 2016, pp.2449–2460.
- [8] Veena P V, Anand Kumar M, Soman K P. "An Effective Way of Word-level Language Identification for Code-mixed Facebook comments using Word-Embedding via Character-embedding" in *International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, Udupi, India, 2017, pp. 1552-1556.
- [9] A Pravalika, VishveshOza, N P Meghana and S Sowmya Kamath "Domain-specific Sentiment Approaches for Code-mixed Social Network Data", in *8th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, Delhi, India, 2017, pp. 1-6.
- [10] P. Yadav and D. Pandya "SentiReview: Sentiment Analysis based on Text and Emoticons" in *International Conference on Innovative Mechanisms for Industry Applications (ICIMIA 2017)*, Bengaluru, India, 2017, pp. 467-472.
- [11] S. Ghosh, S. Ghosh and D. Das "Sentiment Identification in Code-Mixed Social Media Text", July 2017
- [12] R. Singh, N. Choudhary and M. Shrivastava, "Automatic Normalization of Word Variations in Code-Mixed Social Media Text" in *19th International Conference on Computational Linguistics and Intelligent Text Processing*, Hanoi, Vietnam, 2018.
- [13] S. Swami, A. Khandelwal, V. Singh, S. S. Akhtar and M. Shrivastava "A Corpus of English-Hindi Code-Mixed Tweets for Sarcasm Detection" in *19th International Conference on Computational Linguistics and Intelligent Text Processing (CICLing-2018)*, Hanoi, Vietnam, 2018.
- [14] P. Mishra, P. Danda and P. Dhakras "Code-Mixed Sentiment Analysis Using Machine Learning and Neural Network Approaches", August 2018.
- [15] Shalini K, B. Ganesh HB, A. Kumar M and Soman K P "Sentiment Analysis for Code-Mixed Indian Social Media Text With Distributed Representation" in *2018 International Conference on Advances in Computing, Communications and Informatics*, Bangalore, India, 2018, pp. 1126-1131.
- [16] S. Mukherjee, V. Prasan, A. Nediyanath, M. Shah, N. Kumar "Robust Deep Learning Based Sentiment Classification of Code-Mixed Text", in *ICON, LTRC, IIIT H*, Hyderabad, India, 2019.
- [17] Y. K. Lal, V. Kumar, M. Dhar, M. Shrivastava and P. Koehn, "De-Mixing Sentiment from Code-Mixed Text" in *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics: Student Research Workshop*, pp. 371–377, July 2019.
- [18] A. Saini, "A Novel Code-Switching Behavior Analysis in Social Media Discussions Natural Language Processing" in *2019 IEEE International Conference on Big Data (Big Data)*, Los Angeles, CA, USA, 2019, pp. 5957-5961.
- [19] P. Qi, Y. Zhang, Y. Zhang, J. Bolton and C. Manning, "Stanza: A Python Natural Language Processing Toolkit for Many Human Languages" in *Association for Computational Linguistics (ACL) System Demonstrations*, 2020.
- [20] McCallum, Andrew Kachites. "MALLET: A Machine Learning for Language Toolkit." <http://mallet.cs.umass.edu>. 2002.

Crop Prediction Using Soil Nutrients

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Abstract—The fact is that most of Indians have agriculture as their occupation. Farmers usually have the mindset of planting the same crop, using more fertilizers and following the public choice. By looking at the past few years, there have been significant developments in how machine learning can be used in various industries and research. The proposed system uses machine learning in agriculture for the betterment of farmers. Proposed system will help farmers predict the suitable crop for their fields. The surveyed research papers have given a rough idea about using ML with only one attribute. With the aim of adding more attributes to the proposed system and ameliorate the results, which can improve the yields and that can recognize several patterns for predictions. This system will be useful to justify which crop can be grown in a particular region.

Keywords—Machine Learning, Agriculture, Crops, Farmers

I. INTRODUCTION

Crop production may be a complicated development that's influenced by soil and environmental condition input parameters. Agriculture input parameters vary from field to field and farmer to farmer. Collection such info on a bigger space may be a discouraging task. However, the environmental condition info collected in Republic of India at each 1sq.m space in numerous components of the district is tabulated by Indian meteoric Department. The massive such knowledge sets may be used for predicting their influence on major crops of that individual district or place. There are completely different foretelling methodologies developed and evaluated by the researchers everywhere the globe within the field of agriculture or associated sciences. A number of such studies are: Agricultural researchers in alternative countries have shown that tries of crop yield maximization through pro-pesticide state policies have LED to hazardously high chemical usage. These studies have reported a correlation between chemical usage and crop yield [1]. Agriculture is associate trade sector that's

benefiting powerfully from the event of detector technology, knowledge science, and machine learning (ML) techniques within the latest years. These developments return to satisfy environmental and population pressures round-faced by our society, wherever reports indicate a requirement for robust international agriculture yield increase to produce food for a growing population on a hotter planet. Most of the work tired the sector of yield foretelling via cubic centimeter makes use of some kind of remote sensing knowledge over the farm.

In order to support human existence, agriculture aims to expand and increase agricultural yields and thus quality of crops. In the present day, though, people seem to need work like a shot. In agriculture, less and less people are involved. Moreover, the constant growth in humans makes the growing of crops a lot important at the correct time and location, as the environment is dynamic and so changes from traditional weather patterns are a lot more often than before. Food insecurity may be unpredictable and people should utilize state-of-the-art creative technology to build up current circumstances on land, waters and air to produce greater harvests. If the computer code models the interactive impact of climate factors, in particular the impact of maximum events (e.g. warmth, rain and overwater) which take place at completely different growing phases of plants, the information gap can be overcome between old cultivable methods and new agricultural technologies. Clearly, temperature change impacts both native and world food production, thus the planning of computer codes for crop planning requires new technique for temperature change research, temperature change adaption circumstances, and policymakers that will limit food's destructive weather effects. Experimental evidence is used to construct environmental areas with variations in weather and water which are the 2 most important variables to ensure a crop.

The soil type is changed over time by weather and pests

therefore crop management should handle a large amount of information, directly or indirectly linked. It will therefore provide a rapid assessment of the influence of the changes in temperature on agriculture by assuming a simplified reality. Therefore by building models that theoretically improve management techniques, maximize rotating crops to control soil changes, new breeding programs, agricultural activities should be adapted to such climatic changes.

The seasonal climatic change may be determined and documented in an extremely timely way by increasing the forecast value. Later on, machine learning backed by the victimization computer code is timed to evaluate the influence of temperature change and to monitor achievable circumstances which integrate determined changes in weather conditions and distribution of water. Data processing is that an analysis process of the experimental knowledge acquired from totally diverse viewpoints, extracting trends or patterns {info-data} and converting them into user-suitable information, across a variety of places. Users will then further explain and/or describe the links established from the knowledge gathered and generally forecast what knowledge to expect. Machine learning techniques are part of the data processing and discovery of information and are focused entirely on distinctive relationships or patterns across large or huge databases. The patterns, correlations or relations between all this knowledge will be further reflected in the information which is provided to the user as past patterns and future developments. This information provided by machine learning will facilitate farmers with crop cultivation by predicting probabilities of crop losses or stop losses altogether. The next part discusses about proposed methodology of project.

1.2 Purpose and Problem Definition

Agriculture is the mainstay of the state of Maharashtra. It is the main occupation of the people. Almost 81% of the rural population depends on agriculture for livelihood. The state experiences tropical conditions, and the rain pattern differs from region to region. Some regions experience scattered rainfall. The soil is an essential factor that supports plant growth. Plants absorb the nutrients required for their growth from the soil. Therefore, soil analysis is a necessary process to determine the number of available plant nutrients in the soil. Including soil, there are various significant factors like rainfall, precipitation, fertilizer, etc that affect plant growth. Soil analysis determines the content of essential plant nutrients; nitrogen (N), phosphorus (P), potassium (K), pH. According to the content of nutrients in the soil obtained by analysis, it is easier to predict the crop to achieve high production and quality yields.

The proposed system is focusing on predicting the accurate crop yield to the user by analyzing the soil fertility and rainfall in the region entered by the user as an input. For classifying the soil fertility, the main four parameters: Nitrogen (N), Phosphorous (P), Potassium (K), pH value are considered. It is an analytic data technique which has different types of algorithms and models to learn information directly from data. This system will be helpful for farmer to improve productivity. The next part discusses about scope of the proposed system.

1.3 Scope

Many strategies and methods are proposed by researchers around the world. A very few real-time systems are freely available, with that testing soil samples in laboratories are time-consuming as well as costly. Predicting crops based on only nutrients predicts crops less accurately.

Since there is a strong need to develop a product that automates the soil fertility check and analyze process with additional rainfall in that particular region is proposed. This plays a vital role in the growth of the plant. The accurate reading of the proposed system will help farmer for the selection of the crop for cultivation. The next part discusses about literature survey of the proposed system.

II. LITERATURE SURVEY

Many specialists use mechanized agriculture nowadays. Because Decision Tree is a recognized method, it was employed to forecast a controlled learning algorithm and a generalized linear prediction model. An attempt was made to investigate the impact on soya production created by decision-making tree induction approach. Various types of rules are produced from the decision tree for simple comprehension of end-users [3].

Md. Tahmid Shakoor et al. study helps us pick many qualities, such as land capacity, depth, pathway, drainage, texture, erosion and permeability [4]. This work has built two supervised classification machine learning algorithms. This technology automatically receives data from an appropriate source on the weather and soil qualities at a particular coordinate. Another benefit is that their approach works in larger regions and gives a resolution prediction commensurate with the best input data resolution, initially based on the soil data.

The capacity to predict crops before the start of the harvest season. This enables users to make strategy adjustments, for example, to choose a strong genetic difference before they plant or even alter the crop type, in order to further adapt harsh climate fluctuations in the crop cycle [2]. The developed method presents a data-based model for predicting and predicting crop yield utilizing combined soil and climatic dependence. While there are various approaches available for predicting rainfall, the algorithm presented in this study managed to stress Rainfall along with the prediction of agricultural production. The proposed model takes consideration of the most significant environment and soil characteristics affecting crop development such that in the final forecast each component was given equal weight. The research results may help farmers by understanding the capital for investment in the crop to be planted before the seed season starts [6]. The algorithm can help local self-government and financial organizations to assign farmers adequate money or tax credits. Naive Bayes can also be useful for a huge dataset. The use of naive bays and decision tree means that the model is extremely computationally efficient. The system may be scaled as it can be used for testing on various crops. The ideal time to seed, plant development and harvest the plant may be discovered in the yield graphs. The ideal and worse conditions might also be encountered. The model is focused on all farm types and may also be used by smaller farmers. In order to discover the yield of every crop and prescribe pesticide this model may be further developed. It may also be amended to indicate the fertilizer requirements [7]

and watering of plants. The next part discusses about the proposal of the proposed system.

III. PROPOSAL

3.1 Module Description

The system aims to assist users to cultivate the correct crop for higher yield production. For implementing this system, a prototype model representing the field will be considered. To be precise and accurate in predicting crops, analysis of the soil is required. Which can be done based on the nutrients present within the soil and also the crop productivity based on area. The next part discusses about hardware and software requirements of project.

3.2 Hardware and Software Requirements

Following are the hardware and software requirements for developing the system.

Hardware Requirement:

- 4 GB RAM.
- 256 GB HDD.
- Intel 2.8 GHz i3 Processor

Software Requirement:

- Windows 7/8/10
- Python
- Jupyter notebook

The next section focuses on the proposed methodology and algorithms used.

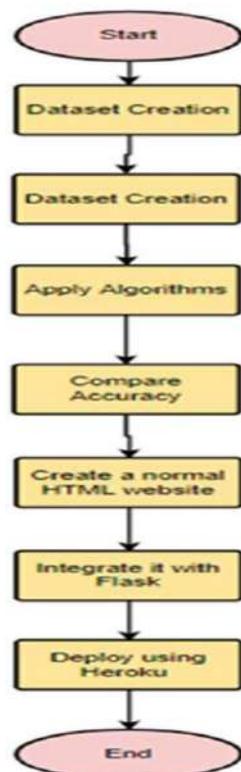


Fig. 1. Workflow of the proposed system

IV. PROPOSED METHODOLOGY

4.1 Details of Works Accomplished

Many machine learning algorithms were tested on the

dataset from Kaggle based on crop recommendation dataset. The parameters that were considered are N i.e., nitrogen, P i.e. Phosphorus, K i.e. Potassium, PH, rainfall, temperature and humidity. The sci-kit learn libraries were utilized for the purpose of implementation. The data set was also included from the Indian government site. The various algorithms implemented include:

NAÏVE Bayes

It's a tribe of algorithms and not one algorithm. All naïve socio-economic classifiers in Bayes assume that, given the class variable, the value of a certain feature is independent of the value for each other. The Thomas Bayes classifier might be the straight probabilistic classifier that supports the use of theorems with strong naïve assumptions of independence (from Bayesian statistics). The Bayes theorem with associated grades of independence between the predictors was supported by classification method. Simply put, the presence of a special feature in an extremely class is assumed by a Naive Thomas Bayes category to be distinct from that of the other. For example, if this is red, spherical, and around a few inches' diameter, the fruit may also be considered as an association grade apple. Even though those characteristics are interdependent and dependent on other characteristics, a naïve classifier in Bayes would regard all these attributes separately to contribute to the likelihood that this fruit is an apple. The class label for each training data set is predicted by these learners. The class label which most of the models predict is voted using the majority voting procedure and the class label is agreed on in the training dataset. Regulations are produced from the ensemble models.

Random Forest

Random forest square measures the associated technique for classifications, regression and various tasks of learning that works by constructing an unpleasant call trees throughout coaching time and by producing the category in which individual trees are categorized or mean predictive. Random forests correctly match your coaching set to the custom of the call tree. Tin Kam Ho's random space methodology, which in the Ho formula could be a result of the 'stochastic discrimination' approach to categorization proposed by Eughe Kleinberg, was established as the fundamental guideline for random call forests. Leo Breiman and Adele Bargainer's have devised a partnership rule, and their trade mark is Random Forests. The addition combines the 'bagging' strategy and random alternatives presented by Breiman first by Ho and then by Amit and Geman in order to build a group of controlled variances called trees. Although random forests are intended naturally to only contain third-dimensional information, it was proven that they may be used for random objects using similarities just in pairs of objects.

Gradient Boosting Classifier

Gradient boosting is an automated regression and classification problem learning approach which creates a prediction model in the form of a set of weak prediction models, generally decision trees. When a decision tree is the weak student, the technique is dubbed gradient-boosted trees, generally exceeding random forests. It creates the model as

usual and generalizes it, enabling the optimization of an arbitrary differentiable loss function.

Bootstrap Aggregating (Bagging)

Bootstrap aggregation, commonly known as the bagging, is the meta-algorithm used in machine learning systems for improving the stability, the precision and the classification of machine learning algorithms. It also minimizes variance and helps prevent excessive installation. For regression and statistical classification, the bagging technology is beneficial. Bagging is employed in decision-making bodies whereby the stability of models in reducing variance and enhancing precision is greatly increased, thereby eliminating the problem of overcasting.

KNN Classifier

In statistics, a non-parameter classification technique initially devised by Evelyn Fix and Joseph Hodges in 1951, [1] and then extended by Thomas Cober, is the k-close neighborhood algorithm (k-NN). [2] It is utilized for regression and classification. The input includes the closest training instances in the data set in both situations. Input The outcome relies on how k-NN is used to classify or regress. k-NN is a classification type in that the function is locally approximated and all calculation is delayed until function evaluation is performed. Since this method is classified based on distance, it may be greatly improved by standardizing training data when the features represent distinct physical components or in vastly different sizes.

Multi-layer Perceptron (Artificial Neural Network)

Multi-layer perceptron (MLP) may be a multi-layer neural feed network between the input and end product layer. Feed forward indicates that knowledge time goes from input to output layer in one direction. MLP square measure generally used to classify, recognize, anticipate and approximate patterns. Associate ANN depends on a number of linked units or nodes called artificial neurons (analogous to biological neurons in associate animal brain). An indicator will pass from one to another each association (synapse) between neurons. The somatic cell receiving (postsynaptic) will then process signal(s) and signal neurons. The computer systems generated by biological neural networks representing animal brains are artificial neural networks (ANNs) or connectionist systems. Square systems.

XGBoost

XGBoost is a Machine Learning method focused on decision- making, using a gradient boosting framework. Artificial neural networks tend to exceed all other algorithms or frameworks when they are predicting issues with non-structured data (pictures, text). In the case of small-to-medium structure/tabular data, however, decision-tab algorithms are now regarded best-in-class.

Logistic Regression

The statistic model for a particular class or event, for example passing/failure, winning/loosing or alive/dead or healthy/sick, is used to model the likelihood of a specific

class/event. This may be expanded to modelling other event classes such as if a picture has a cat, dog, lion etc. This is possible. A probability between 0 and 1 is given to each object detected in the picture with a total of one.

Logistic regression is a statistical model that employs a logistic function in its basic form to model a binary dependent variable, but there are many more complicated variants. The logistic regression [1] (or logit regression) analyses the parameters of a logistic model (a form of binary regression). Mathematically, a binary logistic model contains two potential values as a depending variable, for example pass/fail which is shown with an indicator variable, where the two values are labelled '0' and '1.' In the logistic model, the log-odds for the value labelling "1" are the linear combination of one or more independent variables ("predictors"), each of which may be a binary (2 classes encrypted by an indicator variable) or a continuous vary (any real value). The associated likelihood of a value labelled "1," might range from 0 (of course the value "0") to 1 (of course the value "1"), therefore the labelling: the logistic function, hence the name, is the function which translates log-odds into probability. The next section, focuses on the advantages of the project work. The next section, focuses the results of implementing various algorithms are discussed.

4.2 Result and Analysis

Table I represents the accuracy table of various algorithms for the dataset taken from the website of government of India. All the algorithms give above 90% accuracy as the dataset contains values that are not categorized. Each value in the dataset is a different category due to the different values of the various nutrients in the soil. Gaussian Naïve Bayes gives the maximum accuracy. So it is been used in the proposed system.

Below is the accuracy table of different Algorithms:

TABLE I. ACCURACY TABLE

Algorithm	Accuracy
Gaussian Naïve Bayes	99.53%
Iterative Dichotomiser 3	92.27%
Gradient Boosting Classifier	98.86%
Random Forest Classifier	99.32%
Bootstrap Aggregating (Bagging)	98.40%
KNN Classifier	97.72%
Multilayer Perceptron Classifier	95.90%
XGBoost	98.86%
Logistic Regression	94.54%

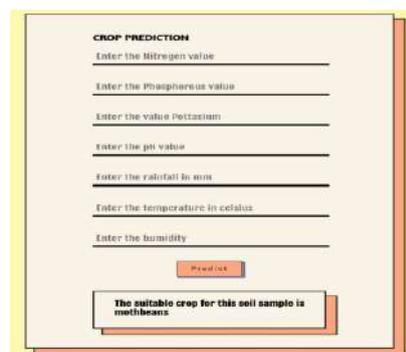


Fig.2. System before entering the values

CROP PREDICTION

Enter the Nitrogen value _____

Enter the Phosphorous value _____

Enter the value Potassium _____

Enter the pH value _____

Enter the rainfall in mm _____

Enter the temperature in celsius _____

Enter the humidity _____

Predict

Fig. 3. System on entering the values

CROP PREDICTION

36 _____

25 _____

45 _____

6 _____

57 _____

35 _____

45 _____

Predict

Fig. 4. Output after entering the values

Fig. 2, Fig. 3 and Fig. 4 represents the system front-end, where the values of various parameters are given, values are entered and the predicted crop will be displayed in the last text box. In the next section the benefits of proposed system are discussed and finally concluded

V. BENEFITS OF PROPOSED WORK

India has small-scale farms. More than 75% of the country's total capital cities are smaller than 5 acres. Most plants feed on rain, with only around 45% of the land watering. According to some estimates, over 55% of India's overall population depends on agriculture. It is around 5% in the United States due of the significant agricultural automation. India is one of the largest agricultural goods producers and nevertheless has very much fewer agricultural production. Productivity needs to be raised so that farmers may earn more income with less labor from the same piece of land. Precision farming offers a method to accomplish it. Precision farming, as the name suggests, is about applying the exact and adequate total of elements such as pee, fertilizer, soil etc. to raise productivity and increase yields in a timely manner. Not all agricultural precision systems deliver optimal outcomes. However, in agriculture the suggestions provided are exact and correct since it can lead to large material losses and money loss in the event of mistakes. Many research is underway to achieve an accurate and effective crop forecast model.

Many strategies and methods are proposed by researchers around the world. A very few real-time systems are freely available, with that testing soil samples in laboratories are

time-consuming as well as costly. Predicting crops based on only nutrients predicts crops less accurately. Since there is a strong need to develop a product that automates the soil fertility check and analyze process with additional rainfall in that particular region is developed. This plays a vital role in the growth of the plant. The accurate reading of proposed system will help farmer for the selection of the crop for cultivation.

The method presented incorporates the soil N, P, K and pH levels and calculates which crops may be best produced under the appropriate soil conditions. As all viable plants are listed, the method enables the farmer to decide which crop to cultivate in their region. This technique therefore helps the farmer determine the optimum profitability of the crop and helps him identify new crops that the farmer did not cultivate until then. In future, this method might be further extended utilizing IOT to obtain the soil's real-time data.

The sensors may be put on the farm to gather information on current soil conditions and consequently systems can enhance the accuracy of the findings. Agriculture may therefore be done in an intelligent manner. The last portion i.e. conclusion is in the following part.

VI. CONCLUSION

The crop prediction thus accurately predicts the crop that can be cultivated for the given values of the nutrients of the soil such as Potassium, Sulphur, Nitrogen, pH and other parameters like Humidity. The proposed system will assist farmers enhance agricultural output, avoid soil deterioration in cropland, and reduce the chemical usage of crops as well as the effective use of water resources. Our system which recognize several patterns for prediction will help farmers predict the suitable crop for these fields and eventually improve the yields. The proposed system is useful to justify the suitable crop to be grown in the particular region. The future work is aimed at to develop a farmer friendly app in their mother-tongue.

VII. REFERENCES

- [1] S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavva, T. Kiruthika and J. Nisha, "Crop recommendation system for precision agriculture," 2016 Eighth International Conference on Advanced Computing (ICoAC), Chennai, pp. 32-36 (2017)
- [2] Jay Gholap, Anurag Ingole, Shailesh Gargade, Jayesh Gohil, & Vahida Attar. Soil Data Analysis Using Classification Techniques and Soil Attribute Prediction. ResearchGate (2012)
- [3] Adhikary, T., Das, A. K., Razzaque, M. A., Chowdhury, M. E., & Parvin, S. Test implementation of a sensor device for measuring soil macronutrients. 2015 International Conference on Networking Systems and Security (NSysS). (2015)
- [4] Ahmad, S., Kalra, A., & Stephen, H., Estimating soil moisture using remote sensing data: A machine learning approach. Advances in Water Resources, 33(1), 69-80. (2010)
- [5] Chiranjeevi M N, Ranjana B Nadagoudar Analysis of Soil Nutrients using Data Mining Techniques. International Journal of Recent Trends in Engineering and Research, 4(7), 103-107. (2018)
- [6] R. Kumar, M. P. Singh, P. Kumar and J. P. Singh, Crop Selection Method to maximize crop yield rate using machine learning technique, International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Chennai, pp. 138-145. (2015)
- [7] "How Decision Tree Algorithms work" available at dataaspirant.com/2017/01/30/how-decision-tree-algorithm-works

A Fault Tolerant Single Sign-On Technique on Cloud Computing

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Abstract—Single sign-on (SSO) systems are implemented to permit a user to log in to a network once and then navigate through the scope of allowed applications smoothly, without the need to re-enter the credentials for each application. In the proposed system when a user attempts to access an application from the service provider through the web browser, the service provider which is in the form of a resource server in the cloud will send a request to the identity provider for authentication. This is a cloud-based service which has two EC2 instances of Resource server and authentication server each. It will be a fault tolerant SSO implementation on cloud computing using Amazon Web Services (AWS) cloud to provide availability and security as we have backup servers on the cloud. For constructing this Single Sign-On service we made use of RSA cryptosystem and digital signature which is a mathematical hashing technique used that validates the authenticity and integrity of any information like messages, digital documents or software.

Keywords—Single Sign-On (SSO), Cloud Computing, AWS, Amazon EC2.

I. INTRODUCTION

SSO is a user authentication service in which a single set of login credentials can be used to access multiple web applications & services. This prevents the need for the user to log in separately to the different applications. A prominent use case of SSO mechanism is Google where a user logs into their Google Account and can access other Google services like Google Drive, Calendar, YouTube, etc. In this mechanism, a service provider is a website which the user wants to log into and identity provider is generally the SSO itself. These entities communicate with each other with the help of tokens. These Tokens don't include authentication credentials like username & password so even if tokens are intercepted in a data breach, the authentication details remain unaffected. Another advantage of SSO is companies can scale up their user base quantity without compromising security.

Firstly, User attempts to access the service provider website. For authentication purposes, the service provider sends a token consisting some details about the user. Then the IP (identity provider) checks if the concerned user is previously authenticated, if so, it grants user access. If the user is not logged in, the user is asked to provide necessary credentials. Once these credentials are validated, the identity provider sends a confirmation token back to the service provider, which is then sent to the service provider. The token

is validated as per the initial configuration. Eventually, the user is granted access to the service.

II. LITERATURE SURVEY

Mahalingam Mani et. al. [1] discussed the case study to provide methods and systems for facilitating sign-on procedures. An authentication plug-in operates to receive authentication credentials in connection with a request to access an application by a client. Once the sign-on is done, subsequent requests are fulfilled by the stored authentication details. Two protocols are used, wherein, the first protocol is HTTP (Hypertext Transfer Protocol) & Session Initiation Protocol (SIP). Java Authentication and Authorization Service (JAAS) is used to converge authentication methods for both Applications.

Parul Garg et. al. [2] in their project provides a solution to SSO web-based services which uses mainframe computers. The user is required to authenticate itself and then enter their credentials for getting access of different applications. This data can be stored on directory servers which is achieved using Internet protocols in the websites having same DNS domains. A signed web token is generated by this domain which is JWE encrypted and then it is sent to client which contains the data of identification of client. When this token is provided to different domains the user gets identified at websites and then he can access those web services.

Satsuki Nishioka et. al. [3] discussed the case study where multiple accounts can be migrated over the web simultaneously, using the authentication system. They have proposed a way to use the AP (Attribute Provider) which has the task of maintaining user credentials as an alternative to IdP (Identity Provider). With the help of this AP the clients can use SSO scheme and visit many SPs (Service providers) simultaneously which curtails the trouble of credential handling on user and also solves the difficulty of IDP transition in the SSO mechanism.

Dr. Kachapuram[4] in the paper, explains how he made use of third-party cloud services and a cloud-based Identity management provider by creating a server that is used for authentication and access control mechanisms. Their whole project is deployed in an Amazon EC2 instance. It requires the installation of Active Directory Domain Services (AaDDS) and InIS (Internet Information Services) which is done in the Virtual Machine, then this virtual machine is added to the Active Directory Domain that is created in the

AWS management console. The user is registered and the token info is stored in the database of the cloud server. This is done with AWS cloud services and OKTA which is a web page developed using PHP to provide seamless navigation among various websites. This project involves an authentication process as well as access control of multiple software systems that enables a client to get to numerous applications with one lot of login certifications.

Krishna Jain [5] in the paper, has utilized the IBM Security Access Manager Enterprise Single Sign-On (ISAM ESSO) using Bluetooth functionality in the smartphone of the user. They have developed a java service system on the server-side (on the laptop) and an android app on the client's smartphone. Server and client communicate via Bluetooth. The mobile app sends the user's credentials to the server on the laptop and credentials are verified, if so then it starts another thread that performs the program service provided on the app. With Bluetooth connectivity above tasks can be performed without Internet. In their system whenever a user logs in with single credential into IMS server and after verification processes the user is authenticated successfully.

Asya I Ivanova et. al. [6] focused on different approaches to deploy Single Sign-On and enhance security. Also categorizing them in 5 layers, which are: Environment, Deployment, Credential setup, Protocols, Hosting in top to bottom fashion. Identification Management is handled by 2 different Identity providers (IDP).

Sagar Gupta [7] focuses on the idea of creating a secure cloud-based single sign-on platform that can be used to connect any device with data security and no IP infringement issues with working environment within organization's security standards. It also reduces overall downtime faced during scheduled updates.

Victoria B. [8] focuses on the SSO implementation for Web Services and its importance. Insecure SSO has more security risks due to more resources needed to be protected compared to conventional client-server authentication. Unsecure SSO systems are prone to various attacks leading to user data theft. Despite growing usage of mobile apps, no protocols provide a robust authorization model for mobile apps.

Sampath Kumar et. al. in their research paper focuses [9] on encryption and challenges to cloud security. The majority of Cloud services use the Application Programming Interface (APIs) to link themselves to cloud administrators. Hence, Insecure APIs act as a hurdle to cloud security. The chance of account hijacking is further elevated due to the existence of Cloud administrators. If a cloud storage system is shut down due to physical damage at data centres, there can be a major data loss. Lack of diligence in cloud security officials is also considered a threat. Despite these challenges, cloud computing benefits businesses by reducing cost on safety & software updates for conventional storage methods. As cloud security is fairly new currently, people are sceptical about these systems.

The existing single sign-on techniques are either developed for web services, mobile devices or cloud computing. The SSO on Bluetooth devices like mobile phones can be used to access services using Bluetooth instead of the internet, but the major drawback of that is, all the services should reside in the Bluetooth range. Also, web based SSO techniques are implemented as simple client-server applications, and are vulnerable to various attacks on user data. Hence cloud based

SSO implementation provides more security. But the existing implementation of SSO on cloud does not support fault tolerance as it is implemented on a single Amazon EC2 instance. Hence there is a need for a fault tolerant SSO implementation on cloud to provide availability and security.

III. PROPOSED METHODOLOGY

A Single Sign-On technique on cloud computing provides security for user data as well as availability. But the existing SSO solutions on cloud are implemented using a single Amazon EC2 instance. The failure or unavailability of this EC2 instance leads to the unavailability of the services using SSO. Hence the proposed system provides a fault tolerant SSO mechanism on cloud computing using Amazon Web Services (AWS) which uses Elastic Load Balancing (ELB) that works with Amazon Virtual Private Cloud (VPC) to provide robust security features.

The proposed system is mainly divided into three major components: Authentication Server/Trusted authority, Resource Server/ Service Provider and Client/User. Authentication servers and resource servers are implemented on cloud using Amazon EC2 instances. It provides secure, resizable compute capacity in the cloud. Also, the features of EC2 Auto Scaling to add or remove EC2 instances helps in improving the fault tolerance. The two copies of Authentication servers are maintained on two different EC2 instances: Primary Authentication Server and Secondary Authentication Server. The client sends a request to the Primary Authentication Server through a web browser to get an authentication token. In case of unavailability or failure of the primary Authentication Server, the request is forwarded to the secondary Authentication Server. Once a client gets an authentication token, it can send a service request to the respective service provider to access the specified service.

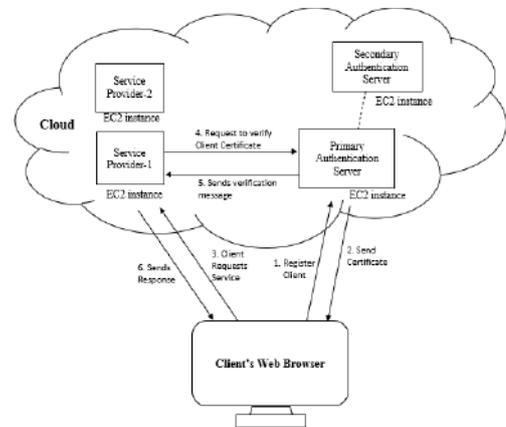


Fig. 1. System Architecture of SSO

There are three entities in the system of SSO namely- User, Trusted Authority and Resource Server or service provider as shown in fig. 1. The client redirects the request for registration via program on Web browser to the Trusted Authority which is the authentication server available on cloud. The Trusted Authority registers the client and sends him/her a certificate or token using the given user ID of the client. The client is then able to request service from the resource server using this certificate. Once the request is sent to a resource server, it connects to the authentication server within the cloud for requesting the verification of certificate provided by the client which is verified and sent back to the resource server. The Server forwards this message to the client.

If the client is successfully verified then he/she is able to access the web services. The proposed system is divided into the following three phases:

- 1) System Initialization Phase
- 2) Registration Phase
- 3) User Identification Phase

A. System Initialization Phase

Trusted authority protects the confidentiality of decryption key d and publishes (e.g., N, n) and decides the RSA keys i.e. the Public Key & the Private Key.

At authentication server-

1. Trusted authority which is the authentication server, selects large prime numbers p and q
2. Calculate $N=p*q$
3. Calculate e, d keypair of RSA
4. Select $g \in \mathbb{Z}_n$ where g is generator, n is large prime number
5. Announce e, g, n, N publicly keep d private

B. Registration Phase

- Each user should choose a unique identity ID as UserID having fixed bit length and send it to a trusted authority.
- Obtain a signature for provided UserID with the help of a cryptographic hash function.
- Then the user is registered on the SSO login page which is shown in fig. 2. All the details of users are stored in the registration database.
- After registration, the user can utilize the SSO scheme to access services at the Web browser.

At client-

1. Select unique identifier (userid) with fixed length
2. Send userid to trusted authority as ID

At Authentication Server-

1. Create hash(userid) using MD5 as h_id
2. Concatenate ID and h_id
3. Calculate $S=(ID || h_id)^d \% N$
4. Send Signature S to client

At Service Provider-

1. Calculate e, d using RSA.
2. Maintain the Resource server ID.

C. User Identification Phase

- User/client sends service request message $m1$ to the server/provider.
- The server generates a verification code and returns the messages to the client which is predominantly made by its RSA signature. Once the certificate/signature is validated, it states that the user has been successfully authenticated by the service provider.

At client-

1. User selects a random integer t
2. Send request message m to service provider
3. Calculate $W = g^t \% n$

At service provider (Resource Server)-

1. Selects a random integer k
2. Select $n1, n2, n3$
3. $Z = g^k \% n$

4. $u = h(Z || IDS || n1)$
5. $v = [u || h(u)]_{ds} \% N_s$
6. Send $Z, v, n2$ to client

At client-

1. $v1' = v_e \% N_s$
verify if $v1' == [u || h(u)]_{ds} \% N_s$
Display message SP is verified.
2. Calculate $KiS = Zt \% n$
3. $KiS = h(IDS || KiS)$
 i is ID of client, S is ID of server.
4. Calculate proof of identity X
 $X = Si h(W || KiS || n2) \% N$
5. Encrypt using keys between res server and client:
 $Y = E[KiS(ID || n3 || n2)]$
6. Send messages W, X, Y to resource server through authentication server. Proof of identity is also a verification credential we are using for accessing services. The generated proof of identity is shown in fig. 3.

At service provider (Resource Server)-

1. Calculate $Kis = Wk \% n$
2. $Kis = h(IDS || Kis)$
3. Decrypt $Y: D_{KS}(Y) = (ID || n3 || n2)$
4. $STD_i = (h(ID_i) || ID_i)$
5. Check if $STD_{ih}(W || Kis || n2) \% N == X_e \% N$
6. Calculate $V = h(n3)$ and send it to client.

At client-

1. Receive V from resource server
2. Calculate $V' = h(n3)$
3. If $V == V'$ print(verified), go to the services page. All the services provided at the resource server can be seen in fig. 4.

IV. RESULT ANALYSIS

The proposed system is implemented using client-server applications in Python and tested for two or more clients registered with the authentication server in a distributed environment. RSA being the most widely used asymmetric algorithm, helps in providing confidentiality, integrity, authenticity, and non-repudiation of data in transit and data storage. Data encryption is an essential tool for the protection of digital data. Data encryption takes data that is legible and encodes it so that it is unreadable to anyone who is unauthorized to access the secret/private key which is used to decode it. Hence, even if an attacker gains access to the data they won't be able to decode it. Fault tolerance in Amazon EC2 will be handled by ELB by automatically sending authentication request to the secondary server. The implementation on cloud is still in progress.



Fig. 2. User registration and login

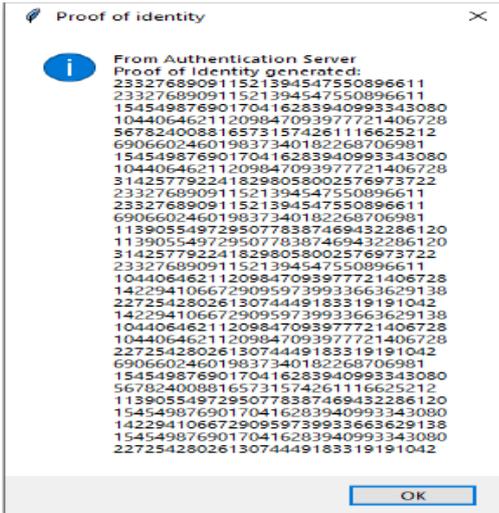


Fig. 3. Proof of identity generated.

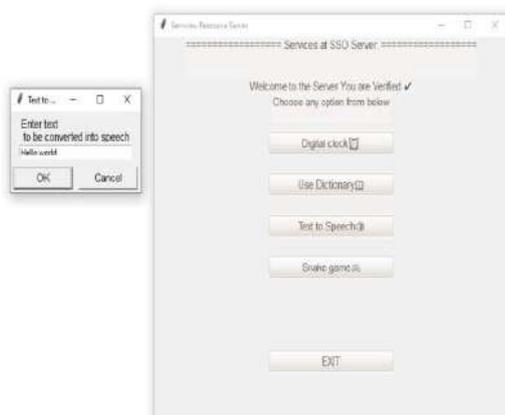


Fig. 4. Services provided by resource server

The SSO mechanism is implemented successfully in distributed systems, but failure of one of the entities leads to overall failure of the SSO mechanism. Hence a fault tolerant SSO mechanism on cloud ensures the availability of authentication servers.

V. CONCLUSION

A Single Sign-On mechanism allows access to multiple applications using the same login credentials. Clients are able to access various services without entering username and password, once authenticated with trusted authority. After registering with trusted authority, the client receives a token, a proof of identity, which is used to authenticate it to access services from the service provider. The SSO mechanism is implemented in distributed systems, but the unavailability of authentication servers leads to failure of the overall system. Hence the cloud based SSO mechanism ensures the availability and fault tolerance due to the secondary authentication server implemented. In the absence of a primary authentication server, the secondary authentication server provides the proof of identity and authentication to the clients. The cloud based SSO mechanism is still in implementation.

REFERENCES

- [1] Mahalingam Mani, David Ahrens, A patent on “Single Sign-on for Applications”, Patent No. US 8,955,079 B2, Issued on February 10, 2015, United States.
- [2] Garg, P. and Dr. Yashpal Singh. “SSO (Single Sign On) Implementation.” (2016).
- [3] S. Nishioka and Y. Okabe, "Centralized Control of Account Migration at Single Sign-On in Shibboleth," *2020 IEEE 44th Annual Computers, Software, and Applications Conference (COMPSAC)*, 2020, pp. 1597-1603, doi: 10.1109/COMPSAC48688.2020.00-27.
- [4] Basavaraju, Kachapuram & M., Dr. (2019). SINGLE SIGN-ON USING CLOUD COMPUTING. 6.
- [5] K. Jain and V. V. Shete, "Single sign-on using bluetooth device," *2016 International Conference on Inventive Computation Technologies (ICICT)*, 2016, pp. 1-5, doi: 10.1109/INVENTIVE.2016.7830186.
- [6] Ivanova, Asya & Vodanovich, Shahper. (2017). Single sign-on taxonomy. 151-155. 10.1109/CSCWD.2017.8066686.
- [7] S. Gupta, "Single Sign-On beyond Corporate Boundaries," *2018 8th International Conference on Intelligent Systems, Modelling and Simulation (ISMS)*, 2018, pp. 38-42, doi: 10.1109/ISMS.2018.00017.
- [8] V. Beltran, "Characterization of web single sign-on protocols," in *IEEE Communications Magazine*, vol. 54, no. 7, pp. 24-30, July 2016, doi: 10.1109/MCOM.2016.7514160.
- [9] Sampath Kumar Pappula, Praveen. (2019). A Comprehensive Study on Single Sign on Technique. 127. 435-441.

Student Academic Performance Prediction Based on Academic and Demographic Attributes using Machine Learning

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Abstract— Self-regulated Student performance prediction is crucial because of the large volume of data generated in educational databases. These methods must be used for knowing students and their learning environment well. The educational institutions are most peculiar about the number of students who will pass/fail for considerable arrangements. The machine learning techniques help to predict student performance well in advance so that the corrective majors have been taken to improve it. Student academic performance is influenced by various attributes like previous academic grades, demographic details, family background, etc. The proposed Student Academic Performance Prediction System is based on supervised learning includes Multiple Linear Regression, Lasso Regression, Decision Tree, and In support of it, an ensemble method is implemented using Random Forest Regressor to ameliorate the performance of the model by combining machine learning techniques.

Keywords— MULTIPLE LINEAR REGRESSION, SUPERVISED LEARNING, DECISION TREE, RANDOM FOREST REGRESSOR, LASSO REGRESSION.

I. INTRODUCTION

The Financial achievement of any country is largely proportional to making secondary and further education more affordable, effective and which is the concern of most Governments. The most essential factor that contributes to expenses in education is the time required by students to graduate. For example, the number of students in the US having loan debt has risen because of the failure of many students to graduate at the proper time. Iraq government provides Higher education for free. Still, it costs the government additional expenses due to failing graduates. To elude these expenses, the Government must be prior informed of the Student. In order to tackle the issue, the incorporation of machine learning algorithms is required for forecasting the

performance of the students and identifying the slow or aberrant students as soon as possible so that actions can be taken prior to improving the performance. Choosing the correct attributes or features which are described as an input to the machine learning algorithm is the most crucial step.

To make it possible for Institutions to perform better it is decisive to understand the student needs well thereby making it possible to design a curriculum that helps every student overcome their fears of a specific subject and increase performance. Hence Machine Learning is the best way to solve the problem by using supervised or Unsupervised Techniques. According to the requirements, a model can be designed to predict the marks in advance of the exam. It will not only help students in improving the overall performance but will also help the teacher to get conspicuous about the student's needs, weaknesses and help them accordingly. The tasks in this research consist of collecting data, pre-processing data, feature extraction to generate the final dataset, evaluating different Machine Learning algorithms, and analysis of results.

II. LITERATURE SURVEY

Virachilai S et. al.[1] have stated that the class quizzes, assignments, lab exams, mid, and final exams are the factors that influence the student's performance in academics. In this paper, machine learning techniques used are ANN, SVM, Decision tree, and Naive Bayes. The dataset implemented by the author is from the website <https://www.kaggle.com>. It consists of data of 305 male and 175 female students. The performance of an algorithm is evaluated on the basis of the Confusion matrix, accuracy, precision, recall, and F1 Score. The Naive Bayes algorithm gives better results.

Osama Ali et. al.[2] have considered Naive Bayes, ANN, Decision Tree, and Logistic Regression algorithms that

predict the performances of Students enrolled in Computer Science stream that is offered by Authors University using a classifier. The modules constructed are compared with ROC index performances and classification accuracy. The dataset was collected from 2015-2016 using a survey in their University. The dataset consists of information from 161 students consisting of 76 and 85, male and female respectively. The model with the highest accuracy is using the ANN technique for classification with 77.04 accuracies.

H. Turabieh[3] has proposed KNN, CNN, Naive Bayes and decision trees models for predicting Students performance. The dataset used here is presented by Cortez and Silva in 2008, which consists of a dataset of secondary education of Portugal for 3 years. The range of the Grading System is from 0(lowest) to 20 (highest), Dataset consists of 649 samples and 33 attributes for each sample. The results claim that CNN has the highest accuracy of 95%.

L. Rechkoski et. al.[4] have generated a model for predicting grades for the courses that are yet to be enrolled by students. The model-based collaborative filtering methods consisting of Probabilistic Matrix Factorization (PMF) and Bayesian Probabilistic Matrix Factorization using Markov chain Monte Carlo(BPMF) have been designed. The prediction model was checked in a simulated environment of an enrollment cycle in winter and Summer semesters based on the actual data-set of enrollments in the author’s institution. Using the performance measurements techniques, the author concludes that the better results are given by PMF-based grade prediction.

M. Gadhavi et al.[5] have proposed a system using the data from 3 internal examination marks of 181 students of Smt. Chandaben Mohanbhai Patel Institute of Computer Applications (CMPICA). A linear regression algorithm is used to predict the final output. The model was tested on 181 students and the minimum value function was 23.32. Also 49.10 & 0.37 were the optimum values. The model design is univariable but can be extended to multiple variables.

E. E vasileva et. al.[6] have built the model using data of 25 students. The final year grade was predicted using the second year grade which students got. Of all the types of neural networks, a multilayer perceptron was selected. To improve the accuracy of the model as compared to the linear regression model an artificial neural network is designed because backpropagation and updation weights are possible in a Neural Network. The accuracy of this model was 97.26

S. E. Sorour et. al.[7] have proposed a PCN method that is used to predict the grade of students. PCN are comments, where P is comment before the classroom, C is comment during classroom activities, N is comment before next

classroom. To grasp students' learning attitudes and learning situations in this study LDA and PLSA models are employed. Data of 2 classes were collected: class A of 60 students and class B of 63 students. It was found that LDA Performs better than PLSA.

X. Zhang et. al.[8] have categorized students according to their grades. classes are poor, average, medium, good, and excellent. The grades of the students, as well as consumer behavior in daily school, the frequency, and books which are issued from the library, and also the number of library entrance guards, are taken into consideration. Naive Bayes, SVM, Decision Tree, Multilayer Perceptron algorithms were used of which Decision Tree gave the highest accuracy of 77.11%.

E. S. Bhutto et. al.[9] stated their research on predicting the Performance of Students based on online learning attributes like the behavior of students or other attributes like engaging in sample tests, participation in discussion groups, going through provided materials, and answering the questions in quiz plays. Two of the most popular machine learning algorithms Logistic Regression and the Support Vector Machine were used. It was found that Logistic regression has 71% accuracy whereas SMA had 78% accuracy.

L. M. Crivei et. al.[10] have used Two Unsupervised machine learning algorithms i.e RAR and PCA . The dataset is from students of Babes,-Bolyai University, ClujNapoca, Romania. It was found that RARs have an overall error of 0.422 and an accuracy of 0.714. The precision P computed for this PCA mapping using $\tau = 1$ is 0.786, higher than the precision value 0.722. When the students with a final grade of less than 4 were ignored, it was noticed that the PCA shape significantly changed which supported their previous assumption

TABLE I: COMPARISON OF EXISTING STUDENT PERFORMANCE PREDICTION SYSTEMS

Research Paper	Features Used	Algorithm	Accuracy(%))
Virchilai S et. al, 2020 [1]	Semester, Discussion, ParentAnsweringSurvey, Topic, RaisedHands, etc	Decision Tree SVM Naive Bayes	71 38 77
Osama Ali et. al, 2019[2]	Department, Studying Style,Using Internet for Study, Studying hours, Social media usage, etc	Decision Tree, Logistic Regression, Naive Bayes, ANN	76.9 74.5 66.5 77
H. Turabieh et. a, 2019.[3]	Academic Subjects, Students marks, demographics, school information,etc	KNN, Naive Bayes, Decision tree,	88 82 82 95

		CNN	
L. Rechkoski et. al.[4]	Academic Grades, Courses enroll	PMF BPMF	PMF performs better
M. Gadhavi et al.[5]	Internal Exam marks, Final Exam Grade	Linear Regression	-
E. E vasilava et. al.[6]	Academic Grades, No of failures, No of absences	multilayer perceptron	97.26
S. E. Sorour et. al.[7]	Comment before classroom, comment during classroom, comment after classroom	LDA, PLSA	LDA Performs better
X. Zhang et. al.[8]	Academic grades, types of books, frequency of book issued from library	Naive Bayes, SVM, Decision Tree, Multilayer Perceptron	33.65 58.41 77.11 65.90
E. S. Bhutto et. al.[9]	Engaging in sample tests, interaction with systems like participation in discussion groups, Student behavior	Logistic Regression, SMA	71 78
L. M. Crivei et. al.[10]	Academic Grades	RAR, PCA	71.4 78.6

III. PROPOSED SYSTEM

The proposed system is divided into various phases: the first step is Data Collection, in the current study data is collected from Kaggle[11]. The second step includes Data Preprocessing and Labeling the data rows and outlier are removed, In the third step Feature Selection and Extraction takes place, the dataset is finalized. The Final steps consist of Splitting the data for Training and Testing, Furthermore feeding the data to Machine Learning Algorithms. Hence, in this case, a trained Regression model can be obtained for taking new inputs and predicting its label. Since output ie G3 (the marks scored by the student) is a continuous value, only regression techniques could be used. While many traditional machine learning models implemented in past only provided a specific range rather than score so they consider classification techniques.

To create an optimal model, trained 4 different Supervised Learning Regression Techniques: Multiple Linear Regression, Lasso Regression, Decision Tree, and Random Forest Regressor.

In Multiple Linear Regression, the task of the model is to predict a dependent variable(label) that depends upon various independent variables. The multiple linear regression finds the linear relationship between independent and dependent variables as

$$y = m_1x_1 + m_2x_2 + m_3x_3 + \dots + c$$

x_1, x_2, \dots, x_n Independent variable; $m_1, m_2, \dots, m_n =$ slopes ; $c =$ intercept variable

Once the data is provided to the multiple linear regression algorithm it finds values of m_1, m_2, \dots, m_n and intercept such that there will be the least mean squared error. It fits data points in the best fit line. By using the gradient descent method. The best fit line is the line for which the value for mean squared error is minimum.

Lasso Regression is used for the regularization of data models and feature selection. Hence lasso model is used over Regression methods for more accuracy, It uses ‘Shrinkage’ where the data values are shrunk in concern with the middle point as mean. The Lasso is well suited for datasets with high collinearity, a crucial factor is due to the automatic variable selection/ parameters removal. The Mathematical Equation for Lasso Regression is,

$$\text{Loss function} = OLS + \alpha * \text{summation of coefficients, } \alpha: \text{penalty parameter}$$

Lasso uses the L1 regularization technique, Since L1 adds a penalty to the coefficient, it may result in sparse models with reduced features models.

A Decision Tree is a tree-like structure that resembles a flowchart. Every leaf node in this model represents a target label and the upper node demonstrates the root node. Such that each branch gives the test outcome, and the internal node shows the testing attributes. A decision tree can be applied to all the models with continuous as well as categorical features. Since decision trees have the functionality of capturing the non-linear interactions between the inputs and target, therefore it is visually very intuitive in generating models from the data. Thereby, creating an overfitting problem and increase variance in the model. The model building uses various measures such as information gain, Gini Index, and Gain ratio, for best dividing the dataset instances into distinctive label classes.

Ensemble learning is a method of combining several decision trees to produce a better-generalized model than just availing the output from a single decision tree, which in turn decreases the variance value of the algorithm. Random Forest is an advancement in bagging(Bootstrap Aggregation) wherein complementary to taking the random subset of data, it also

includes a random selection of attributes rather than implementing all inputs at once to build the tree model. As a result, an ensemble of the various models is found. Average of all the decision trees is used which is more robust than an individual decision tree. Hence, a Random Forest Regressor is able to tackle the cons of the decision tree and provide accuracy more than most of the regression algorithm.

The dataset is collected from the [11] consisted of 33 features consisting of categorical as well as continuous features. And a total of 395 instances in which 208 are Female and 187 are Males. Since all the features do not make a significant impact on the label, incorporated Pearson Correlation Matrix represented in Fig. 1. and using the values a total of 17 features ie 16 Independent attributes, and 1 dependent label is selected.

The features selected can be categorized as:

1. Academic Features: G1, G2, G3, Classroom Activities, Failures, Study-Time, Absences.
2. Family Related: Mother’s Education, Father’s Education, family relations, family support.
3. General Feature: free time, go-outs, travel-Time, Sex, Residential Area.

Here G3 is the output feature it indicates Marks of 3rd Semester. And G1, G2 represent marks of 1st and 2nd semester respectively.

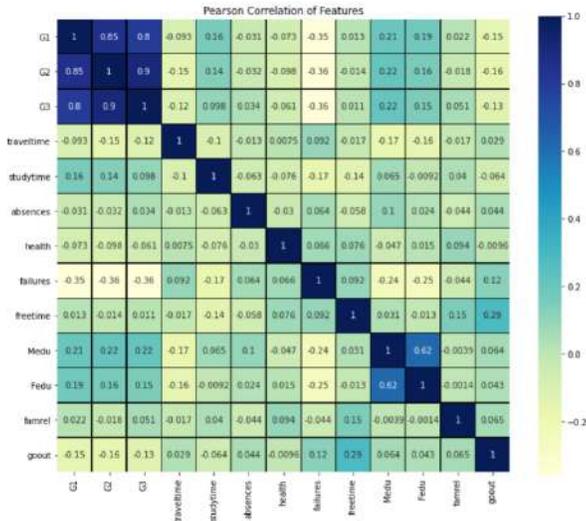


Fig. 1. Pearson Correlation Matrix

From the matrix, it is observed that the G1, G2 are highly correlating (impacting) the output, study-time also display positive outcome, while the Absences demonstrated less effect on output. Failures, go-out overshadowed the label by creating a strictly negative correlation.

In data analysis, it is observed that students from Urban residents were able to score well than students from rural areas. Also, the Family Support provided in the dataset after analysis resulted as from 208 Females Students, 142

were given support from the household. While from 187 Male Students only 100 were given family support. And the Mother Education did impact the performance of a student surpassing Father’s Education. The dataset is divided into training and testing sets with an 80-20 ratio respectively.

The system architecture for the proposed system is shown in fig. 2.

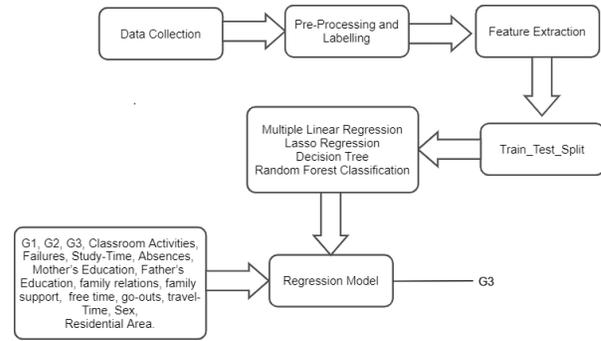


Fig. 2. System Architecture

IV. RESULT ANALYSIS

The dataset of undergraduate students used in the proposed system was collected from Kaggle [11]. The dataset was trained and tested with an 80-20 split and implemented on regression algorithms: Multiple Linear Regression, Lasso Regression, Decision Tree, and Random Forest Regressor, the performance of the models is analyzed on the basis of 4 performance evaluation metrics, namely: Accuracy, RSME, MAE, and R Squared(R2).

Root mean square (RSME) is calculated by identifying residuals and squaring residuals and finding the mean of the squared residuals and finally calculating the root of the mean squared gives RMSE.

$$RMSE = \sqrt{\frac{\sum((predicted_i - actual_i)^2)}{total\ predictions}}$$

Mean Absolute Error (MAE) is an uncomplicated metric that calculates the absolute difference between the actual and the predicted values, and it is robust of an outlier.

$$MAE = \frac{\sum(abs|predicted - actual|)}{total\ predictions}$$

R Squared(R2) is a metric that states the performance of your model and not the losses, R-Squared measures how well the prediction approaches the ground(baseline) truth or how near the data are to be fitted regression line.

$$R2_{Squared} = 1 - \frac{SSr}{SSm}$$

$SSr = Squared\ sum\ error\ of\ regression\ line$

$SSm = \text{Squared sum error of mean line}$

Fig. 3. represents the comparison of performance evaluation metrics for the regression models in the testing phase. From the given figure it can be clearly observed that Random Forest Regressor outperformed all other algorithms with 90.4% Accuracy, but scored less in the R2_Score. Multiple Linear Regression on the other hand performed better than the other two algorithms in overall aspects of the metrics and gave 86.3%, and produced the finest RSME value of 2.6, and the best R2_Score of 0.86 due to its linearity property. Followed by the Lasso Regression which due to its L1 regularization produced the least MAE equals 1.11 and 0.85 R2_Score, with an 85.8% Accuracy, While the Decision Tree did not perform well and generated the worst accuracy of 77.3% with large error.

	Regression Algorithm	Accuracy	MAE	RSME	R2_Score
1	Multiple Linear Regression	86.3%	1.12	2.6	0.86
2	Lasso Regression	85.8%	1.11	2.7	0.85
3	Decision Tree	77.3%	1.14	4.3	0.77
4	Random Forest Regressor	90.4%	1.14	4.3	0.77

Fig. 3. Performance Evaluation Metrics

The Multiple Linear Regression achieved better than most of the models in the evaluation metrics producing a finer model with controlled error and good Accuracy, Although the Decision tree could not execute appreciably, the Model generated by Random Forest Regressor consisted of 100 n_estimators (100 Decision Tree), resulted in a model with less variance and more bias than any individual Decision Tree. The overfitting condition was tackled substantially in the model. Therefore from the current study, the Random Forest Regressor can be referred to as the Optimal Model for the given dataset of Students Academic Marks Prediction. A boxplot is generated for the better visualization of metrics in the testing model in Fig. 4. The metrics displayed include RSME, MAE, R-Squared values for the Regression Models.

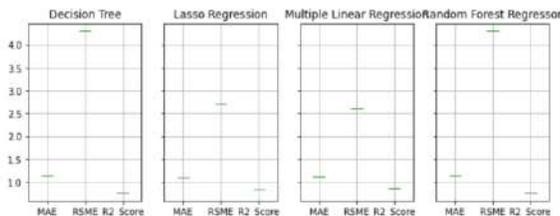


Fig. 4. Performance visualization in Boxplot

To compare how the trained models predict target value, a sample of input attributes were inserted in the Random Forest Regressor and Multiple Linear Regression models

to find the difference between values, been represented in the Table II:

TABLE II: RESIDUAL VALUES FOR SAMPLE DATA

	Actual Value	Predicted Value	Difference
Random Forest Regression	13	13.28	0.28
Multiple Linear Regression	13	12.49	0.51

The Random Forest Regressor was able to predict values closer to the actual value than the value executed by Multiple Linear Regression. Hence the accuracy of the Random Forest Regressor is 90.4% which is greater than the accuracy of Multiple Linear Regression by 4.1%.

V. CONCLUSION

The prediction of students' academic performance is essential for quality education. Hence it is essential to predict students' academic performance and classify them into appropriate categories. From the analysis, it can be observed that the student's performance in an exam is influenced by a wide variety of factors along with the previous academics, such as family relations and support, and the family background of the student.

The proposed system analyzed the student's academic performance using four machine learning algorithms namely, Multiple Linear Regression, Lasso Regression, Decision Tree, and Random Forest Regressor. After comparing the models on various Performance Evaluation parameters, the Random Forest Regressor dispenses superior performance for predicting the student's academic performance, with the highest accuracy of 90.4% and MAE, RSME, R-squared values as 1.14, 4.3, 0.77 respectively.

The proposed research deduces that reducing issues relating to failures in subject and increase flexibility in courses, along with the demographic factors, can have an positive impact on the student's satisfaction and motivation to study. The Educational Institutes should encourage the students to take part in classroom activities, create student-centric course structure, and providing good educational facilities for students. The aggregate of all these factors will create improvement in the education system and successively ameliorate the Students Grades in an Exam. In the future, the proposed system will be implemented using Artificial Neural Network, with additional categories of attributes such as family background, study environment, projects/internships, and lifestyle, etc.

REFERENCES

- [1] Virachilai S, Vamshidharreddy, "Student's Academic Performance Prediction Using Machine Learning Approach," *International Journal of Advanced Science and Technology*, 2020, 29(9s), 6731 - 6737.
- [2] Osama Ali, Samir Qaisar, "Predicting Students Performances Using Machine Learning Techniques," *Journal of University of Babylon for Pure and Applied Sciences*, April 2019 DOI: 10.29196/jubpas.v27i1.2108.
- [3] H. Turabieh, "Hybrid Machine Learning Classifiers to Predict Student Performance," *2019 2nd International Conference on New Trends in Computing Sciences (ICTCS)*, 2019, pp. 1-6, doi: 10.1109/ICTCS.2019.8923093.
- [4] L. Rechkoski, V. V. Ajanovski and M. Mihova, "Evaluation of grade prediction using model-based collaborative filtering methods," *2018 IEEE Global Engineering Education Conference (EDUCON)*, 2018, pp. 1096-1103, doi: 10.1109/EDUCON.2018.8363352.
- [5] M. Gadhavi, C. Patel, "Student final grade prediction based on linear regression," *2017 Indian Journal of Computer Science and Engineering (IJCSE)* ISSN : 0976-5166 Vol. 8 No. 3 Jun-Jul 2017.
- [6] E. E. Vasileva, D. S. Kurushin and S. S. Vlasov, "Early Prediction of the Grade Point Average of University Students Diploma: Neural Network Approach," *2019 XXII International Conference on Soft Computing and Measurements (SCM)*, 2019, pp. 259-262, doi: 10.1109/SCM.2019.8903629.
- [7] S. E. Sorour, T. Mine, K. Goda, S. Hirokawa, "A Predictive Model to Evaluate Students Performance", 2015, *Journal of Information Processing*, Vol.23 No.2 March 2015.[DOI 10.2197/ips.jip.23.192]
- [8] X. Zhang, R. Xue, B. Liu, W. Lu and Y. Zhang, "Grade Prediction of Student Academic Performance with Multiple Classification Models," *2018 14th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD)*, 2018, pp. 1086-1090, doi: 10.1109/FSKD.2018.8687286.
- [9] E. S. Bhutto, I. F. Siddiqui, Q. A. Arain and M. Anwar, "Predicting Students' Academic Performance Through Supervised Machine Learning," *2020 International Conference on Information Science and Communication Technology (ICISCT)*, 2020, pp. 1-6, doi: 10.1109/ICISCT49550.2020.9080033.
- [10] L. M. Crivei, G. Czibula, G. Ciubotariu and M. Dindelegan, "Unsupervised learning based mining of academic data sets for students' performance analysis," *2020 IEEE 14th International Symposium on Applied Computational Intelligence and Informatics (SACI)*, 2020, pp. 000011-000016, doi: 10.1109/SACI49304.2020.9118835.
- [11] <https://www.kaggle.com/vankhoa21991/student-grade-prediction>

R Programming for Sentiment Analysis

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Abstract—Sentiment Analysis or text analysis is all about finding polarity in the script that is whether the content is positive or negative. The scripts or text can be as short as a sentence and as large as a paragraph or even a book for that matter. With the growing age of technology, it is evident that data is being generated at almost every click and is studied to improve the quality of certain products or services. Different technologies are used to explore these areas among which the two main methodologies used are lexicon-based approach and machine learning approach. In this paper, sentiment analysis is carried out on the janeaustenr dataset using a lexicon-based approach in R language. The tidytext package is used which consists of all three lexicons used to retrieve sentiments from the dataset. The sentiment polarity would be visualized using wordcloud.

Keywords—sentiment analysis, lexicons, web scraping, reviews, extraction, polarity, visualization.

I. INTRODUCTION

Sentiment Analysis is the procedure of recognizing and then classifying the opinions that are conveyed in a text to decide the frame of mind of the writer about a particular text or a product whether it is negative, positive or neutral.

It helps us to determine the opinion that is contemplated in the websites, social media feed etc. In sentiment analysis the classification is performed on the data which is further divided into different classes. These classes can be binary in nature that is it can be classified as negative or positive, or it can have numerous classes for example sad, happy, disgust, etc.

Customers have started expressing their opinions and feelings more openly and thus sentiment analysis has become a crucial tool to interpret the sentiments of the customers. It is used to provide better customer service because it helps to analyze the reviews towards the brands by automatically analyzing the customer feedbacks given with the help of the surveys conducted, the recommendation system or the reviews given by the customers on the various social media platforms and websites.

Sentiment analysis is executed on the data to help out the businesses to analyze the sentiments behind the customer reviews, understand the needs of the customer and to provide the insight about the way a consumer is feeling towards their brand. By monitoring this data, we can perceive the overall opinion of the customer to provide a better service. It has

wide ranging applications in various industries such as retail, entertainment, restaurant, hospitality, travel, finance, product-based industries, sales-based companies etc. It has various real-world applications such as KFC, Google, Apple, TripAdvisor etc.

Sentiment Analysis is generally applied on the comments and posts on the social media sites, product reviews, comments on blogs and online datasets. It is mainly used to make correct future predictions.

Every sentiment analysis project has a basic framework of collecting data, cleaning it, analyzing it and then visualizing it. Sentiment Analysis approach is classified in the following manner:

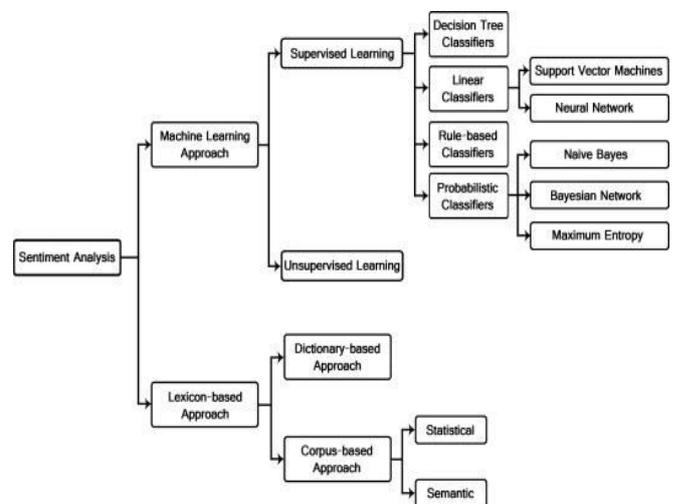


Fig. 1. Classification of domain techniques

The present study has adopted lexicon-based approach which makes use of lexicons (“Afinn”, “bing”, “nrc”) to analyze the sentiments of the books written by Jane Austen. These lexicons are based on unigrams that is on single words. All these lexicons contain many English words and each word is pre-tagged with some sentiment values.

Section II gives the methodology that has been adopted for the analysis of six novels written by Jane Austen. Section III presents the application of experimental implementation of the study. Section IV describes the result of the main framework and the application. Section V

concludes the study and Section VI gives the future scope of the present study.

II. METHODOLOGY

To be able to apply the analytical tools to practical applications, the foundational understanding of sentiment analysis is of utmost importance. The aim is to analyze the emotional quotient of the books written by Jane Austen. In our approach, we are making use of ‘janeaustenR’ package in R. This package consists of the six novels (namely: “Pride and Prejudice”, “Sense and Sensibility”, “Mansfield Park”, “Emma”, “Northanger Abbey”, “Persuasion”) written by Jane Austen. The proposed methodology is illustrated in form of a flowchart below.

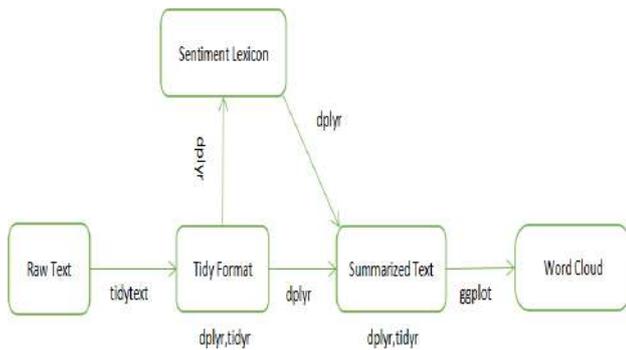


Fig. 2. Proposed system architecture

The methodology consists of five steps:

1. Tokenization

This process is used to split the text into words with each word per row called as token. Tokenization even strips off the punctuation marks and converts the text into lowercase.

For example: The movie is great!

Output: the
movie
is
great

2. Cleaning of data

The books are in their original format which is raw in the context of the project. The text written in the books needs to be converted into a structured format. Cleaning involves removal of stop words (Antijoin). Stop words consists of articles, nouns, pronouns and conjunctions. This process of converting unstructured data to structured format is called tidying.

Output: movie
great

3. Applying Sentiment Lexicons

Lexicons are very similar to dictionaries; however, it consists of meaningful units of words pertaining to certain application like in this case of Natural Language Processing. These lexicons consist of sentiment words, its synonyms and antonyms. Applying these lexicons to the tidy format data, we will be able to gauge the emotional quotient behind the text.

4. Using innerjoin

By definition, it returns all rows from x where there are matching values in y and all columns from x and y. The output obtained after analyzing the sentiments is then summarized using functions from dplyr and tidyr packages.

5. Visualization – Wordcloud

In the tidy text mining approach, the output can be visualized using ggplot2. It displays the data in the form of plots. However, we make use of wordcloud for visualization. It is used to display the words in different sizes depending upon the frequency of each word occurring in the text. The wordcloud divides the text into positive and negative words in the upper and lower half of the window.

III. EXPERIMENTAL IMPLEMENTATION

The present research is carried out in R language. It is called a functional programming language which was developed by Hadley Wickham. It is mainly used for statistical inference, data analysis, data visualization and many more. It consists of many inbuild packages and provides a huge community.

A. Amazon reviews lexicon-based methodology

Here, we made use of a referenced dataset from a repository which consists of 1000 amazon reviews. Alternatively, the reviews can be scrapped using a selector gadget and then creating a dataset in the desired file such as .txt file or a .csv file. Methodology adopted is identical as the main research of Jane Austen novels. Elaboratively, procedure starts by importing the dataset, tokenizing it, cleaning the imported dataset, and applying the three lexicons (“Afinn”, “bing”, “nrc”) and analyzing the opinions of user reviews.

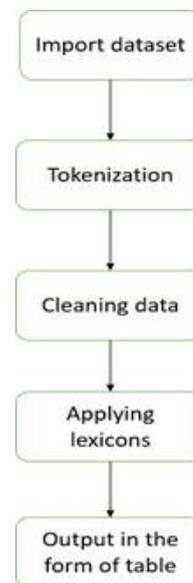


Fig. 3.1. Amazon reviews methodology

B. Web Scraping

Web scraping is the technique used to get the data we want to analyze by finding it in the website's HTML source code. In this project, we have scrapped the data from the comments section of amazon.in. It is carried out using the

rvest library which is used to scrape data easily from the web pages. The URL of a particular page is accessed using read_html() function.

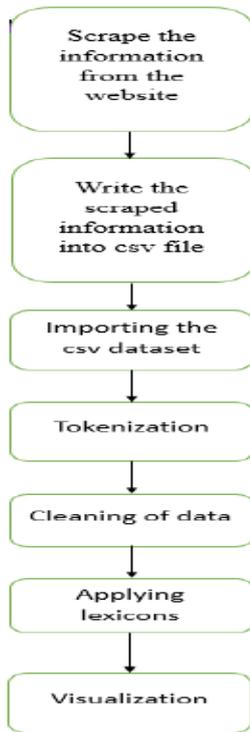


Fig. 3.2. Web Scraping Methodology

IV.RESULT

This section presents the result of a comprehensive study of the Jane Austen novels and its experimental implementation on amazon reviews. The study is adopted using a lexicon-based approach. Fig. 4.1. denotes the plot for afinn lexicon which ranges the words in the range of -5 to 5 where negative range indicates negative words and positive range indicates positive words. Fig. 4.2. shows the bing lexicon which gives binary output that is, it categorizes the words into positive and negative sentiment; the nrc lexicon is an elaborative lexicon since it presents the words into various sentiments such as happy, anger, joy, surprise, and many more as shown in Fig. 4.3. The final result is visualized using wordcloud.

A. Comprehensive study of the Jane Austen novels

Fig. 4.4. gives the idea about the total number of positive and negative words present all over six novels written by JaneAusten.

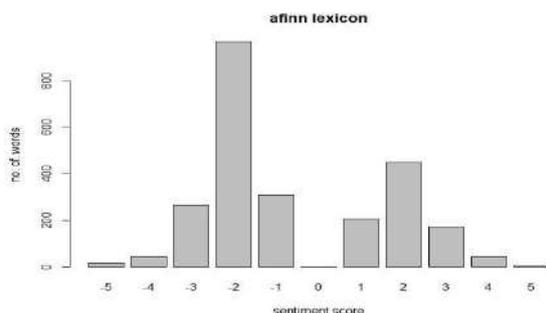


Fig. 4.1. Sentiment score of afinn lexicon

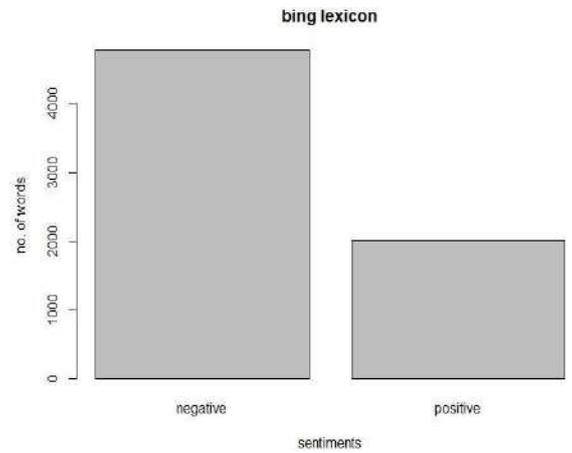


Fig. 4.2. Sentiment presentation of bing lexicon

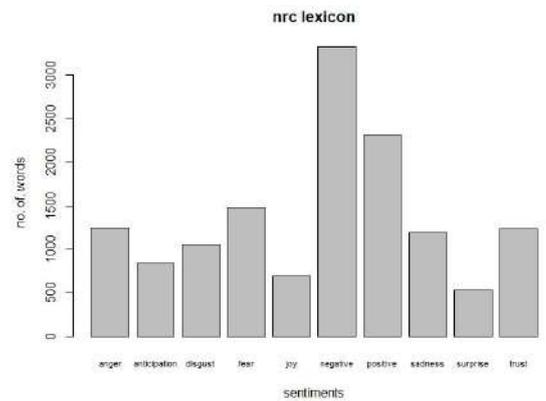


Fig. 4.3. Sentiment presentation of nrc lexicon

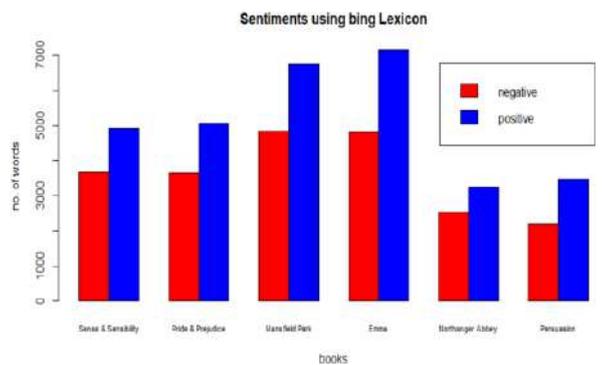


Fig. 4.4. Bing lexicon on all six novel

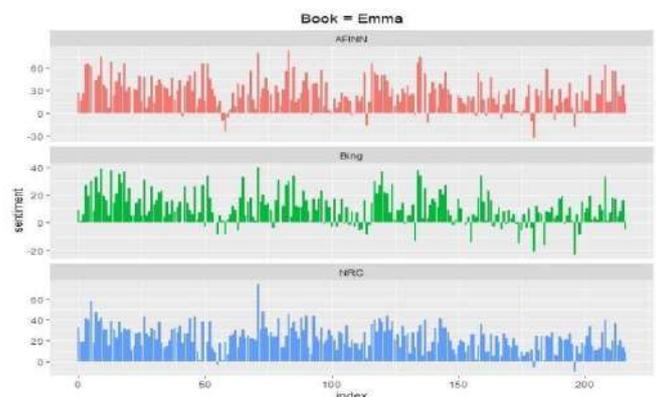


Fig. 4.5. Sentiment narrative of book Emma

Fig. 4.5. estimates the net sentiment present in each chunk of the novel text for each sentiment lexicon. They are all bound together and visualized with the help of ggplot. The afinn lexicon gives the largest absolute values with high positive values. From the bing lexicon, we can see the larger graph of contiguous positive and negative text. Compared to the other two the nrc result is more towards the positive side and defects the similar relative changes in the text.

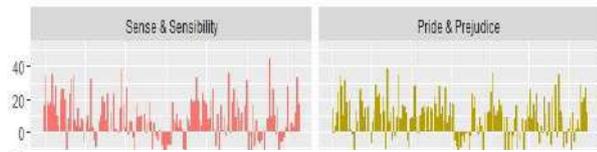
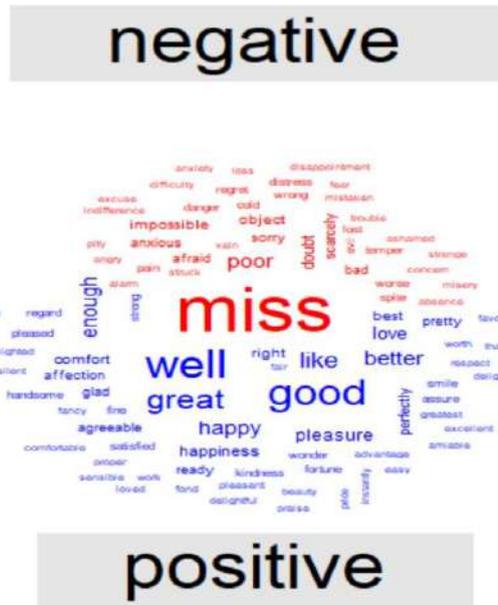


Fig. 4.7. Wordcloud of Jane Austen novels

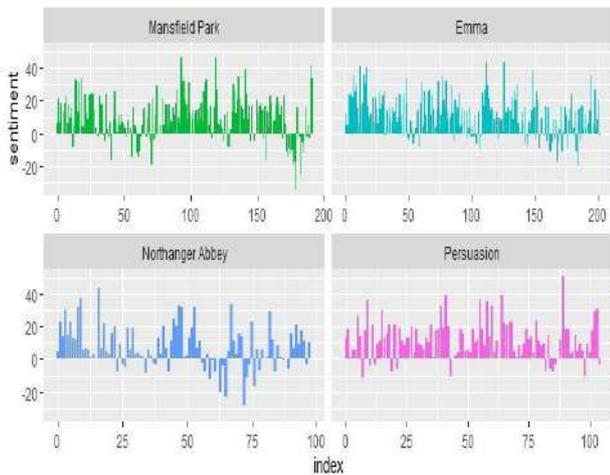


Fig. 4.6. Sentiment narrative of Jane Austen novels

Fig. 4.6. Gives the idea of how the plot changes towards more positive or negative sentiments over the path of the story.

B. Amazon reviews lexicon-based

```
> table(amazon_sent$bing_judgement,amazon_sent$actual_sentiment)

      negative positive
negative  251      14
neutral   150      65
positive   99     421

> table(amazon_sent$nrc_judgement,amazon_sent$actual_sentiment)

      negative positive
negative  183      53
neutral   217     229
positive  100     218

> table(amazon_sent$afinn_judgement,amazon_sent$actual_sentiment)

      negative positive
negative  212      18
neutral   187     105
positive  101     377
```

Fig. 4.8. Tabled output of Amazon Reviews

In Fig. 4.8. the lexicon-based sentiments are compared with the actual labeled sentiments to determine the accuracy and reliability of the sentiment lexicons using the table function. It has been observed out of all the three lexicons, bing seems to be more accurate and reliable.

C. Web Scraping

We have applied the algorithm used to find out the sentiments present in the Jane Austen novels on the scraped data obtained from web scraping to find out the reviews of the product.

- [4] I. Hemalatha, G. P Saradhi Varma and A. Govardhan, "Sentiment Analysis Tool using Machine Learning Algorithms", JNT University Kakinada, Kakinada, A.P., Department of Information Technology, S.R.K.R. Engineering College, Bhimavaram, A.P., JNT University, Hyderabad, A.P., India. 2013.
- [5] Thakare Ketan Lalji, Sachin N. Deshmukh, "Twitter Sentiment Analysis Using Hybrid Approach", Department of Computer Science and IT, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, e-ISSN: 2395-0056, p-ISSN: 2395-0072, June-2016.
- [6] W. Medhat, A. Hassan, and H. Korashy. "Sentiment analysis algorithms and applications: A survey." Ain Shams Engineering Journal 5, no. 4, pp.1093-1113, 2014.
- [7] Rahul Rajput, Arun Kumar Solanki, Review of Sentimental Analysis Methods using Lexicon Based Approach, School of ICT, Gautam Buddha University, India.
- [8] Amit Agarwal, Durga Toshniwal, "Application of Lexicon Based Approach in Sentiment Analysis for short Tweets", Computer Science and Engineering Indian Institute of Technology Roorkee Roorkee, India, 2018.
- [9] Anna Jurek*, Maurice D. Mulvenna and Yaxin Bi, "Improved lexicon-based sentiment analysis for social media analytics", DOI 10.1186/s13388-015-0024-x, 2015.
- [10] Practical Text Analytics, Anandranjan, 2019. (Book)

Fake News Detection on Datasets

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Abstract— Traditional media is no more the only source of gaining news. Social media has taken over traditional media for various reasons, like being easy to use, free of cost, and always available. However, not all news published on social media is genuine, as it can come from unverified sources also. Most people believe what they read, and hence it is essential to check the authentication of news readers. The spread of fake news could cause severe impacts not just politically but also socially. We strongly believe that spread of intentionally created fake news is more harmful than an accidental one. This paper mainly focuses on the deliberate creation and sharing of false manipulated information intended to deceive and mislead audiences. Fake news detection is a classic classification problem though many attempts of solving it through clustering are being made. Our study mainly focuses on classification algorithms. We used various classification algorithms like SVM, DT, LR, passive Aggressive Classifier on datasets to find if the news is real or fake on two different datasets. Evaluation parameters were executed to compare the efficiency of the various algorithm. Later we also try to find out which other social media the author accounts for to stop the spread of fake news.

Keywords— *Mis-Information, Fake-News.*

I. INTRODUCTION

Millions of people join online social media who are of different ages, gender, and interest. This vast and rich collection of user-generated content includes people's opinions about events and products, personal ideas, feelings, and attractions; thoughts about current societal debates and governmental policies; and much more. People meet new friends sometimes of their interest on social media, and it has a huge potential to spread lots of news and include many people participating through comments, tweets, etc. People have a right to express their opinions and could agree or disagree on specific topics. Despite the immense potential of online social media, this technology is misused to execute several undesirable acts, such as generating spam, rumors, fake messages, and fake accounts, gaining more substantial influence, creating chaos, or destabilizing homeland security.

Nowadays, people live in a society where everyone is connected to social networks, on the internet from which they acquire, process, and share information, which leads to an increasing amount of information propagation and diffusion. The emergence and growth of social networking sites like Twitter and Facebook are proven to be very helpful in disaster situations such as natural disasters (Flood, Storm, Earthquake), human-made disasters (Shootouts, Terrorist attacks), and emergencies. But the spread of misinformation on social media can be very dangerous as it reaches out to millions of people in a brief period. The extensive spread of misinformation can have a significant impact on individuals and society. It can shatter the authenticity equilibrium of the news ecosystem. The effect of misinformation came into the limelight during the 2016 US election. Lies were created and

spread as fact to the people. Twitter, Facebook-like media, played an essential part in this propaganda. Fake accounts were created for the massive spread of news. Hence it became a great case study for the researcher studying social media and its impact on day-to-day life. A solution to this problem could be gathering more and more pieces of evidence to prove the story wrong. Propagandists typically manipulate fake news to convey political messages or influence, like creating social bots to spread false reports. Some fake news was just created to trigger people's distrust and make them confused, impeding their abilities to differentiate what's true from what's not.[1]

It is not like fake news is new, but it got more powerful or rather destructive after the 2016 US election [2]. Due to powerful technology and almost unrestricted access to the internet, news spread faster than earlier. It can reach more people in a concise time. Due to social media, it has become even easy to connect to the whole world and pass and absorb information. Modern Technology had made people believe social media is their primary source of daily news.

Research [3] has been done from a journalist's point of view. They could provide analysis and compare the latest news, it asks some six basics questions called 5W+H(what, when, where, who, why, and how)and should presented in descending priority from what is most important to the finer details. It would help them to recheck every information before they could publish it. To reduce the spread of questionable [3] content and to make sure that readers are aware of what they are reading, the spread of fake news needs to stop. In the ongoing Pandemic situation, people are more prone to fake news, which could negatively impact society.

II. LITERATURE SURVEY

In [4], authors improved in their work for adding language models frameworks. The paper significantly concluded that with various parameters considered in pre-processing, detecting fake news with a better score could be obtained. It also thought credibility to a limited extent with combines that could give a good response in phony news detection when combined with other attributes.

In [5] this paper, considering the pandemic situation and the amount of news being generated on social media, Real data was collected through Twitter. The challenge of labeling real-time data is huge, and many researchers tried to solve it in their way. The approach used in this paper was to consider tweet_length, tweet_url, no_of_followers, no_of_re-tweets, user_profile analysis ,etc. Calculating values for all of the parameters and averaging them, later giving it to machine learning and deep learning algorithms to find the result. This paper has a perfect approach towards data labeling and visualizing the data set.

In May 2021, IIT Students came up with an app that could help fake news in video content FakeBuster helps find faces

manipulated on social media to defame or make jokes and even enables users to detect if a video of another person is spoofed during a video meeting. A similar attempt by IIT students in 2018 was made to catch a fake news. It was text news being classified as multi-class detection. Considering the value of the F-score result is divided as mostly true, true, fake, and mostly fake.

In [6], the author tried analyzing news and user credibility (limited only to Twitter users). It attempted to compare the user's statistical emotions by looking for emojis and hashtags while commenting or posting news. A score is generated by using algorithms for news authenticity and also user score. Mutually if they pass the threshold value, the news is considered to be true. The paper is very well managed by explaining acceptance criteria and other details but is limited to Twitter data. Newspapers and other sources of social media is missing

In [7] Author talks about backtracking news shared by third-party news sites. It's the same news, but Reverse-Tracking helps to find out different routes. The paper assumes that fake news has one news producer and many shares, while real news has many sources and can have many claims. The author does not consider true news with subjective posts that are, based on journalist philosophy.

Collective intelligence [8] verifies news from multiple sources, Not depending upon a single source and algorithms to give output but to add it with various sources scoring techniques. Few issues were addressed, like (1) how to get relevant data for the same topic with multiple sources. (2) how to mark the credibility of multiple sources. Retweets and Tweets are given input to a machine learning model and analyze the result through GUI. The typical follower-followee relationship on Twitter facilitates quick information flow over social networks. Crawling data from the Web and applying natural language processing to a classifier, and evaluating a single parameter for efficiency. It was output on four label classes instead of a typical bi label. In, the author tried a clustering algorithm other than standard classification, naming it an unsupervised detection method. News credibility and users' credibility are considered to exploit users' engagements on social media to identify their opinions towards the news's authenticity. The accuracy failed, and hence semi-supervised or supervised algorithms are Preferred over the proposed one.

Using RNN and Bidirectional LSTM on the FNC-1 dataset, a new synonym-based detection of fake news is introduced in [9]. Rumer is a type of fake news that starts with intentional misinformation of data. We focus on five main aspects.[10] starts with collecting relevant data using various approaches and comparing it with publicly available datasets, identifying parameters important for rumor detection, and comprehensive analysis of the existing techniques. On similar lines, [11] has compared supervised algorithms like SVM, LR, DT, RF, DNN. Thought deep learning gave a better output for rumor detection with almost 91% accuracy. Combining machine learning algorithms with some expert knowledge in a given domain has been tried in[12], used classification models for text classification on existing datasets working on stance level detection. The paper also attempted to challenge issues like collecting redundant data on social media and its causes. The difficulty in identifying experts in all domains is a challenging task and practically difficult. Considering media reliability[

13] for fake news detection where various media are compared, and few reliable media are checked. Media also played an important role in stock returns [8], where reviews of shared and other minute details are computed. Few parameters make it easy to identify news is true or fake, but those are not enough. In [14][10] argumental framework is introduced to focus on other attributes contributing to the target class. Social bot [10][15] also plays an important role in spreading fake news, where they act like humans. Author Smitha [2] compared algorithms, namely SVM,LR,DT.Gradient Boosting, RF, X-G Boost, Neural networks with classification metrics like TF-IDF, Count vectorization, Word Embedding on evaluation parameters like accuracy, precision, recall, F-score, and found neural networks giving better results. In [16], the author worked on a network consisting of the news article, creator, and the subject detection problem. The experiment used a GDU model that simultaneously accepts multiple inputs from different sources and can effectively fuse these inputs for output generation with content "forget" and "adjust" gates. An automated system was built, which learned the deep network to output the result. The output generated was a 6-class label instead of typical bi-class detection.

Ricky J. Sethi counter the spread of fake news on social networks by leveraging crowds to help verify alternative facts. A very different approach was proposed in this paper. A web-based approach where the user can upload his version of news and evidence he claims, and the algorithm tries to detect with the existing database how true the news is. It's an open question-answer system where other users can also upload their opinion. In [17] the author scans news from news websites and collects it into a database. The algorithm performs a linguist approach and a neural network to find fact-checking. The paper does not believe the algorithm alone. The output is reconfirmed with manual checking to conduct quality assurance. Later a grade is generated for the news input. The database also keeps track of news rated until now for future analysis. The challenge is to keep all news databases updated, and very time-consuming to double cross-checking of news. Fake images are more common in pictures than text, as it is easy to tamper with images. General people find it difficult to identify between real and fake images [15].

III. FAKE NEWS ANALYSIS

Fake News refers to false information or propaganda published under the guise of being authentic news. Fake news websites and channels push their fake news content to mislead consumers of the content and spread information via social networks and word of mouth [18]. It is often found in traditional news, social media, or fake news websites with no facts. Fake News distracts people from important issues so that these issues remain unsolved. Political polarization and fake or biased news have been topics of interest in recent times. Several solutions are proposed to detect and flag fake news. Many of these solutions seek to prioritize trusted news sources at the server level, such as Google's efforts to partner with fact-checking networks [19]. Another is to poll users for trust in news sources, as in Facebook's approach [20]. One criticism of such top-down approaches is that they restrict user

choice and are tantamount to censorship [21] since they should decide what kind of news articles they wish to read.

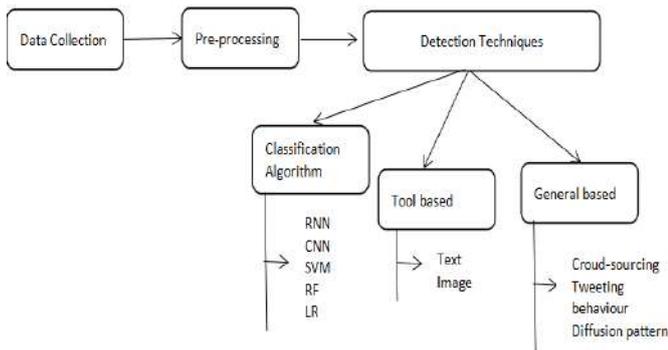


Fig1: General Fake News Detection System

Even though detecting fake news could be solved in many different approaches, classification is considered the most commonly used. A few researchers have tried the clustering approach, and the best result has been obtained by classification. Many tools are also available. In our previous paper, we have a detailed analysis of existing tools and some limitations. Twitter, Facebook, YouTube are the most common platforms from where real-time data is collected. As people are active on social media, they like to comment, share or give their opinion on trending topics. This helps researchers to collect huge Data, which helps in research. Sometimes few pools are set where people give their opinion (especially in Yes or No) types for specific news. Another way of collecting data is by interviewing experts from that particular domain of which the news is trending. Arranging a debate or a healthy conversation among various people of a similar domain having a different opinion does help in collecting real-time data.

Along with the above-discussed general techniques, we do have some standard datasets which are widely used for research purposes. The advantage of using an existing data set is that it has labeled target attributes, which helps train the model. Many experiments could be performed by changing the cross fold values and attribute selection methods to get a different variant of the data set. Such variations are instrumental in analysis and comparing results for the datasets.

IV. DATASETS

The LIAR data set [22] has almost thirteen thousand manually labeled, taken from polifact.com. It is a vast data set and is most widely used in research. The target attribute is true, mostly true, barely true, half true, pants on fire. The distribution is well balanced, around 1050 pants of fire and 2063 entries for true, and 2638 for the fake label. Crowd-sourced data set the CREDBANK[3], Contains about 60 million tweets for about 100 days from late 2015. On around 1000 event news. With expert's opinion on each event. The FakeNewsNet[24] data set which is updated in a periodical manner, contains source, context, and other news multimedia. Items and social background details like user profile, followers/followee concerning fake and truthful materials, gathered from Snopes and Buzz Feed, have been re-posted and shared on Twitter.

The real-world data set ISOT[25] Fake News Data set is a well-balanced one containing over 12,600 false and true news items each. The data set is collected using the real world. BS Detector is another data set that uses the whole article from heading to context. These data set can be collected from a chrome extension called BS Detector. The data set based on inputs from social media is called Social Media based data set or social networking service data set. BuzzFeedNew[22] is one of the data set based on social media. It prominently takes data from nine news agencies on Facebook. The number of posts collected in this news is 2282.

Another Data set is SOME-LIKE-IT-HOAX. It also gathers information from Facebook. It contains about 15,500 posts from 32 different Facebook Pages. This Data set is based on how the publisher's identity is essential and not the number of likes or dislikes on the post. Covid-19 data [4] set was designed by the organizer of the website competition. It collected data over social media.. Fact-checking websites manually verified the news and labeled them "real" and "fake" through tweets, posts, and articles, making some comments about covid-19. The actual size of the data set contains 10,700 news items with 52.345 real and 47.66% fake news. These are 880 unique username handle and 210 unique URL domains in the data. Another standard data set from Kaggle is the fake_or_real news data set. It has around 45000 entries which columns like text title, subject date, and type. Type is the target attribute that has true and fake values. The data set is very much balanced with 23481 fake and 21417 true values. Data is has collected in mid-2017.

V. METHODOLOGY

The first step in detection is pre-processing. Data Pre processing is one of the most important Data Mining steps, which deals with data preparation and transformation of the data set and seeks at the same time to make knowledge discovery more efficient. In the fake_or_real news data set, data was merged from two CSV names, fake.csv, and real.csv. Both are having labeled data. In the covid-19 data set, data was in CSV and had 3 Attributes. Both Data sets had id columns that carried no information. We must get rid of such columns during pre processing so there is not much load on our model. Data set need to be divided into train and test data. Data Split was done as 75% train and 25% test data. Later, removal of stop words, stemming, vectorization was performed. Details of all these techniques are listed below.

A. Stop word Removal

The words which are generally filtered out before processing a natural language are called stop words. These are the most common words in any language (like articles, prepositions, pronouns, conjunctions, etc.) and do not add much information to the text. Examples of a few stop words in English are "the", "a", "an", "so", "what". NLP relies on advanced computational skills, and developers worldwide have created many different tools to handle human language. The pre-defined library was used to remove stop words from both the data set.

B. Vectorization

One of the major challenges that any NLP Data Scientist faces is to choose the best possible numerical/vectorial

representation of the text strings for running Machine Learning models. In a general scenario, we work on a bunch of text information that may or may not be tagged, and we then want to build an ML model that can understand the pattern based on the words present in the strings to predict new text data. We used TF-IDF and Count vector for our research which helps us compare output on these parameters. Count Vectorizer is a way to convert a given set of strings into a frequency representation. TF-IDF means Term Frequency - Inverse Document Frequency. This is a statistic based on the frequency of a word in the corpus, but it also provides a numerical representation of how important a word is for statistical analysis. TF-IDF is better than Count Vectorizers because it not only focuses on the frequency of words present in the corpus but also provides the importance of the words[24]

C. Stemming and Lemmatization

Stemming and Lemmatization Text Normalization (or sometimes called Word Normalization) techniques in the field of Natural Language Processing that are used to prepare text, words, and documents for further processing.[<https://www.datacamp.com/community/tutorials/stemming-lemmatization-python>], Using the nltk library, we have imported the WordNet Lemmatizer, which converts the text data into its actual text.

VI. MODEL BUILDING

Machine Learning (ML) is a class of algorithms that help software systems achieve more accurate results without reprogramming them directly. Data scientists characterize changes or characteristics that the model needs to analyze and utilize to develop predictions.[Fake News Detection Using Machine Learning Approaches]. Deep Learning is a sub field of machine learning concerned with algorithms inspired by the structure and function of the brain called artificial neural networks.

As fake news detection is a classification problem, several we have performed classification algorithms. Following are the details.

A. Decision Tree Classifier

A Decision Tree[26] is constructed by asking a series of questions concerning a data set record. In a decision tree, each leaf node is assigned a class label. The non-terminal nodes, including the root and other internal nodes, contain attribute test conditions to separate records with different characteristics. It is one of the most widely used classification algorithms.

B. Multi Nominal NB

Naïve Bayes[27], which is computationally very efficient and easy to implement, is a learning algorithm frequently used in text classification problems. Two event models are commonly used:

1. Multivariate Bernoulli Event Model and
2. Multivariate Event Model

The Multivariate Event model is referred to as Multi nominal Naive Bayes. Multinomial Naïve Bayes uses term frequency, i.e., the number of times a given term appears in a document. After normalization, term frequency can be used to compute

maximum likelihood estimates based on the training data to estimate conditional probability.

C. Passive-Aggressive algorithms

Passive-Aggressive algorithms are generally used for large-scale learning. It is one of the few 'online-learning algorithms.' In online machine learning algorithms, the input data comes in sequential order. The machine learning model is updated step-by-step instead of batch learning, where the entire training dataset is used at once. Such an algorithm remains passive for a correct classification outcome and turns aggressive in the event of a miscalculation, updating, and adjusting. It is very effective in fake news detection.

D. Logistic regression

Logistic regression is a classification algorithm used when the value of the target variable is categorical.[28] it predicts the probability of occurrence of an event by fitting data to a logit function. Hence, it is also known as logit regression. Since it predicts the probability, its output values lie between 0 and 1. Logistic regression uses an equation as the representation, very much like linear regression. Input values (x) are combined linearly using weights or coefficient values (referred to as the Greek capital letter Beta) to predict an output value (y).

E. LSTM

LSTM stands for Long-Short Term Memory[29]. LSTM is a type of recurrent neural network but is better than traditional recurrent neural networks in terms of memory. Having a good hold over memorizing certain patterns, LSTMs perform fairly better. As with every other NN, LSTM can have multiple hidden layers, and as it passes through every layer, the relevant information is kept. All the irrelevant information gets discarded in every single cell.

LSTM has three main gates.

1. FORGET Gate
2. INPUT Gate
3. OUTPUT Gate

Forget gate is responsible for deciding which information is kept for calculating the cell state, which is not relevant and can be discarded. Input Gate updates the cell state and decides which information is important and which is not. The last gate, which is the Output gate, decides what the next hidden state should be.

VII. PROPOSED SOLUTION

We tried to work with two data sets. Much work has been done on standard data sets; hence we focused on this new data set, covid-19, which mainly focused on spreading fake news during the pandemic situation. We thought it was a very important topic to be considered for our research. Step by step, we designed our solution to the above-stated problem. We started with two Data sets, covid-19 and fake_or_real news. After importing data sets, we did some pre-processing on them. Like, stop word removal, Feature extraction. As stated earlier, all attributes in a data set do not contribute to the target result. Data cleaning cleans the Data before being given to the model. Fig below shows the basic workflow of our research.

Performance metric measures measure how well your data mining algorithm performs on a given data set. A confusion matrix is used to find a correct and incorrect prediction. A confusion matrix is a summary of prediction results on a

classification problem. The number of correct and incorrect predictions are summarized with count values and broken down by each class. The confusion matrix shows the ways how classification predicts the correct and incorrect entries.

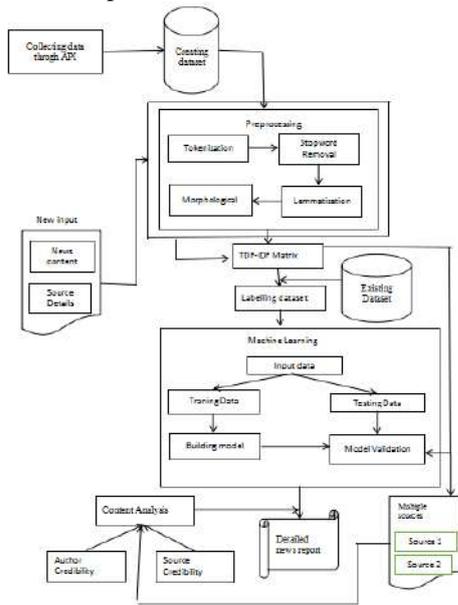


Fig 2: Overview of the system

Evaluating algorithms' performance is a measure to check how well an algorithm is performing on a data set. In this subsection, we review the most widely used metrics for fake news detection. Most existing approaches consider the fake news problem as a classification problem that predicts whether a news article is fake or not:

True Positive (TP): when predicted, fake news pieces classified as fake news. **False Positive (FP):** when predicted, fake news pieces classified as true news. **True Negative (TN):** when predicted, true news pieces classified as true news. **False Negative (FN):** when predicted, true news pieces classified as fake news.

Performance evaluation parameters calculated as follows.

$$\text{Precision} = \frac{|TP|}{|TP| + |FP|}$$

$$\text{Recall} = \frac{|TP|}{|TP| + |FN|}$$

$$\text{F1 Score} = 2 * \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Accuracy} = \frac{|TP| + |TN|}{|TP| + |FP| + |TN| + |FN|}$$

Where T: True P: positive F False N: Negative Finally, we have made a table for our results. It shows our data set run on many algorithms. We are comparing various parameters to find the best one.

As we can see that Passive-Aggressive algorithms has given a better output in both datasets. T run the code front end is developed in python using flask where the user would paste news he wants to confirm. A GUI had been kept basic with only a text box and a predict button. The system is able to detect news as fake or Real.

TABLE 1: COVID-19 DATA SET ON VARIOUS ALGORITHMS AND PERFORMANCE PARAMETERS

Data set	Model	Acc	True/false	precision	recall	F - score
Covid-19	MNB	0.905	T	0.94	0.86	0.90
			F	0.93	0.93	0.93
	DT	0.910	T	0.90	0.92	0.91
			F	0.92	0.91	0.91
	PAC	0.927	T	0.92	0.93	0.92
			F	0.93	0.93	0.93
	LR	0.919	T	0.90	0.94	0.92
			F	0.94	0.90	0.92
	GBC	0.877	T	0.87	0.86	0.85
			F	0.85	0.85	0.86
	SVM	0.913	T	0.91	0.93	0.92
			F	0.93	0.92	0.93
LSTM	0.9	T	0.91	0.90	0.91	
		F	0.92	0.93	0.92	

TABLE 2: FAKE_OR_REAL DATA SET ON VARIOUS ALGORITHMS AND PERFORMANCE PARAMETERS

Data set	Model	Acc	True/false	precision	recall	F -score
Fake_or_real	MNB	0.933	T	0.99	1.00	1.00
			F	1.00	0.99	0.99
	DT	0.994	T	0.99	1.00	1.00
			F	1.00	0.99	0.99
	PAC	0.995	T	1.00	1.00	1.00
			F	1.00	0.99	0.99
	LR	0.986	T	0.99	0.99	0.99
			F	0.99	0.99	0.99
	GBC	0.99	T	1.00	0.99	0.99
			F	0.9	1.00	0.99
	SVM	0.994	T	0.99	1.00	1.00
			F	1.00	0.99	0.99
LSTM	0.911	T	0.98	0.99	0.98	
		F	0.97	0.94	0.96	

VIII. CONCLUSION AND FUTURE WORK

From the above research, we created a system that helps to determine whether the news is misinformation or not. We studied Different Types of Data sets which are available for the detection system and worked on a few. Then we studied different approaches used by different authors and how these different methods applied on data set to gather accuracy and how the system implements the detection of misinformation.

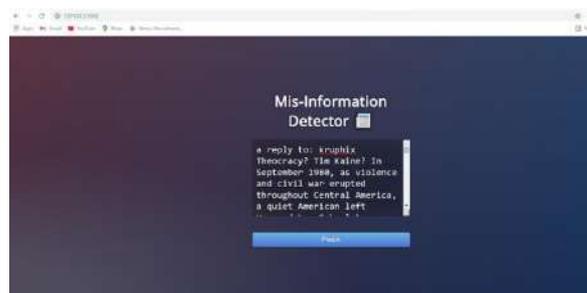


Fig 3 : News inserted in a system for checking

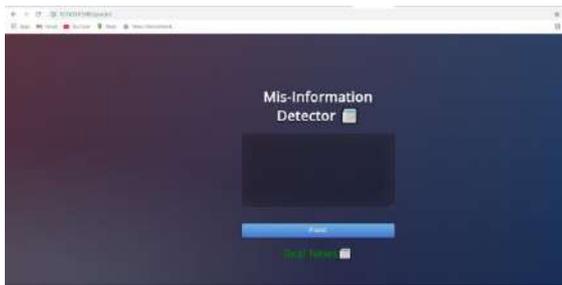


Fig 4: System showing news as real news

We found that the Passive-Aggressive Classifier algorithm has higher accuracy than another different algorithm that we used in the above implementation. It was a very basic implementation, and we will be further working on it. Not just finding a news fake or real but also having multi-class detection like mostly true, mostly fake. We will also like to give importance to the source and author of the news, i.e., user profile. We also wish to work not just on the news but also on the URL of the sites which spread fake news.

IX. RESEARCH GAP

The complexity of fake news detection poses many challenges, and the credibility of the author and Source with single and multiple options leads to many obstacles. There are a lot of research problems in this field that are required to address. Few challenges identified through the literature review are listed below.

- Author Credibility needs to be checked along with shared data. This will be challenging as deciding credibility will require a lot of research and background check.
- Source or author who intent to spread fake news will not do it on only one or few social media, he will try to reach many. Once a news is found to be fake, other social media sites also need to be checked.
- Complexity of the problem increases when, account made by user on social media is found to be fake.

REFERENCES

- [1] Sharma Uma, Siddarth Saran, and Shankar M. Patil. "Fake News Detection using Machine Learning Algorithms." *INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT)* NTASU 9, no. 03 (2020).
- [2] Khan Tanveer, Antonis Michalakis, and Adnan Akhuzada. "SOK: Fake News Outbreak 2021: Can We Stop the Viral Spread?." *arXiv preprint arXiv:2105.10671* (2021)
- [3] Yang Shuo, Kai Shu, Suhang Wang, Renjie Gu, Fan Wu, and Huan Liu. "Unsupervised fake news detection on social media: A generative approach." In *Proceedings of the AAAI conference on artificial intelligence*, vol. 33, no. 01, pp. 5644-5651. 2019
- [4] Das Sourya Dipta, Ayan Basak, and Saikat Dutta. "A Heuristic-driven Uncertainty based Ensemble Framework for Fake News Detection in Tweets and News Articles." *arXiv preprint arXiv:2104.01791* (2021).
- [5] Madani Youness, Mohammed Erritali, and Belaid Boukhalene. "Using artificial intelligence techniques for detecting Covid-19 epidemic fake news in Moroccan tweets." *Results in Physics* 25 (2021): 104266.
- [6] Atodiresei Costel-Sergiu, Alexandru Tănăsescu, and Adrian Iftene. "Identifying fake news and fake users on Twitter." *Procedia Computer Science* 126 (2018): 451-461
- [7] KoHoon, Jong Youl Hong, Sangheon Kim, Libor Mesicek, and In Seop Na. "Human-machine interaction: A case study on fake news detection using a backtracking based on a cognitive system." *Cognitive Systems Research* 55 (2019): 77-81
- [8] Liu Huxiao, Lianhai Wang, Xiaohui Han, Weinan Zhang, and Xun He. "Detecting fake news on social media: A multi-source scoring framework." In *2020 IEEE 5th international conference on cloud computing and big data analytics (ICCCBDA)*, pp. 524-531. IEEE, 2020
- [9] Suyanto Suyanto. "Synonyms-Based Augmentation to Improve Fake News Detection using Bidirectional LSTM." In *2020 8th International Conference on Information and Communication Technology (ICoICT)*, pp. 1-5. IEEE, 2020
- [10] Bondielli Alessandro, and Francesco Marcelloni. "A survey on fake news and rumour detection techniques." *Information Sciences* 497 (2019): 38-55..
- [11] Parikh Shivam B., and Pradeep K. Atrey. "Media-rich fake news detection: A survey." In *2018 IEEE conference on multimedia information processing and retrieval (MIPR)*, pp. 436-441. IEEE, 2018.
- [12] Ahmed Sajjad, Knut Hinkelmann, and Flavio Corradini. "Combining machine learning with knowledge engineering to detect fake news in social networks-a survey." In *Proceedings of the AAAI 2019 Spring Symposium*, vol. 12, p. 8. 2019.
- [13] Seo Youngkyung, Deokjin Seo, and Chang-Sung Jeong. "FaNDeR: fake news detection model using media reliability." In *TENCON 2018-2018 IEEE Region 10 Conference*, pp. 1834-1838. IEEE, 2018
- [14] Sethi, Ricky J. "Spotting fake news: A social argumentation framework for scrutinizing alternative facts." In *2017 IEEE International Conference on Web Services (ICWS)*, pp. 866-869. IEEE, 2017
- [15] Ikarawi, Sarah, Andreas Dengel, Ahmed Abdelsamad, and Syed Saqib Bukhari. "What you see is what you get? Automatic Image Verification for Online News Content." In *2016 12th IAPR Workshop on Document Analysis Systems (DAS)*, pp. 114-119. IEEE, 2016
- [16] <https://www.linkedin.com/pulse/count-vectorizers-vs-tfidf-natural-language-processing-sheel-saket>
- [17] Hyman Joshua. "Addressing fake news: Open standards & easy identification." In *2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference (UEMCON)*, pp. 63-69. IEEE, 2017
- [18] Zhou Xinyi, Atishay Jain, Vir V. Phoha, and Reza Zafarani. "Fake news early detection: A theory-driven model." *Digital Threats: Research and Practice* 1, no. 2 (2020): 1-25
- [19] Buntain Cody, and Jennifer Golbeck. "Automatically identifying fake news in popular twitter threads." In *2017 IEEE International Conference on Smart Cloud (SmartCloud)*, pp. 208-215. IEEE, 2017
- [20] Michał Konstantinos Demestichas, Agata Gielczyk, Álvaro Herrero, Paweł Ksieniewicz, Konstantina Remoundou, Daniel Urda, and Michał Woźniak. "Advanced Machine Learning techniques for fake news (online disinformation) detection: A systematic mapping study." *Applied Soft Computing* (2020): 107050
- [21] Gilda Shlok. "Notice of violation of IEEE publication principles: Evaluating machine learning algorithms for fake news detection." In *2017 IEEE 15th student conference on research and development (SCOREd)*, pp. 110-115. IEEE, 2017
- [22] Seo Youngkyung, Deokjin Seo, and Chang-Sung Jeong. "FaNDeR: fake news detection model using media reliability." In *TENCON 2018-2018 IEEE Region 10 Conference*, pp. 1834-1838. IEEE, 2018.
- [23] Das Sourya Dipta, Ayan Basak, and Saikat Dutta. "A Heuristic-driven Uncertainty based Ensemble Framework for Fake News Detection in Tweets and News Articles." *arXiv preprint arXiv:2104.01791* (2021)
- [24] Khanam Z., B. N. Alwasel, H. Sirafi, and M. Rashid. "Fake News Detection Using Machine Learning Approaches." In *IOP Conference Series: Materials Science and Engineering*, vol. 1099, no. 1, p. 012040. IOP Publishing, 2021
- [25] Oshikawa Ray, Jing Qian, and William Yang Wang. "A survey on natural language processing for fake news detection." *arXiv preprint arXiv:1811.00770* (2018)
- [26] Parikh Shivam B., and Pradeep K. Atrey. "Media-rich fake news detection: A survey." In *2018 IEEE conference on multimedia information processing and retrieval (MIPR)*, pp. 436-441. IEEE, 2018
- [27] Manzoor Syed Ishfaq, and Jimmy Singla. "Fake news detection using machine learning approaches: A systematic review." In *2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI)*, pp. 230-234. IEEE, 2019.
- [28] Hyman Joshua. "Addressing fake news: Open standards & easy identification." In *2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference (UEMCON)*, pp. 63-69. IEEE, 2017
- [29] Zhou Xinyi, Atishay Jain, Vir V. Phoha, and Reza Zafarani. "Fake news early detection: A theory-driven model." *Digital Threats: Research and Practice* 1, no. 2 (2020): 1-25.

Access Control Method for Cloud Data and Data Security in Mobile Cloud Computing

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Abstract—Cloud Computing is a technology used for file storing and file sharing across the internet. It has access control layer which allows register reducer's to access cloud data. Vulnerabilities in access control layer can lead to loss or misuse of data. So, user's records contain attributes which needs to be encrypted for better security at access control layer. So, comprehensive research has been done by studying various research techniques in order to achieve fully hide the attributes of the user. A new technique called AES-128 Full Hidden Access Policy (AES-128FHAP) has been proposed for better security and encryption cost. This method will use AES-128 bit encryption to fully hide the attributes of the user. Through fair comparison of results, the improvement and efficiency of the proposed system is proved.

Keywords—Cloud Computing, access control, new HP-CP-ABE, AES-128FHAP

I. INTRODUCTION

Cloud computing has taken its fore front when it comes to file sharing. Cloud computing helps to share files easily amongst people anywhere across the world. Since, cloud is an online platform, it is essential to keep data secure. If access control is not kept secure, then attacker can get access to data which becomes a threat. Depending on confidentiality of data, access control helps to maintain restriction for user as per hierarchy. Access Control is a method to authenticate and authorize user to fetch information only to what they are allowed to see and handle. Cryptography helps to keep user attribute secure. Cryptography is a technique by which data is encrypted and decrypted to allow data to be kept safe from intruders. Cloud computing is a technology which keep evolving and updating with time. But, updating cloud access policies dynamically can open up some security flaws which becomes threat. Since, cloud computing is now migrating to mobile platforms like smartphones and tablets, so keeping all the security features for low processing devices is a challenge. Also, access control needs to be fully hiding the attributes of user for tighter security. But, it can also increase encryption computational cost. High encryption computational cost allows attackers more time to attack the attributes. So, achieving full hidden policy while keeping encryption computational cost low is a problem that needs to be addressed. Access control gets attacked mainly for the purpose to fetch the information stored on the cloud. Access control contains information of user that helps attacker to get disguised as legitimate users. For better

security, user attributes needs to be fully hidden. Also, keeping encryption cost low will allow less time for attackers to apply attacking techniques which are relevant research problems that needs to be addressed. So, these two problems will be addressed in the research work. So, in order to overcome the problems addressed, we have proposed a new technique called as AES-128 Full Hidden Access Policy (AES-128 FHAP). This method can encrypt all the attributes present in the user data access control layer. It uses symmetric block cipher technique for encryption. Also, encryption computational cost are taken care by keeping very low. The paper is organized as follows: Section II describes the literature survey which focuses on previous study done on this subject and various encryption techniques applied for better security. Section III describes the proposed methodology, which highlights the steps taken for this project work along with flow diagram. Section IV describes implementation and results in the form of graphs. Section V describes the conclusion of the paper.

II. LITERATURE SURVEY

Comprehensive research has been done on the ways to keep Cloud Computing Access secure. Generally, cloud computing data is targeted by breaching the access control layer. Since, this layer consists of user's attributes, so targeting the attributes present in the data base of user can provide them crucial information by which they can bypass the access control layer. Through this, confidential and relevant data can be hacked. Generally, cloud computing data is targeted by breaching the access control layer. Since, this layer consists of user's attributes, so targeting the attributes present in the database of user can provide them crucial information by which they can bypass the access control layer. Through this, confidential and relevant data can be hacked. Different techniques have been applied by different researchers in order to keep cloud access secure. A new HP-CP-ABE scheme was applied [1]. This technique not only achieved full encryption of attribute, but also computational cost was minimal. This technique was a combination of different techniques. PPCMM method was implied [2] which encrypted the attributes partially on mobile platforms. In order to grant access based on hierarchies of a person in the organization, M-HABE was implied [3]. In health care industry, to provide access for patient's health records over

cloud computing, a novel ABE scheme was implied [4]. For searching data in cloud storage by authorized user's EACAS method was implied [5]. For electronic publishing over cloud computing, EACS based ABE was implied [6]. In order to manage cloud electronic health records, SE-AC mechanism was applied [7]. By combining Ethereum block chain and CP-ABE, a new scheme was used [8]. The issue of sensitive data getting leaked was addressed by implementing AuthPrivacyChain [9]. For mobile cloud computing based health care applications, a combination of methods was implied [10]. For mobile cloud computing platforms, CP-ABE was combined with cache-based scheduling algorithm for better encryption [11]. For mHealth, implementation of fine-grained policy hiding and traceable access control scheme called HTAC was implemented [12]. For edge-computing, implementation of CP-ABE was done for compensating network delay that occurs during data uploading on cloud server is done [13]. For intelligent transport systems used through cloud computing, ABE-FPP was implied for security [14]. For outsourcing of cloud data from mobile devices, CP-ABE with partial hidden policy was implied [15]. To encrypt attribute sets in hierarchical manner, HASBE along with extending CP-ABE was implied [16]. For assured deletion of cloud data at backup node of cloud by the authorized users, FADE method was implied [17]. For P2P storage in cloud computing, ACPC was implied in order to secure the attributes of user [18]. In 2020, recently as callable attribute based access control scheme was implied for achieving flexibility, scalability and security in access schemes [19]. So, it was observed that most methods were lacking full hidden policy of attributes. Also, encryption computational cost were high.

III. AES-128FHAP

An input dataset properties are defined which consists of various records of user id's stored in cloud database. These user id's consists of attributes such as first name, last name, password, department, contact number, etc. (upto 20 attributes). This entire dataset is created by using random data generator tools and is stored as .csv file. Now, this dataset is run through encryption code. So, attribute sets need to be chosen for encryption. These attributes are chosen in various forms of datasets like 5 attribute set, 10 attribute set, 15 attribute set, 20 attribute set for robustness. Since, these attributes contain crucial information for data access, so these attributes are encrypted using AES-128 bit encryption algorithm. After Encryption is performed, the dataset file gets encrypted. The encryption cost calculated will be taken as outputs.

A. Dataset properties defined

An input dataset consists of attributes and user id's. User id's upto 1000 records are taken into consideration. Attributes upto 20 are taken into consideration. These attributes consist of relevant user information like first name,

last name, emailid, password, department, contactnumber1, uniqueid, gender, address, country of residence, resident state, residing city, area

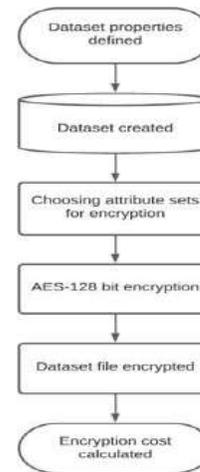


Fig.1. AES-128 FHAP Workflow Diagram

code, graduation university, date of birth, contact number 2, parentname, parentcontactnumber, parentemailaddress. These attributes consists of data types such as int, long, float, char, string depending on type of attribute information. The limits of each attribute are defined accordingly with an input entry of minimum length of 3 and maximum length of 50.

B. Dataset created

Once, data set properties are defined then these data is created by using random data generator software. These tool helps create sample random records of 1000 random user id's along with the attributes specified. Randomly these data will be created where rows will consists of 1000 user id's and columns consists of 20 user attributes. These entire data is saved in .csv file.

C. Choosing attribute sets for encryption

Attribute sets is a group of attributes taken for encryption of data. Since, AES-128 bit support full hidden policy, this means entire 20 attributes can be encrypted together as well. Here, attribute sets of 5, 10, 15 and 20 are considered for encryption. This helps to limit access control for the cloud information to be accessed.

D. AES-128 bit encryption

AES consists of symmetric encryption algorithm. AES uses fixed-block size of 128-bits. Since, 128-bit key encryption is used so, the fixed key size is 128-bits. The 128-bit fixed block used is operated in terms of 4x4 matrix. These 4x4 matrix is represented in terms of 16 bytes by converting 128-bit in bytes like $b_0, b_1, b_2, \dots, b_{15}$.

The number of transformation rounds used for AES-128 bit is 10 rounds. So, the entire algorithm works as follows:-

$$\begin{bmatrix} b_0 & b_4 & b_8 & b_{12} \\ b_1 & b_5 & b_9 & b_{13} \\ b_2 & b_6 & b_{10} & b_{14} \\ b_3 & b_7 & b_{11} & b_{15} \end{bmatrix}$$

1. KeyExpansion – Derivation of round keys is done from cipher key which requires 128-bit round key block for each of the round.

2. Initialroundkeyaddition:

1. AddRoundKey – Using bitwise XOR, combination of each byte of state done with each byte of roundkey.

3. There are 9 rounds in AES-128 bit encryption

1. SubBytes–In this step, byte a_{ij} gets replaced by $SubByteS(a_{ij})$ using 8-bit substitution. It is a non-linear substitution step where,

$$S(a_{i,j}) \neq a_{i,j} \text{ and } S(a_{i,j}) \otimes a_{i,j} \neq FF_{16}(1)$$

2. ShiftRows–In this step, each bytes in the rows are shifted cyclically to the left by 1 position immediately.

3. MixColumns - By invertible linear transformation, 4 bytes of each column are combined using fixed matrix, each column gets transformed.

$$\begin{bmatrix} b_{0,j} \\ b_{1,j} \\ b_{2,j} \\ b_{3,j} \end{bmatrix} = \begin{bmatrix} 2 & 3 & 1 & 1 \\ 1 & 2 & 3 & 1 \\ 1 & 1 & 2 & 3 \\ 3 & 1 & 1 & 2 \end{bmatrix} \cdot \begin{bmatrix} a_{0,j} \\ a_{1,j} \\ a_{2,j} \\ a_{3,j} \end{bmatrix}; 0 \leq j \leq 3$$

4. AddRoundKey-For each round, using XOR, the bytes of state gets combined with round subkey bytes.

4. Final round (10thround)

1. SubBytes

2. ShiftRows

3. AddRoundKey

E. Datasetfileencrypted

After applying AES-128 bit encryption on the dataset, the dataset file gets encrypted with cipher text generated. This ensures the security of the attributes. So, access control layer at cloud is secured in this stage.

F. Encryptioncostcalculation

Once the data set is encrypted, the amount of average encryption cost calculated for the specified attribute set is displayed as the output. In this manner, average encryption cost of considered attribute sets can be calculated.

IV. RESULTSANDDISCUSSION

For evaluation of the AES-128 FHAP, 1000 sample randomrecords of users and 20 attributes are taken. In order to justifythe improvement of AES-128 FHAP with the existing method (newHP-CP-ABE), the same data set of same 1000 records of user with same 20 attributes was taken. Now,

both the encryption algorithms were applied. Also, both the results have been evaluated by assuming there is no communication delay in the network. Increase or decrease in the number ofuser records is irrespective as user attributes are encrypted, soencryption cost varies as per the attribute sets and not on thenumber of user records. The attributes in the set of 5, 10, 15and 20 are taken for 1000 records of user as a reference for study. The results are as follows:-

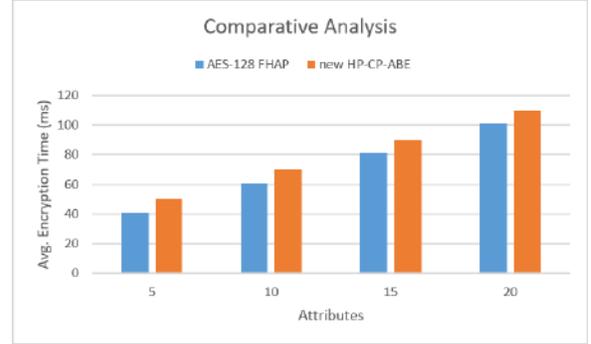


Fig.2.Comparativeanalysisofaverageencryptioncost

From the Fig.2. the bar graph represents that upon full encryption of attribute sets, the AES-128 FHAP has lower encryption computational cost than the new HP-CP-ABE. There is a reduction in encryption cost by around 9ms, whichhas minor variations as attribute sizes and attribute length are different, so encryption happens like wise.

TABLE I: TABULAR RESULTS BETWEEN NEW HP-CP-ABE AND AES-128FHAP

1000user id's	Numberof AttributeDataset	Min. Encryption Cost(ms)	Max. EncryptionCost(ms)	Avg. EncryptionCost(ms)
AES-128 FHAP	5	40.04	42.15	41.10
New-HP-CP-ABE	5	49.08	50.09	50.16
AES-128 FHAP	10	59.96	62.17	61.02
New-HP-CP-ABE	10	69.15	71.06	70.09
AES-128 FHAP	15	79.94	82.08	81.12
New-HP-CP-ABE	15	89.02	91.20	90.15
AES-128 FHAP	20	100.06	102.01	101.00
New-HP-CP-ABE	20	109.03	111.11	110.05

The tabular form of results gives a fair comparison between the AES-128FHAP and new HP-CP-ABE methods. Also, since the encryption is performed on the attributes of users, so encryption cost generated is independent on the number of user records. Attribute size and attribute length leads to minor variations in encryption costs. So, the access control over the cloud computing can be made better secure by the AES-128 FHAP encryption.

V. CONCLUSION

Cloud computing access is increasing day by day, so are its data leaks and security threats. This paper focused on improving the overall efficiency of security over the existing methods. Proposed method was applied and implemented in the paper. A statistical comparison through bar graphs and tabular results was shown with the existing method on same dataset of attributes and user id's. Since, encryption is performed on attributes of users, so even if any random dataset of any number of user records is considered, that will not affect encryption cost. Encryption cost reduction by around 9ms significantly helps to improve efficiency over the existing schemes. It can be concluded fairly that the proposed scheme was better, quicker and difficult to penetrate as it allows less time for the attackers than the existing scheme.

VI. FUTUREWORK

We believe there is always a possibility to improve and can be done by generalizing and more robustness. Since AES encryption has other variants as well such as AES-192 bit and AES-256 bit key encryption. A standard AES-128 encryption is considered for research. Whether these methods help to improve security and are they simple to be applied has been kept as a work for the future. Some other questions pertaining to AES-192 bit and AES-256 bit key encryption like, its robustness and practicality of implementation can be done as a future research work. Also, whether these higher bits encryption models will keep low encryption cost is also kept as a work for the future. So, overall as the technology keeps evolving, more challenges will arise and in the future this proposed method can be improved further.

REFERENCES

- [1] S. Khuntia and P. S. Kumar, "New Hidden Policy CP-ABE for Big Data Access Control with Privacy-preserving Policy in Cloud Computing," 2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2018, pp. 1-7, doi: 10.1109/ICC-CNT.2018.8493698.
- [2] Q. Li, Y. Tian, Y. Zhang, L. Shen and J. Guo, "Efficient Privacy-Preserving Access Control of Mobile Multimedia Data in Cloud Computing," in IEEE Access, vol. 7, pp. 131534-131542, 2019, doi:10.1109/ACCESS.2019.2939299.
- [3] Y. Xie, H. Wen, B. Wu, Y. Jiang and J. Meng, "A Modified Hierarchical Attribute-Based Encryption Access Control Method for Mobile Cloud Computing," in IEEE Transactions on Cloud Computing, vol. 7, no. 2, pp. 383-391, 1 April-June 2019, doi:10.1109/TCC.2015.2513388.
- [4] W. Li et al., "Unified Fine-Grained Access Control for Personal Health Records in Cloud Computing," in IEEE Journal of Biomedical and

- Health Informatics, vol.23, no.3, pp.1278-1289, May 2019, doi:10.1109/JBHI.2018.2850304.
- [5] J.Hao, J.Liu, H.Wang, L.Liu, M.Xian and X.Shen, "Efficient Attribute-Based Access Control with Authorized Search in Cloud Storage," in IEEE Access, vol.7, pp.182772-182783, 2019, doi:10.1109/ACCESS.2019.2906726.
- [6] D.Wuet al., "EACS: An Efficient Access Control Scheme for Electronic Publishing in Cloud Computing," in Chinese Journal of Electronics, vol.27,no.1,pp.60-69,12018,doi:10.1049/cje.2017.11.009.
- [7] K.Riad, R.Hamza and H.Yan, "Sensitive and Energetic IoT Access Control for Managing Cloud Electronic Health Records," in IEEE Access, vol.7, pp.86384-86393, 2019, doi:10.1109/ACCESS.2019.2926354.
- [8] S. Wang, X. Wang and Y. Zhang, "A Secure Cloud Storage Framework With Access Control Based on Blockchain," in IEEE Access, vol. 7, pp.112713-112725, 2019, doi:10.1109/ACCESS.2019.2929205.
- [9] C. Yang, L. Tan, N. Shi, B. Xu, Y. Cao and K. Yu, "AuthPrivacyChain: A Block chain-Based Access Control Framework With Privacy Protection in Cloud," in IEEE Access, vol. 8, pp. 70604-70615, 2020, doi:10.1109/ACCESS.2020.2985762.
- [10] S. Roy, A. K.Das, S. Chatterjee, N. Kumar, S. Chattopadhyay and J.J.P. C. Rodrigues, "Provably Secure Fine-Grained Data Access Control Over Multiple Cloud Servers in Mobile Cloud Computing Based Healthcare Applications," in IEEE Transactions on Industrial Informatics, vol. 15, no.1, pp.457-468, Jan.2019, doi:10.1109/TII.2018.2824815.
- [11] F. Jamal, M. T. Abdullah, Z. M. Hanapi and A. Abdullah, "Reliable Access Control for Mobile Cloud Computing (MCC) With Cache-Aware Scheduling," in IEEE Access, vol. 7, pp. 165155-165165, 2019, doi:10.1109/ACCESS.2019.2953227.
- [12] Q. Li, Y. Zhang, T. Zhang, H. Huang, Y. He and J. Xiong, "HTAC: Fine-Grained Policy-Hiding and Traceable Access Control in mHealth," in IEEE Access, vol. 8, pp. 123430-123439, 2020, doi:10.1109/AC-CESS.2020.3004897.
- [13] Hu Xiong, Yanan Zhao, Li Peng, Hao Zhang, Kuo-Hui Yeh, "Partially policy-hidden attribute-based broadcast encryption with secure delegation in edge computing," Future Generation Computer Systems, vol. 97, pp.453-461, 2019, doi:10.1016/j.future.2019.03.008.
- [14] H.Tian, X.Li, H.Quan, C.-C.Chang and T.Baker, "A Light weight Attribute-Based Access Control Scheme for Intelligent Transportation System with Full Privacy Protection," in IEEE Sensors Journal, vol.21,no.14,pp.15793-15806,15July2021, doi:10.1109/JSEN.2020.3030688.
- [15] Yu J, He G, Yan X, Tang Y, "Q in R. Out sourced cipher text-policy attribute-based encryption with partial policy hidden," Inter-national Journal of Distributed Sensor Networks, May 2020, doi:10.1177/1550147720926368.
- [16] Z. Wan, J. Liu, R. H. Deng, "HASBE: A Hierarchical Attribute-Based Solution for Flexible and Scalable Access Control in Cloud Computing," in IEEE Transactions on Information Forensics and Security, vol. 7, no.2, pp.743-754, April 2012, doi:10.1109/TIFS.2011.2172209.
- [17] Y. Tang, P. P. C. Lee, J. C. S. Lui and R. Perlman, "Secure Overlay Cloud Storage with Access Control and Assured Deletion," in IEEE Transactions on Dependable and Secure Computing, vol. 9, no. 6, pp.903-916, Nov-Dec 2012, doi:10.1109/TDSC.2012.49.
- [18] H. He, R. Li, X. Dong, Z. Zhang, "Secure, Efficient and Fine-Grained Data Access Control Mechanism for P2P Storage Cloud," in IEEE Transactions on Cloud Computing, vol. 2, no. 4, pp. 471-484, 1 Oct-Dec 2014, doi:10.1109/TCC.2014.2378788.
- [19] R. Ahuja and S. K. Mohanty, "A Scalable Attribute-Based Access Control Scheme with Flexible Delegation cum Sharing of Access Privileges for Cloud Storage," in IEEE Transactions on Cloud Computing, vol. 8, no.1, pp.32-44, 1 Jan.-March 2020, doi:10.1109/TCC.2017.2751471.

Age and Gender Estimation through Deep Learning: CNN

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Abstract— The notion of identifying gender and age using pictures is becoming widely attractive. This is due to the fact that numerous smartphone apps and other machine learning implementations are being utilized for entertainment purposes by an increasing number of users globally. As a result, software businesses are generating a lot of revenue. Deep learning is used extensively in this strategy to predict gender and age recognition. Many techniques are used to predict the same thing, however combining deep learning - based learning models can eventually lead in superior outcomes. The proposed approach takes an input test image and preprocess the image by resizing it. The resized image is provided to the Region of Interest Evaluation, its output is provided to the YCbCr color model for skin detection that is provided to the early trained Convolutional Neural Network Module which creates a dense layer and produce prediction score that is provided to the Decision Tree Module for the purpose of labelling which leads to accurate detection of the age and gender. The outcomes demonstrate that the implemented method operates well in its early steps toward age and gender prediction utilizing the ensemble learning method. The scores of precision, recall & accuracy as 87%, 89% and 81% attained through extensive evaluation outperform the conventional approaches considerably.

Keywords— YCbCr Color model, Convolutional Neural network, Decision Tree.

I. INTRODUCTION

The face is the primary source of information in human communication that gives information to identify a person such as an ethnicity, gender, and age, to promote conversation through mood and emotion recognition, and to investigate a person's condition based on social behaviors and cosmetic appearance. Face analysis applications such as face age estimation, gender categorization, facial emotion recognition, and face identification have been established by researchers. Face age estimation is one of these applications that has gotten a lot of attention since it can improve face recognition, facilitate communication, and impact detection methodologies.

The face age estimate is defined as the ability to identify a face image automatically with the exact age or age category of the individual face, such as young or adult. The purpose of an automatic age estimate is to determine if the age is as close as feasible to the actual or apparent age. The number of years a person has lived is known as their actual or real age, whereas appearance age is the age information indicated by their physical appearance. Perceived and estimated age refers to how a person or a machine recognizes an individual's age based on their appearance. Many real-world applications, such as entertainment,

electronic customer relationship management, soft biometrics, and access control and monitoring, benefit from age estimation.

Face analysis is crucial in face-centric applications including human-robot interfaces and face monitoring. In safe face surveillance, facial features could be used to protect personal privacy. Depending on facial expression, gender, and age, a human-robot interface could perform a variety of behaviors. In face-centric applications, age and gender are two of the most important features. In the domains of image processing and computer vision, there has recently been some success in automatically determining age and gender.

Due to the availability and enormous volume of labeled data, as well as high-performance computing, deep learning has advanced fast in recent years. Deep learning is one of the most widely used machine learning approaches in Artificial Intelligence right now. Many traditional feature extraction and subspace learning techniques in computer vision have been overshadowed by deep learning's recent good performance. Combinations of dimensionality reduction, face landmarks, hand-crafted features, regressors, and classifiers have traditionally yielded strong results. Neural networks, on the other hand, have risen to prominence thanks to their ability to learn and memorize features, and they continue to improve in accuracy as more data is collected. As a result, Deep Neural Networks have considerably outperformed traditional classification and regression techniques, even outperforming humans on a number of well-known benchmarks. As a result, using Convolution neural networks and Decision Making algorithms, a highly useful approach for estimating age and gender with very high accuracy has been described in this research. Because of the significant differences between a normal neural network and a Convolution neural network, the Convolution neural network paradigm is extremely valuable and an integral aspect of the suggested technique. Convolution neural networks are extremely different from traditional neural network implementations, and they have a significant advantage in terms of boosting prediction performance. Unlike regular neural networks, Convolution neural networks are capable of remembering or keeping earlier inputs to the system. As a result, the discriminator's performance improves, and the age and gender estimation accuracy improve overall. Traditional neural networks do not have the ability to remember input, which makes it difficult for the network to learn and retain useful information. This enables Convolution Neural Networks to attain extremely high implementation accuracy, which is unmatched by traditional neural network realizations.

Before being used on a testing batch of photos, the Convolution Neural Network is trained on facial images.

After masking using the YCbCr color model, the input to the Convolution Neural Networks is done. This allows for the accurate detection of the image's red Chroma component as well as the image's blue Chroma component, which is extremely useful for skin detection. Through Convolution Neural Networks, this allows for significantly better realization of age and gender prediction. The output of the Convolution Neural Networks is then efficiently categorized using a Decision Making classification strategy to eliminate redundant predictions. One of the most essential aspects of this proposed age and gender estimation technique is the Decision Making approach. The Decision Making technique is one of the most precise classification algorithms currently available. The use of Crisp values for the purpose of classification makes classification a highly precise segregation technique. These values provide for a range of possible values between true and false values, which are generally used to categories a data point for a certain label. The classification strategy efficiently classifies the output of the Convolution neural network to deliver extremely accurate gender and age estimation.

This research article works on the past research papers under the name Literature survey in section 2. The designed approach is elaborated in section 3 of the proposed methodology. The obtained results are evaluated in section 4 of Results and Discussions. This research paper concluded in section 5.

II. LITERATURE SURVEY

Kuan-Hsien Liu [1] explains that there have been a number of different techniques that are being used to determine the facial age of an individual, but most of the approaches have been relying on the regression or classification model or the feature extraction of the facial aging. The authors in this approach define another technique called the system structuring for the determination of age of an individual through the facial image in a constrained manner. The approach utilizes decision fusion, gender grouping and age grouping to realize the goals to achieve the accurate age estimation.

Jiu-Cheng Xie [2] expresses that there are different techniques that are used to determine the age of an individual. The attributes for the detection purposes can be extremely complicated and complex and are governed by multitude of parameters. The age estimation through facial images is one of the most compelling problems in the computer vision paradigm. Therefore, the researchers in this approach have utilized Convolutional Neural Networks for this purpose and an effective age estimation model is generated. The results of the approach convey that the technique achieves the desired outcomes.

Sangmin S. Lee [3] elaborates on the adversarial spatial frequency domain critic, a new deep learning framework for age and gender categorization has been developed. The encoder generator in the proposed framework creates realistic facial pictures by combining actual photos with age and gender labels. To make processed pictures more appropriate for age and gender categorization, an adversarial critic is created. In addition, the researchers look at the spatial frequency domain characteristics of age and gender variables. The authors developed the spatial frequency domain critic network based on extensive research to evaluate the precise frequency bands that are prominent on age and gender features.

Kuan-Hsien Liu [4] narrates that in this research paper for the assessment of apparent human facial age, a stacked deep network fusion model was used. In the first three phases, three well-performing deep architectures are used, and the estimation results for each design are combined in the final stage to improve overall performance. A pre-trained deep CNN model is fine-tuned for the gender categorization job in the first stage. Two gender-specific age groupers are constructed in second stage to categorize the facial photos into two non-overlapping age groups. Ages are calculated from three deep networks in third step and given to fuser in the final stage to refine age estimation findings.

Sadia Mahjabin [5] introduces Automatic age estimation of face images is a difficult challenge in computer vision and image analysis since the ageing process is influenced by a variety of factors such as environment, gender, and ethnicity. In addition, estimating age from face photos with near-perfect accuracy necessitates a significant amount of data and a lengthy training period. The researchers offer an age estimator based on Convolutional Neural Network (CNN) that can almost precisely predict age from facial photos in this publication. Our method uses less training data than previous studies while maintaining a low Mean Absolute Error for age estimate.

ByungIn Yoo [6] narrates that physical age and evident age can be somewhat distinct, and this difference is reliant on ethnicity, gender, and many other factors. Reliable age estimation from a facial image is quite complex, because physical age and evident age can be quite different, and this difference is dependent on ethnicity, gender, and several other factors. The researchers suggest in this article a conditional multitask learning approach in which a deep neural network architecturally incorporates an age variable into gender-conditioned age probabilities. Another significant problem of training age modeling techniques is the lack of precise training labels with discrete values of age. As a result, the authors suggest a label expansion approach for poorly supervised categorical labels that enhances the number of accurate labels.

Albert Clapes [7] discusses that the detection of age of an individual through the use of the facial image by the application of the image processing approaches have been highly difficult and an extremely complicated maneuver for researchers across the world. The computer vision paradigm has been effective in realization of the age estimation approach through multiple researches. The authors in this article propose an effective approach for the age estimation through the use of Convolutional Neural Networks. The results indicate an effective and useful identification approach for accurate age and gender estimation.

Philip Smith [8] explains an image-based gender recognition and age estimation, based on deep neural networks consisting pre-trained weights is depicted in this research work. In order to increase prediction accuracy, transfer learning is investigated utilizing extensive and pre-trained models by assessing the effects of modifications in various training settings and design schemes. Label distribution age encoding, data augmentation, and input standardization are all compared as training strategies. Finally, a hierarchy of deep CNNs is explored, which first classifies participants by gender and then predicts age using distinct female and male age models.

Omaima FathElrahman Osman [9] expresses that the human face is one of the most accurate source for providing the information to determine the identity of a person. Many

new algorithms have been created in the last decade, and prior research on face age estimation were either inadequate or outdated. The authors intend to present an up-to-date study on face age estimate methodologies, given the importance of the ongoing research in this field. First, we review the most up-to-date datasets and performance measures for estimating facial age. After that, we go into age estimation strategies based on three types of face features: hybrid, local, and global, as well as different types of age classification models.

Seok Hee Lee [10] elaborates on the age and gender estimate using a deep residual learning model. Faces are detected in input photographs, and the age and gender of each face are assessed using the method described in this study article. Three deep neural networks are used in the estimate technique, and the authors use residual learning methods. The authors use the IMDB-WIKI database to train the model, which results in a significant improvement thanks to the use of deep residual learning methodologies.

Khaing Suu Htet [11],[12] introduces that concept of commercial analytics which is being used extensively not just in business planning but also in government national planning. As a result, data collecting and data mining are key components of demographic data. In events streaming video, the system suggested to detect and calculate in human gender classification, tracking and counting people of various age groups. Many applications have benefited from automated gender classification and age estimation methods, particularly since the emergence of social media and platform events. Through the use of R-CNN implementation, the recommended approach achieves effective detection.

III. PROPOSED METHODOLOGY

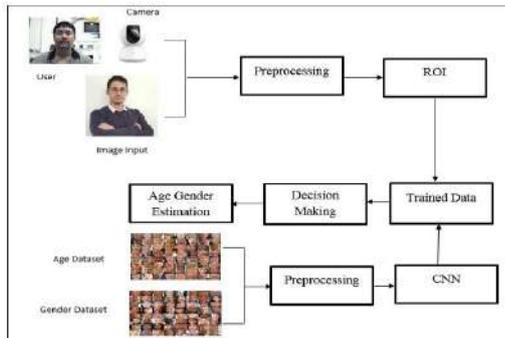


Fig. 1. System Overview Diagram

The proposed technique for estimation of age and gender is displayed in the fig 1 above. The entire process is broken down in a step by step manner in the section below.

Step 1: Data Aggregation & Preprocessing for Age Dataset – This is the initial step of the presented technique for estimation of age through the use of deep learning. The input to this system is in the form of facial images that are collected and provided to the system. The input dataset is collected from the URL – <https://susanqq.github.io/UTKFace/>. This dataset is the UTKFace dataset that contains facial images from the age of 1 to the age of 116 belongs to different races. As the identification of children achieves very low accuracy because the facial features of the children are not so sharp so these images are omitted and a total 16504 images are considered for the experimentation. And also the detection approach is based on CPU, hence the detection approach is

defined specifically to detect in the 16 to 55 age group. The input images are first rescaled to the height and width of 40 pixels. After this the images are segregated into 8 labels namely, 15 – 20, 20 – 25, 25 – 30, 30 – 35, 35 – 40, 40 – 45, 45 – 50, and 50 – 55 to store in a list.

Step 2: Age Dataset training through Convolutional Neural Network– The Convolutional Neural network is being utilized for performing the image processing for the detection of the age of the individual. The Keras – TensorFlow library is being used for the purpose of implementing the neural network in the python environment. The CNN is initialized with the number of classes at 8 as shown previously with a batch size of 1000. The input preprocessed data obtained in the prior step is first divided into two parts, training consisting of 70% of the dataset along with testing which comprises of 30% of the input dataset collected randomly with a random state of 32.

TABLE I. CNN ARCHITECTURE FOR AGE ESTIMATION

Layer Type	Shape	Bias
Conv1	5x5, 1, 32	32
Conv2	5x5, 32, 64	64
Dense	10x10x10, 64, 1024	1024
Output	1024, 8	8

The training is initiated and the various layers of the CNN are designed. There are two Convolution layers in the model. The first layer utilizes a kernel with the size 5x5 with number of kernels as 1 and the output of layer of 32. Similarly, the second layer is implemented with the kernel size as 5x5 with the number of kernels 32 and the output as 64. A dense layer is also initialized with the size as 10x10x64 and an output layer of 1024. The output layer is similarly designed with the shape 1024 and the 8 number of classes. The layers are tabulated with their respective parameters in the table 1 above. The Activation function used in this implementation is the ReLU activation function as given in (1) given below.

$$ReLU = \max(x, 0) \tag{1}$$

The Bias is also initialized for each of the layers to normalize them. For the first convolutional layer is set with a bias value of 32, whereas the second convolution layer is given a bias value of 64. The Dense layer is assigned a bias value of 1024 and the output layer has a bias value of the number of classes that is 8. With these parameters set for the Convolutional Neural Network architecture, the train model is initiated and is run for 1500 epochs. After the completion of the epochs, the trained model is saved as a checkpoint file in the specified location.

Step 3: Data Aggregation & Preprocessing for Gender Dataset – This is the next part of the presented technique for estimation of gender through the use of deep learning in the form of CNN. The input to this system is in the form of facial images that are collected and provided to the system. The input dataset is collected from the URL – <https://www.kaggle.com/cashutosh/gender-classification-dataset>. This dataset contains facial images of two types, the male gender as well as the female gender of different races. In the downloaded dataset, there are 1173 male images whereas 1134 female images. The images need to be preprocessed before the generation of the image data for our designed neural network model. For the preprocessing, the input facial images are resized to a size of 96x96 with color channel no. 3 which indicates the RGB color model. The image needs to be converted into arrays by reading the images. These images are then labeled as 0 for Male and 1

for female. The image data is then generated by these images through the use of various parameters such as, rotation range set at 25, width shift range set as 0.1, height shift range as 0.1, shear range as 0.2, zoom range at 0.2, horizontal flip as true and fill mode set as nearest. This generated image data is then utilized in the next step by the convolutional neural networks.

Step 4: Gender Dataset training through Convolutional Neural Network – The image data generated in the previous stage is utilized as an input in this step of the approach for the evaluation of Convolutional Neural Network for the detection of the gender. The CNN model is first initiated sequentially and the various layers are added as described in the table 2 below.

The CNN model can be easily visualized using the table above. The model initiates various layers for the evaluation of the gender. There are 5 convolution layers, the first layer consists of a 3x3 kernel and 32 in number. The padding is the same and the input shape is the height and width of the image. The activation function is the ReLU activation function. Batch normalization has been performed using the channel dimensions. The MaxPooling2D is realized using a pool size of 3x3. To manage the output of the layers, a dropout of 25% is applied. Additional 4 layers are implemented in this manner with varying number of kernels which are stipulated in Table 2.

TABLE II. CNN ARCHITECTURE FOR GENDER

Layer	Activation
32 x 3 x 3 2D	ReLU
MaxPooling2D (3x3)	
Dropout (0.25)	
64 x 3 x 3 2D	ReLU
64 x 3 x 3 2D	ReLU
MaxPooling2D (3x3)	
Dropout (0.25)	
128 x 3 x 3 2D	ReLU
128 x 3 x 3 2D	ReLU
MaxPooling2D (2x2)	
Dropout (0.25)	
Flatten	
Dense (1024)	ReLU
Dropout (0.50)	
Dense (2)	Sigmoid

ESTIMATION

In addition to these layers, the flatten layer is deployed to flatten the input. The dense layer is implemented using the value of 1024 and activation as ReLU. The batch normalization is performed with a dropout of 50%. The sigmoid activation function is used and the model is trained with the batch size of 64 and 1000 epochs. The trained data is stored in a file h5 extension at a specified location. The sigmoid activation function is given in (2).

$$Sigmoid = \frac{1}{1 + e^{-x}} \quad (2)$$

Step 5: Testing for Gender and Age through Decision Tree – This is the step where the actual testing of the trained models generated previously is being performed. The Tkinter library is being used to design an interactive user interface for this methodology. Once the approach has been initiated, the user is presented with two different options for the testing, namely, through an image and through the camera. If the image option is selected by the user is prompted to browse the image file which is effectively processed before the application of the trained model. If the user selects the camera option, the OpenCV computer vision library is used to initialize the camera, the user can then click a picture by pressing the spacebar. The captured image is processed using the Haar Cascade Classifier which identifies the face in the image. Once the face is detected,

the image is cropped and sent for the evaluation to test the trained models. The images, either form the file selection or captured from the camera are converted into arrays to extract the image data. This is subjected to the evaluation of the probability through the trained models for age estimation acquired previously. The results are then compared according to the dictionary for the age estimation. There are 8 ranges that correspond to a particular age group. The prediction values are classified and two age ranges are achieved as a result.

The image is then further evaluated through the use of the YCbCr colour model. The YCbCr colour model is utilized for the purpose of extracting the skin pixel images. Firstly, the image is evaluated pixel by pixel to extract the Red, Green and Blue pixels. These values are utilized to evaluate the Red Chroma Component and the Blue Chroma component given by (3) and (4) given below.

$$Cb = -0.169 * R - 0.332 * G + 0.500 * B + 128 \quad (3)$$

$$Cr = 0.500 * R - 0.419 * G - 0.081 * B + 128 \quad (4)$$

The Blue Chroma component and the red Chroma component are highly useful in determining the skin colour through assessment of the values. If the Red Chroma component is in the range of 137 to 177, and the Blue Chroma component is between 77 and 127, the value of t is calculated from (5). If the value of t lies between the ranges 190-215, the pixel is converted into white and the count is increased as well as the value of t is added to the sum, else the pixel is converted into black. This is repeated for all the pixels in the group and a binary image is achieved.

$$t = Cb + 0.6 * Cr \quad (5)$$

Once the count and the sum is achieved for a particular image, it is utilized to extract a factor, by dividing the sum by the count. The entire process for the YCbCr colour model is depicted in the algorithm 1 below.

ALGORITHM 1: YC_{BCR} Color model for Age factor approximation

```

// Input: Rescaled image RIMG
//Output: factor
// function: ycberMasking (RIMG)
1: Start
2: SIMG = ∅, count=0
3:   for i = 0 to size of Width of RIMG
4:     for j=0 to size of Height of RIMG
5:       col = RIMG [i,j] (PIX )
6:       R= col [0]
7:       G= col [1]
8:       B= col [2]
9:       Cb = -0.169 * R - 0.332 * G + 0.500 * B + 128)
10:      Cr = 0.500 * R - 0.419 * G - 0.081 * B + 128
11:      if (Cr > 137 && Cr < 177), then
12:        if (Cb < 127 && Cb > 77), then
13:          t = Cb + 0.6 * Cr;
14:          if (t > 190 && t < 215), then
15:            SIMG [i,j] (PIX)=[ 255,255,255]
16:            sum =sum+ t
17:            count =count+1
18:          end if, else
19:            SIMG [i,j] (PIX)=[ 0,0,0]
20:          end if, else
21:            SIMG [i,j] (PIX)=[ 0,0,0]
22:          end if, else
23:            SIMG [i,j] (PIX)=[ 0,0,0]
24:          end if
25:        end for
26:      end for
27:      factor = sum/count
28: return factor
29: stop

```

The Decision Tree then utilizes the values of the factor which are provided for the accurate classification. The if-then rules of the decision tree classify it into 5 sections and achieve the addup value between the ranges of 0-4. This resultant addup value is then added to the lower number of the age range achieved previously to achieve the accurate age of the person.

The image is similarly provided to the gender estimation module that has been previously trained for the detection. The image is first read and converted into an array. This array containing the image data is provided to the test gender estimation module. The gender estimation module performs the prediction through the data stored in a .h5 file and a prediction score is achieved. The prediction score is mapped to the two labels, namely 0 for Male and 1 for Female. The obtained results of the estimated age and gender are provided to the user in an interactive user interface.

IV. RESULT AND DISCUSSION

The proposed approach for age and gender identification through the use of facial images is deployed on a machine based on windows OS. This deployment machine is equipped with 6GB of RAM and an Intel Pentium Core i5 Processor. The Python Programming language is utilized for the development of the methodology with Spyder as the standard IDE. The performance evaluation of the proposed approach is attained through the use of intensive evaluations that are described below.

A. Performance Evaluation through Precision and Recall

Precision and recall performance measures are commonly acknowledged as two among the most suitable techniques for determining technique's correctness. The precision returns the relative accuracy achieved by the age estimation approach. And recall demonstrates the method's absolute precision. Precision and recall are utilized here just to assess facial age detection which will be an important module in the forthcoming CNN procedure for age and gender determination. Equations (6), (7) and (8) can be explored for a more detailed mathematical representation of precision, recall and accuracy respectively.

$$Precision = A/(A + B) \tag{6}$$

$$Recall = A/(A + C) \tag{7}$$

$$Accuracy = \frac{Correctly\ Classified\ Image}{Total\ number\ of\ Images} \tag{8}$$

Where,

- A = the number of accurately detected age and gender.
- B= the number of inaccurately detected age and gender.
- C = the number of accurate age and gender not detected.

The accuracy and recall metrics were used to assess the performance of the face age and gender detection module. The empirical assessment is carried out exhaustively for a variety of facial pictures, and the results are shown in table 3. These face age detection findings are also displayed on a graph, which is shown in fig 2.

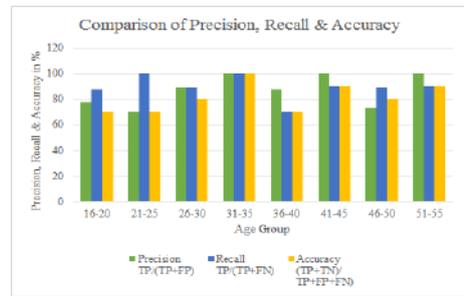


Fig. 2: Graphical Representation of the Precision and Recall Values.

TABLE III. PRECISION AND RECALL PERFORMANCE

Age Group	No. of Test Images	Total number of Proper identification of age and gender (True Positive)	Incorrectly identified proper age and gender (False Positive)	Correctly Identified improper age and gender (False Negative)	Precision TP/(TP+FP)	Recall TP/(TP+FN)	Accuracy (TP+TN)/TP+FP+FN)
16-20	10	7	2	1	77.77777778	87.5	70
21-25	10	7	3	0	70	100	70
26-30	10	8	1	1	88.88888889	88.88888889	80
31-35	10	10	0	0	100	100	100
36-40	10	7	1	3	87.5	70	70
41-45	10	9	0	1	100	90	90
46-50	10	8	3	1	72.72727273	88.88888889	80
51-55	10	9	0	1	100	90	90

The assessment has been performed for the evaluation of the age and gender estimation module. The age and gender estimation approach is evaluated and the outcomes are indicative of an accurate implementation of the approach. The outcomes have been tabulated with a tolerance of +5 and -5 for the age detection which are subsequently compared with the approach for age and gender estimation elaborated in [13], whereas the facial images properly detected for age are properly detected for gender as well. The table 4 compares the presented technique and plots a bar graph in the fig 3.

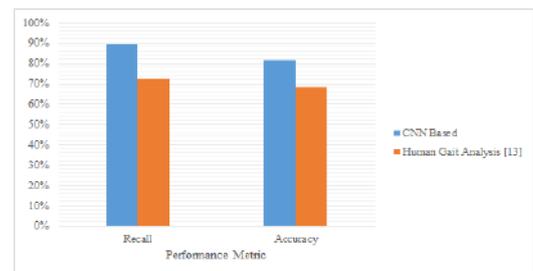


Fig. 3: Recall and Accuracy Comparison with [13]

TABLE IV. PERFORMANCE COMPARISON WITH [13]

Performance Metric	CNN Based	Human Gait Analysis [13]
Recall	89%	72.20%
Accuracy	81%	68.20%

The precision and recall obtained for the facial image detection performance have been indicative of the implementation accuracy of the module. The approach achieves precision of 87% and recall of 89%. Additionally, the accuracy is calculated as 81%. These results are highly satisfactory as the age and gender determination accuracy has considerably better accuracy than the human gait analysis approach stipulated in [13]. This is attributed to the CNN model as the deep learning approach that has been trained accurately and separately from the gender model. The age estimation module is trained on 2 layers and the

gender utilizes 5 layers of the CNN which are strained for longer epochs which lead to a superior performance.



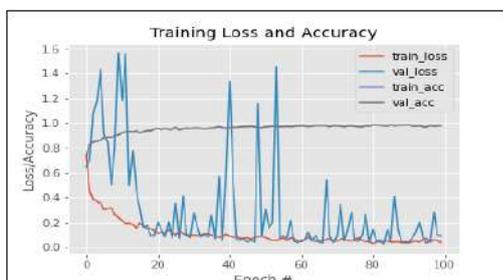
Fig. 4: Real time execution results graph

This approach has been executed through webcam also to determine the age and gender of 20 individuals. The process was executed and the outcomes have been tabulated in the table 5. The Figure 4 demonstrates the outcomes in a line graph for better understand of the achieved accuracy of the age and gender estimation. The evaluation outcomes are then measured to determine that the approach achieves an accuracy of 81% for real time deployment which is a respectable score. The gender Training model through CNN yields accuracy and loss as shown below in the fig 5.

REAL TIME EXECUTION OUTCOMES

Users	Actual Age and Gender	Obtained Age and Gender	Result
User 1	28M	27M	TRUE
User 2	27M	27M	TRUE
User 3	16F	14F	TRUE
User 4	34M	30M	TRUE
User 5	36M	32M	TRUE
User 6	45F	43F	TRUE
User 7	40M	44M	TRUE
User 8	16F	16M	FALSE
User 9	19M	21M	TRUE
User 10	24F	32F	FALSE
User 11	48F	55F	FALSE
User 12	22M	25M	TRUE
User 13	25F	25F	TRUE
User 14	37M	42M	TRUE
User 15	30F	26F	TRUE
User 16	19F	23F	TRUE
User 17	28M	32M	TRUE
User 18	49M	38M	FALSE
User 19	50F	48F	TRUE
User 20	21M	25M	TRUE

Fig. 5: Gender training Accuracy and Loss Details



V. CONCLUSION AND FUTURE SCOPE

This study focuses on determining the age and gender of the supplied image collection. The original image dataset, which contains face images of various age and gender, is divided into two separate categories of testing and training set. During the performance evaluation of the presented methodology, all images are submitted to face feature estimation. When using YCbCr color model, these face characteristics are utilized to determine the factor value for the testing images. This model predicts the addup value abstractly, which give accurate age prediction estimates.

These testing images are put into the Convolutional Neural Network, which is used as a deep neural network to provide model prediction outputs. Decision Tree technique is used to evaluate the gender and age depending on various categorization labels relying on these prediction values. In compared to traditional techniques, the testing findings utilizing precision and recall for age and gender detection methodology demonstrate the system's resilience in achieving the final outcomes for age and gender assessment.

In the future, this approach may be used at real-time CCTV cameras to estimate walking people's age and gender in commercial buildings, airports, and other locations.

REFERENCES

- [1] K. -H. Liu and T. -J. Liu, "A Structure-Based Human Facial Age Estimation Framework Under a Constrained Condition," in IEEE Transactions on Image Processing, vol. 28, no. 10, pp. 5187-5200, Oct. 2019, doi: 10.1109/TIP.2019.2916768.
- [2] J. Xie and C. Pun, "Chronological Age Estimation Under the Guidance of Age-Related Facial Attributes," in IEEE Transactions on Information Forensics and Security, vol. 14, no. 9, pp. 2500-2511, Sept. 2019, doi: 10.1109/TIFS.2019.2902823.
- [3] S. S. Lee, H. G. Kim, K. Kim and Y. M. Ro, "Adversarial Spatial Frequency Domain Critic Learning for Age and Gender Classification," 2018 25th IEEE International Conference on Image Processing (ICIP), 2018, pp. 2032-2036, doi: 10.1109/ICIP.2018.8451616.
- [4] K. Liu, P. K. Chan and T. Liu, "Smart Facial Age Estimation with Stacked Deep Network Fusion," 2018 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), 2018, pp. 1-2, doi: 10.1109/ICCE-China.2018.8448885.
- [5] S. Mahjabin, M. M. Alam and K. H. Talukder, "Age Estimation From Facial Image Using Convolutional Neural Network(CNN)," 2019 International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering (IC4ME2), 2019, pp. 1-4, doi: 10.1109/IC4ME247184.2019.9036477.
- [6] B. Yoo, Y. Kwak, Y. Kim, C. Choi and J. Kim, "Deep Facial Age Estimation Using Conditional Multitask Learning With Weak Label Expansion," in IEEE Signal Processing Letters, vol. 25, no. 6, pp. 808-812, June 2018, doi: 10.1109/LSP.2018.2822241.
- [7] A. Clapés, G. Anbarjafari, O. Bilici, D. Temirova, E. Avots and S. Escalera, "From Apparent to Real Age: Gender, Age, Ethnic, Makeup, and Expression Bias Analysis in Real Age Estimation," 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), 2018, pp. 2436-243609, doi: 10.1109/CVPRW.2018.00314.
- [8] P. Smith and C. Chen, "Transfer Learning with Deep CNNs for Gender Recognition and Age Estimation," 2018 IEEE International Conference on Big Data (Big Data), 2018, pp. 2564-2571, doi: 10.1109/BigData.2018.8621891.
- [9] O. F. Osman and M. H. Yap, "Computational Intelligence in Automatic Face Age Estimation: A Survey," in IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 3, no. 3, pp. 271-285, June 2019, doi: 10.1109/TETCI.2018.2864554.
- [10] S. H. Lee, S. Hosseini, H. J. Kwon, J. Moon, H. I. Koo and N. I. Cho, "Age and gender estimation using deep residual learning network," 2018 International Workshop on Advanced Image Technology (WAIT), 2018, pp. 1-3, doi: 10.1109/IWAIT.2018.8369763.
- [11] K. S. Htet and M. M. Sein, "Market Intelligence Analysis on Age Estimation and Gender Classification on Events with deep learning hyperparameters optimization and SDN Controllers," 2020 IEEE Conference on Computer Applications(ICCA), 2020, pp. 1-5, doi: 10.1109/ICCA49400.2020.9022854.
- [12] K. S. Htet and M. Myint Sein, "Effective Marketing Analysis on Gender and Age Classification with Hyperparameter Tuning," 2020 IEEE 2nd Global Conference on Life Sciences and Technologies (LifeTech), 2020, pp. 247-248, doi: 10.1109/LifeTech48969.2020.1570616797.
- [13] S. I. Gillani, M. A. Azam and M. Ehatisham-ul-Haq, "Age Estimation and Gender Classification Based on Human Gait Analysis," 2020 International Conference on Emerging Trends in Smart Technologies (ICETST), 2020, pp. 1-6, doi: 10.1109/ICETST49965.2020.9080735.

Secured Communication Through the Steganography Technique

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Abstract - Developments in the technology brings the convenience and comfort in all fields. The communication field also offers convenience by means through which the information can be transferred. During the transfer of confidential data, the important aspect which is of great concern is the security of the data. Data scrambling and hiding techniques came into limelight because of the simplicity in their implementation. A combination of data scrambling and data hiding technique can fulfill the requirements with security being primary, amount of data that can be embedded as a secondary issue. Concealing the data by embedding it into another file format while hiding the traces of existence of the message is the process of Steganography. The paper presents a methodology using python programming for providing security in the communication by hiding the information in the JPEG or PNG or BMP image. The proposed system uses Least Significant Algorithm that modifies the pixel values of images according to the information to be hidden into the image. This technique creates the Stego object at the sender side which is transmitted over the network. At the receiver end, the information is extracted using the same algorithm which is used at the side of sender. Hiding the data into least significant bit of the pixels of the images doesn't make a large change in the appearance of the image. Through the analysis of results, it is observed that the system can provide the security to the confidential messages by hiding the message into the least significant bits of image files.

Keywords—Least Significant Bit, Steganography, Cryptography, Stego image, PSNR, MSE.

I. INTRODUCTION

Steganography can be defined as the art and science of communicating in a way which hides the existence of communication. Although cryptography and steganography are often misconfused, they are essentially different. The first one scrambles a message so that it becomes understandable, the other one hides the message so that it cannot be seen. It is commonly believed that steganography could replace cryptography. On the contrary, by using the data scrambling and data hiding techniques together one can create a solid and powerful encryption system, better than that of each of these techniques individually.

Image is one of the important forms of information carrier, especially when it comes to sensitive matter of information such as privacy and security. With digital data as a means of communication, messages can be hidden in the ones and zeroes of text files, images. However, in order to keep message secret, only certain bits of these images can be used. Hence, before the starting of the information hiding

process, the steganographic system must know the redundant bits that can be modified without altering the integrity of the file. After this, the least significant bits from the cover medium can be replaced with data that has to be hidden.

II. LITERATURE SURVEY

Many researchers have contributed their work towards security in the communication through their research papers. The survey of some of the papers is discussed in this section.

Kartik Sharma et al [1] had presented a method for image steganography which is more secure than the earlier steganography implementations. Although, some common steganography techniques were used, its integration with cryptography and neural networks made it arduous to break. The added encryption layer provides further layer of security with deep neural networks. Further, the main reason to add an additional encryption layer was that if the original cover was made public, the secret will still remain secure. The paper suggested a method that provides security using the combination of cryptography and the deep neural network.

K. Arun Kumar et al [2] had explained the detail analysis of data hiding using image encryption based on image. Due to the visibility problems, it is possible to tamper some sensitive information by the simple attacks, detection disabling attacks, ambiguity attacks or removal attacks. Hence it is observed that there is need of some constructive, robust, secured method of hiding data in encrypted form.

Namrata Singh et al [3] presented high PSNR based Image Steganography. In this paper, a new concept of Steganography had been introduced. The propounded method creates difficulty for an unauthorized person to determine presence of secret message. For improving the performance, three parameters like PSNR, MSE and NCC are considered. Through their work, it is observed that parameter like PSNR, NCC are getting increased and MSE is getting decreased for the proposed methodology as compare to discrete wavelet transform and discrete cosine transform based methodology.

Xintao Duan et al [4] had suggested a method for image steganography with generalization ability based on convolutional neural network and deep learning. This paper had offered a technique to hide two secret images into one carrier image. The obtained stego-image is transmitted to the receiver by combining three images into the encoder and the receiver receives the stego-image. Two required secret images were reconstructed at the receiver end. The work had been extended to prune their entire model to further reduce the number of model parameters and achieve faster hiding and extraction.

Pengfei Xue et al [5] had presented a multilayer steganographic method based on audio time domain segmented and network steganography. This paper had offered a multi-layer method based on the collaboration of audio steganography layer and network steganography layer (MLS-ATDSS&NS). In this paper, the authors mainly focused on the capacity, anti-detectability and robustness as the three important elements of steganography. Their proposed method was based on audio steganography. In their study, it is shown that the LSB method has higher capacity compared to other methods.

Habiba Sultana et al [6] had discussed a study on steganography and steganalysis. In this paper, the authors had presented a comprehensive survey of steganography and its classification. This classification of steganography techniques given is based on the various aspects, carrier file and key used. The evaluation parameter of steganography i.e., matrices which are used to measure the visual quality of an image such as MSE, PSNR, SIMM, quality factor, cross-correlation, etc. are also discussed. Also, the classification of steganalysis is described in detail.

III. OVERVIEW OF THE STEGANOGRAPHY

The term Steganography is derived from the Greek word ‘steganos’ meaning covered and ‘graphy’ meaning writing i.e., covered writing. Steganography is the process of hiding information by encoding messages within other seemingly harmless messages, graphics or sounds etc. Steganography is an ancient practice used for the communication. The various ancient methods of steganography were

- Shaving and tattooing,
- In 440 BC, people used to write messages on wood and covered it with wax
- Use of invisible ink
- Microdots and Null Ciphers

Steganography techniques in a digital age uses cryptography and steganography that uses the same principle, to hide messages in a specific medium. However, they have one distinct difference, cryptography is dependent on hiding the meaning of the message, whereas steganography is dependent on hiding the presence of a message altogether. The steganography achieves this through little of its own traits. The extended use of internet and its vast amounts of data needs this trait and for this reason, it can be a very effective method of securing data transfer.

A. Factors defining effectiveness of Steganographic technique:

The effectiveness of a steganographic method can be decided by comparing the resulted stego object with the cover image. There are several factors that defines the effectiveness of a technique. These factors are:

- **Robustness:** The embedded data shouldn't be corrupted when stego data is exposed to attacks such as linear and nonlinear filtering, sharpening or blurring, random noise insertion, rotation and scaling, cropping or breaking, compression, etc.
- **Imperceptibility:** Stego object should just look like an ordinary message. No user or software should arise doubts that the stego file carries any other data. Imperceptibility of the technique should be higher.
- **Payload capacity:** It denotes the amount of confidential information that can be kept in the cover data. Steganographic method objects to carry the maximum amount of confidential data with minimum change in cover data.
- **Mean Square Error (MSE):** It is defined as the average of the difference between a reference image value and a modified image value. Smaller the value of MSE means the more efficient steganography technique.
- **Signal to Noise Ratio (SNR):** SNR is the ratio of signal strength and noise power. It compares the desired signal level with the background noise level.
- **Complexity:** It is desirable if the technique has low complexity that can boost the effectiveness of the technique along with other qualities.

B. Comparison of various steganography methods

Table 1 shows the comparison of various steganographic techniques based on the various factors that defines the effectiveness of the technique.

TABLE I. COMPARISON OF STEGANOGRAPHY METHODS

Method	Payload capacity	Robustness	Imperceptibility	Complexity
Least Significant Bit	HIGH	LOW	HIGH	LOW
Spread Spectrum	LOW	MEDIUM	LOW	MEDIUM
Transform domain	MEDIUM	HIGH	HIGH	HIGH
Parity coding	LOW	HIGH	HIGH	MEDIUM
Phase coding	LOW	HIGH	MEDIUM	MEDIUM
Echo hiding	MEDIUM	HIGH	MEDIUM	MEDIUM
Masking & filtering	LOW	LOW	MEDIUM	MEDIUM

From the Table 1, it can be observed that the Least Significant Bit Algorithm is preferable technique as it has high payload capacity, high imperceptibility and low complexity.

IV. METHODOLOGY

This paper presents a system that uses Graphical User Interface to provide the interface for the user to access the system. The system embeds the confidential message in an

image format so that it is difficult for the intruder to suspect the presence of the message inside the image.

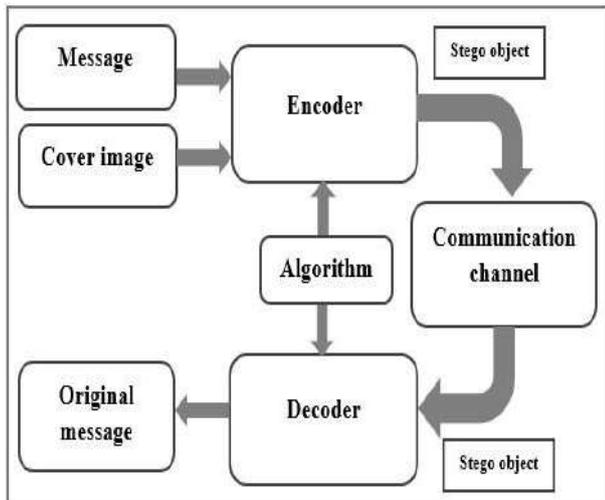


Fig 1. Block diagram of System

As shown in the fig.1, the message to be hidden and the cover image are fed into the encoder i.e., Steganographic encoder. The encoder will use Least Significant Bit (LSB) algorithm to embed the message into the cover image. The encoder will generate the Stego image having the message embedded into the cover image. This stego image is transmitted over the communication channel to the intended receiver.

Upon receiving the message at the receiver end, the decoder i.e., Steganographic decoder will use the same algorithm to extract the message from the stego image. The Stego image can be JPEG or PNG or BMP file format. The receiver knows the exact algorithm and technique hence can correctly decode the message concealed into the image.

As a result, at the output of the decoder the original message embedded into the image will be extracted. Only the receiver having the knowledge of technique used at the transmitter end can successfully reveal the information from the received stego image. The system provides a technique using Python programming that offers security in the communication.

A. Least Significant Bit Algorithm:

Digital images are made up of pixels. Pixels are the smallest element of an image that holds values representing the brightness of a given color at any specific point. An image is represented as a matrix or a two-dimensional array of pixels which contains a fixed number of rows and columns.

Least Significant Algorithm uses the LSB bits of pixel values of cover image into which the secret message is to be embedded. The modification in LSB bit doesn't make a big change the original decimal value.

B. Steps involved in LSB Algorithm:

LSB is a simple approach for embedding information in an image file format. As each pixel is represented by three bytes, three bits can be encoded into each pixel by applying LSB technique to each byte of a 24-bit image. Applying the LSB algorithm to each byte of an image, only one bit can be encoded into each pixel.

The steps involved in Least Significant Bit Algorithm is explained below:

Step 1. Convert the information from decimal to binary:

The secret message to be hidden is taken as input data then it is converted into its equivalent binary form.

Step 2. Read cover image into its decimal form:

After taking the secret message, the cover image fed into the system is converted into its equivalent decimal values.

Step 3. Conversion of the Cover Image from decimal to binary:

The decimal values are converted into its binary equivalent to use the bit values.

Step 4. Breaking the byte to be hidden into the bits:

Suppose the byte is (10000001), it will be divided into 8 bits as [1 0 0 0 0 0 1].

Step 5. Take first 8 byte of original information from the cover image:

Consider the first 8 bytes of cover image is as follow:

10010000 10011010 10011100 10010010
10010110 10011101 10101111 10100101

Step 6. Replace the LSB by one bit of the data to be hidden in following manner,

- First 8 bits of original data from the Cover Image
[1 0 0 1 0 0 0 0]

- First bit of the information to be hidden
1

- Replace the least significant bit

The least significant bit of the cover image will be replaced by Exoring it with the first bit of data.
[1 0 0 1 0 0 0 0] EX-OR [1] → [1 0 0 1 0 0 0 1]

Step 7. Repeat the replace process for all bytes of Cover Image. The process will be completed when all the bits of the information is embedded into the bytes of cover image.

V. RESULTS AND DISCUSSION

The main objective of this technique is to achieve the security in communication. This method uses Graphical User Interface to make it easy for the user to interface with system. User need to login into the system using the credentials. After successful login into the system, the user need to select one of the functions among Conceal (Encoding), Reveal (Decoding) and Share.

Upon selecting the conceal function, the system performs Encoding of the data into the image. It will ask for the secret message to be embedded into the image to transmit. Also, the image into which the message is to be hidden has to fed into the system by selecting that file. The

newly formed image called as stego image will be created once the user will select the Encode button. The process of embedding of the secret message in the required image file format will start once the encode button is pressed after the selection of cover image. This system can select JPG or PNG or Bitmap file to encode the secret message. At the receiver end, upon selection of Reveal function the system will open the window where the user need to select the file to be decoded to extract the original message.

A. Appearance of original images and resulted images

The appearance of the cover image and stego image will not create a visible difference. As an example, the message "Have A Great Day Ahead" is embedded into the JPEG, PNG and BMP formats of cover image. These cover images and the resulted stego images are shown here:

a) JPEG images: As shown in Fig.2 and Fig.3, the cover image and stego image looks nearly same.



Fig 2. Cover image (Coverimg.jpg)



Fig 3. Stego Image (Stegoimg.jpg)

The size of the cover image is 209KB whereas the size of stego image is 180 KB for JPG image.

b) PNG images

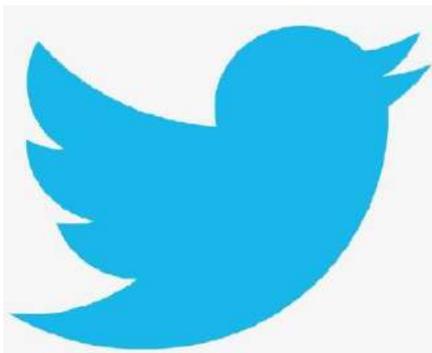


Fig 4. PNG Cover image (twitter.png)

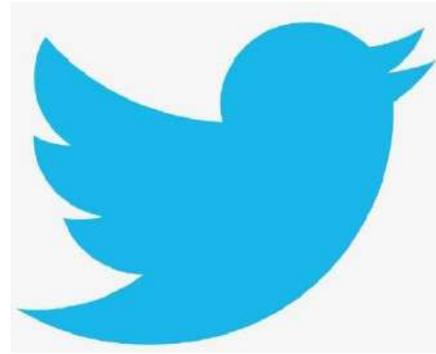


Fig 5. PNG Stego Image (pngimg.png)

The appearance of PNG cover image and stego image is shown in Fig. 4 and Fig. 5. The size of the cover image is 58 KB whereas the size of stego image is 21 KB for PNG image.

c) Bitmap images



Fig 6. BMP Cover Image (coverbmp.bmp)



Fig 7. BMP Stego Image (stegobmp.bmp)

With the same message embedded into the Bitmap image as it was in case of JPG and PNG image, the appearance of cover image and stego image doesn't create a visible difference for BMP image as shown in fig. 6 and Fig. 7.

B. Effect of encoding on the size of images

Embedding the message into the image doesn't create significant change in the appearance of the stego image, but it modifies the size of the actual image.

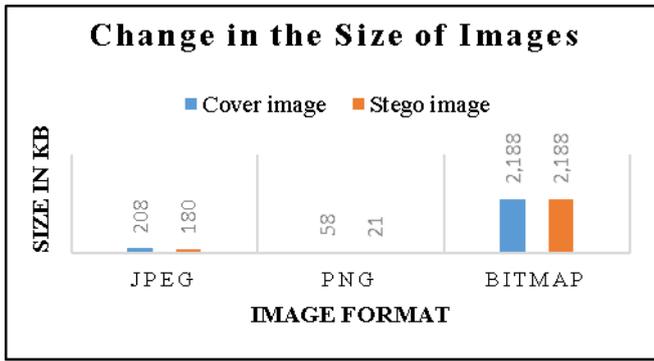


Fig 8. Changes in the size of images

The graph in fig. 8 shows the changes in the size of the image formats for hiding the same secret message into them. The percentage change in PNG image is large for the same size of message hidden.

TABLE II. PERCENT CHANGE IN THE SIZE OF IMAGES

Sr. No.	File format	Size of Image		Percentage change in the image size
		Cover Image	Stego Image	
1	JPEG	179KB	208KB	+16.20%
2	PNG	57.9KB	20KB	-65.45%
3	Bitmap	2.18MB	2.18MB	No change

The message “Have a Great Day Ahead” is embedded in three image file formats as shown in above figures. Table 2 shows the variation in the sizes of stego image compared to that of cover image for the same size of message embedded into it. It is observed that for same message if the selection of type of cover image changes, the percentage change in the size of the resulted stego image compared to original cover image also changes.

VI. CONCLUSION

The main goal of this technique is to provide security in the communication through the application of Steganography technique. Through the survey of various researches, it is found that the Least Significant Bit Algorithm is advantageous in imperceptibility, payload capacity and complexity.

This system uses JPEG, PNG or bitmap images. From the resulted images, it is observed that there is no change in the appearance of selected bitmap cover and stego image.

The percentage change in the size of cover image and stego image for JPEG image is less compared to the PNG image. The appearance of resulted image doesn't give the traces of message embedded into the image.

REFERENCES

- [1] Kartik Sharma, Ashutosh Aggarwal, Tanay Singhania, Deepak Gupta, Ashish Khanna, “Hiding Data in Images Using Cryptography and Deep Neural Network” Journal of Artificial Intelligence and Systems, 2019, 143-162 AIS ISSN Online:2642-2859.
- [2] K. Arun Kumar & S.M. Riyazoddin, “Analysis of Data Hiding Techniques in Encrypted Images - A Survey” Global Journal of Computer Science and Technology, Graphics & Vision Volume 13 Issue 4, (USA) Online ISSN: 0975-4172 & Print ISSN: 0975-4350.
- [3] Namrata Singh, “High PSNR based Image Steganography”, International Journal of Advanced Engineering Research and Science (IJAERS), Vol-6, Issue-1, Jan2019 <https://dx.doi.org/10.22161/ijaers.6.1.15> ISSN: 2349-6495(P) 2456-1908(O).
- [4] Xintao Duan, Nao Liu, Mengxiao Gou, Wenxin Wang and Chuan Qin, “SteganoCNN: Image Steganography with Generalization Ability Based on Convolutional Neural Network”, Entropy 2020, 22, 1140; doi: 10.3390/e22101140.
- [5] Pengfei Xue, Hanlin Liu, Jingsong Hu, Ronggui Hu, “A multi-layer steganographic method based on audio time domain segmented and network steganography” AIP Conference Proceedings 1967, 020046 (2018).
- [6] Habiba Sultana, “A study on steganography and steganalysis”, International Journal of Scientific & Engineering Research, Volume 9, Issue 12, December 2018 ISSN 22295518.
- [7] Kevin Curran, “Text based steganography” International Journal of Information Privacy Security and Integrity, January 2017 DOI: 10.1504/IJPSI.2017.088700.
- [8] G. Kalaiarasi, A. S. Narmadha, J. Nandhini, “Encryption And Decryption Of Data Hiding In Audio Signal Using LSB Algorithm”, International Journal of Advanced Research and Publications ISSN: 2456-9992, Volume 1 Issue 4, Oct 2017.
- [9] Ashadeep Kaur, Rakesh Kumar, Kamaljeet Kainth, “Review Paper on Image Steganography”, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 6, June 2016.
- [10] G. Kalaiarasi, A. S. Narmadha, J. Nandhini, “Encryption And Decryption Of Data Hiding In Audio Signal Using LSB Algorithm”, International Journal of Advanced Research and Publications ISSN: 2456-9992, Volume 1 Issue 4, Oct 2017.
- [11] Huseyin Bilal Macit, Arif Koyun, Orhan Gungor, “A Review And Comparison of Steganographic Techniques, Conference: INES 2018, Antalya, Turkey.
- [12] C. P. Sumathi, T. Santanam and G. Umamaheswari, “A Study of Various Steganographic Techniques Used for Information Hiding”, International Journal of Computer Science & Engineering Survey (IJCES) Vol.4, No.6, December 2013.
- [13] Niels Provos, and Peter Honeyman. “Hide and Seek: An Introduction to Steganography” IEEE Security & Privacy Magazine, May-June 2013.

Enhancement of Thermal and Noise Comfort Environment using High Volume Low Speed Fan (HVLS): A Case Study

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Abstract—An experimental study is carried out on traditional ceiling fans of a class room. Room temperature, air velocity and noise levels are measured. Power consumption and Cubic flow rate of air of the conventional ceiling fan is compared with the 8 feet and 24 feet diameter High Volume Low Speed Fans (HVLS). The comparative study shows that 8 feet HVLS fan offers relatively low CFM per watt ratio compared to conventional ceiling fan, however, noise level is significantly low. A single HVLS fan can replace 8 to 10 normal ceiling fans. Even though the initial investment cost is high, HVLS fan which runs silently with comfortable air movement at lower speeds can be better choice in the places like library, auditorium etc.

Keywords—HVLS, Thermal Comfort, Air velocity

I. INTRODUCTION

Human thermal comfort depends on many factors, in which, temperature, humidity, and air speed are among the most important ones. In cooling scenarios, although low temperature is the first choice for comfort control, moderate air speed as a breeze can enhance thermal comfort at higher temperature by “wind chill” effect. In residential and commercial buildings, temperature control is achieved by using air conditioners, while air speed can be increased by using ceiling fans. The proper use of a ceiling fan in an air-conditioned space can result in better thermal comfort and energy savings. Air movement can have a significant influence on human thermal comfort. When air temperatures are above about 23°C the body normally needs to lose heat in order to maintain a constant internal temperature in summer as well as in winter [1].

Not everyone knows that HVLS fans were actually invented as an alternative to the small box and pedestal-style fans that most people are familiar with. In 1998, Walter Boyd, founder of MacroAir, invented a slow-spinning fan to cool down dairy cows in California that were suffering from heat stress with one goal in mind—to harness the power of air.

High volume low speed fans are an excellent ventilation option for a variety of applications. HVLS fans provide optimum air movement with best-in-class energy efficiency and quiet performance. Technically, A High Volume Low Speed (HVLS) fan is an air circulating device of large diameter. It is available in sizes of 8 feet to 24 feet with ceiling heights over 26 feet. These larger diameter fans can move more air than smaller fans at the same speed. HVLS fan move slowly and distribute large amounts of air at low

rotational speed. Hence, they are called High Volume Low Speed (HVLS) fan.

Unlike a small, high-velocity fan that creates small, turbulent air streams that quickly disperse, an HVLS fan relies on size, not speed, to move a significant amount of air. Originally designed for large spaces such as barns and factories, HVLS fans have evolved as technology has rapidly improved. They now are found in a wide variety of industrial, commercial and residential spaces, often working in conjunction with HVAC systems for energy savings. In fact, energy-efficient HVLS fans have quickly assumed a leading role in the green building movement.

Moshfeghi et al. [2] have done CFD simulation on HVLS fan performance with different blade configurations. High-volume low-speed fans (HVLS) are rather new solutions for generating a silent, comfortable gentle air circulation in large enclosing such as warehouses, large barns and health clubs. Unlike residential ceiling fans that are typically 0.9 m to 1.3 m in diameter, the diameter of HVLS fans are between 2.5 ~ 7.5 m. Also, in spite of normal ceiling fans, HVLS fans rotate very slowly in the range of 45 ~ 80 RPM. The initial cost of these fans is relatively higher depending on size and type of materials used, but the overall energy efficiency as compared to high speed fans are also significantly higher [3,4]. These fans also create less noise because of their low speeds.

II. WORKING PRINCIPLE OF HVLS FAN

For a variety of applications, high volume low speed fans are an efficient ventilation alternative. HVLS fans deliver optimal air flow while delivering industry-leading energy efficiency and silent operation. HVLS fans work on the principle, that cool moving air breaks up the moisture-saturated boundary layer, surrounding the body and accelerates evaporation to produce a cooling effect [5]. These larger diameter fans can move more air than smaller fans at the same speed. The main benefits of HVLS fans are their capability to be used in both summer and winter together with the heating, ventilation and air conditioning; their low noise and gentle air flow and also the average energy savings of 49 percent plus consequent reductions in the generation of CO₂ and carbon.

The HVLS fan and its working principle is as shown in Fig. 1 and Fig. 2. HVLS fans work on the principle, that cool moving air breaks up the moisture-saturated boundary layer, surrounding the body and accelerates rate of evaporation to produce a cooling effect. HVLS ceiling fans

produce a column of air as they turn. This column of air moves down and out along the floor called horizontal floor jet. This deep wall of horizontal moving air is relative to the diameter of a fan, and to the speed of a fan. Once the floor jet reaches the floor, it moves the air outward until it meets a side wall or other vertical surface [5]. Performance of the HVLS fan is compared with the existing ceiling fans of a class room and results are compared.



Fig. 1. HVLS fan [5]

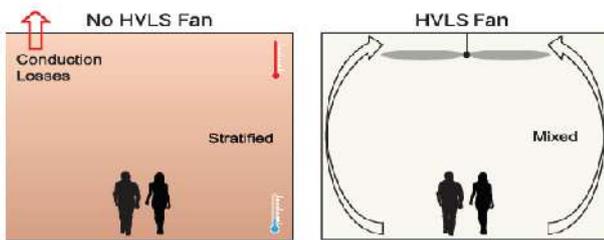
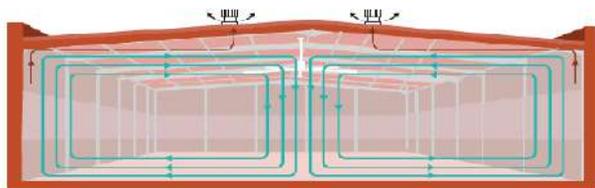


Fig. 2. Working principle of HVLS fan [5]

III. EXPERIMENTS AND RESULTS

The experimentation was carried out on traditional ceiling fans of a classroom located on 2nd floor of university building. The different parameters selected for experimental study are as follows;

1. Air velocity
2. Air flow rate (CFM),
3. Noise level
4. Energy consumption.

This study evaluates the energy saving potential of HVLS fan in comparison with the normal ceiling fan.

The classroom under experimental study has the following specifications:

Dimensions of Classroom = 33 ft × 30 ft × 12 ft

Floor Area = 990 ft²

Number of ceiling fans = 8, Crompton made with a diameter of 4 ft = 1.2 m

The average air velocity from a single fan was measured with the help of Testo make smartphone digital thermal Anemometer. The anemometer has an accuracy of 0.1 m/s with 0.01 m/s of resolution. The average air velocity, V measured 7 ft below from the centre of a single ceiling fan is given by,

$$V = \frac{2.50 + 2.36 + 2.49 + 2.58 + 2.44}{5}$$

$$= 2.47 \text{ m/s} = 148.2 \text{ m/min} = 486.22 \text{ ft/min}$$

For the calculation of air delivery (CFM-Cubic Feet per Minute) from a single ceiling fan, the effective sweep diameter at a height of 7 ft from the centre of a fan was found to be 1.3 m = 4.265 ft.

Therefore,

$$CFM = \text{Effective sweep area of fan} \times \text{Air flow velocity}$$

$$= A_E \times V \tag{1}$$

$$= \frac{\pi}{4} (4.265)^2 \times 486.22 = 6946.42 \text{ ft}^3/\text{min}$$

The noise generated from a single fan is measured with the help of Testo make digital sound level meter. The measuring range of this meter is from +32 dB to +130 dB with accuracy and resolution of ±1.0 dB and 0.1 dB respectively. The noise generated from a single fan was measured to be 64 dB. By putting all 8 fans ON, the average noise generated in the classroom was found to be 72 dB.

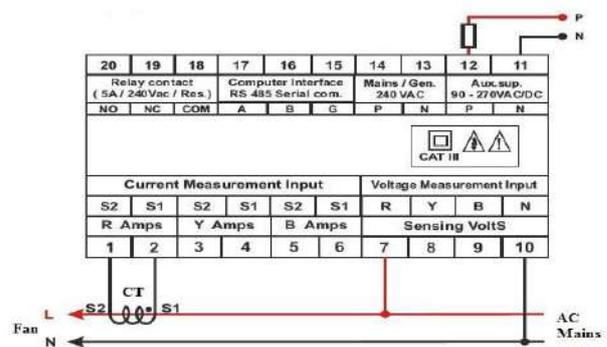


Fig. 3. Connection diagram for energy meter

VERITEK make VIPS 80P 3 phase digital energy meter was used for energy consumption measurement of ceiling fan. Connections were made for single phase energy measurement. Current transformer of ratio 40/5 was used along with energy meter for current measurement. Energy meter gives various parameters such as Active energy (kWh), Voltage (V), current (A), Active Power (watt) and power factor. 0.1 kWh is the resolution for energy meter. Accuracy is ± 0.5% of full scale for voltage, current, and power. Connection diagram for energy meter along with current transformer with fan supply is shown in Fig. 3.

The instantaneous power consumption, apparent current and voltage measured for a single fan at different regulator position of a fan is summarised in Table I.

TABLE I. POWER CONSUMPTION FROM SINGLE FAN

Fan Regulator Position	Wattage (W)	Current (A)	Voltage (V)
1	10.40	0.145	230
2	28.02	0.216	230
3	42.50	0.265	230
4	65.00	0.285	230

The power consumption per fan was found maximum at regulator position '4' of fan. Therefore, the total power consumed from 8 such fans will be equal to 520 Watt.

The comparison of these measured as well as some other parameters with the standard parameters specified by the manufacturers of the HVLS fan in their catalogue is tabulated in the following Table II, and the same is graphically depicted in Fig.4 as a bar chart.

TABLE II. COMPARISON OF TRADITIONAL AND HVLS FAN

Parameters	Traditional 8 Fans (4 ft Diameter)	HVLS fan	
		8 ft Diameter	24 ft Diameter
RPM	380 - 400	154	57
CFM	6946×8 = 55568	42,136	3,97,701
Power (W)	65×8 = 520	640	1400
CFM/Watt	107	66	284
Sound Level (dB)	64	35	65

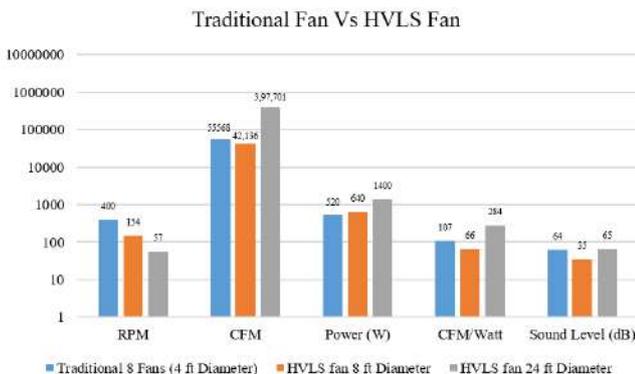


Fig. 4. Comparison of Traditional fan Vs HVLS fan

The results show that 8 feet diameter HVLS fan runs with significantly lower noise and lower speed, almost 50% lower for both, however, CFM slightly lower. It also consumes slightly higher power, almost 20% more than that conventional fan. Please note that here comparison is done with 8 fans. It can be concluded that for the given amount of

CFM in a chosen application, HVLS fan operates with less energy consumption, silent operation with low speed which brings the stress free working environment.

IV. CONCLUSION

The comparative study shows that, HVLS fans are the most efficient and effective air distribution system ever imagined which can replace 8 to 10 normal ceiling fans with a single HVLS fan. Greater the CFM per watt ratio, the less electricity it takes to move air and hence these fans are considered to be highly energy efficient. Even though the initial investment cost is high for HVLS fan, it runs silently with comfortable air movement at lower speeds. HVLS fan can be effectively used in places like Auditoriums, Libraries, Fitness gyms, Stadiums, Restaurants, Brewery and Airports etc. where ceiling heights are more than 18 ft.

REFERENCES

- [1] Ho S.H., Rosario L., Rahman M.M., "Thermal comfort enhancement by using a ceiling fan," Applied Thermal Engineering, vol. 29, 2009, pp. 1648-1656.
- [2] Moshfeghi M., Hur N., Kim Y.J., Kang H.W., "An Investigation on HVLS fan performance with different blade configurations," J. Comput. Fluids Eng. vol. 19, 2014, pp. 80-85.
- [3] Present E., Raftery P., Brager G., Graham L.T., "Ceiling fans in commercial buildings: In situ airspeeds & practitioner experience", Build. Environ., vol. 147, 2019, pp. 241-257.
- [4] Worley J.W., Bernard J.K., "Cooling Effectiveness of High-Volume Low-Speed Fans Versus Conventional Fans in a Free-Stall Dairy Barn in Hot, Humid Conditions", Prof. Anim. Sci., vol. 24, 2008, pp. 23-28.
- [5] Introduction to Specifying HVLS Fans. MacroAir Technologies Inc., www.macroairfans.com

Effect of Magnetic Field on the Damping Behaviour of a Ferrofluid Based Damper

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Abstract— This paper is an extension of our earlier work where we had reported a proof of concept for a ferrofluid based damper. The damper used ferrofluid as damping medium and it was seen that damping efficiency of the damper changes on application of magnetic field. The present paper deals with a systematic study of the effect of magnetic field on the damping efficiency of the damper. Results of these studies are reported. It is seen that damping ratio varies linearly with magnetic field ($\zeta / H = 0.28$ per T) for magnetic field in range of 0.00 to 0.45 T.

It may be mentioned that ferrofluid is different from magnetorheological fluid even though both of them are magnetic field-responsive fluids. The ferrofluid-dampers are better suited than MR Fluid-dampers for their use in automobiles.

Keywords—active dampers, ferrofluids, damping ratio, magnetic field

I. INTRODUCTION

Cars, buses and other vehicles, often, experience random oscillatory motions because of uneven roads or pot holes etc., and these oscillations are damped using shock absorbers or dampers. In general, above dampers work on piston-cylinder principle and their damping characteristics depend on the damping medium (e.g., oil) [1]. Contrary to what are available, one would like to have dampers whose damping behaviour can be controlled externally. This is because if the fact that damping requirements of a vehicle depend on road condition and load etc. The development of Magnetorheological (MR) Dampers has been a major achievement in field of shock absorbers [2, 3]. The damping behaviour of above dampers can be controlled by applying external magnetic field. These dampers use MR fluid as damping medium. The properties of MR fluids were not conducive to the working of viscous dampers and thus these dampers could not be exploited commercially. In a recent work [4], we used a ferrofluid as a damping medium and showed that it is possible to control damping behavior of a ferrofluid based damper also using magnetic field. This paper reports results of a systematic study of the effect of damping efficiency of the damper as a function of magnetic field. It is believed that ferrofluid based dampers are better suited than MR dampers for regular use in buses and cars [4,5].

II. FERROFLUID BASED DAMPERS

Conventional dampers used in cars or buses are piston-cylinder type viscous dampers where the motion of piston is damped by the viscous liquid present in the cylinder. The damping behavior of above damper can be controlled by changing the viscosity of damping medium. It seems, rheology of ferrofluids can be controlled by applying magnetic field [6] and thus these liquids are ideally suited for active dampers. Ferrofluids should not be confused with magnetorheological fluid (MR fluids), even though both of them are magnetic field-responsive fluids. Unlike ferrofluids which consist of nano-sized particles, MR fluids consist of micron sized particle suspended in a suitable oil. The magnetic particles tend to self-aggregate and thus MR fluids are not stable. Moreover, they exhibit hysteresis. On the other hand, ferrofluids are much stable and ferrofluid dampers have advantage of long life. The higher fluidity of ferrofluids as compared to MR fluids makes them better suited in damper applications.

III. DAMPING EFFICIENCY OF A DAMPER

The piston of a piston-cylinder type of oscillator performs an oscillatory motion. The amplitude of oscillations is independent of time in a free oscillator. However, amplitude of oscillations decreases with time in a damped oscillator.

Damping efficiency of a viscous damper is measured in terms of a dimensionless parameter ζ (referred to as damping ratio), which describes how rapidly the oscillations decay from one bounce to the next. The damping ratio ζ is defined in terms of a parameter δ (logarithmic decrement) such that

$$\delta = \frac{1}{n} \ln \left(\frac{x_n}{x_{n+1}} \right) \quad \text{and} \quad \zeta = \frac{\delta}{\sqrt{\delta^2 + 4\pi^2}} \quad (1)$$

where x_n is the amplitude of oscillation at the end of n^{th} cycle. Depending on the value of ζ , the oscillatory motion is referred to as undamped ($\zeta = 0$), underdamped ($\zeta < 1$), critically damped ($\zeta = 1$) or overdamped ($\zeta > 1$). The measurement of damper efficiency or damper ratio ζ involves monitoring the time dependence of amplitude of oscillation.

IV. EXPERIMENTAL DETAILS

Fig.1 is a schematic drawing of the piston-cylinder viscous damper used in present studies. Piston oscillates in a cylinder having diameter of 25.4 mm. The amplitude of oscillation of the piston was monitored as a function of time, and these data are used to calculate the damping efficiency or damping ratio of the damper. Measurements were made under varying experimental conditions. First, data were

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recorded for undamped damper when there was no viscous liquid in the cylinder. The other standard run was taken using water as the damping medium. The main data were taken using ferrofluid as damping medium and exposing it to varying magnetic fields. The damping medium was exposed to magnetic field using permanent neodymium magnets. There was a provision to move the magnets laterally and thereby change the magnetic field. The strength of magnetic field was measured using a hall probe.

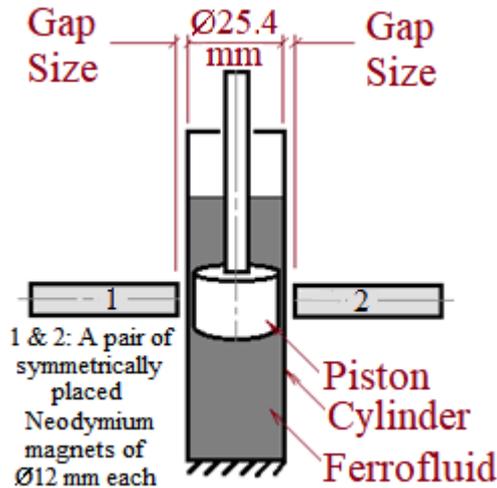


Fig. 1. Piston-cylinder damper using ferrofluid as damping medium. The fluid is exposed to magnetic field using permanent magnets.

The ferrofluid used for above studies was synthesized in our laboratory, the details of which are given in an earlier paper [4]. It consisted of a suspension of oleic acid coated Fe₃O₄ nanoparticles in kerosene. The said nanoparticles were synthesized using co-precipitation technique with FeCl₃ and FeCl₂ as starting materials.

The oscillation behavior of the piston was studied by connecting the piston to the vibrating system (Fig. 2), which consists of a beam pivoted at its one end and supported by a helical spring at the other end. Vibrations are sensed using an accelerometer sensor and its associated electronics [4].

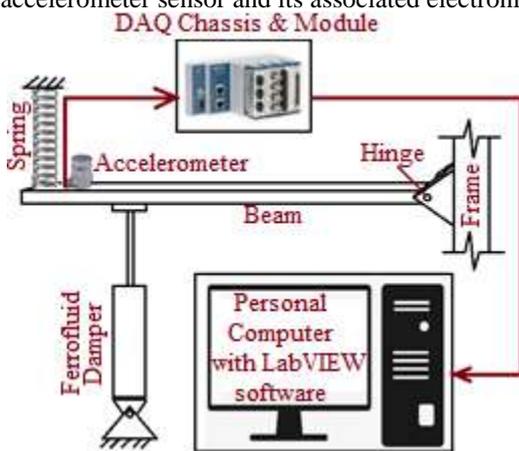


Fig. 2. Vibrating system used for measuring amplitude-time graphs for piston-cylinder damper. The acceleration is measured using uniaxial accelerometer and corresponding electronics.

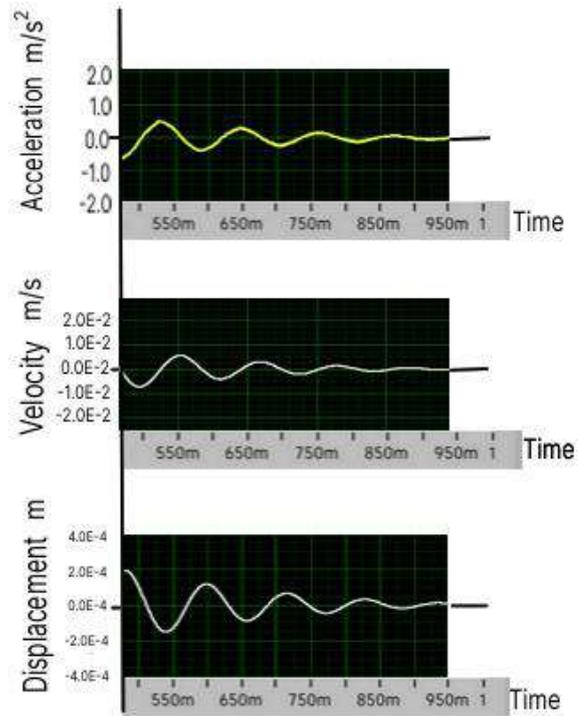


Fig. 3. LabVIEW readings obtained for Displacement, Velocity and Acceleration versus Time, for a typical data corresponding to magnetic field H = 0.32 T.

The amplitude - time graphs are obtained from acceleration - time graphs using standard integrations. This is illustrated in Fig. 3 where amplitude - time graph is obtained from acceleration - time graph for a typical data corresponding to magnetic field H = 0.32 T. The effect of magnetic field H on the amplitude - time graphs have been studied for several values of H in range of 0.00 to 0.45 T.

V. RESULTS AND DISCUSSIONS

The magnetic field in region of ferrofluid depends on the position of magnets or the gap size between the magnet and the cylinder. Fig. 4 gives the variation of magnetic field as a function of gap size. This plot was obtained by measuring magnetic field using a hall probe. In actual experiments, measurements were made for different gap sizes and the above calibration curve was used to obtain the value of the magnetic field.

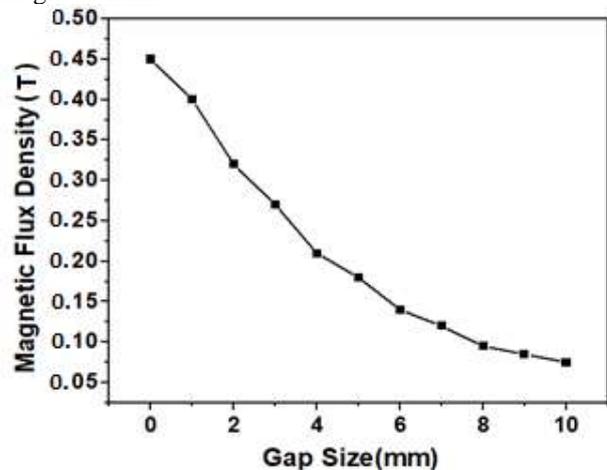


Fig. 4. Calibration curve between gap size and magnetic field.

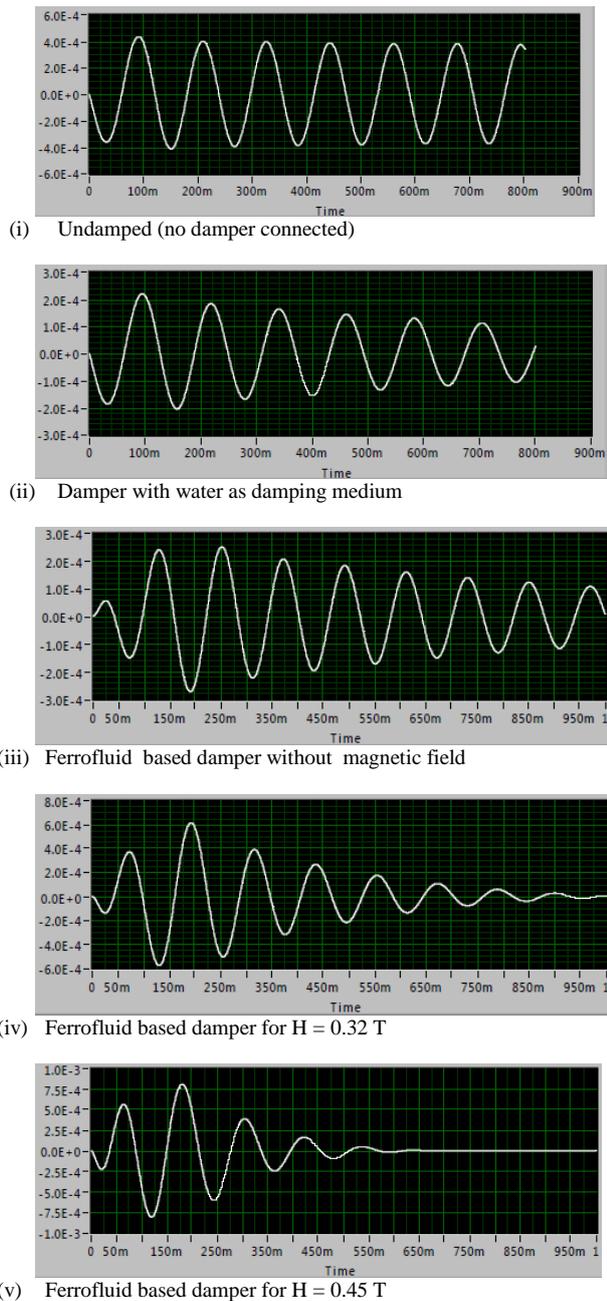


Fig. 5. Displacement versus Time graphs for the piston in viscous medium under different magnetic fields.

Fig. 5 shows the time dependence of amplitude of oscillations of the piston in above piston-cylinder damper corresponding to different magnetic fields (see Table 1). For the sake of completeness, amplitude- time graph of an undamped system is shown in Fig. 5 (i). It is noted that amplitude of vibrations does not change with time. Fig. 5 (ii) shows amplitude- time graph for a damper that uses water as damping medium. The amplitude of vibrations decreases slowly with time. Figures 5 (iii) to 5 (v) show amplitude- time graphs for a damper that uses ferrofluid as

damping medium. It is noted that damping of amplitude of vibration for ferrofluid-based damper is much more than that for water-based damper. Fig. 5 (iii), 5 (iv) and 5(v) correspond to measurements when damping medium was exposed to magnetic fields of 0.00 T, 0.32 T and 0.45 T respectively. It is seen that the damping increases with increase in the magnetic field.

It may be noted that Fig. 5 shows typical data, but actual measurements have been made for a number of H values (Table 1). These data along were used to calculate damping ratio ζ using the formulae given in Section III. Results are shown in Table I. Each measurement was repeated 5 times and average values of ζ are given in Table 1. Variation of ζ with magnetic field is shown in Fig.6. It is interesting that ζ varies linearly with H. Slope of curve suggests that rate of increase of damping efficiency is about 0.28 per T. It seems the magnetic nanoparticles form chains in presence of magnetic field and that gives rise to increase in viscosity and the damping ratio.

TABLE I. EFFECT OF MAGNETIC FIELD ON DAMPING RATIO

Sr. No.	Gap Size (mm)	Magnetic Flux Density (T)	Average Damping Ratio corresponding to five readings
1	100 mm	0	0.020
2	10	0.075	0.043
3	9	0.085	0.046
4	8	0.095	0.043
5	7	0.12	0.050
6	6	0.14	0.054
7	5	0.18	0.056
8	4	0.21	0.067
9	3	0.27	0.076
10	2	0.32	0.091
11	1	0.4	0.099
12	0	0.45	0.148

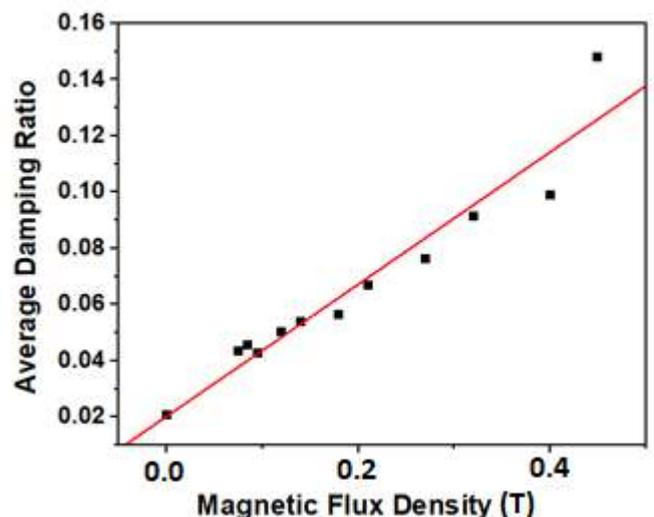


Fig. 6. Variation of damping ratio with magnetic field for ferrofluid based damper.

VI. CONCLUSIONS

This paper deals with ferrofluid based damper, where one uses ferrofluid as the damping medium. In an earlier work, we had provided a proof of concept and showed that the damping behavior of the damper can be varied by applying magnetic field to the damping medium. The present paper reports a systematic study of the variation of damping ratio ζ with the magnetic field H . It is seen that ζ increases linearly with magnetic field up to $H = 0.45$ T. The damping efficiency increases by a factor of 640% as the magnetic field is changed from $H = 0.00$ T to $H = 0.45$ T. In future, we propose to develop a mathematical model for damping efficiency in terms of magnetic field and viscosity of ferrofluid.

The fact that ferrofluids are more stable than MR fluids, it is expected that ferrofluid-dampers are better suited than MR Fluid-dampers for commercial exploitation.

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REFERENCES

- [1] J. C. Dixon, *The Shock Absorber Handbook*, 2nd Edition, John Wiley and Sons, 2007.
- [2] S. Sassi, K. Cherif, L. Mezghani, M. Thomas and A. Kotrane, Innovative Magneto-Rheological Damper for Automotive Suspension: From Design to Experimental Characterization, *Smart Mater. Struct.* 14, pp. 811-822, 2005.
- [3] B. K. Kumbhar and S. R. Patil, A Study on Properties and Selection Criteria for Magneto-Rheological (MR) Fluid Components, *International Journal of Chem. Tech. Research* 6, pp. 3303-3306, 2014.
- [4] M. Durga Rao, P. S. Goyal, B. Panda and R. I. K. Moorthy, Ferrofluids for Active Shock Absorbers, *IOP Conference Series: Materials Science and Engineering* 360, 012002, 2018.
- [5] Chuan Huang et. al., Damping Applications of Ferrofluids: A Review, *Journal of Magnetism* 22, p.109, 2017.
- [6] J. Yao, D. Li, X. Chen, C. Huang and D. Xu, Damping Performance of a Novel Ferrofluid Dynamic Vibration Absorber, *Journal of Fluids and Structures* 90, pp. 190-204, 2019.
- [7] R. Patel, R. V. Upadhyay and R. V. Mehta, Viscosity Measurements of a Ferrofluid: A Comparison with various Hydrodynamic Equations, *J. Coll. Int. Sci.* 263, p. 661, 2003

Membrane Casting Machine for Casting Membranes in Presence of Magnetic Field

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Abstract— The membranes are porous polymeric films and they are routinely used for water treatment. This paper deals with a membrane casting machine, which is best suited for synthesizing nano-composite membranes. The special feature of the machine is that it can be used to cast the membrane in presence of magnetic field, which is not possible in commercially available machines.

Conventional membranes are made of polymeric materials and they are synthesized using commercially available membrane casting machines. Efforts are being made to improve the performance of conventional membranes by incorporating nanomaterials such as metal/ metal oxide nano-particles and carbon nano-tubes (CNTs) into the membrane. In view of above, at times, one has to cast the membranes in presence of magnetic field. For example, one can align nanotubes and enhance water permeability of a CNT-Polymer nanocomposite membrane by casting the membrane in presence of magnetic field. However, commercially available machines do not have provision to apply the magnetic field. We have developed a Table-Top Semi-automatic Membrane Casting Machine where it is possible to cast the membrane in the presence of magnetic field. The magnetic field is applied to the polymer film using an electromagnet and it is possible to vary the magnetic field continuously in the range of 0 – 1500 Gauss. This machine allows synthesis of 100 mm x 100 mm membrane. The operation of the machine has been automated. It is possible to adjust the time of exposure to magnetic field continuously in the range of 1 Sec. to 100 Sec. There is provision to adjust the thickness of the membrane in range of 50 μm to 500 μm . The above machine has been used to cast Polysulfone - MWCNT membranes having vertically aligned nanotubes. It is seen that there is significant increase in water permeability if the membranes are casted in presence of magnetic field. The machine has potential of upgradation for large scale production of membranes.

Keywords— Water purification, CNT-Polymer nanocomposite membranes, Membrane casting machine, Alignment of CNTs, Magnetic Field

I. INTRODUCTION

Membranes are porous polymeric films and are used in many fields such as waste water treatment, industrial separation process and protein recovery etc. [1]. Depending on the pore size, water treatment processes employ several types of membranes. Ultrafiltration membranes for example, have pore size in the range of 5-100 nm and they are used for purification of brackish water [1, 2]. These membranes can reject large particles, micro-organisms, bacteria and soluble macromolecules such as proteins. Efforts are being made world over to improve the water permeability of above membranes. One of the methods for enhancing the water permeability, involves incorporating carbon nanotubes

(CNTs) into them and aligning CNTs in a direction perpendicular to the surface of the membranes [3]. Membranes would continue to play important role in supplying ample and clean water in future cities. This paper deals with development of a prototype Membrane casting machine which can be used for synthesizing CNT based membranes.

Polymeric membranes are usually prepared by process of phase inversion [4] using a polymer solution that consists of two polymers (basic polymer and a pore former) dissolved in a suitable solvent [1, 2]. The synthesis of membrane involves pouring of above solution (referred to as dope) on the casting plate, allowing the plate to pass underneath a casting blade and then submerging the plate in water tank. The polymer solution precipitates in form of a thin polymer sheet. At times, one has to cast the membranes in presence of magnetic field. For example, one can align nanotubes in a CNT - Polymer nanocomposite membrane by casting the membrane in presence of magnetic field. However, commercially available membrane casting machines do not have provision to apply magnetic field. We have developed Table-Top Semi-automatic Membrane Casting Machine where it is possible to cast the membrane in presence of magnetic field [5, 6]. The performance of the machine has been tested by synthesizing Polysulfone-MWCNT composite membranes, having aligned or un-aligned Multiwall Carbon Nanotubes (MWCNTs). This paper reports design details and salient features of the above machine, and also the results of our studies on MWCNT based membranes.

II. MEMBRANE CASTING MACHINE

A. Design considerations

Fig.1 is a schematic representation of membrane casting machine where it is possible to cast the membrane in presence of magnetic field. It consists of a casting plate, a casting blade, an electromagnet and a water tank. Unlike commercial machines where the casting plate is fixed and casting blade is used to spread the dope solution, it is important that one fixes the casting blade in present machine and spreads the dope solution by moving the plate. The casting blade has to be stationary as its movement is restricted by the magnet. The fact that casting plate has to slide underneath the blade, there are several restrictions on choice of casting plate. For example, glass plate will not serve the purpose. To ensure a smooth movement of the plate and to have a better control on the membrane thickness, the casting plate should be made of stainless steel (SS). The surface of the plate has to be suitably machined/ polished to have smoothness within $\pm 10 \mu\text{m}$.

Further, a special care has been taken to avoid the use of magnetic materials (mild steel etc.) in the fabrication of different parts of the machine. Synthesis of membrane in the above design, involves pouring of dope solution on the casting plate, allowing the plate to pass underneath the casting blade and then between the poles of an electromagnet and finally submerging it in water tank. There is a need to automate these operations. There automation should allow control of casting-time and the evaporation-time, The time taken in spreading the dope solution in the form of a film is referred to as casting-time; and the time for which the film is exposed to magnet (or air) before submerging it in water is referred to as evaporation-time. Evaporation-time and casting-time play an important role in deciding the quality of casted membrane. For example, it is useful to use larger casting time (slow plate motion) when dope solution has higher viscosity. Similarly, it would be useful to expose the film to magnetic field for a longer time, when one is aligning MWCNTs using magnetic field. It may be mentioned that one cannot increase evaporation time beyond a limit as, over a time; the film tends to solidify because of its interaction with moisture in the air. In any case, it is desirable that membrane casting machine has a provision to vary both, casting time and evaporation time.

that polymer film is fully submerged in the water. That is, one has not to lift and immerse the plate in water tank. As a part of synthesis cycle, film automatically gets immersed in water. This has been achieved by moving the casting plate at an angle to the horizontal surface. The plate can be moved back to the home position with a push of a button and the machine is ready for next cycle. The casting time and evaporation time can be adjusted continuously in range of 1 sec. to 100 sec. Table-1 gives a summary of the design parameters of the machine. The machine has been successfully used to cast membranes, both, with and without magnetic field.

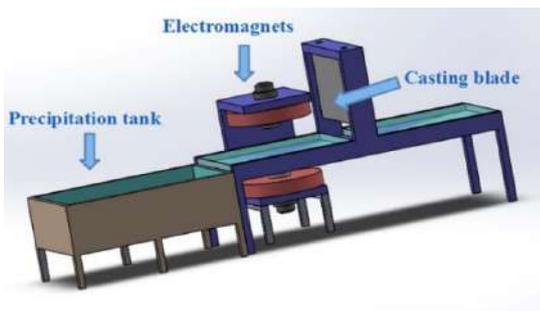


Fig 1. Schematic representation of membrane casting machine, having provision to cast the membrane in presence of magnetic field

B. Characteristic features of membrane casting machine

Fig. 2 is the photograph of the machine which have been indigenously fabricated and installed in our laboratory [5, 6]. The major components of the machine are similar to those shown in the schematic drawing (Fig.1). Casting plate and casting blade are made of stainless steel. Casting plate has been machined/ polished to have a smooth surface over an area of about 150 mm x 150 mm within an accuracy of $\pm 10 \mu\text{m}$. The magnetic field is applied to the polymer film using an electromagnet, which provides uniform magnetic field over an area of 100 mm x 100 mm. It is possible to vary the magnetic field continuously in range of 0 – 1500 Gauss. Spacing between blade edge and the casting plate can be adjusted to obtain film of required thickness in range of 50 μm to 500 μm . That is, total thickness of the film and substrate, if any, can be up to 500 μm . The operation of the machine has been automated. Once one pours dope solution on the plate and presses the start button, the casting plate slides underneath the blade at a speed which is decided by the preset casting-time and then it stays between the pole pieces of magnet for a preset evaporation-time. After elapse of evaporation time, the plate slides in to precipitation tank, such

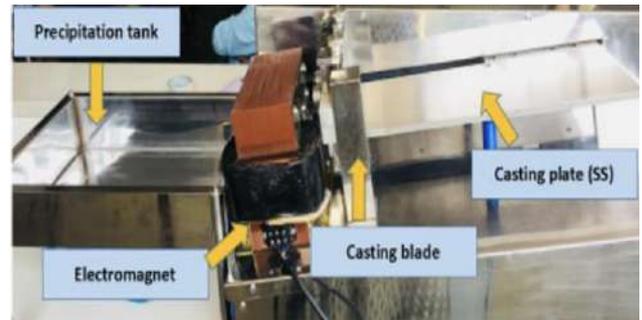


Fig 2. Photograph of semi-automatic table top membrane casting machine

TABLE I. DESIGN PARAMETERS OF MEMBRANE CASTING MACHINE

Sr. No.	Parameter	Value
1.	Membrane Casting in absence of Magnetic Field	Yes
2.	Membrane Casting in presence of Magnetic Field	Yes
3.	Size of membrane	95 mm x 95 mm
4.	Range of allowed thicknesses of Membrane	50 μm – 500 μm
5.	Smoothness of Casting Plate	$\pm 10 \mu\text{m}$ over an area of 150 mm x 150 mm
6.	Material used for casting blade	SS
7.	The area over which magnetic field is uniform	100 mm x 100 mm
8.	Range of magnetic field obtained using electro magnet	0 – 1500 Gauss (continuously variable)
9.	Range of pre-set evaporation time (Time over which film is exposed to magnetic field)	1 – 100 Sec.
10.	Range of pre-set casting time (Time that decides speed of movement of casting plate)	1 – 100 Sec.
11.	Inclination of plate to the horizontal (Required for immersing the plate in water without lifting it)	~ 25 Degrees
12.	Size of Water Tank	30 cm x 20 cm x 15 cm
13.	Automation of operation	Yes
14.	Over-all size of set -up	~ 90 cm x 40 cm x 30 cm

III. TEST EXPERIMENTS ON MEMBRANE CASTING MACHINE

The performance of membrane casting machine has been examined by synthesizing Polysulfone-MWCNT nanocomposite membrane with and without alignment of nanotubes. The degree of alignment of MWCNTs was monitored by measuring the water permeability of above membranes. A higher water permeability would imply a higher degree of alignment of nanotubes. The effect of variation in magnetic field or change in exposure time on water permeability of above membranes has been studied.

Pure Polysulfone (PSf) membrane was synthesized using PSf as base polymer, polyvinyl pyrrolidone (PVP) as pore former, N methyl - 2 - pyrrolidone (NMP) as solvent. First the 7.5 gm of PVP was dissolved in 87.5 ml NMP and then 25 gm of PSf beads were added to the solution. The above solution was kept in sealed glass bottles and agitated vigorously for several hours to attain complete dissolution of PSf. The membrane was casted using semi-automatic membrane casting machine as discussed above. Magnet was kept off while synthesizing pure PSf membrane. The thickness of the membrane was kept at 100 μm .

PSf/ MWCNT nanocomposite membranes containing unaligned or aligned MWCNTs were also synthesized. The alignment of MWCNTs was facilitated by mixing Fe_3O_4 nanoparticles in the dope solution, and casting the membrane in presence of magnetic field [6]. That is, dope solution for Polysulfone-MWCNT nanocomposite was similar to that used for pure PSf membrane, except that small amount of MWCNTs (0.1 gm) and nanoparticles of Fe_3O_4 (1.0 gm) were added to dope as additives. MWCNTs (outer diameter $\sim 6 - 13$ nm, length $\sim 2.5 - 20$ μm) were procured from M/s. United Nanotech Innovations Pvt. Ltd. India and nanoparticles of Fe_3O_4 (size ~ 22 nm) were synthesized in our laboratory [7]. The membranes were casted using above membrane casting machine with magnet in "On" position. The dope solution was poured on casting plate and then the plate was allowed to pass underneath the casting blade and then between the two magnetic poles and finally dipping it in water tank. During the time interval when viscous liquid film is exposed to magnetic field, Fe_3O_4 particles align along the direction of the magnetic field, and their alignment in turn aligns MWCNTs. This viscous liquid film, having MWCNTs aligned in a direction perpendicular to the membrane surface, solidifies on immersion into water.

To examine the role of magnetic field and the exposure time on properties of membranes, three sets of membranes were casted. Set-1 membranes (Sample 1 and 2 in Table 1) were casted in absence of magnetic field and the evaporation-time was kept fixed at $\tau = 5$ Sec. Set-2 and Set-3 membranes were casted in presence of magnetic field. In case of Set-2 membranes (Sample 2- 5) magnetic field was increased from 0 to 1500 Gauss for a fixed evaporation time $\tau = 5$ Sec. In case of Set-3 membranes (Sample 5 - 7), the magnetic field as kept fixed at $H = 1500$ Gauss and the exposure time was varied. All membranes had a fixed thickness of ~ 100 μm .

The water permeability of above membranes was measured to find out if MWCNTs are getting aligned and if the degree of alignment changes with the magnetic field.

Basically, this involved measurement of volume of water that permeates through unit area of membrane in a unit time. The water permeation studies were carried out on circular membrane (~ 35 mm diameter) samples using a cross-flow filtration cell [5], corresponding to a water pressure difference of 2 bar across the membrane. Volume of permeated water was collected for 5 minutes and average of three readings were used to obtain the permeation flux (in units of Liters/square meter/hour - referred to as LM^2H^{-1}). Results of water permeation studies for all membranes are given in Table – 2.

TABLE II. Water permeability of polysulfone – mwcnt nanocomposite membranes

Sr. No.	Composition of membrane	Evaporation time (sec.)	Magnetic field (Gauss)	Average permeated water flux (LM^2H^{-1})
1.	Pure PSf	5 Sec	No field	96
2.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	5 Sec	No field	145
3.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	5 Sec	1000 G	145
4.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	5 Sec	1200 G	341
5.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	5 Sec	1500 G	577
6.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	10 Sec	1500 G	820
7.	PSf + CNT (0.1%) + Fe_3O_4 (1%)	20 Sec	1500 G	567

The value of $F = 96 \text{ LM}^2\text{H}^{-1}$ for permeated water flux for pure PSf membrane, is in reasonable agreement with the values reported in the literature [8, 9]. It is seen that F increases from $96 \text{ LM}^2\text{H}^{-1}$ to $145 \text{ LM}^2\text{H}^{-1}$ on addition of MWCNTs to the PSf membrane. The fact that PSf / MWCNT (sample-2) was casted without magnetic field, it is expected that nanotubes in above membrane would have random orientations. However a small increase in water permeability suggests that MWCNTs provide additional pathways to flow of water, even when nanotubes are not aligned. Further, it is seen that water permeated flux for PSf/ MWCNT membranes (Sample 2 - 5) increases from $145 \text{ LM}^2\text{H}^{-1}$ to $577 \text{ LM}^2\text{H}^{-1}$, when the magnetic field is increased from 0.0 to 1500 Gauss. It is believed increase in water permeation is connected with the fact that nanotubes align in magnetic field and degree of alignment increases with increase in magnetic field. It is seen that degree of alignment or permeated water flux did not saturate at $H = 1500$ G and alignment of MWCNTs started for $H > 1000$ Gauss.

The water permeation studies for Set-3 membranes (Sample 5 - 7) bring out the role of evaporation time τ on the properties of casted membranes. It is seen that permeated water flux increases from $577 \text{ LM}^2\text{H}^{-1}$ to $820 \text{ LM}^2\text{H}^{-1}$ when τ is increased from 5 sec to 10 sec at a fixed magnetic field of 1500 Gauss. This indicates that the degree of alignment of MWCNTs increase with increase in evaporation-time for a fixed magnetic field. It seems, however, that τ cannot be increased indefinitely. When the above polymer film is exposed to air for a long time, it starts to undergo precipitation because of moisture in the air, and magnetic field would not be able to align the MWCNTs. It is believed that the decrease in F in going from $\tau = 10$ sec to $\tau = 20$ sec

for $H = 1500$ G is connected with partial precipitation of the film.

In short, above studies show that membrane casting machine can be fruitfully used to synthesize CNT-polymer nanocomposite membranes having vertically aligned CNTs. The increase in water permeability indicates alignment of CNTs but does not provide information on degree of alignment. No effort has been made to use advanced techniques (transmission electron microscopy or small angle x-ray scattering) to determine the degree of alignment of CNTs. In any case, it is expected that degree of alignment of CNTs (and the water permeability of membrane) would depend on several parameters such as concentration of CNTs, concentration and sizes of Fe_3O_4 particles, viscosity of solution, casting time, strength of magnetic field and evaporation time. These studies are being pursued but are out of scope of present paper. This paper confines itself to design, fabrication and testing of membrane casting machine.

IV. SUMMARY

Polymeric membranes are routinely used for water purification. Water permeability of conventional membranes can be improved if one incorporates carbon nano-tubes (CNTs) into the membrane and aligns the CNTs in the direction of flow of water. It seems nanotubes in CNTs-Polymer nanocomposites can be aligned by casting the membrane in presence of magnetic field. Commercial membrane casting machines, however, do not have provision to apply magnetic field. This paper deals with design and fabrication of a membrane casting machine where it is possible to cast the membrane in presence of magnetic field. The machine has a provision to apply uniform magnetic field over a membrane area of $100\text{ mm} \times 100\text{ mm}$ and it is possible to vary the magnetic field continuously in range of 0 - 1500 G. Synthesis of membrane in the above machine, involves pouring of dope solution on the casting plate, allowing the plate to pass underneath the casting blade and then between the two magnetic poles and finally submerging it in water tank. Operation of the machine has been automated. It is possible to pre-set the membrane casting time and evaporation time (time for which the film is exposed to magnetic field) in the range of 1 - 100 seconds. The thickness of the film can be adjusted in the range of $50 - 500\ \mu\text{m}$.

The machine has been used for casting PSf - MWCNT nanocomposite membranes under varying magnetic fields. It is seen that water permeability of the membrane increases by a factor of 6, when we increase the magnetic field from 0 to

1500 G. Further, it is seen that permeated water flux increases from $577\text{ LM}^{-2}\text{H}^{-1}$ to $820\text{ LM}^{-2}\text{H}^{-1}$ if the time, for which film is exposed to magnetic field, is increased from 5 seconds to 10 seconds. It is believed that higher water permeability of above membranes, is connected with increase in alignment of MWCNTs with the field. No effort has been made to optimize the parameters or to estimate the degree of alignment of MWCNTs. All the same, above studies show that that present membrane casting machine can be used to synthesize CNT-Polymer nanocomposite membranes having vertically aligned CNTs. It may be mentioned that above machine can be easily upgraded for large scale production of CNT based membranes.

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REFERENCES

- [1] R. W. Baker, Membrane Technology and Applications, 2nd ed., John Wiley & Sons, West Sussex, 2004, pp. 3-13.
- [2] D. Das, A. Datta & A. Q. Contractor, "Various Types of Separation Membranes", *Curr Sci*, vol. 110, pp. 1426-1438, April 2016.
- [3] D. S. Sholl and J. K. Johnson, "Making High Flux Membranes with Carbon Nanotubes", *Science*, vol. 312, pp. 1003-1004, May 2006.
- [4] P. V. D. Witte, J. Feijen, P. J. Dijkstra & J. W. A. V. D. Berg, "Phase Separation Processes in Polymer Solutions in Relation to Membrane Formation", *J. Membr. Sci.*, vol. 117, pp. 1-31, 1996.
- [5] P. S. Goyal and Bhakti Hirani, "Machine For Casting Thin Polymer Films Having Aligned Hollow Carbon Nanotubes Embedded in Them", Patent -Application No. 202021003922, dated 29-01-2020.
- [6] Bhakti Hirani and P.S. Goyal, "Synthesis and Water Permeation Studies of Polysulfone Based Composite Membranes Having Vertically Aligned CNTs", *Applied Physics*, arxiv. 2105.10473 (2021).
- [7] B. Panda and P. S. Goyal, "Oleic Acid Coated Magnetic Nanoparticles: Synthesis and Characterizations", *AIP Conf. Proc.*, vol. 1665, pp. 50020, June 2015.
- [8] H. Ravishankar, J. Christy and V. Jegatheesan, "Graphene Oxide (GO) - Blended Polysulfone (PSf) Ultrafiltration Membrane for Lead Ion Rejection", *Membrane*, vol. 8, pp. 77-90, September 2018.
- [9] A. Bedar, R. K. Lenka, N. K. Goel, S. Kumar, R. D. Jain, B. G. Singh, P. K. Tewari, R. C. Bindal, S. Kar, "Enhancement of γ -Radiation Stability of Polysulfone Membrane Matrix by Reinforcement of Hybrid Nanomaterials of Nanodiamond and Ceria", *Mater. Adv.*, vol. 1, pp. 1220-1231, June 2020.

Study of Jet-break-up of Liquids for Heat Extraction

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Abstract— Liquid jets have occurred on universal and sub-atomic scale over the years and have drawn considerable heed both for their potential practical use and for their heuristic engrossment, exhibiting important episodes of applied mathematics and physics. And in many instances, the sprays are formed from break-up of liquid jets or sheets. Experiments were done with the objective to predict the characteristic jet length of water, by studying the break-up of jets, under various parameters, like, diameter of jet, viscosity, surface tension, thereby leading to penultimate competition between inertia of liquid and surface tension, along with the dimensionless numbers, for the ease of prediction of drop size. The experimental setup included the breakdown of water jet with a burette filled with water, allowing it to flow through the nozzle by varying the flow rates, and droplet formation captured on a high-resolution camera. The drop size was measured graphically via reading of pixels from the images obtained. The experimentation was done carefully by maintaining the equilibrium which allowed the settlement of external disturbances, to find out how the thermophysical properties affect the flow and the final break-up of water sheets. The thermophysical properties and dimensionless numbers can shed light on fluids like molten salts using a similar mathematical analysis. For future work, the same concept can be used to design a system to extract heat from molten salts, like Solar Salt® which can be atomized into small granules and heat will be picked by blowing pressurized air in a counter current manner, similar to the Liquid Droplet Heat Exchanger (LDHX) developed in the late 1980's.

Keywords— Droplet formation, jet break-up, jet diameter, jet length

I. INTRODUCTION

Iron and steel industry are the pillars industry of national economy. In the past few decades, iron and steel technology has made tremendous development, namely, global steel production reached 1,527 million tonnes by 2011. However, the steel industry is one of the most energy-intensive industries, and accounts for approximately 4–5% of total world energy consumption. It also has a significant impact on the environment, each tonne of steel produced emits 1.9 tonnes of CO₂, accelerating global warming. Slags are one of the most natural products of all. They are comparable to fluid magma from the earth's core. Just like natural rocks, slags contain trace elements, but these are completely bound up within the crystal lattice, and therefore almost impossible to leach out. Nowadays, in the context of utmost concern for energy saving and emission reduction, one effective solution is to recover the waste heat in steelmaking process. Therefore, it attracts intense attention of the researchers worldwide to develop various heat recovery technologies for iron and steel industry. Study on the technologies for high temperature waste heat recovery of molten slag plays a vital role in achieving the goals of energy saving and emission

reduction in the iron and steel industry, about 1600 MJ/tonne, can power a small city. This paper aims to review the waste heat recovery technology based on the disintegration of liquids into droplets and its thermodynamic properties as widely encountered in nature, basic science, technology as seen in nuclear fission, medical diagnostics, DNA sampling, sprays, etc.

II. LITERATURE REVIEW

Wegner et al [1] investigated the breakup of capillary for many molten oxide jets. A graphite nozzle head allowing the production of an array of laminar slag jets which disintegrate into droplets due to the growth of instabilities. Their results showed consistent droplet formation with the presence of external vibrations. Dorman [2] worked on rating the performance of some nozzles generally used in agricultural purposes. The nozzles created a drop size distribution of the liquid, leading to the derivation of an equation by the means of dimensional analysis contemplating the current operating conditions at the nozzle to the drop diameter. Perrete and Loutaty [4] have made the use of a photographic technique, wherein the drop size of the liquid column was measure in a spray column. Davanlou et al [7] worked on an experimental study work deals break up characteristics of liquids with different surface tension and viscosity from a hollow cone hydraulic inject or nozzle induced by pressure-swirl. Velocity and drop size measurements of the spray using PDPA in both axial and radial directions indicate a dependency on surface tension. Bhagat et al [8] studied the conformation of composite drops by disunion of an axisymmetric composite spout fitted from a compatible smaller jet into another immiscible coflowing fluid, at motley viscosity and viscosity proportions, is numerically shoveled. At high thickness and viscosity rates, due to high shifting and thick force single-handedly, the drop layout is more chaotic and generally multi-core drops are formed. Xiao et al [11] determined a two-phase inrush utterance for atomization modelling, with a Coupled Level Set/ Volume of Fluid (CLSVOF) recipe espoused for interface-pursuit. Ultimately, the influence of liquid consistency on driblet division is numerically probed; the critical Weber number separating misshaping and division governances is well foretold at different Ohnesorge computation in comparison with the experimental data.

III. DROPLET FORMATION

A. Effects of droplet formation

Liquids have been ideal to be used in heat and mass transfer applications currently in many industries. However, breaking-up of liquids as droplets is done as the latter have

higher heat stability than a liquid jet emitting from a nozzle. The flow of the liquid has been the focus as it serves as a flux for hydrodynamic instability leading to droplet formation, and for that, droplet size must be predicted.

B. Prediction of drop size

Droplet diameters have been investigated for many years, coming out with both empirical and theoretical relations, giving out the droplet size based on experimentation. In this case, the result has been issued from a liquid jet via single nozzle. This coupled with the flow dynamics has brought out fruitful results.

IV. THERMODYNAMIC PROPERTIES

The liquid flow dynamics have been a driving influence in the formation of jet and the droplets. Some of these have been discussed below as the major factors:

- **Surface Tension:** Breakup of any jet into droplets is always driven by surface tension due to cohesive forces as water has tenacity, as a jet disintegrates into droplets by the gravitational forces overcoming the cohesive forces.
- **Viscosity:** The resistive force to the flow of the liquid by the liquid itself, showcases the geometry of the flow. Velocity of the flow is heavily dependent on the viscosity, as shown by the results later.
- **Density:** The effect of density variation on the flow of an incompressible and inviscid fluid is twofold. On the one hand, the inertia of the fluid changes in direct proportion to the density. On the other hand, the body force acting on a fluid element also changes in direct proportion to the density.

About the jet break up and droplet diameter, the usage if dimensionless numbers like Reynolds, Ohnesorge and Weber also have some into play:

- **Reynolds:** gives a qualifying guess if a flow is turbulent or laminar. It considers two parameters when calculated, inertial forces and viscous forces. Inertial force is from the movement of an object or in this case the movement of a liquid and the viscous force is the resistance of movement from something amorphous.

$$Re = \frac{\rho v d}{\mu}$$

- **Weber:** describes if a droplet is stable at a certain speed, density, surface tension and size. It is the ratio between the inertial force acting on the droplet and the surface tension of the droplet.

$$We = \frac{\rho v^2 d}{\sigma}$$

- **Ohnesorge:** relates the viscous forces to the inertia and surface tension. The numbers achieved from the below equation can be used to divide the waterjet to different regimes.

$$Oh = \frac{\mu}{\sqrt{\rho \sigma d}} = \frac{\sqrt{We}}{Re}$$

Notations:

Dimensionless Numbers:

Re Reynolds Number

We Weber Number

Oh Ohnesorge Number

Latin letters:

D_{jet} Diameter of jet, cm

L_b Jet breakup length, cm

d Diameter of droplet, cm

v velocity, ms⁻¹

Greek Symbols:

μ dynamic viscosity, Nsm⁻²

ρ density, kgm⁻³

σ surface tension, Nm⁻¹

V. EXPERIMENTAL SETUP

- The experiment to study the formation of jet and droplets was conducted at room temperature at 31 °C. The setup included:
 - Borosilicate burette (50ml)
 - Stand with clamps for holding the burette
 - Volumetric flask (50ml)
 - DSLR Camera (Canon EOS 60D)



Fig 1. Experimental Setup

- The burette held 50ml of each liquid, with the nozzle diameter being 0.6 x 10⁻³ m. After mounting the apparatus, the liquid used in this experiment was filled in the burette above the zero mark and the entire setup was left untouched for just over 15 minutes, which allowed for the settlement of the liquid and any other external disturbances (air, dust particles in the atmosphere) thereby increasing chances of consistent readings to be achieved. All the experiments were done at a room temperature of 31°C

Once the apparatus was settled, the stock knob was opened slowly to get allow the liquid to flow and get rid of any visible air bubbles. At first, the droplets came out and slowly as the opening was increased, the droplet flow was converted into a fine stream of liquid. This was done to achieve continuum of liquid flow. The entire process did go on for 30 seconds. After the time limit, the liquid was refilled in the burette with a flask up to the full mark, while the jet stream was still running. The readings were taken afterwards with the help of a DSLR camera with a focal length to achieve clear images was 1.59 to 1.61m. The images taken were used in software's like Microsoft Paint and Eleif Photo Measure to determine the diameter and length of the jet from direct conversion of the pixel to centimeters.

A. Equations

A stopwatch was required and the of volumetric flow was fixed for each set of readings. The first set of readings were purely experimental without any of the values being set beforehand. The calculation of experimental length was done with the help of the following equations by Grant and Middleman[1] for liquids:

$$\frac{L}{d} = (2.66 \ln(Oh) + 7.68 \left[\sqrt{We} + 3 \frac{We}{Re} \right]) \quad (1)$$

$$\frac{d}{d_{jet}} = (1 + 30h)^{1/6} \left(\frac{3\pi}{\sqrt{2}} \right)^{1/3} \quad (2)$$

TABLE I. THERMOPHYSICAL PROPERTIES OF LIQUIDS

Liquid	Properties		
	Viscosity (Nsm-2)	Surface Tension (N/m)	Density (kg/m3)
Water	0.00078	0.072	996.921
Kerosene	0.00164	0.024	789
Vinegar	0.0012	0.046	1050
Salt Water	0.00097	0.074	1023
Soap solution	0.0078	0.025	1010
Coconut oil	0.98	0.031	910
Castor oil	0.036	0.039	959

We investigate the different parameters that determine the characteristic drop size in the breakup of sheets. We vary both the spraying parameters, such as the pressure, and the fluid parameters, such as viscosity and surface tension. The combined results show that the drop size is determined by a competition between fluid inertia and surface tension, which allows for the prediction of the drop size from equation (1).



Fig 2. Jet break-up of water

B. Results:

Many rounds of the experiments were conducted to rectify the shortcomings and refine the values of jet flow under a short range of velocities, with the nozzle being too small to provide large differences in the final values. The tables II and III reveal the most refined set of readings of the liquids mentioned in table I. Initially water being the prime liquid, the error analysis for the comparison of the theoretical lengths obtained from the equation (1), and experimental lengths came down to a respectable sub-30% range, thereby inducing other liquids later. The aim was to get values as close as possible, to check the validity of the experiment with liquids having varying properties. The results showed that theoretical jet lengths are very much in conjunction with the experimental values, hence deducing that jet lengths can be predicted for further liquids with similar properties.

TABLE II. RESULTS FOR NON-VISCOUS LIQUIDS

Liquid	Water	Kerosene	Vinegar	Salt Water	Soap solution
Jet Diameter (d _{jet})	0.132	0.026	0.026	0.026	0.052
Velocity (v)	0.86	5.28	4.78	5.97	4.38
Ohnesorge Number (Oh) x10 ⁻³	7.55	0.022	0.01	6.913	6.8
Weber Number (We)	13.51	228.7	135.6	128.1	403.02
Reynolds Number (Re)	1450.46	660.45	1087.4	1637.01	2949.2
Experimental Length (L _{ex})	5.71	2.62	1.248	1.976	5.72
Theoretical Length (L _{th})	5.96	1.03	1.42	1.66	5.96

However, the difference between equations (1) and (2) turned out to be a major point of difference when more viscous liquids, were used, like oils, quite evident from table III, where equation (1) was used, the difference between theoretical and analytical values being very high and therefore cannot be accepted for further prediction purposes.

TABLE III. RESULTS FOR VISCOUS LIQUIDS

Oils	Castor	Coconut
D_{jet} (cm)	0.281	0.49
Velocity (m/s)	0.31	0.98
Oh	2.07	0.08
We	4.91	138.14
Re	1.066	145.66
L_{jet} (cm)	0.26	1.18
$L_{analytical}$ (cm)	15.11	7.68

When equation (2) was used, the results fared better. Table IV shows the values of oils being tested to see if the lengths can be predicted. The main parameter for difference between viscous and non-viscous liquids was identified as Ohnesorge number.

TABLE IV. RESULTS FOR VISCOUS LIQUIDS

Liquid	D_p (cm)	D_{jet} (cm)	Oh	LHS	RHS	Error
Castor oil	0.078	0.207	2.08	2.66	2.61	1.91%
Coconut	0.49	0.416	0.08	1.17	1.95	12.50%

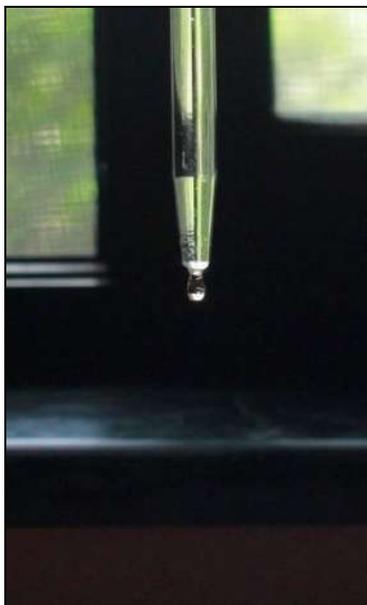


Fig 3. Jet break-up of coconut water

Drawing attention to fig. 3, it was the only instance that a perfect droplet being formed was captured on the camera, as other liquids being less viscous formed a fast-flowing jet. The Ohnesorge number thus provides a ratio of how large the timescales are for a fluid thread or jet of diameter, given

the knowledge of the fluid viscosity, density, and surface tension. In typical jets (with $d \sim 1\text{mm}$) of low viscosity fluids (such as water or aniline), the Ohnesorge number is very small, $Oh \ll 1$; in viscous liquids such as glycerine or machine oils, the Ohnesorge number can exceed unity [19]. Coconut oil, however turned out to be the odd one out as its Ohnesorge number was less than 1. Tables III and IV suggest contrasting values for coconut oil, hence it can be classified as semi-viscous liquid, as it does not satisfy equation (1), but it works for equation (2), thereby indicating that there is a band of values of Oh number, that classify the liquid as viscous and non-viscous. This procedure has been successful in predicting the jet lengths of the liquids at room temperature.

VI. SALTS

The earlier experiments were used with liquids at room temperature. To test the predictability of jet lengths of other liquids, the focus was shifted towards molten salts, which have been used as heat transfer liquids for having high heat capacity and operating temperatures, (250-1000°C). Most of these salts comprise of nitrides, fluorides, and chlorides. These salts have low risk of contamination, and fire hazards and hence can be used in metallurgy, ovens, dryers, kilns, alloy heat treatments.

A. F-Li-Na-K:

This is a ternary eutectic alkaline metal fluoride salt mixture of lithium, sodium, potassium, LiF-NaF-KF (46.5-11.5-42 mol %) having a melting point of 454°C, is a potential coolant for molten salt nuclear reactor with the following properties:

- Density $\rho = 2579.3 - 0.62T$
- Viscosity $\mu = 2.49 \times 10^{-5} e^{(1944/T)}$

B. F-Li-Be:

This is a molten salt made from the mixture of lithium fluoride (LiF) and beryllium fluoride (BeF₂), The 2:1 mixture forms a stoichiometric compound, Li₂BeF₄. It is both a nuclear reactor coolant and solvent for fertile or fissile material and has a melting point of 456°C.

- Density $\rho = 2413.03 - 0.488T$
- Viscosity $\mu = 1.16 \times 10^{-4} e^{(3755/T)}$

C. Solar salt:

It has a composition of 60% NaNO₃, 40% KNO₃ is recognized as the most successful material for solar heat transport and is readily used in solar thermal power plants. This melts at 220°C.

- Density $\rho = 2263.64 - 0.63T$
- Viscosity $\mu = 0.075 - 2.77 \times 10^{-4}(T-273) + 3.49 \times 10^{-7}(T-273)^2 - 1.47 \times 10^{-10}(T-273)^3$

As all the viscosities are the functions of temperature, a common temperature of 477°C was considered to understand the behaviour of the salts.

TABLE V. SALT PROPERTIES

Salt	Density kg/m ³	Viscosity Ns/m ²
F-Li-Na-K	2114.3	0.0003
F-Li-Be	2047.03	0.0173
Solar salt	1791.14	0.006

Considering the viscosity numbers being the prime values for comparisons, the closest of the values of earlier liquids were matched with these salts and the results are shown graphically:

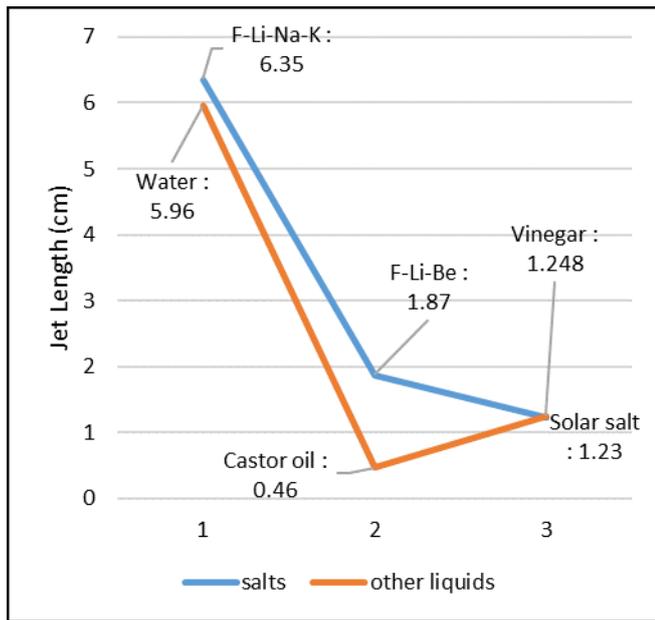


Fig 4. Prediction of jet lengths

The graph shows the predicted values of jet lengths in centimeters, with the closest one being solar salt and vinegar. Hence, this method can thus be used for prediction of jet lengths of other liquids under similar properties.

VII. DESIGN OF THERMAL HEAT EXCHANGER

This jet break-up phenomenon was used to design a liquid droplet heat exchanger which can be used to tap heat from the molten slag. The slag first must be granulated in small particles, as the small particles can be cooled fast, having more surface area. The plant is designed in such a way that the molten slag will fall from the top of the chamber on a rotating disk/cup, which will in turn throw away the slag due to centrifugal force, thereby breaking the highly viscous slag into jets and then droplets. Air will be forced to flow from the bottom of the chamber in the upwards direction, cooling the slag particles as well as taking up the heat from them (fig. 5), and this superheated steam can be used to run the turbines for the generation of power.

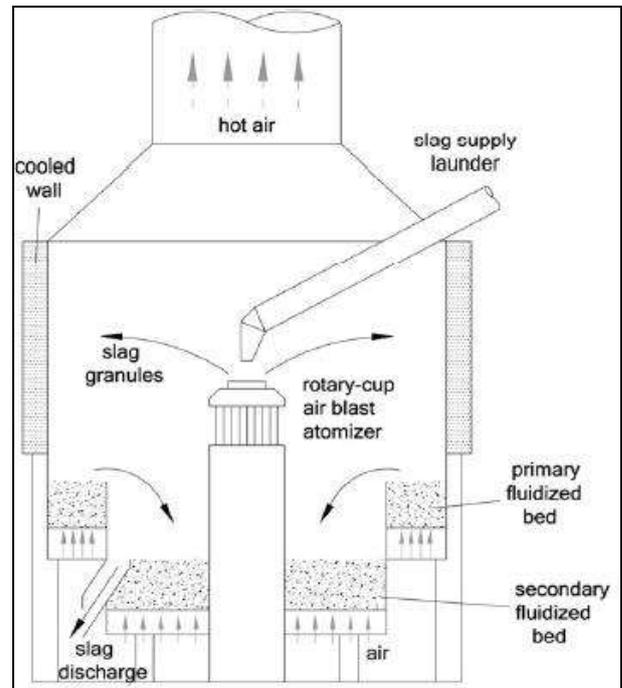


Fig 5. Centrifugal Granulator [22]

A similar heat exchanger was designed for simulation of heat flow with a boxy chamber, with the dimensions:

- L x b x h = 118 x 114 x 114 mm
- Inlet temp of the air = 30 °C
- Core temperature = 1500 °C
- Inlet speed of air = 5m/s
- Diameter of the disk = 30mm
- Total surface area of inner chamber = 74360 mm²

The simulation was run on Simscale, a free online software. The height of the heat exchanger was determined based on jet lengths obtained from the experiments conducted. The distance from the top of the chamber to the disc was 57.5mm, the jet length considered was 57mm, speed of disc was 100 radians/second.

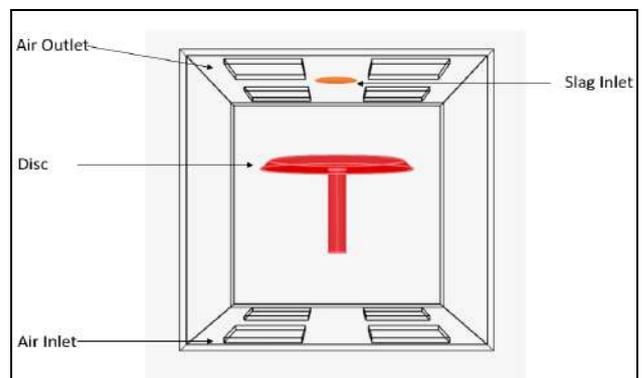


Fig 6. Heat Exchanger

The simulation ran for a time period of 21 minutes, with the plot of the air flow and temperature distribution shown below:

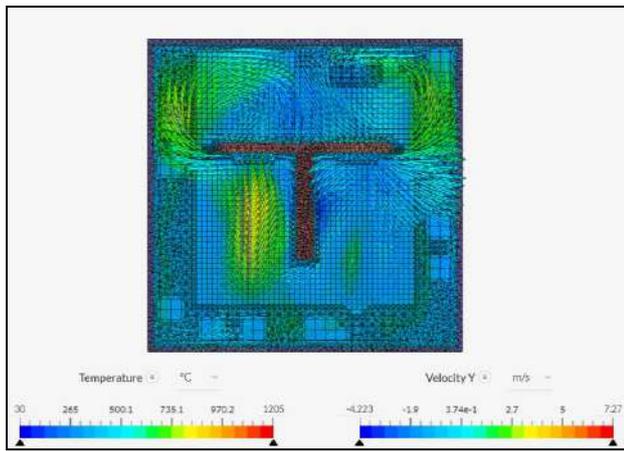


Fig 7. Temperature and air flow cut plot

The air flow is richly variable throughout the chamber, with the most of high temperature of air being detected near the top. The outlet temperature was 990°C, with air speed dropping to 3.7m/s. This shows a temperature drop of 510°C, which is taken up the droplets and the chamber as well.

VIII. SUMMARY

The parameters like velocity and the jet diameter proved to be quite detrimental in determining the droplet diameter as these parameters are essential in the calculation of dimensionless numbers like Reynolds, Weber and Ohnesorge which influence the entire experiment. From thereon, the droplet size can be predicted for other liquids with varying jet lengths and velocities with the extrapolation, including distilled water.

The experiment transcended from low viscosity liquids, like kerosene, vinegar, etc., to high viscosity liquids like castor and coconut oils. The results proved that the thermodynamic properties have significant impact on the flow dynamics of liquids, particularly viscosity and surface tension. The calculation with salts revealed that the viscosity has played a major role again, and the values are comparable with low viscosity liquids, thereby affirming the predictability of jet lengths for other liquids.

XI. CONCLUSION

The simulation has been carried out to get a grasp of how this concept can be used in dry slag granulation to tap into the heat released by molten slag and has yielded seemingly good results for a model of small size. For future work, this field can be explored by making a life-sized model with proper equipments and safety precautions being followed, and experiments can be conducted to show the potential of the heat generated and stored. Investigations are continuing in this field, and if it works out, we may have a major clean energy resource.

REFERENCES

- [1] M. Wegner, T. Kuhlmeier, L. Muhmood, S. Sun and A. V. Deev, "Controlled Disintegration of Multiple Jets of Molten Slag", ISIJ International, 2014
- [2] R. G. Dorman, "The atomization of liquid in a flat spray, Chemical Defence Experimental Establishment", British Journal of Applied Science, 1951.
- [3] Z. Peng, Z. Yuan, X. Wua, J. Cai, F. Fan, Li Tie, G. Fan, C. Pana, K. Liang, "Experimental study on drop formation in liquid-liquid fluidized bed", Chemical Engineering Science, 2008
- [4] M. Perrut, R. Loutaty, "Drop Size in a Liquid-Liquid Dispersion: Formation in Jet Break-up", The Chemical Engineering Journal", 1971.
- [5] X. Xi, L. He, H. Gu, F. Sun, M. Liu, "Numerical study on droplet formation in T-junction microchannel with wall velocity slip", International Conference on Applied Energy, 2018.
- [6] P. Dastyar, M. S. Salehi, B. Firoozabadi, H. Afshin, "Experimental investigation of the effects of surfactant on the dynamics of formation process of liquid drops", Journal of Industrial and Engineering Chemistry, 2020
- [7] A. Davanlou, J. D. Lee, S. Basu, R. Kumar, "Effect of viscosity and surface tension on breakup and coalescence of bicomponent spray", Chemical Engineering Science, 2015
- [8] K. D. Bhagat, T. V. Vu, J. C. Wells, "Formation and Breakup of an Immiscible Compound Jet with Density or Viscosity Stratification", Applied Sciences, 2019
- [9] I. L. Omocea, I. R. Damian, C. Patrascu, C. Balan, "Formation and Break-up of Pendant Drops in a Viscous Liquid", EENVIRO 2016
- [10] W. Lee, L. M. Walker, S. L. Anna, "Geometry and fluid properties in droplet and thread formation", Physics of fluids, 2009
- [11] F. Xiao, M. Dianat, J. J. McGuirk, "A robust interface method for drop formation and breakup simulation at high density ratio using an extrapolated liquid velocity", Computers and Fluids, 2016
- [12] Q. Hu, T. Jiang, H. Jiang, "Numerical Simulation and Experimental Validation of Liquid Metal Droplet Formation in a Co-Flowing Capillary Microfluidic Device", Micromachines, 2020
- [13] V. K Mathur, H. Weinstein, "Note on drop formation at low velocity in quiescent liquids", Chemical Engineering Science, 1979
- [14] S. Schmidt, O. Krüger, K. Göckeler, C. O. Paschereit, "Numerical investigation of the breakup behavior of an oscillating two-phase jet", Physics of fluids, 2018
- [15] D. Chong, Q. Zhao, F. Yuan, W. Wang, W. Chen, J. Yan, "Research on the steam jet length with different nozzle structures", Experimental Thermal and Fluid Science, 2015
- [16] H. E. Edgerton, E. A. Haster, W. B. Tucker, "Studies in drop formation as revealed by the high-speed motion camera", 1937
- [17] C. Armstrong, S. Wiklund, "Characterization of waterjet in the water atomization process", 2018
- [18] S. Kooij, R. Sijs, M. M. Denn, E. Villermaux, D. Bonn, "What Determines the Drop Size in Sprays", Physical Review, 2018
- [19] J. Eggers and E. Villermaux, "Physics of Jets", Progress in Physics, 2017
- [20] K. Shibata, S. Koshizuka & Y. Oka, "Numerical Analysis of Jet Breakup Behavior Using Particle Method", Journal of Nuclear Science and Technology, 2012
- [21] J. D. Pandey, B. R. Chaturvedi, R. P. Pandey, "Surface Tension of Molten Salts", Journal of Physical Chemistry, 1980
- [22] H. Zhang, H. Wang, X. Zhu, Y. J. Qiu, K. Li, R. Chen, Q. Liao, "A review of waste heat recovery technologies towards molten slag in steel industry", Applied Energy, September 2012

Survey of Object Detection Methods in Fruit Detection and Counting

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Abstract— Computer vision is a field of artificial intelligence that deals with extracting useful information from images, videos and performing tasks using that information. Computer vision is used extensively in almost every field. With computer vision techniques, one can easily automate tedious tasks that would take forever when done by humans. Object detection is a computer vision technique that is used to locate and identify objects in an image or a video. This object detection and localization can further be used to count specific objects present in the scene. An application of this technique is counting on-tree fruits from images or videos of the trees in the field. Many researchers have proposed their systems to detect and count the number of fruits for yield estimation. This paper is a review of some studies performed on fruit detection and counting. We address different approaches that use Support Vector Machine (SVM), Convolutional Neural Network (CNN), Faster Region Based CNN (Faster-RCNN), Mask RCNN, GrabCut Model, You Only Look Once (YOLO), Simple Linear Iterative Clustering (SLIC) and Single-Shot Detector (SSD) methods along with their results and drawbacks. In addition to it we mention the research gaps while summarizing these studies. These studies have an average precision of 87.88%. Further, we propose a system using superpixels image segmentation and CNN to fill the research gaps and overcome the drawbacks of the previous works mentioned.

Keywords—Computer Vision, Artificial Intelligence, Object detection.

I. INTRODUCTION

Computer vision can be termed the eye of computers. It enables them to understand the world through image and video inputs. Computer vision consists of methods for acquiring, processing, analyzing, and comprehending images. This field is attracting a lot of attention because it is viewed as one of the most useful instruments for reducing human workload. In the agriculture sector, computer vision has been extensively studied in various aspects of precision agriculture, including autonomous harvesting robots, crop yield estimation, plant phenotyping, animal welfare assessment, plant pest, and disease detection, and so on. Fruits and vegetables are detected and their three-dimensional positions are located using computer vision systems. But, due to varying illumination conditions and severe occlusions, and the lack of publicly available image and video datasets, this field remains challenging. Fruit

recognition, despite receiving less attention, has gained attraction in recent years as a result of its applications in the agricultural and culinary industries.

Fruit recognition seeks to identify fruits based on their type, maturity, or both by analyzing and processing photographs of fruits. These techniques are simple for a human to perform unless he has no prior knowledge of the fruit. Computers, on the other hand, have failed miserably at these tasks. The process of recognizing fruits can be broken down into three key steps: 1) Image acquisition, which is accomplished by using image capture devices to acquire images of the fruit samples. 2) Fruit picture samples are restored, smoothed, or enhanced during pre-processing.

According to some sources, pre-processing also include transforming raw photos to a predefined state (i.e. Grayscale or different color spaces). 3) Image Analysis examines the output of the preprocessing step in order to identify the fruit. Increasing agricultural demands and product development have created new chances for fruit recognition to be used to obtain better products at reduced costs. The current fruit recognition technology is limited to a single type of fruit in a single location. It is not yet robust enough to be utilized to recognize fruit in extreme conditions, environments, or in situations where multiple varieties of fruits must be distinguished.

Once the fruits are recognized and located from the visual inputs, count if on-tree fruits can be obtained which helps in yield estimation. Yield estimation is crucial when it comes to improving field management and getting the outcome for theseason's harvest. Also, farmers can plan their next plantation strategy based on the previous yields. Currently, yield estimation is done mainly by manual counting which is time-consuming. Computer vision may help in improving the efficiency of yield estimation.

The rest of the paper is structured as follows: Section II is the summary of different studies performed on fruit detection and counting. In Section III we discuss the research gaps and propose a system to bridge the research gaps. Finally, the conclusion is given in Section IV.

II. REVIEW OF FRUIT DETECTION AND COUNTING

Lanhui Fu et al. performed banana detection based on color and texture features in the natural environment in the year 2019 [1]. They performed detection of banana fruit

from the images of banana clusters by using a red-green-blue camera. The background from the images was first removed in HSV color space by analyzing the relationship between the S color component and V color component which saved their detection time and improved detection efficiency. The banana area was then found adapting a support vector machine. They used the local binary pattern features and histogram of oriented gradient features of the banana for SVM classification. The dataset used was a custom developed of 4400 image samples. The results show that the system developed can be applied to detect bananas under different illumination and occlusion conditions. However, counting of the fruit has not been addressed in the study. Manya Afonso et al. proposed a system to detect and count tomatoes using the MaskRCNN algorithm [2]. The system managed to get an average precision of 87.5%. However, the dataset developed contained only 123 samples.

J.P. Vasconez et al. devised a system using two approaches, one being Faster RCNN along with Inception V2 and the other one with SSD and Mobilenet [3]. System was prepared to detect and count avocados, apples, and lemons. The models were trained, tested, and validated over a custom-developed dataset consisting of 2858 samples. Nicolai Hani et al., adapted CNN to count number of apples by training the model on 64000 image samples collected from multiple orchids [4].

Fangfang Gao et al. used apples as the sample fruit for testing [5]. They used 12,800 custom-developed image samples. They used the Faster R-CNN-based VGG16 model to detect the fruits hanging on the tree [11]. Their precision for non-occluded, branch occluded, leaf occluded, fruit occluded fruits were 90.9%, 85.8%, 89.9%, 84.8% respectively. The detection speed was nearly 0.241 (s/image). The VGG network used is extremely slow to train and the size of the weights is quite large. Sashuang Sun et al. proposed a method for detecting green apples consisting of fruit region extraction, segmentation, and recognition [6]. For the first section, a modified GrabCut algorithm was developed for the preliminary extraction of fruit target regions in the natural environment. The Ncut segmentation was the second part, and it was designed to handle the challenge of overlapping fruits in targets. In the final step, the three random point reconstruction method was used to generate circle fitting for each apple, based on the recovered contour information. But the methodology was tested on only 200 images of the sample, which was insufficient to justify the occluded fruit scenario.

Addie Ira Borja Parico et al., selected sample fruit for testing as pear [7]. Dataset was custom-developed with 1337 sample images. They used 3 approaches YOLOv4-tiny, YOLOv4, and YOLOv4-CSP for fruit detection and counting [12]. Their models YOLOv4-tiny, YOLOv4, and YOLOv4-CSP reached average precision of 93.93%, 95.72%, and 97.74% respectively. Maryam Rahnemoonfar et al., developed a simulation-based learning method, using deep learning architecture for counting fruits based on CNN and a modified version of Inception-ResNet [8]. The network consists of several convolution and pooling layers in addition to modified Inception-ResNet which helps to capture features in multiple scales. It is trained on simulated data of 24000 sample images which were generated with some degree of overlap along with variation in size, scales, and illumination. But when tested,

it proved effective for synthetic samples with an accuracy of 93.01%, while not so effective for random real images which resulted in average accuracy above 70%.

Xiaoyang Liu et al. used SLIC and an SVM classifier for the detection of apple fruits based on color and shape features [9]. They gathered 1844 image samples from two different orchards and took 444 samples from the cifar-100 dataset. Their precision for different illumination i.e. front light, backlight, sidelight, and artificial light were 95.87%, 90.70%, 94.52%, and 100.00% respectively. And the fruit detection time was noted to be 1.92s. Juan Feng et al. used a thermal camera to acquire an image for apple fruit recognition [10]. They used SVM Classifier on custom-developed 846 image samples. their system acquired an average processing time of 740.42s, and 91.62% of fruit recognition accuracy.

Table I. Summarises the fruit detected, the dataset used, models used, results, and research gaps along with the drawbacks

III. RESEARCH GAPS AND PROPOSED SYSTEM

A. Research Gaps

The system discussed in the earlier section proved to be fruitful in their respective requirements. However, there are research gaps that we discuss in this section.

The lack of a publicly available dataset for the detection of fruits from images lead the researchers to develop their custom datasets. Some of the studies discussed above could manage to collect only a hundred image samples which limit the efficiency and reliability of the system created. Most of the papers focus on the detection of fruit clusters or localization of fruit. Only a few researchers address the fruit counting problem which is crucial in yield estimation. Despite attaining high average precision, not all fruits were detected. Occlusion of fruits by leaves or adjacent fruits and fruits on the ground are often ignored. The regions that do not contain any fruit clusters are identified as fruit regions due to the same color features. Whereas, many of the features from the images are treated as background image noise. Furthermore, incomplete fruit regions and scenarios where fruits were partially ripped were not recognized. While the systems that detected incomplete fruit regions had a large relative error in detection.

The illumination factor has a huge impact while detecting fruits. Fruits in images with direct illumination were not detected. The datasets that were developed do not cover images from every angle. Besides, illumination conditions were controlled while the acquisition of images. Not all illumination conditions were considered which leads to inefficiency of the systems while detecting fruits from images that are brighter, darker, or have different illuminations all over.

Along with these research gaps, the models and architecture used such as VGG and YOLO, have large weights and have high computational costs. A solution that requires comparatively less computation power would be much more appreciated as it can be then implemented on an end-user basis without much hassle.

TABLE I. SUMMARY OF STUDIES PERFORMED

Work cited	Study	Fruit Detected	Dataset	Model	Results	Drawbacks and Research gaps
[1]	Lanhui Fu et al.	Banana	Custom Developed (4400 Samples)	Support Vector Machine, Otsu's threshold	Single-scale detection: Average accuracy =89.63% Average detectiontime = 1.325s Multi-scale detection: Average accuracy =92.55% Average detectiontime = 10.31s	Multi-scale detection is timeconsuming. The count of fruits present in the cluster after detection is not addressed.
[2]	Manya Afonso et al.	Tomato	Custom Developed (123 Samples)	MaskRCNN with R50, R101 and X101	Precision = 81.57% Recall = 82.09%	Less amount of image sample were collected.
[3]	J.P. Vasconez et al.	Avocado, Apple, Lemon	Custom Developed (2858 Samples)	Faster RCNN + Inception V2, SSD + Mobilenet	Faster RCNN +Inception V2: Average Precision = 72% SSD + Mobilenet: Average Precision = 53%	Not all fruits weredetected from the image by the algorithms. The occlusion of fruits by leaves is not addressed.
[4]	Nicolai Hani et al.	Apple	Custom Developed (64000 Samples)	CNN	Average accuracy (yield estimation) = 96.85% Average accuracy (patch counting) = 88.48% w/o pre-or-post processing accuracy = 80% and 94%	Occlusion of fruits by leaves or fruits and fruits on the ground are often ignored. Incorrect selection of the regions during detection. Most of the features are treated as image noise.
[5]	Fangfang Gao et al.	Apple	Custom Developed (12,800 Samples)	Faster R-CNN on VGG16 network	Non-occluded = 90.9% Branch/wire occluded = 85.8% Leaf-occluded = 89.9% Fruit-occluded = 84.8% Detection speed = 0.241(s/image)	The VGG network used is extremely slow to train and the size of weights is quite large.
[6]	Sashuang Sun et al.	Green Apple	Custom Developed (200 Samples)	GBVS-based GrabCut model + Ncut Segmentation Algorithm	Precision = 93.92% Recall Rate = 90.84%	Sparse dataset, due to which insignificant results are obtained for occluded clusters.
[7]	Addie Ira Borja Parico et al.	Pear	Custom Developed (1337 Samples)	YOLOv4, YOLOv4-tiny, YOLOv4-CSP	Average Precision YOLOv4-tiny = 93.93% YOLOv4 = 95.72% YOLOv4-CSP = 97.74%	High computational cost.
[8]	Maryam Rahmemonfar et al.	Tomatoes	Custom Developed (24,000 synthetic sample + 100 real random samples)	CNN (modified version of Inception-ResNet)	Average accuracy (above 70%) for real sample, Average accuracy (93.01%) for synthetic sample	Partially ripped tomatoes are not recognized. Direct illumination and color saturation in synthetic samples leads to misleading results in real samples.
[9]	Xiaoyang Liu et al.	Apple	Custom Developed (1844 samples), Cifar-100 dataset (444 samples)	SLIC and SVM Classifier	Precision = 95.12% Detection time = 1.92s	Pixel-wise segmentation would give out more precise results than the used detection box method.
[10]	Juan Feng et al.	Apple	Custom Developed (846 Samples)	SVM Classifier	Average processing time = 740.04s, Fruit recognition accuracy = 91.62%	The large average relative error in recognition of fruits from incomplete fruit regions.

B. Methodology

Images will be collected from different sources and will then be pre-processed using superpixels segmentation. Superpixels are the product of perceptual pixel grouping,

or, to put it another way, the effect of picture oversegmentation. Superpixels contain more information than pixels and match with picture borders better than rectangular image patches. The datasets will be divided

into training and validation sets. The proposed solution will be tested on the validation sets and on real-world input images.

C. Proposed System

Before the CNN application, we are proposing to implement a segmentation of the input image using superpixels because superpixels are generally used to divide the input image based upon textures. They are larger than pixels and try to combine different parts of the image based upon texture. This will help us in removing background information from the image and we will be getting only foreground information. When this region of interest would be given as input to the CNN, it would be focusing more only on the foreground and there would not be any disturbance of the background which would affect the performance of the CNN. This CNN method would be more accurate compared to the past methods where researchers have used either CNN or image processing. But we intend to combine image segmentation using superpixels and CNN. Superpixel-based segmentation is more accurate compared to k-means, OTSU, or the various other state-of-the-art techniques.

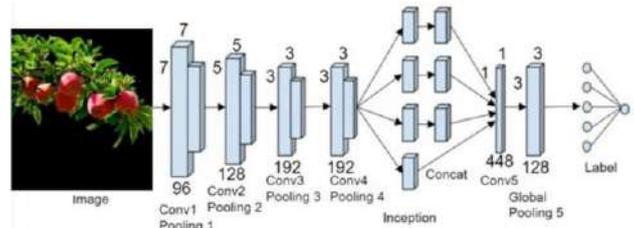


Fig 2. Proposed system using CNN

The input images will be classified according to the fruits detected i.e. a separate class for every unique fruit will be created and hence the output layer of CNN will contain names of the fruit detected as output classes. The CNN will be given an RGB image as an input processed by superpixels in the form of a three-dimensional matrix reshaped into a single column. Suppose the dimension of the input image is $28 \times 28 = 784$, it will be reshaped into 784×1 . Output from CNN will contain the label of the class detected. Fig 2. shows the proposed system using CNN. Fig 3a. and Fig 3b. show the output from the CNN detecting the fruits.

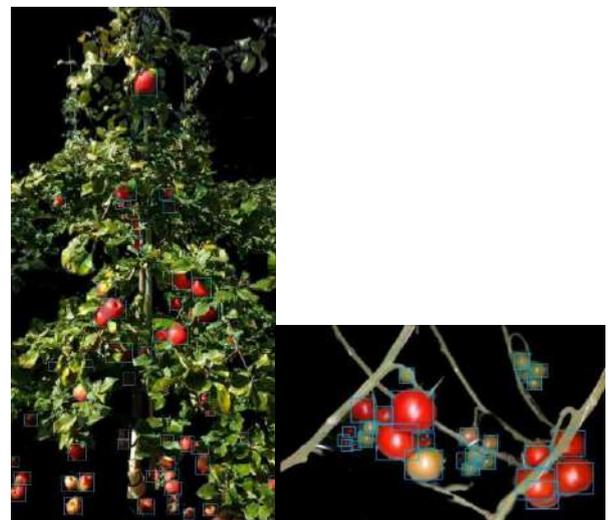


Fig 3. (a) and (b): Output from the CNN

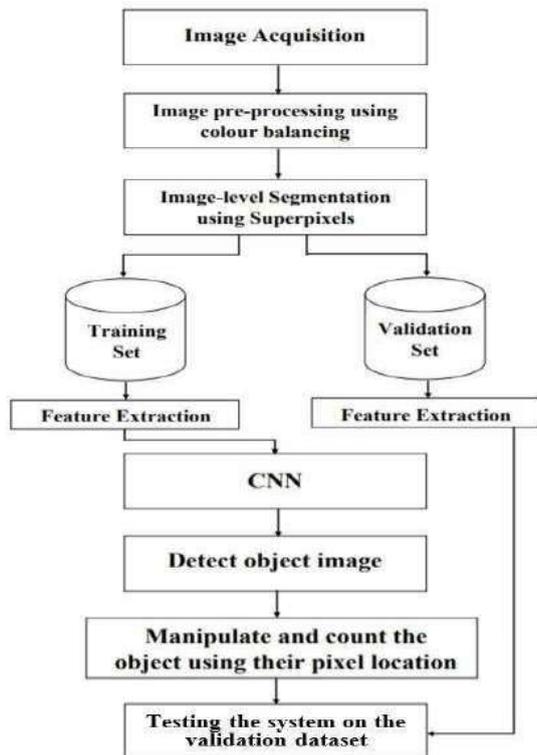


Fig 1. Block diagram for the proposed system

Fig 1. Shows a block diagram of the proposed system detection from varying distances. Finally, we proposed a system using superpixels-based image segmentation combined with CNN to fill the research gaps mentioned in the near future

IV. CONCLUSION

We discussed work done in fruit detection and counting. All the above-mentioned studies were successful in the detection of respective fruits in certain conditions. Most of the studies discussed covered fruit detection under various illumination and occlusion conditions except for a few. Some studies detected and counted fruits with high precision and covered all the challenging aspects while some studies only performed detection and some of them did not address occlusion conditions along with failing to detect or count all of the fruits present in the input image or video. We mentioned the drawbacks of these studies and the research gaps as well. Thus, researchers in this field can benefit from this study and try to fill the research gaps with their proposed systems in the future. We suggest the researchers to consider video-feed as input and carry out real-time detection including on-ground fruits and also detection from varying distances. Finally, we proposed a system using superpixels-based image segmentation combined with CNN to fill the research gaps mentioned in the near future

REFERENCES

- [1] Cheein, "Comparison of convolutional neural networks L. Fu et al., "Banana detection based on color and texture features in the natural environment", *Computers and Electronics in Agriculture*, vol. 167, p. 105057, 2019. Available: 10.1016/j.compag.2019.105057.
- [2] M. Afonso et al., "Tomato Fruit Detection and Counting in Greenhouses Using Deep Learning", *Frontiers in Plant Science*, vol. 11, 2020. Available: 10.3389/fpls.2020.571299.
- [3] J. Vasconez, J. Delpiano, S. Vougioukas and F. Auat in fruit detection and counting: A comprehensive evaluation", *Computers and Electronics in Agriculture*, vol. 173, p. 105348, 2020. Available: 10.1016/j.compag.2020.105348.
- [4] N. Häni, P. Roy and V. Isler, "Apple Counting using Convolutional Neural Networks," 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018, pp. 2559-2565, doi: 10.1109/IROS.2018.8594304.
- [5] F. Gao et al., "Multi-class fruit-on-plant detection for apple in SNAP system using Faster R-CNN", *Computers and Electronics in Agriculture*, vol. 176, p. 105634, 2020. Available: 10.1016/j.compag.2020.105634.
- [6] S. Sun, M. Jiang, D. He, Y. Long and H. Song, "Recognition of green apples in an orchard environment by combining the GrabCut model and Ncut algorithm", *Biosystems Engineering*, vol. 187, pp. 201-213, 2019. Available: 10.1016/j.biosystemseng.2019.09.006.
- [7] A. Parico and T. Ahamed, "Real Time Pear Fruit Detection and Counting Using YOLOv4 Models and Deep SORT", *Sensors*, vol. 21, no. 14, p. 4803, 2021. Available: 10.3390/s21144803.
- [8] M. Rahneemofar and C. Sheppard, "Deep Count: Fruit Counting Based on Deep Simulated Learning", *Sensors*, vol. 17, no. 4, p. 905, 2017. Available: 10.3390/s17040905.
- [9] X. Liu, D. Zhao, W. Jia, W. Ji and Y. Sun, "A Detection Method for Apple Fruits Based on Color and Shape Features", *IEEE Access*, vol. 7, pp. 67923-67933, 2019. Available: 10.1109/access.2019.2918313.
- [10] J. Feng, L. Zeng and L. He, "Apple Fruit Recognition Algorithm Based on Multi-Spectral Dynamic Image Analysis", *Sensors*, vol. 19, no. 4, p. 949, 2019. Available: 10.3390/s19040949.
- [11] K. Simonyan and A. Zisserman, "Very Deep Convolutional Networks for Large-Scale Image Recognition", *Export.arxiv.org*, 2021. [Online]. Available: <https://export.arxiv.org/abs/1409.1556>. [Accessed: 18- Sep- 2021].
- [12] J. Redmon, "YOLO: Real-Time Object Detection", *Pjreddie.com*, 2021. [Online]. Available: <http://pjreddie.com/yolo/>. [Accessed: 18-Sep- 2021].

Concatenation Coding Scheme for Communication System of Future Cities

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Abstract—Future city performance is a multifaceted job but is significantly vital. In general, the future cities of Smart are concerned about programs that use new digital technologies to make the delivery of urban and rural services more efficient and thus increase overall social competitiveness. While digital naming remains at the heart of the city's smart future, the key question is whether investing in smart technology and digital design ultimately contributes to improving the well-being of citizens. A people-centered approach needs the key to transforming a smart city in the future. The development of digital technology provides an unlimited opportunity to improve the lives of millions of people in urban and rural areas. Future City environment creates huge DATA and large communication channels. Results in more error / noise prone environment. So, the smart Digital communication system is to be deployed with Puncturing block and Interleaver block.

Keywords—Puncture FEC, Channel coding, Interleaver, Concatenated code

I. INTRODUCTION

Building Future Smart cities are not only the task of mega cities or the private firms. Governments is having a key role and feature to support state-of-the-art solution delivery, capacity up-building, and up-grading. [01] The Citizens of Future Cities are not only beneficiaries but also role player of the noble futuristic city policies. Taking the consideration of each citizens during the policy cycle reformation is nothing but thinking about, individuals at the core of future cities. The major need of Future cities smart and keen governance. The holistic approach is expected to build and adapt business and contract modules. The re-regularization is also expected during and working the formation of module rather than only controlling and enforcing regulation on public

While expecting much more changes in the traditional network services, the simplicity is also been advisable. So as the present services will not be affected adversely and more sustainable, efficient and flexible will be easily welcome by each part of society. The Information and Digital Technologies are the crucial paraphernalia to adore the inhabitants. Looking through the present situation of global warming, the future city must be greener as compare with as they are expected to be friendlier and faster. The ecofriendly approach should be reflected by developing the city through future transportation, future technology, future infrastructure and health care centers. More ever the future city should be energy efficient.

[02] The digital and ICT-based innovation are supposed to be major stack for the "Smart Future city". These Digital innovations are opening many ways to improve rural and urban services. By improving rural and urban services will

also open doors to many economical opportunities. The benefits and costs of future city development should give equal quantitative benefits to each and every apart of society elements as their contribution.

A. Limitation of Future City

The Future city concepts are limited by own policies. The due care should be taken that the present scenario benefits should that be converted in to future profanity. As per this paper concept the huge Data processing expected in to implementation of Future city, the maximum data utilization should be converted in to valuable Information. Also, this helps to build better policies for dealing and development of technologies. Each city approach to covert it in to Futuristic, will generate massive Data. The development and smart working of every Future city component rely on this Data generation and processing. The lack of massive Data that is massive information processing efficiency will limit the concept to flourish. One of the hurdles is that, the city municipal authority should be capable to incorporate these changes in to their system. The first most important constraint is the money, second is the mindset of inhabitant to adapt the changes for their betterment.

The digital technology innovation Data compatibility between all resources. Need technical manpower. The regular maintenance schedules. The many agencies who are working in that environment should have dedicated data collection and sharing policies.

B. Opportunities ahead Future Smart City

Smart Future cities offer a wide range of prospects for competent service, digital system incorporation, comprehensive service offering to society. The Future city opens innovative traditions to participate in the policymaking and administrative process. The new digital technology not only enforces cost but may also offer comprehensive economical cost-effective solutions. Integrating all system in Real time will improve productivity of system. Like in waste management system, electricity system, water supply system, human mobility system. [02] Powerful vehicles, bicycles and scooters can significantly decrease noise pollution as well as air particle pollution. All those mechanisms are make up for cities clever and effectual. Digital Information and system-communication technologies offers the significant mode to turn traditional cities into Future smart cities.

Digital Technology can promote a faster and more adaptable module of city authority through "e-governance" services and social technologies. Which helps access information and express ideas through online platforms, citizen monitoring and new community labs.

The elements of the future city are shortlisted in Fig.01. There are many elements of the Future city can be discussed, and here 8 different parts are represented in this drawing. Sections of smart cities include the following: Smart Human, Future Health Care, Transportation, Industry, Market, Future Schools, Smart Vehicles of the Future. Different smart cities have different levels of these smart things, depending on their focus.

Human: Is the driving part that leads to the construction of a city facing the city of the future. All information will be available from the Department of Labour to make an appropriate and effective decision.

II. COMMUNICATION SYSTEM COMPONENTS

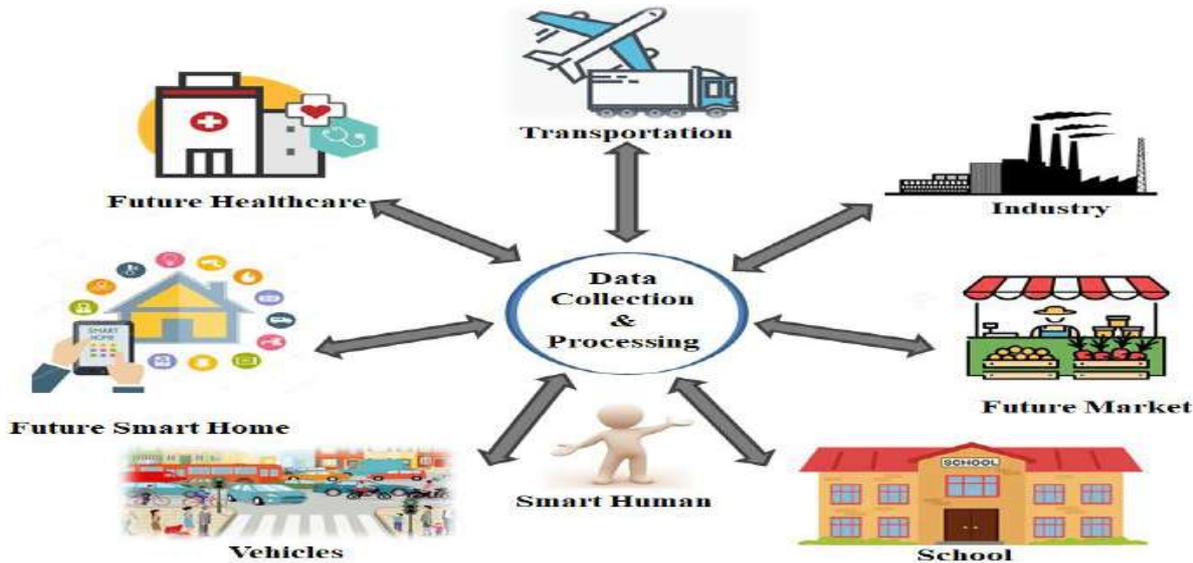


Fig. 1. Elements of the Future Smart City

Smart Home: These homes are also one of the data sources to turn a city into a smart city. Include security features such as web rental, automated home power consumption, maintenance planning, automatic gas lubrication etc. All of these services access and monitor in the web cloud.

Future Health Care: The future city must install this service to make it smarter. All health care facilities are connected to the web and various Data bases are monitored and investigated. In this form of the disease Covid-19 epidemic AI and ML are very important and require medical attention. By clicking all data will be checked and no resolution can be made.

Future Transport System: There are many things that can be used in this section. If travel plans become smart then fuel consumption can be reduced.

Industries: This sector is working hard on Automation. Even this Automation is connected via a smart server to download data on AI and ML to reduce time, money laundering.

Market: Just in the next city one has to click a requirement like buying an apple that person will get a good quality option. AI and ANN will not only provide stock availability to the consumer, but will also provide details on image processing assistance with ANN product quality.

Schools: Converting schools from Pedagogy to Synergy.

Vehicle: This component can be included in smart transport. But the car of the future will own and operate intelligently with AI and ANN.

[03] To effectively provide reliable ultra-latency connectivity and full connectivity to the Internet of Things (IoT) devices, wireless networks can follow the use of intelligent, data-enabled functions by integrating machine learning ideas across wireless contextual and terminal infrastructure. In this context, this paper provides a comprehensive study that looks at how digital communications components, such as Puncturing and Interleaver can be used effectively to support the communication needs of future cities.

A. Puncturing

In the sense coding theory, the Puncturing process is the process of removing some parity bits after inserting the code with the debug code. This has the same effect of encoding with a high-quality debugging code, or a small redundancy. However, by punctured the same decoder can be used no matter how many pieces are inserted, thus puncturing greatly increases the flexibility of the system without greatly increasing its weight.

In some cases, the pre-defined puncturing pattern is used for encoding. After that, the opposite operation, known as de-puncturing, is used with a decoder.

[04] puncturing is applied to UMTS during the measurement process. Also used for Wi-Fi, GPRS and EDGE, and DVB-T and DRM Standards. Puncturing are often used with the Viterbi algorithm in coding systems.

This example demonstrates how to use the Puncture block to pierce the insertion vector using modulus 6 puncturing pattern with 0 in the third and sixth positions, [1; 1; 0; 1; 1; 0]

If you enter a vector of numbers equal to the length of the puncturing pattern, the column vector output indicator removes the second and sixth values from the input signal.

If you enter a vector of twice the length of the specified puncturing pattern, the column vector output signal removes the input signal values in the 3, 6, 11, and 15 positions.

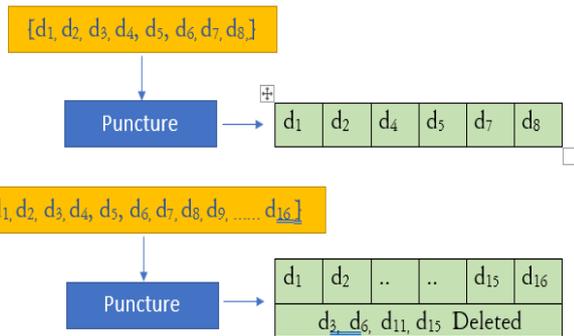


Fig. 2. Puncturing Scheme for Coded Bits

[05] Consider the q -ary code of the length of the q -ary code of length $qk - 1$. Solomon-Stiffier (1964) has shown that all (n, k) group code without duplicate columns can be obtained by removing or adding certain columns or links to this code. We present here the category of group codes (n, k) that are valid and available with a structured algebraic algorithm for piercing. The linking functions for $qk - 1$ are considered as a group (addition) to k generators with additional rules or unity checks provided by the k degree generator polynomial code. 0 column or ID is missing. The pierced links belong to certain subgroups of this group or, by $q \sim 2$ other co-sets of the repetitive group modulo repetitive group of objects $(q - 1)$.

B. Latency issues in the future system

A fraction of second of latency or delay, an independent vehicle that needs to apply its brakes cannot permit for even that may be result by cloud processing, requiring second-part decisions to operate safely. [06] If the network connection is temporarily unavailable, the drone controlled remotely or a assembler working on robotic in a smart factory should always be operational even, with immediate sensations and responses in local (and possibly dangerous) environments. A user who enjoys visuo-tactile needs not only discrete system visual delay but also a small variation of delays to avoid motion sickness. These new-fangled submissions have aroused great attention in the distribution, low consumption and reliability of the ML which calls for massive removal from web-based and regional-centered training and the direction of the novel system developed by the ML. ML Obtaining infancy outcomes with very low real time delay is essential for creating complex Internet-to-Stuff (IoT) systems that reply speedily to expected actions.

Modern communication systems that operate over time on various channels, should be able to adjust the rate depending on the available channel details to ensure the performance of the desired program and maximize throughput. Standard applications often use a variety of coding methods that are appropriate for channel features and meet the requirements for small error values (BER). Each coding scheme is developed independently so that a given scale meets the required performance. However, the complexity of such a system is very high, as it usually requires a separate encoder/decoder pair for each coding

system. Another way to detect rate fluctuations is to systematically enter a lower-level code, called the mother code, as the pieces of higher-level codes are a set of bits of lower-value codes. This method was introduced by Hagen Auer, in which piercings were introduced with specification codes. Its advantage is that it requires one pair of encoding/decoding for the entire price range.

Mother code puncturing can be done randomly or according to puncturing areas designed for a given unity matrix. The first is called random puncturing and the last as intentional puncturing in the following sections. By carefully selecting the sequence of bits to be punctured, we can significantly improve the performance of the code at various price points compared to random puncturing.

Punctured -coding is a method that allows system operators to correct errors further with encoding levels greater than $1/2$, with the desired features of the Viterbi computer with just a greater difficulty than the standard $1/2$ -Viterbi decoder.

This paper also introduces the operation of the Interleaver and Puncturing specification codes. It is shown that convolutional codes provide better error performance compared to data where the coding system is not used. It is indicated that variations in coding will affect the system's ability to correct errors. Therefore, we assume that with convolutional BER codes can be obtained.

C. Interleaver

Interleaver and De-Interleaver are developed and implemented in the background of signal distortion that can happen when pieces of messages are communicated by a sound channel. To recognize the purposes of Interleaver / de-Interleaver, considering and studying the features of the error is important. Two class of errors that affect the construction engineer of the communication system. These two types are Bunch error and arbitrary error.

Random/arbitrary Errors:

Distortion zones are independent. An error in one location will not have any relation with errors in other areas. Communication channels that inserts these class of distortion in signal are called "memoryless channels (because the channel has no information about distortion sites because a local error does not carry an error elsewhere).

Bunch/Burst Errors:

This type of Distortion in digital signal depend on each other. Such seen in channels with deep end features. Distortion in signal generally occur in explosions (distressing successive fragments). An error or distortion in one place has the effect of infecting other consecutive bits. In over-all, these signal distortion are considered reliant and those channels are termed as memory channels.

Block Interleaver:

Interleaving is the process of rearranging the sequence of data sequences before transfer. Block Interleaver is a popular Interleaver employed in digital data transfer. It is simple and easy to use and some types of Interleaver make it difficult to use. The Interleaver block is a column matrix of size Row $(R) \times$ Colum (C) ; where R is the total number of horizontal shift register and C is the total number of vertical shift register. To accomplish the interleaving process, the data

details are inserted in a R x C row-column matrix and extracted back in the column as shown in Figure 3. In a certain order the de-Interleaver block accomplishes the opposite function of the Interleaver where the details are written in R x C row-column matrix column wise and read back in row wise.

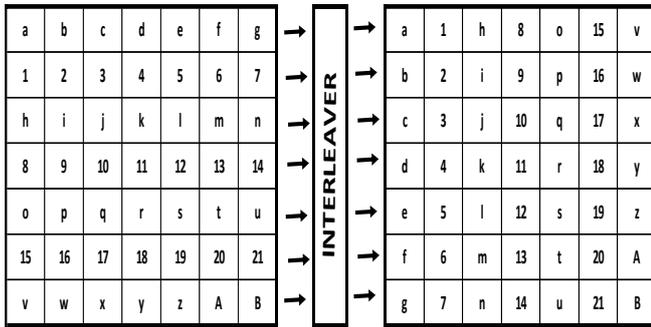


Fig. 3. Block Interleaver

Pseudorandom Interleaver rearranges the content of its input vector-shift registers using random variation. Incoming data is reclassified using a series of permitted indices. A permuter is actually a tool that generates a random pseudo permission for a given memory address. Details are sorted according to fake-random memory addresses.

The de-Interleaver must know the permuter-indices in much the same way as the Interleaver. The de-Interleaver organizes accumulated data back to its original state by using the knowledge of the permuter-indices.

The coding dialogue should be included or at least refer to the “Shannon capacity theorem and Shannon limit”. Shannon capacity refers to the maximum amount of data, or data volume, that can be sent to any channel or medium (wireless, coax, twister pair, fiber etc.).

$$C = B * \log_2 (1 + S / N)$$

where

C- maximum data rate

B bandwidth in Hz (data transfer)

S signal strength received

N is the total Channel Noise Power a/c BW (B)

And statement of Nyquist’s theorem is,

$$\text{Bit-Rate} = 2 * \text{Bandwidth} * \log_2 (L) \text{ bits/sec}$$

If, the signal contains a different L levels

Example: Input Data I = 01Mbits, Channel Capacity C = 01Mb/s. Output Frame = 01Byte each. Following table shows how the Puncture works.

TABLE 1. PUNCTURE SCHEME

No. Puncturing Bits	Available BW (Mbps)	Required BW (Mbps)	BW Difference (Mbps)
1	2	3	4
01	01	0.875	0.125
02	01	0.750	0.250
03	01	0.625	0.375
04	01	0.500	0.500

Maximum information rate that a channel can transmit is termed as “Channel capacity”. “Channel capacity” is termed in bits per second (bps). Channel capacity is a round-off term as measuring takes into account only the full amount of information transferred. The Colum number 4 shows the Shannon capacity theorem C>>R justification for the system with Puncturing component.

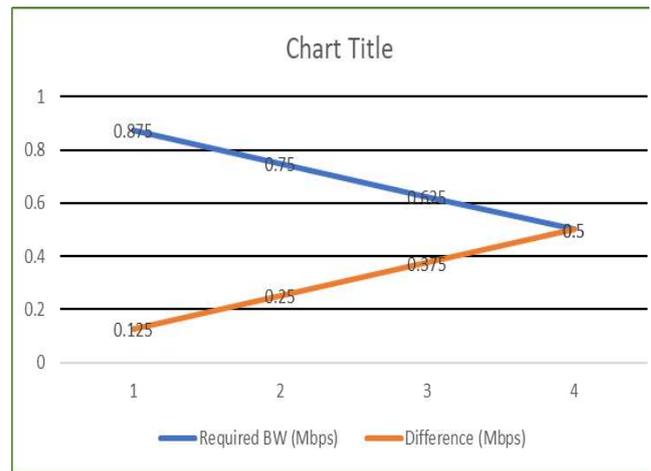


Fig. 4. Puncturing Bits Verses Required BW (Mbps) and BW Difference (Mbps)

A convolutional code is one of the most broadly used FEC channel codes. The convolutional code (N, K) is defined by two parameters K and N, respectively the number of input and output symbols, respectively.

[09] The rate K to N is called the code rate R = K/N. An (N, K) convolutional code is characterized by a (K x N) PGM $G(D) = _g_{i,j}(D)$, where $g_{i,j}(D) \in F_2[D]$ and D represents the delay operator. [The encoding process can be described by $c(D) = m(D)G(D)$, where $m(D)$ is the message sequence vector and $c(D)$ is the coded sequence vector

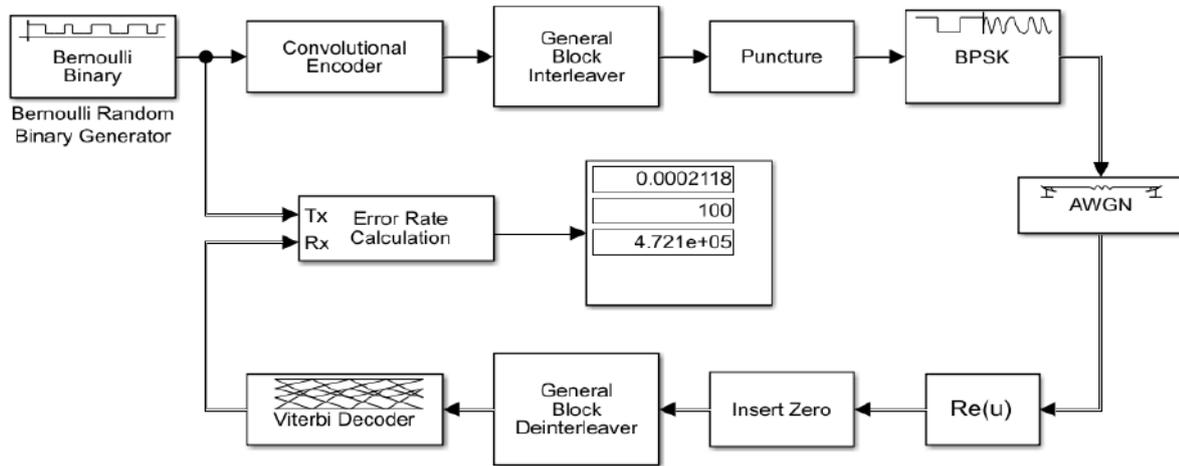


Fig. 5. Communication system with Puncture and Interleaver Block

The most similar of frequently used way to generate a high-rate Convolutional-Code is to break down the lower code (n, 1), called the mother code. The punctured-convolutional encoder available code is gained by periodically removing the inserted symbols from the mother code. The pattern to remove the marks is called the puncturing pattern. PGM of the punctured-convolutional code recording can be found in that of the mother code. Here, we briefly review the idea of K times blocked code embedded within. The mother code (n, 1) can be considered as a code (nK, K) called K times blocked code with K parallel effects and nK results.

As per the figure No. 05 the system result output is:

$$\text{Total Transmitted bits} = 6.052 \times 10^4, \text{BER} = 2.118 \times 10^{-4}$$

III. CONCLUSION

A Future city to flourish, all the major systems expected to work in coloration. The system should utilizing all of their properties to pass-on the challenges. The “ingenuity” of the Future city defines its ability to integrate all its elements, in order to make it more efficient and effective in making decisions. A Future city may have one or more shrewd mechanisms, including keen conveyance, canny health care, latest web, and futured home, etc. The increase of population day by day, the need for smart cities is also growing as available resources are restricted. Future City components are need to be smart to interface with Digital Web. With different sensing elements and advanced communication technique like AI and ML, these components work smart

As newer coding methods are developing, we are able to get closer and closer to the Shannon limit, usually at the expense of higher complexity and computational rates. Puncturing system component will enhance system parameter i.e. Latency, which will be the most demanding system parameter for future city environment. The Interleaver will efficiently work against the burst error situation.

REFERENCES

- [1] Lamia Kamal-Chaoui, “Smart Cities and Inclusive Growth Building on”, 1st OECD Roundtable on Smart Cities and Inclusive Growth, OECD Headquarters, 9 July 2019.
- [2] Saraju P. Mohanty, Uma Choppali, Elias Kougiianos “Everything You wanted to Know about Smart Cities”, IEEE Consumer Electronics Magazine · July 2016.
- [3] Mingzhe Chen, Ursula Challitax, Walid Saad, Changchuan Yin, and Mérouane Debbah, “Artificial Neural Networks-Based Machine Learning for Wireless Networks”, 1553-877X (c) IEEE, 2019.
- [4] Solomon, G. Stiffler, J. J., “Puncturing Syatematic Cyclic Codes”, Information And Control 8, 170-179 (1965) IEEE Convention Record 12.
- [5] Jiaxiang Li, Qingchun Chen, Suyue Gao, Zheng Ma, Pingzhi Fan, “The Optimal Puncturing Pattern Design for Rate-Compatible Punctured Turbo Codes”, International Conference on Wireless Communications & Signal Processing IEEE Xplore, 31 December 2009
- [6] N. Tanuma, R. Marumo, K. Maruta and C. Ahn, “Known Bits Puncturing for Systematic Polar Codes”, 2019 25th Asia-Pacific Conference on Communications (APCC), 2019.
- [7] Runxin Wang and Rongke Liu, “A Novel Puncturing Scheme for Polar Codes”, IEEE Communications Letters, VOL. 18, NO. 12, December 2014.
- [8] Walid Saad, Mehdi Bennis, and Mingzhe Chen, “A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems”, IEEE IEEE Publication Network , 2019.
- [9] Nabeel Arshad and Abdul Basit, “Implementation and Analysis of Convolutional Codes Using MATLAB”, International Journal Of Multidisciplinary Sciences And Engineering, VOL. 3, NO. 8, AUGUST 2012.
- [10] Zaher Dawy, Walid Saad, Arunabha Ghosh, Jeffrey G. Andrews, And Elias Yaacoub, “Toward Massive Machine Type Cellular Communications”, IEEE Wireless Communications, 2016.
- [11] Suayb S. Arslan, Pamela C. Cosman, Laurence B. Milstein, “Concatenated Block Codes for Unequal Error Protection of Embedded Bit Streams,” IEEE Transactions On Image Processing, VOL. 21, NO. 3, March 2012.

Lane Change Detection and Decision Making system using Scan Line LIDAR for ADAS systems

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Abstract— There are an increasing number of ADAS systems available today like lane centering, lane change, adaptive cruise and also the maps like Lanelets, HDMaps are getting better with more information regarding static environments. This work presents the approach for lane change decision making using real time LIDAR data and offline data of lanes. The lane change is the movement of a car moving from one lane to another for the purpose of overtaking the car ahead or any obstacle while checking if the lane is free or not. System discussed in this paper deals with locating other cars, their position relative to vehicles and mapping them to particular lanes while selecting the lane with less obstruction.

Keywords— Lane change, Scan line LIDAR pure pursuit controller HDMaps, Lanelets

I. INTRODUCTION

Autonomous vehicles are vehicles that sense their position, collect data about the surrounding environment, process that data for motion planning, decision making, Path generation, path tracking and move along the generated and planned path without any human intervention. These vehicles are classified based on level of autonomy [1]. There are 5 levels, 0 being no autonomy, Level 1 means either lateral or longitudinal whereas Level 2 has both lateral and longitudinal autonomy. Level 3 are level 2 vehicles but can take total control while performing in certain scenarios like traffic jams. Level 4 are vehicles which can control while moving in certain areas like city, town. Level 5 vehicles can move anywhere without any conditions. Any typical operation of the autonomous car can be broadly summarize using following steps

First step is Localization. Localization is the process of estimating the car position relative to the world; this includes the pose estimation and state of the vehicle. In this step, data which is pre-recorded like HDMaps Lanelets [2][3] are used with sensors like GPS and LIDAR. There are various techniques like post graph optimization, Kalman filter using GPS and LIDAR to locate the vehicle.

The second step is to map the environment around the ego vehicle. This includes object detection and object tracking, lane detection. There are various methods developed for object detection and tracking for various sensors like camera, radar, LIDAR. Each of the sensors has its advantage, LIDAR and radar can be used for distance estimation and camera for classification of objects. Further there are different methods for classification using cameras like Haar's object classification machine learning with models like YOLO, RCNN and CNN. Once an object is detected it is mapped with respect to the car and world using

data from sensors and HDMaps. Further the plane of road is detected using RANSAC algorithm, lane detection uses the image masking techniques they highlight the lanes then using calibration matrices, image sensor properties focal length the distance is estimated.

Third step is planning the routes or path planning and decision making. The sensor data is used along with cost functions for optimizing paths the cost function calculates maximum likelihood this includes functions like Bayes probability theorem, Euclidean distance. This includes behavior planning that is when to stop, start and slow the car. These systems are based on fuzzy logic or state logic, fuzzy logic being the advance, further machine learning Models like NVidia End to End self-driving [4]. A model using 3 cameras for training and a single camera for decision making are used, once the model is trained. Geometric path planning is also done using HDMaps data and Lanelets for situations like overtaking the car, lane change. The geometric technique is used using the width of the car for moving around the car and the path is generated and the lane change is made considering the time of collision.

Last step is controlling the vehicle and its actuation. Here controllers [6]. like Pure-pursuit, Stanley controller, PID controller, MPC controller are used to obtain the desired steering angle and throttle which is then fed to the close loop system and actuators to obtain desired motion. This entire step happens multiple times in a second according to banding rate of the sensors and computation complexity. Lower the time required better the system. Therefore various techniques are used to lower the time of calculation and use of specialized hardware including FPGAs.

The system discussed in this paper deals with finding the object, its position relative to vehicle, world coordinate and checking if it lies ahead in lane of car, if so checking other lanes and thus selecting lane with no object, if object is present in every lane then ego vehicle maintains the speed according to lead vehicle ahead of ego vehicle. This system only detects cars that are on particular lanes.

II. CREATION OF SIMULATION ENVIRONMENT

The simulation environment is created in Webots simulator [7] using available PROTOS (models) for roads, trees, background texture and lights. Webots is an open source robot simulator. The floor size of the world created is 500 by 50m Straight road proto is used to create roads as documented in the documentation section of Webots. The

road is 500 m long with 4 lanes of 3.5m each all moving in forward direction.

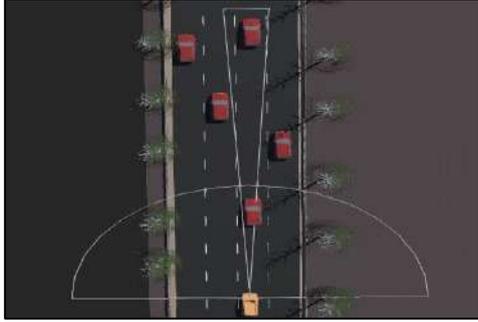


Fig. 1. Simulation

III. VEHICLE AND SENSOR POSITION

For an ego vehicle, Ackerman steering PROTO provided by Webots [7] is used. The body of the car is developed in Solid works and same is imported in Webots as mesh for Bounding Object. LIDAR sensors used are one generic scan line LIDAR of 180 degrees aperture and 20 m range along with one LIDAR of 5 degree aperture and with a range of 50 meters. The LIDARs are positioned at the front bumper at a height of 0.75 m from ground. For GPS, IMU generic sensor models are used from Webots library [7].

IV. CREATION OF MAP DATA

The map data is created by using modified Bresenham's line drawing algorithm [9] as the test road is straight. The same can be achieved by moving vehicles in a simulated world and recording at fixed intervals for each lane. This data includes the position of the lane [x, z, heading angle]. The data for 4 lanes is created such that the coordinates of the below represent the center line of each lane.

$$\text{Lane1} = [[4.63, 500, 3.14], [4.63, 143.5, 3.14] \dots [4.63, 19.0, 3.14], [4.63, 11.5, 3.14]]$$

$$\text{Lane2} = [[8.13, 500, 3.14], [8.13, 143.5, 3.14] \dots [8.13, 12.0, 3.14], [8.13, 11.5, 3.14]].$$

V. LOCALIZATION OF VEHICLE

For localization of the ego vehicle, Lane map data generated in the above section is used along with GPS, IMU. Using GPS data, IMU data and Lane data, Euclidean Distance is found to find Ego vehicle is close to which lane and point in lane and then Pure-Pursuit controller can be used to align. See Fig. 2. If a vehicle is present in lane 2 it will be closest to point X=8.13 for 3rd lane X=11.63 and so on. Then finding the Z point in that lane, this will be the X, Z point of the vehicle and lane in which it is present.

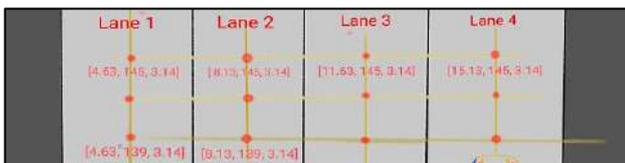


Fig. 2. Map data

VI. FILTERING SENSOR DATA

Sensor data is filtered so that the algorithm only detects the object which is on lanes. Here sensor data of LIDAR is filtered so that at any time it reads data of 4 lanes only and not outside data of curbs or trees as shown in figure. At extreme lanes, data is filtered to record only part of data that lies in lanes at either side. To filter LIDAR data for each lane the starting angle of LIDAR and ending angle is calculated. Table below shows the data for lanes R1, R2 are further regions created from filtered data for decision making. Step to calculate the Start and End angle for the filtered region is as follows. In Fig.3 in triangle ABC, angle B is 90 degrees and side BC can be found out by adding 3.5 m and 1.75 m (width of one complete lane and one half lane) which equals 5.25 m. Side AC is a range of LIDAR, 20 meters so angle made would be cosine of C that equals ratio of side BC by side AC. The angle C comes out as 1.305 radians. End angle can be calculated in a similar way.

Similarly LIDAR data for the rear side can be also filtered if extra LIDAR is used for detection of vehicles behind Ego vehicles. Some data is lost while filtering so offset is used while filtering after trial and error 4m offset was selected. This filtered LIDAR data is further manipulated to give distance for each LIDAR ray and coordinates of each ray.

TABLE I. ANGLES FOR DATA FILTRATION

L	Filtered		R1(left)		R2 (right)	
	Start	End	Start	End	Start	End
1	1.48	2.22	-	-	1.65	2.22
2	1.30	2.02	1.30	1.48	1.65	2.02
3	1.11	1.83	1.11	1.48	1.65	1.83
4	0.91	1.65	0.91	1.48	-	-

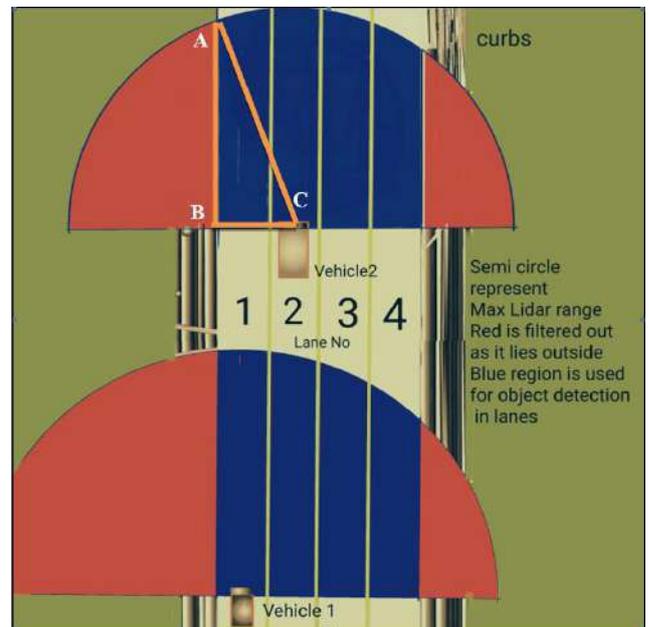


Fig. 3. Filtration of data

VII. OBJECT/CARS DETECTION

Object detection is done by filtered LIDAR data obtained in the previous section and lane map data obtained in 4th section. Object detection is done by analyzing

distance data from filtered LIDAR data such that, the ray which has distance value less than max range of LIDAR is marked as the start of object see Fig. 4. The coordinates are compiled till the ray comes whose distance value is equal to max range. This is the end of the object. These compiled coordinates are denoted as object 1 and this process continues till the rays of LIDAR are finished. This gives the nested list of objects.

A. Car/Object size detection

The horizontal size of the object will be the difference of Start and End of object. This can be used to find out if an object has blocked multiple lanes, see Fig. 4.

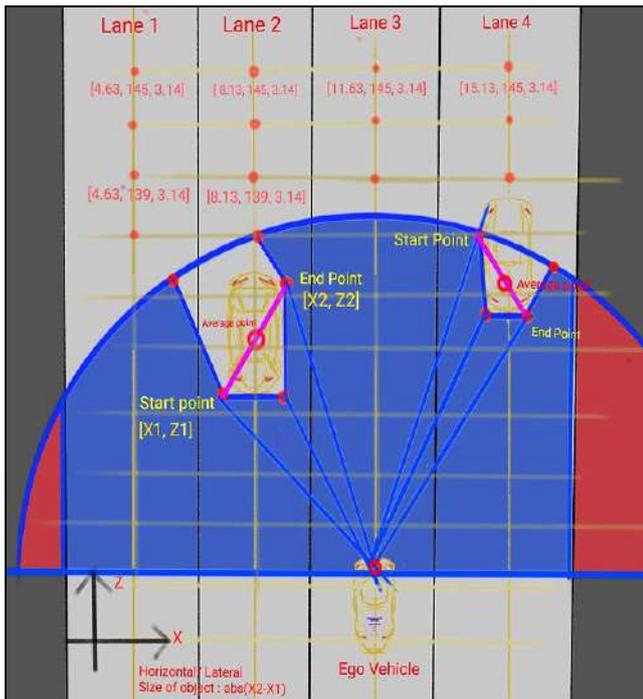


Fig. 4. Object detection and size, object lane estimation

B. Car/ Object lane detection

To detect in which lane the objects are present. Similar approach is used in the localization section that is comparing the Car/object position obtained from above start and end point average (GPS used in Localization section) and Lane map data from 4th section.

VIII. DECISION MAKING

A. Lane Change

There are 3 condition checked before lane change operation

- Is the yaw of the car close to the heading of the road that is $\text{abs}(\text{Yaw-heading}) < 0.2$ this implies that the car is heading in the direction of the road. This is done because if difference is large then car is heading either left or right and while car is heading left or right the LIDAR data filtration will not work and give very large noise
- The lane in which the Ego vehicle is moving is occupied and the distance between the lead vehicle and ego vehicle is more than 5 m. This ensures that the car

does not collide with the lead car. If the distance is less car will cruise control itself to increase distance

- The distance between lead and ego vehicle is less than 20 and greater than 5m and the object is detected.

Once these 3 conditions are satisfied then the algorithm checks which lane is occupied and which is not. For this the 3 lanes are selected one in which ego vehicle is moving, second lane is left of current lane and third is right of current lane. To check if a lane is occupied or not the algorithm takes Objects lanes detected from 6.B section and simply checks if it is present in one of 3 lanes. If yes, flag 10 is returned. If an object is not present in the lane, the algorithm returns the flag as the lane number, any one of [1, 2, 3, 4] respectively. Once all flags of all 3 lanes are acquired if the flag of any lane is 10 it is rejected because lane is blocked. If any lane number is returned as a flag, those lanes are kept. Now it is clear that the currently moving lane is occupied so the vehicle is performing lane change. So the remaining lanes will be left one, right one or both. If only one of them is free, that lane is selected and sent to Pure-pursuit controller and PID controller, but if both the lanes are present then R1, R2 found out in section 5 is used to selects more suitable lane, that is if $R1 < R2$ this implies there is less space on left side so algorithm selects right lane and sends it to pure pursuit and PID controller and left lane number is send if $R2 < R1$. See Fig. 5 shows the flowchart of the algorithm.

If for all three lanes, flag 10 are returned then all three lanes are occupied. In this case the algorithm returns the current lane to the Pure-pursuit controller and vehicle cruise controls.

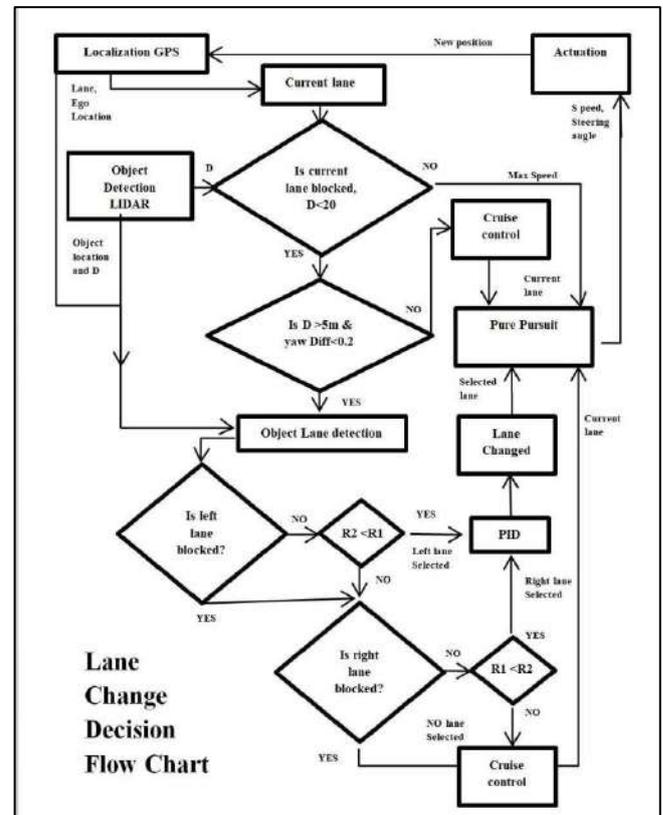


Fig. 5. Lane change Decision Flow chart

B. Cruise control

This happen when selected lane after decision making section is same as current lane and if the distance between the lead vehicle and ego vehicle is less than 5m

IX. VEHICLE CONTROL

As mentioned in the introduction there are various controllers, but a pure pursuit controller is selected because it is more stable and more comfortable for passengers [6].

A. Pure Pursuit Controller

Pure pursuit controller is a geometric path controller based on bicycle models and is with respect to the rear axle of a vehicle. It gives the required steering angle to trace the path created by the point. In this system the point of lane map data is feed to pure pursuit controller and it traces the point which are at center so it not only moves along the particular lane but point being at center of lane, keeps the vehicle at center of lane acting as lane centering The steering angle [5] is given as

$$\delta = \tan^{-1}(2L \sin \alpha / l_d) \tag{1}$$

Where L is vehicle base, l_d is look-ahead distance, $\sin \alpha$ is l_d divided by radius of curvature of path R. In this system this controller is only used within a particular lane while a changing lane PID controller is used.

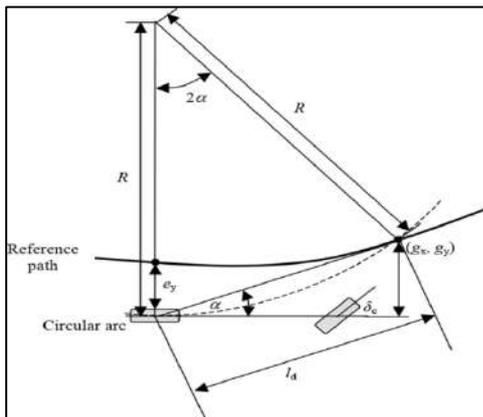


Fig. 6. Pure-Pursuit Controller [5]

B. PID Steering controller

PID controller is used to control a single value in the system, here it is steering angle. The angle is found out by using the difference/error in x coordinate in both lanes. In Fig. 3 the ego vehicle is moving from lane 1 to lane 2, that is its current position is 4.63 and will be updated from GPS for every pass and is moving to 8.13 fixed for every pass. So the difference for the first pass would be 3.5. For each pass of the system this difference is calculated and previous difference is stored till difference is less than 1.5 and then Pure-pursuit controller is used to move in lane. 1.5 is taken as the lane center is 1.75m apart from either end of lane for lane of width 3.5m. So if difference/error is less than 1.5 the car has entered lane 2

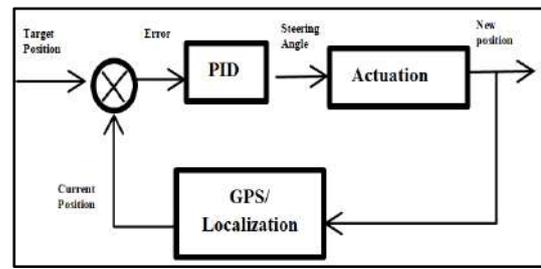


Fig. 7. PID Controller Block Diagram

$$\text{Steering angle} = P * \text{Difference} + I * (\text{Previous difference}) + D * (\text{difference} - \text{Previous difference}) \tag{2}$$

After experimenting following values of P, I, D are selected

$$P = 0.5, D = 20, I = 0.000015$$

This may give angles which are not possible due to geometry and dynamic stability of the vehicle so then this angle is bounded between (-0.2, 0.2) radians. The program for PID controllers is taken from the sample resource section of Webots [7].

C. Speed Controller

The maximum speed of a car is capped at 20 m/s (72km/h). The car moves at this speed if there is no object. Here linear speed control is used based on distance from the lead vehicle. If a car detects the object in its lane and is less than 5m away according to wide LIDAR and less than 10m for narrow LIDAR then speed is equal to 0.75 times distance between lead vehicles and braking intensity is 1/distance. The condition from narrower LIDAR is mandatory to satisfy this because the wide LIDAR can get distance from adjacent lanes. The narrower sensor is as narrow as the width of the lane so this LIDAR has better accuracy. While changing the lane, speed must be low to stabilize the car for comfort and safety. The speed is found out from distance as above but is taken as 0.5 times Speed.

X. SIMULATION RESULTS AND PLOTS

Each plot in the subsequent section contains 4 subplots; the first plot shows lane change movement along the length of road that is lateral v/s longitudinal movement of the car (X v/s Z). The second subplot shows lateral movement of the car v/s time (X v/s t). Third subplots show the speed of the vehicle at a particular time (S v/s t). And the fourth graph shows brake intensity ranging (0 to 1) at any time instance (B v/s t). Green, purple and yellow boxes are other vehicle positions. Red box is Ego vehicle positions. These positions are at any instance of lane change movement. Blue lines are lane boundaries and yellow ones are lane center.

A. Static cars

The ego vehicle was able to move along the road with obstacles as seen in Fig. 8. But as distance between lead vehicles reduced, the Ego vehicle went into cruise control mode, as the distance was less than 1.5m from the lead vehicle the Ego vehicle stopped at the red circle marked in Fig. 8. The speed graph is jerky as there are a lot of obstacles and the speed profile of the controller selected is discrete.

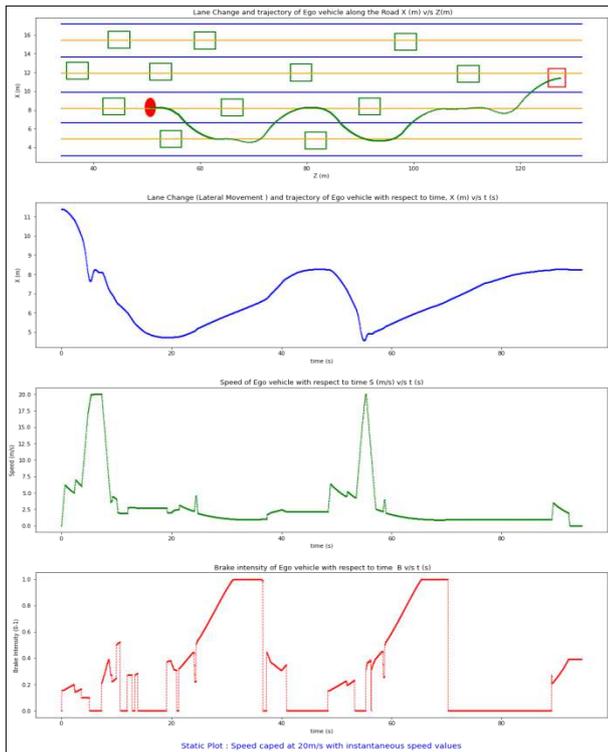


Fig. 8. Static cars Plot 1

The Ego vehicle is applying brakes almost all time again due to many obstacles. Also in Fig.9 average speed values of 150 iteration are used, the overshoot at around $Z=120$ m is less but the sensitivity is dropped and vehicle stops at 70 m after single lane change.

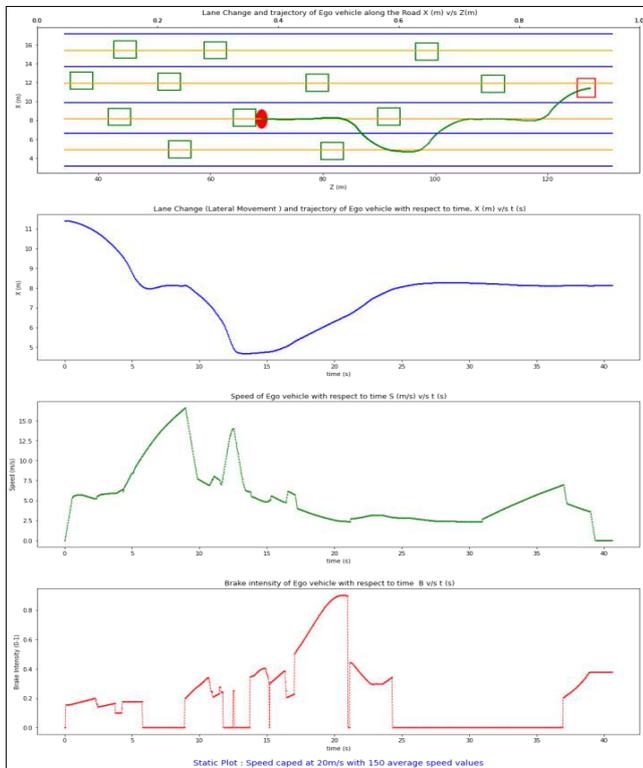


Fig. 9. Static cars Plot 2

B. Moving cars

- *Cars not changing lanes*

In this scenario cars were moving at random speed in a straight line at the center of lanes. The lane change took place at $Z=120$ m and $Z=40$. Red box is the position of the Ego vehicle during lane change and other boxes represent other cars position when lane change was done by the Ego vehicle. Closer the box lowers the speed of the vehicle for example in Fig. 10. See yellow boxes they are closer showing the speed is low and blue boxes are away representing higher speed. The speed graph again has abrupt changes that point to discrete values used. Brake intensity is low only top at $Z=40$ m that also points the green boxes close to red ones at $Z=40$ m. Fig.11. shows the results of averaging speed values, overshoot is decreased while lane change

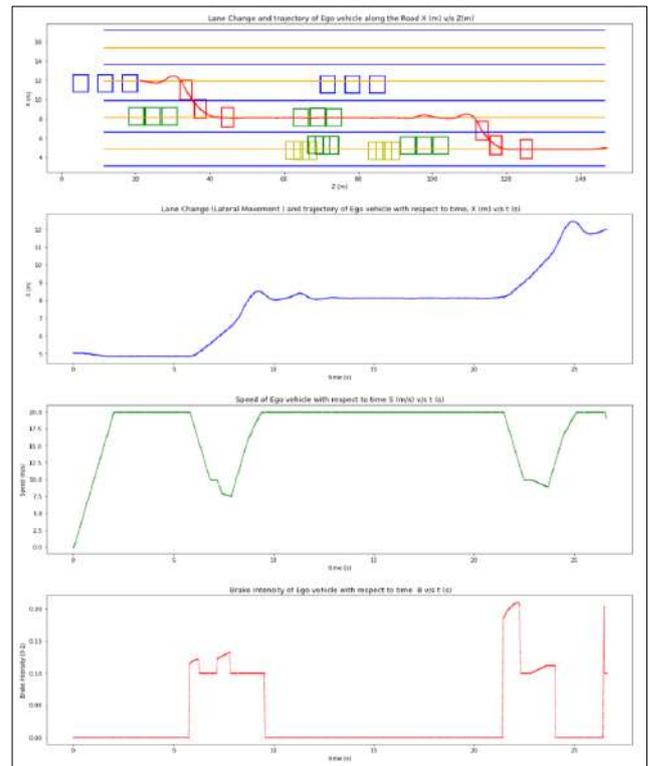


Fig. 10. Moving Cars Plot

- *Car changing lanes also are not at center of lane*

In this scenario cars were moving at random speed, also changing lanes and were kept little offset from lane center to see if lane selection was done properly or not. The speed of black vehicle is more. See in Fig. 12. Around $Z=120$ m to 100 m two lane change took place as the green vehicle also changed the lane. See black, purple, blue boxes (cars) are offset from lane center but algorithm was able to detect if lane was occupied or not. These boxes represent the positions of other cars and ego vehicle at time of lane change. Again the speed graph is jerky; also the brake intensity graph shows many smaller peaks than last scenario; this is expected as cars are changing lanes. No speed averaging is done to check decision performance.

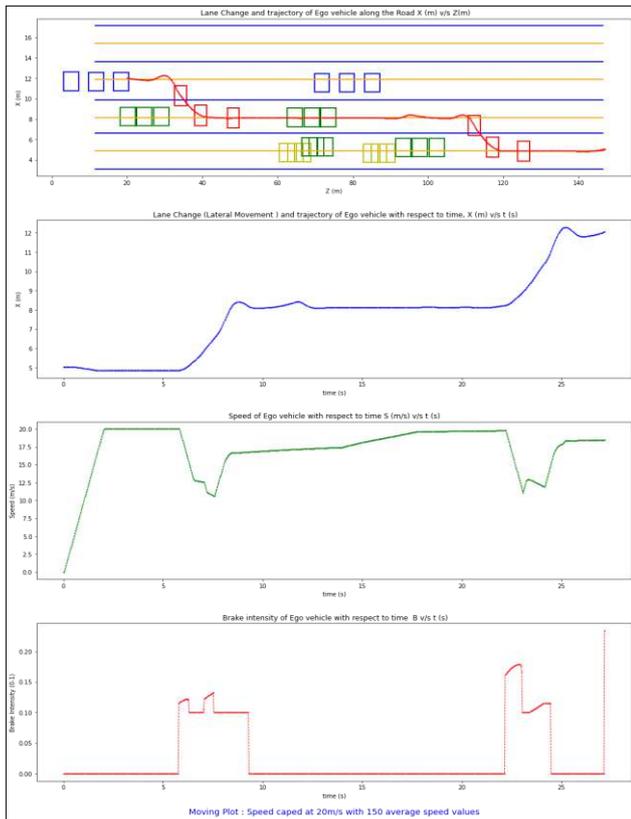


Fig. 11. Moving Cars Plot 2

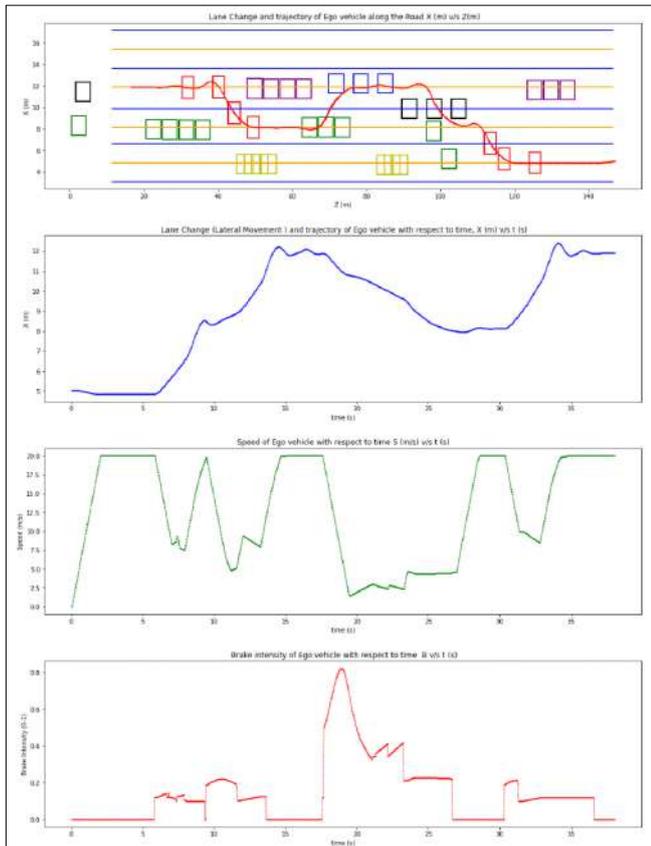


Fig. 12. Moving Cars Plot 3

XI. CONCLUSION

1. The system was able to detect the lanes which are occupied and select the lane
2. The system was able to detect the status of lanes even when other vehicle were at edge of lane
3. The system was able to cruise control if no lanes were available
4. Speed graph is jerky and can be improved, using average values decreases jerk, but decision making is hampered, using advance control like adaptive cruise control rather than cruise control used here can be helpful.

Future Scope

1. The system does not check the vehicles behind the ego vehicle but as an extension to this system using another LIDAR at the rear of the ego vehicle as suggested in section 7 and implementing the same as front LIDAR. While decision making vehicles could use information to decide if it is safe or behind vehicles may collide while lane changing.
2. The system can be extended to work on curved roads by using road heading information created in section 3 and by making the changes to the PID controller to accommodate Euclidean rather than simple distance use here.

REFERENCES

- [1] Kale, J.G., Subramaniam, A., Karle, M.L., and Shailesh Karle, U., "Simulation Based Design and Development of Test Track for ADAS Functions Validation and Verification with Respect to Indian Scenario," SAE Technical Paper 2019-26-0100, 2019, doi:10.4271/2019-26-0100.
- [2] P. Bender, J. Ziegler, and C. Stiller, "Lanelets: Efficient map representation for autonomous driving," in 2014 IEEE Intelligent Vehicles Symposium Proceedings, pp. 420–425, June 2014.
- [3] Lanelet2: A high-definition map framework for the future of automated driving Fabian Poggenhans1, Jan-Hendrik Pauls2, Johannes Janosovits2, Stefan Orf1, Maximilian Naumann1, Florian Kuhnt1 and Matthias Mayr1
- [4] End to End Learning for Self-Driving Cars Mariusz Bojarski, Davide Del Testa, Daniel Dworakowski, Bernhard Firner, Beat Flepp, Praseon Goyal, Lawrence D. Jackel, Mathew Monfort, Urs Muller, Jiakai Zhang, Xin Zhang, Jake Zhao, Karol Zieba
- [5] Development of Steering Control System for Autonomous Vehicle Using Geometry- Based Path Tracking Algorithm-Myungwook Park Sangwoon Lee Wooyoung Han-<https://onlinelibrary.wiley.com/doi/full/10.4218/etrij.15.0114.0123>.
- [6] Comparison of lateral controllers for autonomous vehicle : experimental results Salvador DOMINGUEZI, Alan ALII, Gaetan GARCIA and Philippe MARTINET1
- [7] Webot documentation <https://cyberbotics.com/doc/guide/index>.
- [8] Autonomous Obstacle Avoidance Vehicle using LIDAR and an Embedded System Nikolaos Baras, Georgios Nantzios, Dimitris Ziouzos, Minas Dasygenis.
- [9] Schaum's Outline of Computer Graphics Second Edition

Blockchain Based E-Voting System

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Abstract— Election plays a very important role in a democracy so conducting a secure election is both integral to the goal of an election and an inseparable part of the electoral process. So it is very important to find a new voting system that is immune to fraud as well as this system should have a traceable voting process. Researchers in the field of computer security have been looking at the possibility of using electronic voting systems for decades. The process of reducing the cost of an election voting process and at the same time making a system that is acceptable to the legal legislators and also increasing the security concerns of the elections is very difficult. The electronic voting machines are not considered reliable by the security community due to various security concerns.

These flawed security voting machines can be eliminated by introducing blockchain technology. Blockchain records information in several databases which makes it very difficult and nearly impossible to alter, hack, or cheat the system. A blockchain distributes and duplicates a digital ledger of transactions across the entire network of computer systems connected through peer-to-peer nodes. These database system technologies have features that are operated via advanced cryptography technology. Thus these systems are very highly secure systems that the current database systems. Blockchain based technology can offer countless applications which can be benefitted from the shared economy. So, in our project, we are aiming to apply the blockchain system as a service to use it for electronic voting systems. Thus, we evaluate the potential of implementing blockchain-based applications to minimize security threats and lower the cost of conducting countrywide election.

I. INTRODUCTION

A. MOTIVATION

Elections are the backbone of democracy. An election plays an important role for the future of any country. Elections have to be trustworthy regardless of the organization because it is very much important for all the people involved in these elections. The responsible authority has to ensure people's privacy and vote security and also the counting of votes should be done quickly because it may increase concerns about manipulation of results if counting takes too long. Blockchain mechanism has emerged to overcome the drawbacks of both conventional and e-voting

based elections as it has good features that can eliminate troubles like security of the person casting the vote, privacy of that person, and data integrity of votes. Blockchain provides a shared database that borrows from research from distributed systems, cryptography, and game theory. This database is replicated on multiple computers which are then added by these same computers which will not need any affiliation and a degree of trust for the updates to stand secure. These features provided by blockchain technology are considered remarkable in the computer science field.

B. OBJECTIVE

While designing a chain based system for voting in a crowded country, it is important that the system should be secure. There are a lot of things that are considered while developing a blockchain based secure voting system. The proposed system will have nodes such that humans cannot interfere with them. Any input that is not a vote, will be ignored by the system. For such a system, altering, hacking, or cheating with the system is totally blocked. The second problem is to protect the system from hackers.

C. DEFINITION

Our aim is to provide a better alternative to the conventional voting system in regards to speed, security and consistency. This system should also overcome issues like transparency security, while maintaining Data confidentiality.

II. BACKGROUND STUDY AND RELATED WORK

The election of any government body has to be a trustworthy process. People's privacy and security of votes should be guaranteed. Also, the time taken for counting votes should be less because if the process takes longer time, it increases concern about vote manipulation.

Trust has been a controversial issue of all the elections due to various reasons. These security concerns arise mostly during the paper election as it is easy to manipulate ballots thus changing the election result. For example, in India, there is still controversy about the privacy and security of the election. The time factor is also a challenge for announcing

the result. The Electronic Voting Machine (EVMs) which are used for polling are not connected online. So the transportation of EVMs to the counting center takes time. It took 4 phases of 21 days for polling in the general election of 2004. While in 2009 five phases took over 28 days for polling. On the other hand, 2014 general elections polling took place in nine phases for 37 days. Seldom has it taken days to get the results as post-election all EVM machines are gathered at one place and then compilation (consolidation) of the result of each EVM is done on result day. This process may take 4-6 days which may seem very time-consuming. There are some efforts to eliminate the drawbacks of the traditional voting system. These efforts led to an online-based e-voting system.

E-voting was adopted in the Austrian Federation of Students election in 2009 and Switzerland for some elections. Although e-voting makes selection operations easy, privacy and security worries continue.

E-voting is considered by some countries as an alternative to the traditional voting system. The pioneer country in the e-voting process in Estonia which held online voting between 2005 and 2007. On the other hand, Blockchain-based election has not been commonly applied yet. It is in the development process in recent years. South Korea is one country known to successfully conclude a Blockchain-based voting system in 2017. Also, some papers provide good knowledge about Blockchain based voting systems and offer different ideas about the same. In this, the voting process relies on citizen's email addresses that can be hacked or manipulated easily. Anyone can register with any other email address and vote on someone else's behalf. In this system, stealing or changing votes is possible.

Researchers put forward a blockchain-based voting system that is based on peer-to-peer connections. The main aim of the research was to secure the identification of users and responsibility of the votes to the Blockchain. Researchers proposed an isolated voting format. This solution has a solid fix for a system having a vote commitment format but we put forward a different system that depends upon a government administered system. In this system, we prefer to adopt a unique arrangement for a chain that contains different key-value pairs which represent vote.

Blockchain is used in various fields like Internet of Things(IoT). As this system has various devices, and each device receives and processes different data, we can get many new perspectives from this area. Researchers converse about the blockchain IoT interactions which make way for a hybrid model that uses different chains at different layers and levels which persuaded us in our blockchain-based e-voting system. Researchers converse about the blockchain IoT interactions which make way for a hybrid model that uses different chains at different layers and levels which persuaded us in our blockchain-based e-voting system.

A one-time ring signature system was suggested in one paper to ensure that the identity of voters is kept secure. But for this system to work, every user must have a public key pair thus the signing-in process becomes more complex if the new candidate is added thus also increasing the CPU power. This structure doesn't depend upon any trusted center but this structure can be given the authority of selecting a candidate from the government who will, in turn, be the trusted center

for the ongoing election process. Some past research are given below in the Table 1.

A. Blockchain as a service

Blockchain is a system that records information in such a way that it is nearly impossible for anyone to change, hack, or cheat with it. A blockchain is like a digital ledger that has transactions which are duplicated and distributed to all the computer systems in the blockchain network. Each block which is in the chain contains the number of how many times the transactions have happened, after every new transaction in the blockchain, the transaction is recorded and added to the ledger of all participants. The decentralized database managed by multiple participants is known as Distributed Ledger Technology (DLT). Blockchain is a type of DLT in which transactions are recorded with an immutable cryptographic signature called a hash. This basically means that if one block in one chain was altered, it would be instantly evident it had been interfered with, if anyone wants to tamper or corrupt the blockchain data, he has to alter the data across all the blocks in the chain, in every distributed version of the chain.



Fig. 1 Properties of Distributed Ledger Technology

III. SYSTEM IMPLEMENTATION

The citizen and government are the standard use case of the election system. Government plays a vital role as they provide a license to citizens who can vote or can prevent citizens from voting again. Also, the candidates that are participating in the election are determined by the government and citizens. The ballot box information, citizen ballot box relation, and candidates lists are also provided by the government as they are the trusted party in the elections.

Once citizens cast votes they will be added to the blockchain which we will be proposing below and the votes in this system are guaranteed about being immutable. All the anonymous votes cast by citizens are terminated as a chain after the election and then an official conclusive result is declared within a few hours. For assurance, the chain is accessible to the third party and so that they can count the vote.

TABLE I. PAST RESEARCHES

Researches	Architecture and Design	Security Considerations	User Authentication
1.	<ul style="list-style-type: none"> ● Blockchain permission ● Maintain data integrity 	<ul style="list-style-type: none"> ● data integrity 	<ul style="list-style-type: none"> ● Asymmetric authentication
2.	<ul style="list-style-type: none"> ● Smart Contract ● POA Permissioned blockchain ● Exonum,Quorum and Geth Frameworks 	<ul style="list-style-type: none"> ● Secure authentication via identify verification ● Does not allow to trace voters from vote ● Transparent 	<ul style="list-style-type: none"> ● Identity verification service
3.	<ul style="list-style-type: none"> ● Multi-tiered ● Two factor authentication ● Encryption based on public-private key 	<ul style="list-style-type: none"> ● User authentication ● Monitoring and auditing for data integrity ● Risk of voter to forget their ID, password 	<ul style="list-style-type: none"> ● Randomly generated password to use on polling station
4.	<ul style="list-style-type: none"> ● Zcash tokens ● Authentication with Challenge-Handshake Authentication Protocol 	<ul style="list-style-type: none"> ● Anonymity ● Privacy ● Transparency 	<ul style="list-style-type: none"> ● Challenge-Handshake Authentication Protocol ● The voters' email authentication
5.	<ul style="list-style-type: none"> ● Smart contract on Ethereum 	<ul style="list-style-type: none"> ● Anonymity 	<ul style="list-style-type: none"> ● Asymmetric authentication

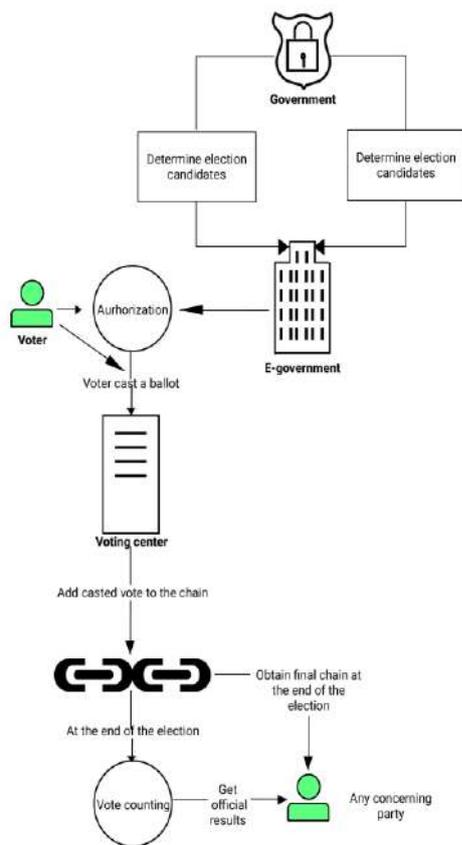


Fig. 2 System Implementation

A. Client-side Frontend Interface

The web-applications begin with a very basic requirement. The user has to register themselves before voting unless they have their Voter ID. To register, they have to provide their driver's license, registrar district, first name, and last name. This web application voting system is not just secure, but also hassle-free and quick-witted like in a democratic country of billion people, India. The registration process is followed by the verification of the authenticity of the driver's license and says whether it has been registered previously or not.

```

// Check to see if we've already enrolled the user.
const userExists = await wallet.exists(voterId);
if (userExists) {
  let response = {};
  console.log('An identity for the user ${voterId} already exists in the wallet');
  response.error = 'Error! An identity for the user ${voterId} already exists in the wallet. Please a different license number.';
}

```

Fig. 3. Enrolled register

If there is an error in the Voter ID or Registrar ID it throws an error, code for which is shown in Fig.4.

```

constructor(voterId, registrarId, firstName, lastName) {

  if (this.validateVoter(voterId) && this.validateRegistrar(registrarId)) {

    this.voterId = voterId;
    this.registrarId = registrarId;
    this.firstName = firstName;
    this.lastName = lastName;
    this.ballotCreated = false;
    this.type = 'voter';
    if (this._isContract) {
      delete this._isContract;
    }
    if (this.name) {
      delete this.name;
    }
    return this;

  } else if (!this.validateVoter(voterId)){
    throw new Error('the voterId is not valid.');
```

Fig. 4 Voter registration error

The verification is the return function of API connected. The code for which is shown in Fig.5.

```

registerVoter(voterId, registrarId, firstName, lastName)
return Api().post('registerVoter', {
  voterId: voterId,
  registrarId: registrarId,
  firstName: firstName,
  lastName: lastName,
})
},
validateVoter(voterId) {
return Api().post('validateVoter', {
  voterId: voterId
}

```

Fig. 5. API verification

Error is thrown after it validates the registerer with a set of activated run spinners as shown in Fig. 6.

```

async validateVoter() {
  await this.runSpinner();

  if (!this.loginData.voterId) {
    console.log("Ithislogin");
    let response = 'Please enter a VoterId';
    this.loginReponse.data = response;
    await this.hideSpinner();
  } else {
    const apiResponse = await PostsService.validateVoter(
      this.loginData.voterId
    );
    console.log("apiResponse");
    console.log(apiResponse.data);

    if (apiResponse.data.error) {
      // console.log(apiResponse);
      console.log(apiResponse.data.error);
      this.loginReponse = apiResponse.data.error;
    } else {
      this.$router.push("castBallot");
    }

    console.log(apiResponse);
    this.loginReponse = apiResponse;
    // this.$router.push('castBallot')
    await this.hideSpinner();
  }
},
async runSpinner() {
  this.$refs.spinner.show();
},
async hideSpinner() {
  this.$refs.spinner.hide();
}
}

```

Fig. 6. Error run spinner

The API Verification can be done through a locally hosted derivative as shown in Fig. 7.

```

//get voter info, create voter object, and update state with their voterId
app.post('/registerVoter', async (req, res) => {
  console.log('req.body: ');
  console.log(req.body);
  let voterId = req.body.voterId;

  //first create the identity for the voter and add to wallet

```

Fig. 7. Create key

If everything proceeds smoothly, the blockchain's smart contract system creates a public and private key for the voter with the help of authority and an orderer certificate that is deployed on the cloud or hosted locally. Then these keys are added to the wallet.

```

import axios from 'axios'

export default() => {
  return axios.create({
    baseURL: 'http://localhost:8081'
  })
}

```

Fig. 8. Local host

Information regarding private-public key foundation, and how Hyperledger Virtual Container puts into practice of identity can be read officially on IBM Platform. After these, we use the driver's license and Register ID number to login (the same used to register). The user submits a vote from the list of ballots as shown in Fig. 9.

```

//create votableItems for the ballots
let repVotable = await new VotableItem(ctx, 'Republican', ballotData.fedDemocratBrief);
let demVotable = await new VotableItem(ctx, 'Democrat', ballotData.republicanBrief);
let indVotable = await new VotableItem(ctx, 'Green', ballotData.greenBrief);
let grnVotable = await new VotableItem(ctx, 'Independent', ballotData.independentBrief);
let libVotable = await new VotableItem(ctx, 'Libertarian', ballotData.libertarianBrief);

//populate choices array so that the ballots can have all of these choices
votableItems.push(repVotable);
votableItems.push(demVotable);
votableItems.push(indVotable);
votableItems.push(grnVotable);
votableItems.push(libVotable);

```

Fig. 9. Code image ballot selector

The application checks the virtual blocks from the chain and tells whether they have casted a vote already. If everything executes according to the plan, the political party receives a vote to which the user has elected. The world state receives a request soon. The application then updates the current election poll standings to depict how many votes each political party currently has received as shown in Fig. 10.

```

//update state with new voter
await ctx.stub.putState(newVoter.voterId, Buffer.from(JSON.stringify(newVoter)));

```

Fig. 10. New voter

Elections are never absurdly all around the year. We have an election object to restrict within that period.as shown in Fig. 11.

```

//Nov 3 is election day
let electionStartDate = await new Date(2020, 11, 3);
let electionEndDate = await new Date(2020, 11, 4);

//create the election
election = await new Election(electionData.electionName, electionData.electionCountry,
electionData.electionYear, electionStartDate, electionEndDate);
    
```

Fig. 11. Election span

The front end of the system is accompanied by Vue.js 3.0.11 which is a progressive open-source (Github) Javascript framework to build user-web interfaces and one-page applications.

B. Server-side Backend Interface

Ordering services that receive each agreement (transaction) action must have a signature from a valid public & private hash key combination. The system servers will then track back every agreement to a registered voter in the application, while making an associate audit as shown in Fig. 12.

In conclusion, even though this is a simple protocol, single page and purpose specific national-level application, a team of developers will have to somehow implement a hard-fork Hyperledger Development Network workspace, high sovereignty custom networks and security as a services modules for enabling interoperability to decrease the cases of unwarranted or intrusive interference. This will in-turn enhance experience of users and increase the trust factor in the application encouraging voters to step forward.

- Hyperledger Fabric v2.0 is a modular blockchain framework that lives to its standard and delivers high degrees of scalability, interoperability, modularity, decentralized sovereignty governance, and resiliency for developing blockchain based products.
- Node.js 14.16.1 is an open-source, asynchronous event-driven Javascript runtime framework designed to build and handle scalable network applications.

C. Blockchain Deployment

Steps to undertake the mining process of the project, So that we can implement:

- Setup, and use the IBM Blockchain Platform 2.5.2 service.
- Build a back-end layout using Blockchain's Hyperledger Fabric API's.
- Create and use of Kubernetes Cluster to deploy, operate and monitor your Hyperledger Fabric nodes.
- Host a Node.js web-application using a Fabric SDK that interacts with deployed smart contracts.

The Blockchain component depends on three sources of information:

1. IBM Blockchain Platform provides the users with total control over the blockchain network interface that simplifies

and accelerates user experience to deploy and monitor components on the blockchain's cloud kubernetes service.

2. Blockchain technology prefers to operate on Linux OS due to security concerns. Nowadays with an increase of Windows OS usage, IBM Cloud Kubernetes Service lets you create a highly secure container and deploy a cluster of compute hosts. A Kubernetes cluster lets you securely access the tools that you need for deployment, update, schedule, self-heal, and for scaling the web-applications on the cloud.

3. IBM Blockchain Platform Extension for VS Code assists users in creating, testing, and debugging smart contracts, also allows the connection with Hyperledger Fabric environments, and builds applications that help to transact on your blockchain network.

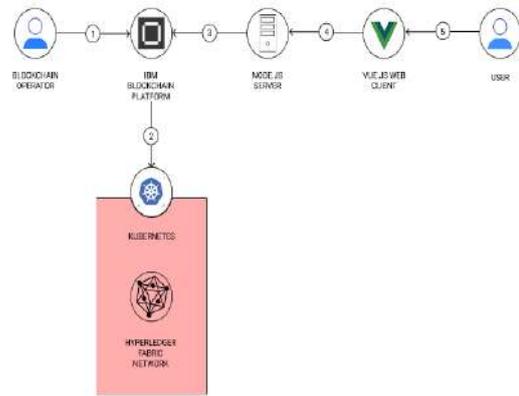


Fig. 12 Implementation Process

D. What are Smart contracts

Smart contracts will automatically execute when all the conditions and pre-established terms are met as they are lines of code that are stored in blockchain. They are programs that run as they've come upon to pass the folks that developed them. The advantages of smart contracts are most noticeable in business alliances, as they're generally used to impose some kind of agreement so that all contributors are often sure of the result as they are beyond the reach of the intermediary involvement.

IV. CONCLUSION AND FUTURE SCOPE

The strength of a democratic country comes from authorized and strong elections. To maintain a strong democracy, the government should ensure that the election system must be substantial for its citizens. In this research paper, we propose a blockchain-based e-voting system that functions using smart contracts which provide a trustworthily, secured and systematic cost-efficient election system in leveled nature. This research paper offers new possibilities for transparency. For future work, this blockchain system can be modified with an OpenCV - Image processing component that can capture the facial feature and test with the Driver License Identity with synchronized and consensus algorithms for better performance and enhancing the security.

REFERENCES

- [1] R. Hanifatunnisa and B. Rahardjo, "Blockchain based e-voting recording system design," 2017 11th International Conference on Telecommunication Systems Services and Applications (TSSA), Lombok, 2017, pp. 1-6.
- [2] R. Krimmer, A. Ehringfeld, and M. Traxl, "The Use of E-Voting in the Austrian Federation of Students Elections 2009," Internet: <https://pdfs.semanticscholar.org/6b8f/34a5bd3e7eabc7e3a9a3f008187>
- [3] "The Geneva Internet Voting System," Internet: https://www.coe.int/t/dgap/goodgovernance/Activities/Evoting/EVoting_Documentation/passport_evoting2010.pdf [Nov.25, 2018]
- [4] F. Hjalmarsson, G. K. Hreiarsson, M. Hamdaqa and G. Hjalmtýsson, "Blockchain-Based E-Voting System," 2018 IEEE 11th International Conference on Cloud Computing (CLOUD), San Francisco, CA, 2018, pp. 983-986.
- [5] S. Olnes, J. Ubacht and M. Janssen, "Blockchain in government: Benefits and implications of distributed ledger technology for information sharing", Government Information Quarterly, vol. 34, no. 3, pp. 355-364, 2017.
- [6] A. Barnes, C. Brake, and T. Perry, "Digital Voting with the use of Blockchain Technology," Available: <https://www.economist.com/sites/default/files/plymouth.pdf> [July. 2, 2021]
- [7] A. Barnes, C. Brake, and T. Perry, "Digital Voting with the use of Blockchain Technology," Available: <https://www.economist.com/sites/default/files/plymouth.pdf> [July. 2, 2021]
- [8] M. Pawlak, A. Poniszewska-Marańda and N. Kryvinska, "Towards the intelligent agents for blockchain e-voting system," Procedia Computer Science, vol. 141, pp. 239-246, 2018.
- [9] P. Tarasov and H. Tewari, "The Future of E-voting," IADIS International Journal on Computer Science and Information Systems, vol. 12, no. 2, pp. 148-165.
- [10] Bartolucci, S., Bernat, P., Joseph, D. (2018). SHARVOT: Secret SHARE-Based VOTing on the Blockchain. 2018 IEEE/ACM 1st International Workshop on Emerging Trends in Software Engineering for Blockchain (WETSEB), 30-34.
- [11] A. Reyna, C. Martín, J. Chen, E. Soler and M. Díaz, "On blockchain and its integration with IoT. Challenges and opportunities", Future Generation Computer Systems, vol. 88, pp. 173-190, 2018.
- [12] B. Wang, J. Sun, Y. He, D. Pang and N. Lu, "Large-scale Election Based On Blockchain", Procedia Computer Science, vol. 129, pp. 234- 237, 2018.
- [13] Fririk Hjalmarsson, Gunnlaugur K. Hreiarsson, School of Computer Science, Reykjavik University, Iceland, fridrik14, gunnlaugur15@ru.is
- [14] IJCSNS International Journal of Computer Science and Network Security, VOL.19 No.12, December 2019.

Optimal Routing for Solid Waste Management System using IoT Based Smart Bin

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Abstract –The advent of Internet of Things (IoT) in solid waste management system reduces its complexity and opens a new corridor for its effective management. This paper proposes a smart sensor based smart bins for waste collection networks to avoid overflowing of garbage in the residential areas. Also, it proposes ant colony optimization techniques to find the shortest route for waste collection trucks from waste bins to dump yards with the help of IoT server. The proposed system is designed in such a way that the IoT server continuously monitors the filling level of garbage in the waste bins. Based on these real time data the ant colony optimization technique, which is developed in the IoT server, provides an optimal routing for waste collection network. The performance of the proposed system is validated with appropriate experimental results.

Keywords— *Internet of Things, Solid waste management, Optimal routing, and Ant colony optimization.*

I. INTRODUCTION

Recent trends in internet like Internet of Things (IoT) opens up new corridor for many technological advancements in both industrial and commercial areas like solid waste management, water management, healthcare, transportation and home automation.

Among these, the IoT created a revolution in solid waste management system especially in wastage collection and disposal. This is considered as important milestone in this area. Because, improper waste management creates lot of environment based issues like (i) overflowing of garbage in the residential areas and (ii) excessive emission of green gases in to the environment from waste collection trucks

The above issues can be overcome by frequent scheduling of trucks to collect the wastages from the waste bins. However, it is not an economically feasible idea. IoT yields better solution for this issue with the help of smart sensors. The smart sensors embedded with waste bins detect the level of the garbage in the bins and send the information to the controller, which is also attached with the bin. Then, this information is transferred to the IoT server with the help of WiFi module. In this paper, the ultrasonic sensors are used to monitor the level of garbage in the waste bins with the help of microcontroller unit.

The microcontroller unit is used to estimate the level of garbage in the waste bins based on the information collected from the ultrasonic sensor. Then, this information is sent to “ThingSpeak” IoT platform via WiFi module. Based on the information collected in the IoT server, the optimal routing for waste collection network is obtained using Ant Colony Optimization (ACO) technique.

The paper is organized as follows. A detailed literature review is given in section 2, about IoT based smart bins and its effectiveness in solid waste management systems. Then, the proposed system is neatly elaborated in section 3 and then, the results are discussed in section 4. Finally, conclusion is given in section 5.

II. LITERATURE REVIEW

Vast amount of research works are carried out in solid waste management system especially in waste collections and disposals. This task is considered as a difficult and cumbersome. A proper planning and execution is needed for municipal authorities to collect the waste from waste bins in appropriate time before it is overflowing to its surroundings. The most important difficult task in this area is to predict the filling level of wastages in the bins. Because, rate of filling of wastages in the bins is depends on the population level in that area. This is a most difficult task in metropolitan cities especially in urban areas where population level is unpredictable. But, IoT provides better solution for this issue. In A. Gopi et al [1], the authors used ultrasonic sensor, to predict the filling level of wastages in the bins. Then, this information sends to IoT server using Node MCU development board.

In Mithinti et al [2], the authors proposed an ultrasonic sensor and load cell to estimate the level of garbage filled in the waste bin. Later, this information sends to mobile application via microcontroller unit with the help of WiFi module. Dijkstra’s shortest path algorithm is also proposed by authors to estimate the shortest path between the truck yards to dump yards.

In M. Srinivas et al [3], the authors proposed an ultrasonic sensor to detect the level of wastages in the bins. Then, this information transferred to ‘ThingSpeak’ IoT platform with the help of Arduino Uno and WiFi module. The ultrasonic, gas and humidity sensors are proposed for waste bins in S. Akshayaa et al [4]. In this work, the ultrasonic sensor is used to detect the filling level of the waste bins. Then, the sensors information sends to the IoT server through Arduino Uno and WiFi module. In S. K. Memon et al [5], the authors proposed a ultrasonic sensor to detect level of wastes in the bins and WeMos D1 mini, to send the data to ‘ThingSpeak’ IoT server. In T. Ali et al [6], the authors proposed ultrasonic and weight sensors to predict the level and weight of wastages in the smart bins. The authors also proposed a flame, humidity and temperature sensors to ensure the safety of the waste bins. Then, the sensors signals are sent to the server with the help of wireless module. The authors used MySQL database to

store the information collected from the sensors. In P. Argulwar et al [7], the authors proposed a ultrasonic sensor to detect the garbage level in the smart bin. Then, RF transmitter is used to send the information to the centralized server system with the help of PIC microcontroller. Additionally the authors introduced LCD display, to display filling level of garbage in the smart bins. So that, waste collection truck driver can estimate their schedule according to the data.

From the literature survey, it is concluded that a proper system is needed to monitor the garbage level in the waste bins. The weight of the waste bins, temperature and humidity are not that much essential parameters for waste management as these approaches are not economically feasible. The review also reveals that a suitable optimal routing system is needed for waste collection network in order to reduce the overall expense of the system.

III. PROPOSED SYSTEM

The proposed system is designed to minimize the daily expense of the waste management system by optimizing the routing of the waste bins network by ant colony optimization technique [8-10]. This is achieved by monitoring the level of wastages in the smart bins with the help of IoT server. In this paper, for demonstrative purpose, the waste bins network was developed for University of Technology and Applied Sciences (UTAS), Iabri based on its building plan and amount of wastages accumulated in different locations.

The Fig.1 shows the UTAS, Iabri campus layout with 15 smart bins. The Fig. 2 shows the same waste collection network with distances between the smart bins. The total distance between the bins is 640 metres. The distance between the bins is represented in Table 1.

The filling level of smart bins is sensed by ultrasonic sensors. These sensors are fitted at the centre of the lid, in order to estimate the filling level by measuring the distance between its positions to wastages with the help of microcontroller unit. The ultrasonic sensor has transmitter and receiver sections. The transmitter sends the ultrasonic waves in the form of sound bursts. The reflected ultrasonic waves from the obstacles are received by the receiver.

The microcontroller unit attached with the ultrasonic sensor estimate the distance by multiplying the speed of the ultrasonic waves with its reflected time from the obstacles. $d = c * t$, where 'c' represents the speed of the ultrasonic waves (341 metres per second in air) and 't' represents the time taken by the ultrasonic waves reflected back from the obstacles[11-13].

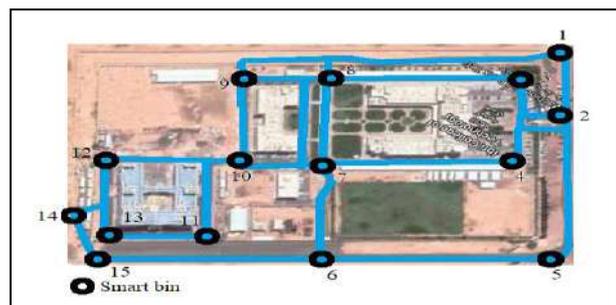


Fig.1. Waste collection network of UTAS, Iabri

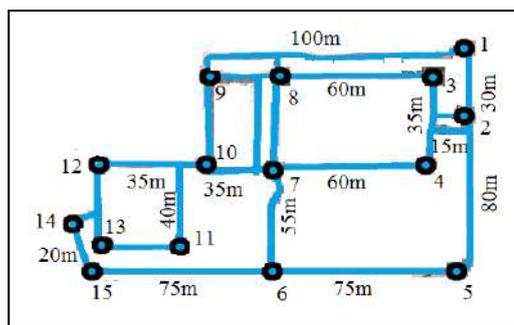


Fig.2. Waste collection network with distances

TABLE 1. DISTANCE BETWEEN THE BINS

Waste bin locations	1-2	2-3	3-4	4-5	5-6
Distance(m)	30	30	35	115	75
Waste bin locations	6-7	7-8	8-9	9-10	10-11
Distance(m)	55	35	35	35	45
Waste bin locations	11-12	12-13	13-14	14-15	Total
Distance(m)	70	40	20	20	640

The status of the waste bins are categorized in to three types based in the wastes level in the bins. They are:

- (a) *Stage 1:* If the wastes filling level in between the range 0 to 39%, then that waste bin is considered as in stage 1. It is used to predict the duration of filling of the waste bins to research its full level. It is used to predict the possible routing for waste collection trucks at the earliest.
- (b) *Stage 2:* If the wastes filling level in between the range 40 to 79%, then that waste bin is considered as in stage 2. This stage represents that the waste bin at any time turned to be stage 3 for collection of wastes. This stage is used to predict the optimal routing for the consecutive trips.
- (c) *Stage 3:* If the wastes filling level in between the range 80 to 100%, then that waste bin is considered as in stage 3. This stage indicates that the waste bin is ready to empty it for next cycle.

The smart sensor unit and its connection diagram are shown in Fig. 3 and 4. In this paper HC-SR04 ultrasonic sensor is used as a level sensor. The trigger and echo pins of the sensor is connected with digital I/O pins 7 and 6 in the Arduino Uno development board (Microcontroller unit) respectively.

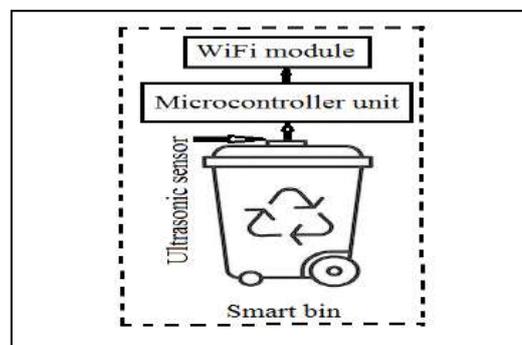


Fig.3. The smart sensor unit of smart bin

The ESP8266 is used as a WiFi module. The transmitter (TX) and receiver (RX) pins of the WiFi module are connected with RX (Receiver) and TX (Transmitter) of the Arduino Uno board.

The data received from the smart bins are recorded in different fields of the private channels in the ‘ThingSpeak’ IoT server. In this paper, 3 of its private channels are used for data collection and storage [14-15].

The code written in the microcontroller unit to send the ultrasonic sensor data to the IoT server is explained with the following steps.

- (i) Initializing WiFi network
- (ii) Representing ‘ThingSpeak’ IP address and channel ‘API’ key
- (iii) Assigning the microcontroller unit digital I/O pins for sensor and WiFi module.
- (iv) Estimating the level of garbage in the waste bins based on the ultrasonic sensor data and sending the same to the IoT server via WiFi module.

The collected sensor data appeared in the private channels as shown in Fig.8. Based on the status of the smart bins, the optimal routing for waste collection network is obtained by ACO technique which is developed in the IoT server,

The ACO technique is initially proposed by Dorigo as a metaheuristic technique for combinatorial optimization problems [16]. It is developed based on the social behavior of the biological ants to find the shortest distance between the nest to the food source.

These intelligent creatures achieve this by a chemical substance called pheromone. As the ants travels from its nest to search a food. It leaves the pheromone trials on its way so that other ants can follow that path.

Initially, each ant moves in its own fashion and deposit the pheromone on its path. Then, the ants select the particular path in the node based on pheromone concentration and also deposit the pheromone on its path. So the frequently used path is reinforced with subsequent ants [17]. It increases the possibility of other ants utilizing the same path for their tour.

This is achievable by the evaporative nature of pheromone trails. The continuous efforts of ants for selecting the random paths in the new nodes make the ant colony to reach the food even though obstacles on its path. Based on state transition rule, the movement of ants between the nodes is estimated as

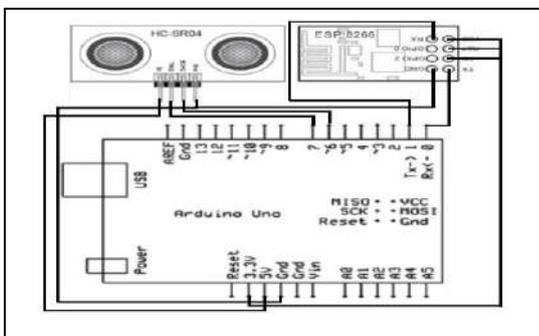


Fig.4. Connection diagram of smart sensor unit

$$i = \begin{cases} \arg \max \{ \tau(a,b)^\alpha \eta(a,b)^\beta \}, & \text{if } (q \leq q_o) \\ I, & \text{otherwise} \end{cases}$$

$$i = \begin{cases} \arg \max \{ \tau(a,b)^\alpha \eta(a,b)^\beta \}, & \text{if } q \leq q_o \\ I & \text{otherwise} \end{cases} \quad (1)$$

Here ‘I’ represent the probabilistic transition function, ‘ τ ’ represents the state transition rule, ‘a’ and ‘b’ represents the nodes, ‘ α ’ represents the pheromone exponential weight, ‘ β ’ represents the heuristic exponential weight and ‘ η ’ represents the reciprocal of distance.

The ants navigate one node to another node by using state transition rule. While the ants in navigation, they update the pheromone by local updating rule.

$$\tau_{local}(a,i) = (i - \rho)\tau(a,i) + \rho\Delta\tau(a,i) \quad (2)$$

Here ‘ ρ ’ represents the pheromone evaporation coefficient. $\Delta\tau(a,i)$ represents the initial amount the pheromone trail. After all ants visits all nodes. Then, the global update is estimated by

$$\tau(a,i) = (1 - \rho)\tau(a,i) + \rho\Delta\tau(a,i)$$

$$\tau_{global}(a,i) = (i - \rho)\tau(a,i) + \rho\Delta\tau(a,i) \quad (3)$$

The step-by-step procedure of ACO is represented as follows.

- (i) Initialize ACO parameters. The ACO parameters are (i) Number of iterations, (ii) Number of ants, (iii) Initial value of pheromone and (iv) Evaporation rate.
- (ii) Allocate artificial ants in the nodes in random manner.
- (iii) Initialize the ants to move to the next node by state transition rule.
- (iv) Update the pheromone trial by local updating rule.
- (v) Check the presence of ants in all the nodes. if any of the nodes is left out without ant go to step (ii).
- (vi) Estimate the global update and calculate the optimal path.
- (vii) If stopping criterion is not met go to step (ii).The flow chart of the ACO is shown in Fig. 5

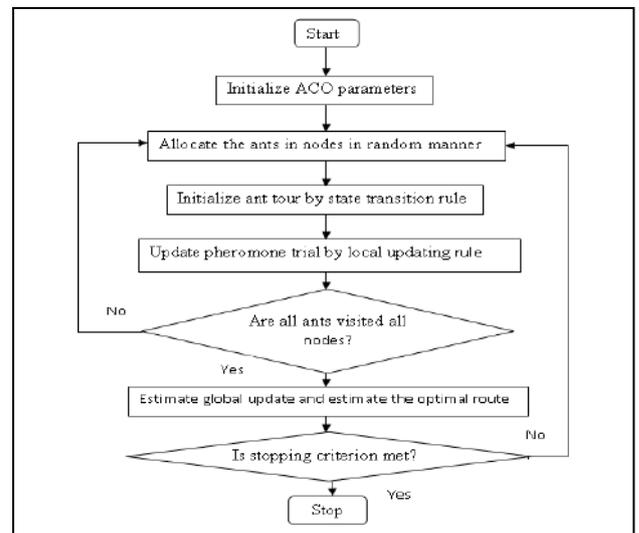


Fig.5. Flowchart of ACO

IV. EXPERIMENTAL RESULTS

The proposed system is validated with 15 smart bins that were placed in different locations in the campus of University of Technology and Applied Sciences, Ibra as shown in figure 6. Their locations and distance were given in Table 1. The filling capacity and filling rate of the wastages in smart bins are almost same as they were located in the same campus. Each smart bin is equipped with following three components

- i. Level fill sensor – Ultrasonic sensor (HC-SR04)
- ii. Micro controller unit - ATmega 328
- iii. WiFi module - ESP 8266

The circuit arrangements of these components are shown in Fig. 7.

The system is designed to collect the wastages form the smart bins where the garbage level was crossing 80% of its total filling capacity. The recorded filling level status of the smart bins 1, 6 and 8 during the time period of 10.40 to 11.00 am on 23.04.2021 is shown in Fig. 8.

Then, the optimal routing for the waste collection network is estimated by ACO based on the data collected from the smart bins in the MATLAB software by M-file coding. The parameters and its values considered for ACO is given in Table 2.

The ACO parameters are optimized by trial and error method by filling all 15 smart bins with its full capacity. The Fig. 9 shows the optimal routing obtained by ACO for given waste collection network when number of iteration is randomly selected as 300 with number of ants 40 and evaporation rate 0.05. The experimental results shown that the total length obtained by ACO is 505m. by keeping number of ants and evaporation rate as constant. The experiments were carried out for the iterations 50, 100, 200, 400 and 500. The experiments results seem optimized when number of iterations at 50. Because when number of iterations at 40. The ACO lost its optimization as the optimal routing length is increased to 540m as shown in Fig. 10.



Fig.6. Smart bin with level fill sensor unit

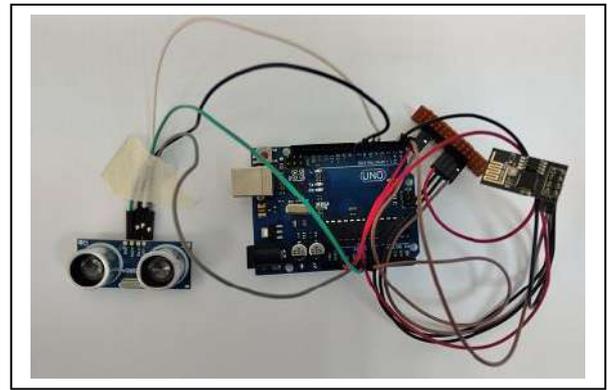
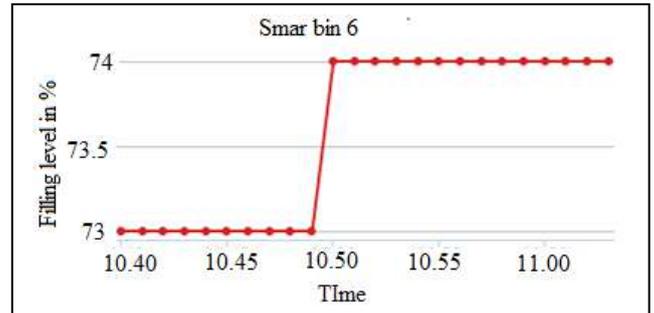
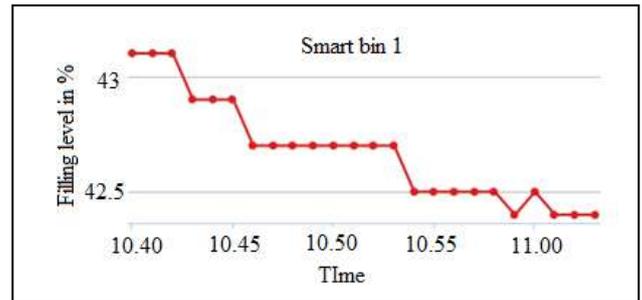


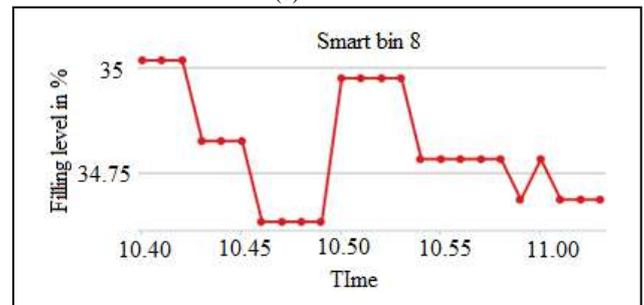
Fig. 7. Circuit connection between level fill sensor,



(a)



(b)

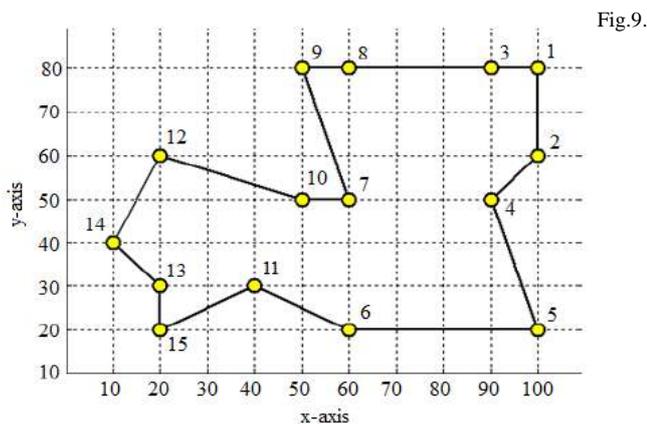


(c)

Fig. 8. Field views of recorded level fill sensor data collected from smart bins (a) 1, (b) 6 and (c) 8 in ‘ThingSpeak’ private channels.

TABLE I. ACO PARAMETERS

Parameters	Values
Number of iterations	400
Number of ants	30
Pheromone exponential weight	1
Heuristic exponential weight	1
Evaporation rate	0.06



Optimal routing of ACO for number of iterations 50, 100, 200, 400, 500 with number of ants 40 and evaporation rate 0.05.

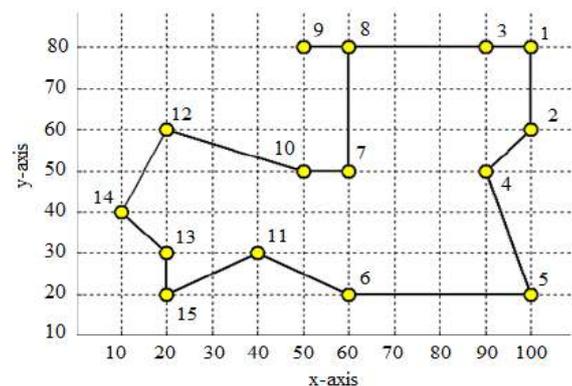


Fig.10. Optimal routing of ACO for number of iterations 40, number of ants 40 and evaporation rate 0.05.

Then, the experiments were carried out by changing the evaporation rate as 0.01, 0.02, 0.03, 0.04 by keeping number of iterations as 50 and number of ants as 40. The results shown that the ACO lost its optimization when the evaporation rate as 0.02. The optimal length is increased to 575m as shown in Fig. 11.

By keeping the number of iterations as 50 and evaporation rate as 0.03. The experiments were carried out by changing number of ants as 10, 20, 30, 40, 50, 60 and 70. The algorithm lost its optimization at when number of ants is equal to 10 as shown in Fig. 12. The experimental results shown that the ACO is yielding optimized results for the parameter values (i) number of iterations 50, (ii) evaporation rate 0.03 and (iii) number of ants 20.

Then, the ACO is implemented for finding optimal routing of waste collection network according to the filling level of waste bins. Fig. 13 shows the optimal routing obtained by ACO when waste bins 7 and 10 are in the stages of 1 and 2. Similarly, Fig. 14 and Fig. 15 represent the optimal routing when 1, 2, 12 and 1, 2, 9, 12 bins are in the stages of 1 and 2. The Table 3 shown the optimal routing length obtained by ACO for the above three setups.

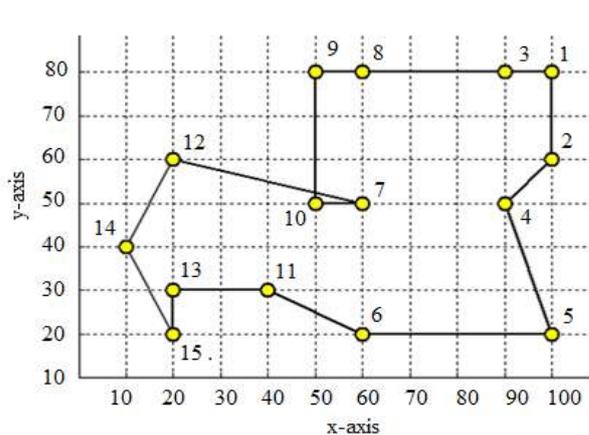


Fig.11. Optimal routing of ACO for number of iterations 50, number of ants 40 and evaporation rate 0.02.

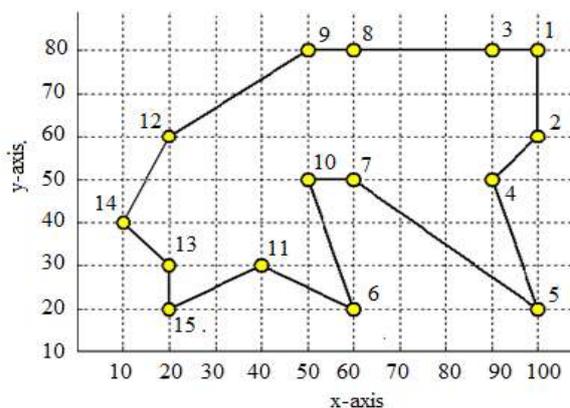


Fig.12. Optimal routing of ACO for number of iterations 50, number of ants 10 and evaporation rate 0.02.

Waste bins (Stages 1 and 2)	Optimal length (m)
7,10	435
1,2,12	405
1,2,9,12	340

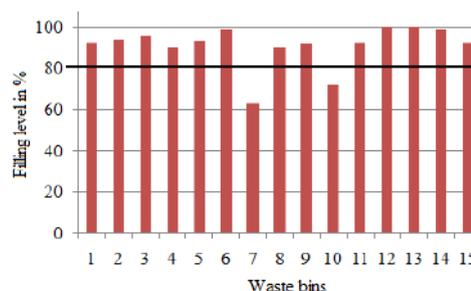
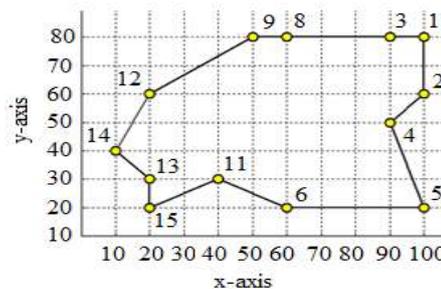


Fig. 13. Optimal routing when bins 7 and 10 are in the stages of 1 and 2

V. CONCLUSION

Optimal routing is considered as one of the most important parameter in the waste management system as it determines the overall expense. It also reduces the carbon foot print. In this paper, ACO technique is proposed to obtain the optimal routing for the waste collection network with the help of the smart sensors. The level fill sensors are used to sense the level of garbage in the waste bins. Then, this information sent to

considering traffic congestion in the waste collection routes in the network.

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REFERENCES

- [1] Gopi, J. A. Jacob, R. M. Puthumana, A. K. Rizwana, S. Krishnapriya and B. Manohar, "IoT based smart waste management system", 8th International Conference on Smart Computing and Communications, Kochi, India, pp. 298-302, 2021.
- [2] S. Mithinti, A. Kumar, S. Bokadia, S. Agarwal, I. Malhotra and N. Arivazhagan, "IoT Based Smart Bin for Smart City Application", International Conference on Intelligent Computing and Control Systems, Madurai, India, pp. 1468-1472, 2019.
- [3] M. Srinivas, S. Benedict and B. C. Sunny, "IoT Cloud based Smart Bin for Connected Smart Cities - A Product Design Approach", 10th International Conference on Computing, Communication and Networking Technologies, Kanpur, India, pp. 1-5, 2019.
- [4] S. Akshayaa., R. Evangeline., S. Haritha Sree and B. Banuselvasaraswathy, "Smart bin for Clean Cities using IOT", 7th International Conference on Advanced Computing and Communication Systems, Coimbatore, India, pp. 1280-1283, 2021.
- [5] S. K. Memon, A. R. Memon and A. A. Memon, "Smart Garbage Bin: An IoT Platform for Smart Waste Management System in Pakistan", 3rd International Conference on Computing, Mathematics and Engineering Technologies, Sukkur, Pakistan, pp. 1-5, 2020.
- [6] T. Ali, M. Irfan and A. S. Alwadie, "IoT-Based Smart Waste Bin Monitoring and Municipal Solid Waste Management System for Smart Cities", Arab Journal of Science and Engineering, pp.1-14, 2020.
- [7] P. Argulwar, S. Borse, K. N. Argulwar and U. S. Gurunathappa, "IoT-Based Smart Garbage Management System", International Conference on Intelligent Computing and Applications. Advances in Intelligent Systems and Computing, vol 632, 2018.
- [8] F. Dahan, K. E. Hindi, A. Ghoneim and H. Alsalman, "An Enhanced Ant Colony Optimization Based Algorithm to Solve QoS-Aware Web Service Composition", IEEE Access, vol. 9, pp. 34098-34111, 2021.
- [9] S. Zhang, J. Pu and Y. Si, "An Adaptive Improved Ant Colony System Based on Population Information Entropy for Path Planning of Mobile Robot", IEEE Access, vol. 9, pp. 24933-24945, 2021.
- [10] M. He, Z. Wei, X. Wu and Y. Peng, "An Adaptive Variable Neighborhood Search Ant Colony Algorithm for Vehicle Routing Problem With Soft Time Windows", IEEE Access, vol. 9, pp. 21258-21266, 2021.
- [11] L.Koval, J. Vaňuš and P. Bilik, "Distance Measuring by Ultrasonic Sensor", International Journal of IFAC-Papers On Line, vol. 49, Issue. 25, pp. 153-158, 2016.
- [12] G. Kumaravel, V. Iankumaran, Suaad Abdullah Al Maqrashi and Manar Khalifa Saif Al Yaaqubi, "Automated Date Fruits Sorting Machine using Fuzzy Logic Controller", International Journal of Recent Technology and Engineering, vol.8, Issue.4, pp.1089-1093, 2019.
- [13] Obed Appiah, Ebenezer Quayson and Eric Opoku, "Ultrasonic sensor based traffic information acquisition system; a cheaper alternative for ITS application in developing countries", Scientific African, vol. 9, pp.1-12, 2020.
- [14] Aswathi Vinu, S.Abhijith, AR.Sruthy and V.V. Suhail, "Waste Management System With Thingspeak", International Research Journal of Engineering and Technology, vol.6, Issue. 6, pp.3869-3872, 2019.
- [15] K. K. K. Win, T. N. Win and K. W. Kyaw, "Experimental Design and Analysis of Vehicle Mobility in WiFi Network", IEEE Conference on Computer Applications, Yangon, Myanmar, pp. 1-4, 2020.
- [16] M. Dorigo, M. Birattari and T. Stutzle, "Ant colony optimization", IEEE Computational Intelligence Magazine, vol. 1, Issue. 4, pp. 28-39, 2006.
- [17] Guilherme V. Batista, Cassius T. Scarpin, José E. Pécora and Angel Ruiz, "A New Ant Colony Optimization Algorithm to Solve the Periodic Capacitated Arc Routing Problem with Continuous Moves", Mathematical Problems in Engineering, vol. 2019, pp.1-12, 2019.

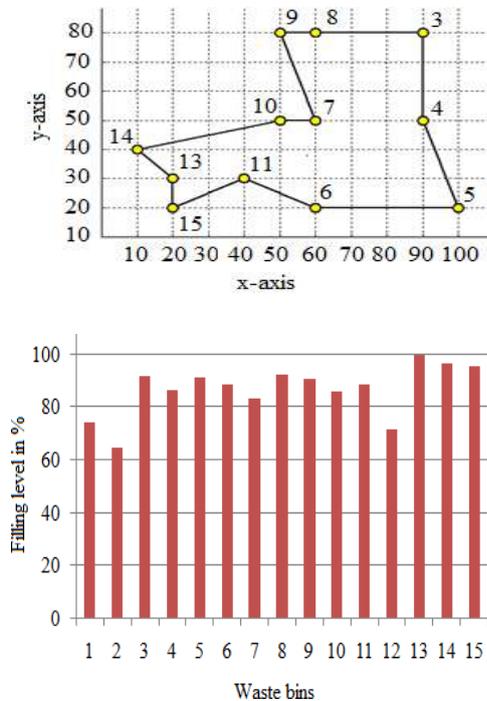


Fig.14. Optimal routing when bins 1,2 and 12 are in the stages of 1 and 2

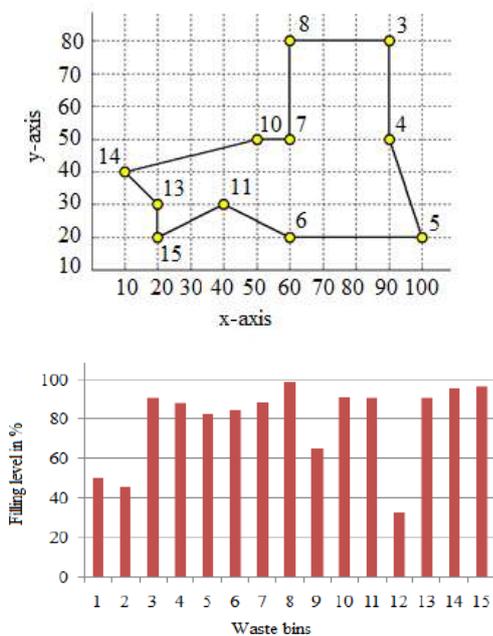


Fig.15. Optimal routing when bins 1, 2, 9 and 12 are in the stages of 1

the IoT server with the help of microcontroller unit and WiFi module. The experimental results shown that the proposed system is efficient for obtaining optimal routing for waste collection network. In future this work may be extended with

Challenges and Alternatives for Application of New Refrigerants in HVAC & R Products

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Abstract— Environmental issues of ozone depletion and global warming have been the key drivers for new refrigerant developments. As a result, several new chemicals are being introduced to meet the challenges of being environment-friendly, energy efficient and safe. This Paper looks back at the historical development of refrigerants briefly and then outlines the multiple options, both current as well as future for different products/applications in the Refrigeration and Air Conditioning field. For each end use application, current as well as new alternate refrigerants are compared on four key parameters viz. ODP, GWP, COP and Safety Group. There is no single alternative, which can be considered best on all the four parameters. Hence, there is need of optimal selection on the part of product designers and manufacturers as well as end users and customers. Global and local regulations in force have to be adhered. Safety to the end users as well as technicians is an important criterion in the current scenario.

Keywords— Ozone depletion, Global warming, ODP, GWP, COP, Safety Group, Energy efficient, Regulations, Safety

I. INTRODUCTION

Refrigerants are a family of chemicals used in refrigeration and air conditioning equipment, foams, insulation, aerosols, fire suppressants and other applications. Their major use is as a working fluid to produce cooling effect. The broad two categories of the refrigerants are natural and synthetic.

It was in early '70s that Professor Sherwood Rowland and his Post-Doc assistant Mario Molina from University of California, Irvine researched and found that there was a reduction of concentration of Ozone in the upper layer of atmosphere viz. Stratosphere. It was their path-breaking paper in Nature [1], which brought world's attention to the Ozone depletion. Ozone, while present at that level in a very thin layer protects the inhabitants as well as plants on Earth from Sun's harmful Ultraviolet (UV-C) rays. Montreal Protocol that was aimed at gradual phase-out of CFC's enforced the chemical manufacturers to develop Ozone-friendly gases. In the Rowland-Molina discovery, the significant finding was the Chlorine atoms in CFC molecules were causing the chain reaction and splitting of Ozone molecules. Therefore the alternate chemicals devoid (or with minimal presence) of Chlorine were developed. This is what led to the development of HCFC's and HFC's. Fig 1 depicts and summarizes the historical evolution of the refrigerants from the 19th century till date.



Fig 1. Evolution of Refrigerants (Source: Honeywell Inc.)

Apart from the direct effect due to chemical reaction of the refrigerant molecules in the atmosphere, there is an indirect effect. The indirect effect refers to the warming caused due to energy consumption by any system/machine. Since the major source of power generation is coal that generates CO₂, the more the power consumed, more will be the emissions. In case of any refrigeration or air conditioning equipment, the indirect effect is order of magnitude higher than direct effect. Taking example of an Air Conditioner, it has been proven that the indirect effect is almost 42 times the direct effect! Hence, there is major thrust and efforts on improving energy efficiency of appliances as well as industrial products and systems.

II. NEW ERA

Thus, use of these non-Ozone Depleting Substances increased; particularly HFC's since with the absence of Chlorine they do not cause destruction of Ozone layer. While the environmental issue of Ozone depletion seemed to settle down, another climate change issue started looming. This was the global warming; first brought to the forefront by IPCC with their timely Reports. So how do the refrigerants cause global warming and climate change? For this first a metric is defined. It is called GWP, which means the potential for greenhouse effect of 1 Kg of any gas relative to that of 1 Kg of CO₂ which is considered to be 1. The global warming potential of a refrigerant is an index representing the energy absorbed by or contained in a refrigerant when released into the atmosphere relative to that of CO₂ over a period, typically 100 years as presented in Lashof and Ahuja [2]. Now just to give an example of GWP's of HFC's; refrigerant R-134a which is one of the most commonly used refrigerants has a GWP of 1300[3]!

The Kigali Amendment to the Montreal Protocol lays down the schedule of phase-down of HFC's (this is different and unlike the phase-out of CFC's as per original Montreal Protocol) for different Groups of countries. Figure 2 shows the Schedule.

Summary of the Kigali Amendment to the Montreal Protocol: HFC Reduction Schedule						
		A5 Group 1	A5 Group 2	Non-A5		
		"Developing Countries - Faster Track"	"Developing Countries"	"Developed Countries"		
Countries Included		China, African Group, GRLLAC (Latin American and Caribbean Group ¹), Thailand, Malaysia, Indonesia, Cambodia, West Asian Countries (except those in Group 2), Turkey, Pacific Islands, Maldives, Sri Lanka	GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates), India, Iran, Pakistan, Iraq	Andorra, Australia, Azerbaijan, Belarus ^{**} , Canada, European Union with its 28 members, Holy See, Iceland, Israel, Japan, Kazakhstan, Liechtenstein, Monaco, New Zealand, Norway, Russian Federation ^{**} , San Marino, Switzerland, Tajikistan ^{**} , Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America, Uzbekistan ^{**}		
Base Line Definition in CO₂ Equivalence	Reference Years	Average of 2020-2022	Average of 2024-2026	Average of 2011-2013		
	Formula to Calculate Base Line	Base Line Group 1 = Average HFC Consumption (2020-2022) + 85% HCFC Baseline (2009-2010)	Base Line Group 2 = Average HFC Consumption (2024-2026) + 65% HCFC Baseline (2009-2010)	Base Line Non-A5 = Average HFC Consumption (2011-2013) + 15% Actual HCFC Baseline (2011-2013)		
Freeze Date		2024	2028	None		
Reduction Steps	Year	2024	2028	2019	2024	
	Total % of Base Line Remaining	100%	100%	90%	60%	
		2029	2032	2024	2024	
		90%	90%	80%	30%	
		2035	2037	2029	2024	
		70%	80%	20%	20%	
	2040	2042	2034	20%		
	50%	70%	2034	20%		
	2045	2047	2036	15%		
	20%	15%	2036	15%		

¹ https://en.wikipedia.org/wiki/United_Nations_Regional_Groups#Western_European_and_Others_Group_28WEOG-28

** Non-A5 Countries follow a modified reduction for first two steps (2020 (5%) and 2025 (35%)), and the base line includes 25% of HCFC base line.

Fig 2. HFC Phase-down Schedule (Source: Johnson Controls, Inc.)

The present chemical alternative development task is much more complex and challenging. The challenges are multifold: new gases must have low GWP, should be non-toxic, non-flammable and possess thermodynamic properties required as per application. Apart from these, there are many non-technical, commercial and logistic requirements to be met. One of the requirements is these gases should be unstable and possess low atmospheric life while chemically stable inside the systems. This paradoxical requirement has arisen because higher stability and longer atmospheric lifetime results into adverse environmental effects as is observed with both the CFC's and HFC's.

III. THE NEW GENERATION OF REFRIGERANTS

Many of the new chemical developments are under progress and testing. However, chemical manufacturers have zeroed down primarily to a new class viz. HFO's as well as HCFO's. They are unsaturated HFC's and HCFC's. Kujak and Schultz [4] provide a good insight into next generation refrigerants. Four factors are going to decide the future of refrigerants. These are: direct environmental effects, indirect environmental effects, safety for consumers and service technicians and product sustainability. As can be seen from Fig 3 as per ASHRAE 34 Standard [5], the Safety Group classification for most of the CFC's and HFC's is Class A1; the most safe type. An exceptional "natural" refrigerant which has stood the test of time is Ammonia; which is B2L class but is a good fluid thermodynamically (as well as available locally) and hence used widely in Ice Plants, Cold Storages and most of Industrial Refrigeration plants.

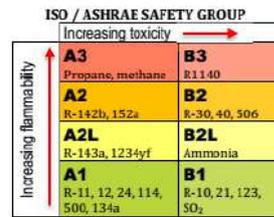


Fig 3. ASHRAE Safety groups [5]

Another interesting gas which is being researched upon is CO₂ itself. This is also a good alternative from environmental considerations. However, technical challenge with CO₂ is that the cycle is trans critical and its efficiency is poor. Bitzer report [6] outlines multiple options for HCFC's as well as HFC's. Kujak [7] discusses flammability issue of new refrigerants. Roundtable conversation [8] provides a good overview of various options.

IV. ALTERNATE NEW REFRIGERANTS AND THEIR APPLICATIONS

With the Kigali Amendment to the Montreal Protocol coming into force gradually first in developed countries followed by Article 5 countries, there is a global development in the application of new refrigerants. In the Refrigeration and Air Conditioning field, there are different applications and end users; primarily based on conditions of temperature and humidity to be maintained. The following is a list of main categories:

- Positive Displacement Chillers (Water Cooled/Air Cooled)
- Centrifugal Chillers
- Air Conditioners
- Domestic Refrigerators/Freezers
- Industrial Refrigeration/Cold Storage
- Transport Air Conditioning

The above is the list of main types of products which are in turn used in different applications and systems. Chillers are primarily used in either comfort or industrial air conditioning plants. They provide chilled water to the air circulating units (called Air Handling Units) which in turn supply conditioned air to the spaces. Chillers are classified in mainly 2 categories viz. Positive Displacement and Centrifugal. These indicate the type of compressors used in the Chillers. Positive Displacement compressors are reciprocating, scroll and screw type. Typical capacity range of these types of Chillers are from approx 25 TR upto 300 TR. The larger range is handled by Screw compressors while the middle and smaller range consists of Scroll or Reciprocating compressors. Further these Chillers can be either air cooled or water cooled. This indicates the cooling medium for the condensers. Since water is a better heat transfer medium as well as water temperature can be maintained constant by the Cooling Tower, water cooled chillers have better energy efficiency than air cooled types. However there are many sites or locations where availability of cooling water is an issue. Hence air cooled chillers are used. Since air is poor heat transfer medium as well as summer temperatures in India go high, the efficiency of air cooled chillers is less. Centrifugal chillers are used for large capacities ranging from approx 250 TR to 1000 TR or even larger. These are essentially water cooled types. Also they use centrifugal compressors which are characterized by high flow rate and smaller pressures. Their efficiency is high.

Air Conditioners, either the Window or Split or Packaged types essentially supply cooled and dehumidified air to the space. The type of condensers are air cooled. Also their capacities are limited; from 1 TR to maximum 15 TR. Domestic refrigerators have two compartments viz. Freezer and Refrigerator. The compressor has to operate at a low evaporating temperature in order to maintain low temperature in the Freezer compartment. Industrial refrigeration and cold storage are used in many applications and industries ranging from dairy industry, Ice Plants, breweries, pharmaceutical, process industries; etc. The temperature required will vary depending upon the application and process requirement. However most common applications are sub Zero temperatures and according the analysis is done in this Section.

The last type of product or application considered is the transport air conditioning; be it car or bus or railway coach air conditioning. While essentially it involves maintaining comfort conditions for the passengers, these applications are more demanding in terms of mechanical strength requirement, vibration and fatigue resistance and also a wide range of air temperatures which it encounters during the vehicle journey.

Now the further part of this Section will be the comparative analysis of these products for different refrigerants ranging from currently used HFC's to the upcoming HFO's,

For each of the above application, different alternatives were analysed and compared for their properties. This includes COP results computed from cycle analysis developed by Honeywell [9] and Chemours [10]. Tables I through VI presents the data and results of the study. Design parameters such as evaporating temperature, condensing temperature, subcooling etc. are a part of product design and development phase. The data assumed in the current analysis are based on author's past experience and need not be generalized. There are good, promising new refrigerants, which can meet both the low GWP requirements and being energy efficient. However many of the new alternatives are under development/commercialization and will need more field trials for their commercial usage.

TABLE I. POSITIVE DISPLACEMENT CHILLERS (WATER/AIR COOLED)

R No.	Type	ODP	GW P	COP (Water Cooled) ^a	COP (Air Cooled) ^b	SG
R22	HCFC	0.05	1760	5.8	3.96	A1
R134a	HFC	0	1300	6.1	4.06	A1
R407C	HFC blend	0	1624	5.6	3.7	A1
R410A	HFC blend	0	1924	5.94	3.42	A1
R513A	HFC / HFO blend	0	572	5.94	3.86	A1
R450A	HFC / HFO blend	0	547	5.78	3.9	A1
R515B	HFO blend	0	299	6.1	4.01	A1
R1234ze (E)	HFO	0	1	6.11	4.05	A2L

^a For Water Cooled
Evaporating Temp: 4 °C Condensing Temp: 42 °C Superheat 5 °C (DX)

-----":5.5 °C -----": 42 °C -----"
(Flooded)
^b For Air Cooled
Evaporating Temp: 4 °C Condensing Temp: 55 °C Superheat 5 °C (DX)
-----":5.5 °C -----": 55 °C -----"
(Flooded)

TABLE II. CENTRIFUGAL CHILLERS

R No.	Type	OD P	GW P	COP ^c	SG
R123	HCF C	0.02	93	6.79	B1
R134a	HFC	0	1300	6.33	A1
R1233zd(E)	HCF O	~0	1	6.72	A1
R514A	HFO blend	0	2	6.80	B1

^c Evaporating Temperature: 5.5 °C, Condensing Temperature: 41 °C

TABLE III. AIR CONDITIONERS

R No.	Type	ODP	GW P	COP ^d	SG
R22	HCF C	0.05	1760	4.29	A1
R410A	HFC blend	0	1924	3.72	A1
R454B	HFO / HFC blend	0	473	3.94	A2L
R32	HFC	0	677	4.0	A2L
R290	HC	0	3	4.14	A3

^d Evaporating Temperature: 7 °C, Condensing Temperature: 55 °C

TABLE IV. DOMESTIC REFRIGERATORS/FREEZERS

R No.	Type	ODP	GW P	COP ^e	SG
R134a	HFC	0	1300	2.58	A1
R290	HC	0	3	2.57	A3
R600a	HC	0	4	2.73	A3

^e Evaporating Temperature: -25 °C, Condensing Temperature: 55 °C

TABLE V. INDUSTRIAL REFRIGERATION / COLD STORAGE

R No.	Type	ODP	GWP	COP ^f	SG
R22	HCFC	0.05	1500	2.43	A1
R404 A	HFC blend	0	3943	2.1	A1
R448 A	HFO blend	0	1273	2.3	A1
R717 (NH ₃)	Natural	0	0	2.46	B2 L

^f Evaporating Temperature: -30 °C, Condensing Temperature: 42 °C

TABLE VI. TRANSPORT AIR CONDITIONERS

R No.	Type	ODP	GWP	COP [§]	SG
R134a	HFC	0	1300	3.67	A1
R1234yf	HFO	0	0	3.33	A2L
R744 (CO ₂)	Natural	0	1	*	A1

* R744 (CO₂) operates in a trans-critical cycle and its COP is poor.
 § Evaporating Temperature: 7 °C, Condensing Temperature: 60 °C

V. CONCLUSION

Refrigerants have been undergoing phenomenal changes over last few decades. The current scenario is even more challenging due to multiple requirements to meet the regulations, customer safety, cost and availability. Kigali Amendment to Montreal Protocol is under adoption in several countries to phase down HFC’s. There is not a single, best alternate refrigerant for any application. However, as per the comparative analysis presented in this Paper, there are promising alternatives, which can be used to replace the existing refrigerants. Manufacturers and product designers do have good choices to develop their products using any of the alternatives and make the products sustainable and energy efficient.

VI. ABBREVIATIONS (LISTED ALPHABETICALLY)

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CFC	ChloroFluoroCarbon
COP	Coefficient of Performance
GWP	Global Warming Potential relative to CO ₂ , based on 100 years’ time horizon
HC	HydroCarbon
HCFC	HydroChloroFluoroCarbon
HCFO	HydroChloroFluoroOlefin, Unsaturated HCFC
HFC	HydroFluoroCarbon
HFO	HydroFluoroOlefin, Unsaturated HFC
HVAC & R	Heating, Ventilation, Air Conditioning and Refrigeration
IPCC	Inter-Governmental Panel on Climate Change
ODP	Ozone Depletion Potential
R No.	Refrigerant Number
SG	Safety Group
TR	Ton of Refrigeration

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REFERENCES

- [1] Mario J Molina and F S Rowland, “Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone, Nature 249”, pp. 810-812, 1974.
- [2] Lashof, D.A. and Ahuja, D.R., “Relative contribution of greenhouse gas emissions to global warming”, Lett. Nat. 334 1990 (6266) 529-531
- [3] ISHRAE Position Document on Refrigerants. ISHRAE Journal. 2015.
- [4] Kujak, S., and Schultz, K., “Insights into the next generation HVAC & R refrigerant future. Science and Technology for the Built Environment”, October 2016, ASHRAE, Atlanta, GA.
- [5] ANSI/ASHRAE Standard 34. 2019. Designation and Safety Classification of Refrigerants. Atlanta : ASHRAE
- [6] Bitzer Refrigerant Report 21. www.bitzer.de
- [7] Steve Kujak. Flammability and New Refrigerant Options. ASHRAE Journal, May 2017.
- [8] Roundtable: A Conversation on Refrigerants. ASHRAE Journal, March 2021.
- [9] Genetron Properties Suite 1.4.1, Honeywell Inc. <https://www.honeywell-refrigerants.com>
- [10] Chemours Refrigerant Expert 1.0, Chemours Inc. <https://www.opteon.com>

Applicability of Big Data Analytics in Sustainable Supply Chain Management: A Proposed Framework

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Abstract— The extensive use of digital devices in business operations continually generates voluminous and varied data sets that are called big data (BD). The BD has got great potential to turnaround a business by means of big data analytics (BDA). The aim of this study is to explore the factors affecting the applicability of BDA in sustainable supply chain management (SSCM). Through an extensive literature survey a total of ten factors have been identified as per PESTEL framework which covers political, economic, social, technological, environmental and legal categories of factors. The identified factors are environmental policy and regulations, sustainable performance, competitive advantage, managerial and leadership commitment, stakeholders involvement and capabilities, technology resources and readiness, technology integration, lean and green practices, improvement in environmental performance, compliance with state regulations. The BDA is the moderating factor between these ten factors and SSCM. A research model has been proposed with pertinent hypotheses development for structural equation modelling. The outcome of the suggested execution of the model is expected to help managers in overcoming their lacunae and setting priorities regarding investment in BDA technologies for competitive advantage.

Keywords— *Big data analytics, Sustainable supply chain management, PESTEL framework, Structural equation modelling*

I. INTRODUCTION

Big data analytics (BDA) is made up of two parts – big data and data analytics [1]. The first part ‘big data’ (BD) refers to the massive amount of data that is generated in business operations due to the extensive use of sophisticated technologies such as barcodes, sensors, RFID and Internet of Things etc. [2]. The second part ‘data analytics’ refers to the use of advanced technologies for the analysis of these voluminous and complex data sets. These technologies include data mining, statistics, predictive and descriptive methods, artificial intelligence etc. [3]. BDA has a special role to play in the present era of highly dynamic and unstable business environment wherein the managers have realized the importance of data driven decision making rather than depending on the intuitions [4]. The rapidly growing manufacturing sector also calls for the adoption of BDA capabilities for supporting substantial business advantage and improved organizational performance [5]. When we talk about performance and competitiveness of a business, the term operations’ sustainability automatically comes in picture. BDA plays a crucial role in operations’ sustainability. Companies widely accept this as BDA contributes to the strategic planning of the organizations for improved organizational performance and enhanced sustainability of the supply chain [6]. This is in line with the United Nations’ agenda for sustainable development, which recommends the collection, processing, and dissemination of

all the varieties of big data for effective policy making, monitoring, and progress evaluation [7].

Even though the BD is recognized to be a latest worldwide sensation and this new way of business offers new opportunities, there are unanticipated new challenges also for generating new business models and fine tuning the existing operations for creating space for business gains [8]. The advent of BDA has not spread to business operations in the same proportion. Many organizations are seen to be reluctant to the implementation of BDA due to psychological and organizational issues and lack of understanding of the its benefits [9]. Manufacturing sector of developing economies is facing challenges in the implementation of BDA systems in their operations [10]. The objective of this paper is to address this issue. It explores the possibilities of employing BDA for quality improvement of business decisions. The research objectives are articulated as follows:

RO1: Identification of the PESTEL factors for adoption of BDA technologies for SSCM.

RO2: To develop a conceptual framework for the above mentioned purpose.

The article is organized in four sections. Section 2 elucidates the literature on BDA, SSCM, PESTEL analysis, and the research gaps. Section 3 gives an account of the various PESTEL factors that are crucial to the application of BDA in SSCM. Section 4 and 5 present the conceptual model and the methodology respectively. Section 6 discusses the conclusion of the study.

II. LITERATURE REVIEW

A. BDA in Manufacturing and Supply Chain Operations

In the current times the manufacturing firms have to operate in increasingly complex and uncertain environment with the processes involving complicated operations and constraints [11]. In this scenario the BDA is receiving increasing attention as an enabler for improved performance of manufacturing processes. The widespread use of distributed control and state of the art ICT technologies has led to considerable evolution of the production processes [12]. In the same way BDA has become a significant enabler for SC operations too. SCM may be defined as planning, organizing and directing of all the functions involved in the transfer of raw material from supplier to the manufacturer, distribution of final product to the customer, and relationship management with all the stakeholders of supply chain [13]. Sharing of information in the SC has a positive effect on the performance of large as well as small scale organizations [14,15]. Obviously, BDA plays an important role in SC and operations management [16]. Application of BDA in the manufacturing supply chain has been increasing significantly both in the developed and developing countries. BDA

technologies are capable of analyzing the SC data on a continual basis and share the results in real time. This is highly helpful in generating new insights into the issues at hand and making decisions for solving complex problems throughout the SC. In the wake of the above mentioned benefits, a number of manufacturing companies are inclined towards improving their performance level by means of BDA but there are many barriers too such as lack of understanding of BDA, lack of technological infrastructure, lack of funds etc. These and many other problems are often observed to derail the process of implementation of BDA in manufacturing SC [17].

B. BDA in Sustainable Supply Chain Management

BDA has been proved to have a positive impact on the environmental, economic, and social aspects of supply chain performance [18]. This is in line with the UN's three pillars of sustainable development viz. environmental protection, economic development and social development which are not just interdependent but are reinforced also by each other. During recent years, the industrial world has seen a number of emerging technologies that have brought about a significant impact on the supply chain sustainability. BDA may be used in decision making regarding manufacturing or any type of supply chain. All the types of firms can adopt BDA for flexibility and control [19] and the orientation of a firm does not really play an important role in this regard. BDA with predictive analytics increases not only the overall reliability, but also an improved firm performance. Not just operations but BDA plays an important role in improving the overall reliability and a better firm performance [5]. Also, apart from sustainable operations the BDA plays an important role in sustainability assessment also [20]. BDA can assist a manufacturing firm not only to achieve social welfare but economic benefits too, while minimizing the environmental impacts [21]. It can also do the requisite data integration, in order to minimize emission mitigation and energy consumption [22]. GSCM in conjunction with BDA has a crucial role to play in an organization's sustainability practices. It is considered to be an important approach to strike a balance amongst the environmental, social and economic issues of a firm, and to enhance the organizational sustainability [23].

C. PESTEL Analysis

PESTEL analysis is an extensively used framework for identifying the factors that influence a business. It covers political, economic, social, technological, environmental and legal factor [24]. This analysis is useful in evaluation of the macro environment and is a tool for prerequisite analysis for long term planning in an industry [25]. In current times the operational environment is changing constantly and effective decision making has become a real challenge. So, the study of merely the internal factors doesn't really suffice and a detailed analysis of external factors is vital. The PESTEL framework is a great tool for this purpose. It results in value added and sustainable business decisions. Each state, country or industry has its unique characteristics and degree of availability of relevant information. In these circumstances PESTEL analysis needs to be devoted to a particular state, nation or industry [26].

D. Research Gaps

From the literature review quite a few research gaps have been identified with regards to the implementation of BDA systems in SSCM. Despite wide acceptance of the fact that BDA may be instrumental in gaining business value, and its growing popularity, there is still a scarcity of academic literature on its potential to turnaround business performance [18]. Also, the knowledge about the organizational challenges that are significant in its implementation is still very limited. The companies still face lack of clarity as to how should they build BDA capabilities, implement the BDA program and overcome the organizational barriers [27, 28]. Further, fewer researchers have taken up an all-inclusive investigation on the major factors that affect an organization's project to implement big data [29]. This study attempts to address this issue by using the comprehensive PESTEL framework for identifying the important factors. Quite limited work has been done for underlining the enablers and barriers to successful adoption of BDA in SSCM [30]. This work attempts to fill this gap too.

III. BDA – PESTEL FACTORS FOR SSCM

Through an extensive literature survey, the factors that influence the adoption of BDA in manufacturing are identified. These factors belong to all the categories as suggested in PESTEL analysis. A total of ten factors were identified, one each from political and legal category and two each from economic, social, technological, and environmental categories. The abovementioned ten factors are further divided into thirty one sub-factors. Table 1 shows the PESTEL factors and corresponding sub-factors. An understanding of the impact of these factors on BDA may be important for managers for effective decision making regarding SSCM.

IV. CONCEPTUAL FRAMEWORK

Based on sec 2 and sec 3 a conceptual model is developed as depicted in Fig.1. The model consists of ten PESTEL factors viz. environmental policy and regulations, sustainable performance, competitive advantage, managerial and leadership commitment, stakeholders involvement and capabilities, technology resources and readiness, technology integration, lean and green practices, improvement in environmental performance, compliance with state regulations. BDA is the eleventh factor and is a mediator between sustainable manufacturing and other ten factors. The sub-factors considered for BDA are big volume, big velocity, big compatibility and modularity, BDA investment, BDA connectivity, BDA technical knowledge and technology management, BDA business and relational knowledge [3]. This forms the basis for the questionnaire. The seven point Likert scale may be used for evaluation of these sub-factors by the respondents. The respondents for the study may be senior managers from Indian manufacturing industry and the members from academia. The responses may be collected by e-mails and interviews. For the validation of the questionnaires and the sub-factors experienced academicians and industry executives may be consulted. Based on the suggestions from these experts, questionnaire may be finalized. On basis of the aforesaid eleven factors, the hypotheses are developed as follows:

TABLE I. COMPREHENSIVE LIST OF THE PESTEL FACTORS

PESTEL Factor	Factors	Sub-factors	References	
Political	Environmental Policy and Regulations	Emission cap and trade, and Carbon tax policy	[35] [49]	
		Environmental policy	[37] [46]	
		Government Regulations and Standards	[32][16] [36] [38] [39] [49]	
Economic	Sustainable Performance	Reduction in material and energy cost	[40] [42] [51]	
		Improvement in cost and operational performance	[36] [41] [8] [44] [46] [19]	
		Reduction in environmental cost	[43]	
		Long-term economic and financial viability	[45]	
	Competitive Advantage	Creation of competitive advantage	[39] [43] [19]	
		Improvement in Globalization	[38]	
Social	Managerial and Leadership Commitment	Managerial skills, practices and commitment	[32][33][16][18][38][39][8][44][45]	
		Collaborative performance and Relational practices	[32] [33] [8] [46] [19] [47] [49]	
		Organizational barriers and Change efficacy	[34] [18] [39] [8] [49]	
	Stakeholders Involvement and Capabilities	Employee Involvement and capabilities	[32][34][18][38][39][41][45][47] [49]	
		Organisational learning and Stakeholders' training practices	[36][38][8][44][46][19][48] [50]	
		Data driven decision making culture	[17] [39] [41] [44] [48] [49]	
	Technological	Technology Resources and Readiness	Technology resources and readiness	[33] [18] [38] [49] [51]
			Technical skills and Innovative capability	[33] [44] [48] [51] [49]
			Information and Data quality	[33] [35] [43] [49] [51] [49]
Technology Integration		Appropriate selection and adoption of BDA technologies	[18] [38] [43] [8] [49]	
		Technology and Data related barriers	[34] [51]	
		Data security and privacy	[18] [49]	
Environmental	Lean and Green Practices	Application of life cycle assessment	[38] [46]	
		Application of Green products and processes	[37] [38] [42] [8] [19]	
		Lean and green manufacturing	[32] [36] [37] [42] [8] [19]	
	Improvement in Environmental Performance	Emission mitigation	[37][38][42][8][44][45][46][48]	
		Reduction in air pollution, waste water and solid waste	[37][38][8][44][45][46][48][50]	
		Optimization of material and energy consumption	[37] [38] [8] [44] [45] [46]	
Legal	Compliance with State Regulations	Compliance with business laws and regulations	[45]	
		Compliance with environmental regulations	[37]	
		Compliance with laws related to data security and privacy	[39]	

- H1: Environmental policy and regulations have a positive impact on adoption of BDA.
- H2: Sustainable performance has a positive impact on adoption of BDA.
- H3: Competitive advantage has a positive impact on adoption of BDA.
- H4: Managerial and leadership commitment has a positive impact on adoption of BDA.
- H5: Stakeholders involvement and capabilities have a positive impact on adoption of BDA.
- H6: Technology resources and readiness have a positive impact on adoption of BDA.
- H7: Technology integration has a positive impact on adoption of BDA.
- H8: Lean and green practices have a positive impact on adoption of BDA.
- H9: Improvement in environmental performance has a positive impact on adoption of BDA.
- H10: Compliance with state regulations has a positive impact on adoption of BDA.
- H11: BDA has a positive impact on SSCM.

The proposed model needs to be analysed using exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and structural equation modelling (SEM).

A. Exploratory Factor Analysis

Exploratory factor analysis (EFA) is an orderly simplification of interrelated measures. Conventionally, the EFA has been used for exploring the probable underlying factor structure of a set of observed variables without imposing a predetermined structure on the outcome. It is a

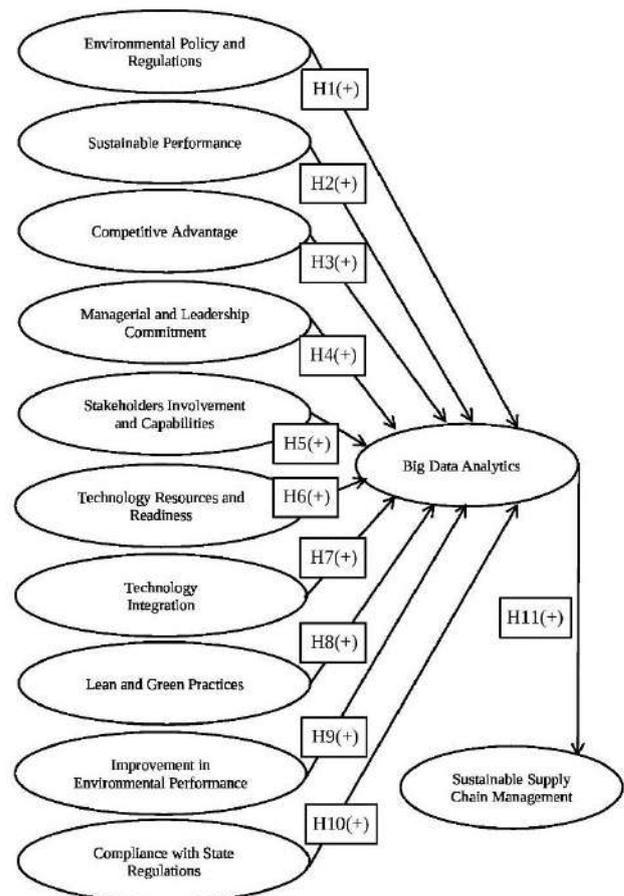


Fig 1. THE CONCEPTUAL MODEL

technique for variable reduction. It identifies the latent constructs and the underlying factor structure of a set of variables [52]. EFA is a technique for variable reduction. It identifies the latent constructs and the underlying factor structure of a set of variables. It hypothesizes the construct, which is a variable not measured directly and estimates factors which influence responses on observed variables. It allows identifying and describing the number of latent constructs or factors. It includes unique factors error due to unreliability in measurement.

B. Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) is a statistical technique for verifying the factor structure of a set of observed variables. CFA allows the testing of the hypothesis that a relationship between observed variables and their underlying latent constructs exists. The researcher uses theoretical knowledge, empirical research, or both, then hypothesizes the relationship pattern in advance and then tests the hypothesis statistically. The use of CFA could be impacted by the research hypothesis being tested, sample size, measurement instruments, multivariate normality, parameter identification, outliers, missing data or interpretation of model fit indices [53]. The CFA and EFA are used for examining the validity, reliability, and structure of the identified factors in decision making scenario [18].

C. Structural Equation Modelling

Analysis of research data and interpretation of results can be a complex and confusing task to do. Traditional statistical approaches for data analysis are a bit inflexible. They specify the default models in which the assumed measurement occurs without error. On the other hand, in structural equation modelling (SEM), the model needs to be specified on basis of theory and research. It is multivariate technique that incorporates measured variables and latent constructs. Also, it clearly specifies the measurement error. The diagrammatic representation of the model allows for specification of the relationships amongst variables [54]. SEM is a complete statistical approach for testing hypotheses about relations among observed and latent variables [55]. It is a methodology to represent, estimate, and test a theoretical network of linear relations between variables [53]. It helps testing the hypothesized patterns of directional relationships and non-directional relationships among a set of observed i.e. measured variables and unobserved i.e. latent variables [56]. There are two goals of SEM. The first is to comprehend the patterns of correlation/covariance among a set of variables and the second is that with the model specified, to explain their variance as much as possible [57].

The SEM technique has been widely used in BDA-SEM studies in India and abroad. A couple of studies carried out in India and their authors are, the mediating role of BDA on the performance of sustainable supply chain by Raut et al., (2021), and the role of data driven decision making culture on the operational and cost performance of manufacturing units by Dubey et al., (2019) [9, 40]. Similarly, Ashrafi et al. (2019) analyzed the role of BDA on the agility of Iranian firms in context of innovation competence and information quality, Côte-Real et al. (2020) explored the business processes in US and Europe for assessing the effect of data quality on business performance through IoT and BDA capabilities, and Wang and Ali (2021) from China studied the prospects of prediction of direct and indirect connection

between BD and the agility and effectiveness of supply chain [48, 49, 58].

V. PROPOSED METHODOLOGY

In order to accomplish the above stated research objectives the proposed methodology has been depicted in Fig 2. The work begins with an extensive literature survey on BDA. An exhaustive list of influential factors for application of BDA in SSCM is prepared. These factors then are condensed into eleven factors and thirty eight sub-factors. Out of these, the ten PESTEL factors are presented in Table 1. These identified success factors are instrumental in development of hypotheses while the sub-factors are the basis for preparation of exhaustive questionnaire. The questionnaire needs to be validated by a panel of experts from academia and industry. This panel may comprise of experienced professors from industrial engineering and IT departments of leading institutes, and senior managers and data analysts from industry. After pilot study the questionnaire may be finalized and data collected from respondents from manufacturing firms. Statistical analysis of may then follow by structural equation modelling (SEM), while the cause and effect relationships amongst factors may be obtained through a suitable MCDM technique. The output of this analysis will result in the ranking of significant factors that govern the successful application of BDA in SSCM. This in turn will lead to an insight into managerial implications and conclusion.

VI. CONCLUSION

BDA currently is used in many applications such as banking, agriculture, finance, marketing, stocks, healthcare etc. In manufacturing industry, it is extensively used in various components of supply chain and the predictive nature of BDA has been observed to be of remarkable advantage for sustainability of supply chains. With a scrupulous implementation of the proposed model, all the above mentioned factors can be effectively taken care of and they may turn out to be the key drivers for performance enhancement of the organization through a BDA enabled sustainable supply chain. In order to achieve this it's incumbent on the company heads to deploy resources on this front as it may prove to be a vehicle for the other factors also to contribute to the success of the organization in a big way.

For a BDA enabled decision making system to succeed, the authenticity of information and its format are vital. In recent studies on BDA implementation in Indian context, Raut et al. (2019) have deliberated on the mediating effect of BDA on sustainable performance in Indian manufacturing industries, and Narwane et al. (2019) have explored into the use of cloud computing in the manufacturing sector which is a key technology for BDA [18, 31]. There are a few more such studies which show that Indian manufacturing sector can be greatly benefited through the modern day technological developments in the in the field of BDA. This paper is an extension to the above mentioned studies. The authors believe that the suggested conceptual framework will be instrumental in the implementation of BDA technologies in SSCM.

A. Limitations

The research model presented here has certain limitations too that would have to be considered while applying the

model in a particular context. For example this study addresses the

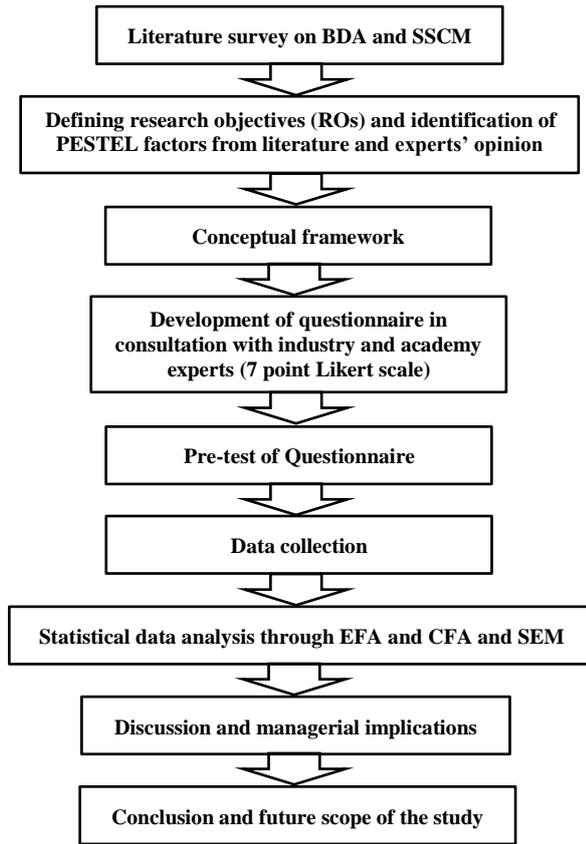


Fig 2. PROPOSED METHODOLOGY

manufacturing supply chain exclusively, so the results may not be applicable to other industry sectors. Another limitation is regarding the scale of operations of the organization. The results obtained from this study belong to the large scale organizations, and they may not be suitable for SMEs due to the cost constraint. Since a chunk of the cost incurred in BDA application is consumed into availing analytics services, small scale industries may choose only to have the basic physical infrastructure necessary for BDA and outsource the analytics services. Finally, the factors included in this study have been derived from literature. They are no doubt comprehensive but opinions can be taken from the experts from industry and academia for their validation.

B. Future Scope

As shown in the proposed methodology the model can be tested using EFA-CFA-SEM approach. This will give the relative significance of factors and in turn will help managers and practitioners in deciding the priorities regarding investment of funds. Future studies on the topic may consider the industry sectors other than manufacturing such as healthcare, hospitality, automobile or process industries. Also the studies may focus on adoption of BDA systems in small scale industries in order to address their specific requirements and challenges. Further, the BDA implementation in supply chain operations is a costly affair and warrants the need of an effective BDA performance measurement system to be in place. The measures for BDA performance are different from the performance measures used for ordinary supply chain, as they need to be monitored

on real time basis requiring prompt action on the part of managers. The future studies may take up the development of BDA performance measurement system for monitoring the BDA capabilities of an organization.

REFERENCES

- [1] Waller, Matthew A., and Stanley E. Fawcett. "Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management." (2013): 77-84.
- [2] Yan, Jihong, Yue Meng, Lei Lu, and Lin Li. "Industrial big data in an industry 4.0 environment: Challenges, schemes, and applications for predictive maintenance." IEEE Access 5 (2017): 23484-23491.
- [3] Barbosa, Marcelo Werneck, Alberto de la Calle Vicente, Marcelo Bronzo Ladeira, and Marcos Paulo Valadares de Oliveira. "Managing supply chain resources with Big Data Analytics: a systematic review." International Journal of Logistics Research and Applications 21, no. 3 (2018): 177-200.
- [4] Arunachalam, Deepak, Niraj Kumar, and John Paul Kawalek. "Understanding big data analytics capabilities in supply chain management: Unravelling the issues, challenges and implications for practice." Transportation Research Part E: Logistics and Transportation Review 114 (2018): 416-436.
- [5] Gunasekaran, Angappa, Thanos Papadopoulos, Rameshwar Dubey, Samuel Fosso Wamba, Stephen J. Childe, Benjamin Hazen, and Shahriar Akter. "Big data and predictive analytics for supply chain and organizational performance." Journal of Business Research 70 (2017): 308-317.
- [6] Singh, Rajesh Kr, Sunil Luthra, Sachin Kumar Mangla, and Surbhi Uniyal. "Applications of information and communication technology for sustainable growth of SMEs in India food industry." Resources, Conservation and Recycling 147 (2019): 10-18.
- [7] Ali, Qaisar, Asma Salman, Hakimah Yaacob, Zaki Zaini, and Rose Abdullah. "Does big data analytics enhance sustainability and financial performance? The case of ASEAN banks." The Journal of Asian Finance, Economics, and Business 7, no. 7 (2020): 1-13.
- [8] Shukla, M., and M. K. Tiwari. 2017. "Big-Data Analytics Framework for Incorporating Smallholders in Sustainable Palm Oil Production." Production Planning & Control 28(16): 1365-1377. doi:10.1080/09537287.2017.1375145.
- [9] Raut, Rakesh, Vaibhav Narwane, Sachin Kumar Mangla, Vinay Surendra Yadav, Balkrishna Eknath Narkhede, and Sunil Luthra. "Unlocking causal relations of barriers to big data analytics in manufacturing firms." Industrial Management & Data Systems (2021).
- [10] Robmann, Bernhard, Angelo Canzaniello, Heiko von der Gracht, and Evi Hartmann. "The future and social impact of Big Data Analytics in Supply Chain Management: Results from a Delphi study." Technological Forecasting and Social Change 130 (2018): 135-149.
- [11] Cheng, Ying, Ken Chen, Hemeng Sun, Yongping Zhang, and Fei Tao. "Data and knowledge mining with big data towards smart production." Journal of Industrial Information Integration 9 (2018): 1-13.
- [12] Belhadi, Amine, Karim Zkik, Anass Cherrafi, and M. Yusof Sha'ri. "Understanding big data analytics for manufacturing processes: insights from literature review and multiple case studies." Computers & Industrial Engineering 137 (2019): 106099.
- [13] Brandenburg, Marcus, Tim Gruchmann, and Nelly Oelze. "Sustainable supply chain management—A conceptual framework and future research perspectives." Sustainability 11, no. 24 (2019): 7239.
- [14] Chen, Caixia, Tongyu Gu, Yuru Cai, and Yixiong Yang. "Impact of supply chain information sharing on performance of fashion enterprises: An empirical study using SEM." Journal of Enterprise Information Management (2019).
- [15] Ali, Zulqurnain, Bi Gongbing, and Aqsa Mehreen. "Supply chain network and information sharing effects of SMEs' credit quality on firm performance: Do strong tie and bridge tie matter?." Journal of Enterprise Information Management (2019).
- [16] Lamba, Kuldeep, and Surya Prakash Singh. "Modeling big data enablers for operations and supply chain management." The International Journal of Logistics Management (2018).
- [17] B. Esmaeliani, S. Behdad, and B. Wang. "The evolution and future of manufacturing: A review", Journal of Manufacturing Systems, Volume 39, pp.79-100, 2016.

- [18] Raut, Rakesh D., Sachin Kumar Mangla, Vaibhav S. Narwane, Bhaskar B. Gardas, Pragati Priyadarshinee, and Balkrishna E. Narkhede. "Linking big data analytics and operational sustainability practices for sustainable business management." *Journal of cleaner production* 224 (2019): 10-24.
- [19] Dubey, Rameshwar, Angappa Gunasekaran, Stephen J. Childe, Thanos Papadopoulos, Zongwei Luo, Samuel Fosso Wamba, and David Roubaud. "Can big data and predictive analytics improve social and environmental sustainability?." *Technological Forecasting and Social Change* 144 (2019): 534-545.
- [20] Belaud, Jean-Pierre, Nancy Prioux, Claire Vialle, and Caroline Sablayrolles. "Big data for agri-food 4.0: Application to sustainability management for by-products supply chain." *Computers in Industry* 111 (2019): 41-50.
- [21] Wadmann, Sarah, and Klaus Hoeyer. "Dangers of the digital fit: Rethinking seamlessness and social sustainability in data-intensive healthcare." *Big Data & Society* 5, no. 1 (2018): 2053951717752964.
- [22] Papadopoulos, Thanos, Angappa Gunasekaran, Rameshwar Dubey, Nezhil Altay, Stephen J. Childe, and Samuel Fosso-Wamba. "The role of Big Data in explaining disaster resilience in supply chains for sustainability." *Journal of Cleaner Production* 142 (2017): 1108-1118.
- [23] Song, Ma-Lin, Ron Fisher, Jian-Lin Wang, and Lian-Biao Cui. "Environmental performance evaluation with big data: Theories and methods." *Annals of Operations Research* 270, no. 1 (2018): 459-472.
- [24] Song, Ma-Lin, Ron Fisher, Jian-Lin Wang, and Lian-Biao Cui. "Environmental performance evaluation with big data: Theories and methods." *Annals of Operations Research* 270, no. 1 (2018): 459-472.
- [25] Kaušale, Linda, and Ineta Geipele. "Integrated approach of real estate market analysis in sustainable development context for decision making." *Procedia Engineering* 172 (2017): 505-512.
- [26] Shabanova, LBa, GNB Ismagilova, LNC Salimov, and MGA Akhmadeev. "PEST-Analysis and SWOT-Analysis as the most important tools to strengthen the competitive advantages of commercial enterprises." *Mediterranean Journal of Social Sciences* 6, no. 3 (2015): 705.
- [27] Hazen, Benjamin T., Joseph B. Skipper, Christopher A. Boone, and Raymond R. Hill. "Back in business: Operations research in support of big data analytics for operations and supply chain management." *Annals of Operations Research* 270, no. 1 (2018): 201-211.
- [28] Shen, Bin, and Hau-Ling Chan. "Forecast information sharing for managing supply chains in the big data era: Recent development and future research." *Asia-Pacific Journal of Operational Research* 34, no. 01 (2017): 1740001.
- [29] Mikalef, Patrick, Maria Boura, George Lekakos, and John Krogstie. "Big data analytics capabilities and innovation: the mediating role of dynamic capabilities and moderating effect of the environment." *British Journal of Management* 30, no. 2 (2019): 272-298.
- [30] Zailani, Suhaiza, Kannan Govindan, Mohammad Iranmanesh, Mohd Rizaimy Shaharudin, and Yia Sia Chong. "Green innovation adoption in automotive supply chain: the Malaysian case." *Journal of Cleaner Production* 108 (2015): 1115-1122.
- [31] Narwane, Vaibhav S., Balkrishna E. Narkhede, Bhaskar B. Gardas, and Rakesh D. Raut. "Cloud manufacturing issues and its adoption: past, present, and future." *International Journal of Management Concepts and Philosophy* 12, no. 2 (2019): 168-199.
- [32] Dubey, Rameshwar, Angappa Gunasekaran, Stephen J. Childe, Samuel Fosso Wamba, and Thanos Papadopoulos. "The impact of big data on world-class sustainable manufacturing." *The International Journal of Advanced Manufacturing Technology* 84, no. 1-4 (2016): 631-645.
- [33] Mikalef, Patrick, Maria Boura, George Lekakos, and John Krogstie. "Big data analytics and firm performance: Findings from a mixed-method approach." *Journal of Business Research* 98 (2019): 261-276.
- [34] Walter, Elizabeth. *Cambridge advanced learner's dictionary*. Cambridge university press, 2008.
- [35] Lamba, Kuldeep, Surya Prakash Singh, and Nishikant Mishra. "Integrated decisions for supplier selection and lot-sizing considering different carbon emission regulations in Big Data environment." *Computers & Industrial Engineering* 128 (2019): 1052-1062.
- [36] Hamdan, Sadeque, and Ali Cheaitou. "Supplier selection and order allocation with green criteria: An MCDM and multi-objective optimization approach." *Computers & Operations Research* 81 (2017): 282-304.
- [37] Gandhi, Sumeet, Sachin Kumar Mangla, Pradeep Kumar, and Dinesh Kumar. "Evaluating factors in implementation of successful green supply chain management using DEMATEL: A case study." *International strategic management review* 3, no. 1-2 (2015): 96-109.
- [38] Sun, Shiwei, Casey G. Cegielski, Lin Jia, and Dianne J. Hall. "Understanding the factors affecting the organizational adoption of big data." *Journal of Computer Information Systems* 58, no. 3 (2018): 193-203.
- [39] Mani, Venkatesh, Catarina Delgado, Benjamin T. Hazen, and Purvishkumar Patel. "Mitigating supply chain risk via sustainability using big data analytics: Evidence from the manufacturing supply chain." *Sustainability* 9, no. 4 (2017): 608.
- [40] Dubey, Rameshwar, Angappa Gunasekaran, Stephen J. Childe, Constantin Blome, and Thanos Papadopoulos. "Big data and predictive analytics and manufacturing performance: integrating institutional theory, resource-based view and big data culture." *British Journal of Management* 30, no. 2 (2019): 341-361.
- [41] Badiezhadeh, Taliva, Reza Farzipoor Saen, and Tahmoures Samavati. "Assessing sustainability of supply chains by double frontier network DEA: A big data approach." *Computers & Operations Research* 98 (2018): 284-290.
- [42] El-Kassar, Abdull-Nasser, and Sanjay Kumar Singh. "Green innovation and organizational performance: the influence of big data and the moderating role of management commitment and HR practices." *Technological Forecasting and Social Change* 144 (2019): 483-498.
- [43] Jebble, Shirish, Rameshwar Dubey, Stephen J. Childe, Thanos Papadopoulos, David Roubaud, and Anand Prakash. "Impact of big data and predictive analytics capability on supply chain sustainability." *The International Journal of Logistics Management* (2018).
- [44] Wu, Kuo-Jui, Ching-Jong Liao, Ming-Lang Tseng, Ming K. Lim, Jiayao Hu, and Kimhua Tan. "Toward sustainability: using big data to explore the decisive attributes of supply chain risks and uncertainties." *Journal of Cleaner Production* 142 (2017): 663-676.
- [45] Kurnia, Sherah, Md Mahbubur Rahim, and Marianne Gloet. "Understanding The Roles Of Is/It In Sustainable Supply Chain Management." In *PACIS*, p. 50. 2012.
- [46] Dubey, Rameshwar, Angappa Gunasekaran, Stephen J. Childe, Zongwei Luo, Samuel Fosso Wamba, David Roubaud, and Cyril Foropon. "Examining the role of big data and predictive analytics on collaborative performance in context to sustainable consumption and production behaviour." *Journal of Cleaner Production* 196 (2018): 1508-1521.
- [47] Waibel, Markus W., Lukas P. Steenkamp, N. Moloko, and G. A. Oosthuizen. "Investigating the effects of smart production systems on sustainability elements." *Procedia Manufacturing* 8 (2017): 731-737.
- [48] Ashrafi, Amir, Ahad Zare Ravasan, Peter Trkman, and Samira Afshari. "The role of business analytics capabilities in bolstering firms' agility and performance." *International Journal of Information Management* 47 (2019): 1-15.
- [49] Côte-Real, Nadine, Pedro Ruivo, and Tiago Oliveira. "Leveraging internet of things and big data analytics initiatives in European and American firms: Is data quality a way to extract business value?." *Information & Management* 57, no. 1 (2020): 103141.
- [50] Bonilla, Silvia H., Helton RO Silva, Marcia Terra da Silva, Rodrigo Franco Gonçalves, and José B. Sacomano. "Industry 4.0 and sustainability implications: A scenario-based analysis of the impacts and challenges." *Sustainability* 10, no. 10 (2018): 3740.
- [51] Zhang, Yingfeng, Shuaiyin Ma, Haidong Yang, Jingxiang Lv, and Yang Liu. "A big data driven analytical framework for energy-intensive manufacturing industries." *Journal of Cleaner Production* 197 (2018): 57-72.
- [52] Child, Dennis. *The essentials of factor analysis*. Cassell Educational, 1990.
- [53] Schumaker, R. E., and R. G. Lomax. "A beginner's guide to structural equation modelling". Mahwah, NJ: Lawrence Erlbaum Associates, Publishers, pp. 251-294. (1996).
- [54] Suhr, Diana. "The basics of structural equation modeling." Presented: Irvine, CA, SAS User Group of the Western Region of the United States (WUSS) (2006).
- [55] Rigdon, E. E. "Structural Equation Modeling in Modern methods for business research." (1998).
- [56] MacCallum, Robert C., and James T. Austin. "Applications of structural equation modeling in psychological research." *Annual review of psychology* 51, no. 1 (2000): 201-226.
- [57] Kline, Rex B. "Assumptions in structural equation modeling." New York: The Guilford Press (2012).
- [58] Wang, Y. and Ali, Z., 2021. Exploring big data use to predict supply chain effectiveness in Chinese organizations: a moderated mediated model link. *Asia Pacific Business Review*, pp.1-22.

CFD Analysis of Heat Transfer in Spiral Coil

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Abstract— It is well established that the rate of heat transfer in a spiral coil is more compared to that of the straight pipe. In the present work, CFD investigation of rate of heat transfer and pressure drop inside spiral tube is reported. CFD simulation is carried out for Spiral coils by varying coil parameters such as (i) diameter of tube (ii) Pitch of coil (iii) Number of Turns and their influences on heat transfer has been studied. The CFD analysis of laminar flow was carried out using the Fluent solver of the CFD package. The CFD results are compared with experimental results of earlier investigators and they are found to be good agreement.

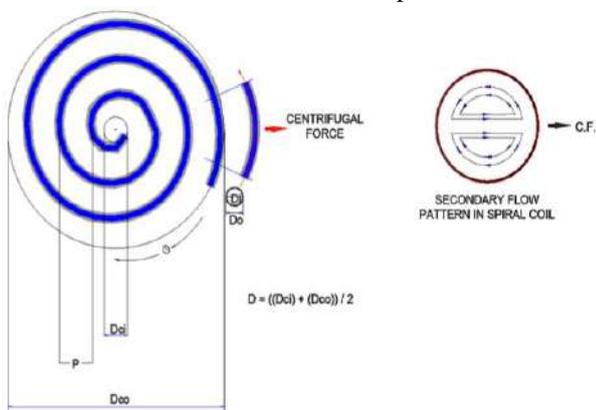
Keywords—Curved Tubes; Spirally Coiled tube; Curvature ratio; Newtonian fluids.

I. INTRODUCTION

Spiral coils are curved tubes that are frequently utilised in a wide range of technical applications such as heating, cooling, HVAC systems, steam generators and condensers in power plants and nuclear reactors. Secondary flow originates in the pipe cross section of a curved tube caused by changes in the inertial and centrifugal powers. Because of the differences in inertial and centrifugal forces in a curved tube, a secondary flow emerges in the pipe's cross section. The output of the secondary flow induces considerable changes in heat transfer and flow in these tubes. Because of the differences in inertial and centrifugal forces in a curved tube, a secondary flow emerges in the pipe's cross section. The output of the secondary flow induces considerable changes in heat transfer and flow in these tubes. Heat Transfer explains the rates at which heat is exchanged between cold and heated

Fig 1. The geometry and the function of the spiral coil secondary flow pattern

bodies. Heat Transfer is a temperature distribution



measurement that describes the rate at which heat energy is dispersed over a surface chosen for examination owing to surface temperature gradients and the temperature difference between surfaces. Conduction, convection, and radiation are the three methods through which heat is transferred. Because

the temperature involved in the process is modest, radiation heat transfer is not considered in this research. Conduction is determined by the material used, while convection is crucial in the heat transfer of a fluid that passes through a heat exchanger. The rate of heat transmission and pressure decrease in a spiral tube are determined by the following parameters: The Reynolds number, the Prandtl number, and the Graetz number Newtonian or non-Newtonian fluid, thermal boundary condition of the wall, coil-to-tube radius ratio, tube section, length-to-diameter ratio, coil pitch, number of turns, and so forth. These parameters' effects on spiral pipe heat transfer and flow friction were specified and examined. Early studies on curved tubes in general focused on experimental rather than analytic or theoretical work. Kubair and Kuloor investigate heat transfer using a variety of helical coils, straight tube, and spiral coil [1]. Spiral coil efficiency is also higher than straight pipe or helical coil performance. This same author [2] developed correlations of friction concerns for various liquids running through spiral coil tubes in laminar, transition, and turbulent flow. Paisarn Naphon et al. [3] investigated the effect of a curvature ratio on both heat transmission and flow generation in spirally coil horizontal tubing. The predicted consequences for convective heat transfer and flowing patterns were in good agreement with the experimental study. Because of the centrifugal force that Nusselt numbers, the pressure drop produced from spirally coiled tubes is 1.49 to 1.50 times larger than with ordinary straight tubes. Naphon et al. Anthony Bowman and Hyunjae Park [4] have published a research on the transmission of heat and pressure drop characteristics in toroidal and spiral coils. CFD analysis of a toroidal tube system was done in order to predict the laminar flow and heat transfer properties, and the findings were compared to existing experimental test and numerical data. The analysis was carried out for the non-slip wall condition, which is enforced at the inner wall surface of the coiled tube. It is enforced at the inside wall surface of the coiled tube based on their findings. Based on their findings, spiral tube heat exchangers have an effectiveness ratio that is 20-30% greater than toroidal tube heat exchangers. Because of this, spiral coil heat exchangers were preferred over toroidal heat exchangers. Experimental methodology has been used to determine the flow of petroleum base oils SN70, SN150 and SN300 under isothermal stable state and a combination of isothermal steady state & non-isothermal unstable state conditions for "Graetz issue.". the experimental setup which developed by Rahul Patil, Mariappan Nadar, Rashed Ali [5]. A current dimensionless number is added which is proved by the analyzation method without dimensions. The Nusselt number is associated with the Newtonian fluid number, depending on the experimental evidence. A variety of correlations are established of Newtonian fluids in isothermal

stable state (total of 130 trials) and a mixture of isothermal stable state & non-isothermal unstable state cases (total 154 trials). The correlations established are compared with the correlations formed by prior researchers, but are still reported to be in good agreement. The same authors [6] who investigated the effect of Dean Number on heat transfer to petroleum base oils flowing through spiral coils using the same experimental setup and it was reported that a rise in the curvature ratios also increases the heat transfer to oil. An overall consequence of the rise in Dean number across all coils is to rise the transfer of heat, but as the average radius of the spiral coil increases the transfer of heat and decreases due to the resulting decrease in centrifugal force. Wall temp is held constant throughout the present study. At fluid bulk temperature, the properties are determined. The within heat transfer coefficient is determined as above represented orally, calculating assorted non-dimensional numbers such as Nusselt Number, Reynold Number, Graetz Number, Prandtl Number and Dean Number. Dimensional analytics methodology is used to identify the specific type of the appropriate correlation. The major objective of this study in this field was also to validate an experimental observation with the findings of the CFD analysis for Newtonian liquids using constant fluid property, and to detect changes in spiral coil flow patterns for various Nusselt number values.

II. NUMERICAL COMPUTATION

Numerical Simulations was run utilizing commercial CFD package software program for various Reynolds number in laminar as well as turbulent flow. The double precision, segregated, 3D version method is used to overcome the equations governing of mass, momentum and energy.

Equations and thermophysical properties regulating laminar flow:

SN150 oil is used here as a test fluid and is regarded as an incompressible, homogeneous, steady and Newtonian fluid of negligible impact of viscous heating. The Flow was Base on Equations Navier-Stokes using fluent package. The single-phase homogeneous flow governing equations in the Cartesian co-ordinates (x, y, z) are as follows:

Continuity equation:

$$\rho \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right) = 0$$

Navier–Stokes equations (momentum equations):

$$\rho \left(u \frac{\partial u}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial w}{\partial z} \right) = \mu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right) - \frac{\partial p}{\partial x}$$

$$\rho \left(u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} \right) = \mu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2} \right) - \frac{\partial p}{\partial y}$$

$$\rho \left(u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} \right) = \mu \left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2} \right) - \frac{\partial p}{\partial z}$$

Energy equation:

$$\rho \left(u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} + w \frac{\partial T}{\partial z} \right) = \frac{k}{C_p} \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right)$$

where p, T, u, v and w represents the pressure, temperature and Velocities in directions x, y & z, etc.

TABLE I. Physical Dimensions of spiral coil used

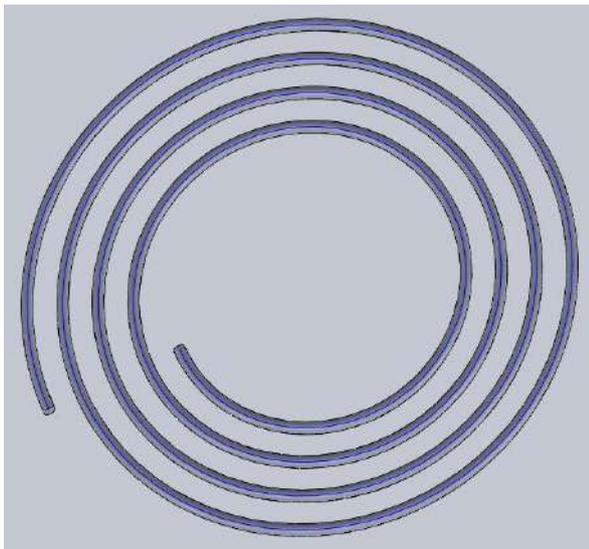
Spiral Coils	Max. diameter of coil (D _{co})	Min. Diameter of coil (D _{ci})	Avg. diameter of coil (D)	Pitch of coil (P)	Number of turns (n)	Outer diameter of tube (D _o)	Inner diameter of tube (D _i)
Coil-I	200	100	150	12.50	4	5.91	4
Coil-II	400	100	250	12.50	12	5.91	4
Coil-III	500	100	300	50	4	9.85	8

TABLE II. Types of coils, Test fluid & Different flow rates used in Experimental work.

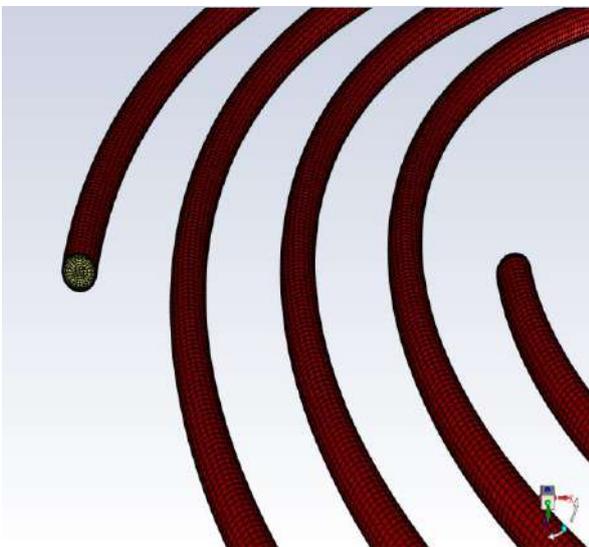
Spiral Coils	Test Fluid	Range of Different mass flow rate (lps)
Coil-I	SN150	0.002444 - 0.05241
Coil-II	SN150	0.014973 - 0.049267
Coil-III	SN150	0.00508 - 0.092226

A. CFD Modelling

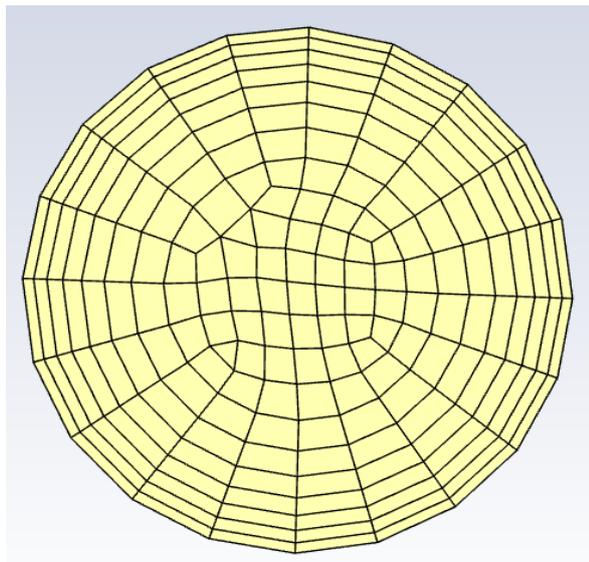
The particular geometry utilized in the numerical modelling is the same as the experimental configuration shown in Figure 1. Figure 1 depicts a conventional coiled spiral tube as well as coil-1, the computational domain for this research. Solid works was used to create the Coil-1 geometry. Figure 2 (a) formalized paraphrase & The mesh was then constructed, as illustrated in Fig. 2(b) and (c) with the help of a commercial CFD software. The volume of fluid in the pipe was meshed in this model using uniform hexahedral grids, and the mesh was produced at the boundary layer. Further increases or decreases in element size were discovered to be beyond the capabilities of the computer. Convective heat transfer in the pipe (natural convection), conduction through the tube wall, and convective heat transmission to the coils fluid were used to represent heat flow from hot steam in the steam chamber to cold fluid in the spiral tube (forced convection). They are regarded as non-slip in the momentum equation. The coil is made of pure copper. Specific heat 381 (J/kg K) is regarded a benchmark for shell conduction. The Coupled method is used to solve velocity and pressure distributions by using the coupling equations of continuity and momentum. The viscous-laminar model is used to describe laminar flow. The governing equations were solved using a laminar model. In addition, a convergence criteria based on the Facet average process was given as a surface monitor for output temperature. Table 3 summarises the simulations' conventional boundary conditions for this CFD investigation.



(a) CAD model of spiral coil-I



(b) Complete Mesh coil-I



(c) Enlarge Cross Sectional View of grids

Fig. 2. Grids used in the analysis

B. Grid Generation

Before settling on the best coarse mesh, the grid dependency of the solution was investigated for three different mesh element sizes, as shown in Fig. 2. (c). Fine meshing with lower element sizes (approx. 3289370 cells) is not achievable for this bulky structure, which is beyond of the computer's capability. Furthermore, as the number of computational cells increases, the cost of computing rises as convergence and iteration consistency get more complex, as does memory and processor time. As a result, the grids presented in Fig. 2 (c). For this study, uniform hexahedral grids were used because they produce findings that are more similar to the experimental data with less than a 20% variation in Nusselt number, interior heat transfer coefficient (h_i), and output oil temperature. It yields cost-effective and time-efficient solutions that are suitable for industrial applications. FLUENT took around 18 hours to complete some of the tests on an Intel CORE i5 CPU machine with 8 GB RAM.

Spiral Coils	Inlet Temp. of Oil (°C)	Mass Flow Rate (lps)	Inside Surface Temp. (°C)
Coil- I	36.9	0.002444	103.7767
	38.6	0.005624	100.9584
	37.4	0.020256	101.2766
	37.2	0.025254	100.757
	38.6	0.030906	100.6429
	38.6	0.039726	100.6103
	38.5	0.044162	100.499
	39.6	0.05241	99.87939

III. RESULTS AND DISCUSSION

This section presents a description of temperature fields as well as a comparison of CFD heat transfer results with experimental data. This section is separated into two sections: findings and conversation for Cfd simulation.

A. Comparison of CFD results with experimental results for different conditions

Table III shows the results of an analysis of CFD tests on various conditions with experimental findings in a commercial CFD software. A total of seven runs were done for comparison of experimental results with CFD measurement data. All of the parameters required to compute the outlet temperature of oil, h_i , and Nu as CFD results were derived from the results of seven simulation runs.

A.1 Comparison of inside heat transfer coefficient (h_i)

Fig. 3 depicts the inner heat coefficient values based on experimental data for coil-I, CFD output findings, and constant temperature fluid characteristics. The average coefficient of internal heat transfer values for seven mass flow rates under varied conditions are as follows: 1718.205643 W/m²K for experimental findings, 1274.598883 W/m²K for fluid characteristics assessed using FLUENT. In the preceding example, the minimum and maximum average deviation in coefficient of internal heat transfer values was determined to be 12.20-17.33 percent, which is reasonable. CFD measurements of SN150 fluid characteristics are expected to be less accurate than experimental data.

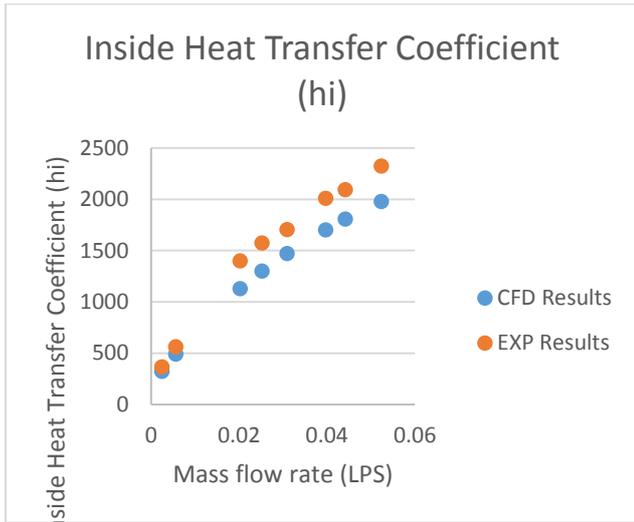


Fig. 3. Comparison of experimental inner heat transfer coefficient and CFD inner heat transfer coefficient

A.2 Comparison of inner Nusselt Number (Nu)

The important heat transfer parameter addressed in That Heat Exchanger model is the Nusselt number. Its value of internal heat transfer coefficient (hi) is obtained from the FLUENT output for both CFD calculations, as is its value of thermal conductivity (k) from the FLUENT solver output. Comparison results for the inner Nusselt number obtained from experimental data and standard fluid characteristics for seven different mass-flow rates in a spiral coil under isothermal heat transfer conditions are displayed.

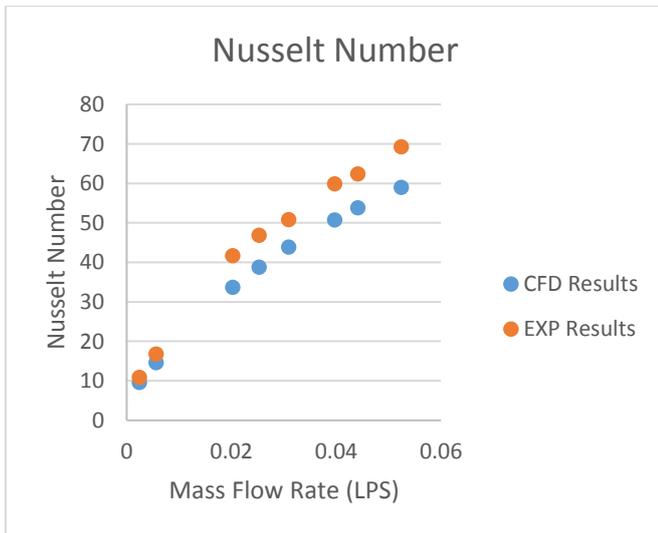


Fig. 4. Comparison of Experimental Nussult Number and CFD Nussult Number

Nusselt's inner numbers' average values the following values are given for seven mass flow rates: 51.23122; based on

experimental data, 43.45069165; and for CFD findings, for verification reasons. However, we cannot empirically measure the Nusselt number at any point in the fluid domain, as this is only possible using CFD code. In terms of design, we find that there would be no significant variation in heat exchanger efficiency. CFD computation predicts correct outcomes and provides important fluid physics data.

A.3 Comparison of outlet temperature

Validation of experimental data estimated oil outflow temperature values using thermometer with data from CFD analysis The research file of solver FLUENT by two temperature limitations for temperatures acquired from outlets.

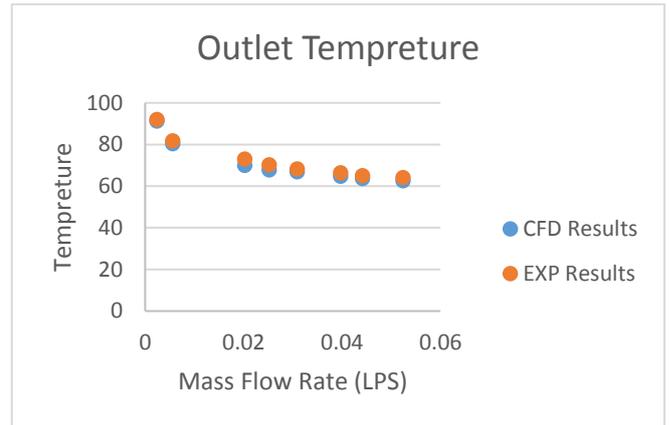


Fig. 5. Comparison of Experimental outlet Temp. and CFD outlet Temp.

The comparison of experimentally measured temperatures at the outside wall surface using thermocouples with CFD measurement results extracted from the FLUENT solver data catalog.

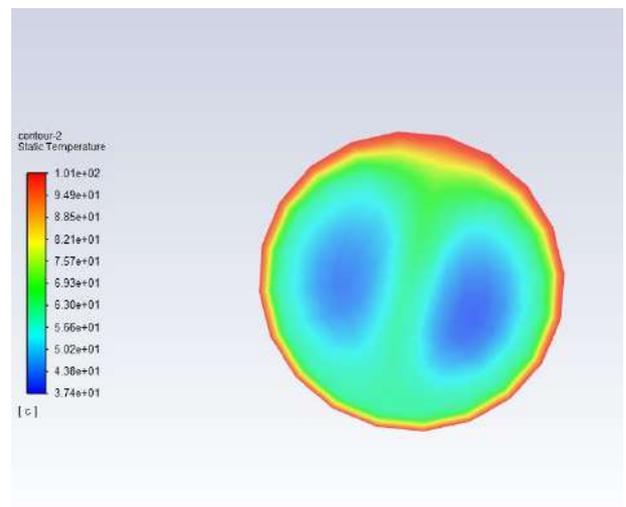


Fig. 6. Cross sectional view of Outlet Temp. contours

The experimental evaluation matched CFD estimations by more than 2.85 percent deviance. The comparison of these experimental temperature data with the CFD calculation results demonstrates the observed parameters, which was one of the major purposes of this CFD research. Based on experimental data, the coefficient of internal heat transfer was calculated using the outer wall surface temperatures calculated by thermocouples rather than the internal wall temperature, taking into account the negligible surface temperature differences in outer and inner wall temperatures due to the wall thickness being very low. It was confirmed using the heat balance method, and the temperature differential between the outside and inside walls was determined to be smaller. However, using CFD code, it is obtained from the FLUENT solver's report file, and their values are determined to be closer. These wall temperature data are utilised in the CFD code to calculate the inner heat transfer coefficient. That is an amazing feature of CFD code, which allows us to analyse temperature and velocity values at any location in the fluid domain.

IV. CONCLUSION

The experimental results that is oil outlet temperature, inside heat transfer coefficient, and Nusselt Number as reported by Rahul patil [5] is validated using Ansys Fluent software and found to be in good agreement.

The effects of steam temperature on the inside heat transfer coefficient have been studied, and it is found that as the inlet steam temperature rises, the coefficient of heat transfer rises as well.

It is also found that the heat transfer coefficient is greatest for smaller diameter coils and lowest for larger diameter coils. It is observed that as the diameter of the tube increases, so does the heat transfer coefficient. Temperature variations at several points on the tube surface studied. It has been observed that the temperature on the outer side of the tube is higher than on the inner side, as a result of secondary flow.

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REFERENCES

- [1] V. Kubair, N.R. Kuloor, Comparison of performance of helical and spiral coil heat exchangers, *Indian J. Technol.* 4 (1965) 1-4.
- [2] V. Kubair, N.R. Kuloor, Flow of Newtonian fluids in Archimedean spiral tube coils: Correlation of the laminar, transition and turbulent flows, *Indian J. Technol.* 4 (1966) 3-8
- [3] P. Naphon, J. Suwagrai, Effect of curvature ratios on the heat transfer and flow developments in the horizontal spirally coiled tubes. *International Journal of Heat and Mass Transfer* 08 (2006) 002.
- [4] Anthony Bowman, Hyunjae Park, 2004, CFD study on laminar flow pressure drop and heat transfer characteristics in Toroidal and spiral coil systems, ASME International Mechanical Engineering Congress and Exposition California USA, 1-9.
- [5] Rahul Patil, 2017, Experimental Studies on Heat Transfer to Newtonian Fluids through Spiral Coils, *Experimental Thermal & Fluid Science* (Springer), 1-18.
- [6] Rahul Patil, Nadar, Rashed Ali, 2016, The influence of Dean Number on heat transfer to Newtonian fluid through spiral coils with constant wall temperature in laminar flow, Springer-Verlag Berlin Heidelberg.
- [7] P. Naphon, S. Wongwises, A review of flow and heat transfer characteristics in curved tubes, *Renewable and Sustainable Energy Reviews* 10 (2004) 463-490.
- [8] V. Kubair, N.R. Kuloor, Heat transfer to Newtonian fluids in spiral coils at constant tube wall temperature in laminar flow, *Indian J. Technol.* 3 (1965) 144-146
- [9] V. Kubair, N.R. Kuloor, Heat transfer to Newtonian fluids in coiled pipes in laminar flow, *Int. J. Heat Mass Transfer.* 9 (1966) 63-75.
- [10] 10. Dr. Madhukar S.Tandale, Sandeep M. Joshi 2008. Design of Heat Exchanger for Waste Heat Recovery from Producer Gas, 5th WSEAS Int. Conf. on Heat and Mass Transfer (HMT'08). pp 83-88.
- [11] 11. Rakesh Baghel and Sushant Upadhyaya, 2013 "Effect of Coil Diameter on pressure Drop in Archimedean Spiral Coils". , *IJAER* 8. 2151 – 2156.
- [12] 12. Jia-dong Ji, Pei-qi GE, Wen-bo BI, 2014, Numerical Investigation of flow and heat transfer performances of horizontal spiral coil pipes, *Journal of Hydrodynamics* (Elsevier), 576-584.
- [13] 13. Deshpande, Pramod M., Dr. Dawande Shrikant, Study of Hydrodynamic of Horizontal Spiral coil tube, *international journal of Advanced Engineering Research and studies*, E-ISSN2249-8974.
- [14] 14. S.S. Pawar, Vivek K. Sunnapawar, 2014, Experimental and CFD investigation of convective heat transfer in helically coiled tube heat exchanger, *Chemical engineering research and design* (Elsevier), 1475(1-19).
- [15] 15. J. Eustice, 1910, Flow of water in curved pipes, *Proc. R. Soc. A-84*, 107-118.
- [16] 16. Hui Zhu, Hanqing Wang, Guangxiao Kou, 2014, Experimental study on the heat transfer enhancement by Dean Vortices in spiral tubes, *International Journal Of Energy And Environment (IJEE)*, Volume 5, 317-326.
- [17] 17. Jay J. Bhavsar, V.K. Matawala, S. Dixit, July-2013, Design and Experimental analysis of spiral tube heat exchanger, *International Journal of Mechanical and Production Engineering*, 37-42.
- [18] 18. Manoj Kumar, Vishal Gupta, Samarjeet Bagri, June-2017, A review on design and development of spiral coil heat exchangers, *IRJET*, Volume 04, 2251-225.

Replacement of Fine Aggregate with Shredded PET and PVC Wastes in Concrete Paver Blocks

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Abstract— Plastics waste is increasing day by day and becomes a threat to our environment since it causes pollution. The amount of plastic waste mainly enters the environment when it is poorly managed through open dumping, open burning, and disposal in waterways. There are the rapidly growing segments of the municipal solid waste. Pavement blocks are the perfect materials on the pathways and streets for simple laying and finish. Therefore, environmental pollution can be reduced by incorporating PET and PVC wastes in the construction of pavement blocks. Waste PET bottles and PVC materials in shredded form replace fine aggregates in mix proportion of 1:1.65:2.83 without compromising the compressive strength of pavement block as per IS 15658: 2006. Experimental results showed that the pavement block with 3% replacement of fine aggregate with shredded waste PET bottles has higher strength and also met the standards of M40 grade concrete. Since waste PET bottles and PVC materials are generated in large quantities, this method provides a remedial measure to control the pollution and also helps to avoid the accumulation of plastic waste which is a non-degradable pollutant.

Keywords— Shredded waste, PET waste, PVC waste, Pavement Blocks, Waste plastic bottles

I. INTRODUCTION

Environmental pollution is one of the most critical threats faced by our planet in the present-day scenario [1]. Environmental pollutants have various adverse health effects from early life. Some of the most important harmful effects are perinatal disorders, infant mortality, respiratory disorders, allergy, malignancies, cardiovascular disorders, increase in stress oxidative, endothelial dysfunction, mental disorders and various other harmful effects [2,3]. Plastic is one of the major environmental pollutants [4]. Plastic waste materials include various household plastic materials, surplus, obsolete, broken, old plastic furniture, anti-static packaging materials and equipment's containing plastic [5]. Disposal of waste plastics is causing a great challenge in the world as a whole as the usage of plastics is growing day by day and it takes centuries for waste plastics to decompose. Hence, there is the need to adopt effective methods to utilize these plastics [6,7].

Exposure of plastic wastes to high temperature can lead to leaching of toxic chemical constituents to food and water [4]. Since plastic wastes are non-biodegradable, its dumping on open land will cause pollution which will result in major

effects on environment. Presence of waste polyethylene terephthalate (PET) bottles can pollute natural water streams, killing aquatic animals. Also clogging of urban drainage systems may result in urban floods if it is not properly managed [5]. Recycling of Polyvinyl Chloride (PVC) pipes, cables and wires into a new construction product such as fibre reinforced concrete (FRC) is found to be the best solutions for disposing of PVC materials [8]. Research studies shows that the use of plastic material as a partial replacement fine aggregate as well as coarse aggregate in manufacturing bricks, Paver Blocks & Solid Blocks are giving good results [9]. Well cleaned Polyethylene (PE) wastes are mixed with sand and aggregate at various percentages to achieve high strength bricks with good thermal and sound insulation properties thus decreasing the overall cost of construction [10,11]. Thus the quantity of sand/clay taken from river beds/mines gets reduced and becomes economical as the surplus quantity of plastic waste is available naturally [10].

The paver block is used in outdoor versatility application and also it is used in street road and other construction places. Concrete paving blocks are ideal materials on the footpaths and roads for easy laying, better look and finish. Paver block has low cost maintenance and easily replace with a newer one at the time of breakage [12]. There are various types of Industrial waste available in local markets, and certain of it can be used in the construction industry for utilization of waste material and eco-friendly techniques [11]. Various waste materials like fly ash, rice husk ash, paper sludge and different fibres are used for improving strength of paver block [13]. In this paper, fine aggregate is replaced by shredded waste PET bottles and PVC materials in various proportions without compromising the compressive strength.

II. MATERIALS AND METHODS

The experimental trial mixes with partial replacement of fine aggregate with waste plastics were conducted to identify the best mix design for a concrete pavement block to get the optimum strength. The pavement block was developed by considering the basic engineering properties of construction materials. Paving block with PET waste and PVC materials

were developed based on a series of standard test methods as per IS 15658: 2006.

A. Materials

The materials selected for developing pavement block includes cement, fine aggregate, coarse aggregate, admixtures, shredded PET waste, Shredded PVC waste and water. The size of the mould selected is 27x15x8cm as shown in Fig.1 (a). The mould was prepared according to IS specifications with an aspect ratio less than 4 [13].

Cement used for making plastic blended pavement block is 53 grade OPC (Ordinary Portland Cement) [10]. Studies show that both river sand and stone dust can be used for manufacturing precast concrete pavement block. The manufactured sand (M-sand) is used as fine aggregate in the experimental studies.

Crushed and semi-crushed aggregates shall be used for ensuring adequate durability. The aggregate used for production of blocks shall be sound and free of soft or honeycombed particles. Other types of aggregates such as slag and crushed, over-burnt brick or tile with regard to strength, durability of concrete and free from harmful effects may be used in preparation of concrete for production of paver blocks [14]. The nominal maximum size of coarse aggregates used in the production of paver blocks is 12 mm [13].

Master Glenium SKY 8233 is the super plasticizer used as an admixture in the manufacture of plastic blended pavement block [15]. This admixture has the properties of eliminating vibration, gives early strength, high modulus of elasticity, low permeability, reduced shrinkage and creep. It gives improved adhesion to reinforcing and stressing steel and has better resistance to carbonation and aggressive atmospheric conditions [16]. Since it has low permeability, the durability can be increased.

The waste plastic bottles (LDPE-Low Density Polyethylene) and PVC (Polyvinyl Chloride) are shredded into small pieces having size less than 4.75mm as shown in Fig.1 (b) and (c). These shredded waste plastic bottles are replaced with fine aggregates in various proportions [17]. Studies show that the replacement of fine aggregates for PET/GBFS aggregates of size 5–15 mm resulted into a decrease in the compressive strength. Also found 9.1% loss in compressive strength for a 25% replacement of fine aggregates with a W/C = 0.45 and 28 curing days. Increasing the replacement percentage increases loss in compressive strength [18].

Water used for mixing, and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel [12].

B. Method

By incorporating shredded waste PET bottles and PVC wastes as raw materials in manufacturing pavement blocks by partial replacement of fine aggregate can reduce the dumping of waste to an extent. According to IS 15658:2006, the grade

of concrete used for medium traffic flow is M40 [13]. Therefore, the concrete pavement block is designed for M40 grade concrete. For the mix design the selected water-cement ratio is 0.38[19].

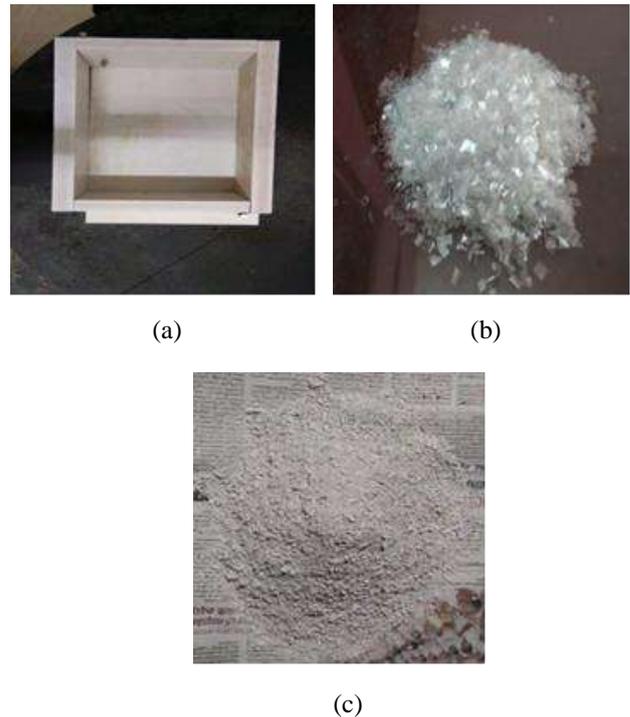


Fig.1. (a) Mould (b) Shredded plastic (c) Shredded PVC waste

1) Mix Design

The preliminary tests for cement, fine aggregate and coarse aggregate were conducted for designing the mix. Physical properties like specific gravity, grain size analysis, water absorption, bulk density and percentage voids of raw materials were conducted [20].

Aggregates differ in their size, shape and working conditions of the material, which depend on size and nature of loads, working temperature, environmental aggressiveness etc. The aggregate can be affected by static, dynamic, permanent, variable or cyclic loads. Hence, various tests were conducted to ensure strength and properties of aggregates [19]. Therefore, the mechanical properties such as crushing, toughness, angularity number and hardness were tested.

Mix design was done according to IS 10262:2009 (Concrete mix proportioning-guidelines) and the obtained mix proportion is 1:1.65:2.83 (cement: fine aggregate: coarse aggregate).

2) Casting of Samples

Samples of partial replacement of fine aggregates with 1%, 3% and 5% shredded waste plastics (PET and PVC) and control samples without plastic wastes were casted and cured for 28 days [19]. The required amount of cement and M-sand were mixed thoroughly and coarse aggregate was added into it and mixed till uniformity is attained. Water along with the admixture was poured into a small depression made in the heap of mix. Slump test was conducted to ensure workability

of the mix. Then the mix was filled into the mould in three layers by tamping 35 times each layer as shown in Fig.2. The surface finishing was done using trowel and it was kept for 24 hours. The sample was removed from the mould and was cured for 28 days as shown in Fig.3.



Fig.2. Casting of Samples



Fig.3. Curing of Samples

3) Testing of Samples

The compressive strength of samples was tested in compression testing machine after the curing period of 28 days. The sample was placed between the jaws of machine and the load was applied. The applied load at the point of breaking of sample was noted and the compressive strength was calculated.

III. RESULTS AND DISCUSSION

A. Test on cement

The specific gravity of cement was conducted in Le Chatlier’s apparatus and the obtained value is 3.01. It was confirmed that the obtained value of specific gravity of cement is within the range as per IS 8112-2013. Therefore, the cement is of good quality and was used for the manufacture of plastic blended pavement block.

B. Tests on fine aggregates

The tests on specific gravity, bulk density and percentage voids were done based on IS 2386 (part 3):1963. The resulted value of specific gravity is 2.44, which indicates that the material has higher strength. The bulk density of loosely packed aggregate was obtained as 1140 kg/m³ which are lower than the bulk density of compacted aggregates. Generally, loose well- aggregated porous soils have lower bulk density. Percentage voids in the range of 53.2% is acceptable since voids in unit volume of aggregates are the space between particles in an aggregate mass not occupied by solid minerals. Grain size analysis was conducted and found that the aggregates fall on Zone II category as per IS 383: 1970. Test results are shown in Table.1.

TABLE I. TEST RESULTS OF FINE AGGREGATES

Physical Properties	Values
Specific gravity	2.44
Bulk density of loosely packed aggregates	1140 kg/m ³
Bulk density of compacted aggregates	1280 kg/m ³
Percentage voids	53.2%
Grain size analysis	Zone II

C. Tests on coarse aggregates

Physical properties of coarse aggregates such as specific gravity, water absorption, bulk density and percentage voids were determined as per IS 2386 (part3):1963. The obtained value of specific gravity of coarse aggregate falls within the range of 2.5 to 3. The IS code shows that the water absorption shall not be more than 0.6 per unit by weight and the obtained value is 0.25%, hence it is acceptable. The bulk density of coarse aggregate was obtained as 1346 kg/m³ which is in the range of 1200-1750 kg/m³ as per IS specifications. The test results are shown in Table 2.

TABLE II. PHYSICAL PROPERTIES OF COARSE AGGREGATES

Physical Properties	Values
Specific gravity	2.63
Water absorption	0.25%
Bulk density	1346 kg/m ³
Percentage voids	48.8%

The mechanical properties of coarse aggregates such as crushing, toughness, angularity number and hardness were found as shown in Table 3. The tests on impact, crushing and abrasion were done according to IS 2386 (part 4):1963. The IS code shows that aggregate impact value of 23.07% is satisfactory for the concrete for pavement use. The angularity number of 5.09 falls within the range of 0 and 11. Aggregate crushing value of the coarse aggregate used for cement concrete pavement surface shall not exceed 30% and the obtained value is 28.19% which is acceptable. According to the IS specification, Los Angeles abrasion value of aggregates for pavement concrete should not be more than 35%. But the obtained value is 39.72% which is greater than the specified value. Due to non-availability of other aggregates the experimental study was conducted using the same aggregate for casting concrete pavement block.

TABLE III. PHYSICAL PROPERTIES OF COARSE AGGREGATES

Mechanical Properties	Values
Aggregate impact value	23.07%
Angularity number	5.09
Aggregate crushing value	28.19%
Los Angeles abrasion value	39.72%

D. Grain size analysis of Plastic wastes

Grain size analysis of shredded waste PET bottles and PVC materials were conducted to check whether these can be incorporated in the production of paver block. Dried shredded PET bottles and PVC wastes of 100 g was taken and two sets of sieves were arranged in the order of sieve sizes. Then the dried shredded PET and PVC wastes were placed on the top of 4.75mm IS sieve. Sieving was completed in 10 minutes using a sieve shaker. Weight of the sample retained on each sieve was noted. Particle size distribution curve was obtained and it was found that grading of samples falls on zone II as per IS 383:1970.

Fig.4 and Fig.5 represents the particle size distribution curve of PET and PVC waste. It can be seen that for PET waste aggregates, about 75 % of the particles is of size less than 2.36mm. Similarly, in PVC waste aggregates also 94% of the particles is having less than 2.36 mm of size. Strength of concrete depends on grading of aggregates. Well graded aggregates require only less quantity of cement and water to fill up the voids present in it which contributes to higher strength of concrete. In the present study an irregularity was observed in the particle size distribution curve due to the presence of gap graded shredded plastic wastes which may affect the compressive strength of concrete pavement tile.

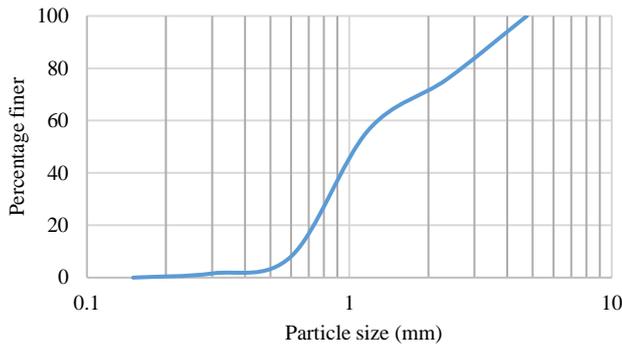


Fig.4. Particle size distribution curve of shredded PET wastes

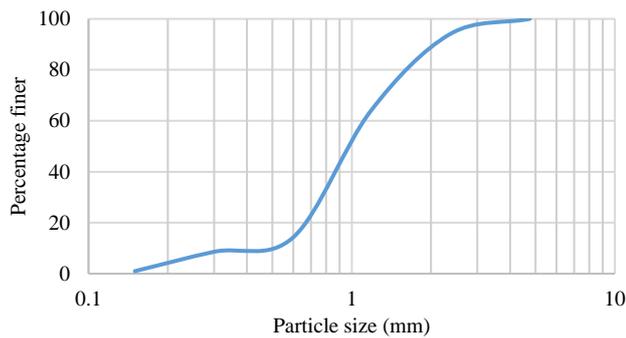


Fig.5. Particle size distribution curve of shredded PVC wastes

E. Effect of temperature on Plastic wastes

Thermo gravimetric analysis (TGA) is an analytical technique used to determine a materials thermal stability and its fraction of volatile components by monitoring the weight change that occurs as the sample is heated at a constant rate [21]. Thermo gravimetric analysis of PET and PVC wastes was conducted to study the effect of temperature.

As per the thermo gravimetric analysis, it was observed that there is no change in the weight of PET waste and PVC waste upto a temperature of 400°C and 300°C respectively. A rapid decrease was found in both the plastic wastes as the temperature was increased from 400°C and 300°C. A Gradual decrease in the sample weight was observed in both the analysis with an increase in temperature from 450°C due to decomposition of the material. The pavement blocks casted using the plastic waste is found safe to use as one of the construction materials as it is not getting exposed to higher

temperature. Fig.6 and Fig.7 shows the thermo gravimetric analysis of PET waste and PVC waste.

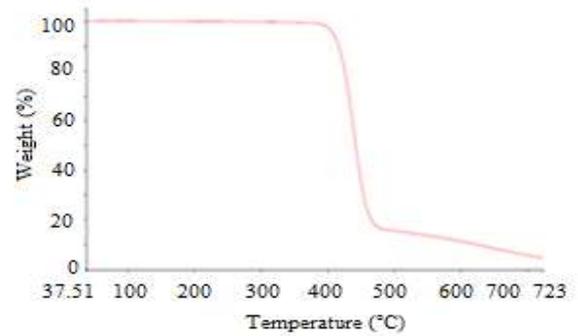


Fig.6.TGA of PET waste

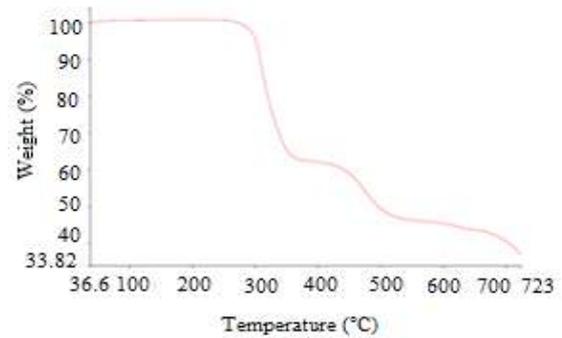


Fig.7. TGA of PVC waste

F. Testing of Compressive strength

The compressive strength of samples was tested in compression testing machine after curing for 28 days. Fig.8 (a) and (b) represents the samples with shredded PET bottles and PVC waste. Fig.9 and Fig.10 represents the compressive strength of control sample and samples with varying percentages of shredded PET waste and PVC waste.

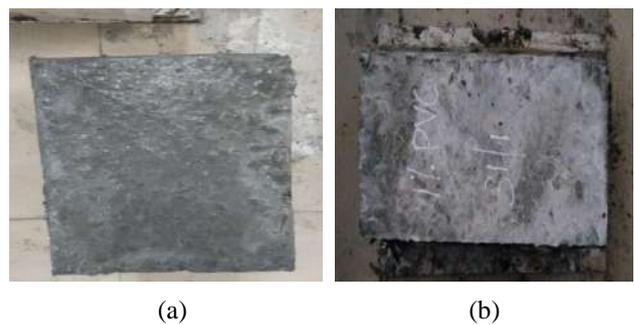


Fig.8. (a) Sample with shredded PET waste (b) Sample with Shredded PVC waste

Studies generally show that replacing PET bottles aggregate in a concrete mix will reduce the tensile and compressive strength due to the ineffective bond between the PET bottles aggregate and other materials used in concrete [22]. The results affirmed that as the quantity of waste aggregates increases the bond between the aggregates and the other materials is getting reduced thereby decreasing the compressive strength of concrete. Hence only lesser

percentage of replacement is possible to produce a quality concrete.

According to the test results after curing at 28 days, the compressive strength of pavement block having 1% and 3% replacement of fine aggregate with shredded PET bottles were observed 0.28% and 4.3% more strength respectively than the control sample. But sample having 5% replacement with shredded waste PET bottles was showing the compressive strength of 24.29% lesser than the control sample. Therefore, the pavement block having 1% and 3% replacement with shredded waste PET bottles can be used effectively as they are having more compressive strength than the control sample. It was observed that the sample having 3% replacement with shredded waste PET bottles is having the higher strength.

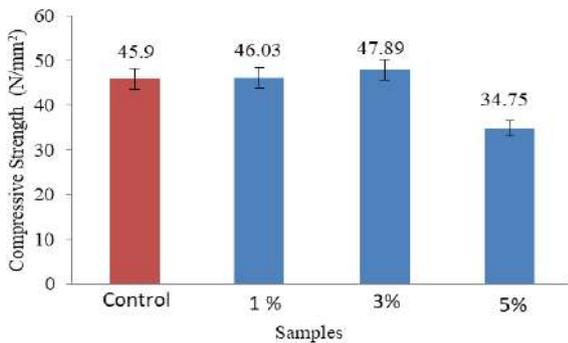


Fig.9. Compressive Strength of paver blocks with PET waste

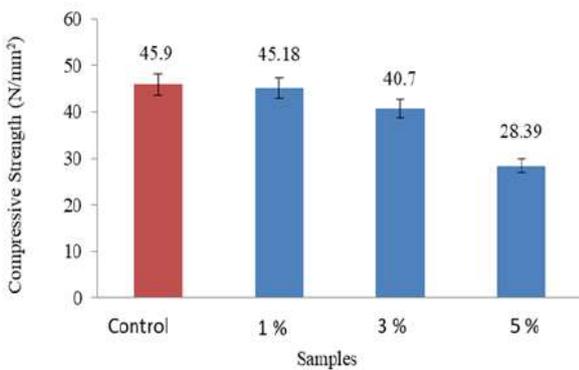


Fig.10. Compressive Strength of paver blocks with PVC waste

Fig. 10 shows that the compressive strength of samples having 1%, 3% and 5% shredded PVC wastes are found 1.56%, 11.32% and 38.14% lesser strength respectively than the strength of control sample. Therefore, the pavement block with shredded PVC wastes is contributing less strength and hence cannot be effectively used.

IV. CONCLUSION

Pavement blocks are available in various types based on the loads applied and site of installation. Incorporating plastic waste in the production of helps in reducing the environmental pollution as well as reduces the amount of waste generation up to an extent. The shredded PET bottles and PVC wastes are replaced by fine aggregate in the concrete mix having a suitable mix proportion and the

strength was analysed. The utilization of waste plastic in the production of concrete paver block proves to be economical and has productive way of disposal of plastic waste. The compressive strength after 28 days of curing for pavement block having 1% and 3% replacement with shredded waste PET bottles is showing more strength than the control sample in which the sample with 3% replacement is having the higher strength. The compressive strength of pavement block with 1%, 3% and 5% of shredded PVC wastes is showing lesser strength than the control sample and hence cannot be effectively used. In comparison with PVC waste replacement, pavement block with 3% shredded waste PET bottles is having the higher strength. Also, the thermogravimetric analysis showed that the PET waste remains unchanged in the mass till the temperature of 400°C whereas the PVC waste was stable only till the temperature of 300°C. Hence it is proved that the replacement of fine aggregate with 3% shredded plastic waste PET bottles produced pavement blocks of suitable size with higher compressive strength.

REFERENCES

- [1] Ankit Kumar¹, Vikas Srivastava and Rakesh Kumar, 'Effect of Waste Polythene on Compressive Strength of Concrete', Journal of Academia and Industrial Research (JAIR) Volume 3, Issue 3 August 2014.
- [2] B. Shanmugavalli, K.Gowtham, P. JebaNalwin, B. EswaraMoorthy, 'Reuse of Plastic Waste in Paver Blocks', International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-018, Vol. 6 Issue 02, February-2017.
- [3] BabooRai, S TabinRushad, Bhuvesh K R,S K Duggal, 'Utilization of waste plastic in manufacturing of bricks and paver blocks', International Scholar Research Notices Civil Engineering, Volume 2012.
- [4] Bhimaji Dashrath Kanawade, Sonali Ratnakar Nawale, 'Strength and Durability of Concrete Paver Block', Advances in Civil & Structural Engineering Volume 2 Issue 3.
- [5] Stanley O. Osubor, Kamoru A. Salam, Taiwo M. Audu, 'Effect of Flaky Plastic Particle Size and Volume Used as Partial Replacement of Gravel on Compressive Strength and Density of Concrete Mix', Journal of Environmental Protection, 2019.
- [6] Dinesh S, Dinesh A, Kirubakaran K, 'Utilization of waste plastic in manufacturing of bricks and paver blocks' International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 11 No.3 (2016).
- [7] Eric AbabioOhemeng, Peter Paa-Koffiyalley, John Dadzie, Susan DzifaDjokota, 'Utilization of waste low density polyethylene in high strength concrete pavement block production', Civil and Environmental Research, ISSN 2224-5790, ISSN 2225-0514 Vol.6, No.5, March 2014.
- [8] L. R. Bandodkar, A. A. Gaonkar, N. D. Gaonkar, & Y. P. Gauns, 'Pulverised PET Bottles as Partial Replacement for Sand', International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011.
- [9] Senthil Kumar Kaliyavaradhan, Tung-Chai Ling, 'Performance of concrete with PVC fibres', In Use of Recycled Plastics in Eco-efficient Concrete (pp. 369-385).
- [10] Nor Baizura Hamid, SitiNoraizaAbRazak, MardihaMokhtar, MohdErwanSanik, MasiriKaamin, Ahmad Hakimi Mat Nor, MohdZakwanRamli, 'Development of Paving Blocks using Waste Materials,' International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-9S3, July 2019.
- [11] B. Shanmugavalli, K.Gowtham, P. JebaNalwin, B. Eswara Moorthy, 'Reuse of Plastic Waste in Paver Blocks', International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-018, Vol. 6 Issue 02, February-2017.
- [12] Mukesh Chavan, Shubham Tamhane, Sunil Chavan, RushikeshPhuge, 'Manufacturing of pavement block by using waste plastic and sea sand', International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 3Mar 2019.
- [13] IS15658:2006, 'Precast concrete blocks for paving-specification', Bureau of Indian Standards.
- [14] Dinesh S, Dinesh A, Kirubakaran K, 'Utilization of waste plastic in manufacturing of bricks and paver blocks' International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 11 No.3 (2016).

- [15] S Agyeman, N K Obeng-Abenkra, S. Assamah, 'Exploiting recycled plastic waste as an alternative binder for paving blocks binder', Case Studies in Construction Materials, Volume 11, December 2019.
- [16] Mohan D.M.S, Vignesh.J , Iyyappan.P , C.Suresh , 'Utilization Of Plastic Bags In Pavement Blocks', International Journal of Pure and Applied Mathematics, Volume 119 No. 15, 2018.
- [17] Baboo Rai, S TabinRushad, Bhuvesh K R,S K Duggal, 'Utilization of waste plastic in manufacturing of bricks and paver blocks', International Scholar Research Notices Civil Engineering, Volume 2012.
- [18] Binu, A.M., Vinod, A.S., Sethuraj, P. and Akil, S., Experimental study on the replacement of coarse aggregates with recycled hospital plastic waste in paver blocks. International Journal for Advance Research and Development, Volume4(6),pp.1-3.,2019.
- [19] IS 10262:2009, 'Concrete mix proportioning-guidelines'.
- [20] Ganesh Tapkire, Satish parihar, Pramod Patil, Hemraj R Kumavat, 'Recycled Plastic Used In Concrete Paver Block', International Journal of Research in Engineering and Technology eISSN: 2319-1163, pISSN: 2321-7308.
- [21] Mohammad Farhat Ali, Muhammad Salman Qureshi, 'Catalyzed pyrolysis of plastics: A thermogravimetric study', African Journal of Pure and Applied Chemistry Vol. 5(9), pp. 284-292, 9 September, 2011.
- [22] Pacheco-Torgal, F., Ding, Y. and Jalali, S., 'Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): An overview'. Construction and Building Materials, Volume 30, pp.714-724, 2012.

Evaluation of Pull-out Test of FRP Headed Bars to Determine Bond Strength of Concrete

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Abstract— The reinforced beam-column joints are known as the vulnerable and critical region of a reinforced concrete moment resisting structure subjected to seismic loads. If beam-column joints behave in a brittle manner then the structure will display a brittle behaviour and if beam-column joints behave in a ductile manner, the worldwide behaviour of structures will be ductile. The RC beam-column joints are subjected to large shear stresses in the joint region under the action of seismic forces. The stresses produced due to moments and shear forces of converse signs on the member ends on either side of the joint core. High bond stresses are also forced on reinforcement bars in going into the joint. The diagonal cracking and crushing of concrete in the joint core are due to the axial compression and joint shear stresses effect in principal tension and compression stresses in the column. The use of fibre-reinforced polymers (FRP) has been increased during the last decade. Due to enhanced fabrication technology, there are some available products with very high tensile strength in comparison with the conventionally available FRP materials. However, employing these new bars in construction as main reinforcement requires very long development length which may be difficult to satisfy in some structural members. Thus, providing the FRP bars with headed studs at the ends is expected to enhance the mechanical anchorage and yield a satisfactory development length for the FRP bars. Furthermore, the headed FRP anchors may provide a suitable alternative to the FRP bent bars in some applications when the surrounding concrete is of enough thickness to overcome the splitting failure such as in case of the bridge barriers. To verify the applicability of such models also to exterior beam-column joints, where a better anchorage for the beam reinforcement is possible, embedded bars are being used. In order to check the response of such behavior, tests are performed on software for the cyclic loading. Excellent response is to be expected. After a detailed description of the observed performance of each test, an explanation is offered for the surprisingly.

Keywords— Bond stresses, Embedded bars, Exterior RC Beam-Column joints, FRP headed bars, Metal headed bars, Pull out loads

I. INTRODUCTION

A. Traditional Reinforced Concrete

Beam column joints in a reinforced concrete moment resisting frame are crucial zones for transfer of loads effectively between the connecting elements (i.e. beams and columns) in the structure [1].

A majority of the traditional reinforced concrete frame buildings, existing across the Middle East, lack adequate confinement in beam-column joints, or in other words, are shear deficient because they were constructed before the introduction of seismic codes for construction [2]. This research studies the experimental behavior of full-scale

beam-column space (three dimensional) joints under displacement controlled cyclic loading [3].

B. Traditional Techniques

Research carried out in previous years has enabled the development of design standards that provide seismic requirements and reinforcement detailing that result in better seismic performance of newly-designed structures and minimize the probability of damage and/or collapse. As pointed out by Pantaildes et al. this can be achieved by preventing the brittle failure of joints in reinforced concrete (RC) frame structures, maintaining its integrity and reducing its stiffness degradation.[4]. However, there is a considerable number of buildings worldwide that have been designed, detailed and built without specific seismic requirements that may be vulnerable to seismic events, as demonstrated by recent earthquake on an existing RC structure, several strengthening techniques have been developed, studied, and applied in previous decades.[5]. Traditional techniques include concrete and steel jacketing of the frame elements, however these techniques are complex, intrusive, and labour intensive.[6] More modern techniques such as base isolation and supplemental damping devices have also been developed, but some challenging aspects still need to be addressed such as cost, invasiveness, and practical implementation [7].

C. Pull-out test for calculating Bond Stress[7]

1. Prepare concrete mix as per mix design for different grade of concrete.
2. Cast the concrete cube of different grade having size of (300*300*300) mm. Using 12 mm, 16 mm, 20 mm bars having Glass fiber head of different shapes [8].
3. Perform the pull-out test on Universal Testing Machine (UTM) using pull out test attachment at 28 days age.
4. Attach a dial gauge for finding the slip between steel and concrete and draw the curve between load and slip [8].
5. Take the reading of load at 0.125mm slip and at bond failure.

The bond stress is calculated by using the equation [9],

$$\sigma = \frac{P}{\pi \times D \times L} \quad (1)$$

Where,

σ = Bond Strength

D = Diameter of Bar

L = Development Length of bars

P = Maximum load applied from UTM

II. PREPARATION FOR EXPERIMENT:

A. For 12mm dia. bars:

Size of head

1. Square: (35*35*6) mm
2. Rectangular: (36*30*6) mm
3. Circular: 36mm dia.

B. For 16mm dia. bars:

Size of head

1. Square: (45*45*8) mm
2. Rectangular (50*36*8) mm
3. Circular: 46mm dia.

C. For 20mm dia. bars:

Size of head

1. Square: (50*50*10) mm
2. Rectangular (64*40*10) mm
3. Circular: 56mm dia.

TABLE I. NO. OF SPECIMENS

Grade of Concrete	Shape of heads			Total no of specimens
	Square	Rectangular	Circular	
M20	9	9	9	81
M30	9	9	9	
M40	9	9	9	

TABLE II. DETAILS OF SPECIMENS [10]

Dia. Of bar db mm	Area of bar Ab mm ²	Embedment length mm			Thickness of head Th mm
		10db	12db	14db	
12	113.097	120	144	168	6
16	201.061	160	192	244	8
20	314.1	200	240	280	10

TABLE III. RESULTS OF METAL & FRP SQUARE HEADED BARS FOR 16MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	Metal	FRP	Metal	FRP	
160	56.19	56.1	6.99	6.98	Both
192	70.24	67.9	7.28	7.04	Metal
224	80.6	82.26	7.16	7.31	FRP

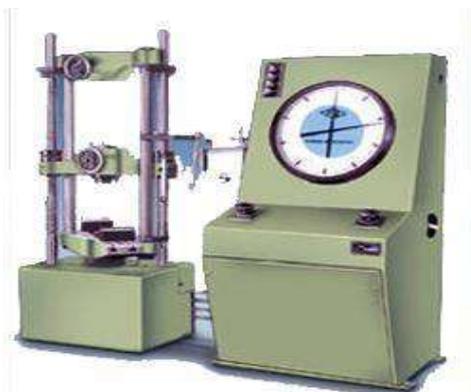


Fig. 1. Universal Testing Machine^[12]

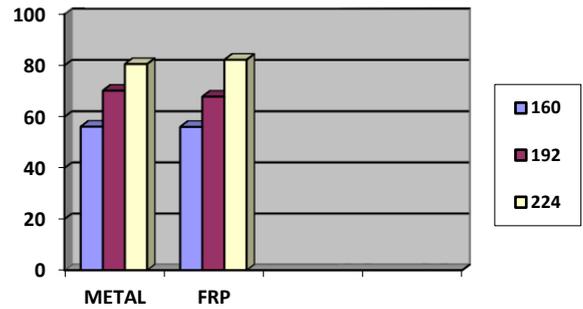


Fig. 2. Results of Metal & FRP Square Headed Bars for 16mm dia bars.

TABLE IV. RESULTS OF METAL & FRP SQUARE HEADED BARS FOR 16MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	Metal	FRP	Metal	FRP	
160	56.19	56.1	6.99	6.98	Both
192	70.24	67.9	7.28	7.04	Metal
224	80.6	82.26	7.16	7.31	FRP

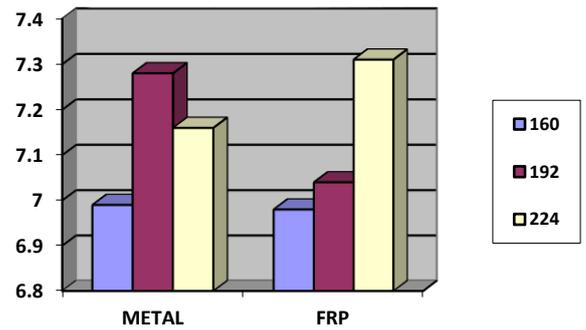


Fig. 3. Results of Metal & FRP Square Headed Bars for 16mm dia bars.

TABLE V. RESULTS OF METAL & FRP CIRCULAR HEADED BARS FOR 16MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	Metal	FRP	Metal	FRP	
160	57.38	53.85	7.13	6.7	Metal
192	75.28	65.3	7.8	6.77	Metal
224	85.9	77.65	7.63	6.9	Metal

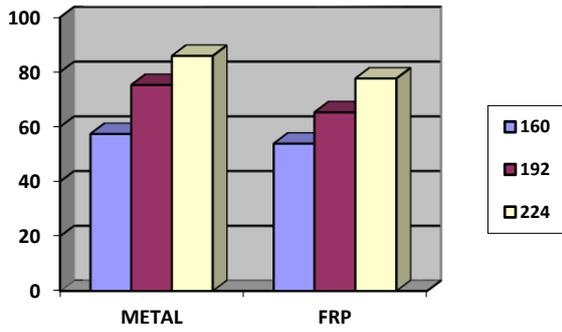


Fig. 4. Results of Metal & FRP Circular Headed Bars for 16mm dia bars.

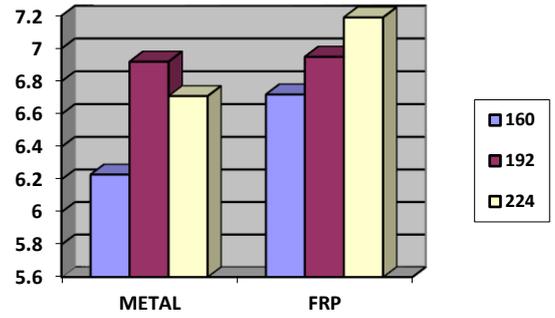


Fig. 7. Results of Metal & FRP Rectangular Headed Bars for 16mm dia bars.

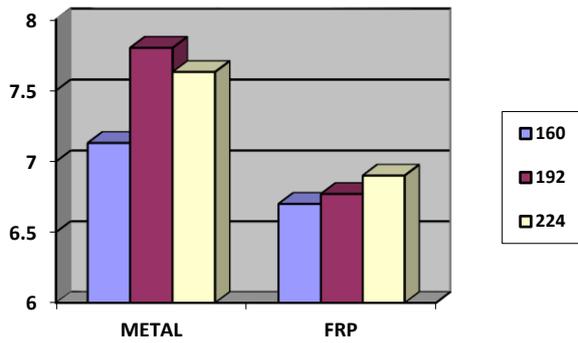


Fig. 5. Results of Metal & FRP Circular Headed Bars for 16mm dia bars.

TABLE VII. RESULTS OF METAL & FRP SQUARE HEADED BARS FOR 20MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	<i>Metal</i>	<i>FRP</i>	<i>Metal</i>	<i>FRP</i>	
200	79.28	105	6.31	8.36	FRP
240	88.84	133.9	5.89	8.89	FRP
280	90.28	158.9	5.13	9.04	FRP

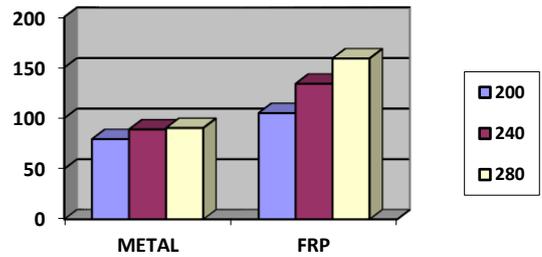


Fig. 8. Results of Metal & FRP Square Headed Bars for 20mm dia bars.

TABLE VI. RESULTS OF METAL & FRP RECTANGULAR HEADED BARS FOR 16MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	<i>Metal</i>	<i>FRP</i>	<i>Metal</i>	<i>FRP</i>	
160	50.1	54.01	6.23	6.72	FRP
192	66.8	67.04	6.92	6.95	FRP
224	75.6	80.91	6.71	7.19	FRP

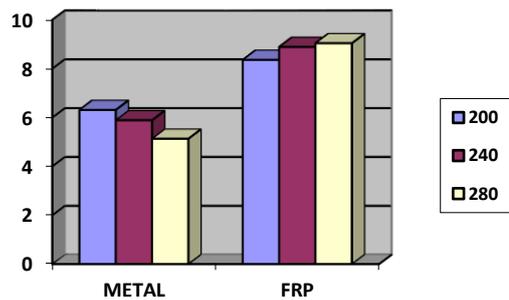


Fig. 9. Results of Metal & FRP Square Headed Bars for 20mm dia bars.

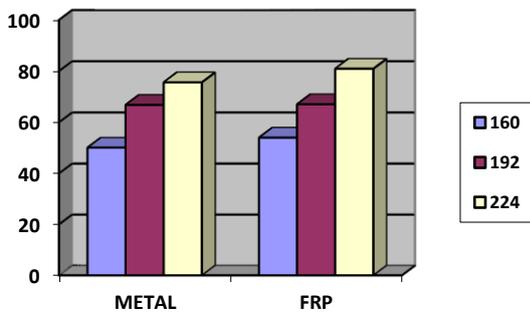


Fig. 6. Results of Metal & FRP Rectangular Headed Bars for 16mm dia bars.

TABLE VIII. RESULTS OF METAL & FRP CIRCULAR HEADED BARS FOR 20MM DIA BARS

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	<i>Metal</i>	<i>FRP</i>	<i>Metal</i>	<i>FRP</i>	
200	89.18	103.4	7.1	8.24	FRP
240	100.83	129.4	6.68	8.59	FRP
280	112.82	152.9	6.41	8.7	FRP

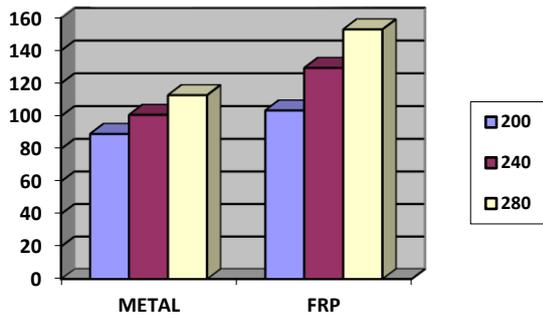


Fig. 10. Results of Metal & FRP Circular Headed Bars for 20mm dia bars.

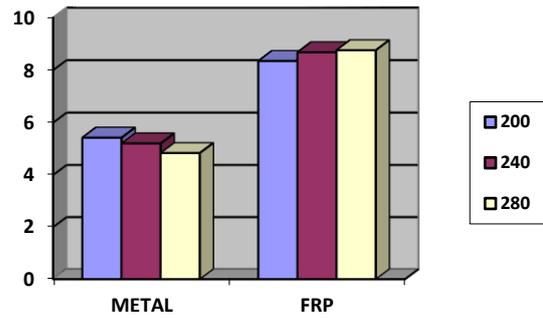


Fig. 13 Results of Metal & FRP Rectangular Headed Bars for 20mm dia bars.

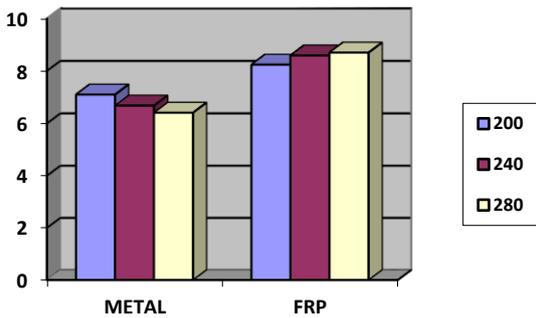


Fig. 11 Results of Metal & FRP Circular Headed Bars for 20mm dia bars.

TABLE IX. RESULTS OF METAL & FRP RECTANGULAR HEADED BARS FOR 20MM DIA BARS.

Embedment Depth in mm	Maximum Load in KN		Bond Strength in MPa		Which material is better
	Metal	FRP	Metal	FRP	
200	89.18	103.4	7.1	8.24	FRP
240	100.83	129.4	6.68	8.59	FRP
280	112.82	152.9	6.41	8.7	FRP

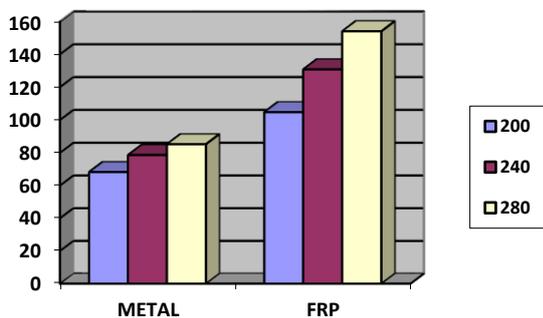


Fig. 12 Results of Metal & FRP Rectangular Headed Bars for 20mm dia bars.

III. FOR M20 CONCRETE MIX DESIGN USING METAL AND FRP HEADED BARS

1) For 16mm dia bars

- In square headed bar, the pull out load results for metal and FRP headed bars are nearly same, but the bond strength of FRP bars increases with the increase in the embedded length, which is not the case for the metal headed bars. It shows good result for only 14 time dia embedded length.
- In circular headed bar, the pull out load as well as the bond strength results for metal headed bars are more as compared to FRP headed bars.
- In rectangular headed bar, the pull out load results for metal and FRP headed bars are nearly same, but the bond strength of FRP bars increases with the increase in the embedded length, which is not the case for the metal headed bars.

2) For 20mm dia bars

- In square headed bar, the pull out load results of FRP bars increases with the increase in the embedded length, however this is not the case in metal headed bars. They show the same results for all embedded length. The bond strength of FRP bars increases with the increase in the embedded length, which is not the case for the metal headed bars. It shows good result for only 12 time dia embedded length.
- In circular headed bar, the pull out load of FRP headed bar having more value compare to metal headed bar. The bond strength of FRP bars in all embedded length most of same result, which is not the case for the metal headed bars. It shows good result for only 12 time dia embedded length.
- In rectangular headed bar, the pull out load results for metal headed bars are nearly same for all case, however the FRP headed bar having pull out load increases with the increase in the embedded length, but for bond strength for FRP headed bars nearly same for all embedded length but also more compare to metal bar in all embedded length.

IV. FOR M20, M30 AND M40 CONCRETE MIX DESIGN USING FRP HEADED BARS[11]

1. For 20mm bar the result shows that the bond strength increases with respect to increase in embedment depth, grade of concrete as well as Square head has maximum bond strength in comparison of Rectangular and Circular head. Circular headed bar has minimum bond strength in all specimen.

2. For 16mm bar the result shows that the bond strength increases with respect to increase in embedment depth, grade of concrete as well as Square head has maximum bond strength in comparison of Rectangular and Circular head. Circular headed bar has minimum bond strength in all specimen.

3. For 12mm bar the result shows that the bond strength increases with respect to increase in embedment depth, grade of concrete as well as Square head and Rectangular head has nearly equal strength wherever Circular head has little less strength.

SUMMARY

In M20 , for 20 mm and 16 mm dia bar, there is the bond strength of FRP bars increases with the increase in the embedded length compare to metal headed bar for the same.

Because of the results of M20 , FRP headed bars only can be apply for M30 , M40 mix design for concrete with rectangular and square headed bars.

The gross area of circular head has minimum area in comparison of square and rectangular head therefore the bond strength of circular headed bar has minimum bond strength.

REFERENCES

- [1] Subramanian, N., and D.S. Prakash Rao, "Design of Joints in RC Structures with Particular Reference to Seismic Conditions, The Indian Concrete Journal, Vol. 77, No. 2, Feb. 2003, pp. 883-892.
- [2] Jain, S.K., and C.V. R. Murty, (2002) 'Proposed Draft Provisions and Commentary on Ductile Detailing of RC Structures Subjected to Seismic Forces (IS 13920', Document No. IITK-GSDMA-EQ11-V4.0, IITK-GSDMA Project on Building Codes, 67 pp. <http://www.iitk.ac.in/nicee/IITK-GSDMA/EQ11.pdf> -Accessed on 17th July 2013).
- [3] Gregoria Kotsovou , Harris Mouzakis – " Exterior RC beam–column joints: New design approach.", Engineering Structures 41 (2012) 307–319.
- [4] S.M. Kulkarni, Y.D. Patil - " A Novel Reinforcement Pattern for Exterior Reinforced Concrete Beam-Column Joint.", Procedia Engineering 51 (2013) pp. 184 – 193.
- [5] Hwang, S.-J., H.-J. Lee, T.-F. Liao, K.-C. Wang, and H.-H. Tsai, (2005), ' Role of hoops on Shear strength of Reinforced Concrete Beam-Column Joints', ACI Structural Journal, Vol.102, No.3, May-June 2005, pp.445-453.
- [6] S. Rajagopal, S. Prabavathy – "Investigation on the seismic behavior of exterior beam–column joint using T-type mechanical anchorage with hair-clip bar.", Journal of King Saud University – Engineering Sciences (2015) 27, 142–152.
- [7] Dhake Pravinchandra, Jape Anuja, Patil Hemant and Patil Yogesh "Behavior of exterior beam column joints with diagonal cross bars and headed bars " IJSCER Vol. 4, No. 1, February 2015
- [8] IS 456 (2000), "Code of Practice for Plain and Reinforced Concrete." Bureau of Indian standard,2000.
- [9] IS 5816 (1999): "Method of Test Splitting Tensile Strength of Concrete".
- [10] ACI-ASCE Committee 352. (2002), 352R-02: Recommendation for design of beam-column joints in monolithic reinforced concrete structures, American Concrete Institute, Farmington Hills, MI., 37 pp.
- [11] IS 10262-2009 "Concrete mix proportioning-Guidelines".Bureau of Indian standard,2009..
- [12] IS 516-1959 "Methods of tests for strength of concrete". Bureau of Indian standard,2002.

Promising Friction and Wear-reducing Additive in Lubrication- Recent Progress & Perspective

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Abstract: Aluminium oxide nanoparticles have great capabilities to improve friction and wear properties. This review focuses on the synthesis methods of alumina nanoparticles, development and applications of alumina based nano fluid in tribology, and factors affecting tribological properties of lubricants with alumina as nano additive. Alumina is white colored oxide of aluminium which has wide range of applications in catalyst, surface protective coatings, fire retardants, and composite materials. High hardness, high insulation, high stability, conductivity, mechanical strength, wear resistance, high melting points, transparency, and electrical and chemical resistance are the properties exhibited by alumina. The replacement of organic molecules in lubricant systems by tiny particles of solid material like alumina is not very straightforward and has been considered as a feasible option in recent studies.

Keywords- Alumina nanoparticles, Lubrication, Nano fluid, Synthesis.

I. INTRODUCTION

Friction and wear play important role in the proper functioning of machines. The efficiency of the machine can be increased by minimizing the friction losses. Failure of mechanical systems by friction and wear leads to additional cost of equipment, repairing, installation of new components, thus affecting the economy[1]. The recent studies show that tribological development can save the power loss in the generation, transportation, and industrial processes by 11%. The leakage in lubrication systems of various machines results in lubricants lost in the environment, and the soil, water bodies, and air getting contaminated by volatile lubricants[2].The additives are required to add in lubricants to enhance its performance.

In recent years the nanoparticle additives in lubricating oils plays an important role in aiding lubrications and leads to a reduction in emission and improving the fuel economy [1-30]. Materials with particle size less than 100 nanometers (0.1 Micron Meter) is defined as Nanoparticle. The nanoparticles have a very small particle size, higher surface area so that they have high reactivity[3].As compared to the traditional organic additives the nanoparticles are considered thermally stable at high temperatures environmentally friendly, have excellent physical and chemical properties and limited tribo chemical reactions. Another advantage of the addition of nanoparticles in lubricant oils is that they can pass through the filters[1].The nanoparticles can be used in diesel and biodiesel as additives which can effectively improve engine performance, fuel efficiency, and exhaust emission characteristics[4].These materials specifically designed on anti-wear and extreme pressure chemistries can significantly lower the sulfur and phosphorus level in the lubricant additive, and therefore provide environmental

benefits[2].The nanoparticles used in refrigerants known as nano refrigerant which enhance heat transfer rate and reduce the energy consumption [4].The nanoparticles have a great potential in colloidal systems and have several applications in lubrication, oil extraction, biomedical, cancer therapy, and drug delivery.

It is difficult to select a specific additive because there exists an infinite number of choices, which includes Carbon and its derivatives Graphene, Diamond, Carbon nanotubes, SWCNT, MWCNTs, Metal nanoparticles Ag, Sn, Fe, Bi, Ni, Cu, Ti, Co, Pd, Au, Metal oxides ZrO₂, TiO₂, Fe₃O₄, Al₂O₃, ZnO, CuO, Metal sulfides WS₂, CuS, MoS₂, and NiMoO₂S₂, Rare earth compounds La, LaF₃, CeO₂, La (OH)₃, Y₂O₃, CeBO₃and Ce, Nano composites mixed or doped additives Cu/SiO₂, Cu/graphene oxide, Al₂O₃/SiO₂, serpentine/La(OH)₃, Al₂O₃/TiO₂, Ceramics, Quantum dots, Semiconductors, Polymeric Nanoparticles, and others like PTFE, CaCO₃, Zn, Al₂O₄, ZrP, SiO₂, Hydroxide, BN, Serpentine Zeolite. In formulating lubricants, the challenge is not to find synergetic combination but also to minimize unfavorable interactions that can result in product instability and foam generation. The best approach is to utilize multifunctional additives to simplify formulations. The use of specific additive combinations is dependent upon the application.

A. Alumina Nanolubricants

Nanostructured alumina has many applications like biomedical implants, catalyst support, absorbents, fire retardants, polymer matrix composite, insulator, clinical field, electronic fields, etc. Alumina having many applications as it having great properties like chemical and thermal stability, conductivity, mechanical strength, wear resistance, high hardness, high melting points, and electrical and chemical resistance [5, 6, 15]. Alumina has four different phases alpha, beta, gamma, and delta. Among this alpha alumina is the most popular phase among researchers as it is very stable and having great properties like high hardness, high stability, high insulation, and transparency [16]. Alumina nanoparticles are having great properties as a lubricant additive as they could significantly reduce the interfacial friction as well as improving load-bearing capacity. The properties of Nano fluids are influenced by the characteristics of nanoparticles. The method of synthesis and functionalization of alumina nano-particles plays an important role in wide range of potential applications in various industries[5].

B. Synthesis of alumina Nanoparticles:

Alumina can be synthesized by various methods like vapor phase reaction, mechanical milling, sol-gel, hydrothermal, combustion, solvothermal method,[7] laser ablation, Microwave-Assisted technique and precipitation method [7][8][9][16-17]. Among all these sol-gel is the most favorable and most investigated as it produce highly pure and high specific surface area solid particles[6].

Chu et al.[7] synthesize alumina nanoparticles by a solvothermal method by using $\text{Al}(\text{NO}_3)_3$ and NaOH solutions. Precipitated aluminum hydroxide calcinated at 600°C for 12h. The nano-sized $\gamma\text{-Al}_2\text{O}_3$ nanoparticles with an average particle size of 40 nm were synthesized. Piriya Wong et al. [10] synthesized alumina nanoparticles using laser ablation technique in deionized water. Various energy levels 1, 3, 5 are used for laser ablation. After laser ablation Al_2O_3 particles were obtained suspended in deionized water. The laser ablation method is fast, highly accurate and the collection of nanoparticles is easy. Ali et al.[11] synthesize $\alpha\text{-alumina}$ (Al_2O_3) nanoparticles by precipitation technique by the formation of $\text{Al}(\text{OH})_3$, after filtration, drying, calcined 550°C for 5 h. $\gamma\text{-Alumina}$ nanoparticles with average particle size 30–50 nm were synthesized and characterized. Mostafa and Allahverdi [12] synthesized $\gamma\text{-alumina}$ nano powder from aluminum foundry waste. The extraction of alumina involves Aluminum foundry tailing which includes sieving, washing, leaching, filtration, precipitation, purification, re-precipitation, and finally calcination. The synthesized $\gamma\text{-alumina}$ from waste can be used for catalytic applications. Hasanpoor et al.[13] synthesize alumina nanoparticles from a green plant by using a Microwave-Assisted technique. Aluminum nitrate and plant extracts were mixed and microwaved centrifuged and washed with ethanol and deionized water. 60-300nm average size alumina nanoparticles were synthesized. Bhattacharyya and Behera[14] synthesize nano $\alpha\text{-alumina}$ powder by acid leaching process from calcined kaolin. Kaolin powders were calcinated at 750°C for 2 h and then dispersed in hydrochloric acid. Acid activation was carried out at 70°C for 6 hrs. and followed by cooling and filtration. Sodium hydroxide solution used to precipitate leached liquor at high alkaline conditions. After precipitation, washing, and drying 1200°C processes takes place to synthesize pure $\alpha\text{-alumina}$ with a size range less than 100 nm. Khazaei et al.[15] synthesize $\gamma\text{-Alumina}$ Porous Nanoparticles by an aqueous sol-gel method by using sodium aluminate liquor, HCl , NaOH , and structure-stabilizing agents Polyethylene glycol (PEG) and polyvinyl alcohol (PVA). By drying gel at 100°C for 2 h and calcined in a furnace at 800°C for 4 h $\gamma\text{-Al}_2\text{O}_3$ nanoparticles with average crystallite sizes were 2.58 nm and 3.07 nm synthesized by sol-gel method. Farahmandjou and Golabiyani [16] Ethanol & aluminum nitrate solution is mixed with water and heated to 80°C simultaneously ethanol solution added drop by drop. The PH value has to maintain at 2-3. After evaporating for 3 hrs, cooled to room temperature and calcined at 500°C for 5 hours. $\alpha\text{-Al}_2\text{O}_3$ nanoparticles ceramic are synthesized by sol-gel method with an average diameter of 28 nm. L. Fu et al. [17] studied the synthesis of nanostructure $\gamma\text{-Al}_2\text{O}_3$ Nano powder by microwave plasma synthesis. The alumina powder as a precursor is put in the reaction chamber with

the axial flow of oxygen to convert it into plasma. The vaporized alumina oxide was collected in a nitrogen-cooled thermophoretic collector. The oxygen flow rate, pressure, temperature plays important role in the synthesis of alumina nano powder. Saravanakumar [18] studied the synthesis of $\alpha\text{-alumina}$ from waste aluminum dross i.e. waste generated in the aluminum melting process by the plasma process. The sample is placed in a cleaned graphite crucible is dropped reaction chamber and argon gas will pass through the cathode hole. The sample size and time are important factors for experimentation. At a large temperature in the crucible, reaction chamber, and arc region the ultrafine Al_2O_3 Nanopowder synthesized. Bhoi et al.[9] Studied Al_2O_3 nanoparticle synthesis by precipitation method and characterization of nanoparticles by X-ray diffraction and scanning electron microscopy analysis. The results show that the calcination temperature is an important factor that influences the stability and processing time of Al_2O_3 NPs. the crystallite size of the sample increases with an increase in calcination temperature. The results show the size of synthesized Nanoparticles is in the range of 53-72 nm by the cost-effective precipitation method. Mohamad et al. [6] studied the sol-gel method to synthesis alumina (Al_2O_3) nanoparticles. The results show white powder of $\alpha\text{-alumina}$ formed at 1100°C and 1200°C with the rapid growth of the crystalline size about 48 nm on average. The transformation from $\gamma\text{-}$ to $\alpha\text{-alumina}$ occurred at 1100°C of sintering temperature and above with an average crystallite size of 49 nm. Rajaeiyan et al. [8] alumina nanoparticle synthesis and compare with sol-gel and co-precipitation method and their properties are studied. The sol-gel method synthesized the alpha-alumina nanoparticle of size 10-15nm and co-precipitation method of 10-50nm. PH, reaction temperature and reaction time, the concentration of the initial solution and material, have an important role in getting ceramic powders with desired shape and size are different parameters that have to be considered.

Synthesis method and reaction temperature play key roles to control the phase formation of the alumina Nano crystals.

C. Nanoparticle lubrication systems mechanisms:

In the recent development of nanoparticles as additives has been extensively researched and proved that nanoparticle additive shows better properties compared to traditional solid lubricants. In nanoparticle lubrication systems the grooves, valleys, and micro-cracks get filled by the nanoparticles creating a mending effect that eventually supports the tribo pair and improves anti-friction anti-wear properties. The alumina nanoparticles are promising nano additive for lubrication as it is eco-friendly nontoxic and has superior thermal, chemical and lubricating properties. Nanoparticles react with a surface which improves the lubrication by various mechanisms, The major mechanisms are the 1. mending effect- grooves, valleys, and micro-cracks will be filled by the nanoparticles[19], 2. Tribofilm formation the nanoparticles react with the specimen and form the protective layer[11][20][21][22]. 3. ball bearing/rolling-rolling of nanoparticles between contacting surfaces, 4. surface polishing effect- The nanoparticles may get Tribo-sintered on the surfaces[21].

D. Development and Applications of Alumina based Nanofluid in tribology:

The nano lubricant preparation is a very important process that leads to its stability and performance. The suspension must have stability, homogeneity, dispersion stability, and durability. There are two methods of preparation of Nano fluids: a one-step method and two-step method. Among these, the two-step method is popular where nanoparticles are synthesized separately and dispersed in the base fluid. Al_2O_3 nanoparticles with various sizes and different concentrations are added to base lubricant to evaluate its properties. The tribological properties are investigated on four ball tribological testers by ASTM D4172 and ASTM D5183 [19]. The analysis of signal-to-noise (S/N) ratio, analysis of variance (ANOVA) [23], Integrated Taguchi-Grey relational approach is used to decide the optimum concentration of nanoparticles and load [19]. The morphology, microstructure, homogeneity, and particle size of alumina powders can be examined with the transmission electron microscope (TEM), Scanning electron microscope (SEM). Specific surface areas were measured using the BET-N₂ technique [8]. The new lubricants are designed for a cleaner environment and to increase fuel economy [24].

Ali [21] studied the addition of hybrid $\text{Al}_2\text{O}_3/\text{TiO}_2$ 8-12 nm sizes nanomaterials as additives to commercial engine Castrol EDGE professional A5 5W-30 lubricants along with oleic acid to improve scuffing resistance and reducing friction power losses. The result shows a reduction of frictional power loss by 40-51%. The wear rate in the piston ring is decreased by 17% which acts as a solid lubricant and the viscosity index increased by 1.87%. The friction coefficient decreased by 47.61% under the boundary lubrication regime. Ali [24] studied tribological properties of Al_2O_3 and TiO_2 nanomaterials in automotive piston ring assembly. The avg. 8–12 nm size nanoparticles with 0.05, 0.1, 0.25, and 0.5 wt.% concentration wear added with oleic acid in engine oil Castrol EDGE professional A5 5W-30. The results show that the coefficient of friction is reduced by 11% and 2.6% for 0.25 wt.% concentration. Kinematic viscosity decreases because of the presence of nanoparticles. The viscosity index increased by 1.86%. Al_2O_3 nano lubricant was more effective in improving the anti-wear and scuffing resistance via the formation of self-laminating protective films. Ghalme et al. [19] studied the tribological performance of aluminum oxide nanoparticles in lubricating oil (SAE10W40). The 0.5% wt concentration and 250 N load show the reduction in wear scar by 20.75 and coefficient of friction by 22.67%. The tribological performance is improved by the mending effect and ball-bearing effect of Al_2O_3 . Khalilpourazary et al. [25] studied the effect of the addition of alumina nanoparticles in mineral-based oil 25W-50 as an additive to investigate spur gear surface roughness and hob tool wear in the hobbing process. The result shows an expressive decrease in the hob tool crater and flank wear. Arithmetic surface roughness value decreases in spur gear manufacturing. Luo et al. [26] evaluated tribological properties of lubricating oil by adding Al_2O_3 nanoparticles with various concentrations as additives. 0.1 wt% concentration reduces friction coefficient by 17.61% and 23.92% for four-ball and thrust-ring respectively. The wear

scar diameter was reduced by 41.75%. Kedzierski [27] studied kinematic viscosity and density measurement of commercial polyester lubricant (RL68H) with the addition of aluminum oxide (Al_2O_3) nanoparticles at elevated temperature. The liquid density decreased with temperature and increased with Al_2O_3 mass fraction for the temperature range of the study. Kedzierski [28] studied the effect of Al_2O_3 nanoparticles and R134a/polyol ester mixtures on the pool boiling performance on the Turbo-BII-HP boiling surface. The nano additive increases the R134a boiling performance and remains dispersed in the liquid. Singh et al. [29] studied the physicochemical and tribological analysis along with the morphological study of the alumina nanoparticles in polanga oil. The friction analysis shows that the minimum coefficient of friction was obtained at 0.075%, whereas an increase was observed at 0.1% concentration. At the sliding speed of 200 rpm, the maximum coefficient of friction of around 0.0737 was observed for the 0.1% concentration, and a minimum of around 0.0548 was obtained for the 0.075% concentration. The maximum wear being observed at 200 rpm and the minimum at 800 rpm. Suthar et al. [30] studied tribological properties of jojoba oil by adding various concentrations of Al_2O_3 nanoparticles as additives. 0.1% shows the minimum coefficient of friction which will increase with an increase in the concentration of nanoparticles. Paras et al. [31] studied the tribological behavior of two synthetic lubricants: GL-4 (SAE 75W-85) a fully formulated oil and Poly-alpha olefin 8 (PAO 8) base oil by adding CuO and Al_2O_3 nanoparticles as additives of 50 nm size with 0.5, 1.0, and 2.0 wt.% concentration. Fitriana et al. [32] studied the effect of alumina nanoparticles as a lubricant in minimum quality lubrication in the drilling process on cutting parameters. Alumina nanoparticles with 13 nm size with 1.2 vol.% added in MQL and conventional cutting fluid. The result shows good surface roughness properties as compared to conventional. Prabu et al. [33] studied tribological characteristics of metalworking fluids with copper and alumina nanoparticles as additives. The anti-wear, antifriction, and extreme pressure tests, anti-corrosive, Density, PH value Dispersion stability are examined. The results show nanofluid increases load-carrying capacity as compared to base fluid and the COF is reduced by 15% for alumina nanoparticles. Nanofluids show better resistance towards corrosion. The above study shows the potential of nanoparticle additives for replacing conventional contaminant additives, such as sulfur and phosphorous. The nano alumina shows better results towards anti-friction and anti-wear properties compared to copper nanoparticles [33]. The surface mass fractions, temperature, and concentration play an important role in viscosity and density of nano lubricant. These factors are important in heat transfer and flow applications [27].

E. Dispersion stability of nano fluid:

The van der Waals force is responsible for a non-homogeneous and unstable mixture of nanoparticles which also leads to agglomeration of particles. There are various techniques to improve the dispersion stability and uniformity such as magnetic stirrers, ultrasonic baths, homogenizers, and high-shear mixers. Visualization method,

Zeta potential analysis, UV spectra, Electron Microscopy Methods (TEM and SEM), and 3ω -Method are the methods that measure the stability of nanofluid. Brownian motion, particle agglomeration, particle clustering, and interfacial layer effect have recently identified a mechanism for augmentation in thermophysical properties. The appearance of nanoparticles on the friction surfaces proved by EDS measurements [34][35].

Luo[34] et al. studied the synthesis of $\text{Al}_2\text{O}_3/\text{TiO}_2$ nanocomposites by hydrothermal method and its surface modifications by silane coupling agent KH-560. The surface modification properties are analyzed by Zeta potential which shows great results for modified nanoparticles. The results show the $\text{Al}_2\text{O}_3/\text{TiO}_2$ Nano composite has better tribological properties compare to unmodified. Liu et al.[36] Studied the dispersion stability of Al_2O_3 Nano lubricants in polyalphaolefin oil with oleic acid as surfactant. The ultrasonic amplitude and prolonging the ultrasonic time plays important role in dispersion stability while synthesis. The results also show 0.005wt% and 0.01wt% Al_2O_3 nanoparticle has very good dispersion stability for more than 160 days. Abdullah et al. [23] studied tribological performance optimization of hexagonal boron nitride (hBN) and alumina (Al_2O_3) nanoparticle additives in diesel engine oil SAE 15W40. It was found that a contribution of 0.5 vol.% of hBN and 0.3 vol.% of oleic acid as a surfactant can be used as an optimal additive composition in a conventional diesel engine to obtain lower COF. Jiao [35] studied the tribology properties of alumina/silica ($\text{Al}_2\text{O}_3/\text{SiO}_2$) composite nanoparticles as lubricant additives and compare them with the pure Al_2O_3 and SiO_2 nanoparticles. The nanoparticles were synthesized with a hydrothermal method and in situ modified with silane coupling agent gamma- glycidoxypropyltrimethoxy silane KH560. $\text{Al}_2\text{O}_3/\text{SiO}_2$ composite nanoparticles were fully modified with KH560. The sample is tested for sedimentation by dispersing nanoparticles in lubricating oil for 30 min by ultrasonic prob and checked after 3 months. Result shows that the $\text{Al}_2\text{O}_3/\text{SiO}_2$ composite particles showed better anti-wear performance than those of pure Al_2O_3 or SiO_2 particles. SiO_2 has good dispersion stability as compared to Al_2O_3 nanoparticles. Noor[37] studied the effect of surface modification of alumina nanoparticles which deals with various property improvements of Al_2O_3 NPs. The alumina nanoparticles are coated with Oleic Acid and Silica Dioxide and their effect on chemical properties and NPS structure are studied.

The sedimentation and agglomeration can be minimized by chemical and physical treatments such as the addition of surfactant, surface modifications. The oleic acid as surfactant shows hydrophobic properties and improves the stability. The amount of surfactant used is an important parameter because excess use is undesirable. The excess use of surfactants affects viscosity, chemical and thermal characteristics. There is surfactant-free approach, the surface modification technique which also gives long-term stability to nanofluids [35]. The surface modification method is also important to decide nanomaterial characteristics. The coatings on surfaces can be confirmed by SEM, FTIR, and XRD analysis, which show improvements in the nanoparticle properties. The researcher suggested

biocompatible polymers as coating material so can be used for medical applications.

F. Challenges and future perspectives:

The use of nanoparticles in the lubrication of mechanical systems has become an interesting research line. The use of alumina nanoparticles is suitable for reducing friction and wear. Many results show alumina has good potential as an additive in mechanical applications. Still there are many problems and challenges are faced by researchers because of differences in results obtained by researchers, lack of understanding of mechanisms that takes place at the Nano scale, environmental influence, technological performances, and cost of novel nano additives for commercial use. The effect of various factors on stability like mixing temperature, settling time, Ultra sonication duration, and Nanoparticles/Surfactant Concentration have to be studied. There are also some challenges associated with nano lubricants, cost of production, high accuracy and purity requirements for some applications, and reliable control on characteristics of nanomaterials. The important parameters which affect the performance, characteristics of nano lubricant are the size of nanomaterials, the shape of nanomaterial, its concentration in the base fluid, morphology, surface functionalization, dispersion compatibility, lubrication conditions. The specific application of alumina nanoparticles in commercial product has not yet been mentioned, and their application as an additive has significant to improve the properties of bio-lubricants. For prospects, research work could be carried out to investigate the effect of different nanoparticles in various non-edible, edible vegetable oils and compare them as antifriction and antiwear additives.

There is much more work that can be done in the development and industrialization of alumina as a super additive. 1. The anti-frictional properties and the mechanisms at nanoscale should be studied with molecular dynamics simulation. 2. The experimental and the simulation characterization of alumina nanoparticles has to be analysed to explain nanoscale mechanisms and their effect on properties. 3. New strategies have to be developed for maintaining the stability of nanofluids. 4. The nanofluids have to analyse on serious points like toxicity, health hazards while using in bio-tribological engineering and biomedical applications. 5. New cost-effective method to produce nanoparticles has to be developed for commercialization.

II. CONCLUSION

Evaluating various properties and challenges of the alumina nanoparticles can provide a good scope of future development in lubrication. Aluminan nanoparticles have a great influence on the friction and wear properties, which will lead to savings to energy and life of systems. The research has to focus on tribological performance, environmental influence, and cost associated with nano bio-lubricants.

To enhance the knowledge in the field of nanoparticles as additives in the lubrication system, the

combined approaches of experimental and theoretical efforts are needed.

REFERENCE

- [1] M. Akbulut, "Nanoparticle-Based Lubrication Systems," *J. Powder Metall. Min.*, vol. 01, no. 01, pp. 1–3, 2012.
- [2] P. Nagendramma and S. Kaul, "Development of ecofriendly/biodegradable lubricants: An overview," *Renew. Sustain. Energy Rev.*, vol. 16, no. 1, pp. 764–774, 2012.
- [3] S. K. Das, S. U. S. Choi, and H. E. Patel, "Heat transfer in nanofluids - A review," *Heat Transf. Eng.*, vol. 27, no. 10, pp. 3–19, 2006.
- [4] W. Dai, B. Kheireddin, H. Gao, and H. Liang, "Roles of nanoparticles in oil lubrication," *Tribol. Int.*, vol. 102, pp. 88–98, 2016.
- [5] S. Said, S. Mikhail, and M. Riad, "Recent processes for the production of alumina nano-particles," *Mater. Sci. Energy Technol.*, vol. 3, pp. 344–363, 2020.
- [6] S. N. S. Mohamad, N. Mahmed, D. S. Che Halin, K. Abdul Razak, M. N. Norizan, and I. S. Mohamad, "Synthesis of alumina nanoparticles by sol-gel method and their applications in the removal of copper ions (Cu²⁺) from the solution," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 701, no. 1, 2019.
- [7] T. P. M. Chu *et al.*, "Synthesis, characterization, and modification of alumina nanoparticles for cationic dye removal," *Materials (Basel)*, vol. 12, no. 3, pp. 1–15, 2019.
- [8] A. Rajaeiyan and M. M. Bagheri-Mohagheghi, "Comparison of sol-gel and co-precipitation methods on the structural properties and phase transformation of γ and α -Al₂O₃ nanoparticles," *Adv. Manuf.*, vol. 1, no. 2, pp. 176–182, 2013.
- [9] N. K. Bhoi, H. Singh, and S. Pratap, "Synthesis and Characterization of Alumina Nanoparticles: A Case Study," *J. Inst. Eng. Ser. C*, vol. 101, no. 2, pp. 407–413, 2020.
- [10] V. Piriya Wong, V. Thongpool, P. Asanithi, and P. Limsuwan, "Preparation and characterization of alumina nanoparticles in deionized water using laser ablation technique," *J. Nanomater.*, vol. 2012, 2012.
- [11] S. Ali, Y. Abbas, Z. Zuhra, and I. S. Butler, "Synthesis of γ -alumina (Al₂O₃) nanoparticles and their potential for use as an adsorbent in the removal of methylene blue dye from industrial wastewater," *Nanoscale Adv.*, vol. 1, no. 1, pp. 213–218, 2019.
- [12] M. Mahinroosta and A. Allahverdi, "Production of nanostructured γ -alumina from aluminum foundry tailing for catalytic applications," *Int. Nano Lett.*, vol. 8, no. 4, pp. 255–261, 2018.
- [13] M. Hasanpoor, H. Fakhr Nabavi, and M. Aliofkhaeaei, "Microwave-assisted synthesis of alumina nanoparticles using some plants extracts," *J. Nanostructures*, vol. 7, no. 1, pp. 40–46, 2017.
- [14] S. Bhattacharyya and P. S. Behera, "Synthesis and characterization of nano-sized α -alumina powder from kaolin by acid leaching process," *Appl. Clay Sci.*, vol. 146, no. April, pp. 286–290, 2017.
- [15] A. Khazaei, S. Nazari, G. Karimi, E. Ghaderi, K. Mansouri Moradian, and Z. Bagherpor, "Synthesis and Characterization of γ -Alumina Porous Nanoparticles from Sodium Aluminate Liquor with Two Different Surfactants," *Int. J. Nanosci. Nanotechnol.*, vol. 12, no. 4, pp. 207–214, 2016.
- [16] X. Su, S. Chen, and Z. Zhou, "Synthesis and characterization of Alumina (Al₂O₃) nanoparticles prepared by simple sol-gel method," *Appl. Surf. Sci.*, vol. 258, no. 15, pp. 5712–5715, 2016.
- [17] L. Fu, D. L. Johnson, J. G. Zheng, and V. P. Dravid, "Microwave Plasma Synthesis of Nanostructured," *Society*, vol. 37, pp. 1635–1637, 2003.
- [18] R. Saravanakumar, K. Ramachandran, L. G. Laly, P. V. Ananthapadmanabhan, and S. Yugeswaran, "Plasma assisted synthesis of γ -alumina from waste aluminium dross," *Waste Manag.*, vol. 77, pp. 565–575, 2018.
- [19] S. Ghahme, P. Koinkar, and Y. Bhalerao, "Effect of aluminium oxide (Al₂O₃) nanoparticles addition into lubricating oil on tribological performance," *Tribol. Ind.*, vol. 42, no. 3, pp. 494–502, 2020.
- [20] B. A. Kheireddin, "Tribological Properties of Nanoparticle-Based Lubrication Systems," no. August, 2013.
- [21] M. K. A. Ali, H. Xianjun, L. Mai, C. Bicheng, R. F. Turkson, and C. Qingping, "Reducing frictional power losses and improving the scuffing resistance in automotive engines using hybrid nanomaterials as nano-lubricant additives," *Wear*, vol. 364–365, pp. 270–281, 2016.
- [22] M. Hemmat Esfe, A. A. Abbasian Arani, and S. Esfandeh, "Improving engine oil lubrication in light-duty vehicles by using of dispersing MWCNT and ZnO nanoparticles in 5W50 as viscosity index improvers (VII)," *Appl. Therm. Eng.*, vol. 143, no. April, pp. 493–506, 2018.
- [23] M. I. H. C. Abdullah, M. F. Bin Abdollah, H. Amiruddin, N. Tamaldin, and N. R. M. Nuri, "Optimization of tribological performance of hBN/Al₂O₃ nanoparticles as engine oil additives," *Procedia Eng.*, vol. 68, pp. 313–319, 2013.
- [24] M. K. A. Ali, H. Xianjun, L. Mai, C. Qingping, R. F. Turkson, and C. Bicheng, "Improving the tribological characteristics of piston ring assembly in automotive engines using Al₂O₃ and TiO₂ nanomaterials as nano-lubricant additives," *Tribol. Int.*, vol. 103, pp. 540–554, 2016.
- [25] S. Khalilpourazary and S. S. Meshkat, "Investigation of the effects of alumina nanoparticles on spur gear surface roughness and hob tool wear in hobbing process," *Int. J. Adv. Manuf. Technol.*, vol. 71, no. 9–12, pp. 1599–1610, 2014.
- [26] T. Luo, X. Wei, X. Huang, L. Huang, and F. Yang, "Tribological properties of Al₂O₃ nanoparticles as lubricating oil additives," *Ceram. Int.*, vol. 40, no. 5, pp. 7143–7149, 2014.
- [27] M. A. Kedzierski, "Viscosity and density of aluminum oxide nanolubricant," *Int. J. Refrig.*, vol. 36, no. 4, pp. 1333–1340, 2013.
- [28] M. A. Kedzierski, "Effect of concentration on R134a/Al₂O₃ nanolubricant mixture boiling on a reentrant cavity surface," *Int. J. Refrig.*, vol. 49, pp. 36–48, 2015.
- [29] Y. Singh, A. Sharma, N. Singh, and A. Singla, "Effect of alumina nanoparticles as additive on the friction and wear behavior of polanga-based lubricant," *SN Appl. Sci.*, vol. 1, no. 3, 2019.
- [30] K. Suthar, Y. Singh, A. R. Surana, V. H. Rajubhai, and A. Sharma, "Experimental evaluation of the friction and wear of jojoba oil with aluminium oxide (Al₂O₃) nanoparticles as an additive," *Mater. Today Proc.*, vol. 25, no. xxxx, pp. 699–703, 2019.
- [31] L. Peña-Parás, J. Taha-Tijerina, L. Garza, D. Maldonado-Cortés, R. Michalczewski, and C. Lapray, "Effect of CuO and Al₂O₃ nanoparticle additives on the tribological behavior of fully formulated oils," *Wear*, vol. 332–333, pp. 1256–1261, 2015.
- [32] S. Fitriana, B. Kristiawan, E. Surojo, A. T. Wijayanta, T. Miyazaki, and S. Koyama, "Influence of minimum quantity lubrication with Al₂O₃ nanoparticles on cutting parameters in drilling process," *AIP Conf. Proc.*, vol. 1931, no. February, 2018.
- [33] N. Rajendhran, S. Palanisamy, P. Periyasamy, and R. Venkatachalam, "Enhancing of the tribological characteristics of the lubricant oils using Ni-promoted MoS₂ nanosheets as nano-additives," *Tribol. Int.*, vol. 118, pp. 314–328, 2018.
- [34] T. Luo, X. Wei, H. Zhao, G. Cai, and X. Zheng, "Tribology properties of Al₂O₃/TiO₂ nanocomposites as lubricant additives," *Ceram. Int.*, vol. 40, no. 7 PART A, pp. 10103–10109, 2014.
- [35] D. Jiao, S. Zheng, Y. Wang, R. Guan, and B. Cao, "The tribology properties of alumina/silica composite nanoparticles as lubricant additives," *Appl. Surf. Sci.*, vol. 257, no. 13, pp. 5720–5725, 2011.
- [36] A. Nanolubricants and H. Liu, "Effect of Mixing Temperature, Ultrasonication Duration and Nanoparticles / Surfactant Concentration on the Dispersion Performance of."
- [37] M. Z. M. Noor, N. A. Sollahundin, and S. Irawan, "Surface Modification of Aluminium Oxide (Al₂O₃) Nanoparticles (NPs) on Detection of Crude Oil Production," *Proceedings*, vol. 2, no. 20, p. 1273, 2018.

Early Detection of Alzheimer's Disease through Cognitive Skill Based Gaming

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Abstract— At present, one of the rising problems in India is the Alzheimer's disease which is a progressive neurodegenerative disease, causing brain cells to waste away and destroying memory and other important cognitive operations. Its symptoms, such as memory loss and confusion, develop slowly but gradually get worse over time, becoming severe enough to interfere with everyday tasks. Presently, Alzheimer's has no acceptable cure and at best medications to treat the symptoms can be found. Thus, detecting Alzheimer's disease at an early stage can prove vital to its treatment. This paper approaches the same by proposing a fun and easy to play smartphone Android game application that tackles the cognitive symptoms seen during the early stages of Alzheimer's using a set of seven games. Most of the games are modeled on the classical pen-and-paper MoCA test, a screening assessment for detecting cognitive impairment. The scores of the games played are used to detect the presence of early Alzheimer's through the proposed Deep Neural Network model, trained and validated using crowd sourced data. The deep learning model gives a high accuracy of 98.94 percent and a good precision-recall trade-off with 0.1 recall and 0.97 precision.

Keywords— Alzheimer's disease, MoCA test, Cognitive skills, Deep learning

I. INTRODUCTION

Brain disorders are prevalent worldwide and millions of new cases are recorded every year. The Alzheimer's disease is one such frequent type of brain disorder which rapidly destroys the brain cells, causing mental decline, delusion and behavioural changes.

A study conducted revealed that close to 44 million people suffer from Alzheimer's disease, which easily accounts for more than half of global dementia cases. Solely in India, the cases of Alzheimer's were estimated to be more than 4 million in 2018, making the country third highest in terms of caseloads in the world [1]. To make things worse, close to the end of 2030, these figures are expected to cross 7.6 million [2].

However, despite the numbers, the general awareness regarding Alzheimer's disease remains dreadfully low throughout the world and even more so in the country. Consequently, Alzheimer's becomes quite difficult to recognize from the beginning. Since it is normally found in elderly patients, the early symptoms are mistakenly thought to be a consequence of aging instead of owing to a progressive disease.

Presently, Alzheimer's has no cure, but treatments can temporarily help improve its symptoms to an extent. Customarily, methods such as detailed clinical assessments, neuroimaging, and recently even blood tests are being used for the diagnosis of Alzheimer's disease [3]–[5]. Under clinical assessments there are many cognitive screening tests available to detect early signs of cognitive impairments such as the Montreal Cognitive Assessment (MoCA), the Mini-Mental State Exam (MMSE), the Self-Administered Gerocognitive Exam (SAGE), among others.

The MoCA is found to have good overall discriminant validity for mild cognitive impairment [6], and, in addition, it has been shown to have a high test-retest reliability (consistency of results) of 0.92 [7]. The MMSE has exhibited both good test-retest reliability in the range 0.80–0.95 and acceptable sensitivity and specificity [8]. The SAGE is another reliable instrument with a test-retest reliability (Spearman rank correlation) of 0.84 [9] and overall good validity.

It has been researched that the risks of dementia are not entirely irrevocable; some of them are potentially modifiable, for example, through improved diet, exercise, and avoiding smoking. By that very fact, it is clear that there is a need for early (prodromal) detection of Alzheimer's disease. Through early detection the healthcare providers get a good chance to monitor patients more closely and supervise their conditions over time. This also allows the patients, their caretakers, and the healthcare team to work on risk reduction strategies.

Keeping exactly this in mind, the paper proposes a solution for this situation. A smartphone application is proposed on cognitive skill based gaming aspects that target the early symptoms of Alzheimer's. Based on the scores of the games the application will detect the prodromal stage of Alzheimer's disease. The aim of the application is to attain high sensitivity (recall) in detecting the early signs so as to encourage users to seek professional help and get treatments as soon as possible. This makes the application suitable for real-time use.

The rest of the paper is structured as follows. Section II provides a review of related works and their analysis. Section III elaborates the details of the proposed work. Section IV presents the results accomplished along with the model evaluation metrics and its analysis. Finally, in Section V the work is concluded, giving scope for further work.

II. RELATED WORK

Several research papers were studied on the existing game applications for Alzheimer’s and the various machine learning and deep learning models used for the detection of Alzheimer’s, be it using imaging, speech, language, or other features.

A. Existing Applications

Total seven mobile applications were studied that target various symptoms of Alzheimer’s. The Table I summarizes the features, abilities tested, and pros & cons of these seven applications. All the tools mentioned are prognostic in nature (they help improve the symptoms and/or are only a means to predict the problem instead of identifying it), except the Alzheimer’s Disease Pocket card, which is a diagnostic application.

TABLE I. OUTLINE OF EXISTING APPLICATIONS

Existing App	Features	Abilities Tested	Pros & Cons
MoCA App [10]	Standardised app version for administration of MoCA	Processing speed, Memory	Tracks the results and data can be uploaded but needs supervision
Smart-kuber [11]	Total 5 mini games of 5-10 minutes	Attention, Memory	High concurrency with MoCA
Colour – Shape Test [12]	Shape and colour matching for over 2 minutes	Attention, Episodic memory, Speed	Co-relates with established measures of speed but relatively small screen
Sea Hero Quest [13]	Mental process of 3D-navigation tested	Spatial navigation	Fun & exiting and includes VR edition
Whack-a mole [14]	Time based Go, No-Go discrimination task	Stimuli inhibition	Interactive but impact of form factor should be examined
Alzheimer’s Disease Pocket card [15]	Information and assessment tools provided	Language, Thinking ability, Memory	Tools like clock drawing integrated but can be dull & monotonous
Episodix [16]	Gamification of CVLT	Episodic memory	Game resolution needs to be improved

B. Existing Models

A number of machine learning models were used by different researchers for Alzheimer’s detection. These papers are outlined briefly below.

Park et al. [18] use electronic healthcare data as the input features for training different models such as Random Forest, SVM, and Logistic Regression. RF was found best with an accuracy of 82.3% and AUC of 89.8%. Valladares Rodríguez et al. [23] employed classical pen-and-paper tests and found Random Forest to be best with an average F1 score of 0.99. Tanveer et al. [19] used medical imaging and blood spectroscopy for training different models such as SVM, Artificial Neural Network (ANN), and other deep learning methods. Petti et al. [20] used speech and language for training Neural Nets, SVMs, and Decision Trees. The classifiers performed well with average accuracies of 89% and 82% in AD and MCI detection respectively.

Castellazzi et al. used Resting-state fMRI and DTI to train ANN, SVM, and Adaptive Neuro-Fuzzy Inference System. The ANFIS was the best with an accuracy of 84%. Jo et al.

[21] used multimodal neuroimaging data and found that the Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) were the most efficient with an accuracy of 96.0%.

Albright et al. [22] used Alzheimer’s Disease Neuroimaging Initiative (ADNI) data and trained SVM, Logistic Regression, Random Forests, Multi-Layer Perceptron (MLP), and RNN. MLP was found the most efficient with a mAUC score of 96.31%. Basaia et al. [24] considered the single cross-sectional brain structural MRI scans for training CNNs and achieved highest rate of 99%.

C. Analysis of Existing Systems

It is observed that the existing applications target mostly the elderly population; the age group targeted needs to be broadened. Furthermore, the concurrency of the games with professional employed tests is not made very clear and most of the applications do not perform detection of Alzheimer’s.

Coming to machine learning models, more than half of the systems use images as the input features for training. MRI scans and advanced equipment are indeed a good approach but most people don’t get such checkups that often. A few other authors have considered health-care datasets with some using scores of classical pen-and-paper tests for detection, but mostly there isn’t much of a gaming aspect to it.

III. PROPOSED WORK

The architecture of the proposed system can be seen in Fig.1. The use of a smartphone Android game application has been proposed to detect the early symptoms of Alzheimer’s. On the basis of how the user performs in the cognitive skill based games, the results are generated and stored which are then used to determine the underlying cognitive impairment.

The proposed model is a Deep Neural Network used as a binary classifier. The model is trained and tested on crowd sourced data and it outputs the classification as either NC (Normal Controls) or MCI (Mild Cognitive Impairment).

A. Proposed Cognitive Skill Games

The Android game application contains a total of seven games based on certain parameters which are Memory, Concentration, Naming and Attention. Most of the games were

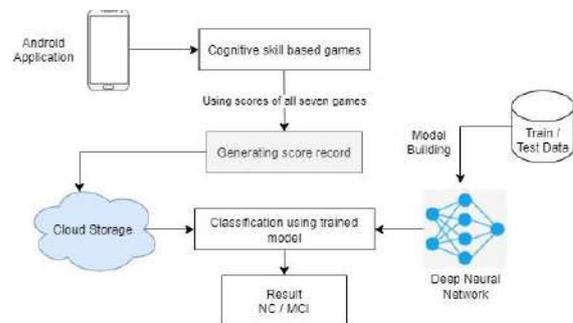


Fig. 1. Proposed Architecture

inspired from the traditional Montreal Cognitive Assessment (MoCA) test used for Alzheimer’s detection by health professionals.

The MoCA is a pen-and-paper test that tells whether a person shows signs of dementia and it is shown to be 94 percent accurate. [5] The Table II shows the games, their task formats and the scoring.

TABLE II. PROPOSED COGNITIVE SKILL BASED GAMES

Game	Abilities Tested	Task Format	Scoring
Pattern Matching	Memory, Problem Solving	Find and match identical images	Correct and incorrect matches.
Color Mixing	Concentration Patience	Mix shades of colors to create given color.	Total time taken
Catch the Sequence	Episodic Memory, Attention, Response Time	Detect 3-digit sequence from pseudo-random digits.	Correct and wrong sequences detected.
Animal Crossing	Naming, Recognition	Match animal images to their correct names	Correct identifications.
Perfect Letter	Attention, Response Time	Tap the perfect letter when it appears on screen.	Correct and wrong taps made.
Call to Mind	Memory, Attention	Recall words in a certain color.	Correctly recalled words
Serial Seven	Attention, Problem Solving	Subtract 7 from 100, a total of 5 times	Correct subtractions.

The MoCA scoring scheme was replicated for modelling the scoring of the proposed games. In this way, the games designed would have high concurrency with the traditional verified methods of detection.

The screenshots shown in Fig. 2 are of one of the games implemented in the application, that is Perfect Letter. As seen in Fig. 2a, a list of letters are shown on the screen at a rate of one per second and the player needs to tap on the perfect letter seen on-screen. The scores are then shown as seen in 2b. Right Score represents correct taps and Wrong Score represents each wrong tap.

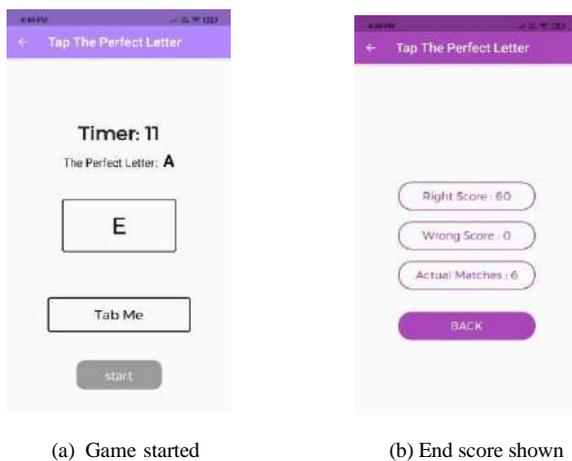


Fig. 2. Perfect Letter Game

The proposed Android application has been published on Google Playstore under the name of 'Alzho' [25], available for users to download and use. Fig. 3. Shows the Alzho App with its Login (Fig. 3a) and Navigation (Fig. 3b) screens.

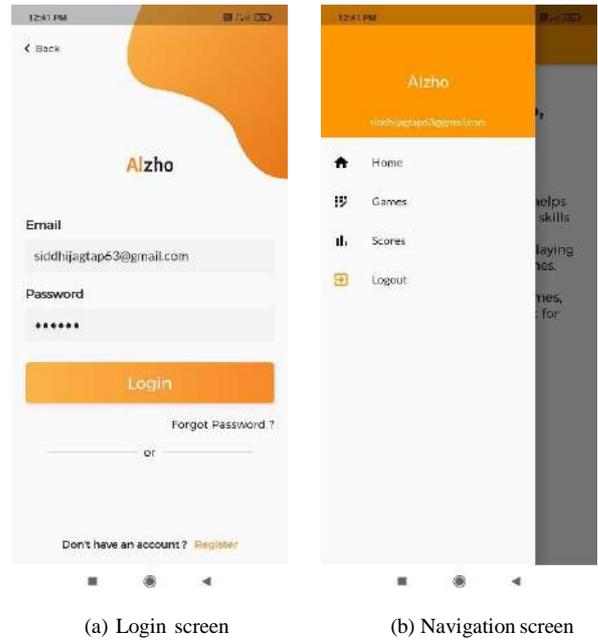


Fig. 3. Alzho App

B. Data Collection

The dataset used for training and validating the proposed model was collected through crowd sourcing. The dataset contains eight fields with seven fields for the individual game scores and one field for the label as 0, for NC, or 1, for MCI.

The data collected was pre-processed and all missing values were filled in. The bar chart plotted in Fig. 4 shows the average of normalized scores of each game with respect to both NC and MCI.

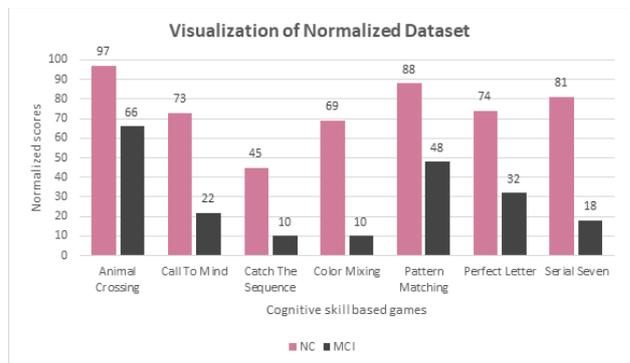


Fig. 4. Normalized Dataset

The dataset was highly imbalanced as the records of the mild cognitive impairment class were extremely low. To overcome the class imbalance problem, the minority class was oversampled to make it equal to the majority class. The final dataset used, hence, contained equal weightage of each class.

C. Deep Neural Network Model

The concept of deep learning is used for the proposed model. The Deep Neural Network classifier was selected for the system as Neural Networks show good performance for disease detection tasks and are able to map non-linear relationships between features. Furthermore, Keras models are easily integrated with mobile applications by using the Tensorflow Lite which is a lightweight solution to run TensorFlow models. The proposed Deep Neural Network model is a

Sequential model of three Dense layers; two hidden layers using the ReLU activation function, and one output layer with the sigmoid activation function. The input dimension is of seven nodes, one for each of the games.

The architecture of the proposed Deep Neural Network is illustrated in the Fig. 5

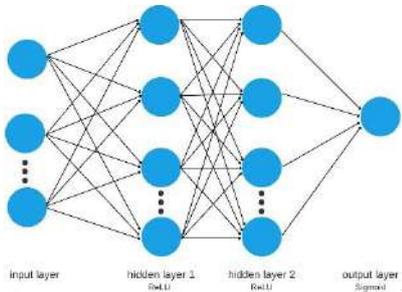


Fig. 5. Deep Neural Network

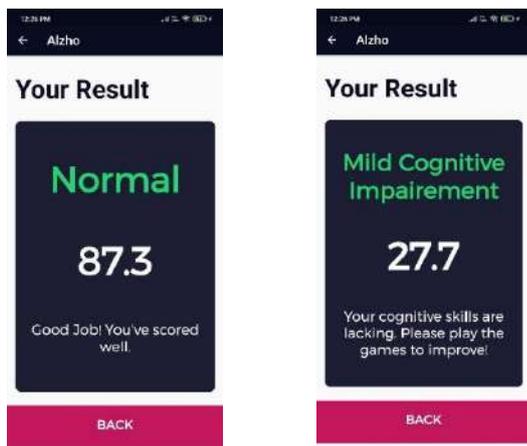
ReLU activation is used for hidden layers as it is simple to implement and less susceptible to vanishing gradients. The sigmoid activation function is chosen for the output layer as it produces output values in the range of 0 to 1, which is required for the binary classification problem. Hence the output layer will give the result as either 0 (NC) or 1 (MCI).

IV. RESULTS AND DISCUSSIONS

The results were achieved and have been discussed as follows along with the different evaluation metrics for validation of the model.

A. Results

After playing all games the user will be able to see their detection result where it shows either NC (Fig. 6a) or MCI (Fig. 6b) result based on their scores. The final score shown to the user is the percentage total of all their current scores. The result of Normal or MCI, on the other hand, is determined by the output that the model predicts and not on the score shown.



(a) NC result (b) MCI result
Fig. 6. Detection result shown in application

A number of test cases were implemented for the deep neural network model by varying the hyperparameters such as the total number of layers, the epochs, and the batch size. The different evaluation metrics were noted such as the accuracy and the F1 score. The Table III shows the five leading test cases found.

The **fifth test case** with 3 dense layers, epoch of 150, and batch size of 10, gave the best results and hence is the proposed model.

B. Analysis

The various evaluation metrics considered for the deep learning model are discussed along with the analysis for importance of each input feature.

TABLE III. MODEL TEST CASES

Test Cases	Dense Layers	Epoch3	Batch Size	Accuracy	F1 Score
1	2	700	12	0.9787	0.9791
2	3	500	15	0.9574	0.9592
3	5	400	5	0.9592	0.9751
4	4	350	9	0.9787	0.9791
5	3	150	10	0.9894	0.9895

1) Evaluation Metrics

The Deep Neural Network model showed satisfactory evaluation metrics with a high accuracy of 98.94 percent. The precision-recall trade-off too came out to be good with a precision of 97.92 percent and a recall of 100 percent. The F1-score, which is the harmonic mean of precision and recall, takes both metrics into account at once. The model has a F1-score of 98.95 percent.

It is important to be able to predict all the actual mild cognitive cases due to them being in the minority. Thus, the perfect recall of 0.1 makes the model highly sensitive.

2) Confusion Matrix

The confusion matrix for the binary classification problem is a 2x2 matrix which compares the actual target values with the predicted values by the machine learning model. The confusion matrix can be visualized in Fig. 7.

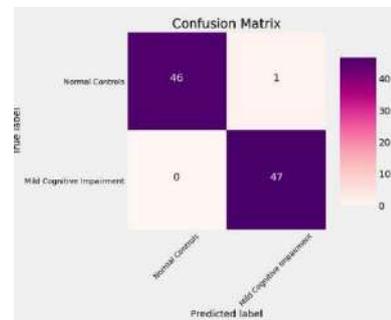


Fig. 7. Confusion Matrix

It can be seen that out of the true MCI cases, all of them have been successfully predicted as MCI. On the other hand, out of all the true NC cases, except one, all were predicted as NC by the model.

3) AUC - ROC Curve

AUC - ROC curve acts as a performance measurement for classification problems. ROC (Receiver Operating Characteristic Curve) is a probability curve and AUC (Area Under Curve) represents the degree or measure of separability. Higher AUC tells how much the model is able to distinguish between classes.

The curve has been plotted in Fig. 8. The model gives an **AUC of 0.9846** for the testing data. This indicates that there is a 98.46% chance that the model will be able to distinguish between classes.

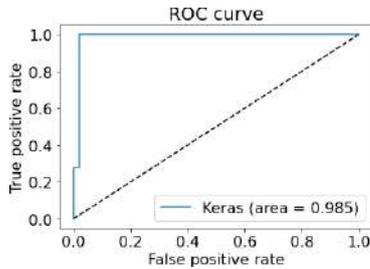


Fig. 8. AUC - ROC Curve

4) Feature Importance

The seven input features, which are nothing but the scores of each game, were evaluated for their importance in the classification task. The pie chart plotted in Fig. 9 shows the significance of the features relative to each other.

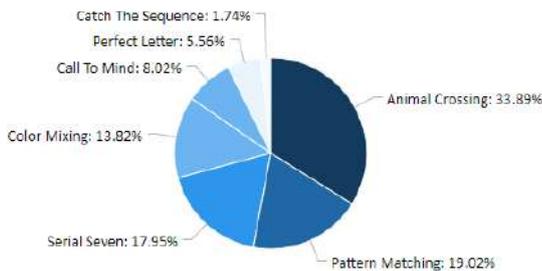


Fig. 9. Feature Importance Chart

REFERENCES

- [1] A. Sengupta, Memory's Last Breath: Living With Alzheimer's In India, News18, Jul. 2018. Accessed on: Jul. 14, 2021. [Online].
- [2] D. Brahma, The persistence of memory: The burden of Alzheimer's disease in India, Brookings, Sep. 2019. Accessed on: Jul. 13, 2021. [Online].
- [3] P. J. Whitehouse, "Evaluation of Early Detection Methods for Alzheimer's Disease", *Dialogues in clinical neuroscience*, vol. 12, pp. 101-108, 2019.
- [4] S. J. Kiddle, N. Voyle and R. J. Dobson, "A Blood Test for Alzheimer's Disease: Progress, Challenges, and Recommendations", *Journal of Alzheimer's Disease*, vol 64 s1, pp. S289-S297, 2018.
- [5] J. M. Kang, Y.-S. Cho, S. Park, B. H. Lee, B. K. Sohn, C. H. Choi,
- [6] J.-S. Choi, H. Y. Jeong, S.-J. Cho, J.-H. Lee and J.-Y. Lee, "Montreal cognitive assessment reflects cognitive reserve", *BMC Geriatr*, vol. 18, pp. 261, 2018.
- [7] S. Hoops, S. Nazem, A. D. Siderowf, J. E. Duda, S. X. Xie, M. B. Stern,
- [8] Weintraub, "Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease", *Neurology*, vol. 73(21), pp. 1738-1745, 2009.
- [9] T. Tong, M. Chignell, M. C. Tierney, J. S. Lee, "Test-Retest Reliability of a Serious Game for Delirium Screening in the Emergency Department", *Frontiers in Aging Neuroscience*, vol.

It can be seen that the most important input was of the game 'Animal Crossing', followed by 'Pattern Matching' and 'Serial Seven'. This could possibly mean that the parameters Naming and Recognition are quite significant in the early detection of Alzheimer's (Table II). The other important parameters seen are hence Memory, Attention, and Problem Solving.

In closing, the proposed app 'Alzho' stands out as a prognostic app meant to reliably detect the onset of Alzheimer's and encourage users to seek proper diagnosis if mild cognitive impairment is indeed detected. The incorporated games are interesting enough for all age groups and can be played as a regular memory exercise to improve one's cognitive skills as well.

V. CONCLUSION AND FUTURE WORK

Alzheimer's disease is a progressive disorder that causes problems with memory, thinking, and behaviour. Currently Alzheimer's has no proper cure though treatments are available for its symptoms. Hence, to detect the presence of the disease at an early stage, a smartphone Android game application is proposed.

A mobile application is built with a total of seven games that tackle the cognitive impairment abilities that prove vital in the early detection of Alzheimer's. Their scoring has been based on the traditional cognitive screening test, Montreal Cognitive Assessment (MoCA).

The Deep Neural Network model was proposed for the binary classification task. The model achieved a high accuracy of 98.94 percent and a F1 score of 98.95 percent.

In the future, more games can be added and higher difficulty levels can be set for the games, to detect whether the users show any early symptoms of Alzheimer's even more accurately. The application can also be deployed on iOS and other platforms. Further work can be carried out to compare the ability of the proposed app, to detect mild cognitive impairment early on, with that of the MoCA App.

- [8], pp. 258, 2016.
- [10] M. J. Baek, K. Kim, Y. H. Park, S. Kim, "The Validity and Reliability of the Mini-Mental State Examination-2 for Detecting Mild Cognitive Impairment and Alzheimer's Disease in a Korean Population", *PloS one*, vol. 11(9), pp. e0163792, 2016.
- [11] D. W. Scharre, S.-I. Chang, R. A. Murden, J. Lamb, D. Q. Beversdorf, M. Katakai, H. N. Nagaraja, R. A. Bornstein, "Self-administered Gerocognitive Examination (SAGE)", *Alzheimer Disease & Associated Disorders*, vol. 24, pp. 64-71, 2010.
- [12] "MoCA, Cognitive Assessment". Accessed on: Sep. 18, 2021. [Online].
- [13] Available: <https://www.mocatest.org/app/>
- [14] C. Boletsis and S. McCallum, "Smartkuber: A Serious Game for Cognitive Health Screening of Elderly Players", *Games for Health Journal*, vol. 5(4), pp. 241-251, 2016.
- [15] R. M. Brouillette, H. Foil, S. Fontenot, A. Corroero, R. Allen, C. K. Martin, A. J. Bruce-Keller and J. N. Keller, "Feasibility, Reliability, and Validity of a Smartphone Based Application for the Assessment of Cognitive Function in the Elderly", *PLoS One*, vol. 8(6), pp. e65925, 2013.
- [16] "SEA HERO QUEST" May 03, 2016. Accessed on: Sep. 18, 2021.
- [17] [Online]. Available: <https://glitchers.com/project/sea-hero-quest/>
- [18] T. Tong and M. Chignell, "Developing a serious game for cognitive assessment: choosing settings and measuring performance", *Proceedings of the Second International Symposium of Chinese CHI*, pp. 70-79, 2014.

- [19] N. Polzer, H. Gewald, "Can Cognitive Assessments be Fun? A Review of Playful Mobile Applications to Assess Cognitive Health", *PSAKU International Journal of Interdisciplinary Research*, vol. 8(1), 2019.
- [20] S. Valladares-Rodríguez, M. J. Fernández-Iglesias, L. Anido-Rifón, D. Facal and R. Pérez-Rodríguez, "Episodix: a serious game to detect cognitive impairment in senior adults. A psychometric study", *PeerJ*, vol. 6, pp. e5478, 2018.
- [21] G. Castellazzi, M. G. Cuzzoni, M. C. Ramusino, D. Martinelli, F. Denaro, A. Riccia-rdi, P. Vitali, N. Anzalone, S. Bernini, F. Palesi,
- [22] Sinforiani, A. Costa, G. Micieli, E. D'Angelo, G. Magenes and C. M. G. Wheeler-Kingshott, "A Machine Learning Approach for the Differential Diagnosis of Alzheimer and Vascular Dementia Fed by MRI Selected Features", *Frontiers in Neuroinformatics*, vol. 14, pp. 25, 2020.
- [23] J. H. Park, H. E. Cho, J. H. Kim, M. M. Wall, Y. Stern, H. Lim, S.
- [24] Yoo, H. S. Kim and J. Cha, "Machine learning prediction of incidence of Alzheimer's disease using large-scale administrative health data", *npj Digital Medicine*, vol. 3, pp. 46, 2020.
- [25] M. Tanveer, B. Richhariya, R. U. Khan, A. H. Rashid, P. Khanna, M. Prasad and C. T. Lin, "Machine Learning Techniques for the Diagnosis of Alzheimer's Disease: A Review", *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 16 1s, pp. 35, 2020.
- [26] U. Petti, S. Baker and A. Korhone, "A systematic literature review of automatic Alzheimer's disease detection from speech and language", *Journal of the American Medical Informatics Association*, vol. 27, pp. 1784-1797, 2020.
- [27] T. Jo, K. Nho and A. J. Saykin, "Deep Learning in Alzheimer's Disease: Diagnostic Classification and Prognostic Prediction Using Neuroimaging Data", *Frontiers in Aging Neuroscience*, vol. 11, pp. 220, 2019.
- [28] J. Albright, "Forecasting the progression of Alzheimer's disease using neural networks and a novel preprocessing algorithm", *Alzheimer's & Dementia: Translational Research & Clinical Interventions*, vol. 5, pp. 483-491, 2019.
- [29] S. Valladares-Rodríguez, L. Anido-Rifón, M. J. Fernández-Iglesias, J. Manuel and D. Facal-Mayo, "A Machine Learning Approach to the Early Diagnosis of Alzheimer's Disease Based on an Ensemble of Classifiers", *Springer, Cham*, vol. 11619, pp. 383-396, 2019.
- [30] S. Basaia, F. Agosta, L. Wagner, E. Canu, G. Magnani, R. Santangelo and M. Filippi, "Automated classification of Alzheimer's disease and mild cognitive impairment using a single MRI and deep neural networks", *NeuroImage: Clinical*, vol. 21, pp. 101645, 2019.
- [31] "Alzho App" May 13, 2021. Accessed on: Aug 12, 2021. [Online]. Available:<https://play.google.com/store/apps/details?id=co.te.am.alzho>



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