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SANKALCHAND PATEL UNIVERSITY

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FOR A BETTER TOMORROW

Special Edition

(ICMAETM-24)

SANKALCHAND PATEL UNIVERSITY
JOURNAL OF SCIENCE, TECHNOLOGY AND MANAGEMENT RESEARCH
(SPU-JSTMR)

RESEARCH JOURNAL

International Conference on Multidisciplinary Approach in Engineering, Technology and Management (ICMAETM-24)

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ICMAETM-24

(Special Edition)

Chief Editor(s)

Prof. (Dr.) Prafulkumar Udani

Prof. (Dr.) Hetalkumar Shah

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Sankalchand Patel Vidyadham Ambaji-Gandhinagar,
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SANKALCHAND PATEL UNIVERSITY
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International Conference on Multidisciplinary Approach in Engineering, Technology and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047 (ICMAETM-24)

24th & 25th May, 2024

International Conference on

Multidisciplinary Approach in Engineering, Technology and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047

24th & 25th May, 2024

Chief Patron

Shri Prakashbhai Patel

President , Sankalchand Patel University, India

Patron

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Provost, Sankalchand Patel University, India

Convener

Prof.(Dr.) Hetalkumar N. Shah
Director (Technical),
Sankalchand Patel University, Visnagar

Conference Secreatry
Prof. (Dr.) Manish M Patel
Professor, Sankalchand Patel College of Engineering, Visnagar

Conference Coordinator

Dr. Bibhabasu Mohanty
Assistant Professor, Sankalchand Patel College of Engineering, Visnagar

About University

Nootan Sarva Vidyalaya Kelavani Mandal (NSVKM) was established in 1952, by Shri. Sankalchand Patel, a freedom fighter and a social entrepreneur. The aim was always to create a value based diversified education system for the students of North Gujarat. The university was established on 9th May 2016 vide Gujarat Private Universities (Amendment) Act, 2016 and is spread across 84 acres of land. Today, the university is home to various institutes offering Medical, Paramedical, Technical, & Science Courses. The university also houses some of the most stateof-the-art infrastructure in North Gujarat.

Today, the trust successfully administers educational institutions right from primary schools to graduate and post graduate colleges and other professional courses including Ph.D. programs. The trust's unswerving efforts towards the growth of education have earned its institutes many merits and a resilient name in the educational campaign of India.

Our Trust has the experience of the education field of 65 years at its disposal and it is fully equipped with all infrastructure and computer facilities. Almost 66 acres of land has been acquired to construct various buildings for various institutions. Sankalchand Patel University is committed to provide high quality education through Quality Teaching, Research, Consultancy and Community outreach services. The University is committed to continuous improvement in the academic and administrative processes by fostering Cooperation, Innovation, Professionalism, and Integrity. The vidhyadham is situated near Gandhinagar-Ambaji link road in VISNAGAR and surrounded by natural surroundings in the lap of nature.

About Institute

Sankalchand Patel College of Engineering established in 1999 by Nootan Sarva Vidhyalay Kelvani Mandal – VISNAGAR with an aim of producing world-class professionals in the specialized fields of Engineering, Management, and MCA. The Institute is constituted by Sankalchand Patel University, Visnagar and approved by All India Council for Technical Education (AICTE), New Delhi.

Sankalchand Patel College of Engineering was established with an objective of producing world-class professionals in the field of Engineering and its branches. Institute offer various courses in B.Tech, Bsc.IT, and M.Tech Programs.

Great emphasis is laid upon the holistic development of the students, thus helping them build up academic excellence which in turn helps with the right career opportunities. The aim is to not only create dynamic and enthusiastic professionals, but also good citizens who will aid in the overall progress and development of this country. An institute is committed to provide excellence in various ways, such as ensuring high-quality education, research, and infrastructure, or through commitment to student support and a positive learning environment.

President's Message

Shri Prakashbhai S. Patel

Sankalchand Patel University (SPU) is one of the leading universities in the North Gujarat Region which offers various courses from Science and humanities to technical and Medical streams at one campus. The SPU strives to achieve our mission, "We serve society to develop and prosper by building human capital".

I feel very proud that Sankalchand Patel College of Engineering is going to organize an International Conference on **Multidisciplinary Approach in Engineering, Technology, and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047** on 24th May to 25th May, 2024. As we prepare to welcome scholars, researchers, and practitioners from various disciplines, I am filled with excitement at the prospect of the rich exchange of ideas and insights that this conference promises.

The theme of this conference, "**A Roadmap for Viksit Bharat @ 2047**," underscores the critical importance of interdisciplinary collaboration in addressing the complex challenges facing our society today. As we strive towards building a sustainable and prosperous future for Bharat, it is imperative that we harness the collective wisdom of multiple disciplines to develop innovative solutions that are socially inclusive, environmentally responsible, and economically viable.

The fields of engineering, technology, and management play a pivotal role in shaping the trajectory of our nation's development. From infrastructure projects to digital innovations, from sustainable energy solutions to effective governance strategies, the contributions of these disciplines are indispensable in realizing our vision for Viksit Bharat by 2047.

I am confident that this conference will serve as a platform for meaningful dialogue, knowledge exchange, and collaboration among researchers, practitioners, policymakers, and industry leaders. Together, we can explore new approaches, identify emerging trends, and chart a course towards a more sustainable and equitable future for Bharat.

As we come together to explore the intersections of engineering, technology, and management for sustainable development, let us embrace the spirit of collaboration, creativity, and empathy. May this conference be a catalyst for transformative ideas, fruitful partnerships, and tangible outcomes that contribute to the betterment of our society and the realization of **Viksit Bharat @ 2047.**

Sincerely,

Prakash Patel
President
Sankalchand Patel University

Provost's Message

Prof. (Dr). Prafulkumar Udani

Dear Colleagues and Participants,

As the Provost of Sankalchand Patel University, it is my privilege to welcome you all to the International Conference **on Multidisciplinary Approach in Engineering, Technology, and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047**. This conference serves as a timely platform for scholars, researchers, practitioners, and policymakers to come together and explore innovative solutions to the complex challenges facing our nation on its journey towards sustainable development.

The theme of this conference, "**A Roadmap for Viksit Bharat @ 2047**," underscores the urgent need for interdisciplinary collaboration in shaping the future of our nation. As we aspire to build a more inclusive, resilient, and sustainable Bharat by 2047, it is imperative that we leverage the collective expertise of diverse disciplines such as engineering, technology, and management.

Engineering and technology innovations are at the forefront of driving progress and transformation in our society. From renewable energy systems to smart infrastructure, from digital connectivity to sustainable agriculture practices, the potential for technological solutions to address pressing societal challenges is vast. However, the successful implementation of these solutions requires effective management strategies that prioritize sustainability, equity, and social responsibility.

I am confident that this conference will provide a conducive environment for interdisciplinary dialogue, knowledge sharing, and collaboration. By bringing together experts from academia, industry, government, and civil society, we can foster innovative thinking and develop actionable strategies that contribute to the realization of Viksit Bharat @ 2047.

I extend my heartfelt appreciation to the organizers for their dedication and hard work in convening this conference. Their efforts have ensured a diverse and thought-provoking program that promises to inspire and enlighten participants from across disciplines.

As we embark on this collective journey towards Viksit Bharat @ 2047, I wish you all a stimulating and productive conference experience. May our deliberations lead to tangible outcomes that contribute to the sustainable development and prosperity of our nation.

Warm regards,

Prof. (Dr). Prafulkumar Udani
Provost, Sankalchand Patel University

Conference's Secretary Message

Dr. Manish M. Patel

Dear Participants and Guests,

On behalf of the organizing committee, it is my pleasure to extend a warm welcome to all of you to the International Conference on **Multidisciplinary Approach in Engineering, Technology, and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047**. We are thrilled to have you join us for this important and timely event, which aims to explore innovative approaches to sustainable development and contribute to the vision of a prosperous and equitable Bharat by 2047.

we are reminded of the pressing challenges facing our nation and the world at large. From climate change and environmental degradation to social inequality and economic disparities, the need for sustainable solutions has never been more urgent. It is our belief that through multidisciplinary collaboration and innovative thinking, we can address these challenges and pave the way for a brighter future.

The theme of this conference, "**A Roadmap for Viksit Bharat @ 2047**," highlights our commitment to charting a course towards sustainable development that is inclusive, equitable, and environmentally responsible. Over the next few days, we have an exciting lineup of keynote speeches, panel discussions, paper presentations, and workshops that will explore the intersections of engineering, technology, and management in addressing key sustainability issues.

I would like to express my sincere gratitude to all the participants, presenters, sponsors, and volunteers who have contributed to the success of this conference. Your dedication and enthusiasm are truly commendable, and it is thanks to your collective efforts that we are able to convene this important gathering.

To the participants, I encourage you to actively engage in the discussions, share your research findings, and exchange ideas with your fellow colleagues. Let us seize this opportunity to learn from each other, build new partnerships, and inspire actionable solutions that will contribute to the sustainable development of Bharat.

As we embark on this journey together, I wish you all a productive and enriching conference experience. May our discussions be fruitful, our collaborations be meaningful, and our contributions be impactful in shaping the roadmap for Viksit Bharat @ 2047.

Thank you once again for your participation and support.

Warm regards,

Dr. M. M. Patel
Conference Secretary, SPCE, SPU

BANCHHANIDHI PANI I.A.S.
Commissioner,
Technical Education

Government of Gujarat

Office of the Commissionerate of Technical Education
Block No. 2, 6th Floor,
Karmayogi Bhavan, Sector-10-A,
Gandhinagar-382010

Date 21 MAY 2024

Message

On behalf of Commissionerate of Technical Education, Government of Gujarat, I am writing to extend our heartfelt congratulations to Sankalchand Patel College of Engineering, Visnagar for organizing the "**International Conference on Multidisciplinary Approach in Engineering, Technology and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047 (ICMAETM-24)**" from 24th & 25th MAY 2024 at Sankalchand Patel University, Visnagar.

I extend my best wishes for successful completion of the conference.

With Best wishes,

Banchhanidhi Pani, IAS
Commissioner, Technical Education
Gandhinagar

Dr. Rajul K. Gajjar
Vice Chancellor

GUJARAT TECHNOLOGICAL UNIVERSITY
VGEC Campus, Chandkheda,
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E-mail : vc@gtu.ac.in

Date: 18/05/2024

MESSAGE

I am pleased to learn that Sankalchand Patel University, Visnagar is organising a conference on Multidisciplinary Approach in Engineering, Technology and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047" (ICMAETM-24) scheduled on 24th and 25th May 2024.

I extend my congratulations to all stakeholders of Sankalchand Patel University, and best wishes for the success of this Conference.

With best wishes,

Dr. Rajul K. Gajjar

About Conference (ICMAETM-24)

The International Conference on Multidisciplinary Approach in Engineering, Technology and Management for Sustainable Development: A Roadmap for Viksit Bharat @ 2047 (ICMAETM-24) was successfully organized by Sankalchand Patel College of Engineering, Visnagar, from 24-05-2024 to 25-05-2024 in association with Gujarat Council on Science and Technology (GUJCOST). This landmark event brought together over 150+ delegates & participants from diverse disciplines which fostering an environment of collaboration and innovation.

The conference commenced with an inspiring inaugural session, presided over by Shri. C. M. Patel, Vice chairman, Nootan Sarva Vidyalaya Kelvani Mandal as the Chief Guest, Dr. Praful Kumar Udani, Provost Sankalchand Patel University, Visnagar, Dr. Hetalumar Shah, Director Sankalchand Patel University, Principals of different institutions and Dr. Manish M. Patel, Conference Secretary graced the Dias.

Dr. Praful Kumar Udani, emphasized the critical role of sustainable development in achieving the vision of a developed India by 2047. Dr. Hetalumar Shah, highlighted the intersection of engineering, technology, and management in driving sustainable growth. There was a MoUs signing ceremony in between industries and Sankalchand Patel University. The industry like Gyatri Micron limited, AAMC Training India, Data flair, Royal castor limited, Investosure Consultant Pvt. Ltd. Vibranium Alltech pvt. Ltd., Nutec Infotech Pvt Ltd Aquint Global Techskill India Pvt Ltd were present for the signing ceremony.

ICMAETM-24 featured a robust agenda with multiple tracks focusing on various aspects of sustainable development; various tracks are Mechanical Engineering, Civil Engineering, Computer Engineering and Information Technology, Electrical and Electronics Engineering, Management & Others.

For the two days international conference speakers from Dr. Georgio Giacinto, University of Cagliari, Italy, Dr. Subramanyam Murala, Trinity College Dublin, Ireland, Dr. Paurav Shukla, South Hampton Business School, UK, Dr. Ajay M. Sidpara, Indian Institute of Technology, Kharagpur, Dr. Rajeev Kumar Mishra, Delhi Technological University, New Delhi, Dr T. P. Sharma, National Institute of Technology, Hamirpur, Dr. Naran Pindoria, Indian Institute of Technology, Gandhinagar, Prof. M. K. Barua, IITRAM, Ahmedabad, Dr. Praghnesh Bhatt, Pandit Deendayal Energy University, Gandhinagar, Dr. Rama Moondra, Adani Institute of Digital Technology Management, Ahmedabad were invited and the experts delivered their sessions. Industry personal from Nutec Infotech Pvt. Ltd. also delivered a session on the 2nd day of the conference.

The conference received an overwhelming response with 180 paper submissions, out of which 95 were selected for presentation. These papers covered a wide range of topics, including sustainable infrastructure, environmental management, and digital transformation, Artificial Intellingence, Machine learning and IOT, Intelligent system and automation, Blockchain and Cyber security, Power Electronics, Power Generation , Transmission and distribution, Materials and Manufacturing, Smart Technologies in mechanical engineering, Marketing and strategy, Operation management and information system, Emerging technologies in business etc.

The conference concluded with a vibrant closing ceremony, the Guests, lauded the efforts of all participants and organizers. The best papers and presentations were awarded, and the conference outcomes were summarized, emphasizing actionable steps and future collaborations.

the importance of continued innovation, policy development, and education to achieve the vision of Viksit Bharat by 2047.

International Advisory Committee

S. No	Name of Expert	Affiliation
1	Dr. Joel Rodrigues	Federal University of Piauí (UFPI), Brazil
2	Dr. Sheng-Lung Peng	National Taipei University of business, Taiwan
3	Dr. Rengaswamy Jayaganthan	Indian Institute of TechnologyDelhi Madras, India
4	Dr. Akshai Aggarwal	Former Vice-Chancellor of the Gujarat Technological University. (GTU), India
5	Dr. Iman Farshchi	MAHSA University, Malaysia.
6	Dr. Mohammad H. Hosni	Kansas State University, USA.
7	Dr. Giorgio Giacinto	University of Cagliari, Italy.
8	Dr. Lim Way Soong	Multimedia University, Malaysia.
9	Dr. Farrokh Mistree	University of Oklahoma, US.
10	Dr. B. Rasitha	Carolina University, Winston-Salem, US.
11	Dr. George Rukaria	Maasai Mara University, Narok, Kenya.
12	Dr. Narottam Sahoo	Gujarat Counsil on Science & Technology (GUJCOST), India.
13	Dr. Ketan Kotecha	Symbiosis Institute of Technology, India.
14	Dr. Sudip Misra	Indian Institute of Technology Kharagpur, India.
15	Dr. Pankaj Setia	Indian Institute of Management Ahmedabad, India.
16	Dr. Vasant Matsagar	Indian Institute of Technology Delhi, India.
17	Dr. Sandeep Goyal	Department of Science and Technology, Govt. Madhya Pradesh, India.

Keynote Speakers

1) Dr. Georgio Giacinto

Expert: Dr. Georgio Giacinto, Professor of Computer Engineering, University of Cagliari, Italy (Online)

Topic: Artificial Intelligence and Cyber Security

In keynote speech, Dr. Giacinto has discussed about the introductory concepts of Machine Learning and Cyber Security. He presented the research work carried out by his research team on Malware analysis and detection.

He demonstrated how to detect malicious PDF file and details of Reverse Mimicry Attacks. He also demonstrated "IntelliAV"- Android Malware detector based on Machine Learning and its performance as well as Malicious Office Documents process.

Dr. Giacinto has highlighted the research challenges related to vulnerability detection and Dos and Don'ts of Machine Learning in Computer Security.

2) Dr. Subramanyam Murala

Expert: Dr. Subramanyam Murala, Professor, School of Computer Science and Statistics (SCSS), Trinity College, Dublin, Ireland (Online)

Topic: Deep Generative AI for Computer Vision

Dr. Murala has presented details of Auto- Encoders along with Supervised Learning, Unsupervised learning, Semi-Supervised Learning, Classification and Regression wot suitable examples of each topic.

He discussed in detail the concept of Auto-Encoder with reference to Computer Vision domain. He also discussed about GAN (Generative Adversarial Network) and its architecture including Training Discriminator, Training Generator and Applications of GAN such as Image to Image translation and face aging.

3) Dr. Ajay M. Sidpara

Expert: Dr. Ajay M. Sidpara, Mechanical Engineering Department, IIT Kharagpur (Offline)
Topic: Fabrication of microneedles for biomedical applications

Dr. Sidpara has presented about types of microneedles, applications, characteristics and fabrication methods of microneedles array. He also demonstrated the fabricated microneedle array. He discussed the fabrication of microneedles involves various techniques, including micro-molding, photolithography, 3D printing, laser cutting, and etching. Depending on the intended application, they can be made from silicon, metals, polymers, ceramics, or even biodegradable materials. Biodegradable microneedles are particularly promising for drug delivery, as they dissolve after insertion, releasing the drug in a controlled manner.

4) Dr. Rajeev Kumar Mishra

Expert: Dr Rajeev Kumar Mishra, Delhi Technological University, New Delhi (Offline)

Topic: Vehicle Induced Exhaust Emission: A Policy Perspective

The present talk provides information about first-hand and comprehensive analysis of the vehicular emission and effects of different facors like age, mileage, stringency of emission norms and maintenance categories on the exhaust emissions from in-use cars. It is revealed from our study that the emission characteristics of petrol-driven passenger cars of various makes and models for CO and HC emissions with respect to both vehicle age and mileage are strongly interdependent. The emission equations generated from our study can reliably predict the emission levels for CO and HC based on the age and/or mileage of cars.

5) Dr T. P. Sharma

Expert: Dr T P Sharma, Asso. Professor & Head, Computer Centre, Deptt of CSE, NIT Hamirpur (Offline)

Topic: Large Scale Distributed Systems: Characteristics, Design Constraints and Research Challenges

Dr Sharma has presented the concepts of synchronous and asynchronous systems and highlighted the characterization & modeling of the large scale distributed systems.

Dr Sharma has discussed about the basic concepts, characteristics and research issues of synchronization problem in distributed systems. Also highlighted the design constraints of the distributed systems.

He has highlighted that how advancement in technology can play a key role to work for the Viksit Bharat Vision @2047. He emphasized that technologies like AI and multidisciplinary approach will do paradigm shift in technological development.

6) Dr. Naran Pindoria

Expert: Dr. Naran Pindoria,Asso Professor, Electrical Engineering Deptt., IIT Gandhinagar (Offline)

Topic: Energy Transitions in India: Towards possible Net Zero and Sustainable energy future

With reference to Viksit Bharat @2047 vision, Dr.Pindoria has highlighted that India's announcement that it aims to reach net zero emissions by 2070 and to meet fifty percent of its electricity requirements from renewable energy sources by 2030 is a hugely significant moment for the global fight against climate change. India is pioneering a new model of economic development that could avoid the carbon-intensive approaches that many countries have pursued in the past – and provide a blueprint for other developing economies.

7) Dr. Rama Moondra

Expert: Dr Rama Moondra, Dean, Adani Institute of Digital Technology Management (Offline)

Topic: Role of Artificial Intelligence in Education

In the age of Artificial Intelligence, the imperative to continuously learn, unlearn, and relearn is paramount. As AI transforms industries and reshapes th e workforce, those who embrace lifelong learning will not only thrive but also shape the future of this rapidly evolving landscape. It's not just about acquiring new skills but also about adapting to changing paradigms and fostering a mindset of agility and resilience. In this dynamic environment, the ability to learn, unlearn, and relearn becomes not just a competitive advantage but a necessity for personal and professional growth.

8) Prof. M. K. Barua

Expert: Prof. M K Barua, Director IITRAM, Ahmedabad (Offline)

Title: Journey Towards Developed India: Some Initiatives

Prof. Barua presented the criteria for developed country such as education, healthcare, economy and technological Innovation and adoption and discussed the several factors playing key role in development in the India such as Digital Transformation, Public Policy and Governance, Innovation and Entrepreneurship and Global competitiveness.

9) Dr. Praghnesh Bhatt

Expert: Dr Praghnesh Bhatt, Asso Professor, Electrical Deptt, PDEU, Gandhinagar (Offline)

Topic: Integration of Distributed Energy Resources in Active Distribution Network: Challenges and Solutions

Dr Bhatt has stressed that Power system dynamics is changing partly due to the large scale deployment of renewable energy sources into the electric grid. Integration of distributed energy resources (DERs), energy storage, and microgrid have introduced new challenges and opportunities for managing power system operation. Source and load control at the distribution level is quickly becoming a key requirement of this evolving system. Voltage regulation, frequency response baselining, anti-islanding, voltage ride through, and reactive margin support are amongst the technical challenges in the Smart Grid era.

10) Dr. Paurav Shukla

Expert: Dr. Paurav Shukla, Professor, Southampton Business School, London (Online)

Topic: Sustainable consumption

Dr Shukla stressed that sustainable consumption is not just a buzzword; it's a critical imperative for safeguarding our planet's future. By adopting mindful purchasing habits, supporting eco-friendly initiatives, and advocating for systemic change, individuals and societies can play a pivotal role in reducing environmental degradation and promoting a more sustainable way of life. It's a collective responsibility that requires concerted efforts from governments, businesses, and consumers alike. Together, we can create a more equitable, resilient, and environmentally conscious world for generations to come.

List of Reviewers

Sr. No	Name	Institute Name
1	Dr Lalit S Thakur	Technical Manager, GEO Dynamics, Vadodara, India.
2	Dr Bjavin G patel	Asso. Professor & HoD, GIDC Degree College, Navsari, India.
3	Dr Yogesh Shah	Associate Professor, IIT RAM Ahmedabad, India.
4	Dr Nipa A Desai	Priincipal & Professor, Neotech College Vadodara , India.
5	Dr Jiten Shah	Associate Professor, IIT RAM Ahmedabad, India.
6	Dr Jayesh Pitroda	Associate Professor, BVM Engg College, V V Nagar, India.
7	Prof. Mayuri Wala	Research Scholar, GTU Ahmedabad, India.
8	Dr Dhruvesh Patel	Associate Professor & HoD, PDEU Gandhinagar, India.
9	Dr Nirbhay Chuabe	Dean-Faculty of Computer Studies & Professor Ganpat University, India.
10	Dr. A. N. Jani	Dean Engineering, Navrachna University, Baroda, India.
11	Dr. Vijay Cahvda	Professor - CS, KSV University , Gandhinagar, India.
12	Dr. Vinod Chaplot	Dean CS & Engineering, Bhupal Nobles University, Udiapur Rajasthan, India.
13	Dr. Paresh Solanki	Associate Professor & HOD, U.V.Patel College of Engineering, Ganapat Vidhyanagar, India.
14	Dr. Mehul Barot	Professor, LDRP Institute of Technology, Gandhinagar, India.
15	Dr. Dhaval Parikh	Professor & HOD, GEC- Gandhinagar, India.
16	Dr. Kiran Amin	Principal, U.V.Patel College of Engineering, Ganapat Vidhyanagar, India.
17	Dr. Rajan Patel	Professor & Dean, Gandhinagar Institute of Technology, India.
18	Dr. Payal Chaudhary	Assistant Professor, School of Technology, Pandit Deendayal Energy University, Gandhinagar, India.
19	Dr. Sameer Patel	Associate Professor, School of Technology, Pandit Deendayal Energy University, Gandhinagar, India.
20	Dr. Vijay Ukani	Associate Professor, NIRMA University, India.
21	Dr. Sapan Mankad	Assistant Professor, NIRMA University, India.
22	Dr. Gaurav Raval	Associate Professor, NIRMA University, India.

23	Dr. Bhargav Y. Vyas	Associate Professor, L. E. College, Morbi, India.
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25	Dr. Mahesh H. Pandya	Associate Professor, L. E. College, Morbi, India.
26	Dr. Sanjay R Vyas	Professor, LDRP ITR, India.
27	Dr. Pinkal J. Patel	Lecturer, Government Polytechnic Ahmedabad, India.
28	Dr. Bhinal Mehta	Assistant Professor, PDEU, Gandhinagar, India.
29	Dr. Tejas B. Maninar	Assistant Professor, Shantilal Shah Engineering College, Bhavnagar, India.
32	Dr. Lokesh Ganganani	Assistant Professor, Department of Information Technology, LDRP, Gandhinagar, India.
33	Dr. Mehul Parikh	Associate Professor, Department of IT, L.D. Engineering College, Ahmedabad, India.
34	Dr. Kedar A. Pathak,	Associate Professor, Indrashil University, Ahmedabad, India.
35	Dr. Jagdish M Prajapati,	Associate Professor, M S University, Vadodara, India.
36	Dr. Harshit K Dave,	Associate Professor, SVNIT, Surat, India.
37	Dr. Kesar B Judal	Principal, GEC Palanpur, India.
38	Dr. M N Khan	College of Engineering, Majmaah University Majmaah 11952, Kingdom of Saudi Arabia.
39	Dr. Ravi Kant	Associate Professor, SVNIT, Surat
40	Dr. Tushar M Patel	Professor, MED-LDRP KSV, Gandhinagar, India.
41	Dr. Alpesh Mehta	Asst Prof, GEC Dahod, India.
42	Dr. Dhaval Patel	Prof. GEC, Palanpur, India.
43	Dr. Jigar V. Patel	Director, KIM, Kalol, India.
44	Dr. Jatinderkumar R. Saini	Director, Symbiosis, Pune, India.
45	Dr. Ronak Patel	Associate Professor, Uka Talsadiya, India.
46	Dr. Namrata Gupta	Principal, Bkdkm Managed Smt. B. K. Mehta I.T. Centre, Palanpur, India.
47	Dr. Monica Gahlawat	Associate Professor, L.J. University, Ahmedabad
48	Dr. Rakesh Bhatnagar	Assistant Professor, S. K. Patel Institute of Management & Computer Studies, India.
49	Dr. Vinod L Desai	Department of Computer Science, Gujarat Vidyapith, India.

50	Dr. Vijay Cahvda	Professor - CS, KSV University, Gandhinagar, India.
51	Dr. Ashish Sharma	Maulana Azad University, Rajasthan, India.
52	Dr. Nimesh Modi	Department of Computer Science, HNGU, Patan, India.
53	Dr. Dilendra Hiran	Pacific University Rajasthan, India.
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59	Dr. Giorgio Giacinto	University of Cagliari, Italy
60	Dr. Lim Way Soong	Multimedia University, Malaysia
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62	Dr. B. Rasitha	Carolina University, Winston-Salem, US
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Research/Review Papers on
Science, Technology and Management Research

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Note: All inquiries regarding the Journal may please be sent to
Editor, SPU-JSTMR, Sankalchand Patel University, Visangar 384315, India through Email:
communications.spujstmr@spu.ac.in

Chief Editor's Message

It is with immense pride and professional satisfaction that I present this Special Edition of **SPU-Journal of Science,Technology and Management Research (SPU-JSTMR)** dedicated exclusively to the International Conference held on 24th & 25th May, 2024 at Sankalchand Patel Univeristy on Modern Approaches in Engineering, Technology, and Management (ICMAETM-24). This edition represents the collective intellectual efforts and innovative contributions of researchers, academicians, industry experts, and scholars from across disciplines.

ICMAETM-24 has provided a dynamic platform for knowledge exchange and interdisciplinary dialogue, emphasizing the need for modern and sustainable solutions in engineering, technology, and management. The conference brought together leading researchers, practitioners, and scholars to share the latest advancements in science, technology and management areas. The SPU-JSTMR Journal is peer-reviewed and open access journal of the university. The conference papers published in the special edition of this journal represent some of the most compelling contributions, showcasing both theoretical innovations and practical applications. Each paper has undergone a rigorous peer-review process to ensure the highest academic standards, and in many cases, the authors have extended or revised their work based on feedback received during the conference and through the journal's editorial review.

We sincerely express our gratefulness to Honourable President Shri Prakashbhai Patel, for all his support in undertaking the publication of research articles and perfectly completing the task. We thank the conference organizers, keynote speackers, reviewers, authors, editors and journal committee members for their contributions to this issue.

We hope that this special edition will inspire continued research, collaboration, and academic excellence in the years to come.

Sincerely,

Chief-Editors, SPU-Journal of Science,Technology and Management Research

Prof. (Dr.) Prafulkumar Udani
Provost, Sankalchand Patel University

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A Review on Pavement Maintenance System for Low Volume Roads

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Abstract: Road network serves as backbone of country as it provides support for development and growth of nation. If road condition is good and network is adequate it enables quick, safe and comfortable movement for goods and passengers between two places. Pavement maintenance plays quite important role in upkeeping service life of any road. After the introduction of PradhanMantri Gram SadakYojna significant improvement is there in village road development. There is need for maintenance system for these PMGSY roads as no systematical maintenance practices are followed by concerned agencies for these low volume roads. Pavement maintenance system comprises of inspecting pavement condition, rating pavement condition, prioritizing road network and optimizing various pavement maintenance strategies in systematic manner. First of all, data is collected from field by conducting various experiments regarding pavement condition and entered into database. This collected data is analyzed according to codal guidelines and based on that various maintenance strategies are optimized. Soft computing-based Pavement maintenance system would be more beneficial rather than conventional pavement maintenance system due to budgetary constraints of various government road agencies. Pavement maintenance system would be helpful in achieving maximum benefits under allocated budget. Road network prioritization and optimization of alternative maintenance strategies would be helpful in awarding contracts and arranging labors, materials, equipments for small scale pavement maintenance projects.

Keywords: Low volume road, Maintenance, Pavement condition, Economy

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I. INTRODUCTION

Road network plays an important role in economic development of any nation as it links industries and service sector with consumers. For holistic development, it is most important to connect rural areas with nearby trade centers and urban areas. Rural road connectivity plays important role in economic and social development of region as well as of nation. According to Economical Survey 2022 – 2023 around 65 percent population of total population lives in villages in India. For livelihood, 47 percent population of total population is dependent on agriculture and activities allied to agriculture. As two third population residing in rural areas it is most important to provide road connectivity amongst villages and towns. Only road network provision is not sufficient but to maintain road network in good condition for improvement in livelihood of villages is also needs to be considered. PradhanMantri Gram SadakYojna (PMGSY) is the scheme of Government of India which focuses on development of road network in rural area.

For the maintenance of road assets in longer run, timely maintenance is very beneficial. Pavement maintenance reduces the deterioration rate of pavement which ultimately improves service life of pavement. Timely maintenance of pavement not only not only improves service life but also reduces number of accidents and also reduces operating cost of vehicles.

Maintenace plan of road network must follow some principles having scientific basis. In first step condition of pavement and strength of pavement needs to be evaluated. To identify the type of distress, location of distress and severity of distress pavement condition surveys needs to be conducted. In depth reviews to determine the causes of distresses are done after the visual inspection and conduction of pavement condition surveys. Based on distress analysis decision needs to be taken that whether to initiate maintenance work or needs to investigate more for evaluation of maintenance requirements. After that maintenance plan should be formed for all the roads which comes under jurisdiction of concerned road agency.

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II. NEED FOR PAVEMENT MAINTENANCE SYSTEM

Having road connectivity is not only enough, but it is also essential to maintain this road network and to keep these roads in good condition. Normally, Village roads are maintained by state agencies in India. There are no any systematic maintenance practices adopted by concerned road agencies for maintenance of pavement. As construction of Village roads accelerated after 2000 and continuing, in current time allocated budget for maintenance activities to concerned agencies is very limited. There is a need to develop for Pavement Maintenace System for village roads so that maximum roads can be maintained in limited budgetary constraints.

In current practice, selection of maintenance treatment for pavements having distresses by concerned state agencies does not follow any systematic process with scientific basis. Road agencies have budgetary limitations for maintenance of low volume village roads. Pavement maintenance system would be helpful in achieving maximum benefits with limited budget. Timely maintenance of pavement would be helpful in minimizing maintenance cost and maintaining service life of pavement. As the maintenance gets delayed, many times pavement can not treated and complete rebuilt of pavement requires in that case. According to World bank document Selecting Road Maintenance Systems (1997) depending upon the category of road and number of vehicles, due to timely maintenance of pavement the rate of return can be as high as 15% to 20%

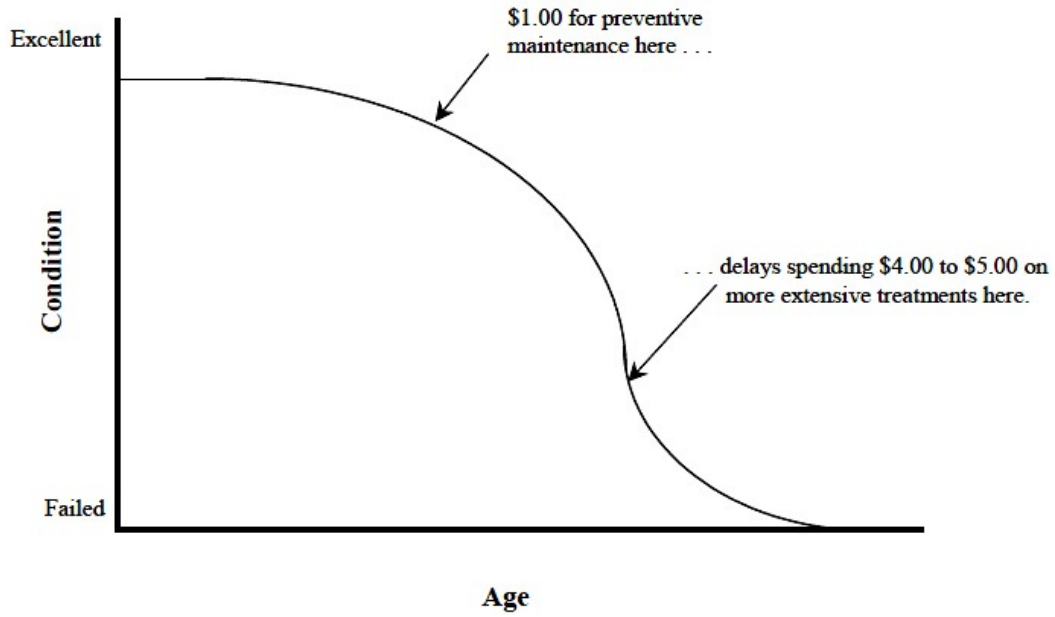

Fig. 1 Effects of delays in maintenance on cost of maintenance (World Bank Document, 1997)

III. LEVELS OF PAVEMENT MAINTENANCE SYSTEM

Pavement maintenance system can be implemented at two levels:

1) Network level
2) Project level

In network level pavement maintenance system, all roads under jurisdiction of concerned agency are evaluated at same time. Aim of network level pavement maintenance system is to develop a maintenance program by prioritizing maintenance requirement such that under total budget agency can yield maximum benefit. Network level pavement maintenance system can work on more approximate data as compared to project level management. In network level system, short term budget needs and long-term budget needs as well as present condition and future condition of overall network are having main concerns. Network level management is helpful in prioritizing the maintenance work. In network level maintenance system, roads are mainly evaluated through visual inspection and no complex methods are adopted to collect the pavement condition data.

Project level pavement system is focused on particular location under the jurisdiction of concerned agency rather than overall network in network level system. When the agency analyzes total road network under its jurisdiction, after that particular location for project level pavement maintenance system can be identified. As in network level pavement maintenance system no

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detailed data had been collected, to propose maintenance strategy for particular location detailed investigations needs to be carried out. So, in project level maintenance once the location is identified than detailed data collection and data analysis is carried out for project level maintenance planning. Project level maintenance planning would be more economical and more beneficial rather than network level maintenance planning. Project level maintenance planning can be done for multiple locations at single time after network level identification.

IV. FRAMEWORK OF PAVEMENT MAINTENANCE SYSTEM

Pavement maintenance system is a sequential process which is useful to agencies associated with road maintenance works starting from evaluation of existing conditions to selection of maintenance strategies so that the pavement can be serviceable up to its design life. Data collected would be first stored into database and analysis would be performed. Based on information revealed from analysis various strategies would be optimized.

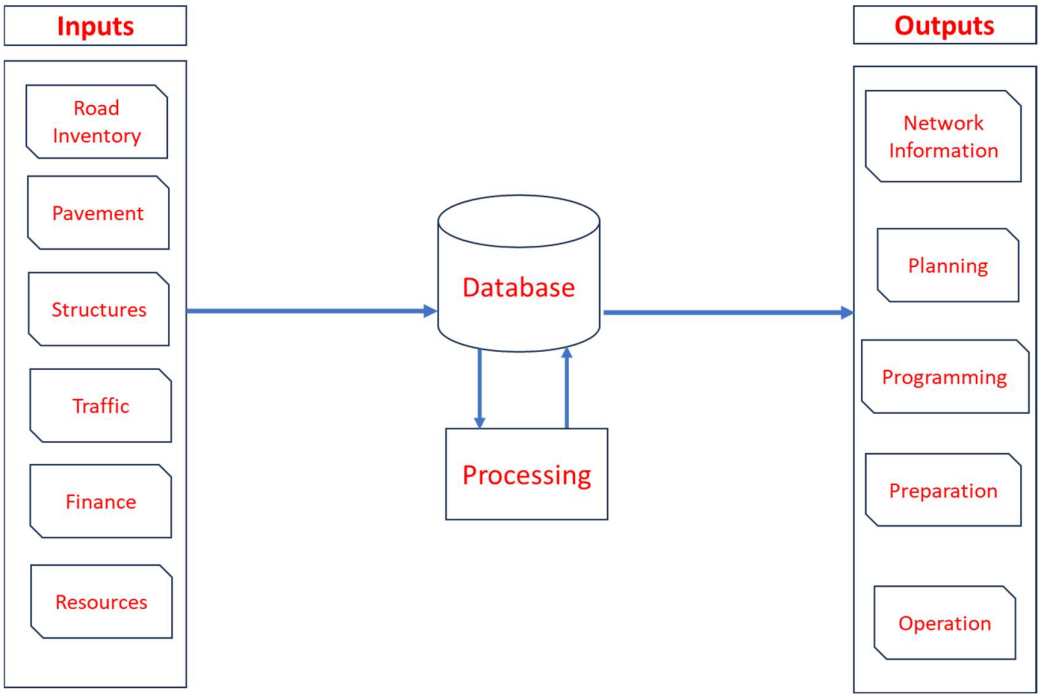

Fig.2 Framework of Pavement Maintenance System (Proceedings of the Highway Policy Seminar for Countries of the Former Soviet Union, 207 – 216 p.)

For national highways, state highways and urban roads system with automated monitoring is essential whereas for village roads system with visual inspection may be appropriate. In Pavement Maintenance System as huge data is collected, it is essential to have strong database mechanism. Data is analyzed and information revealed based on data analysis would be further uses for decision making process.

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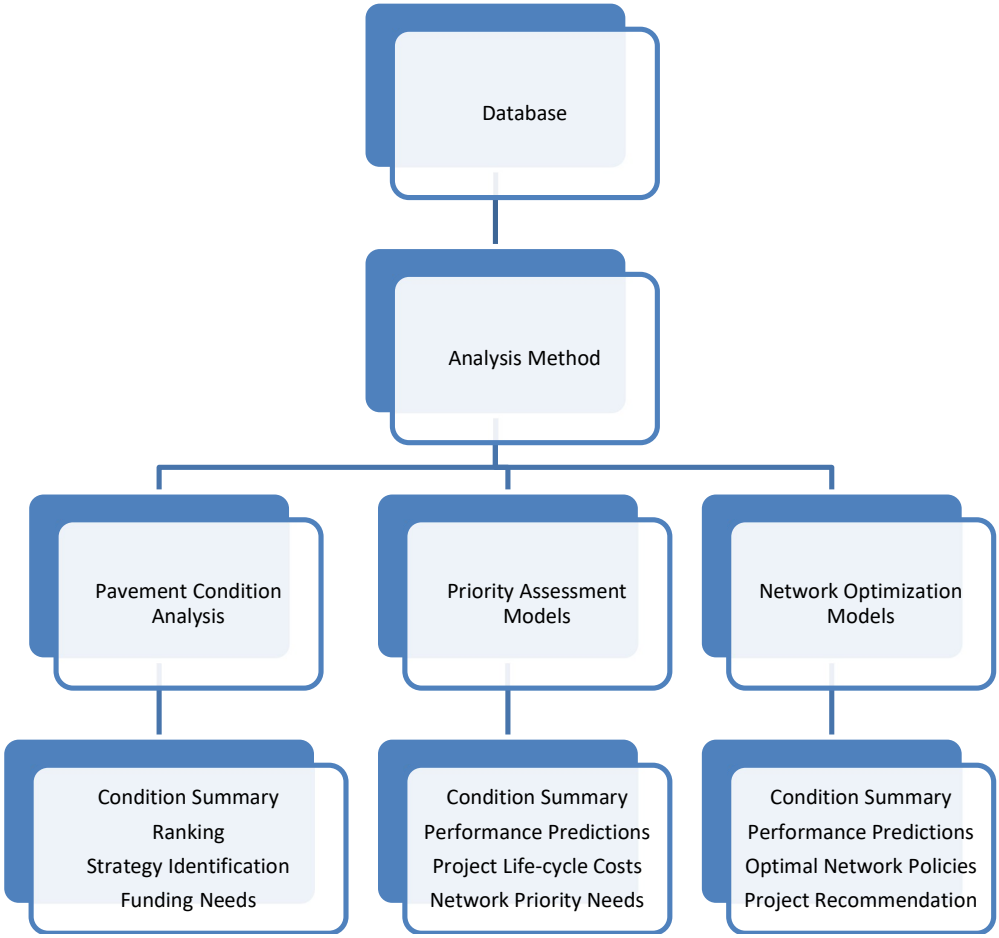

Fig. 3 Modules of Pavement Maintenance System, (Al-Kheder, 2005)

V. METHODOLOGY

A. Selection of road network

Due to limited budget for pavement maintenance, there is a need for prioritizing roads having basis of scientific methodology. To prioritize roads multiple factors like distresses in pavement, vehicle volume, nearby places having socio – economical importance is very important. Rutting, Raveling, Patching, Pothole, Cracking are considered as distresses in pavement. Total traffic, Total commercial traffic, Total truck traffic are various factors which being considered for vehicular factors. Medical facilities, educational facilities, Demographics are considered as socio – economic factors.

Pavement distress can be defined as deficiency in current condition of pavement as compared to its original condition. Pavement distresses having similar characteristics needs to be grouped. According to IRC 30, pavement distresses can be classified as below:-

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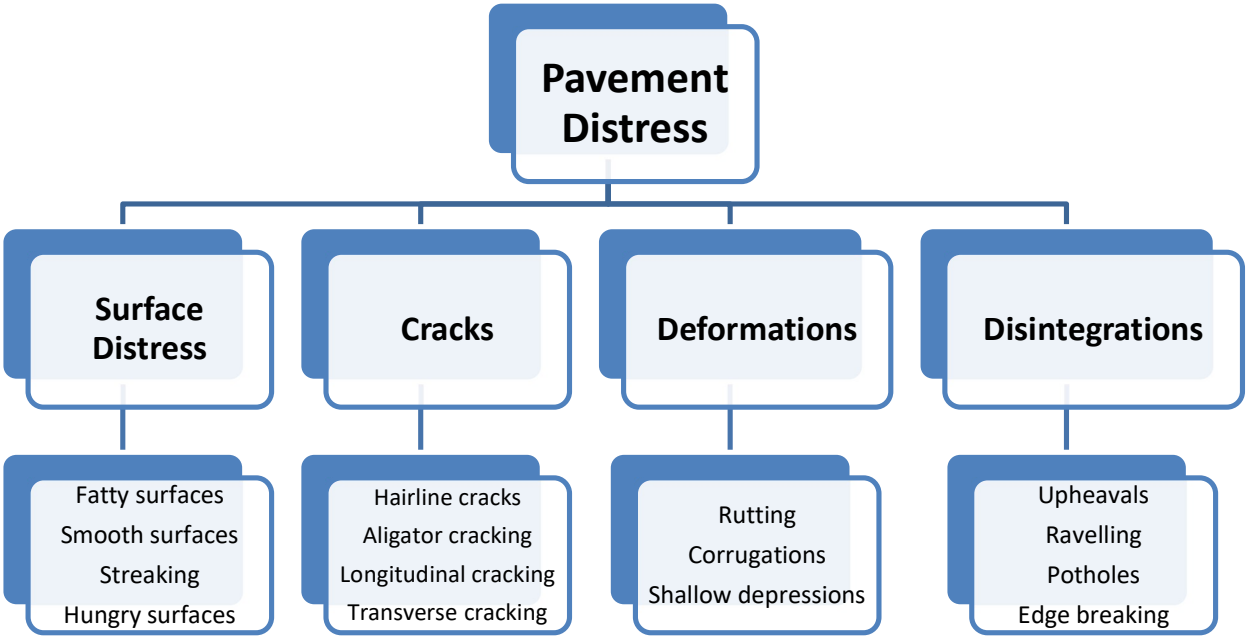

Fig. 4 Classification of Distresses according to IRC 82 - 2015

Due to insufficient quality and quantity surface distresses occurs. Normally, surface distresses are limited to the surface only. Cracks occurs in bituminous pavement with passing time. Based on severity, cracks are classified into various groups. When changes occur in original shape of pavement surface, it is known as deformation. Deformation in pavement is not limited to single layer. Normally, it extends to multiple layers. Defects which in initial stage if not corrected than leads towards completely reconstruction of pavement are considered as Disintegration.

Abhayet. al. (2016) developed Pavement Performance Index (PPI). Formula of PPI developed is based on rating criterion and severity weightage. Saranyaet. al. (2013) considered cracking area, pothole area, Roughness, Ravelling and vehicle damage factor for their study of pavement deterioration modeling. They had developed cracking, pothole, roughness progression model and developed Riding Comfort Index (RCI) model. Mathew et. al. (2008) used Artificial Neural Network and Regression Analysis for development of Pavement Deterioration Model. They had considered ravelling, pothole, roughness and edge failure for modeling purpose. Reddy et. al. (2005) developed Riding Comfort Index (RCI) for pavement maintenance needs. Moazamiet. al. (2011) considered total 19 distresses having different types for their study. To make easier evaluation all 19 distresses had been converted into Pavement Condition Index (PCI).

Traffic had been considered as important factor by many researchers for network level pavement maintenance system. L. Janani. et. al. (2018) considered traffic as important factor for prioritization of pavement maintenance sections. They had developed Maintenance Priority Index (MPI). Qaseemet. al. (2023) conducted study to establish relationship between Pavement Condition Index and Traffic Characteristics. Socio – Economic factors are considered in many studies of pavement maintenance system. As there are many factors IRC SP 20 – 2002 can be referred to convert all facilities value into road utility value.

B. Prioritization of Pavement

If one considers network of roads within cluster, all roads are not having same amount of deterioration and does not require maintenance at one moment. The roads having more damage and more importance are the one which should be prioritize first for maintenance. First of all, damage in roads is first assessed and then on basis of traffic and socio – economic factors, roads are selected. Ranking system needs to be implemented for maintenance works. There are various methods available for ranking like empirical methods, expert opinion etc. Empirical models need lots of data and are costly. If collected data is not accurate or less in quantity, reliability of model is not up to mark. Hence, opinion from experts having expertise in pavement maintenance are taken for ranking purpose. Experts having good skills, experience, knowledge are interviewed and various sets of questions are asked to them related to various types of failures in pavement. Based on opinion of experts ranking is done for prioritizing maintenance. Expert opinion method is very economical and gives better results as compared to empirical models.

Delphi technique is interactive technique which is used for ranking priority by interviewing experts. At least two rounds are organised in forms of written question answer in Delphi technique. At the end of first round interviewer gives summary of the opinions and judgements by all respondents. Based on this all respondents are asked to reconsider their opinion based on other's

opinions. In next round, attempts are made to achieve unique solution. Dhamaniyaet. al. (2014) calculated the utility values of roads for network level planning of maintenance works for roads developed under PMGSY by Delphi technique.

When boundary of dataset or information is not clear cut at that time Fuzzy set theory founds to be very effective for decision making process. From Fuzzy set theory Fuzzy logic can be derived. Chandranet. al. (2007) conducted study for eight pavement sections to develop Pavement Maintenance System. They had formulated Fuzzy membership functions. Based on that for each pavement section Fuzzy Condition Index was determined. For prioritization of pavement sections Fuzzy rankings were used.

Thomas L. Saaty developed Analytical Hierarchy Process for decision making based on Mathematics and Psychology. In AHP multilevel hierarchical structure of goals, objectives, criteria, sub criteria and alternatives is involved. Questions are designed and respondents compares expert opinions to determine the importance of factors through pair – wise comparisons. Chiraget. al. (2019) used Analytical Hierarchy Process for Pavement Maintenance Prioritization. They had considered traffic characteristics and distress data. Consistency ratio was calculated by dividing consistency index with random index to check consistency in judgements. Sarfarazet. al. (2017) used objective based Analytical Hierarchy Process for prioritization of pavement maintenance works. Total 28 road sections from Mumbai city were selected for study. While interviewing experts for pavement maintenance works, opinions given by experts are based on their skill, knowledge and experience, it does not consider the actual quantitative physical conditions of roads. Solutions based on Analytical Hierarchy Process were compared with Road Condition Index.

C. Optimization

Quality of maintenance treatment and its cost both plays significant role in pavement maintenance prioritization. Basically, there are two types of pavement maintenance optimization model.

1) Linear Optimization Model
2) Multi Objective Optimization Model

In linear optimization model aim is to maximize quality of maintenance with limited costs. In multi objective optimization model aim is to minimise cost of maintenance and improving maintenance quality. Bosurgi&Trifiro (2007) developed model for pavement maintenance management which were based on Artificial Neural Networks and Genetic Algorithms. Over a short period, Artificial Neural Network provided one optimal solution among many others. Mathew & Isaac (2007) used three models to determine future performance of pavements. Models were developed by Artificial Neural Network, Deterministic Regression Analysis and Multivariate Adaptive Splines. They had concluded that artificial neural network model is best amongst three for future pavement condition prediction.

VI. IMPLEMENTATION PROBLEM

Many developing countries may face problem in adopting and implementing pavement maintenance system due to: -

- Attitude of users; To implement Pavement maintenance system genuine commitment is essential
- Resistance to modifications also affects the implementation
- Issues related to work culture; No incentives for adopting modified practices
- Financial problems at local level
- Vacant positions of key staff or staff lacking adequate experience
- Training issues; Less time for staff to attend training due to operational reasons, Less time for practice and revision
- Old versions of hardware and software and lack of resources

VII. FINDINGS FROM THE STUDY

- Pavement maintenance system at local agency level which are associated with PMGSY roads will enable concerned decision makers to utilise maintenance budget for maximising benefits and effective use of resources.
- Asit depends on stronger political will, it is quite essential to have commitment for change from political side and strong support to implement the change
- There is a scope for utilization of HDM – 4 cost modelling for optimization purpose
- Delphi technique would be useful for expert selection which may in later stage would be used for rating by Analytical Hierarchy Process

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Dynamic Mode Parameter Control for VVC: An Approach to Balancing Compression Efficiency and Computational Complexity

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Abstract: Video compression, crucial for efficient multimedia storage and transmission, benefits from the Versatile Video Codec (VVC), excelling in compression efficiency. However, rising resolutions and complexities strain computational resources. This paper delves into dynamic mode parameter control within VVC to optimize compression and complexity balance. By adapting VVC's mode parameters based on content characteristics, network conditions, and quality requirements using machine learning and scripting algorithms, we optimize encoding parameters in real-time. Through extensive experimentation, we demonstrate that this approach significantly enhances VVC's flexibility for high-resolution streaming and real-time communication, while also shedding light on the potential of integrating machine learning into video coding pipelines for adaptive compression. Overall, this research not only advances understanding of VVC but also offers a promising solution for addressing the evolving demands of multimedia applications where balancing compression efficiency and computational complexity is crucial.

Key Words:VVC, Compression, Efficiency, Computational, Complexity.

I. INTRODUCTION

In the realm of multimedia content storage and transmission, efficient video compression stands as a cornerstone. The Versatile Video Codec (VVC) emerges as a cutting-edge solution, promising substantial gains in compression efficiency over its predecessors [1]. However, as video resolutions and complexities surge, so do the computational demands, potentially posing barriers to widespread adoption. This paper explores a novel approach– Dynamic Mode Parameter Control – within the VVC framework, aimed at striking an optimal balance between compression efficiency and computational complexity. By dynamically adjusting VVC's mode parameters based on various factors including content characteristics, network conditions, and quality requisites, we aim to optimize encoding parameters in real-time. This introduction sets the stage for our investigation into the feasibility and efficacy of this adaptive strategy in enhancing VVC's flexibility for diverse multimedia applications, from high-resolution streaming to real-time communication, while also considering the integration of machine learning techniques to further refine the compression process.

A. Mode Parameters of VVC

VVC, the Versatile Video Codec, encompasses a comprehensive set of mode parameters crucial for efficient video compression. These parameters include intra prediction modes, determining how pixels within a coding block are predicted spatially; inter prediction modes, exploiting temporal redundancy by referencing previously coded frames; transform coding methods like DCT or DWT, converting pixel values into frequency-domain coefficients; quantization techniques, adjusting coefficient precision to balance compression and image quality; and entropy coding schemes such as arithmetic coding or CABAC, further compressing data by assigning shorter codewords to more probable symbols. Together, these mode parameters govern the delicate balance

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between compression efficiency and computational complexity in VVC encoding, with dynamic adjustment offering adaptability to varying content characteristics and encoding conditions, ensuring optimal performance across diverse multimedia applications.

The partitioning step divides a video frame into non-overlapping blocks in order to prepare it for the different encoding decisions, such as prediction, transformation, and quantization. In video coding standards such as HEVC [3].

B. Compression Efficiency and Computational Complexity

Video compression efficiency is paramount in digital multimedia technology, aiming to reduce data while preserving perceptual quality. Key metrics like Peak Signal-to-Noise Ratio (PSNR) gauge compression quality, with higher PSNR indicating better efficiency. However, PSNR has limitations, prompting the use of metrics like Structural Similarity Index (SSI). Computational complexity, referring to resources needed for compression, is crucial for real-time applications. Encoding/Decoding Time and Algorithmic Complexity are key metrics. Efficient memory usage and algorithm scalability also impact computational complexity. Balancing compression efficiency with computational feasibility ensures the development of practical, widely applicable video compression technologies, meeting evolving digital media demands.

II. RELATED WORKS

In recent research on VVC codec, multiple papers have been proposed to enhance video compression efficiency and reduce computational complexity. Notable contributions from Papers [2], [4], [5], and [6] shed light on distinct aspects of this landscape.

In "Rate Control Technology for Next Generation Video Coding Overview and Future Perspective" [2], the effectiveness of rate control was demonstrated through tests on video sequences of various resolutions using reference software such as JM19.0, HM16.26, and VTM18.0. The experiments, utilizing YUV video sequences from official recommended sources, set the target bit rate to 100,000, with 50 input video frames and encoding configurations including LDB, LDP, and RA. Notably, only JM software used default configuration and lacked support for higher resolution videos. The chosen SDR video sequences ranged from RaceHorses (416 × 240) to Traffic (2560 × 1600). Results indicated significantly higher average PSNR values for HM and VTM compared to JM. The research transition from HEVC to VVC is evident, with HM reference software still widely used. However, VVC reference software research is in its infancy, typically focusing on hierarchical structure and various algorithms to achieve higher negative BD-rate values and lower RBE values. Notably, experiments often compare HM and VTM, with frame and CTU levels being more studied than GOP level. While some experiments achieve notable performance improvements within acceptable bit rate accuracy ranges, bit allocation accuracy in RA configurations varies considerably.

In the paper "Adaptive intra-refresh for low-delay error-resilient video coding" [4], we introduce an efficient model for selecting intra-refresh cycle sizes based on network packet loss rates. Our linear model adapts cycle sizes without relying on sequence-specific parameters, enhancing flexibility. Experimental results validate the algorithm's effectiveness. Currently, one cycle size applies to entire video sequences regardless of scene changes, prompting future work on frequent parameter updates for adaptive scene-based selection. Additionally, we aim to extend this approach to the HEVC standard.

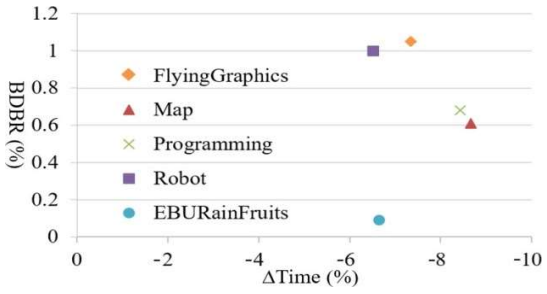

Fig.1:BDBR and Time of the proposed algorithm under LD configuration

In [5], Yu and Jung introduce an adaptive perceptual quantizer (APQ) for high dynamic range (HDR) video compression with HEVC Main 10 Profile. The proposed technique adjusts the transfer function (TF) based on HDR content, mapping luminance to luma adaptively. By extracting maximum and minimum luminance values, a scaling factor ratio is obtained to adjust the PQ-TF, resulting in APQ-TF. This ratio, adaptive to HDR content, is updated per-frame and encoded as metadata. In decoding, the ratio is used to adjust the inverse PQ-TF, yielding inverse APQ-TF. Compared to PQ-TF, APQ-TF covers a larger range of luma values, reducing quantization distortion, and maintains better perceptual uniformity, enhancing color retention. Flickering artifacts from adaptive quantization are mitigated using a low-pass filter. Experimental results show that HDR video coding with APQ-TF saves more bitrate while preserving perceptual uniformity. Future work includes exploring adjustments to other parameters in PQ-TF and investigating the relationship between APQ and DRA, with consideration for combining APQ-TF and DRA.

The paper [6] proposes a machine learning-based framework for fast intra mode decision in HEVC Screen Content Coding (SCC). Unlike traditional methods, which check IBC and PLT modes for SCBs, the framework utilizes decision trees with dynamic features to make mode decisions separately. This sequential arrangement reduces computational complexity by 47.62% on average, with a minimal increase in BDBR (1.42%). Future work may explore fast SCC encoding algorithms based on CNNs, despite their high computational complexity. Strategies like increasing stride size and designing multi-output CNNs could mitigate this drawback, with this paper serving as a baseline for future CNN approaches.

III. METHODOLOGY

Dynamic control of mode parameters in VVC (Versatile Video Coding) encoding is a crucial technique used to optimize compression efficiency while adapting to varying content characteristics and network conditions.

A. Content Analysis

Content analysis in the context of video encoding, such as VVC (Versatile Video Coding), involves analyzing the visual and temporal characteristics of the video content to inform encoding decisions.

i. Algorithm of Motion Detect

The key part of the logic involves computing the absolute difference between pixel values of corresponding pixels in consecutive frames, converting the difference to grayscale, summing the intensities, and comparing the total difference to a motion threshold.A simplified mathematical expression to represent the core logic of the motion detection could be expressed as follows:

Let I_t be the intensity matrix of the current frame,$I_{(t-1)}$ be the intensity matrix of the previous frame and

ΔI_t is the absolute intensity difference matrix:$\Delta I_t = | I_t - I_{(t-1)} |$

Let ΔI_{gray} be the grayscale representation of ΔI_t ,and Total Different be the sum of pixel intensities in ΔI_{gray}:

$\Delta I_{gray} = \text{ConvertToGray}(\Delta I_t)$

$\text{TotalDiff} = \sum(i,j)\Delta I_{gray}(i,j)$

Finally, the motion detection decision is based on comparing TotalDiff with a threshold:

MotionDetected = TotalDiff > motionThreshold

ii. Motion Analysis

Motion Complexity: Measuring the complexity of motion helps decide whether to use different block sizes, prediction modes, and reference frames.

Motion Estimation: Motion analysis identifies areas of motion within a frame. Algorithms detect moving objects or regions, which helps determine where motion compensation may be applied.

B. Encoder Parameters affected by Content Analysis

***i. Quantization Parameters (QPs*)**: Content analysis helps determine the complexity of different regions in a video frame. In more complex regions with fine details, lower quantization levels (smaller QP values) may be chosen to preserve quality. In less complex regions, higher quantization levels may be used to achieve more significant compression. Higher motion complexity, high texture detail, or intricate patterns may lead to lower QP values.

***ii. Prediction Modes (Intra/Inter*)**: The analysis of motion complexity and scene changes informs the choice between intra-frame and inter-frame prediction modes. Intra prediction is often used for keyframes or scenes with minimal motion, while inter prediction is efficient for scenes with motion. Scenes with high motion complexity may benefit from inter prediction, while static scenes may use intra prediction.

***iii. GOP (Group of Pictures) Structure**:* The duration of shots, scene changes, and temporal characteristics influence the choice of GOP structure. Shorter GOPs may be used for fast-changing scenes, while longer GOPs can be efficient for steady scenes.

C. Network-Aware Adaptation

Dynamic control methods may also consider the network conditions during video transmission. For example, in streaming applications, the system could dynamically adjust parameters based on available bandwidth, upload speed, latency, or other network characteristics to optimize video quality while maintaining a consistent streaming experience. The available bandwidth of the network is a critical factor in video streaming. Network-aware adaptation involves monitoring the current bandwidth and dynamically adjusting video encoding parameters, such as bitrates, to match the available network capacity. This helps prevent issues like buffering or low video quality due to insufficient bandwidth.

Bandwidth is commonly calculated as the amount of data that can be transmitted through a network connection in a given amount of time. The formula for calculating bandwidth is:

Bandwidth = Amount of Data/Time

i. Encoder Parameters affected by Network Bandwidth

***1.1 Bitrate Control Parameters*:** The available network bandwidth influences the choice of target bit rate for video encoding. Bitrate control parameters determine the amount of data allocated to represent each second of video. In situations of limited bandwidth, lower target bit rates may be chosen to prevent buffering and ensure smooth playback. In low-bandwidth conditions, the encoder may use a lower target bit rate to generate a more bandwidth-friendly video stream.

1.2. Quantization Parameters (QPs):The quantization process controls the trade-off between video quality and compression efficiency. In low-bandwidth scenarios, higher quantization levels (larger QP values) are typically used to reduce the amount of data transmitted over the network. Higher QP values may be employed to achieve more aggressive compression and lower bit rates.

ii. System Resource Availability

System resource availability plays a crucial role in the implementation of Dynamic Mode Parameter Control (DMPC) in video compression. DMPC involves adapting encoding parameters in real-time based on changing conditions, and the availability of system resources can significantly influence the effectiveness of dynamic adjustments.

iii. Encoder Parameters affected by System Resource

***1.1 Parallel Processing*:** Leverage multi-core processors and parallel processing capabilities to distribute the encoding workload across multiple threads or cores. This can significantly improve encoding speed and efficiency, especially on modern hardware architectures.

***1.2 Thread Management*:** Increasing the number of threads can lead to faster encoding but may also increase system resource utilization.

1.3 Buffer Management: Optimize buffer sizes and configurations to match the available system memory. Proper buffer management helps prevent memory-related bottlenecks during the encoding process.

IV. EXPERIMENTAL SETUP

In the quest for an algorithm that can discern the authenticity of video content analysis, the experimental setup forms the backbone of our endeavor.

A. Hardware and Software Configuration

i. The simulations are performed using:

The encoding experiments were conducted on a system equipped with an Intel® Core™ i7-8650U CPU running at 1.90 GHz. processing speed with maximum clock speed around 2112 MHz and using Microsoft windows Machine operate on x64 bit architecture systems with RAM (Random Access Memory) capacity of 16GB.OpenCV (Open-Source Computer Vision Library) is a comprehensive open-source computer vision and machine learning software library that has gained widespread popularity for its versatility and extensive functionality.Emgu.CV serves as a .NET wrapper for OpenCV, providing seamless integration and enabling developers to utilize OpenCV functionalities directly in C# projects.

ii. Test Sequences

Four HD video sequences in 8-bit YCbCr 4:2:0 format, obtained from [7], with a resolution of 1280×720, are selected as the test dataset. Each sequence differs in duration and total frame count. Table I provides an overview of the sequences, including their names, and parameters like resolutions, frame rates, number of frames, and bit depth.

TABLE I

DATA SET FOR TESTING ON CONTENT ANALYSIS

Sequence Name	Frames	Resolution	Bit Rate
FVDO_Freeway	232	1280x720	3.73 Mbps
FVDO_Plane	298	1280x720	1.53 Mbps
FVDO_Shore	684	1280x720	3.73 Mbps
FVDO_Golf	311	1280x720	1.15 Mbps

iii. Encoder Configuration

VVenC is employed for VVC encoding tasks, with configurations set for random access mode using varying quantization parameters (QP). A group of pictures (GOP) structure of 32 frames is applied, utilizing a hierarchical approach. Between the intra and inter keyframes, frames are encoded using bi-directional prediction within this hierarchy. Given the high computational demands of VVC encoding, enabling multithreading via command line options can significantly improve CPU performance. Further specifics about the command configurations are detailed in the following sections.

VVenC- 1.8.0:Each video sequence is encoded using a fixed quantization parameter (QP) value of 32. The corresponding command line examples for performing the encoding on a Windows operating system are provided below.

Encode**:** vvencapp.exe -i<input raw file> -s <frame size> -f <frames to be encoded> -fr<frame rate> -c <file type> -- internal-bitdepth<bit depth size> -o <bit stream file>

V. RESULTS & SUMMARY

Content analysis is conducted in this paper with the aim of assessing the content complexity of a given video and identifying frames with distinct static and motion characteristics. This involved analyzing spatial and temporal features of the video frames. For content complexity, spatial complexity was measured by examining textures, colors, and object layouts within frames. Temporal complexity was assessed by analyzing the rate of change between consecutive frames. Higher spatial and temporal complexities indicate scenes with more intricate visual information and dynamic content. The results revealed varying levels of content complexity throughout the video. Scenes with intricate details, rapid motion, or dynamic changes were identified as high-complexity segments, while static or slow-changing scenes were classified as low-complexity.

To determine quantization parameters based on the motion complexity of the given content, these parameters are used in the VVC encoder to encode video for better compression efficiency and reduced computational complexity. When motion complexity is high, the quantization parameter (QP) is set low; conversely, for lower motion complexity, the quantization parameter (QP) value is set high as shown in Table II.

TABLE II

RESULTS OF CONTENT ANALYSIS OF VIDEO SEQUENCES

Sequence Name	Motion Frames	Motion Complexity	QP Value
FVDO_Freeway	231	5628.55	28
FVDO_Plane	297	1388.51	54
FVDO_Shore	683	2122.50	50
FVDO_Golf	310	7178.95	18

Here, Table III presents compression efficiency in YUV-PSNR values, while Table IV compares encoding times between the default QP value method and the proposed QP value method using the OpenCV library.

TABLE III

RESULTS OF COMPRESSION EFFICIENCY YUV-PSNR VALUE OF VIDEO SEQUENCES IN BOTH METHODS

Sequence Name	Frames	Purposed (%)	Default(%)
FVDO_Freeway	232	40.1293	37.8095
FVDO_Plane	298	32.4533	43.1862
FVDO_Shore	684	36.3305	44.1994
FVDO_Golf	311	52.3971	43.1975

TABLE IV

RESULTS OF TIME COMPARISON VIDEO SEQUENCES IN BOTH METHODS

Sequence Name	Frames	Purposed (s)	Default (s)
FVDO_Freeway	232	6126.020	4742.400
FVDO_Plane	298	2848.430	4127.567
FVDO_Shore	684	6450.000	10283.213
FVDO_Golf	311	13552.432	4863.841

In less complex regions, higher quantization levels may be used to achieve more significant compression. Higher motion complexity, high texture detail, or intricate patterns may lead to lower quantization to decrease encoder time.

VI. CONCLUSION

In conclusion, our study on Dynamic Mode Parameter Control (DMPC) for Versatile Video Coding (VVC) highlights its potential in balancing compression efficiency and computational complexity. By dynamically adjusting quantization parameters based on content complexity, we achieved significant improvements in compression efficiency while reducing computational overhead. Through content complexity analysis and the implementation of a dynamic quantization parameter adjustment approach, we observed better compression ratios without compromising visual quality. This method not only enhances encoding performance but also reduces computational complexity, leading to faster encoding times and more efficient resource utilization. While our findings underscore the promise of DMPC for VVC, further research is warranted to refine complexity analysis methods and explore advanced techniques for dynamic parameter adjustment, ultimately advancing the efficiency and scalability of VVC encoding systems for diverse multimedia applications.

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Metabolic Metrics: A Comprehensive Analysis Web Tool for Nutritional Assessment

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Abstract: Health is the greatest asset. There is a saying that says your health depends more on what you don't do than what you do. For the best possible health and wellness, people must have access to the services and health information they need to make informed decisions. The primary goal of this comprehensive analysis web tool is to provide a new web-based nutrition and diet tracker that allows users to monitor their macronutrients, BMI, and calories. In terms of macronutrients and calories, it recommends foods for people who are underweight and do not adhere to their diet. Additionally, it recommends certain exercises for people who overeat and consume more calories than necessary.

Keywords: Diet, Analyzer, Calories, Nutrition

1. INTRODUCTION

The increasing prevalence of obesity and associated health problems around the globe in recent years has led to a rise in interest in calorie-tracking devices.[1] The calorie analyzer is one piece of increasingly popular equipment that may be used to determine how many calories a variety of foods, meals, and recipes contain. This invention has a great deal of potential to enable people to make educated food decisions, encouraging better lifestyles and halting the global obesity pandemic.

The calorie analyzer estimates the calorie content of foods using a range of methods, such as image recognition, ingredient databases, and machine learning algorithms. It is founded on ideas from nutritional analysis and food science. Customers can obtain it just by inputting a photo or a description of the food. Furthermore, compared to manual tracking or depending solely on standardized nutritional labels, the calorie analyzer offers a more practical and accessible way to track caloric intake, potentially revolutionizing conventional dietary evaluation approaches.

This technique is useful not just for people who are trying to control their weight but also in clinical settings where precise dietary assessment is necessary to treat a variety of illnesses. The efficiency and accuracy of calorie analyzers, however, are still being researched and developed despite their possible advantages. To improve the functionality of these tools and increase their usefulness for end users, more research is required to address issues including inconsistent portion sizes, ingredient composition, and image recognition algorithms' accuracy.

Our objective is to present a thorough analysis of the cutting edge in calorie analyzer technology, looking at its foundational ideas, uses, constraints, and potential future developments. Through a comprehensive analysis of the current body of literature and the identification of research gaps, we aim to further enhance this ground-breaking instrument for encouraging better eating habits and reducing the worldwide obesity epidemic.[2]

1.1 Problem Statement: In the field of nutrition and health management, precisely calculating caloric intake is a crucial issue. There is still a considerable distance to be covered before accurate and practical measurement of calorie intake can be achieved,

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even with the abundance of equipment and techniques available. Current techniques, such as self-reporting via meal diaries or smart phone apps, are prone to errors because of selective recall, human error, and the difficulty of precisely measuring portion sizes. Furthermore, the wide variety of foods consumed worldwide may not be included in conventional approaches such as food labels and nutritional databases, resulting in partial or erroneous calculations. Furthermore, the time and work involved in manual tracking may discourage people from regularly keeping an eye on their caloric intake, which would make it more difficult for them to meet their dietary objectives and lead healthy lives. [3]

1.2 Problem Introduction: The rise in obesity and diet-related illnesses in recent years has brought attention to the critical need for efficient methods and instruments for tracking and controlling caloric intake. Precise assessment of caloric intake is crucial for people aiming to attain and sustain a healthy weight, in addition to medical practitioners engaged in nutritional advice and intervention initiatives. However, because of the intrinsic complexity of human food behavior and the limits of current measurement technologies, precisely quantifying calorie intake is a substantial task. [4]

The objective of this project work is to assess the precision, usability, and efficacy of a calorie analyzer as a tool for assessing caloric intake could be the aim of a research project paper on the subject. This could entail assessing how well it performs in comparison to accepted calorie-tracking techniques (such as food diaries or direct calorimetric), looking into any potential effects on dietary practices and health outcomes, and investigating any shortcomings or potential areas for development.

The structure of this paper is going to be as follows: Section I introduces an overview of IoT technology In Section II, we explore the technologies being used in this Analysis Web Tool In Section II, we explore a literature survey related to our system, In Section III, describe the methodologies used in this project work, Section IV & V Tools & Technologies used for the implementation of this work and Results and discussion respectively. We make some concluding remarks in section IV.

II. LITERATURE SURVEY

A research paper that focuses on the literature survey component of a calorie analyzer would conduct a complete analysis of the body of knowledge on technology, dietary assessment techniques, and calorie measurement devices. The goal would be to compile and evaluate earlier studies in order to pinpoint potential, problems, and gaps in the field.

An extensive review of the literature on calorie analyzers—devices that measure caloric intake—is presented in this work. We assess the many technologies and approaches used in the creation of calorie analyzers, as well as the difficulties and constraints related to these devices, through a comprehensive analysis of the literature. A broad spectrum of literature sources, such as scholarly articles, conference proceedings, and technical reports, are covered by our survey. We highlight significant developments, trends, and gaps in the sector and offer insightful information for the next studies and projects. This review of the literature advances our understanding of dietary assessment technologies and provides guidance for the development and application of calorie analyzers, which will enhance health monitoring and intervention.[5]

2.1 Requirement Validation: To make sure that the suggested solution adequately answers the needs and difficulties of calorie estimation, it is imperative to validate the requirements before moving forward with the construction of a calorie analyzer. In this validation process, the efficacy, usability, and practicality of the suggested solution are evaluated concerning the user expectations and the defined requirements.

The technical feasibility of the suggested calorie analyzer is assessed by a feasibility analysis, which takes into account several aspects such as sensor precision, data processing capacity, and compatibility with current technologies. In order to make sure the analyzer is simple to use and intuitive, usability assessment entails comprehending the user interface, acceptability by target users, and ease of use. The main goal of the effectiveness evaluation process is to confirm that the analyzer can reliably and accurately estimate calorie intake in a variety of dietary settings.[6]

2.1.1 Functional requirement: The goal of a research article on the functional requirements of a calorie analyzer is to list the precise features and capabilities that the apparatus must have in order to measure calorie intake accurately. Accuracy, precision, user interface, data storage, and networking needs may be among them. The identification, validation, and implementation of these functional requirements during the analyzer's development may also be included in the article. [9]

2.2.2 Non-functional requirement: A study that focuses on the calorie analyzer's non-functional requirements would look at features that go beyond the device's core capabilities. This could involve elements like performance, security, scalability, usability, and reliability. These non-functional requirements are essential to guaranteeing that the device fulfills users' needs and performs well in a variety of situations. [10]

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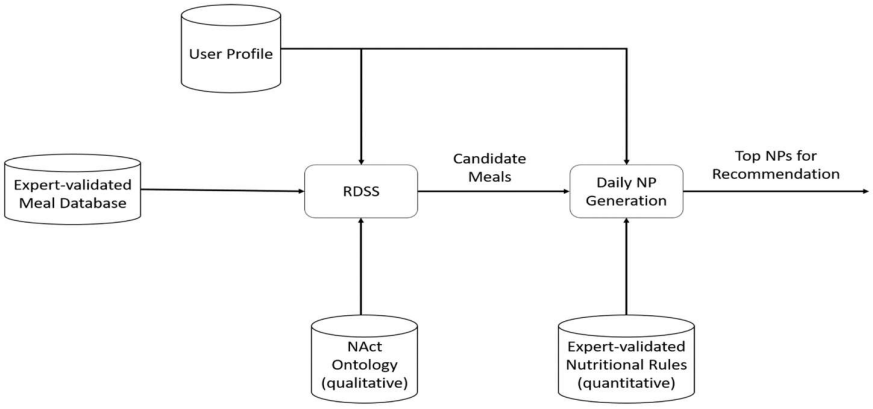

Fig. 1 Requirement Validation

III. METHODOLOGY

The process of creating a calorie analyzer is complex, combining data processing algorithms, sensor technologies, and user interface design. The procedure comprises multiple crucial phases, such as gathering data, creating algorithms, training models, and validating them.

We describe in this part the specifics of our system's deep neural network technique. Creating a pre-trained model file with the CNN network is the initial stage in our process. To accomplish this, first a group of photographs from a specific class (for example, 50 images from the apple class) are captured, and then each image is labelled with an object name-set (apple being the object). These photos are utilized to train the system and will be regarded as the collection of pertinent (positive) photographs. We retrain the system using the set of negative images (images devoid of the pertinent object) in the second training phase. Since we used the backdrop photos to train the algorithm, it is unable to classify in our instance.

We describe the specifics of our system's deep neural network approach within this segment. Utilizing the CNN network, our method begins with creating a pre-trained model file. To do this, first take a group of pictures of a specific class (for example, 50 pictures of the apple class), and then label those pictures with an object name-set (apple being the object). These photos are utilized to train the system and will be regarded as a collection of pertinent (positive) photographs.

We retrain the system using the collection of negative images (images devoid of the pertinent object) in the second training phase. Since we used the background photographs to train the algorithm, it does not classify the images in our case as belonging to the Apple class. We load the model file into the program and test it against the user-submitted photographs that were shot after the model file was formed from the training. After that, the algorithm recognizes images and creates a list of probabilities compared to the label name.

Therefore, during the learning phase, we will be able to adjust the weights and bias to obtain the output closer to the intended result. To identify weights and biases that minimise the quadratic cost function C (web), we must train the neural network. The goal is to identify the weights and biases that minimise the cost C by applying gradient descent. There are comparable components to the gradient vector. By estimating the gradient by computing for a small sample of randomly selected training inputs, the stochastic gradient descent technique can be utilised to accelerate learning. It turns out that we can rapidly obtain a fair estimate of the true gradient by averaging across this short sample, which speeds up gradient descent and learning.[7]

IV. TOOLS & TECHNOLOGY

The goal of a research paper on the technology of a calorie analyzer could be to examine the technical features of the apparatus, including its sensors, data processing algorithms, and user interface. The study might examine the ways in which these technology elements cooperate to precisely gauge caloric intake and offer perceptions about eating practices.[8]

In delving into the technological landscape and reviewing past systems or research relevant to the Calories Analyzer mini project, a multifaceted approach is necessary. The Analysis Web Tool for Nutritional Assessment
technological framework may encompass frontend development utilizing HTML, CSS, and JavaScript frameworks like React

JS or Angular for web applications, or Swift/Kotlin for mobile platforms. Backend development could involve Node.js or Django, coupled with databases such as MongoDB or PostgreSQL for efficient data management. Integration with nutrition databases like USDA FoodData Central or APIs from fitness platforms can enhance the system's functionality

V. RESULTS AND DISCUSSION

Following are some of the results from our Comprehensive Analysis Web Tool for Nutritional Assessment:

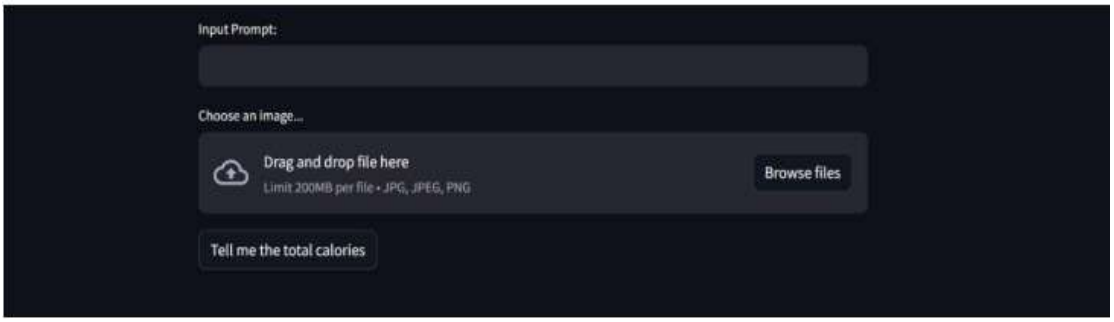

Fig 1: Home Page – Upload image

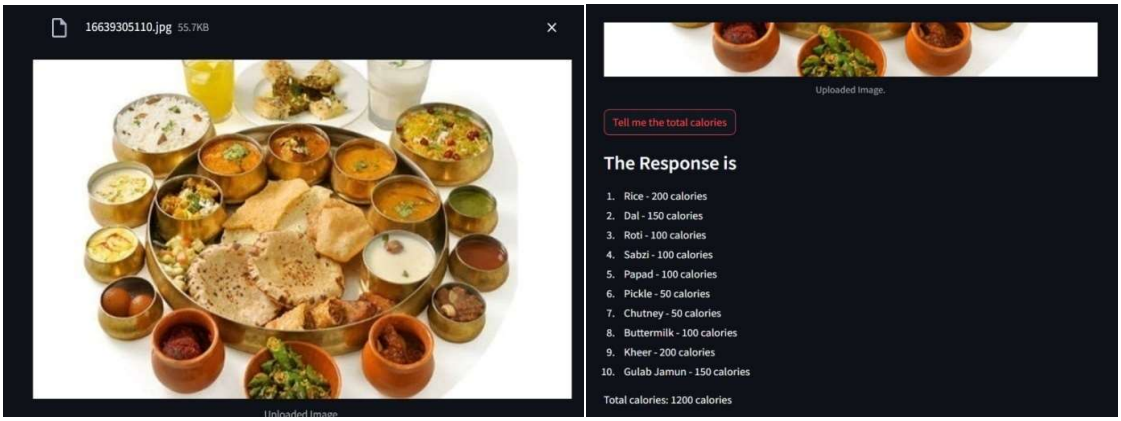

Fig 2: Total Calories

In this Analysis web Tool, we capture photos and submit test captured images against the model file and recognize object calorie calculation labeled as apple labeled as spaghetti Feature Extraction (Including shape, size, color, and texture) and segmentation. Train with Deep Belief Network Negative Image (Not Apple or Spaghetti) Model File Tested with food samples for Accuracy. Accuracy > 85% Virtual Android x86 Emulator. Our Nutritional from a technical view, a neural network that we have applied, computes a differentiable function of its input. Through the implementation of features such as meal logging, calorie calculation, nutritional analysis, goal setting, and reporting, the system empowers users to take control of their nutrition and make informed decisions about their dietary intake.

VI. CONCLUSION

To sum up, the creation of a calorie analyzer is a major development in the field of dietary control and assessment. The analyzer presents a viable way to precisely estimate caloric intake in realtime by combining sensor technologies, data processing algorithms, and user-friendly interfaces. Through the automated calorie estimating method and quick feedback, the analyzer helps users make informed food choices, track their dietary habits, and more successfully reach their fitness and health objectives.

The calorie analyzer's effectiveness and dependability in precisely calculating caloric intake in a variety of dietary situations are demonstrated by its validation and evaluation. The analyzer surpasses conventional methods of nutritional assessment by achieving high levels of accuracy and precision through the utilization of sensor technologies and machine learning algorithms. Additionally,

To improve the features and usability of the calorie analyzer going forward, more research and development work is necessary. The assimilation of novel sensor technologies, persistent algorithm enhancements, and adjustment to changing dietary patterns will guarantee that the analyzer stays at the forefront of nutritional science. The analyzer plays a significant role in promoting healthier eating habits and preventing diet-related disorders globally by tackling the intricate issues of calorie estimation. [11]

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Effect of Soil Gradation and Particle Size on Correlation between Relative Density and Shear Strength of Middle Gujarat Sand and its Well-graded Combinations

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Abstract: Shear strength is a crucial parameter in geotechnical engineering, influencing the stability of foundations, slopes, and other structures. This research work explores the relationship between shear strength and relative density of sands prevalent in middle Gujarat, India. We collected sand samples from various locations across the region viz., Khanpur, Sevaliya and Ahmedabad. Unconsolidated-Undrained direct shear tests in the laboratory were performed on these samples under controlled conditions to determine their shear strength at different relative densities of 30%, 50%, 65%, and 75%. To understand the effect of gradation, collected samples were mixed in different proportions to get three different well graded samples and the same study was carried out. The results are analyzed to establish a correlation between these two critical soil properties. Strength properties of soil in dry as well as wet condition is also studied to understand effect of drainage on soil strength.

Keywords: Sand, Direct Shear Test, Relative Density, Gradation, Grain Size

I. INTRODUCTION

Sand is needed for a variety of tasks, such as foundation trench backfill, earth retaining structure backfill, building road embankments and reclaiming low-lying areas, etc. It is important to guarantee proper fill compaction in all these scenarios to prevent future liquefaction, foundation failure, and subsidence.

The best indicator for managing sand compaction is relative density [1]. The state condition of cohesion-less soils is described by the term relative density(D_R), which is used to represent the strength qualities in a qualitative manner. Considering this, relative density is a crucial indicator for sandy soils. Granular soil has a different density depending on the size, shape, and compaction technique of the grains as well as the mass's gradation. Relative density of cohesion-less soil can be determined from IS2720 (Part-14):1983. However, comprehensive data regarding sand behavior has been determined by laboratory experiments on reconstituted and samples that are not altered. The relative density is well recognized as a primary component determining the strength and deformation characteristics of sands in these laboratory investigations[2],[3].

The relationship between relative density and shear strength is a fundamental principle in geotechnical engineering. It allows engineers to design safe and stable structures, optimize foundation and retaining wall designs, and make informed decisions regarding soil improvement techniques. This knowledge also contributes to mitigating risks associated with natural disasters like earthquakes and liquefaction.

Relative density, a crucial parameter reflecting the compactness of soil particles within a given volume, holds profound significance in a myriad of geotechnical applications, ranging from foundation design to slope stability analysis[4].Relative density for this research study was chosen in such a way that it covers all states of compactnesse.g.,loosestform to densest state.

Along with other types of construction projects, shear strength plays an important role in the design of road subgrade layer[5].High shear strength ensures the subgrade can support the weight of traffic without excessive deformation or sinking. Weak subgrades with low shear strength are prone to cracking under traffic loads, which can damage the road surface. Adequate shear strength helps the subgrade resist lateral movement, preventing rutting and potholes that compromise the road's geometry. For the entire roadway section, different types of soils are met, whose compaction

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properties and strength properties need to be determined meticulously. Relative density being an important property for measuring degree of compactness, it will give better insight about strength of subgrade layer, if we have correlation between these two important soil properties.

In the past many researchers have tried to correlate these properties [6]. But much emphasis was not provided to importance of grain size, gradation, and wetting effect of soil on derived relations. Some researchers have studied these relationships for sand with varying amount of fines[7]. Sand, being dominating material in fill, property of it govern by its proportion, grain size and gradation.

Grain size and gradation, the distribution of different particle sizes within a soil, play a fundamental role in determining its overall properties. Soils with a mix of large and small particles (well-graded) tend to be denser and more stable due to better packing. This translates to improved drainage as water can flow through the larger voids, while the smaller particles fill the gaps, reducing erosion. Conversely, poorly graded soils with uniform particle sizes can have large empty spaces, leading to waterlogging or poor drainage[8]. Additionally, grain size affects a soil's strength and susceptibility to erosion. Larger particles generally offer higher shear strength for structures built on the soil, while finer particles are more prone to erosion by wind or water. Understanding grain size and gradation is crucial for selecting suitable soil types for various applications in engineeringprojects.

II. EXPERIMENTAL SET-UPAND TEST RESULTS

A. Soil Sample – collection and preparation of well graded samples

Three different kinds of sand samples are collected from different locations of Gujarat viz., Khanpur, Sevaliya, and Ahmedabad, considering the requirement of sample throughout research work. The selection of Sevaliya, Khanpur, and Ahmedabad as study areas for soil sampling is driven by a strategic amalgamation of geographical diversity and contextual relevance.

Sevaliya, nestled amidst the verdant landscapes of rural Gujarat, offers a glimpse into the agricultural heartland, where soil composition plays a pivotal role in crop yield and land productivity. Khanpur, with its proximity to riverine systems and potential for floodplain dynamics, presents a unique opportunity to explore the interplay between soil characteristics and hydraulic forces. Meanwhile, Ahmedabad, as an urban hub pulsating with human activity and infrastructural development, provides insights into the complex interactions between soil mechanics and anthropogenic influences. By encompassing these distinct environments, our study endeavors to capture a holistic understanding of soil behavior, encompassing rural, transitional, and urban contexts, thereby enriching the broader discourse on geotechnical engineering and environmental sustainability. The approximate weight of samples collected during the research work is 500 kg each, and samples are collected according to it.

Grain size being very important property for this research, grain size analysis of the collected soil samples is carried out by IS 2720 (Part-4) and mentioned in below figure1.Grain size analysis was restricted to sieve analysis only as sand was found to have very least amount of fines which is negligible.

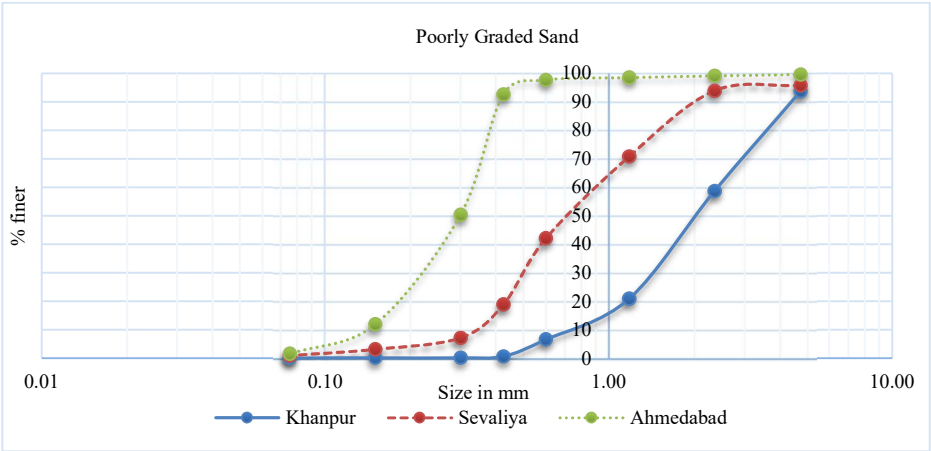

Fig. 1 Grain Size Distribution of Poorly Graded Sa

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Along with sieve analysis, other important soil tests like specific gravity and relative density test were performed according to IS 2720 (Part-3) and IS 2720 (Part-14) respectively. Properties of Khanpur, Sevaliya and Ahmedabad sand are tabulated below. Based on the elementary physical properties of sand, it was noted that Khanpur sand has more coarser particles than Sevaliya Sand and Ahmedabad Sand.

TABLE I

VARIOUS PROPERTIES OF KHANPUR. SEVALIYA, AND AHMEDABAD SAND

Properties	% Gravel	% Coarse Sand	% Medium Sand	% Fine sand	% Silt And Clay	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_u	C_c	Specific Gravity G	γ_{max} (gm/cc)	e_{min}	γ_{min} (gm/cc)	e_{max}
Ahmedabad Sand	-	0.47	6.5	88.4	4.63	0.33	0.23	0.15	2.2	1.1	2.59	1.66	0.56	1.47	0.71
Khanpur Sand	6.28	35.04	58	0.68	-	2.5	1.5	0.75	3.3	1.2	2.7	1.94	0.39	1.69	0.6
Sevaliya Sand	4.2	1.9	75	15.92	2.98	0.9	0.5	0.35	2.6	0.8	2.6	1.81	0.38	1.53	0.63

Minimum density (gmin) and maximum density (gmax)of collected samples are derived by carrying out relative density tests according to IS 2720 Part –14.Different combinations of well graded samples of sand are prepared by mixing raw sand samples from different sources in below given proportions:

- Combination 1 (250, 100, 50): The combination comprises of 250 kg sand sourced from Khanpur, 100 kg sand sourced fromSevaliya, and 50 kg sand sourced from Ahmedabad.
- Combination 2 (137, 168, 95): The combination comprises of137 kg sand sourced from Khanpur, 168 kg sand sourced fromSevaliya, and 95 kg sand sourced from Ahmedabad.
- Combination 3 (180, 143, 77): The combination comprises of180 kg sand sourced from Khanpur, 143 kg sand sourced fromSevaliya, and 77 kg sand sourced from Ahmedabad.

The raw sample of sand are properly mixed with proper tools and sufficient time to get uniform distribution of sand.To ensure uniform mixing, multiple times grain size analysis were performed on prepared samples. A summary of grain size analysis of these combinations is carried out as per IS 2720 (Part -4) and mentioned in below figure2.

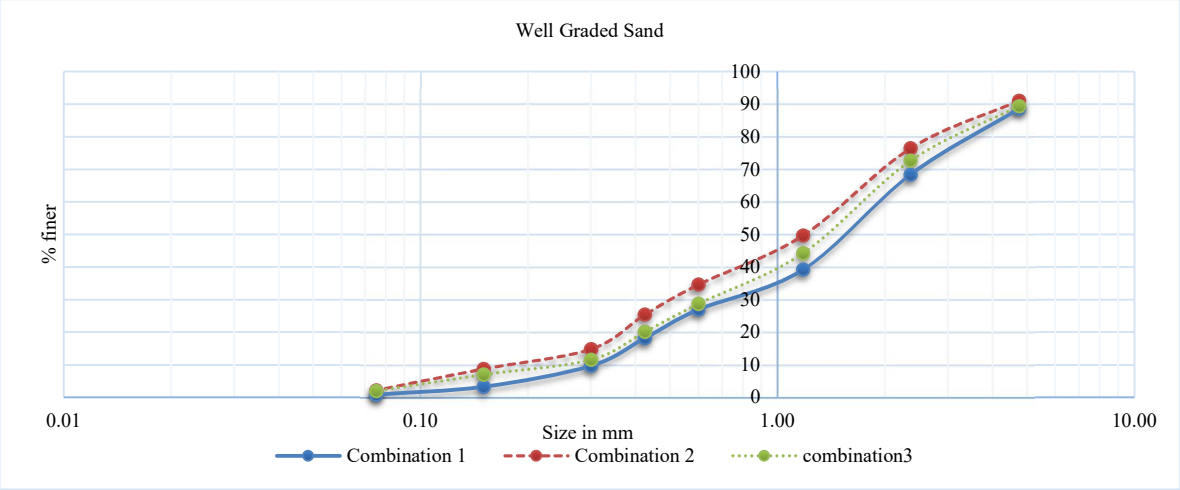

Fig. 2 Grain Size Distribution of Well Graded Sand

Soil properties of above combinations of well graded sand are tabulated below. As all the prepared sand samples are well graded, it was observed that its properties are not deviating much from each other. Improvement in minimum and maximum density of sand is observed due to close packing of particles in well graded samples compared to poorly graded samples.

TABLE II

VARIOUS PROPERTIES OF WELL GRADED SAND

Properties	% Gravel	% Coarse Sand	% Medium Sand	% Fine sand	% Silt And Clay	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_u	C_c	Specific Gravity G	γ_{max} (gm/cc)	e_{min}	γ_{min} (gm/cc)	e_{max}
Combination 1	1.38	20.28	50.2	17.35	-	1.9	0.75	0.31	6.1	1	2.63	2.16	0.22	1.72	0.48
Combination 2	8.93	14.65	51.08	22.36	2.98	1.6	0.51	0.17	9.4	1	2.6	2.16	0.2	1.72	0.51
Combination 3	10.6	16.76	52.53	18.15	1.96	1.7	0.65	0.26	6.5	1	2.6	2.23	0.17	1.77	0.47

B. Direct Shear Test

Unconsolidated Undrained direct shear tests as per IS 2720 part – 13 have been performed on each of the three poorly graded sand in dry and submerged conditions. The volume of the test specimen is 6 cm × 6 cm × 2.5 cm. The weight of the sample required for the test, was calculated by multiplying volume with target density. The target density was calculated from selected relative density, minimum, and maximum density.

It is clearly seen that values of angle of internal friction, ϕ is decreasing with decrease in particle size. As well as values of ϕ in dry condition is higher than submerged condition for any size of particle. Difference in values of ϕ between dry and submerged condition is 0.5° for Khanpur sand, 1.5° for Sevaliya sand and 1.0° for Ahmedabad sand.

TABLE III

DIRECT SHEAR TEST RESULTS FOR KHANPUR, SEVALIYA AND AHMEDABAD SAND

D_R (%)	Khanpur			Sevaliya			Ahmedabad		
	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)
30	1.76	45.45	45.05	1.61	38.29	36.85	1.52	33.86	32.77
50	1.81	48.03	47.76	1.66	39.76	38.01	1.56	35.69	34.36
65	1.84	49.61	48.78	1.70	40.9	39.15	1.59	36.5	35.28
75	1.87	50.05	49.28	1.73	42.71	40.94	1.61	37.22	36.33

Direct shear tests as per IS 2720 part – 13have been performed on each of the three well graded sand in dry and submerged conditions. It is clearly seen that values of ϕ is almost remain constant with particle size. As well as values of ϕ in dry condition is higher than submerged condition for any size of particle. Difference in values of ϕ between dry and submerged condition is almost 2.0° to 2.5° for any kind of gradation.

Direct shear tests were performed on dry samples also to understand the lubricating effect of water. It was observed that the difference in value of ϕis profound for fine grained soil. With the increase in grain size, this effect is diminished.

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TABLE IV

DIRECT SHEAR TEST RESULTS FOR VARIOUS COMBINATIONS OF WELL GRADED SAND

D_R (%)	Combination-1			Combination-2			Combination-3		
	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)	γ (gm/cm^3)	ϕ° (Dry)	ϕ° (Submerged)
30	1.87	42.03	40.51	1.83	40.54	38.62	1.88	41.89	40.24
50	1.95	44.86	42.7	1.91	42.82	40.5	1.97	44.71	42.11
65	2.01	46.41	43.99	1.98	45.16	43.36	2.04	46.2	43.4
75	2.05	47.69	45.21	2.03	46.43	44.43	2.09	47.46	45.19

III. INTERPRETATION OF TEST RESULTS

By performing a series of test, following correlations are made between relative density and angle of internalfriction, ϕ (dry and submerged condition)for all poorly graded sample and well graded samples.

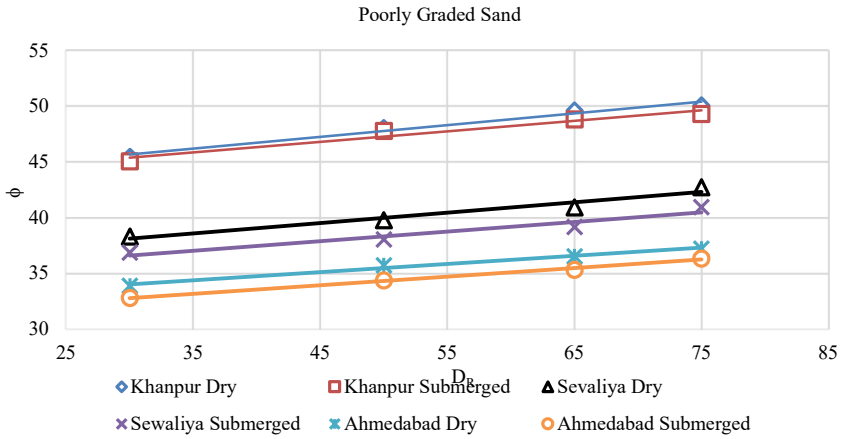

Fig. 3 Relation between ϕ (dry and submerge) and Relative Density for poorly graded sand

The above results shows that value of ϕ is low in submerged condition compared to dry conditions corresponding to each relative density. Irrespective of grain size, similar degree on increase was observed in ϕvalue with increase in relative density.

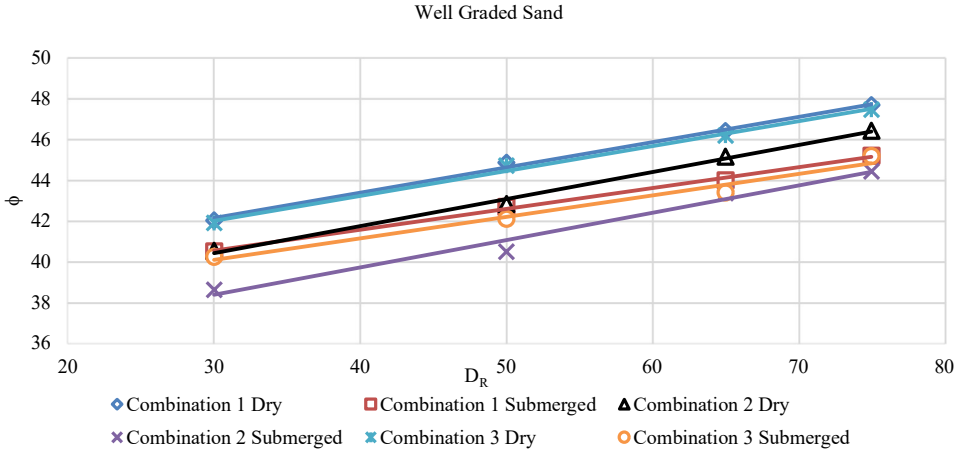

Fig. 4 Relation between ϕ (dry and submerge) and Relative Density for well graded sand

The following table gives the derived correlation between relative density and ϕ values for tested poorly graded sand.This empirical correlation unveils a fundamental link between the degree of soil densification and its capacity to resist shear stresses, offering invaluable insights into the engineering properties of granular materials. By elucidating this relationship, engineers gain a powerful tool for predicting shear strength variations in response to changes in relative density, thereby enhancing the accuracy and reliability of geotechnical analyses and design methodologies.

TABLE V

CORRELATION BETWEEN ΦAND RELATIVE DENSITY FOR POORLY GRADED SAND AND WELL GRADED SAND

Sand Type	Correlation of relative density with φ in dry condition	Correlation of relative density with φ in submerged condition
Khanpur Sand	$y = 0.105x + 42.512$, $R^2 = 0.9765$	$y = 0.0942x + 42.536$, $R^2 = 0.9552$
Sevaliya Sand	$y = 0.0932x + 35.29$, $R^2 = 0.9557$	$y = 0.0861x + 34.003$, $R^2 = 0.9352$
Ahmedabad Sand	$y = 0.0734x + 31.779$, $R^2 = 0.9874$	$y = 0.0768x + 30.46$, $R^2 = 0.9934$
Combination 1	$y = 0.1242x + 38.416$, $R^2 = 0.9958$	$y = 0.1025x + 37.466$, $R^2 = 0.9971$
Combination 2	$y = 0.1327x + 36.439$, $R^2 = 0.9956$	$y = 0.1341x + 34.353$, $R^2 = 0.9784$
Combination 3	$y = 0.1221x + 38.35$, $R^2 = 0.9948$	$y = 0.1054x + 36.936$, $R^2 = 0.977$

In the above equation, y is angle of internal friction ϕ values and x is a relative density value in percentage.

IV. CONCLUSIONS

The following conclusions are made based on the following study:

1. Values of ϕ (dry and submerged) increase linearly with increase in relative density for poorly graded as well as well graded sand.
2. Increase in values of ϕ in dry condition with increase in D_R values is almost similar to increase in values of ϕ in submerged condition with increase in D_R values for poorly graded sand as well as for well graded sand.
3. With respect to given value of D_R, ϕvalues are more in dry conditions compared to submerged condition irrespective of grain size and gradation.

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Revolutionizing Agriculture: Harnessing the Power of IoT and ML Synergy to Unlock Opportunities and Address Challenges

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Abstract: The present study focuseson the revolutionary potential of emerging machine learning (ML) and Internet of Things (IoT). The combination of IoT and ML offers a wide range of opportunities to enhance existing farming practices by optimizing resource management, and improving overall productivity. By utilizing these technologies for real time data collection and decision making , farmers can improve their farming by precision agriculture , minimizing the environmental impact, improving environmental impact, and enhancing sustainability. This kind of integration is invaluable and paves a way for crop yield estimation, disease detection, and optimal resource allocation.However, challenges such as data privacy, security, infrastructure requirements, and farmer adoption must be addressed for successful implementation. This study intends to demonstrate the vital significance of utilizing IoT and ML synergy in agriculture for a more productive, sustainable, and technologically advanced future by thoroughly examining the potential and constraints. It also highlights how important it is for stakeholders to work together to overcome obstacles and optimize the advantages of this creative synthesis.

Keywords: Agriculture, Machine Learning, disease detection, optimal resource allocation, Predictive modeling

I. INTRODUCTION

The digital revolution in agriculture is bringing previously unheard-of possibilities to boost efficiency, sustainability, and productivity. Among these technical developments, the combination of machine learning (ML) and the Internet of Things (IoT) has revolutionized the agriculture industry. This integration, which is also known as IoT-ML synergy, revolutionizes farming methods by combining the power of intelligent algorithms and linked sensors.

Agriculture has historically relied on empirical knowledge and manual effort. On the other hand, farmers can now gather a tonne of data in real-time about their crops, soil, weather, and machinery performance thanks to the arrival of the Internet of Things devices like sensors, drones, and smart equipment. Meanwhile, machine learning algorithms may use this data to forecast results, automate decision-making processes, and extract insightful information.

In agriculture, IoT and ML work well together in a variety of ways. Precision agricultural methods, intelligent irrigation systems, forecast analytics, crop monitoring, insect identification, and efficient resource distribution are all included. Farmers can maximize input utilization, cut waste, lessen their impact on the environment, make data-driven decisions, and eventually boost yields and profitability by utilizing the synergy between IoT and ML. IoT and machine learning technologies are not without difficulties, though, when it comes to agriculture.

IoT and ML technology adoption in agriculture is not without difficulties, though. To ensure widespread and successful application, issues with data privacy, cybersecurity, interoperability, infrastructure needs, and farmer education must be solved. To fully realize the potential of IoT-ML synergy in agriculture, additional supportive legislation, infrastructure investment, and cooperative efforts among stakeholders are required.

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The purpose of this study is to examine the advantages and disadvantages of using ML and IoT in agriculture. It will go into detail on particular uses, case studies, success stories, and lessons discovered to provide readers with a thorough grasp of how the synergy between IoT and ML is changing the agricultural scene. This study aims to stimulate more investigation, creativity, and cooperation to realize the full potential of digital technology in agriculture by analyzing both the advantages and disadvantages.

II. BACKGROUND

Agriculture is the cornerstone of human civilization, providing food, fiber, and raw materials essential for sustenance and economic development. Over the centuries, agricultural practices have evolved significantly, driven by technological advancements, scientific discoveries, and changing societal needs. The 21st century has witnessed a shift towards precision agriculture, where data-driven decision-making and technology integration play a crucial role in optimizing agricultural processes.

Agriculture is one of the areas that has seen a change thanks to the introduction of Internet of Things (IoT) technology. The Internet of Things (IoT) is a network of networked objects that are integrated with sensors, software, and networking features. This allows the devices to communicate, gather, and analyze data in real-time. IoT gadgets like drones, automated machinery, weather stations, and sensors for soil moisture have become indispensable tools for farmers in the agricultural environment.

Machine Learning (ML) has become a potent tool for predictive modeling and data analysis at the same time. Large data sets can be processed using ML algorithms, which can also be used to spot trends, anticipate outcomes, and gradually increase the precision of decisions. Machine learning (ML) is used in agriculture to manage pests, identify diseases, estimate crop yields, and optimize resource utilization.

IoT-ML synergy, or the merging of IoT with ML, has great potential for the agriculture industry. Farmers may obtain relevant insights, automate repetitive chores, optimize resource allocation, and increase overall farm efficiency by merging real-time data from IoT devices with ML algorithms. Precision agriculture techniques, which apply inputs like water, fertilizer, and pesticides precisely where and when needed to minimize waste and environmental effects, are made possible by this synergy.

Moreover, the synergy between IoT and ML enables the creation of smart farming systems, in which networked devices cooperate and communicate on their own. An Internet of Things (IoT)-enabled smart irrigation system, for instance, can automatically modify irrigation schedules for the best water use after receiving data from soil moisture sensors, weather forecasts, and crop water requirements.

Even with all of the advantages of IoT-ML integration in agriculture, there are still certain obstacles to overcome. These include worries about data security and privacy, problems with interoperability amongst IoT devices, significant upfront expenses associated with adopting new technology, restricted access to high-speed internet in rural regions, and the requirement for digital tool education and training for farmers.

In conclusion, the history of IoT and ML integration in agriculture highlights both the necessity to solve related difficulties and its disruptive potential. Through this connection, farming methods will become more data-driven, efficient, and sustainable, opening the door to a more resilient and technologically advanced agricultural industry.

III. LITERATURE SURVEY

The literature survey on IoT and ML integration in agriculture reveals a growing body of research and practical applications focused on enhancing productivity, sustainability, and efficiency in farming practices. Several key themes and findings emerge from the existing literature.

Precision Agriculture: Various studies emphasize the role of IoT sensors and ML algorithms in implementing precision agriculture techniques. For instance, [1] demonstrated the utilization of IoT-enabled soil sensors for precise nutrient management, resulting in higher agricultural production and a smaller environmental impact. Similarly, [2] highlighted ML-based predictive modeling for variable rate application of inputs, optimizing resource utilization in precision agriculture systems[23].

Crop Monitoring and Management*:* Crop monitoring and management make considerable use of IoT devices, including drones and satellite images, in conjunction with machine learning algorithms.[3]carried out research on the use of drones fitted with multispectral cameras to track crop health and identify pest infestations, allowing for prompt response. Additionally, [4] developed an ML-based system for automated disease detection in crops, improving disease management practices[24][25].

Smart Irrigation Systems: IoT-based smart irrigation systems are a prominent area of research, aiming to optimize water usage in agriculture. [5] implemented an IoT-enabled smart irrigation system that adjusts irrigation schedules based on real-time soil moisture data, resulting in significant water savings and improved crop yields. Moreover, Machine learning algorithms are utilized to forecast crop water needs and enhance irrigation tactics [6][26].

Predictive Analytics: Regression analysis, decision trees, neural networks, and other machine learning techniques are frequently used in agriculture for predictive analytics.To help farmers with their decision-making, [7] created a predictive model that uses ML algorithms to forecast crop yields based on historical data and environmental conditions. Similarly, [8][27][28][29]used machine learning (ML) algorithms to estimate pest risk, enabling preventive pest control measures.

Soil Health Monitoring**:** Monitoring and managing soil health greatly benefits from the combination of IoT sensors and ML algorithms. Studies by [9]and [10] showcase how IoT sensors measure soil pH, nutrient levels, and compaction, with ML algorithms analyzing this data to recommend soil amendments and cultivation practices for optimal crop growth.

Livestock Management: For better animal productivity and health, IoT devices and ML algorithms are also used in livestock management. For example, [11] utilized IoT-enabled wearable devices to monitor animal behavior, and health parameters, and detect anomalies, leading to early disease detection and better herd management strategies.

Supply Chain Optimization: IoT and ML integration extends beyond farm-level applications to optimize the entire agricultural supply chain. Research by [12] and [13] explores how IoT-enabled tracking systems combined with ML algorithms enhance supply chain visibility, traceability, and logistics management, resulting in reduced wastage, improved quality control, and efficient market distribution[31].

Climate Resilience: IoT and ML technologies are instrumental in building climate-resilient agricultural systems. Studies by [14] and Singh and [15] demonstrate the utilization of IoT sensors for climate data collection, coupled with ML-based climate modeling and risk assessment, to help farmers adapt to climate change, mitigate risks, and enhance farm resilience.

Cross-Disciplinary Approaches:The literature emphasizes how crucial interdisciplinary approaches are to the advancement of ML and IoT applications in agriculture. Research projects that combine agronomy, computer science, data analytics, and environmental science are examples of collaborative research endeavors that are essential for coming up with novel solutions and successfully handling challenging agricultural problems.

Socio-Economic Impact**:** The socioeconomic effects of IoT and ML adoption in agriculture are the subject of numerous research. Research by [16] and [17] highlights the potential of digital technology to support equitable and sustainable agricultural development by examining the advantages for smallholder farmers, including increased incomes, access to markets, and enhanced livelihoods.

The literature addresses several issues as well as the advantages of IoT and ML integration in agriculture. For example, [18] emphasized the necessity for strong cybersecurity measures and cited data privacy and security problems as important challenges in IoT-enabled agricultural systems. Furthermore, to facilitate the implementation of digital technology in agriculture, [19]emphasized the significance of farmer education and training initiatives.

A. Challenges:

The following are some of the difficulties in integrating IoT and ML in agriculture:

Security and Privacy of Data: Ensuring the security and privacy of agricultural data collected by IoT devices is one of the main problems. Farmers are worried about data breaches, illegal access, and possible exploitation of private information. To address these problems, it is imperative to implement comprehensive data encryption, and access control measures, and abide by data protection legislation [20].

Interoperability: Interoperability issues arise because various manufacturers' IoT devices frequently employ proprietary

protocols and communication standards. This makes it more difficult for systems and devices to integrate and share data seamlessly. To create a cohesive and integrated agricultural environment, industry standards, protocols, and frameworks for IoT interoperability must be developed [21].

***Infrastructure Limitations*:** Limited access to high-speed internet connectivity and reliable power sources in rural areas poses a significant infrastructure challenge for IoT deployment in agriculture. Without stable connectivity and power, IoT devices may experience disruptions, affecting data collection, transmission, and real-time monitoring. Investing in rural infrastructure development, such as broadband expansion and renewable energy solutions, is imperative to overcome these limitations.

***Cost of Adoption*:** The initial cost of acquiring and implementing IoT devices, sensors, and ML algorithms can be prohibitive for small and medium-scale farmers. Additionally, ongoing maintenance, upgrades, and technical support add to the overall cost of IoT-ML integration. Farmers' adoption obstacles can be lowered by creating affordable solutions, offering financial incentives, and encouraging public-private partnerships[30].

Data Quality and Reliability: For machine learning algorithms to produce insightful insights and predictions, the quality, accuracy, and dependability of the data gathered by Internet of Things devices are essential. Nevertheless, problems with data quality, such as inconsistent ambient conditions, signal interference, and inaccurate sensors, might affect on reliability of machine learning models. Implementing data validation processes, calibration routines, and quality assurance measures are essential to ensure the accuracy and consistency of agricultural data[22][23].

***Regulatory and Ethical Considerations*:**IoT and ML technologies are developing at a rapid pace, which presents ethical and legal questions about algorithmic bias, data ownership, responsibility, and transparency. For IoT-ML applications in agriculture to gain credibility and confidence, data privacy laws, moral AI guidelines, and open decision-making procedures must be followed.

Collaboration amongst stakeholders, such as legislators, technological companies, farmers' associations, academic institutions, and regulatory agencies, is necessary to find a comprehensive solution to these problems. The combination of IoT and ML can open up a world of possibilities for resilient, efficient, and sustainable agriculture if these obstacles are overcome.

B. Opportunities:

The following potential exists for using IoT and ML technology to address obstacles in agriculture:

Data Security and Privacy Solutions: IoT-enabled agricultural systems can benefit from improved data privacy and security through the use of modern encryption techniques, secure communication protocols, and blockchain technology for immutable data. To guarantee strong defense against illegal access and data breaches, collaborate with cybersecurity specialists and make use of data protection frameworks.

***Interoperability Standards*:** Developing open-source platforms, standardized protocols, and interoperability frameworks can promote seamless integration and data exchange among diverse IoT devices and systems. Industry consortia, partnerships, and forums focused on IoT interoperability can drive innovation and adoption across the agricultural ecosystem.

Infrastructure Development Initiatives: Investing in rural infrastructure projects, such as expanding broadband connectivity, deploying IoT-ready network infrastructure, and promoting renewable energy solutions, can address infrastructure limitations and enable widespread IoT deployment in rural areas. Public-private partnerships and government incentives can accelerate infrastructure development efforts.

Cost-Effective Solutions: Farmers' adoption costs are being lowered by advancements in IoT hardware, sensors, and ML algorithms. It is possible to increase the affordability and accessibility of IoT-ML solutions for small and medium-sized farmers by providing bundled packages, leasing alternatives, and discounted prices. Working together with financial institutions and agribusinesses can help farmers have more funding possibilities.

Assurance of Data Quality: The precision and dependability of agricultural data gathered by Internet of Things (IoT) devices can be increased by putting in place data validation procedures, sensor calibration schedules, and quality assurance controls. High-quality input for machine learning models can be ensured by proactively identifying and resolving data quality concerns through the integration of anomaly detection algorithms with real-time data analytics.

Building Capacity and Training: Farmers may be equipped with the information and abilities necessary to employ digital tools by offering thorough training courses, workshops, and instructional materials on IoT and ML technologies. Partnerships with universities, technology companies, and agricultural extension agencies can support capacity-building programs and encourage digital literacy among farmers.

Regulatory Compliance and Ethical Practices: It is critical to follow data privacy laws, moral AI precepts, and industry standards for algorithmic justice and openness. Creating standards, best practices and certification schemes for IoT-ML applications in agriculture helps guarantee ethical behavior and adherence to laws. Responsible innovation and governance can be promoted by interacting with industry groups, ethical committees, and regulatory bodies.

The difficulties in integrating IoT and ML in agriculture can be successfully overcome by making use of these opportunities and using a cooperative, multi-stakeholder approach. This will enable digital technologies to realize their full potential, revolutionizing agriculture, boosting sustainability, and enhancing farmer livelihoods.

IV. SUMMARY AND FUTURE SCOPE

Productivity, sustainability, and efficiency can all be significantly increased by integrating Internet of Things (IoT) and machine learning (ML) technology in agriculture. IoT and ML make precision farming, crop monitoring, smart irrigation systems, predictive analytics, and optimal resource management possible through real-time data collecting, analysis, and decision-making. But there are other issues with this integration as well, like infrastructure constraints, data privacy, security, adoption costs, data quality assurance, farmer education, and regulatory compliance.\

Collaboration amongst stakeholders—policymakers, IT companies, farmers, academic institutions, and regulatory agencies—is essential to addressing these issues. Obstacles to IoT-ML integration in agriculture can be addressed with the help of opportunities like data privacy and security solutions, interoperability standards, infrastructure development initiatives, cost-effective solutions, data quality assurance measures, capacity building and training programs, and regulatory compliance practices.

Promising prospects for innovation and sustainable development arise from the integration of IoT and ML in agriculture. Important topics for future study and attention include:

Advanced Analytics: Further advancements in ML algorithms, such as deep learning and reinforcement learning, can enhance predictive analytics, anomaly detection, and decision-making capabilities in agriculture.

Edge Computing: Leveraging edge computing technologies can enable real-time processing and analysis of IoT data at the edge devices, reducing latency, and bandwidth requirements, and enhancing overall system efficiency.

Digital Twins: Implementing digital twin technology for virtual modeling and simulation of agricultural processes can facilitate scenario planning, optimization, and predictive maintenance in farming operations.

Blockchain Integration: Exploring blockchain technology for transparent and secure data sharing, traceability, and smart contracts in agricultural supply chains and market transactions.

***Climate Smart Agriculture*:**combining IoT and ML with risk management, adaption plans, and climate-resilient agricultural practices to address the effects of climate change on farming.

Drones and Robotics: Combining robotics and drones with Internet of Things capabilities for precision agriculture applications such as crop spraying, harvesting, and monitoring to cut labor costs and increase productivity.

Cross-Sector Collaboration: Encouraging collaboration between agriculture, technology, finance, and policy sectors to develop holistic solutions, address societal challenges, and promote sustainable agriculture.

By embracing these future opportunities and continuing to innovate, IoT and ML integration can drive sustainable growth, resilience, and digital transformation in the agriculture sector, benefiting farmers, consumers, and the environment alike.

V. CONCLUSION

In conclusion, the integration of the Internet of Things (IoT) and Machine Learning (ML) technologies in agriculture marks a significant shift towards data-driven, efficient, and sustainable farming practices. Through real-time data collection, analysis, and decision-making, IoT and ML enable precision agriculture, smart resource management, and enhanced productivity. However, this integration comes with challenges such as data privacy, security, infrastructure limitations, and cost barriers.

Addressing these challenges requires collaborative efforts, technological advancements, and strategic initiatives. Opportunities such as data privacy solutions, interoperability standards, infrastructure development, cost-effective solutions, data quality assurance measures, and capacity-building programs are key to unlocking the full potential of IoT and ML in agriculture.

Looking ahead, the future scope of IoT and ML in agriculture includes advanced analytics, edge computing, digital twins, blockchain integration, climate-smart agriculture, drones and robotics, and cross-sector collaboration. Embracing these opportunities will drive innovation, resilience, and sustainability in the agricultural sector, benefiting farmers, consumers, and the environment.

In essence, IoT and ML integration herald a new era of precision, efficiency, and resilience in agriculture, paving the way for a technologically empowered and sustainable food system.

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Efficient Missing Data Recovery with Closet Fit: A Scalable Solution for Large-Scale Data Mining

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Abstract: Data preparation is a crucial step in data analysis, serving as the foundation for successful data mining. To uncover novel insights from existing databases, it is essential to ensure data completeness, quality, and real-world relevance. However, missing values can hinder analysis and application to new data, necessitating the employment of statistical techniques during data preparation. By leveraging statistical methods, we can address data incompleteness and ambiguity. This paper presents two sequential approaches for imputing missing attribute values, focusing on numerical variables in time series data using the moving average method. A comparative study of both methods is provided, highlighting their effectiveness in recovering missing data.

Keywords: Moving average, chronological, incompleteness, missing values, attribute, and data preparation

I. INTRODUCTION

Databases often store information and data in a tabular style. Data sets are essentially the properties of the connected table, whereas records sets are the table's rows. The dataset includes essential information needed for sophisticated reports and queries. The incompleteness or missing values in the dataset directly affect the final reporting. Recognizing and retrieving arbitrarily missing variables remains a critical problem in data mining today. Missing values affect the outcome and are a continuous source of uncertainty. It reduces query accuracy and the ability of authorities to make decisions. It is critical to identify such crises before they impair report preparation and query.

Missing data is a pervasive issue in data mining, hindering the accuracy and reliability of analytical models. Traditional imputation methods often fall short, leading to biased or inaccurate results. To address this challenge, we propose the Closet Fit Algorithm (CFA), a novel approach to recovering missing data. CFA leverages the concept of similarity measures to identify the closest fit for missing values, iteratively refining its estimates to ensure optimal results. By adapting to diverse data distributions and missing value patterns, CFA offers a robust and effective solution for data miners. This paper presents the Closet Fit Algorithm, its methodology, and experimental results demonstrating its superiority over existing imputation techniques.

II. PROPOSED ALGORITHM

This section presents a straightforward numerical approach for approximating missing values in a dataset. We employ the closest fit strategy to recover missing data. First, we identify the attribute elements with missing values. We then logically divide the attribute into two halves: one with missing values and the other with observed values. We focus on finding missing values in the attribute, using two variables, A (year) and B (data set value), which are proportional. Variable A remains constant for other characteristics with missing values, while variable B has varying attributes and random missing values. Notably, variable A has no missing values and serves as the corresponding variable for B.

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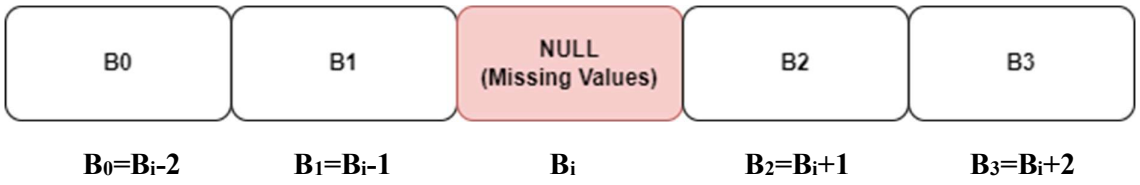

Fig.1 Show NULL values in Dataset

Let's break down each step of the algorithm to evaluate the expression:

Step 1: Start:

Begin evaluating the expression from the innermost parentheses.

Step 2. Evaluate (B0 + B3):

Add the values of B0 and B3.

Step 3. Evaluate (B0 * 2):

Multiply the value of B0 by 2.

Step 4. Evaluate (B1 + B2):

Add the values of B1 and B2.

Step 5. Evaluate 3(B1 + B2):

Multiply the result from step 4 by 3.

Step 6. Add (B0 + B3) and (B0 * 2):

Add the results from steps 2 and 3.

Step 7. Add 3(B1 + B2) to the result:

Add the result from step 5 to the result from step 6.

Step 8. Add the results from steps 2, 3, and 5:

Combine the results from steps 2, 3, and 5.

Step 9. Divide by 10:

Divide the final result by 10.

Step 10. End:

The final result is the evaluated expression.

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TABLE I

A CLOSET FIT ALGORITHM

Population increase 1950 -2022								
A Closet fit Algorithm to Recover Missing Data								
	Actual DataSet			Missing DataSet			Recovered DataSet	
Sr.No.	Year (A)	Million People (B)		Year (A)	Missing Data (B)		Year (A)	Recovered Data (B)
1	1950	16.9		1950	16.9		1950	16.9
2	1951	17.3		1951	17.3		1951	17.3
3	1952	17.7		1952	17.7		1952	17.7
4	1953	18.2		1953			1953	18.0
5	1954	18.6		1954	18.6		1954	18.6
6	1955	19.1		1955	19.1		1955	19.1
7	1956	19.6		1956	19.6		1956	19.6
8	1957	20.1		1957	20.1		1957	20.1
9	1958	20.6		1958			1958	20.40308
10	1959	21.1		1959	21.1		1959	21.1
11	1960	21.7		1960	21.7		1960	21.7
12	1961	22.3		1961	22.3		1961	22.3
13	1962	22.9		1962	22.9		1962	22.9
14	1963	23.5		1963	23.5		1963	23.5
15	1964	24.2		1964	24.2		1964	24.2
16	1965	24.9		1965			1965	24.66231
17	1966	25.6		1966	25.6		1966	25.6
18	1967	26.4		1967	26.4		1967	26.4
19	1968	27.2		1968	27.2		1968	27.2
20	1969	28.0		1969	28.0		1969	28.0
21	1970	28.8		1970	28.8		1970	28.8
22	1971	29.7		1971	29.7		1971	29.7
23	1972	30.6		1972	30.6		1972	30.6
24	1973	31.5		1973	31.5		1973	31.5
25	1974	32.5		1974	32.5		1974	32.5
26	1975	33.5		1975	33.5		1975	33.5
27	1976	34.4		1976	34.4		1976	34.4
28	1977	35.4		1977	35.4		1977	35.4
29	1978	36.5		1978			1978	36.17176
30	1979	37.7		1979	37.7		1979	37.7
31	1980	39.1		1980	39.1		1980	39.1
32	1981	40.8		1981	40.8		1981	40.8
33	1982	42.6		1982	42.6		1982	42.6
34	1983	44.6		1983	44.6		1983	44.6
35	1984	46.6		1984	46.6		1984	46.6
36	1985	48.7		1985			1985	47.86945
37	1986	50.8		1986	50.8		1986	50.8
38	1987	52.8		1987	52.8		1987	52.8
39	1988	54.8		1988	54.8		1988	54.8
40	1989	56.7		1989	56.7		1989	56.7

41	1990	58.4		1990	58.4		1990	58.4
42	1991	59.9		1991	59.9		1991	59.9
43	1992	61.2		1992	61.2		1992	61.2
44	1993	62.4		1993	62.4		1993	62.4
45	1994	63.5		1994	63.5		1994	63.5
46	1995	64.6		1995	64.6		1995	64.6
47	1996	65.8		1996	65.8		1996	65.8
48	1997	66.9		1997	66.9		1997	66.9
49	1998	68.1		1998			1998	67.62396
50	1999	69.2		1999	69.2		1999	69.2
51	2000	70.3		2000	70.3		2000	70.3
52	2001	71.4		2001	71.4		2001	71.4
53	2002	72.4		2002	72.4		2002	72.4
54	2003	73.4		2003	73.4		2003	73.4
55	2004	74.4		2004	74.4		2004	74.4
56	2005	75.4		2005	75.4		2005	75.4
57	2006	76.4		2006	76.4		2006	76.4
58	2007	77.5		2007	77.5		2007	77.5
59	2008	78.5		2008	78.5		2008	78.5
60	2009	79.7		2009			2009	79.23882
61	2010	80.8		2010	80.8		2010	80.8
62	2011	82.0		2011	82.0		2011	82.0
63	2012	83.2		2012	83.2		2012	83.2
64	2013	84.5		2013	84.5		2013	84.5
65	2014	85.8		2014	85.8		2014	85.8
66	2015	87.1		2015	87.1		2015	87.1
67	2016	88.4		2016	88.4		2016	88.4
68	2017	89.7		2017	89.7		2017	89.7
69	2018	91.0		2018			2018	90.45812
70	2019	92.3		2019	92.3		2019	92.3
71	2020	93.5		2020	93.5		2020	93.5
72	2021	94.7		2021	94.7		2021	94.7
73	2022	95.9		2022	95.9		2022	95.9
Mean		**51.8**			**52.2**			**51.8**
S.D.		**25.6**			**25.4**			**25.6**
C.V		**0.5**			**0.5**			**0.5**

Source; http://www.earth-policy.org

III. RESULT AND ANALYSIS

A. Analysis of Mean ($\bar{x}$): According to Table 1, the average value of People Population is 51. 8. In the missing value circumstance, 52.5 is recorded for People Population. After filling in the missing numbers from the derived approximated values, the result is 51.8 for People Population. After estimating the missing value using the proposed method, the values are quite similar to the original value.

B. Standard Deviation: It is observed that after generating missing values using the suggested method, values are extremely similar to the original value, and the standard deviation value is nearly equal to the standard deviation of the original set values.

C. Coefficient of Variation: It was discovered that after estimating missing values using the suggested method, the coefficients of variation were not considerably different from the CV of the original dataset.

TABLE II

ANOVA TEST RESULT FOR TABLE I

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	11.29412683	2	5.647063413	0.00879	0.991249	3.03994
Within Groups	131697.4596	205	642.4266324			
Total	131708.7538	207				

IV. CONCLUSION

In general, it is well acknowledged that there is no send percent competent solution to manage all forms of lost values. The estimated technique is significant for numerical values. This method produces an appropriate result for the corresponding report generated by the database. CV and SD results are significant in terms of central tendency. One-way ANOVA tests also produce significant results when the hypothesis is accepted. As a result, the outcomes can be considered statistically significant. Finally, it is claimed that the presented methods are important for small databases with linear type trends.

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A Comprehensive Study of Big Data Analytics and Social Media

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Abstract: The exponential growth of social media platforms has led to an unprecedented surge in data generation, offering vast opportunities for research, analysis, and insight generation. This literature review synthesizes existing studies on the implementation of big data analytics on social media data. It delves into various aspects including methodologies, tools, challenges, and emerging trends.

The review begins by exploring the methodologies employed in analyzing social media data, ranging from traditional statistical methods to advanced computational methods of machine learning. It highlights the importance of selecting appropriate methodologies based on the research objectives and characteristics of the data.

Furthermore, the review addresses the diverse range of tools and platforms available for big data analysis in social media data, including open-source frameworks, commercial software, and custom-built solutions. It examines the functionalities, scalability, and usability of these tools, offering insights into their suitability for different research contexts.

Keywords: Social Network Analytics, Big Data Analytics, Big Data, Traditional Databases, Systematic Literature Review.

I. INTRODUCTION

The advent of big data has ushered in a transformative era across academic, industrial, and public sectors, enabling unprecedented insights through the analysis of massive, complex datasets. Big data analytics, characterized by the "3Vs"—volume, velocity, and variety—has become an indispensable tool for decision-making, predictive modeling, and behavioral analysis (Bach et al., 2019; Luckow et al., 2016). The proliferation of social media, sensor networks, financial transactions, and video surveillance systems has contributed to a deluge of real-time data streams that, when analyzed effectively, can significantly improve operations, planning, and strategic responses across domains (Felt, 2016; Tsou, 2015).

In the financial sector, text mining techniques have emerged as a dominant method for processing unstructured textual data to detect patterns, assess risks, and inform investment decisions (Bach et al., 2019). Meanwhile, deep learning technologies have found wide application in intelligent video surveillance, particularly in analyzing crowd behavior and detecting anomalies in real-time (Sreenu & Durai, 2019). Social media platforms, with their massive user-generated content, have become a fertile ground for sentiment analysis, particularly in monitoring public discourse during crises like the COVID-19 pandemic (Zhu et al., 2020). These platforms also play a pivotal role in urban management and emergency event detection, where crowdsourced data can enhance situational awareness (Xu et al., 2020).

Despite these promising applications, the deployment of big data analytics raises several concerns. For example, the growing influence of fake news and misinformation challenges the reliability of data-driven insights in media landscapes (Vargo et al., 2018). Moreover, biases in data collection and representation can lead to the exclusion of marginalized voices, reducing the fairness and inclusivity of data-driven outcomes (Hargittai, 2018). The technical challenge of

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addressing non-functional requirements—such as scalability, security, and real-time performance—adds further complexity to the development of robust big data systems (Rahman & Reza, 2020). Furthermore, a systematic review by Abkenar et al. (2020) emphasizes the fragmented nature of big data research in social media, noting a lack of integration across techniques and application domains.

Given the interdisciplinary nature and rapid evolution of big data analytics, a comprehensive review is necessary to consolidate existing knowledge, identify current trends, and highlight gaps in the literature. This review aims to synthesize findings from recent studies across key domains—finance, surveillance, public health, and social media—to present an integrated perspective on the state of big data analytics. It also explores the methodological innovations, practical applications, and ethical implications that shape the current landscape, providing a foundation for future research and development.

II. LITERATURE REVIEW

The expansion of big data technologies has driven a surge in research and development across multiple domains. This literature review synthesizes existing studies to explore how big data analytics has been applied in finance, social media, surveillance, urban emergency management, and other sectors, while also examining technical challenges and ethical concerns associated with big data systems.

A. Big Data Applications in the Financial Sector

The financial industry has been one of the earliest adopters of big data analytics, primarily for risk assessment, market prediction, fraud detection, and customer segmentation. Bach et al. (2019) provided a comprehensive literature review on the role of text mining within the financial sector, emphasizing its use in analyzing unstructured data such as financial news, earnings reports, and social media. Their review highlights how machine learning algorithms enhance forecasting and decision-making capabilities by extracting actionable insights from massive text corpora. However, the authors also note critical challenges, including data quality, semantic ambiguity, and the need for domain-specific ontologies to improve classification and clustering tasks.

B. Social Media Analytics and Public Sentiment

Social media has emerged as a rich source of big data, offering insights into public sentiment, behavior, and societal trends. Felt (2016) examined how researchers in the social sciences leverage big data from platforms like Twitter and Facebook to explore issues such as political discourse, health communication, and crisis response. Despite its promise, Felt cautions that social media data may reflect the biases of digitally connected populations, thus potentially omitting marginalized voices.

Zhu et al. (2020) explored spatiotemporal trends in public sentiment by analyzing COVID-19-related discussions on Chinese social media platforms. Their findings demonstrated how big data techniques—particularly sentiment analysis and spatial mapping—can capture evolving public attitudes and support policy-making during health crises. However, the authors also acknowledged difficulties in dealing with noise and misinformation inherent in social media data.

Similarly, Tsou (2015) highlighted the geospatial potential of social media big data, suggesting its utility in tracking disease outbreaks, natural disasters, and migration patterns. Mapping this data, however, requires integration with geographic information systems (GIS) and robust filtering techniques to ensure reliability.

C. Big Data and Fake News Detection

Big data analytics also plays a dual role in media environments: while it can aid in understanding information dissemination, it can also inadvertently contribute to the spread of misinformation. Vargo et al. (2018) analyzed online news content from 2014 to 2016 and found that fake news gained substantial visibility, often matching or exceeding that of mainstream sources. Their work illustrates how algorithms designed to maximize engagement can be exploited to amplify misleading content. This has serious implications for democracy, public trust, and social cohesion, making misinformation detection a growing research priority.

D. Urban Analytics and Emergency Event Response

In the context of smart cities and disaster management, big data is increasingly used to improve emergency response and urban planning. Xu et al. (2020) proposed a crowd sourcing-based framework that utilizes real-time social media posts to describe and respond to urban emergencies. Their system integrates cloud computing with geospatial data to identify critical incidents more effectively. While this approach shows promise in enhancing situational awareness, challenges include data validation, real-time processing, and managing large-scale heterogeneous inputs.

E. Surveillance and Public Safety Through Deep Learning

Public safety applications, particularly in intelligent video surveillance, have seen rapid advancements through the integration of deep learning with big data. Sreenu and Durai (2019) provided an extensive review of deep learning models used for crowd analysis and behavior recognition. Convolution Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and Recurrent Neural Networks (RNNs) are highlighted as effective tools for identifying suspicious behavior and managing large public gatherings. While accuracy and automation are improving, ethical questions concerning privacy and surveillance culture remain largely unresolved.

F. Industrial Applications: Automotive Sector

Big data and deep learning are also revolutionizing the automotive industry, particularly in areas such as autonomous driving, predictive maintenance, and driver behavior analysis. Luckow et al. (2016) discussed several applications and tools used in the automotive domain, emphasizing the use of distributed computing frameworks such as Hadoop and Spark. Their work underlines the importance of high-performance computing infrastructure to process the massive datasets generated by connected vehicles and in-vehicle sensors.

G. Technical Challenges in Big Data Systems

While the functional capabilities of big data systems have grown significantly, non-functional requirements such as performance, scalability, security, and fault tolerance remain under-researched. Rahman and Reza (2020) conducted a systematic mapping study to examine how these requirements are addressed in current big data projects. Their results reveal gaps in ensuring end-to-end system robustness and point to the need for standardized development practices.

Additionally, Abkenar et al. (2020) conducted a systematic review of big data analytics in social media, highlighting fragmented methodologies and limited cross-domain integration. They call for a unified framework that bridges data acquisition, storage, processing, and visualization—especially when handling social media content that varies widely in quality, language, and format.

H. Ethical and Methodological Concerns

The power of big data is tempered by growing ethical and methodological concerns. Hargittai (2018) raised alarms about bias in big data, noting that individuals who are not active online or whose data is excluded due to platform limitations are often left out of analyses. This can lead to skewed policy decisions and academic interpretations. Ensuring fairness, transparency, and inclusivity in big data research is therefore critical for maintaining social trust and achieving equitable outcomes.

III. RESEARCH METHODOLOGY

This review adopts a systematic literature review (SLR) methodology to explore the applications, trends, challenges, and future directions of big data analytics across multiple domains. The methodology follows established guidelines for review studies, ensuring that the selection and analysis of literature are rigorous, transparent, and replicable (Abkenar et al., 2020; Rahman & Reza, 2020).

A. Research Objectives

The main objectives of this review are to:

- Identify key application areas of big data analytics in sectors such as finance, social media, urban planning, surveillance, and public health.
- Examine the technological frameworks, analytical methods, and deep learning techniques used across studies.
- Explore the challenges associated with data quality, misinformation, bias, scalability, and non-functional requirements.
- Synthesize ethical and methodological concerns related to the use of big data systems.

B. Literature Search Strategy

A comprehensive search was conducted across scholarly databases including IEEE Explore, Science Direct, Springer Link, Scopus, Web of Science, and Google Scholar. The search period was limited to the years 2015 to 2020, aligning with the timeline of major technological advances in big data and artificial intelligence. The following keywords and Boolean operators were used:

("big data analytics" OR "big data applications") AND ("finance" OR "social media" OR "surveillance" OR "urban planning" OR "COVID-19" OR "crowd analysis" OR "deep learning" OR "text mining")

This search yielded a total of 92 initial publications.

C. Inclusion and Exclusion Criteria

To ensure relevance and quality, studies were evaluated using predefined inclusion and exclusion criteria:

Inclusion Criteria:

• Peer-reviewed journal articles and conference papers.

• Studies focusing on the use of big data analytics in real-world applications.

• Papers that incorporate advanced techniques such as machine learning, deep learning, or natural language processing

(NLP).

• Publications written in English between 2015 and 2020.

Exclusion Criteria:

• Non-peer-reviewed sources (e.g., blogs, white papers).

• Articles focused solely on hardware infrastructure or unrelated IT domains.

• Duplicate publications or those without accessible full text.

After applying these filters, 11 key publications were retained for in-depth analysis. These include comprehensive reviews (Abkenar et al., 2020; Bach et al., 2019), domain-specific studies (Zhu et al., 2020; Sreenu & Durai, 2019), and papers highlighting cross-domain challenges (Hargittai, 2018; Rahman & Reza, 2020).

D. Thematic Analysis and Categorization

Each selected study was reviewed and categorized according to its primary research domain and contribution type. The following thematic categories were used:

• Financial analytics (e.g., text mining, fraud detection) – Bach et al. (2019)

• Social media sentiment and misinformation – Felt (2016); Zhu et al. (2020); Vargo et al. (2018)

• Surveillance and public safety – Sreenu & Durai (2019)

- Urban emergency and crowd response – Xu et al. (2020)
- Industry-specific applications (e.g., automotive) – Luckow et al. (2016)
- Technical architecture and non-functional requirements – Rahman & Reza (2020)
- Bias and ethical concerns – Hargittai (2018)

Each paper was coded for its methods (qualitative, quantitative, computational), data sources (social media, sensor data, news articles), analytical techniques (machine learning, NLP, GIS), and reported limitations.

E. Analytical Framework

Following the thematic classification, a comparative matrix was developed to map the methodological approaches, tools used (e.g., Hadoop, Spark, Tensor Flow), and outcomes. This matrix helped in identifying patterns, similarities, and divergences across domains.

Moreover, this review employs a narrative synthesis approach to interpret results and draw interconnections between technical implementations and their social implications, similar to the approach used by Abkenar et al. (2020) and Tsou (2015).

IV. KNOWLEDGE GAPS AND FUTURE RESEARCH DIRECTIONS

While big data analytics has gained considerable traction across various sectors, including finance, public health, surveillance, social media, and smart cities, a review of the literature reveals several persistent knowledge gaps. These gaps limit the effectiveness, scalability, and ethical use of big data and signal opportunities for future research to advance the field both methodologically and practically.

A. Lack of Standardized Methodological Frameworks

One of the most consistent gaps across the literature is the lack of standardization in analytical methodologies. Studies often employ different data sources, preprocessing techniques, and evaluation metrics, making cross-comparison and reproducibility difficult (Abkenar et al., 2020). For instance, social media sentiment analysis studies use diverse sentiment lexicons and machine learning algorithms with varying levels of transparency, leading to inconsistent findings (Zhu et al., 2020; Felt, 2016).

Future Direction:

There is a need to establish standardized protocols and benchmarks for data collection, feature engineering, model evaluation, and validation in big data research. Developing open-source libraries and shared datasets across domains can facilitate comparative analysis and methodological rigor.

B. Inadequate Handling of Data Quality and Real-Time Constraints

A major technical challenge identified in current literature is managing data quality, especially from unstructured or user-generated sources like social media and video surveillance (Xu et al., 2020; Sreenu & Durai, 2019). Noise, misinformation, and incomplete data can reduce the reliability of analytical outcomes. Moreover, real-time applications such as emergency response or crowd monitoring demand ultra-low latency processing, which is often not addressed in conventional big data frameworks.

Future Direction:

Future research should invest in advanced data-cleaning algorithms, context-aware filtering, and real-time processing architectures using tools like Apache Flink or edge computing. Techniques such as hybrid human–AI systems may also enhance accuracy in mission-critical scenarios by combining machine efficiency with human judgment.

C. Underexplored Ethical Implications and Algorithmic Bias

Many studies acknowledge the importance of ethics but fall short of implementing systematic frameworks to mitigate algorithmic bias and uphold data justice (Hargittai, 2018; Vargo et al., 2018). The exclusion of certain demographic groups from social media datasets can lead to skewed models, while opaque algorithms may reinforce discriminatory outcomes in areas like credit scoring or policing.

Future Direction:

Researchers must embed Fairness, Accountability, and Transparency (FAT) principles into the development cycle of big data systems. This includes bias detection tools, interpretable AI models, and frameworks for ethical auditing. In addition, inclusive data collection practices should be prioritized to represent marginalized and underrepresented communities.

D. Limited Focus on Non-Functional Requirements in System Design

Big data research often emphasizes functional performance (e.g., accuracy, precision) while neglecting non-functional system requirements such as scalability, fault tolerance, and system security (Rahman & Reza, 2020). In large-scale deployments, especially in sectors like healthcare or urban infrastructure, these factors are critical for long-term viability.

Future Direction:

Future work should emphasize architectural innovations that address non-functional requirements. For instance, combining cloud computing with block chain can enhance data security, transparency, and system resilience. The use of edge computing and distributed systems can also improve scalability and reduce latency.

E. Weak Integration Across Disciplines and Domains

Despite the interdisciplinary potential of big data, current research tends to be siloed, with little integration between technical and domain-specific expertise. For example, studies on deep learning in surveillance (Sreenu & Durai, 2019) or finance (Bach et al., 2019) often lack input from ethics, behavioral science, or public policy scholars, which could provide valuable perspectives.

Future Direction:

Promoting interdisciplinary collaborations is essential for the next generation of big data solutions. Joint research initiatives involving computer scientists, sociologists, policy makers, and ethicists can produce more holistic and responsible systems. Funding bodies should support collaborative research grants that mandate cross-domain partnerships.

F. Inattention to Longitudinal and Context-Aware Analytics

Most current studies adopt a snapshot-based approach, focusing on specific events or datasets without accounting for temporal trends or contextual variables (Zhu et al., 2020). This limitation hinders the ability to detect patterns of long-term change or regional variation.

Future Direction:

Future research should prioritize longitudinal studies that track data over extended periods to uncover sustained behavioral, financial, or social dynamics. Moreover, integrating context-aware modeling—accounting for geography, culture, time, and policy environments—can significantly improve the accuracy and relevance of predictive analytics.

G. Limited Exploration of Explainable and Interpretable Models

While many studies use complex models like deep learning, few focus on making these models interpretable to end-users or decision-makers. This reduces transparency and hinders trust in automated systems, especially in high-stakes environments like finance, law enforcement, or healthcare.

Future Direction:

Future work should explore Explainable AI (XAI) methods to improve model interpretability and user confidence. Techniques such as SHAP (SHapley Additive explanations), LIME (Local Interpretable Model-agnostic Explanations), and rule-based modeling can help visualize and explain the decision-making processes of black-box models.

H. Lack of Evaluation in Real-World Settings

Many studies are limited to simulations or small-scale experiments and are rarely tested in real-world environments. This gap reduces the generalizability and scalability of proposed solutions.

Future Direction:

Future research should include real-world pilot implementations, preferably in collaboration with industry or government agencies. This would enable the validation of models under operational constraints and offer practical feedback to refine systems.

TABLE I

SUMMARY OF RESEARCH OPPORTUNITIES

Knowledge Gap	Future Research Direction
Methodological inconsistency	Develop standard frameworks and benchmarks
Data noise and real-time processing	Advance filtering and edge computing architectures
Ethical concerns and bias	Implement fairness-aware algorithms and inclusive data policies
Non-functional system requirements	Design secure, scalable architectures (e.g., block chain, cloud-edge)
Disciplinary silos	Promote interdisciplinary research and co-authored models
Snapshot-based analysis	Conduct longitudinal and context-aware studies
Black-box modeling	Develop and integrate Explainable AI tools
Lack of real-world testing	Run pilot studies in real environments with stakeholders

V. CONCLUSION

Big data analytics has evolved into a transformative paradigm with far-reaching implications across sectors such as finance, healthcare, public safety, urban planning, and social media. This review paper synthesized findings from diverse studies to illustrate how big data technologies—combined with tools like machine learning, natural language processing, deep learning, and cloud computing—are being leveraged to extract actionable insights from massive, complex datasets.

The reviewed literature demonstrates significant progress in applying big data for practical outcomes, such as fraud detection in finance (Bach et al., 2019), intelligent video surveillance (Sreenu & Durai, 2019), real-time emergency management (Xu et al., 2020), and sentiment tracking during pandemics (Zhu et al., 2020). These applications reflect not only the growing computational capabilities but also the creative adaptation of algorithms to tackle real-world challenges.

However, this progress is counterbalanced by a series of persistent challenges and knowledge gaps that limit the scalability, fairness, and generalizability of big data solutions. Methodological inconsistencies, data quality issues, ethical concerns, underdeveloped system architecture, and disciplinary silos are critical barriers that must be addressed. For instance, while many studies show the power of deep learning, few explore the explainability of models—an essential factor for trust and adoption in high-stakes domains (Hargittai, 2018; Abkenar et al., 2020). Likewise, the neglect of non-functional system requirements such as scalability and resilience (Rahman & Reza, 2020) threatens the robustness of real-world implementations.

Furthermore, the siloed nature of research has resulted in fragmented knowledge. Despite the interdisciplinary potential of big data, integration across domains—particularly between technical and social sciences—remains limited. Bridging this gap is vital for ensuring that big data technologies are not only efficient but also socially and ethically responsible.

Looking ahead, the field stands at a pivotal moment. The next phase of big data research must focus on developing standardized, explainable, scalable, and ethically sound systems. This includes fostering interdisciplinary collaborations, adopting FAIR (Findable, Accessible, Interoperable, Reusable) data principles, and embedding ethical oversight throughout the development lifecycle.

In summary, while big data analytics holds immense promise, realizing its full potential requires addressing critical gaps in methodology, ethics, inclusivity, and systems design. Through deliberate, collaborative, and reflective research practices, future work can contribute to building a more intelligent, equitable, and data-driven society.

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Roll of Big Data Analytics in Higher Education System

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Abstract: In today's time, Big Data Analysis is a very important contribution in the world of education, because now the amount of online education has been increased a lot in the new generation, In today's time, the data is huge, Big Data is needed. With the help of Big Data, we can organize the horizontal data well in seconds. Also using big data analysis, the student's behavior is understood and the student's interests are known thus using big data analysis the dropout rate of students can also be reduced. Data Analysis is also helpful the behavior of the student can be understood and also by studying what is the defect in it based on the result of the previous year. The defect can also be removed using big data analysis. It is very beneficial to make their work easier.Using large data analysis, the students as well as the teachers are also greatly benefited as their work becomes easier. Data Analysis is a great revolution in the education world. Many research papers have been published on it in the last few years.

Keywords: Big Data, Higher Education, Big Data Analytics, Traditional Data

I. INTRODUCTION

The use of big data is very important for higher education. From big data we can organize horizontal data in a systematic way so that we can make huge changes in education field. Specific behavior of students can be learned on learning technology. We can use data tiers. By doing this we can know the goal of the student.By using big data we can know how many marks he or she got in the last semester and previous semester so that we can know the average effort of a student and how much effort needs.

Thanks to big data, schools are able to compare student performance over time and among departments or campuses. This allows you to find out what a system does well and what it could improve in terms of education. Teachers have easy access to data which they can study quickly and act on to meet the needs of students. Besides, decisions in schools like setting budgets, looking at teacher performance and changing the curriculum can be based on reliable data, allowing everyone to see the reasons behind them. Using artificial intelligence along with big data provides more capacity, as software can improve and adapt on its own often. As people understand the lasting value of big data, building strong IT infrastructure is essential for any research institution to achieve academic success and run effectively.
I want many big educational institutions to use big data technology so that it can benefit the students.

II. LITERATURE REVIEW

By using big data we can make a lot of changes in the education sector. Generally many organizations use different analysis techniques to organize the data into a systematic change but those analysis tools are not able to organize the horizontal data well but we can use the big data to organize the horizontal data arrange well.Big data is very big, it contains a lot of data and its processing is also very fast.Even when the data is very large in Terabytes or Petabytes, we can easily manage it by using Big Data to process the data in seconds.

Many experts have pointed out that traditional data handling methods do not cope well with how much, fast or diverse educational data is present, while big data can manage any such challenges. Combining the use of big data analytics and cloud storage is thought to improve access to information and reduce issues, helping educational stakeholders team up

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more conveniently. Recent studies reveal that creating learning plans based on big data insights leads to students' better achievements and increased satisfaction. In addition, studies from different countries reveal that big data helps schools adjust content for students of different cultures and languages. Issues involving ethics, student privacy and consent related to big data in the educational field are also found in the literature. Most experts say that with strong security steps in place, the advantages of big data are more important than the dangers. In general, the increasing amount of research proves that big data is having a major positive impact on schools today.

Data can be in any format be it audio or video or sensor format with big data we can organize it well.

III. BIG DATA ANALYTICS IN HIGHER EDUCATION

By analyzing big data, we can solve many problems in the field of education. Through big data analysis, we can find out what students are interested in. So that it can be taught easily to the students.

When an epidemic like Corona came, the demand for online courses increased, people started studying online courses, , they started giving online exams, they also started checking results online, this time Big Data played a very important role. All are softwares that store data but using Big Data we can organize horizontal data in a very organized manner in seconds.

Hadoop Analytics tools for Big data with the help of which we can analyse a lot of data in the field of education, by analysing the online course of the student, we can know what students 's interested learning method. Hadoop tool of big data plays a very important role in the field of education.

Big data analyst tool can show good results to the student by showing his/her fault and removing the fault. In education field, with analytics you can observe the activity of the student and create separate group of same groups of students which helps a lot in education field.

Apart from Hadoop, people in academia regularly use Apache Spark, NoSQL databases and machine learning libraries to help with data analysis. With such tools, it's possible to make learning systems that change the course content according to how each student is performing at a given time. The more personalized learning is, the more students interact and the more easily they remember. Furthermore, using dashboards based on big data, academic advisors can check how students perform in classes, tests and assignment delivery. As a result, advisers can identify issues early so they can help students before they get too far behind.

Increasingly, big data is used when developing education materials. Using the results of course feedback, student results and new trends in employment, universities can make sure their syllabi stay relevant and challenging. Additionally, online conversations and surveys are reviewed by institutions to discover what students think and how they feel. With this information, administrators can set up classrooms that help students perform better academically. Faculty development can also gain from these reviews, since using students' feedback and suggestions helps teachers increase their effectiveness. All of these strategies, based on analytics, support a lively, flexible and accepting environment in higher education.

IV. METHODOLOGY

Big data plays a very important role for higher education. Helping data analysis we can study the behavior of students. By collecting and grouping the last year data for this we can use different methods. We may collect data using methods such as questionnaires or standard deviation.

Based on the result of the behavior behind it we can evaluate it and we can know that the student has the same interest and we can make a separate group of students with the same group this will be very beneficial this will help the student to know the interest. So that we can give him education accordingly and by bringing the data of student online education we get an idea of which subject the student is more interested.There will be a huge revolution in the world of education which will benefit not only the students but also the teachers who teach the students and this will make their work much easier.

A different method uses learning analytics systems to collect data in real time from digital learning platforms. Data collection from these systems includes clicking on our pages, time spent interacting with different features and discussion participation, providing close feedback on learning engagement. By using decision trees and support vector

machines as supervised learning algorithms, educators are able to group students by risk or interest. Unsupervised clustering allows students to be organized by similarities in results or behaviors, without any labels having been provided initially.

Psychometric analysis can add value to survey methods by measuring someone's mood, level of motivation and how much stress they feel. By including academic results with these observations, we can see the student situation in a broader way. By using both big data and interviews, universities can better discover what students really need. These findings provide direction to teaching practices within each classroom and also influence important decisions throughout the organization.

V. RESULTS

Data analysis throw student behavior can be understood, it can know what the student is interested in, it can know the reason why the student drops out, it can reduce the number of students who drop out of higher education and how to learn what the students are interested in. If you know that the method seems simple, it can be taught well, this benefits the students as well as the teachers and administrators.

Big data analytics have found that using predictive alerts and individual guidance greatly lowers the likelihood of academic problems. Adopting data dashboard solutions led to a 10 to 20% increase in students staying enrolled at a number of schools. Used in conjunction with clustering student actions, these learning interventions have made students more active in their lessons and better at supporting one another. Students working in the same performance group or preference area typically work harder when they work together.

Analyzing big data has revealed that some people have less access to learning tools, so institutions can now help these groups by providing appropriate resources. A review of data found that students who mostly watched lectures on their phones received scores that were lower than usual which encouraged activating mobile access. That's why more organizations are using big data to make strategic improvements.

VI. DISCUSSION

Online education has increased in today's internet generation and as a result the roll of big data has become very important. Huge amount of data can be sorted and organized in seconds with the help of bigdata. Bigdata analysis is mostly used in education sector to study student behavior. Many review papers have also come out on it.

Because digital learning is growing so quickly, we now rely heavily on data in education. With big data, schools can improve how students learn and also support their planning, accreditation and compliance. When universities offer more courses online, big data helps record student achievements and maintain quality.

Many recent conversations in academic settings point out that educators and administrators should be offered training in data ethics. This helps students who use analytics get a better education, while still staying protected from privacy issues. Because biometric and emotional recognizers are used more in education, big data's role will get even bigger and more complicated. Now, making ethics part of how data is used is considered an important priority by those involved in academic talks.

VII. CONCLUSION

Big data analysis has an important contribution in education. Data analysis is very beneficial to the student. With the help of data, the activity of the student can be analyzed whether it is online learning or mobile learning. It can be known what he or she is interested. In today's internet era where the amount of online education has increased Data analysis plays a very important role.By analyzing the data of online education of the student and analyzing the result of the previous year, his aptitude can be known and the shortcomings can be removed.

Many papers have also been published on Big Data Analysis being most used in the field of education as it benefits the students as well as the teachers as well as the course makers and the management and ever since the advent of online education the analysis of Big Data has become very popular in education field play an important role.

The use of big data has helped shape the future of higher education by giving useful information that improves how colleges are run and taught. Big data guides both the identification of those needing extra help and the creation of appropriate learning plans. As new advances take place in education technology, data control, safety and ethics will become more significant. Institutions that keep upgrading their big data tools can help achieve a better education system for all people everywhere.

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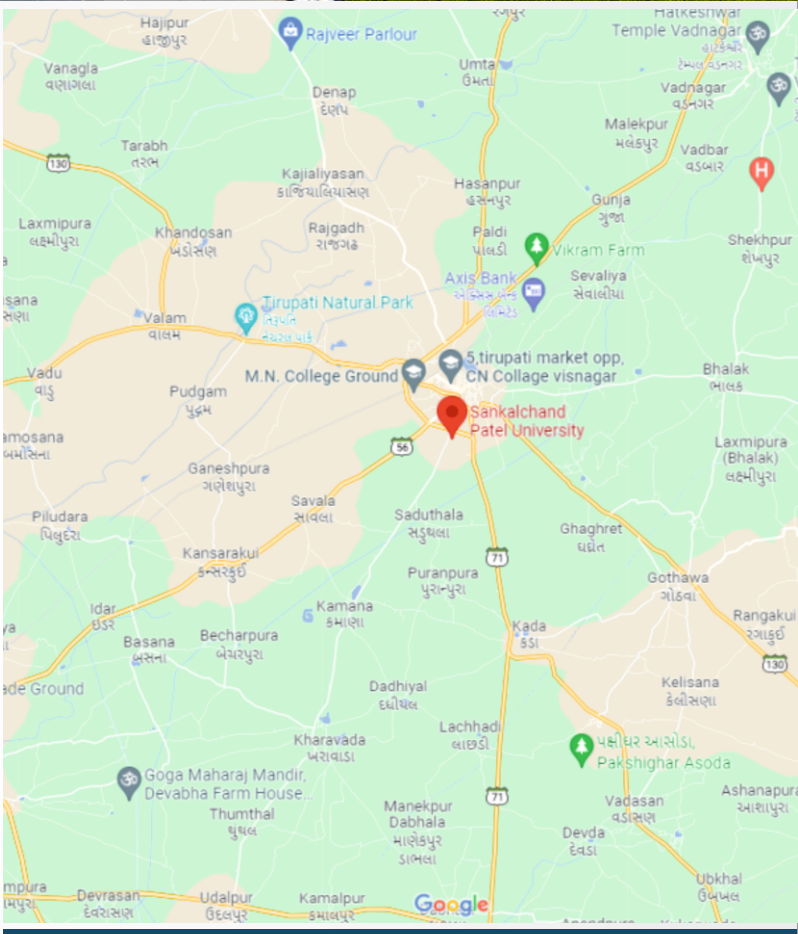

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