



(Accredited by NAAC)

Jawahar Education Society's,  
**INSTITUTE OF TECHNOLOGY,  
MANAGEMENT & RESEARCH, NASHIK.**

(Approved by AICTE, New Delhi, DTE, Government of Maharashtra, Affiliated to Savitribai Phule Pune University)

### 3.2.2 Number of books and chapters in edited volumes/books published and papers published in national/ international conference proceedings per teacher during the year.

| Sr. No. | Name of the teacher | Title of the book/chapters published | Title of the paper                                   | Title of the proceedings of the conference                                                  | Name of the conference                                                                 | National / International | Year of publication | ISBN/ ISSN number of the proceeding | Affiliating Institute at the time of publication                                     | Name of the publisher                                                                          | Page No. |
|---------|---------------------|--------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------|---------------------|-------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------|
| 1       | Mr. R. R. Sonawane  |                                      | Solar Operated Tilling Machine for Night Agriculture | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International            | 2025                | ISBN - 978-93-341-1286-3            | Jawahar Education Society's Institute of Technology, Management and Research, Nashik | Jawahar Education Society's, Institute of Technology, Management and Research, Nashik. 422 222 | 8        |

|   |                   |  |                                                      |                                                                                             |                                                                                        |               |      |                          |                                                                                      |                                                                                                |    |
|---|-------------------|--|------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----|
| 2 | Mr. Y. R. Girase  |  | Solar Operated Tilling Machine for Night Agriculture | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management and Research, Nashik | Jawahar Education Society's, Institute of Technology, Management and Research, Nashik. 422 222 | 27 |
| 3 | Mr. A. A. Patil   |  | Solar Operated Tilling Machine for Night Agriculture | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management and Research Nashik  | Jawahar Education Society's, Institute of Technology, Management and Research, Nashik. 422 222 | 28 |
| 4 | Dr. M. V. Bhatkar |  | Alternate to SF6 Gas in Gas Insulated Switchgear     | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management and Research, Nashik | Jawahar Education Society's, Institute of Technology, Management and Research, Nashik. 422 222 | 32 |

|   |                  |  |                                                                                     |                                                                                             |                                                                                        |               |      |                          |                                                                                      |                                                                                                                                              |    |
|---|------------------|--|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|----|
| 5 | Mrs. S.G. Bidkar |  | Role of Artificial Intelligence and Machine Literacy in VLSI Design- A Brief Survey | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management and Research, Nashik | Jawahar Education Society's, Institute of Technology, Management and Research, Nashik. 422 222                                               | 40 |
| 6 | G.P.Mohole       |  | Urbancrew: In-Time Service Solution On Figure Click                                 | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research           | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 47 |
| 7 | G.P.Mohole       |  | Supply Chain Management Using Blockchain                                            | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research           | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 54 |

|    |              |  |                                                                                               |                                                                                             |                                                                                        |               |      |                          |                                                                            |                                                                                                                                              |    |
|----|--------------|--|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|----|
| 8  | G.P.Mohole   |  | Nexus NFT Using Blockchain                                                                    | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 62 |
| 9  | V.D.Badgujar |  | Blockchain Based Biometric EVM using Cloud Integration for Enhanced Security and Transparency | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 69 |
| 10 | S.N.Botekar  |  | Enhancing Navigation for Railway Station Facilities and Location                              | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 78 |

|    |             |  |                                                                                                 |                                                                                             |                                                                                        |               |      |                          |                                                                            |                                                                                                                                              |     |
|----|-------------|--|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 11 | S.N.Botekar |  | Tracking and Detecting Depression Level using Facial Recognition and PEN & IQ test              | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 91  |
| 12 | S.P.Zope    |  | Stockpile: A Multi-tier Inventory Management System for Wholesalers, Shopkeepers, and Customers | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 96  |
| 13 | S.P.Zope    |  | Smart Hire Using Machine Learning                                                               | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 101 |

|    |                  |  |                                                                            |                                                                                             |                                                                                        |               |      |                          |                                                                            |                                                                                                                                              |     |
|----|------------------|--|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 14 | S.S.Jadhav       |  | Deep Learning-Based Helmet Detection and Number Plate Recognition for Road | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 107 |
| 15 | M.S.Shelar       |  | The Echo: Enhance Collaborative Overcraft Observer                         | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 115 |
| 16 | Dr. Sonal Borase |  | A Wearable Smart System to Assist Visually Challenged                      | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 123 |

|    |                  |  |                                                                                                            |                                                                                             |                                                                                        |               |      |                          |                                                                            |                                                                                                                                              |     |
|----|------------------|--|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 17 | Dr. Sonal Borase |  | Blue Eyes Technology: Revolutionizing Healthcare Management through Emotion and Vital Parameter Monitoring | PROCEEDING OF 1ST INTERNATIONAL CONFERENCE ON "Emerging Trends in Engineering and Sciences" | International Conference on Emerging Trends in Engineering and Sciences (ICETES -2025) | International | 2025 | ISBN - 978-93-341-1286-3 | Jawahar Education Society's Institute of Technology, Management & Research | Jawahar Education Society's Institute of Technology, Management and Research, Nashik Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222 | 130 |
|----|------------------|--|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------|------|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----|

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES

# ICETES-2025

7<sup>th</sup> – 8<sup>th</sup> February 2025



Research that transforms lives  
**ICETES**

Organized by



**JAWAHAR EDUCATION SOCIETY'S  
INSTITUTE OF TECHNOLOGY, MANAGEMENT AND RESEARCH, NASHIK**  
Approved by AICTE, Delhi Affiliated to Savitribai Phule Pune University  
(NAAC Accredited)

In Association With



Computer Society of India and Google Developer Group, Nashik

ISBN: 978-93-341-1286-3

PROCEEDING ICETES-2025



**PROCEEDING OF 1<sup>ST</sup> INTERNATIONAL CONFERENCE ON  
“Emerging Trends in Engineering and Sciences”**

**Concluded on  
February 7<sup>th</sup> and 8<sup>th</sup> 2025**

**Organized by**

**Jawahar Education Society's  
Institute of Technology, Management and Research, Nashik  
(NAAC Accredited)**

**In Association With**

**Computer Society of India and Google Developer Group, Nashik**

**Dr. M. V. Bhatkar  
Conference Chair**

**Mrs. G. P. Mohole  
Convener**

**Dr. S. P. Zope  
Co-Convener**

## **ICETES-2025**

1<sup>st</sup> International Conference on Recent Trends in Emerging Trends in Engineering and Sciences

*All the papers published in this conference proceeding have been peer reviewed*

Copyright © 2025 the publisher, the editors & the authors

All rights are reserved by ICETES International Conference

No part of this publication may be reproduced, distributed or transmitted in any form or by any means. Including photocopying, recording or other electronic or mechanical methods without prior written permission of the publisher & the copyright holders

ISBN: 978-93-341-1286-3

### **Disclaimer:**

Abstract of accepted papers are published in this Proceeding of ICETES-2025 with the understanding that the same work has been submitted not published elsewhere. Concurrent submission to other publications or journals is viewed as breach of ethics. The authors are responsible for obtaining copy right and other clearance prior to submitting materials for consideration and acceptance. Views and Ideas expressed in the abstracts are solely from respective authors Organizers are not responsible for authentication of the papers published in this proceeding book.

The authors are solely responsible for any legal matter resulting out of violation of copy right act. This book is being published in the interest of authors and research community for private circulation only Errors, if any are purely unintentional and readers are requested to communicate such errors to the editors or publishers to avoid discrepancies in future.

### **Published by**

Jawahar Education Society's Institute of Technology, Management and Research, Nashik  
Survey No: 48, Gowardhan, Gangapur Road, Nashik- 422222

### **Prepared By**

Mrs. Geetanjali Prashant Mohole  
Ms. Dipti Dilip Survase

Printed and bound in India

**Chief Patron:**

Hon. Late. Rohidasji C. Patil (Founder, Jawahar Education Society)

**Patron:**

Hon. Shri. Vinay R. Patil (President, Jawahar Education Society)

Hon. Shri. Kunal R. Patil (Secretary, Jawahar Education Society)

**International Advisory Committee:**

Dr. Ajit Kumar Verma (Professor, Western Norway University of Applied Sciences, Norway)

Dr. Pankaj Koinkar (Vice Director (CIREC), Tokushima University, Japan)

Dr. Leena Patil (Senior Scientist, Vanderbilt University, USA)

Dr. Pranav Pawar (BITS Pilani, Dubai, UAE)

Dr. Lewis Parsons (University of the Witwatersrand, South Africa)

Dr. Hrishikesh Shahane (Researcher, University of the Witwatersrand, South Africa)

Mr. Vivek Karandikar (Co-Founder, Imaginatix , USA)

Mr. Yogesh Tripathi (AWS Solutions Architect, USA)

Dr. Yogesh Kale (Research Data Architect, RENCI, USA)

**National Advisory Committee:**

Dr. A. Srividya (Retd.Professor in Civil Engineering, IIT Bombay.)

Dr. N. J. Uke (BOS Chairman,Computer Engineering SPPU, Pune)

Dr. R. S. Prabhu Gaonkar (Professor, IIT, Goa)

Dr. S. A. Deokar ( BOS Chairman, Electrical Engineering SPPU, Pune)

Dr. P. N. Mahalle (Professor, VIIT, Pune)

Dr. R. D. Kulkarni (Ex. Scientific Officer, BARC, Mumbai)

Mr. Shreekant Patil (Entrepreneur & Mentor at BHASKAR Startup India, Nashik)

Dr. B. D. Nandre (Associate Professor, MESWCOE, Pune)

Dr. A. P. Shelorkar(Associate Professor,KBTCOE, Nashik)

**Conference Chair:**

Dr. M. V. Bhatkar

Principal

**Convener:**

Mrs. G. P. Mohole Head, Computer Engineering and AI & DS

**Co-convener:**

Dr. S. P. Zope, Assistant Professor, Computer Engineering

**Organizing Committee:**

Mr. S. B. Patil, Head, Information Technology

Mr. Y. R. Girase, Head, Mechanical Engineering

Mrs. S. A. Thete, Head, Eletrical Engineering

Mr. S. B. Kajabe, Head, Civil Engineering

Dr. Mrs. A. K. Sanap, Applied Science & Humanities

Mr. M. A. Patil, T&P Officer

Mr. A. A. Patil, NSS Coordinator

Mr. R. R. Sonawane, Alumni Coordinator

Ms. N. R. Gawali, Librarian

### **Session Chair:**

Dr. Ranjana Prakash Dahake, Associate Professor, MET'S IOE BKC Nashik  
Dr. Bhushan D. Nandre, Associate Professor, M.E.S. Wadia College of Engineering Pune, India  
Dr. Niharika Prasanna Kumar, Associate Professor, RV Institute of Technology and Management  
Dr. Neeta Deshpande, Associate Professor, Gokhale Education Society's R H Sapat College of Engineering, Nashik  
Dr. Dnyaneshwar Khemachandra Kirange, Associate Professor, SSBT's College of Engineering and Technology, Jalgaon  
Dr. Prashant M. Yawalkar, Professor and Head, MET's Institute of Engineering, Nashik  
Dr. Uday Chandrakant Patkar, HOD and Assistant Professor, Bharati Vidyapeeth's College of Engineering Lavale, Pune  
Dr. Yogita Mukundraj Ahire, Assistant Professor, PVG's College of Engineering and Shrikrushna S. Dhamankar Institute of Management, Nashik  
Dr. Shrinivas Sonkar, Head & Associate Professor, Amrutvahini College of Engineering Sangamner  
Dr. Jaya Suryawanshi, Assistant Professor, MVPS's KBT COE Nashik  
Dr. Vijay More, Associate Professor, MET's Institute of Engineering, Bhujbal Knowledge City, Nashik  
Dr. Sharad Sitaram Dhamal, Associate Professor, Matoshri College of Engineering & Research Centre, Eklahare, Nashik

### **Reviewers:**

Dr. Pavan N. Ghumare, Associate Professor and Head of Department, MET's Institute of Engineering, Bhujbal Knowledge City.  
Dr. Ravindra Munje, Professor, K K Wagh Institute of Engineering Education and Research  
Dr. Kailas K. Sanap, Assistant professor, HPT Arts and RYK Science College Nashik  
Dr. Dnyaneshwar K. Kirange, Associate Professor, SSBT's College of Engineering and Technology Jalgaon  
Dr. Manoj Ashok Wakchaure, Associate professor, Amrutvahini college of engineering  
Dr. Shrinivas Sonkar, Head & Associate professor, AVCOE sangamner  
Dr. Vijay Bhikaji More, Associate Professor, MET's Institute of Engineering, Bhujbal Knowledge City, Nashik  
Dr. Bhalchandra R. Mandre, Professor, SSVPS BS Deore College of Engineering, Dhule  
Dr. Ranjit Gawande, HoD AI&DS Engineering, Matoshri College of Engineering and Research Centre Nashik  
Dr. Ranjana Prakash Dahake, Associate Professor, MET BKC IOE Nashik  
Dr. Mangesh Nikose, Associate Professor, Sandip University  
Nuzhat Prova, PhD Candidate, Pace University,  
Dr. Niharika Prasanna Kumar, Associate Professor, RV Institute of Technology and Management  
Sowmiya Baskar, Assistant professor, S.I.V.E.T. College, Chennai-73  
Geetanjali Mohole, Assistant Professor, Jawahar Education Society's Institute of Technology Management and Research, Nashik  
Dr. Sonal Borase, Assistant Professor, Jawahar Education Society's Institute of Technology Management and Research, Nashik  
Anbarasu Aladiyan (Compunnel, Inc.), Lead Software Engineer, Compunnel, Inc  
Vishwajit Barbudhe, Assistant professor, Sandip institute of technology and research centre nashik  
Dr. Umesh Pawar, Assistant Professor and Head CSE, Sandip University Nashik, MS, India  
Dr. Nisha Deepak Patil, Assistant Professor, MET' IOE NASHIK  
AJAY KUMAR AGARWAL, ASSOCIATE PROFESSOR, JB KNOWLEDGE PARK, FARIDABAD, HARYANA, DELHI NCR, INDIA  
Dr. Jaya Rameshwar Suryavanshi, Assistant professor, MVPS KBT COE NASHIK  
Sumitra Amit Jakhete, Assistant Professor, Pune Institute of Computer Technology  
Vinay kumar kasula, Sr. Systems Analyst, University of the Cumberlands  
Surbhi Dilip Pagar, Assistant Professor, DYPIEMR  
Ajit Desai, Director of Marketing, Deltek

Mr.Ghorpade Pradip Prabhakar, Assistant Professor, VPKBIET,Baramati  
Dr. Vivek Waghmare, Associate professor, Pune Vidyarthi Griha's College of Engineering & Shrikrushna S. Dhamankar Institute of Management, Nashik  
Dr. Yogita Ahire, Associate professor, Pune Vidyarthi Griha's College of Engineering & Shrikrushna S. Dhamankar Institute of Management, Nashik  
Dr. Sharmila Zope, Assistant Professor, Jawahar Education Society's Institute of Technology Management and Research, Nashik  
Yukti Varshney, Assistant Professor, Moradabad Institute of Technology , Moradabad  
Siva Venkatesh, Solutions Manager, Cisco Systems,  
Shanmugasundaram Senathipathi, Consulting Manager, Capgemini  
Dr. Bajirao Subhash Shirole, Assistant Professor, Sanghavi College of Engineering, Nashik  
Mahesh Ashok Patil, Assistant Professor, Jawahar Education Society's Institute of Technology Management and Research, Nashik  
Dr.Neeta Deshpande, Associate professor, Gokhale Education society's R H Sapat College of Engineering Nashik  
Pooja J. Patel, Assistant Professor, Jawahar Education Society's Institute of Technology Management and Research, Nashik,  
Pavan Kumar Gollapudi, Quality Engineering Assocaite Manager, Accenture  
Dr. Rupali Patil, Assistant Professor, K J Smayya college of Engineering, Mumbai  
Dr. Pankaj Hiranman Zope, Associate Professor, SSBT's College of Engineering and Technology Bambhori Jalgaon  
Yogesh Arjun Shinde, Assistant Professor, Amrutvahini College of Engineering  
Dr. Navnath D. Kale, Senior Assistant Professor, MIT Academy of Engineering, Pune

## MESSAGE FROM CHIEF PATRON

Dear Organizers and Participants,

Greetings to you all!

We applaud the hard work made by the institute, for a wonderful and stimulating national conference. The Conference is very well organized, both logistically and in terms of its contents.

The broad spectrum of themes listed for discussions conveys its intellectual integrity.

International conference on “**Emerging Trends in Engineering and Sciences**” speaks of the use of new research, and innovations to focus more on recent developments. This conference is a platform for all the professors, researchers, and students to share their ideas and innovations with the outside world. Science and Technology is an area where innovation is taking place every day, and every innovation changes the market trend and the global economy.

We appreciate and acknowledge the efforts of the institute who left no stone unturned to make this conference a success. A special mention of the tireless efforts of the Conference chair, Conference Convener and organizing committee of the conference who made the conference see the light of day. All the staff and students of the institute deserve our appreciation for their coordinated effort to make this conference a success. I do congratulate the authors of the research articles submitted for the conference/proceedings.

We are impressed with the most productive, well-planned conference which would be memorable and successful.

Our best wishes to all the stakeholders!

**President / Secretary**

Jawahar Education Society

## **MESSAGE FROM CONFERENCE CHAIR**

The International Conference on Emerging Trends in Engineering and Sciences (ICETES-2025) aims to create a common platform for students, academicians, researchers, developers, and practitioners to discuss and present various research initiatives, outcomes, and experiences. A conference platform is not only to learn new aspects, other perspectives, and the latest information but also a good way of networking.

The papers being presented have been selected based on blind reviews and are of very high standards. An opportunity has been provided for research scholars to discuss their problems and an achievement with senior researchers is a welcome gesture. I am sure the conference has all the ingredients researchers look for in a conference and this conference will provide a new perspective to the researchers. A conference serves its purpose when the delegates get good opportunity to network for further research. I am very happy to state that being the First international conference (ICETES-2025) provides a platform for such an exchange of information.

The various technical and non-technical committees have put in admirable effort in making the conference a memorable one for all the delegates. I take this opportunity to congratulate all the delegates for their participation and contribution.

My best wishes to all the stakeholders!

**Dr. M. V. Bhatkar**  
**Conference Chair**

## **MESSAGE FROM CONVENER**

It is my great pleasure and honor to welcome everyone to the 1<sup>st</sup> International Conference on Emerging Trends in Engineering and Sciences (ICETES-2025). It brings together all researchers and practitioners from academia and industry to discuss foundations, techniques, and tools for automated analysis, design, implementation, testing, and maintenance of software systems.

This publication contains the proceedings of the conference, which was held at the institute on 7<sup>th</sup> - 8<sup>th</sup> February in Nashik. The conference featured keynotes, presentations, experiences, and discussions.

For the technical research track, we have received an overwhelming response for the number of submissions, of these few have been desk-rejected, while remaining considered for the final reviewing process.

As a highlight, ICETES-25 attracted internationally and nationally renowned keynote speakers, whose talks feature a quite diverse set of topics.

I would like to thank all the sessions' chairs, as well as the paper presenters and the attendees. Numerous organizing committee members have helped in various ways to make the event a success.

Last but not least, I would like to thank our Management and Principal for their faith and providing various kinds of support for the organizing the conference.

**Mrs. G. P. Mohole**  
**Convener**

## TABLE OF CONTENTS

| S.No | Paper Code | Paper Title<br>Authors                                                                                                                                                                                        | P.No |
|------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 1    | 02         | Revolutionizing Healthcare: Harnessing Artificial Intelligence for Overcoming Big Data Analytics Challenges<br>Chetan Ganpat Malavade, Megha Jonnalagedda                                                     | 1    |
| 2    | 04         | Blind Spot Identification on Roads Using Geometric Analysis in Indian Scenarios<br>Pranil Ashok Rao, Kedar Nagnathrao Ghogale                                                                                 | 7    |
| 3    | 05         | Vehicle Expiry Identification System: An Automated Compliance Solution<br>Parag Achaliya, Piyush Gosavi, Sidhant Ambure, Rutwa Yeole, Gunjan Bhansali                                                         | 14   |
| 4    | 06         | A Comprehensive Review of the Power of Machine Learning and Deep Learning in Cybersecurity<br>Prathamesh V Chavan, Nilesh V Alone                                                                             | 20   |
| 5    | 08         | Prediction of Hypertension Using XG Boost Algorithm<br>Yash Chandrakant Jagdale, Priyanka Subhash Jadhav, Pranav Vitthal Londhe, Pawan Babanrao Avhad, Harshal Mahesh Nalawade, Pradnya Mehta                 | 26   |
| 6    | 09         | Usage of Artificial Intelligence for Reviving Ancient Indian Scripts<br>Tushar B Kute, Premanand P. Ghadekar                                                                                                  | 33   |
| 7    | 11         | Automated Brain Tumor Detection and Classification Using a Deep Learning Approach<br>Ms. Akshata Bhamare, Dr. Archana Vaidya, Dr. Dipak V. Patil                                                              | 39   |
| 8    | 13         | Soil Image Classification and Crop Recommendation Using Machine Learning<br>Manali Pusalkar, Shruti Pande, Sakshi Sethi, Ankita Lonkar, Prof.Urmila Pawar                                                     | 46   |
| 9    | 16         | Visualizing Text: A Multifaceted Examination of AI-Driven Image Generation and Its Evaluation, with Implications for Video Synthesis<br>Dr.Niharika P Kumar, Kemthur Suraj, Divya Mallikarjuna, Harini Yalipi | 53   |
| 10   | 17         | Emotion Based Movie Recommendation System Using Deep Learning<br>Karishma Vijay Kankariya, Dr. Prashant M Yawalkar                                                                                            | 60   |
| 11   | 21         | Deep Q-Network Based Strategic Gameplay in a Minimalistic Card Game Simulation<br>Dr. Ajitkumar Shitole, Abhishek Baga, Sahil Bhilave, Pratiksha Bhosale, Rushikesh Andhale                                   | 67   |
| 12   | 22         | Survey on AI-Enabled Workspace for Note taking, Task Management & Collaboration with Geolocation<br>Ojas Desai, Pranav Nair, Pranav Pawar, Jaimeen Shah, Sangeetha Selvan                                     | 73   |
| 13   | 24         | Machine Learning Approach for Alzheimer's Diagnosis and Wellness Optimization<br>Saloni Dongare, Devjani Maity, Aparna Prakash, Prof.Payel Thakur, LakshmiPriya Sreedharan                                    | 80   |

|    |    |                                                                                                                                                                              |     |
|----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 14 | 25 | A Systematic Review on Satellite Image Segmentation using Deep Learning<br>Mrs. A. S. Gavade, Savali Shigawan, Prachi Kolte, Prerana Yadav, Sakshi Ingale                    | 86  |
| 15 | 31 | Comparative study on Identification and Prediction of Diverse Cyber Attacks with<br>NSLKDD & UNSW_NB15 Dataset<br>Swati Gawand, Dr. Meesala Sudhir Kumar                     | 91  |
| 16 | 33 | AI-Driven Mental Health Assistant: Enhancing Emotional Wellbeing with Llama-2<br>and Sentiment Analysis<br>Tejas Mahadik, Dr. Kirti H. Wanjale, Dr. Varsha Jadhav            | 96  |
| 17 | 35 | Harnessing Blockchain Technology to Revolutionize Healthcare Management<br>Samradni Salunke, Akshada Warkhede, Khushal Khemnar, Kasturi Shirole                              | 103 |
| 18 | 37 | Website Usability using AI<br>Amey Mohole, Rutuja Lomate, Kaiwalya Koparkar, Sudarshan Sanap                                                                                 | 108 |
| 19 | 38 | Deep Learning-Based Helmet Detection and Number Plate Recognition for Road<br>Ms. Sonali M. Gotraj, Prof. (Dr). N. R. Wankhade                                               | 113 |
| 20 | 39 | Convolutional Neural Network to Identify Sign Language for Hearing Impaired<br>Samradhny Sonwane, Varsha Jadhav, Kirti Wanjale                                               | 120 |
| 21 | 42 | Krushividnyan: Predictive Analysis and Crop Cost Management<br>Rutuja Vaidya, Sejal Patil, Snehal Pawar, Ruchika Kapadnis, Prof. A. A. Pundlik                               | 127 |
| 22 | 43 | Solar Operated Tilling Machine for Night Agriculture<br>Mr. Chaitanya Chaudhari, Mr. Shubham Ghotekar, Mr. R. R. Sonawane,<br>Mr. Y. R. Girase, Mr. A. A. Patil              | 132 |
| 23 | 45 | Virtual Try-On Systems: A Review of Methods for Garment Occlusion and Realism<br>Pankaj Agarwal, Prajwal Kadam, Ajit Chaudhari, Sahil Bhosale,<br>Dr Shradha Khonde          | 135 |
| 24 | 46 | Agriculture Food Supply Chain Traceability Using Blockchain<br>Prof. G. M. Bhandari, Sudhanshu Paropate, Adwaita Bhadre, Dhruvkumar Patil,<br>Chaitanya Thakor               | 141 |
| 25 | 49 | Smart Waste Management System Using IoT and KNN<br>Prof. Ashwini Pawale, Anuradha Dadasaheb Thombare, Prajakta Prabhakar Landge,<br>Gauri Babaji Gadge, and Dipti Sopan Dake | 147 |
| 26 | 51 | TrustChain: Empowering Transparent and Secure Voting through Blockchain<br>Technology<br>Nadeer Ansari, Taha Shaikh, Yash Wakade, Mehul Tamboli                              | 150 |
| 27 | 52 | Designing Image Based Captcha Using Machine Learning<br>Sonali Deshmukh, Dr. G. M.Bhandari, Prof. S. S Patil                                                                 | 156 |
| 28 | 54 | A Survey on Automated Storyboard System using Semantic Segmentation and NLP<br>Dr. Shraddha Khonde, Sushant Jadhav, Aniket Patil, Swarali Kakade, Swamini Patil              | 160 |

|    |     |                                                                                                                                                                                                        |     |
|----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 29 | 55  | Real-Time Object Detection Using Deep Learning<br>Shraddha Khonde, Pratik Manjare, Saniraj Desai, Gunjan Narkhede, Shivam Rathod                                                                       | 166 |
| 30 | 57  | Review Paper on Social Media Fake Account Identification Using Machine Learning<br>Rohini Ashok Gamane, Dr. Vaibhav Dabhade                                                                            | 173 |
| 31 | 58  | Automated Cricket Highlight Generation using Advanced Video Processing Techniques<br>Dr. Shraddha Khonde, Shraddha Lalbegee, Rida Shaikh, Afifa Shaikh, Saniya Sayye                                   | 179 |
| 32 | 66  | AI-ML Based Career Counselling for Computer Department<br>Pratham Sharma, Prathamesh Sonawane, Sanket Shinde, Harshvardhan Patil, Bhushan Gholap                                                       | 186 |
| 33 | 67  | A Survey on Recreational Suitability Assessment and Information System for Indian Beaches<br>Sanskriti Thorve, Chetana Bahale, Anuja Chavan, Gaurav Pandarkar, Prof. Rekha Kotwal                      | 192 |
| 35 | 73  | Real-Time Math Solver Using Hand Gestures with AI<br>Prof. Rekha Kotwal, Vyankatesh Jadhav, Sakshi Jagtap, Rashi Magar, Viraj Pandit                                                                   | 197 |
| 36 | 74  | Cardiovascular Illness Detection and Categorization with Innovative Neural Networks<br>Ms Anuradha S Deokar, Dr. Madhavi A Pradhan                                                                     | 204 |
| 37 | 75  | Vehicle Number Plate Recognition using LLM aided OCR<br>Bhagyashree Lambture, Ketaki Nerkar, Priyanka Rote, Vedah Nawale                                                                               | 211 |
| 38 | 81  | Societal Effects and Challenges Before the Applications of Data Mining Techniques in Retail Sector<br>Khushbu Mahesh Pawar, Deepak V. Nandre                                                           | 218 |
| 39 | 82  | Plant Disease Detection and Classification using Deep Learning: A Review<br>Tejaswini B. Kushare, Shyamrao V. Gumaste                                                                                  | 224 |
| 40 | 85  | Integrating BIM and FEM Tool for Design of Non-Prismatic Member to Minimize Connection and Bracing<br>Nirmal G. Lohar, Ketan A. Salunke, Sachin U. Pagar                                               | 230 |
| 41 | 94  | Deep Learning Based Carbon Emission Monitoring<br>Namrata M. Pagar, Monali P. Mahajan                                                                                                                  | 234 |
| 42 | 95  | A Comparative Study on Object Detection for Visually Impaired using Artificial Intelligence and Machine Learning Technology<br>Arvind Mugdha, Pajgade Nandini, Megha, Nimbalkar Atharva, Deore Shalaka | 238 |
| 43 | 99  | CNN-Based Deep Learning Framework for detection of ROI in Breast Cancer Images<br>Satish L Yedage, Indrabhan S. Borse                                                                                  | 244 |
| 44 | 100 | Inductive Coupling for Wireless Charging of Electric Vehicles<br>Prof. Dr. Deepa S. Bhandare, Sumedh Kulkarni, Pratik Kunjir, Prof. Dr. Vidula S. Jape, Prof. Dr. Shalaka Chafekar                     | 248 |

|    |     |                                                                                                                                                                                                                             |     |
|----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 45 | 101 | DVWA Vulnerability Analysis: A Comprehensive Cybersecurity Ecosystem Perspective<br><br>Niharika Prasanna Kumar, Sarah Rajgoli, Aiman Sabah                                                                                 | 256 |
| 46 | 103 | Medicinal Plant Identification using Image Processing and Machine Learning Algorithm<br><br>Shailendra M. Pardeshi, Tarini Patil, Dr. Rajnikant B. Wagh, Dhanashri Girase, Dipashri Patil, Bhumika Mahale, Vipul D. Punjabi | 262 |
| 47 | 104 | A Dual-Approach System for Lung Cancer Detection: Images and Symptoms<br><br>Sakshi Chavhan, Monali Khairnar, Rudram Patil Mansi Raut, Dr. Satish Devane                                                                    | 270 |
| 48 | 105 | Improving Marathi POS Tagging Accuracy by Addressing Linguistic Ambiguities and Exploring Effective Techniques<br><br>Chhaya Suhas Patil, Amit Prakashrao Patil, Vaishali Bhagwat Patil                                     | 276 |
| 49 | 108 | Symptom Checker Framework: Leveraging Machine Learning for Early Diagnosis in Healthcare Systems<br><br>Prof. Komal R. Jadhav, Prasad Sacchidanand Bhat, Mohan Muralidhar Jadhav, Kunal Eknath Thakare                      | 282 |
| 50 | 109 | Agrovision : Your Ai Companion for Smart Farming<br><br>Komal Jadhav, Bhagyashri WankarShanuj, TiwariJaswantSingh, Akash Oad, Dr. Sonali Sonavan                                                                            | 287 |
| 51 | 111 | A Review of Personalized Haircare Product Recommendation System Using Ingredient-Based Analysis and Machine Learning<br><br>Diksha Dhumal, Kesar Tank, Samrudhi Magdum, Sanchayita Gaikwad, Shalaka Deore                   | 293 |
| 52 | 112 | Pynq Framework Based Defect Detection Using Convolutional Neural Networks<br><br>Mr. Jadhav Shrijivan, Mr. Lokare Pratik, Ms. Nikam Aditya, Dr. R. K. Shashtri                                                              | 299 |
| 53 | 114 | Deep Learning for Driver Drowsiness Detection: A Comprehensive Review<br><br>Aryan Parishwad,Dhruv Rathod, Shravani Borude, Ruchika Kadambande, Shalaka Deore                                                               | 303 |
| 54 | 115 | Local Markets, Global Flavors: Your Personalized Grocery Experience<br><br>Payal Jadhav, Jagruti Salunkhe, Nikita Patil, Dhanashri Borse, Sagar U                                                                           | 310 |
| 55 | 117 | Automated Information Retrieval System for Equity Research Analysis Using LLM<br><br>Sayali Belhe, Swapnil Nandre, Tanvi More, Vishwajeet Patil, Srushti Shinde                                                             | 316 |
| 56 | 121 | Emotion-Aware Voice Personal Assistant: A Human Centric Approach to Intelligent Interaction<br><br>Prof. Radhika Fulzele, Priyanka Sekhar, Shubham Rane, Rosh Jaison, Shifali Kotian                                        | 320 |
| 57 | 123 | Divorce Prediction Using Artificial Intelligence & Deep Learning<br><br>Mrs. Vidya V. Jagtap, Dr. Geetanjali Jindal, Ms. Pallavi L Rahinj                                                                                   | 327 |

|    |     |                                                                                                                                                                                                                                        |     |
|----|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 58 | 126 | Digital Garbage Management and Energy Conservation<br>Dr. Arti Mohanpurkar, Anam Sayyad, Shreeya Maliye                                                                                                                                | 332 |
| 59 | 128 | AI-ML-based System for Predicting Prices of Agricultural Products<br>Ms. Sakshi Chaudhari, Ms. Gautami Sanap, Ms. Tejal Sangale,<br>Ms. Prerana Wagh, Ms. Manisha Thombare                                                             | 337 |
| 60 | 129 | Advancing Marathi Nlp: Multiword Expression Detection with L3cube-Bert<br>Ujwala P. Mahaja, Ajay S. Patil, Nita V. Patil                                                                                                               | 341 |
| 61 | 130 | Investigation of Deviations from Classical Metric Space<br>Megha Pingale (Kothawade), Farhat Shaikh                                                                                                                                    | 348 |
| 62 | 131 | Automatic Shutter Systems Using PLC for Automotive Industry<br>S. R. Pandit, Gaurav Nikam, Sujit Gadhe                                                                                                                                 | 354 |
| 63 | 132 | Urbancrew: In-Time Service Solution on Figure Click<br>Geetanjali Mohole, Kuldeep Girase, Rushikesh Pawar, Abhishek Pagar,<br>Kunal Chaudhari                                                                                          | 358 |
| 64 | 133 | Simplifying Diabetic Retinopathy Diagnosis with VGG-NIN: A Survey<br>Tejashri Kakad, Neeta Deshpande                                                                                                                                   | 364 |
| 65 | 134 | Explore the Suicidal Notes to Understand the Negation Behavior Behind It: Through<br>Multi-Labeled Sentiment Analysis<br>Shivam R. Bandal, Airattel Joel Manoj, Amarjit Babu M J, Sachin Singh,<br>Dr. Monali Patil, Prof. Diksha Kale | 371 |
| 66 | 136 | Speech Emotion Recognition using a Minimal Dataset and Machine Learning<br>Algorithms<br>Parimal Mate, Varsha Jadhav                                                                                                                   | 378 |
| 67 | 138 | Supply Chain Management Using Blockchain<br>Yash Mahajan1, Vaishnavi Damarlu, Shivam Gunjal, Komal Kadam,<br>Shubham Thorat G.P. Mohole                                                                                                | 385 |
| 68 | 141 | FinVia - Where Finance Meets Insight<br>Siddhesh Sandeep Bangar, Aditya Satheesan, Zaid Sajid Khalfe,<br>Shaligram Srinivas Mashalkar, Prof. Diksha Vilas Kale                                                                         | 392 |
| 69 | 142 | Utility Maximization of Multi Route Tour Planning Problem for Tourist using Type-2<br>Fuzzy Logic and Improved Genetic Algorithm<br>Tanuja Bera, Somnath Maji, Pramit Ghosh, Manoranjan Maiti                                          | 398 |
| 70 | 143 | Predicting Educational Performance of Students Using Machine Learning<br>Ms. Rupali Biru Rahinj, Mr. N. R. Wankhade                                                                                                                    | 404 |
| 71 | 145 | Emerging Trends in AI-Powered Knowledge Management: A Comprehensive<br>Literature Review<br>Sarah Rukhmuddin, Rajgoli, Niharika, Prasanna Kumar, Anirudh Madhusudan Balgi,<br>Darshan Gowda, S R, Shivangi Singh                       | 409 |

|    |     |                                                                                                                                                                                                                       |     |
|----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 72 | 146 | Gas and Flame Emergency Shutdown System<br>Saeed Palekar, Komal Pingle, Sudiksha Chavan, Satish Nikam                                                                                                                 | 416 |
| 73 | 147 | Securing Healthcare 5.0: A Review of Applications, Security Challenges, and Future Perspectives<br>Mahesh B Sonje, Sandip S Patil                                                                                     | 422 |
| 74 | 148 | Neuroimaging in Clinical Trials for Huntington's Disease: Emerging Research Findings: The Advancement Directions and Implications<br>Vinod B Bhamare, Sandip S Patil                                                  | 431 |
| 75 | 150 | Smart Hire Using Machine Learning<br>Sharmila Zope, Kanchan Thorat, Swam Mali, Anagha Shewale, Shubham Arsule                                                                                                         | 441 |
| 76 | 152 | Blockchain Based Biometric EVM using Cloud Integration for Enhanced Security and Transparency<br>Tanvi Sonawane, Surabhi Chavhan, Diksha Gaval, Tejashri Sonawane, Mr. V. D. Badgajar                                 | 446 |
| 77 | 156 | Development and Validation of Novel First Order Derivative UV Spectrophotometric Method for Telmisartan in Bulk and Formulation<br>Sarika R. Jadhav, Shashikant N. Dhole                                              | 454 |
| 78 | 157 | Deepfake Video Detection<br>Dr. K. A. Shirsath, Nikhil Singh Jodha, Khushi Solanki, Tejas Mehetre, Gitesh Deshmukh                                                                                                    | 458 |
| 79 | 158 | Optimizing Police Resource Allocation and Performance: A Data-Driven Approach<br>Dr. K. A. Shirsath, Pranav Pansare, Omkar Sonawane, Sakshi Nagare, Tanmay Chaudhari                                                  | 463 |
| 80 | 160 | Survey Paper: Fine-Grained Sentiment Analysis Using Attention Mechanisms in Machine Learning and Deep Learning<br>Priyanka Pravin Patil, Dr. Sunil Gupta                                                              | 470 |
| 81 | 162 | Design, Development and Experimental Investigation of Lightweight Carbon Fiber Reinforced Magnesium Alloy Composite<br>Mr. Avhale Digambar Pandurang, Prof. Dr. S M Satao                                             | 478 |
| 82 | 163 | Hand-drawn Electronic Component Detection and Simulation using Deep Learning and Flask<br>Anmol Arun, Gayathri Poduval, Sejal Patil, Amar Shah, Rupali Patil                                                          | 487 |
| 83 | 164 | Spectral Classification of Chandrayaan-2 IIRS Using AI / ML for Understanding Geological Diversity of Moon<br>Ms. Pawar Bhakti, Ms. Shelar Shweta, Ms. Omase Sneha, Dr. R. K. Shastri, Vidya Pratishthan's Kamalnayan | 493 |
| 84 | 165 | Emerging Role of ICT in Chemical Sciences<br>Dr. Kailas K. Sanap, Dr. Sandeep S. Kahandal, Dr. Vijay J. Desale, Dr. Anita K. Sanap                                                                                    | 498 |

|    |     |                                                                                                                                                                                                           |     |
|----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 85 | 166 | A Review on Early Detection and Progression Prediction of Diabetic Retinopathy Using Multimodal Analysis<br>Mrs. Swati Kiran Rajput                                                                       | 502 |
| 86 | 167 | Flex Fuel Engine Technology Integrated with Gasoline Direct Injection: A Review<br>Pratik K. Sonawane, Krishna S. Shrivastava                                                                             | 508 |
| 87 | 169 | Abusive Offensive and Threatening Marathi Language Detection from Social Media Comments Using GRU, RNN, LSTM and BiLSTM<br>Bhushan Nikam, Ajay Patil, Nita Patil                                          | 515 |
| 88 | 170 | Enhancing Navigation for Railway Station Facilities and Location<br>Tanmay Kalal, Vaishnavi Talele, Mahesh Sapate, Abhijit Dhoble, Mrs. S. N. Botekar                                                     | 521 |
| 89 | 173 | Admission Assistance Voice BOT<br>Suvarna Bhagwat, Sanika Warule, Sanika Khokarale, Anujay Mule, Atharv Kawalase, Monali Patil                                                                            | 533 |
| 90 | 174 | QR Based Attendance Tracking<br>Suvarna Bhagwat, David Bobby Zachariah, Atharv Shaligram Main, Kashmira Nilesh Deokar Atharv, Uday Lad, Manisha Deshmukh                                                  | 539 |
| 91 | 180 | Automated Skin Lesion Classification Using Ensemble of Machine Learning and Deep Learning<br>KrishnaKumar B Sharvithaa D, Priyadarshini K, Rajeshwari M                                                   | 545 |
| 92 | 182 | A Deep Learning Based Approach for Phishing URL Detection Using LLM<br>Ms. Bhagyashree Lambture, Srushti Chordia, Rutika Dabholkar, Aditya Bhargude                                                       | 552 |
| 93 | 184 | The Future of Diploma Education in India: Transformations Under the National Education Policy (NEP) 2020<br>Priti B. Kudal, Dhanashree S, Joshi, Sonali, K. Mandlik, Priyanka, V. Kadam, Chetna N. Purkar | 558 |
| 94 | 192 | Electrospun Nanofibers for Tissue Repair<br>Archana Shantaram Gadakh, Abhijeet Dattatray Kulkarni                                                                                                         | 561 |
| 95 | 194 | A Review of Recent Use of Vision Processing Devices in Image Identification and Real-World Applications<br>Abhijit Ravindra Kulkarni, Dr. S. P. Agnihotri                                                 | 565 |
| 96 | 200 | Measuring the Impact of Technical Debt on Development Effort in Software Projects<br>Kartik Gupta                                                                                                         | 573 |
| 97 | 202 | Enhancing Real-Time EEG Analysis: EOG Artifact Removal Using GPGPU<br>Mahesh Khadtare, Dr. Gajanan K. Kharate, Dr. Dnyaneshwar Ahire                                                                      | 579 |

|     |     |                                                                                                                                                                                      |     |
|-----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 98  | 203 | Optimizing MI-BCI Systems with NVIDIA Jetson Orin Nano<br>Mahesh Khadtare, Dr. Gajanan K. Kharate, Dr. Dnyaneshwar Ahire                                                             | 587 |
| 99  | 204 | Nexus NFT Using Blockchain<br>Priya Kotwal, Rushikesh Admane, Anam Shaik, Mohin Shaik, G.P. Mohole                                                                                   | 594 |
| 100 | 205 | Forecasting the Interdependence of Compressive and Split Tensile Strength of Quartz Sand Concrete<br>N. Tejaswini, A. Sreenivasulu, B. Krishna Rao                                   | 600 |
| 101 | 206 | Estimating Wheat Farm Yield Using UAV Multispectral Imaging<br>Dr. Harsha Patil, Ms. Kanchan Borade                                                                                  | 604 |
| 102 | 213 | Tracking and Detecting Depression Level using Facial Recognition and PEN & IQ Test<br>Krushnal Choudhary, Hrutika Pagare, Shantanu Sambhare, Sakshi Aher and Mrs S. N. Botekar       | 610 |
| 103 | 214 | Stockpile: A Multi-tier Inventory Management System for Wholesalers, Shopkeepers, and Customers<br>Mr. Vaibhav D. Sonawane, Ms. Trupti N. Pathade, Mrs. Sharmila P. Zope             | 614 |
| 104 | 215 | Comparative Study Biochar Bricks on Other Different Types of Bricks<br>Nilesh A Ahire, Suhas U Pandit, Ganesh R Sawant, Sudarshan R Vhatkar                                          | 618 |
| 105 | 216 | Role of Artificial Intelligence and Machine Literacy in VLSI Design- A Brief Survey<br>Sunita D. Giri, Sunita G. Bidkar, Anuja D. Giri                                               | 624 |
| 106 | 217 | Synthesis and Structural Characterization of SiO <sub>2</sub> -GO Hybrid Materials for Enhanced Lithium-Ion Battery Anodes<br>Pawan D. Somavanshi, Yogesh U. Sathe, Swapnil N. Dhole | 631 |
| 107 | 218 | Signify: An Enhancing ASL Communication Model with Deep Learning<br>Vipul Devendra Punjabi, Shailendra .M. Pardeshi, Dr. Rajnikant B. Wagh, Dr. Dharmaraj R. Patil                   | 638 |
| 108 | 219 | Unveiling Error Estimation: Harnessing Banach Contraction Principle for Linear Equations Systems<br>J. M. Soni, L. S. Patekar                                                        | 645 |
| 109 | 220 | Multi Capacitor-Based Active Cell Balancing Techniques for Lithium-Ion Batteries<br>Prof Devendra J Goyar, Prof. Pooja R Shastri, Prof. Mugdha Kulkarni                              | 649 |
| 110 | 241 | Enhancing Online Safety: Machine Learning Approaches for Toxic Comment Classification in Social Media<br>Meghan Diwate, Swaraj Bhumare, Lokesh Gandhi, Prof. Silkesha Thigale        | 653 |
| 111 | 248 | Comparative Investigation of Classification Algorithms using Parkinson's Disease Acoustic Analysis Dataset to Choose Best Classifier for Best Result<br>Dr. Puja Gholap              | 660 |

|     |     |                                                                                                                                                                                                                                      |     |
|-----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 112 | 249 | Implement an Advanced Algorithm for Cloud Data Encryption and Multi-Keyword Search Using Cryptographic and Semantic Techniques<br>Narendra Shyam Joshi, Dr. Kuldeep . Sambrekar, Dr. Abhijit J. Patankar, Tushar Kaloge, Vishal Ohol | 667 |
| 113 | 250 | The Intersection of Ergonomics and Machine Learning in Designing Passenger Safety Systems for Autonomous Vehicles<br>Santosh Sancheti, Kainjan Sanghavi, Mahesh Sanghavi, Rahul Chandor, Dipak Sancheti                              | 675 |
| 114 | 251 | Digital Twins for Predictive Maintenance and Performance Enhancement in Autonomous Vehicles<br>Kainjan Sanghavi, Santosh Sancheti, Mahesh Sanghavi, Goba Shinde                                                                      | 685 |
| 115 | 255 | Cryptanalysis of SDES Using Machine Learning: Predicting Plaintext from Ciphertext<br>Vinod Shantaram Mahajan, Dr. Hitendra D. Patil                                                                                                 | 695 |
| 116 | 259 | Blue Eyes Technology: Revolutionizing Healthcare Management through Emotion and Vital Parameter Monitoring<br>Priya Ray, Harshal Pagar, Sonal Borase                                                                                 | 698 |
| 117 | 261 | A Wearable Smart System to Assist Visually Challenged<br>Tushar Khairnar, Kiran Bodke, Sonal Borase, Mahesh Patil                                                                                                                    | 702 |
| 118 | 155 | Review Paper on Food Images Recognition and Calorie Estimation<br>Prof. Dr. Yogita Bhise, Nishant Bhise, Shruti Thorat                                                                                                               | 708 |
| 119 | 225 | The Echo: Enhance Collaborative Overcraft Observer<br>Shivam Bhamare, Gaytri Jaware, Rahul Bombale, Pravin Borse, Mrs. Manisha Shelar                                                                                                | 713 |
| 120 | 16  | Alternate to SF6 Gas in Gas Insulated Switchgear<br>Rahul S. Patil, M.V. Bhatkar                                                                                                                                                     | 720 |

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mr. R. R. Sonawane has  
presented paper entitled SOLAR OPERATED TILLING AND SOWING MACHINE FOR NIGHT  
AGRICULTURE

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mr. Y. R. Girase has  
presented paper entitled SOLAR OPERATED TILLING AND SOWING MACHINE FOR NIGHT  
AGRICULTURE

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mr. A. A. Patil has  
presented paper entitled SOLAR OPERATED TILLING AND SOWING MACHINE FOR NIGHT  
AGRICULTURE

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Solar Operated Tilling Machine for Night Agriculture

**Mr. Chaitanya Chaudhari, Mr. Shubham Ghotekar**

Jawahar Education Society's Institute of Technology, Management & Research, Nashik  
chaudharichaitanya826@gmail.com

**Mr. R. R. Sonawane, Mr. Y. R. Girase, Mr. A. A. Patil**

Assistant Professor, Mechanical Engg. Department  
Jawahar Education Society's Institute of Technology, Management & Research, Nashik  
rrsmechjit@gmail.com

**Abstract---**This project aims to design and fabricate a machine that can plough, sow, and till fields using solar power, reducing the need for fossil fuels and manual labour. The objective of this project includes selecting the appropriate components, designing the machine, fabricating the machine using various manufacturing processes, and testing the machine for agricultural purposes. To achieve the objective the procedure is to study different mechanisms, select the appropriate power transmission system, design machine parts and conduct FEA to ensure machine durability. In comparison with the traditional method, results like tilling and sowing machine gives better performance. This machine can revolutionize small-scale farming, promote sustainable agriculture practices, and contribute to rural development.

**Keywords---**Agriculture, Tilling, Sowing, Ploughing, Machine, Manual, ECO-friendly.

## I. INTRODUCTION

Agriculture is the major source of income in India. There is a huge requirement for development in farming areas, which can be obtained by using modern and progressed mechanical techniques for cultivating processes like digging, planting, water systems, etc. India is a place that is known for its huge populace, where food requirement is major concern. Indian economy is dependent on Agriculture field from a longtime. In Indian agriculture, the arrangement of seedbeds for tillage culturing utilizing extra machinery and tilling tools is expanded to work apparatuses. A power tiller or cultivator is one of the culturing machines generally appropriate for seedbed preparation. In a power tiller machine, the sharp edge/blade is the main part, which is locked in with the dirt to sort out a seedbed and blend the fertilizer. For increasing the maximum removal of unwanted plants which grow along with a cultivated crop efficiently with the tilling blade use. That is because of utilizing and increasing the fertility of the land to increase crop productivity.

## II. PROBLEM STATEMENT

The tilling and ploughing the land requires more manpower therefore the cost of manpower becomes a financial burden for farmers, particularly for those who are on a tight budget.

- Working with hand tools can be dangerous and cause

injuries to the worker, resulting in pain and possibly loss of work time.

- The physical demands of using hand tools can be strenuous, and workers may experience fatigue after completing their tasks. The use of fossil fuels in machines contributes to global warming, which is a significant environmental issue.
- Conducting various tasks individually, such as tilling, ploughing, and sowing, can be time- consuming and result in longer periods of work.

## III. OBJECTIVES

The main purpose of this project is to create a versatile agricultural machine that can perform multiple tasks and operations.

- By reducing the need for manual labour, the machine aims to decrease the costs associated with hiring workers.
- The primary goal is to increase crop productivity rates by using a machine designed to perform tasks accurately and consistently.
- The machine aims to reduce planting time, allowing farmers to complete planting more quickly and efficiently.

## IV. LITERATURE REVIEW

1] Sonu Yadav, et al, [2021] design power tiller machine for small farming area. For small farming area, farmer needs more manual effort which further increases cost of tilling. The machine uses a wheel and this wheel is welded with angles for tilling process. An electric motor drives the wheel with the help of chain sprocket arrangement. The use of such motorized tilling machine reduces human effort at very low cost. This unique portable design reduces labour time as well as cost of tilling. It also increases agricultural output and efficiency.

2] Dr. P. Selvakumar et.al,[2020] designed the machine which perform multiple work such as tilling, ploughing and seed sowing simultaneously. This machine consists of three wheels out of that, one wheel is provided at front end and remaining two wheels at the rear end. Electric motor used to drive the shaft instead of Diesel Engine. During the farming, the sequence of operation are followed such as tilling, seed sowing and hilling of sand by shovel etc.

Therefore such machine makes work so simple and reduces man power and it's cost.

3] Shabbir J. Karjatwala, et al, [2018] design the mini cultivator and tiller model for 1.5 hector areas. In this paper researcher compared traditional method with new technological model. This model reduces the cost of traditional method and performed multifunction like tilling, Ploughing etc.

4]Kalash Singhal,et al, [2018] design solar operated seed sowing machine. This machine developed to carry out different farming activities. I.C Engine causes air and noise pollution in farming area which can be reduced by use the use of solar energy. In this machine, a solar panel is used to utilize solar energy and this energy is stored inside a 24V battery. This battery drives the DC motor which further rotates the cutter for digging operation. This machine is designed for seed sowing and irrigation purpose.

5] Md. Aqib Naque,et al, [2013] design machine soil tiller and weeder for small land area. This machine uses engine and chain sprocket arrangement for cutter and tilling. This machine helps the farmer to reduce labour cost and increased productivity.

## V. PRACTICAL IMPLICATIONS/ APPLICATIONS

The practical implications of the machine are significant for the agricultural sector. The following are some practical implications of the project:

1. Increased productivity: The solar-operated tilling and sowing machine has the potential to significantly increase crop productivity rates. As the machine is powered by solar energy, it can work for longer hours without incurring any additional costs, which can ultimately result in higher crop yields.
2. Cost savings: By using this machine, farmers can save a significant amount of money as it reduces the need for manual labour and eliminates the need for fossil fuels. Additionally, the machine's compact design ensures it takes up minimal space, which saves on storage costs.
3. Eco-friendly farming: This machine is designed to be eco-friendly, as it does not emit any pollutants or greenhouse gases. By using this machine, farmers can contribute to a sustainable environment by reducing their carbon footprint and mitigating the negative impact of traditional farming practices on the environment.
4. Adaptable to different farming requirements: The design of the machine is flexible and can be adapted to different farming needs by attaching external tools. This makes it an all-in-one solution for various tasks, including ploughing, sowing, and tilling.

## VI. RESULTS AND DISCUSSION

By taking trials on the field of this machine and gathering all information on other possible methods we

have got the following results.

1) The project aimed to address the challenges faced by farmers in performing various agricultural tasks by developing a solar-operated tilling and seed sowing machine. By fulfilling the needs of farmers who struggle with rising labour costs and availability, the project objective is to improve the efficiency and productivity of agricultural operations.

2) The machine has successfully overcome the limitations of traditional sowing methods, with a lower capital cost than other farming equipment, eco-friendliness, and ease of troubleshooting. These benefits make the machine a valuable asset to Indian agriculture, contributing to increased efficiency and sustainability. Overall, the project has resulted in a significant improvement in agricultural practices, benefiting farmers and the industry as a whole.

TABLE 1. COST COMPARISON

| Sr.No. | Parameter                            | Manual Method | Seed Sowing Machine |
|--------|--------------------------------------|---------------|---------------------|
| 1      | Cost per Guntha (100m <sup>2</sup> ) | Rs. 100-150/- | Rs. 10-20/-         |
| 2      | Time per Guntha (100m <sup>2</sup> ) | 1-2 days      | 1 day               |
| 3      | No. of Labours                       | 1             | 1                   |

1 Guntha = 1089 sq feet =101.171 square meter  
Sowing machine speed = 1m in 5 seconds

∴For 1 Guntha time required = is 1388 min = 23.13 hr.

The speed of the machine is 1 m in 5 seconds. In 50 sec, it covered 10 m distance and in 8.33 min it covered 100 m. But this is for just 1 row and we have a total of 166 rows in 100 square meters for the distance between both the teeth is 30 cm. So the time calculated for 1 Guntha (100 square meters) is 1388.2 min or 23.13 hr.

TABLE 2. SEED ISOLATION DISTANCE

| Sr. No. | Types of Seed | Distance ( cm ) |
|---------|---------------|-----------------|
| 1       | Groundnut     | 15              |
| 2       | Onion         | 15              |
| 3       | Okra          | 30              |

Table 2 shows the different types of seeds and the distance between the planting of two successive seeds. While sowing the groundnut, the distance between two successive ground nut is 15 cm measured. For the onion, the distance measured is 15 cm and for okra, the distance measured is 30 cm.

TABLE 3. SEED DISTANCE MEASURED WITH DIFFERENT ROTORS

| Sr. No. | Type of Rotor ( No. of Teeth ) | Measured Distance ( cm ) |
|---------|--------------------------------|--------------------------|
|---------|--------------------------------|--------------------------|

|   |   |    |
|---|---|----|
| 1 | 4 | 30 |
| 2 | 6 | 22 |
| 3 | 8 | 16 |

Table. 3 shows the different types of rotors and the distance measured by them. For the 4 teeth rotor, the measured distance is 30 cm. The 6 teeth rotor has a measured distance of 22 cm and the 8 teeth rotor has a measured distance of 16 cm.

TABLE 4. RESULT OF SOWING DEPTH

| Sr. No. | Type of Seed | Sowing Depth Measured ( cm ) | Sowing Depth Required (cm ) |
|---------|--------------|------------------------------|-----------------------------|
| 1       | Groundnut    | 6                            | 5-7                         |
| 2       | Onion        | 3                            | 2.5                         |
| 3       | Okra         | 2                            | 2                           |

Table 4 shows the comparison of the sowing depth measured and the sowing depth required. It is for groundnut, onion and okra. For groundnut, the required depth is 5-7 cm and the measured distance by machine is 6 cm. Onion has a required depth of 2.5 cm and the measured distance by machine is 3 cm. Okra has a required depth of 2 cm and the measured distance by machine is 2.

## VII. CONCLUSION

Solar-operated tilling and sowing machine greatly reduce the need for manpower and function effectively. This system helps the farmers for crop cultivation in particular farm fields. It reduces overall time required for the plantation of crops and increases the production rate. This machine also reduces cost of the plantation compared with conventional methods. It does not use any fossil fuel. It is pollution free machine. This machine is portable so farmers can keep this entire setup in a less space. Depending upon the work type, attachments (external) can be added to the machine. Therefore, the machine can be utilized for a variety of tasks.

## ACKNOWLEDGMENT

We would like to take this opportunity to express our honour, respect, deep gratitude and genuine regard to the Head of the Mechanical Engineering Department, Prof. Y. R. Girase, for giving us valuable guidance during our project work as a constant source of inspiration and motivation.

We are also extremely grateful to Dr. M. V. Bhatkar, Principal, JESITR, Nashik for his various suggestions and kind help during our project work.

## REFERENCES

- [1] Sonu Yadav, Harshal Deshmukh, Chetan Dhapodkar, Ashish Singh Parihar, Guman Viridi, Prof. Prashant Rahate, "Portable Electric Tiller Machine", IJARST, Volume 7, Issue 1, July 2021.
- [2] Dr. P. Selvakumar, Dhanishk M, Ashwin V, Arun

Kumar P N, "Design and Fabrication of Agricultural Land Tilling and Planting Machine", Volume 9, Issue 02, ISSN 2277-8616, Feb. 2020.

[3] Shabbir J. Karjatwala, Chetan L. Kurkute, Saurabh S. Lad, Hitesh K. Jadhav, Tejshree R. Daithankar, "Design, Development and Fabrication of Mini Cultivator and Tiller", Open Access International Journal of Science and Engineering, Volume 3, Special Issue 1, March 2018.

[4] Kalash Singhal, Gaurav Prajapati, Vipul Saxena, "Solar Powered Seed Sowing Machine", International Journal of Applied Engineering Research, ISSN 0973-4562, Volume 13, Number 2018, P.259-262.

[5] Md. Aqib Naque, Akhtar Ali Rizvi, Amogh V. Tijare, Prof. A. B. Tupkar "Design, Development and Fabrication of Soil Tiller and Weeder", IJIT, Vol. 2, Issue 2, April 2013.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Dr. M. V. Bhatkar has  
presented paper entitled Alternate to SF6 gas in Gas insulated switchgear

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

**Dr. M. V. Bhatkar**  
Conference Chair

# Alternate to SF<sub>6</sub> Gas in Gas Insulated Switchgear

Rahul S. Patil<sup>#</sup>, M.V. Bhatkar<sup>\*</sup>

<sup>#</sup>Electrical Engineering Department, K. K. Wagh IEER, Nashik.

<sup>\*</sup>Jawahar Education Society's Institute of Technology, Management and RESEARCH Nashik.

**Abstract---**For many years, SF<sub>6</sub> has been the preferred dielectric medium in electrical power applications, particularly in high voltage gas-insulated equipment. However, with the recognition that SF<sub>6</sub> has an extremely long atmospheric lifetime and very high global warming potential, governments have pursued emission reductions from gas-filled equipment. The electrical power industry has responded to this environmental challenge applying SF<sub>6</sub>-free technologies to an expanding range of applications which have traditionally used SF<sub>6</sub>, including gas-insulated switchgear, gas-insulated circuit breakers and gas-insulated lines or bus bars. Some of these SF<sub>6</sub>-free solutions include gas mixtures containing fluorinated compounds that have low climate impact, among them, a fluoronitrile and a fluoroketone developed as Novec™ 4710 Insulating Gas and Novec™ 5110 Insulating Gas, respectively. Both fluoronitrile and fluoroketone mixtures are successfully used in gas-insulated equipment currently operating on the grid where they reduce greenhouse gas emissions by more than 99% versus SF<sub>6</sub>. This paper reviews these leading components of alternative-gas mixtures with updates on the performance, safety and environmental profiles in electrical power applications.

**Keywords---**Sulfur Hexafluoride; SF<sub>6</sub>; Insulation; Dielectric Medium; SF<sub>6</sub>-free; SF<sub>6</sub>-Alternative; Fluoroketone; Fluoronitrile.

## 1. INTRODUCTION

Sulfur hexafluoride, SF<sub>6</sub>, has been a critical component in high voltage applications for several decades with the installed base of gas-filled equipment continuing to grow. Its combination of chemical, electrical, and physical properties has made SF<sub>6</sub> the preferred dielectric medium in gas-insulated switchgear (GIS), gas circuit breakers (GCB) and gas insulated lines (GIL). While much of the equipment operating on the electrical grid today depends upon the use of SF<sub>6</sub>, the industry has been searching for an alternative due to environmental concerns over the properties of this highly stable insulating gas. A long atmospheric lifetime of 3200 years results in a global warming potential (GWP) for SF<sub>6</sub> of 23,500, making it the most potent greenhouse gas identified to date. Identification of viable alternatives to SF<sub>6</sub> is complicated by the unique combination of properties required in dielectric applications. Unfortunately, the very properties that make SF<sub>6</sub> an ideal insulating gas, namely chemical inertness, are the same properties that make it exceptionally long lived in the atmosphere. Therefore, any replacement of SF<sub>6</sub> as an insulating gas must implicitly have some form of reactivity to facilitate degradation in

the atmosphere and overcome the environmental concerns. The materials also need to be non-flammable and low enough in toxicity to allow for safe handling using practices similar to those currently used within the industry. Alternatives certainly need to have very high dielectric strength, providing performance as close to SF<sub>6</sub> as possible. Since the gas-filled also be stable over the working life of this equipment without contributing to corrosion or other adverse effects on the device. Most importantly, to be sustainable alternatives, new compounds need to have acceptable combinations of environmental properties, including no ozone depletion potential and significantly reduce the greenhouse gas emissions from these applications compared to SF<sub>6</sub>, since this is the principal reason for transitioning to new technology. properties for electric power applications. They both have been shown to function as a key dielectric component in insulating gas mixtures while providing significantly lower climate impact. As a result, the electric power industry has begun implementing SF<sub>6</sub>-alternative gas mixtures based upon these compounds over the last several years [1–4]. The fluoronitrile and fluoroketone are recognized within the electric power industry Novec™ 4710 Insulating Gas and Novec™ 5110 Insulating Gas, respectively [5]

## 2. Required Physical and Chemical Properties of Insulation Gas

An environmentally sustainable insulation gas alternative to SF<sub>6</sub> should be compliant with the stringent requirements of high-voltage applications [6,7]. The physical and chemical properties include.

- High-dielectric strength;
- Good arc-quenching capability;
- High heat dissipation (high thermal conductivity);
- Low boiling point and high vapor pressure at low temperature;
- Compatibility with other materials; and
- Design compactness.

In addition, it also has to meet environmental and safety requirements, such as

- Low GWP;
- No ozone depletion potential (ODP);
- Low toxicity; and
- Non-flammable and nonexplosive.

## 2. Alternatives to SF<sub>6</sub> in HVGIS

Research on SF<sub>6</sub> alternative gases intensified after the adoption of the Kyoto protocol in 1997. Natural origin gases were identified as promising alternatives [13,14], most importantly CO<sub>2</sub> as a carrier gas for switching applications [15–20]. Numerous investigations have identified the most promising gases and mixtures to be used for replacing SF<sub>6</sub> in HV Switchgear, see, e.g., [16,17,20] for overviews. Electric insulation and interruption properties, global warming potential on a 100 year horizon GWP<sub>100</sub>, toxicity, chemical stability under operating conditions, flammability, material compatibility, heat dissipation capability, ozone depletion potential (ODP) and CO<sub>2</sub> footprint in terms of life cycle assessment (LCA) of total equivalent CO<sub>2</sub> emissions (e.g., [9,21]) must be considered. This led to the selection of the following molecules as most suited for HV switchgear applications: CO<sub>2</sub>, O<sub>2</sub>, Heptafluoroisobutyronitrile, (CF<sub>3</sub>)<sub>2</sub>-CF-CN or simplified C<sub>4</sub>F<sub>7</sub>N (C<sub>4</sub>-FN) and 1,1,1,3,4,4,4-heptafluoro-3-(trifluoromethyl)-2-butanone [10,22]. C<sub>4</sub>-FN has become the preferred fluorinated additive in HV switchgear applications [17,20,23–27] due to its relatively low boiling point and high electric strength. Figure 2 shows the chemical structures of the molecules of interest compared to SF<sub>6</sub>. Other molecules investigated, as e.g., HFO-1234ze for application in MV switchgear or CF<sub>3</sub>I were mostly studied in academia (for references see [17,20]) and will not be discussed further here. They have several drawbacks regarding decomposition and toxicity in high current switching applications. Another fluid that was investigated is 1,1,1,3,4,4,4-heptafluoro-3-(trifluoromethyl)-2-butanone [17,28], also referred to as CF<sub>3</sub>C(O)CF(CF<sub>3</sub>)<sub>2</sub> or, even more simply, C<sub>5</sub>F<sub>10</sub>O (C<sub>5</sub>-FK). C<sub>5</sub>-FK was used in a manner similar to C<sub>4</sub>-FN but, due to its significantly higher boiling point of 26.9 °C at 0.1 MPa, was found to be less suitable for HV switchgear applications. It found application mainly in MV switchgear [17]. The properties of the gases of interest are shown in Table I.

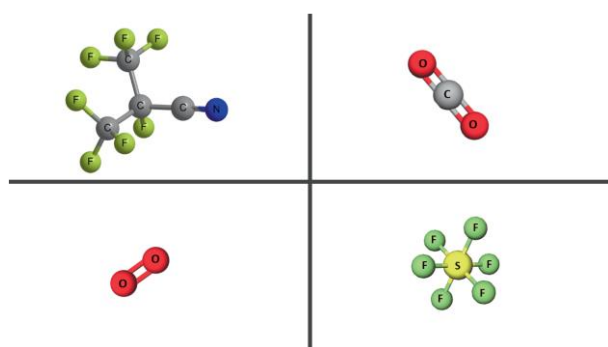


Fig. 2. Molecular structures of SF<sub>6</sub> and SF<sub>6</sub> alternatives

The boiling point of C<sub>4</sub>-FN is –4.7 °C at 0.1 MPa, which is significantly higher than that of SF<sub>6</sub>. For this reason, it must be mixed with a buffer gas, such as CO<sub>2</sub>, to allow for low temperature applications. All the gases presently of interest are nontoxic, non-flammable and have no ozone depletion potential (ODP) [10,17,20]. The GWP<sub>100</sub> of C<sub>4</sub>-FN is 2750, which is significantly lower than that of SF<sub>6</sub> (24300) and allows a reduction of the CO<sub>2</sub> equivalent by 99% for the C<sub>4</sub>-FN gas mixtures relevant for use in

electrical equipment [10,29]. The electric withstand of pure C<sub>4</sub>-FN is about twice that of SF<sub>6</sub> at a reference pressure of 0.1 MPa, see e.g., the overview [30]. CO<sub>2</sub> has a dielectric withstand only slightly lower than air [17,20,30]. O<sub>2</sub> admixture of 10%–20% can increase the electric strength of the gas slightly by about 6%–10% [31] and reduces the formation of gaseous and solid decomposition products in high current switching applications [32,33]. The O<sub>2</sub> concentrations typically used are in the range of mole fractions of 10% . . . 30% [17,20,22,27]. For very low temperature applications of –50 °C only CO<sub>2</sub>/O<sub>2</sub> mixtures are used [17,19,20]. Some physical properties of the mixtures of interest are given in Table II. For a filling pressure of about 700 kPa and 3.5 mol% C<sub>4</sub>-FN in CO<sub>2</sub>/O<sub>2</sub> an electric strength comparable to SF<sub>6</sub> at a GWP<sub>100</sub> of about 293 is achieved. This mixture can be used down to –30 °C and is favored for low-temperature CB applications. Further properties of SF<sub>6</sub> alternative gases and mixtures are given in Refs [9,16,17,20].

The electric insulation for different gases and mixtures was investigated by determination of fundamental properties as the ionization and attachment rates, e.g., [30,34–38], or by breakdown tests in simplified electrode geometries, e.g., [24,25,30]. A comparison of pressure dependence of electric strength for various gases and mixtures under switchgear conditions is shown in Figure 3.

| Table I.                                                                   |                          |                                         |                  |                    |                                   |
|----------------------------------------------------------------------------|--------------------------|-----------------------------------------|------------------|--------------------|-----------------------------------|
| Physical properties of pure gases compared to SF <sub>6</sub> from [10,16] |                          |                                         |                  |                    |                                   |
|                                                                            | Molecular weight (g/mol) | Density (kg/m <sup>3</sup> ) at 0.1 MPa | Boiling point/°C | GWP <sub>100</sub> | Electric strength/p.u. at 0.1 MPa |
| SF <sub>6</sub>                                                            | 146                      | 6.17                                    | –64              | 24300              | 1                                 |
| CO <sub>2</sub>                                                            | 44                       | 1.98                                    | –78.5            | 1                  | ~ 0.3                             |
| C <sub>4</sub> -FN                                                         | 195                      | 7.9                                     | –4.7             | 2750               | ~ 2                               |
| O <sub>2</sub>                                                             | 32                       | 1.43                                    | –182.96          | 0                  | ~ 0.3                             |
| N <sub>2</sub>                                                             | 14                       | 1.25                                    | –195.8           | 0                  | ~ 0.3                             |

A C<sub>4</sub>-FN/CO<sub>2</sub>/O<sub>2</sub> gas mixture defined for a minimum operating temperature of –300 °C and a filling pressure of 700 kPa (@ 20 °C) has a similar electric strength as SF<sub>6</sub> at 450 kPa. Thus, for switchgear using SF<sub>6</sub> alternative gas mixture a slight increase of pressure compared to SF<sub>6</sub> is necessary to obtain similar insulation performance. CO<sub>2</sub> and air cannot reach the insulation performance of SF<sub>6</sub> at 450 kPa even when extrapolated to higher pressures well above 1 MPa [39,40]. For such gases the equipment needs to be increased in size for lowering of electric fields. Arcing in CBs, as it occurs during switching operations, leads to partial gas decomposition, which needs to be considered in the properties of the gas mixture after arcing such as the electric strength. Gas compositions and properties of gas mixtures under arcing are addressed in various overviews, e.g., [9,17,20,41,42].

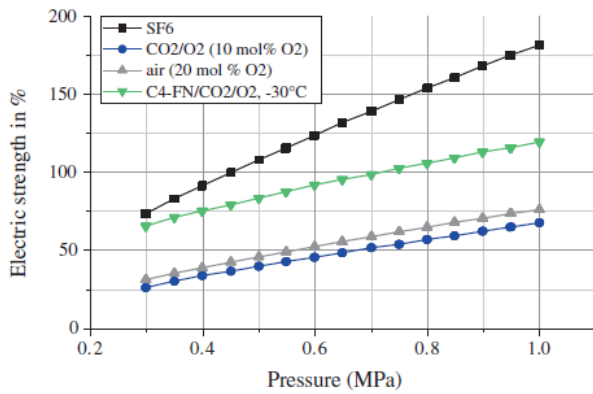


Fig. 3. Relative insulation performance of SF6 alternative gases and mixtures, compared to SF6 at 0.45 MPa adapted from Ref. [23]

In C4-FN/CO<sub>2</sub>/O<sub>2</sub> mixtures typical remaining products in a switchgear after arcing are C4-FN, CO<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, CF<sub>4</sub>, and very low amounts of CO, which is efficiently reduced by the addition of O<sub>2</sub>. Note that decomposition of C4-FN molecule occurs only in the very small fraction of the gas which is in direct contact with the arc. This small change in composition has only a negligible effect on the insulation strengths at operating conditions [9,17,20]. As shown in [17,20], gas decomposition of C4-FN does not affect the lifetime of the CB for typical C4-FN concentrations and switchgear volumes. The switching performance of SF6 alternative gas mixtures was investigated in various studies, see for overviews [17,20]. This was done by investigation of the short-line-fault interruption, so called thermal interruption capability but also on the electric recovery after arcing. Figure 4 shows a comparison of the thermal interruption capability of CO<sub>2</sub>-based gas mixtures and air to SF6. The performance of CO<sub>2</sub>-based gas mixtures is slightly below SF6 and reaches about 67% to 87% of the SF6 performance. This seems not to depend significantly on the addition of fluorinated compounds, which can likely be explained by the low percentage added, as was explained in Ref. [43].

### 3. Properties of Gas Mixtures

Due to their higher boiling points and corresponding lower vapor pressures, the Novec gases are used in gaseous mixtures rather than as pure materials. Dilution in gaseous mixtures allows the equipment to operate at temperatures well below the boiling points of these materials without condensation. Once gases form a homogeneous mixture, they do not physically separate unless liquefied by cooling below the condensation temperature or compressed to very high pressures. Similarly, although gas density will vary with height in a vertical column, the mixture does not separate over time with the higher molecular weight components concentrating at lower elevations. Figure 2 shows the change in gas density as a function of height in a column of gas for several gases. The pressure exerted by the column of gas above any point creates a greater density compared to higher elevations. Thus, the density of a gas decreases at higher elevations. Larger variations occur as the molecular weight of the gas increases since

the greater mass produces higher pressures at the lower elevations. However, the concentrations of individual components in a gas mixture do not change with height. The pressure exerted by the column of gas mixture above a molecule of any component is the same, resulting from the density of the gas mixture above it rather than any individual pure gas. As a result, all components of a mixture are exposed to the same gravitational force and pressure. Therefore, no driving force is created to cause a separation. A similar conclusion was reached in the 1982 EPRI Report EL-2620 [26]: “In the absence of condensation, a gas mixture will not separate into its component gases over a short or long period of time even when the molecular weights of the component gases are markedly different.” Accordingly, gas separation has not been observed experimentally [25–27]. For example, a gas mixture containing Novec 4710 gas and CO<sub>2</sub> was stored in a 2-m vertical tube at 15 °C for 6 months with no change in composition detected over the height of the tube [27]. Table 2 shows a comparison of representative gas mixtures that are used in high voltage systems relative to pure SF6. The dielectric breakdown voltage of a gas mixture varies with the concentration of Novec gas as well as the total pressure of the mixture. As shown in Figure 3, it is possible to compensate for the lower dielectric strength of a dilute gas mixture by increasing the total gas pressure used within the system. In fact, that is the strategy often employed by manufacturers of gas-insulated equipment. Numerous systems using Novec gas mixtures are currently operating on the grid, including installations of GIS, GCB and GIL. These systems have been designed to deliver performance comparable to similarly rated SF6 equipment, [38,39].

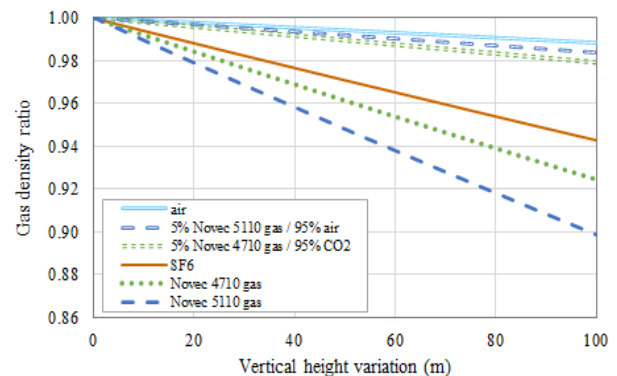


Figure 2. Variation in gas density as a function of gas column height. Gas mixtures are described in Table 2

| Gas Formulation (mole %) | 100% SF6 | 5% Novec 4710/ 95% CO2 | 5% Novec 5110/ 95% Air |
|--------------------------|----------|------------------------|------------------------|
| Typical GIS Pressure     | 4        | 6                      | 6.5                    |

|                                                          |       |       |       |
|----------------------------------------------------------|-------|-------|-------|
| (bar)                                                    |       |       |       |
| Gas density<br>@ 25°C<br>(kg/m <sup>3</sup> )            | 24.75 | 12.48 | 10.67 |
| Condensation<br>temperature<br>(°C)                      | -38   | -27   | 0     |
| Dielectric<br>breakdown<br>voltage<br>relative to<br>SF6 | -     | ~ 1   | ~ 1   |

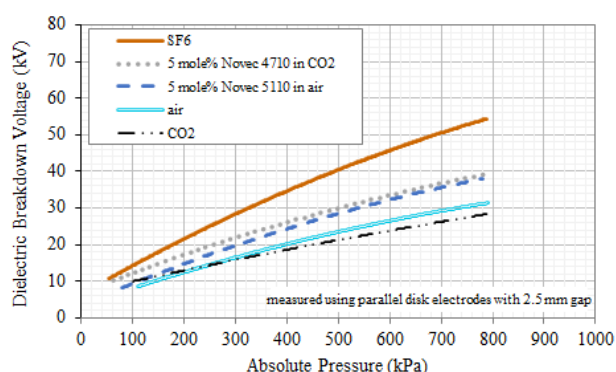


Fig.3 Dielectric breakdown voltage of gas mixtures compared to pure SF6.

2.3. Recent and ongoing product developments Over the last years roadmaps for CBs using SF6 alternatives were shown by the leading manufacturers [46–48], and products entered the market, e.g., see Refs [39,41,42,44–46]. Hitachi Energy launched CO<sub>2</sub>/O<sub>2</sub>- and C<sub>4</sub>-FN/CO<sub>2</sub>/O<sub>2</sub>-based products under the brand ‘Econiq™’; they are available for 72.5 and 145 kV LTB and GIS, 420 kV GIS, DTB and gas-insulated lines (GIL) at the time of this writing. Also, a “retrofill” solution for 420 kV GIL was launched. In 2024 further products for 420 kV and higher ratings up to 550 kV will be addressed. During the next few years additional products, including for ratings of 245 kV are planned. General Electric (GE) launched C<sub>4</sub>-FN/CO<sub>2</sub>/O<sub>2</sub>-based products under the brand g3 for 420 kV GIS and 145 kV DTB in 2023. Products for 72.5 kV DTB and 245 kV GIS and LTB are planned for 2024. For 2025 170 kV GIS, 245 kV DTB and 420 kV LTB have been announced. In 2026 ratings of 362 and 550 kV DTB and LTB will be addressed. Siemens Energy has available circuit breakers with ratings up to 145 kV that use vacuum circuit breakers and air insulation. Higher ratings are under development. The use of CO<sub>2</sub>/O<sub>2</sub> has been discussed by Toshiba [43] but no product is currently available. For 72/84 kV ratings Toshiba developed a VCB/air GIS which was successfully tested and energized in a pilot installation in 2023 [46]. Hyundai Electric mentioned that it successfully developed 170 kV, 50 kA GIS in 2021 using a C<sub>4</sub>-FN/CO<sub>2</sub> mixture and that development of a 145 kV GIS with air and vacuum circuit breakers is ongoing [48].

### 3. High Voltage Switchgear Reliability

HV switchgear is composed of different operating devices, including circuit breakers, disconnectors, earthing switches, voltage transformers, and current transformers. Like any other electromechanical device, switchgear components are prone to degradation, which can occur due wear and aging as a function of their operation and environmental conditions.

According to CIGRE [42], switchgear malfunctions are classified as ‘minor’ and ‘major’ failures. Major failures cause the cessation of one or more of the fundamental functions of switchgear, resulting in an immediate change in the system operating conditions. In contrast, when a minor failure takes place, the HV equipment is still able to operate, although not under normal conditions. Circuit-breakers are key components of power transmission and distribution systems; therefore, most of the monitoring systems applied on HV switchgear are usually dedicated to this device. As described by CIGRE [45], maintenance methods can be divided into time-based maintenance (TBM), condition-based maintenance (CBM) and reliability-centered maintenance (RCM) [41]. The development of reliable and simple condition monitoring methods, which can allow the implementation of CBM and RCM, offers a clear opportunity for maintenance improvement. However, such maintenance services need diagnostic and prognostic models able to estimate the probability of failure and/or remaining useful life (RUL) of the operating power grid (PG) assets. Implementation of algorithms for the detection of failures and lifetime estimation depends on the availability of measurement data from the considered PG assets. Once the data is available, it needs to be correlated and linked through diagnostic/prognostic models for failure detection or prediction [41]. Methods for diagnostics of switchgear working conditions, as well as prognostic of its remaining useful life are summarized in the next sections.

### 4. CONCLUSIONS

Gas mixtures containing a fluoroketone or a fluoronitrile, Novec™ 5110 Insulating Gas and Novec™ 4710 Insulating Gas, respectively, are being implemented as low climate impact alternatives to SF<sub>6</sub>. When used at higher pressure, these gas mixtures can deliver dielectric performance comparable to SF<sub>6</sub> in high voltage systems. The safety of Novec gases has been evaluated through a series of toxicological studies which demonstrate that the hazard profiles of the gas mixtures containing these materials are safe to handle in gas-filled equipment. Both alternative gases have significantly lower GWPs than SF<sub>6</sub>. Moreover, their shorter atmospheric lifetimes prevent measurable accumulation of these gases in the atmosphere. This results in substantial reduction (>99.9%) in GHG emissions over the expected working life of equipment using these alternatives, irrespective of the GWP for the individual gas mixture components. As a result, these advanced materials enable insulation technologies that can make a meaningful contribution to reducing the environmental impact of high voltage applications. Therefore, limiting alternative-gas technologies based on GWP alone could be counterproductive to the goal of

reducing the climate impact from electric power applications. In fact, the European Commission report in 2020 stated “In specific sites where the voltage rate must be maintained and space is restricted, such as substations at power plants or in urban areas, currently designs based on fluoronitriles may be the only viable alternative to SF6 based switchgear” [25]. Gas insulated equipment containing Novec 4710 gas mixtures first started operating on the grid in 2017, while equipment containing Novec 5110 gas mixtures first started operating on the grid in 2015. More than 100 equipment bays containing alternative gas mixtures have now been installed by multiple utilities located primarily in Europe with recent installations in Asia and North America.

As a new potential alternative insulation gas to SF6, g3 that is composed of Novec<sup>TM</sup> 4710 and CO2 or N2 shows its high performance as an insulation medium of gas-insulated power facilities. This paper presents a comprehensive overview of alternate gases for applications in high-voltage, gas-insulated equipment, and conclusions are as follows:

1. From the AC/DC breakdown voltage and partial discharge characteristics, the addition of a few ratios of 4710 to the buffer gas significantly increases the dielectric strength of the gas mixture, which is almost equivalent to that of SF6.
2. At the same time, g3 presents a good compromise between high dielectric strength and low ambient temperature requirements, which met the requirement of the minimum ambient operating temperature of power facilities.
3. In addition, the switching bus-transfer current test, temperature rise test, and liquefaction temperature calculation also verified the validity of g3 gas for high-voltage insulation applications.
4. As for environmental concerns, g3 gas reduces the GWP of more than 94% compared with SF6. It has an ODP of zero and an atmospheric lifetime as short as 30 years, which is only 1% of that of SF6. equipment, while significantly reducing greenhouse gas emissions.

#### REFERENCES

[1]. Hyrenbach, M.; Paul, T.; Owens, J. Environmental and safety aspects of AirPlus insulated GIS. CIREN Open Access Proc. J. 2017, 1, 132–135. [CrossRef]

[2]. Kieffel, Y.; Biquez, F.; Vigouroux, D.; Ponchon, P.; Schlernitzauer, A.; Magous, R.; Cros, G.; Owens, J. Characteristics of g3—An alternative to SF6. CIREN Open Access Proc. J. 2017, 1, 54–57. [CrossRef]

[3]. Kieffel, Y.; Irwin, T.; Ponchon, P.; Owens, J. Green Gas to Replace SF6 in Electrical Grids. IEEE Power Energy Mag. 2016, 14, 32–39. [CrossRef]

[4]. Cigré. Technical Brochure 802—Application of Non-SF6 Gases or Gas-Mixtures in Medium and High Voltage Gas-Insulated Switchgear;

Cigré: Paris, France, 2020.

[5]. Xiao, A.; Owens, J.; Bonk, J.; Zhang, A.; Wang, C.; Tu, Y. Environmentally Friendly Insulating Gases as SF6 Alternatives for Power Utilities. In Proceedings of the ICEMPE 2019—2nd International Conference on Electrical Materials and Power Equipment, Guangzhou, China, 7–10 April 2019; pp. 42–48.

[6]. Seeger, M.; Smeets, R.; Yan, J.; Ito, H.; Claessens, M.; Dullni, E.; Franck, C.M.; Gentils, F.; Hartmann, W.; Kieffel, Y.; et al. Recent development of alternative gases to SF6 for switching applications. ELECTRA 2017, 291, 26–29.

[7]. Kieffel, Y.; Irwin, T.; Ponchon, P.; Owens, J. Green gas to replace SF6 in electrical grids. IEEE Power Energy Mag. 2014, 14, 32–39. [CrossRef]

[8]. Niemeyer L. A systematic search for insulation gases and their environmental evaluation. In Gaseous Dielectrics VIII, vol. 19. Christophorou, Olthoff (eds). Plenum Press: New York; 1998; 459–464.

[9]. Christophorou L, Olthoff JK, Green DS. Gases for Electrical Insulation and Arc Interruption: Possible Present and Future Alternatives to Pure SF6. Gaithersburg, MD: US Department of Commerce, Technology Administration, National Institute of Standards and Technology; 1997.

[10]. Uchii T, Hoshina Y, Kawano H, Suzuki K, Nakamoto T, Toyoda M. Fundamental research on SF6-free gas insulated switchgear adopting CO2 gas and its mixtures. In Proceedings of International symposium on ecotopia science ISETSO7. Nagoya University, EcoTopia Science Institute: Nagoya, Japan; 2007.

[11]. Seeger M, Smeets R, Yan J, Ito H, Claessens M, Dullni E, Franck CM, Gentils F, Hartmann W, Kieffel Y, Jia S, Jones G, Mantilla J, Pawar S, Rabie M, Robin-Jouan P, Schellekens H, Spencer J, Uchii T, Li X, Yanabu S. Recent development and interrupting performance with SF6 alternative gases. Electra 2017; 291:26–29.

[12]. Smeets R, lathouwers A, Arens M, Attar E, Berteloot T, Blanchet G, Claessens M, Demarthe N, Doche R, Douchin J, Ecsery M, Götte N, Grégoire C, Heinz T, Inoue T, Ito H, Jain R, Jia S, Jeanmaire A, Johnson D, Jung HE, Kim K-H, Lee A, Li X, Mantilla J, Martín M, Muratovic M, Nguyen NM, OWENS J, Park JH, Perret M, Pesch D, Pietrzak P, Ramesh M, Rostron J, Sato M, Schiffbauer D, Smith Støa-Aanensen NS, Valmacco D, Waldron M, Wolke B, Yan X. Current interruption in SF6-free switchgear, vol. 871. CIGRE: Paris France, Technical Brochure; 2022.

[13]. Niayesh K. Green HV switching Technologies for Modern Power Networks. In Chapter 4: Environmentally Friendly High-Voltage AC Switching Technology: Gas Circuit Breakers with SF6 Alternative Gases. IET: Shanghai, China; 2023; 227–312.

- [14] Buying green! A Handbook on Green Public Procurement. EU Publications:Luxembourg, Europe. <https://op.europa.eu/en/publication-detail/-/publication/8c2da441-f63c-11e5-8529-01aa75ed71a1/language-en>.
- [15] 3M™. Novec™ 4710 Dielectric Fluid. 3M Company: Saint Paul, MN; 2021.
- [16] Gatzsche M et al. Moving Towards Carbon-Neutral High-Voltage Switchgear by Combining Eco-Efficient Technologies, vol. A3. CIGRE: Paris, France; 2022; 656.
- [17] Kieffel Y, Biquez F. SF6 alternative development for high voltage switchgears. In 2015 IEEE Electrical Insulation Conference (EIC). IEEE: Seattle, WA; 2015; 379–383.
- [18] Nechmi HE, Beroual A, Girodet A, Vinson P. Fluoronitriles/CO2 gas mixture as promising substitute to SF6 for insulation in high voltage applications. IEEE Transactions on Dielectrics and Electrical Insulation 2016; 23:2587–2593.
- [19] Li X, Zhao H, Murphy AB. SF6-alternative gases for application in gas-insulated switchgear. Journal of Physics D: Applied Physics 2018; 51:153001. <https://doi.org/10.1088/1361-6463/aab314>.
- [20] Walter MM, Leguizamon D, Maksoud L, Berteloot T, Kieffel Y, Perret M, Owens J, Xiao A, Bonk J, Delorme M. Low temperature behaviour and dielectric performance of fluoronitrile/CO2/O2 mixture. CIGRE Centennial Session; 2021, revised paper; D1–D213.
- [21] 3M™ Novec™ 5110 Dielectric Fluid. 3M Company: Saint Paul, MN; 2021.
- [22] Owens J. Greenhouse gas emission reductions through the use of sustainable alternatives to SF6. In 2016 IEEE Electrical Insulation Conference (EIC). IEEE: Montreal, QC; 2016; 535–538.
- [23] Franck CM, Owens J, Juhre K, Pachin J, Kieffel Y, Psotta T, Bendig M, Raschke C, Deschler J, Rodriguez M, Doiron C, Ryu J, Gentils F, Sagareli S, Girodet A, Straumann U, Glomb S, Summer R, Haddad AM, Zel LVD, Hammer T, Walter M, Henley S, Widger P, Kindersberger J, Wiener J, Kurte R, Yasuoka T, Lee BW, Zhou B. CIGRE TB 849 Electric Performance of New Non-SF6 Gases and Gas Mixtures for Gas-Insulated Systems. CIGRE: Paris, France; 2021. <https://e-cigre.org/publication/849-electric-performance-of-new-non-sf6-gases-and-gas-mixtures-for-gas-insulated-systems>.
- [24] Uchii T, Yoshida D, Tsukao S, Taketa K, Tsuboi K. Recent Development of SF6 Alternative Switchgear Using Natural-Origin Gases in Japan, vol. A3. CIGRE Session: Paris, France; 2022; 10643.
- [25] Andr e-Maouhoub E, Andr e P, Makhoulouf S, Nichele S. Production of graphite during the extinguishing arc with new SF6 alternative gases. Plasma Chemistry and Plasma Processing 2020; 40:795–808.
- [26] Bousoltane K. Investigation on the influence of the O2 content in fluoronitrile/CO2/O2 (g3) mixtures on the breakdown in highvoltage circuit-breakers. In Energies 2020. 22nd International Conference on gas discharges and their applications (GD 22), Sept: Novi Sad (Serbia); 2018; 2, 107–111.
- [27] Chachereau A, H osl A, Franck CM. Electrical insulation properties of the perfluoronitrile C4F7N. Journal of Physics D: Applied Physics 2018; 51(49):495201.
- [28] Nechmi H, Beroual A, Girodet A, Vinson P. Effective ionization coefficients and limiting field strength of Fluoronitriles-CO2 mixtures. IEEE Transactions on Dielectrics and Electrical Insulation 2017; 24(2):886–892.
- [29] Long Y, Guo L, Chen C, Shen Z, Chen Y, Li F, Zhou W. Measurement of ionization and attachment coefficients in C4F7N/CO2 gas mixture as substitute gas to SF6. IEEE Access 2020; 8:76790–76795.
- [30] Chachereau A, H osl A, Franck CM. Electrical insulation properties of the perfluoroketone C5F10O. Journal of Physics D: Applied Physics 2018; 51(33):335204.
- [31] H osl A, Chachereau A, Pachin J, Franck CM. Identification of the discharge kinetics in the perfluoronitrile C4F7N with swarm and breakdown experiments. Journal of Physics D: Applied Physics; 52(23):235201. <https://doi.org/10.1088/1361-6463/ab0f45>.
- [32] Seeger M, Stoller P, Garyfallos A. Breakdown fields in synthetic air, CO2, a CO2 / O2 mixture, and CF4 in the pressure range 0.5-10 MPa. IEEE Transactions on Dielectrics and Electrical Insulation 2017;24(3):1582–1591. <https://doi.org/10.1109/TDEI.2017.006517>.
- [33] Juhre K. High pressure N2, N2/CO2 and CO2 gas insulation in comparison to SF6 in GIS applications. In 14th International Symposium on High Voltage Engineering ISH . EPFL: Beijing, China; 2005:3.
- [34] Wu Y, Wang C, Sun H, Murphy AB, Rong M, Yang F, Chen Z, Niu C, Wang X. Properties of C4F7N–CO2 thermal plasmas: Thermodynamic properties, transport coefficients and emission coefficients. Journal of Physics D: Applied Physics 2018; 51:155206.
- [35] Zhang B, Xiong J, Chen L, Li X, Murphy AB. Fundamental physicochemical properties of SF6-alternative gases: A review of recent progress. Journal of Physics D: Applied Physics 2020; 53:173001 (25pp). <https://doi.org/10.1088/1361-6463/ab6ea1>.
- [36] CIGRE webinar on. Fundamentals of current interruption in SF6and its alternatives. <http://currentzeroclub.org/downloads/>.
- [37] Koike T et al. Development of SF6-Free 72/84kV GIS Using Synthetic Air as an Alternative to SF6 , vol. 1. CIGRE B3/A3 Colloquium: Birmingham, UK; 2023; 146.
- [38] Niayesh K. Green HV switching technologies for modern power networks. In Chapter 3: Environmentally

Friendly High-Voltage AC Switching Technology: Vacuum Circuit Breakers. IET: Shanghai, China; 2023; 227–312.

[39] Slade P. The Vacuum Interrupter Theory, Design, and Application. 2nd ed. CRC Press: Boca Raton, FL.

[40] Hermosillo V et al. Environmental Performance of Dead-Tank

Circuit Breakers with SF6 and Alternative Gases. CIGRE A3-102:

Paris; 2020.

[41] Econiq. Accelerating the transition towards a carbon-neutral energy future. <https://www.hitachienergy.com/products-and-solutions/highvoltage-switchgear-and-breakers/econiq-eco-efficient-hv-portfolio>.

[42] GE Renewable Energy Grid Solutions. CIGRE colloquium.

[https://www.gegridsolutions.com/products/reference/g3\\_roadmap\\_2025-brochure-en.pdf](https://www.gegridsolutions.com/products/reference/g3_roadmap_2025-brochure-en.pdf).

[43] Siemens Energy – a global leader in energy technology. <https://assets.siemens-energy.com/siemens/assets/api/uuid:1e83b691-89a5-42f0-a42a-8d70c62832b7/2020-08-siemens-energy-blue-portfolio-customer-presentation-en-.pdf>.

[44] Stoller P et al. SF6 Alternative Circuit Breaker for 145 kV Gas Insulated Switchgear. CIGRE A3-658: Paris; 2022.

[45] Revaud B et al. 245kV Single Break Capability for Air Insulated Switchgear SF6-Free Circuit-Breaker. CIGRE A3/B3 Colloquium: Birmingham, UK; 2023; 136.

[46] Darles L et al. Presentation of SF6-Free Dead-Tank Circuit Breaker Rated 145kV, 63kA. CIGRE A3/B3 Colloquium: Birmingham, UK; 2023; 127.

[47] Gregoire C et al. Update on the Development of 420 kV GIS Substations Switchgear Using Environment Friendly C4FN / O2 / CO2 Gas Mixture. CIGRE A3/B3 Colloquium: Birmingham, UK; 2023; 130.

[48] Uchii T. High-Voltage Switchgear Technology Applying CO2/O2 Natural-Origin Gas Mixture as an Alternative Insulating and Interrupting Medium to SF6, vol. 1. CIGRE B3/A3 Colloquium: Birmingham, UK; 2023; 147.

# Role of Artificial Intelligence and Machine Literacy in VLSI Design- A Brief Survey

<sup>1</sup>Sunita D. Giri, <sup>2</sup>Sunita G. Bidkar, <sup>3</sup>Anuja D. Giri

<sup>1</sup>Department of Electronics & Telecommunication Engineering, SECS, JSPM University Pune. <sup>1</sup>sdg.secs@jspmuni.ac.in

<sup>2</sup>Department of Electrical Engineering, Savitribai Phule Pune University. <sup>2</sup>rajmanesunita@yahoo.com

<sup>3</sup>Department of Electrical Engineering, SECS, JSPM University Pune.

<sup>3</sup>giri.anuja27@gmail.com

**Abstract---**In VLSI design, three parameters are most important: area, power, and speed. While designing a VLSI chip, these parameters must be carefully considered. However, due to the complexity and small area constraints, achieving an optimal design can be a very challenging task. Manually to achieve this is time-consuming, and require significant resources. In contradiction, the innovative learning techniques of artificial intelligence (AI) offer a range of promising automated solutions for managing the difficult and data-intensive design and testing problems associated with very-large-scale integration (VLSI). Using Algorithms for AI and machine learning (ML) in VLSI design and production help to expedite the process, greatly cutting down on time and effort required to analyse and process data across various abstraction levels. The AI/ML-driven techniques for VLSI design and production that have been developed recently are thoroughly reviewed in this paper. We also look at how AI/ML technologies might be used in the future to change the VLSI design environment, with an emphasis on finding quicker, smarter, and more effective solutions.

**Keywords**—AI/ML , VLSI, CMOS.

## I. INTRODUCTION

Since the 1960s, the number of transistors integrated onto a single chip has grown at an exponential rate.[1] [2] The ongoing miniaturization of transistors across multiple technological generations has enhanced the density and performance of these devices [3]. Modern very-large-scale integration (VLSI) technology enables the development of complex digital systems on a single chip. The rising demand for portable electronics in recent years has led to a surge in the need for power-efficient designs with advanced features. Highly sophisticated and scalable VLSI circuits are essential to meet the growing demands of the electronics industry. Device downscaling remains a key driver in the advancement of integrated circuit (IC) technology, resulting in better device performance. The rapid downscaling of CMOS technology has presented both significant challenges and new opportunities for device engineers. As transistor sizes shrink, the complexity of the semiconductor manufacturing process increases. When approaching atomic scales, further scaling Artificial intelligence (AI) has offered effective solutions to a becomes increasingly difficult. Despite the reduction in device size, many performance aspects begin to degrade.[4]

Artificial Intelligence (AI) has offered effective solutions to a wide range of challenges across various industries. The foundation of AI is modeled after human intelligence, enabling machines to replicate human-like reasoning and perform tasks of varying complexity. Machine learning (ML) is a subset of AI, focused on learning from data. The key objectives of AI/ML are to learn, reason, predict, and perceive. AI/ML techniques excel at identifying patterns and trends in large datasets, empowering users to make informed decisions. These algorithms are capable of processing multi-dimensional and multivariate data with high computational efficiency, continuously improving their accuracy and effectiveness. They also enhance decision-making by optimizing relevant processes. AI/ML applications are vast and varied. AI/ML methods have been widely applied in VLSI design and technology. This paper provides a comprehensive overview of the literature on AI/ML algorithms applied to VLSI design and modeling across various abstraction levels.

## II. EXISTING REVIEWS

In 1985, Robert first brought attention to how AI was affecting VLSI design. His paper provided an overview of existing VLSI-AI tools and emphasized the importance of integrating AI's expanded capabilities into CAD systems. The benefits of applying AI to the VLSI design process and its applications are discussed in [5] and [6]. Khan et al. [6] specifically examined the role of AI in the IC industry, with a focus on expert systems and various systems that rely on knowledge like the design advisor for NCR, design automation support, and redesign, all of which are employed in VLSI design. The rapid advancements in AI/ML have spurred significant research, leading to numerous innovative efforts to design, develop, and apply learning strategies in VLSI design and manufacturing. The use of neural networks (NNs) in both digital and analog VLSI circuits, as well as knowledge-based systems, has been reported in [7]. Additionally, [8] reviews the possibility of using data analytics and machine learning to optimize physical design. A comprehensive review of opportunities and recent uses of deep learning in physical design can be found in [9]. Beerel et al. [10] discussed the difficulties and possibilities of methods based on machine learning in asynchronous CAD/VLSI. They suggested developing a design adviser, an ML-driven advice system that uses place-and-route, logic synthesis, and standard RTL tools to track and document the actions of various designers. Elfadel et al. [11] provided an in-depth discussion of various ML techniques applied in areas such

as physical design, power and heat analysis, inability analysis, forecasting yields, and physical design. They presented a deep reinforcement learning (DRL) evaluation loop into an AI-based physical design approach. This approach automates the exploration of the design region, aiming to generate superior structural layouts meet time restrictions and placement optimization, ultimately leading to improved outcomes in subsequent stages like clock-tree synthesis (CTS) and routing.

Machine learning (ML) is increasingly attracting the interest of researchers and academic communities in the field of EDA. Integrating ML into IC design and manufacturing helps designers by minimizing the time and effort required for data analysis, optimizing the design process, and accelerating time to market [13]. Rapp et al. offered an extensive overview of the latest advancements in ML applications for CAD across various abstraction levels [12].

The reviews cited above offer a comprehensive analysis of the methods of AI/ML that have been suggested in the literature, focusing primarily on the different layers of abstraction used in the design of digital VLSI. This review provides a synthesis of the existing literature on the use of AI/ML algorithms at different levels of abstraction in VLSI design and modeling.

### III . VLSI Design Flow

A conventional digital IC design flow consists of multiple hierarchical levels, as illustrated in Fig. This flowchart represents a generalized design process, encompassing both the front-end and back-end stages of full-custom/semi-custom IC designs. The design specifications provide an abstract description of the digital circuit's functionality, interface, and overall architecture

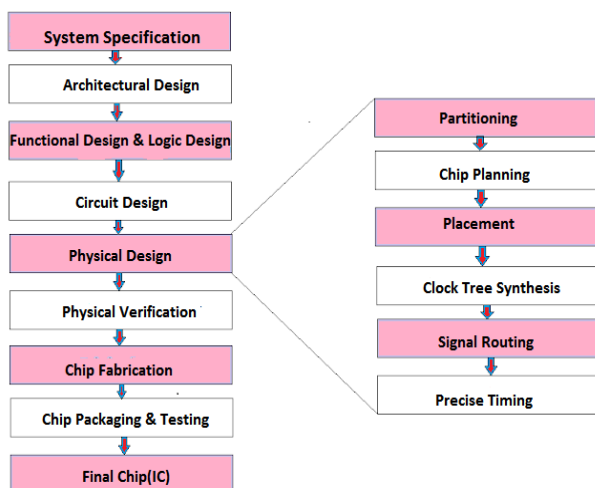


Fig. 1 VLSI Design Flow

These specifications include block diagrams detailing the functional aspects, timing parameters, propagation delays, required package type, and design constraints. Additionally, they serve as a formal agreement between the design engineer and the vendor.

At the architectural design level, decisions regarding the system's basic architecture are made. This includes choices such as whether to implement reduced instruction set computing (RISC) or complex instruction set computing (CISC) processors, as well as the number of arithmetic logic units (ALUs) and floating-point units. The output of this stage is a micro-architectural specification that provides functional descriptions of subsystem units. Based on these descriptions, architects can estimate the system's performance and power consumption.

The next stage in the design flow is the behavioral design level, where The circuit's working description generally appears in Verilog HDL or VHDL.. By leaving out implementation specifics, this level offers an elevated representation of the system's functionality. Validation of timestamp is performed at the subsequent level, known as the Register Transfer Level (RTL) description. A High-Level Synthesis (HLS) tool can automatically translate system specifications in C/C++ into HDL. Alternatively, a logic synthesis tool generates a netlist, which is a gate-level representation. The resulting gate-level netlist satisfies the necessary timing, space, and power requirements thanks to the logic synthesizing tool. Test benches and simulations are used for logic validation., while formal verification and scan insertion, part of the Design for Testability (DFT) process, are performed to verify the RTL mapping [14].

Next, system partitioning is done to break down large and complex systems into smaller, more manageable modules, followed by floorplanning, placement, and routing. The floorplanning stage estimates the chip area required for the implementation of standard cells or modules and plays a crucial role in optimizing design performance. Sub-sections, gates, and flip-flops are then positioned using the place-and-route tool, and then Clock Tree Synthesis (CTS) and restart routing are performed. Afterward, sequencing is done for every block.. Layout confirmation guarantees that the design complies with electrical and physical design regulations and corresponds to the original layout after positioning and routing are finished. Tools like Design Rule Check (DRC) and Electrical Rule Check (ERC) are used for this verification.. The final output, a GDS-II file, is sent to semiconductor foundries for IC fabrication. IC fabrication itself involves a series of intricate physical and chemical processes, all of which must be executed with the highest degree of accuracy and precision.

### IV. BRIEF ON AI/ML ALGORITHMS

In contemporary fields of science and technology, statistical learning has become essential, playing a critical role in extracting valuable insights from the massive volumes of data generated across various domains. This data can be mined to identify patterns and dependencies between parameters, which can then be used for future analyses and predictions. Statistical learning techniques are widely applicable in solving actual issues. The technology known as artificial intelligence (AI) allows machines to mimic human actions., with machine learning

(ML) and deep learning being the primary subsets of AI. ML enables machines to learn autonomously from past data without explicit programming, while deep learning is a key subset of ML (see Fig. 2(a)). ML involves continuous learning and self-correction as new data becomes available. While ML is capable of handling structured and semi-structured data, AI can manage structured, semi-structured, and unstructured data. ML can be categorized into three main types: supervised learning, unsupervised learning, and reinforcement learning.

#### A. Supervised Learning

Regression and classification are the two primary subcategories of supervised learning. One technique for data analysis that extracts models that reflect significant data classes is classification. [39]. On the other hand, regression is used to predict numerical data that may be unavailable, instead of making predictions about distinct class labels. Analysis of regression is typically employed for numerical prediction of continuous-valued functions [16]. Prediction in this context refers to both numerical and class-label predictions. The classification/regression process can be seen as a function that predicts a mapping of  $Y=f(X)$ , where  $Y$  represents the output variables and  $X$  denotes the input variables. This for a new input trio  $X$ , the function for mapping is trained to predict the corresponding class label  $y$ . The need for a lot of objective data is one of the primary obstacles to supervised instruction., labeled training data, which can be difficult to obtain in certain applications like VLSI.

#### B. Unsupervised Learning

Unlike supervised learning, unsupervised learning does not require labeled training data, which reduces the effort needed to generate data. However, achieving point estimates or the desired output for a given input vector is more challenging with unsupervised learning. Unsupervised learning is primarily used to discover hidden patterns within data. Key applications of unsupervised learning include clustering and dimensionality reduction, such as through Principal Component Analysis (PCA). Grouping items into subsets or "clusters" so that they are more similar to one another than to those in other clusters is known as clustering. [19].

#### C. Semi-supervised Learning

Semi-supervised learning serves as a bridge between supervised and unsupervised learning methods. It is particularly effective when labeled data is scarce, however, a lot of unlabeled data is accessible. This method is highly useful for automating the labeling of data, combining the strengths of both supervised and unsupervised learning. In certain applications, semi-supervised learning outperforms using supervised or unsupervised learning independently. The process begins with a small set of labeled data, and algorithms are then applied to generate pseudo-labels for the unlabeled dataset. Subsequently, these pseudo-labels are combined with the labeled data, and the model iteratively incorporates the unlabeled data to refine its accuracy [20, 21].

#### D. Reinforcement Learning

A subfield of machine learning called reinforcement learning is concerned with connecting events to behaviors.. It is centered around goal-oriented learning through interactions [22]. Unlike supervised learning, which depends on examples of correct behavior, or unsupervised learning, which seeks to uncover hidden patterns, reinforcement learning learns from experience and aims to discover the optimal solution that maximizes the reward signal.

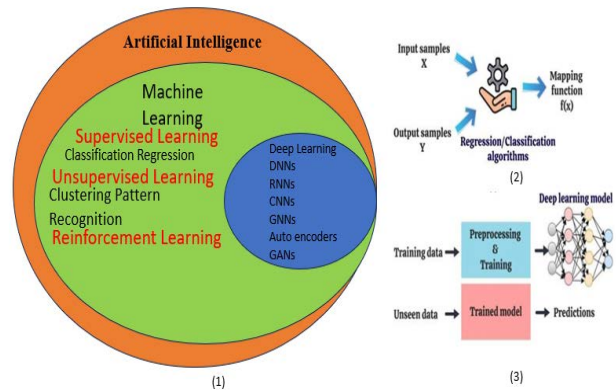


**Figure 2 :** (1) Overview of Artificial Intelligence techniques (2) Learning function of classification/regression algorithms (3) Deep learning training and prediction

#### E. Deep Learning

Deep learning, a subset of machine learning, is particularly effective for processing large datasets. It enables computers to build complex concepts from simpler ones. A key example of a deep learning model is the feed-forward network, or multi-layer perceptron (MLP), which is a type of artificial neural network (ANN) (see Fig. 2(3)). An MLP is a mathematical function made up of several simple functions that converts a set of input values to output values.. A shallow neural network (SNN) consists of one or two levels that are concealed, whereas tens or even hundreds of layers make up a deep neural network (DNN). DNNs extract features progressively from lower to higher levels, allowing them to uncover distributed patterns in data. Deeply belief networks, stacked autoencoders (SAE), and deep convolutional neural networks (DCNNs) are examples of common DNN types[23]. Lately, DNNs have made significant advancements in computer vision, with DCNNs being particularly effective for visual tasks [24]. Recurrent neural networks are another method of deep computing (RNNs),[25] Deep reinforcement learning (DRL) and generative adversarial networks (GANs) [28] in circuit simulation. The opportunities for creating solutions to many of the problems in IC fabrication and design are expanding due to the quick developments in AI/ML. We examine the applications of AI/ML at several abstraction levels of VLSI design and analysis in the sections that follow, starting with circuit simulation. AI has begun to take on a role of transformation in circuit simulation, offering significant improvements in speed, accuracy and

optimization. Traditionally, circuit simulation is a computationally intensive process, involving the use of numerical methods such as SPICE (Simulation Program with Integrated Circuit Emphasis) to resolve the equation system governing the behavior of electronic components. However, these methods can be time-consuming, especially for large, complex circuits. AI techniques, particularly machine learning (ML) and deep learning (DL), offer promising solutions to enhance circuit simulation in various ways.

#### *A . Device Level in VLSI Design*

The **device level** is the foundational layer in the VLSI design process, where individual semiconductor devices such as transistors, capacitors, and resistors are modeled, analyzed, and optimized. At this level, the primary goal is to ensure that each component operates as expected under various conditions, while meeting the performance, power, and reliability requirements for the entire system. Machine learning (ML) and artificial intelligence (AI) have begun to be crucial in improving device-level design., enabling faster simulations, optimized performance, and innovative solutions to challenges posed by smaller transistor geometries and increasing complexity.

At the device level of VLSI design, AI and machine learning are becoming indispensable tools for improving the speed, accuracy, and optimization of semiconductor devices. From device modeling and parameter extraction to optimization and reliability prediction, AI techniques are accelerating the design process and enabling more advanced, efficient, and reliable devices.

#### *B . Gate Level in VLSI Design*

The **gate level** is one of the key abstraction levels in VLSI design, sitting between the device level and the register-transfer level (RTL). At this stage, the design is described in terms of logic gates such as AND, OR, NOT, NAND, and NOR gates, and their interconnections. The primary goal at the gate level is to represent the functionality of the digital circuit using these gates and ensure that the design meets timing, power, and area constraints. AI and machine learning (ML) are playing an increasingly important role at this level, helping to improve optimization, enhance performance, and address the growing complexity of modern VLSI circuits.

At the gate level of VLSI design, AI and machine learning techniques are increasingly being used to optimize the synthesis, timing, power, testing, and fault detection processes. These techniques offer significant advantages in terms of speed, accuracy, and design efficiency, helping to address the growing complexity and scaling challenges of modern VLSI circuits. By incorporating AI-driven optimization and predictive models, gate-level design is becoming more efficient, allowing for faster development of high-performance, low-power, and reliable integrated circuits. As VLSI technology continues to evolve, AI is poised to play an even more crucial role in enhancing gate-level design and optimization.

#### *C . Circuit Level in VLSI Design*

The circuit level in VLSI design is where the digital logic components (such as gates, flip-flops, multiplexers, etc.) are interconnected to form functional circuits. At this level, designers focus on ensuring that the circuit operates correctly, efficiently, and meets the required performance, power, and area constraints. The circuit-level design process includes tasks like sizing transistors, optimizing interconnections, and verifying circuit functionality. Given the increasing complexity of modern circuits, especially as VLSI technology scales to smaller nodes, Artificial Intelligence (AI) and Machine Learning (ML) techniques are becoming more integral in streamlining these processes, improving design accuracy, and reducing the time required for circuit optimization.[38]

At the **circuit level** of VLSI design, AI and ML are playing an increasingly important role in improving efficiency, performance, power, and reliability. By applying AI techniques such as reinforcement learning, neural networks, and evolutionary algorithms, designers can accelerate optimization processes, reduce design time, and create more efficient and reliable circuits. As the complexity of VLSI designs continues to grow, the integration of AI will be crucial in addressing the challenges of power consumption, delay, fault detection, and manufacturability. These AI-driven innovations at the circuit level are enabling the development of high-performance, low-power, and robust integrated circuits for the next generation of electronic devices.

#### *D . RTL Level in VLSI Design*

At the RTL level, the design is typically described using hardware description languages (HDLs) such as Verilog or VHDL, and the focus is on designing logic that performs specific tasks based on input data and clock signals. AI and ML techniques are increasingly being integrated into the RTL design process to improve efficiency, optimize performance, and automate many of the tasks that traditionally required manual intervention.

At the RTL level, AI and ML are playing an increasingly important role in optimizing VLSI designs. By automating tasks such as synthesis, simulation, verification, and optimization, AI-driven techniques can significantly reduce the design cycle, improve performance, and minimize power consumption while also helping to achieve area efficiency. As the complexity of VLSI designs continues to grow, the integration of AI and ML into the RTL design process is becoming essential for creating high-performance, energy-efficient, and cost-effective integrated circuits.

#### *E . Post Layout Simulation*

Post-layout simulation is a critical step in the VLSI design process, ensuring that the final design performs as expected in its physical form. The integration of AI and ML techniques into post-layout simulation offers significant advantages, including improved accuracy, faster verification, and more efficient optimization. By leveraging machine learning models for parasitic

extraction, timing analysis, power optimization, and signal integrity checks, designers can ensure that the final layout meets performance, power, and design rule requirements, while reducing the time and resources needed for manual validation and debugging.

#### V. AI IN ARCHITECTURES

With the introduction of AI and ML approaches, VLSI architectural design has changed dynamically. Advances in neural network algorithms, coupled with innovations in high-bandwidth and high-performance semiconductor technologies, have opened new pathways for addressing the challenges associated with hardware implementations of complex real-time applications. A number of architectural advancements over the last few decades have been crucial to the advancement of VLSI technology.. The majority of these advancements stem from the need for innovative applications that demand fast processing rates, increased dependability, lower implementation costs, and quicker time to market.. Application fields like the Internet of Things (IoT), automotive systems, image and signal processing, and speech processing are the main focus of the architectural solutions offered in the research literature.

#### Memory Systems

Memory systems play a critical role in the overall performance of VLSI architectures, particularly in the context of advanced real-time applications such as AI/ML, image processing, and signal processing. The increasing complexity and performance demands of these applications necessitate efficient memory architectures that can handle high data throughput, low latency, and power consumption constraints.

In summary, the design and optimization of memory systems in VLSI architectures are pivotal to achieving high-performance, low-power, and reliable solutions for real-time, edge-based applications.

#### VI. AI AT THE SYSTEM ON CHIP(SOC)

The integration of Artificial Intelligence (AI) into System on Chip (SoC) designs has become a crucial aspect of modern VLSI architecture, particularly for edge computing and real-time applications. SoCs, which integrate all necessary components—such as processors, memory, input/output interfaces, and AI accelerators—onto a single chip, provide an efficient and compact solution for deploying AI algorithms and models directly at the edge.[26, 27]

The incorporation of AI into SoC designs offers several advantages and challenges that impact the overall system performance, power consumption, and cost. The integration of AI into SoCs is transforming edge computing by enabling high-performance, low-latency, and power-efficient AI applications. As AI continues to advance, future SoC designs will likely feature more powerful accelerators, improved energy efficiency, and more sophisticated AI models optimized for real-time decision-making across a wide range of industries.

#### VII. AI IN PHYSICAL DESIGN

VLSI physical design involves a range of complex combinatorial problems that often require numerous iterations to reach convergence. As semiconductor technology scales down, the complexity of these design challenges has increased significantly, driven by stricter design rules and design-for-manufacturing (DFM) constraints. This makes it increasingly difficult to find optimal solutions [42]. Traditionally, these issues and violations were identified and addressed manually. However, with the advancement of technological nodes, the manual approach to design closure is struggling to meet the demanding market timelines. Moreover, the design quality and the effectiveness of the manufacturing process in later stages of the design flow are highly sensitive to decisions made in the earlier stages, which, in turn, increases turnaround times and slows down the design closure process. As a result, accurately predicting valid designs early in the process is becoming more critical, especially at advanced technological nodes. Because they offer high-level abstractions, machine learning and pattern-matching algorithms have been beneficial at different phases of physical design. and improving the quality of results. These methods serve as a valuable intermediary, linking each stage of the process and offering essential feedback to help achieve faster design closure.

#### VIII. AI IN MANUFACTURING

The manufacturing of an integrated circuit (IC) involves a variety of complex processes, such as wafer preparation, epitaxy, oxidation, diffusion, ion implantation, lithography, etching, and metallization. These processes are carried out in advanced fabrication facilities that require continuous human oversight. Once the ICs are fabricated, they are enclosed in specialized packages to shield them from external and environmental factors that could cause damage.

#### IX. AI AT TESTING

The integration of Artificial Intelligence (AI) into the testing phase of VLSI design has become a transformative approach, offering significant improvements in efficiency, accuracy, and scalability. Traditional testing methods, which rely heavily on manual processes or predefined algorithms, often struggle with the complexity and scale of modern integrated circuits (ICs), especially as semiconductor technology continues to advance. AI-driven testing techniques address these challenges by automating and optimizing various stages of the testing process.

Incorporating AI into the testing process of VLSI designs is revolutionizing the way semiconductor chips are validated and verified. By automating test generation, optimizing test patterns, predicting defects, and analyzing large volumes of test data, AI enhances the efficiency and accuracy of the testing phase. Furthermore, AI-driven approaches enable faster design closures, reduce testing costs, improve yield prediction, and shorten time-to-

market, all while ensuring the high-quality performance of advanced ICs. The adoption of AI in testing is thus becoming an essential component of modern VLSI design and manufacturing workflows.

#### X. VLSI- AI/ML SOURCES OF TRAINING DATA

Incorporating Artificial Intelligence and Machine Learning into VLSI design and manufacturing processes requires vast amounts of high-quality training data. AI/ML algorithms, particularly supervised learning models, rely on labeled datasets to learn patterns, make predictions, and optimize design processes. However, collecting and preparing such data in the context of VLSI is challenging due to the complexity, variety, and size of the data involved.

#### XI. CHALLENGES AND OPPORTUNITIES FOR AI/ML IN VLSI

*1)Challenges:* The integration of AI/ML in VLSI holds tremendous potential to revolutionize various stages of the semiconductor design and manufacturing process. However, challenges such as data scarcity, model scalability, and integration with existing tools must be addressed.

*2)Opportunity:* At the same time, AI/ML presents exciting opportunities to automate design, enhance manufacturability, predict defects, optimize testing, and reduce time-to-market. As AI/ML techniques continue to evolve, they will be instrumental in overcoming the limitations of traditional design processes, helping the semiconductor industry tackle the increasing complexity of modern VLSI designs.

#### CONCLUSION

In conclusion, the integration of AI and machine learning into VLSI design marks a groundbreaking shift in the field. While traditional methods are effective, they often struggle with the growing complexity and demands for optimizing area, power, and speed. AI/ML offer smarter, automated solutions that streamline the design process, saving time, resources, and improving performance. As these technologies continue to evolve, they are set to revolutionize VLSI design, enabling faster, more efficient, and innovative solutions. The future of chip design looks bright, with AI/ML playing a central role in shaping the next generation of VLSI technology.

#### REFERENCES

- [1] Deepthi Amuru<sup>a,\*</sup>, Harsha V. Vudumula<sup>a</sup>, Pavan K Cherupally<sup>a</sup>, Sushanth R Gurram<sup>a</sup>, Amir Ahmad<sup>b</sup>, Andleeb Zahra<sup>a</sup> and Zia Abbas AI/ML Algorithms and Applications in VLSI Design and Technology.
- [2] J. Carballo, W. J. Chan, P. A. Gargini, A. B. Kahng, S. Nath, Itrs 2.0: Toward a re-framing of the semiconductor technology roadmap, in: 2014 IEEE 32nd International Conference on Computer Design (ICCD), 2014, pp. 139–146. doi:10.1109/ICCD.2014.6974673.
- [3] G. E. Moore, Cramming more components onto integrated circuits, reprinted from electronics, volume 38, number 8, april 19, 1965, pp.114 ff., IEEE Solid-State Circuits Society Newsletter 11 (2006) 33–35.
- [4] H. . P. Wong, D. J. Frank, P. M. Solomon, C. H. J. Wann, J. J. Welser, Nanoscale cmos, Proceedings of the IEEE 87 (1999) 537–570.
- [5] H. Iwai, Logic lsi technology roadmap for 22 nm and beyond, in: 2009 16th IEEE International Symposium on the Physical and Failure Analysis of Integrated Circuits, 2009, pp. 7–10. doi:10.1109/IPFA.2009.5232710.
- [6] G. Rabbat, Vlsi and ai are getting closer, IEEE Circuits and Devices Magazine 4 (1988) 15–18.
- [7] M. Z. A. Khan, H. Saleem, S. Afzal, Application of vlsi in artificial intelligence (2012).
- [8] J. Delgado-Frias, W. Moore, VLSI for Artificial Intelligence, vol- ume 68, 1989. doi:10.1007/978-1-4613-1619-0.
- [9] L. Capodiecici, Data analytics and machine learning for design- process-yield optimization in electronic design automation and ic semiconductor manufacturing, in: 2017 China Semiconductor Tech- nology International Conference (CSTIC), 2017, pp. 1–3.
- [10] A. B. Kahng, Machine learning applications in physical design: Re- cent results and directions, in: Proceedings of the 2018 International Symposium on Physical Design, 2018, pp. 68–73.
- [11] P. A. Beerel, M. Pedram, Opportunities for machine learning in elec- tronic design automation, in: 2018 IEEE International Symposium on Circuits and Systems (ISCAS), 2018, pp. 1–5.
- [12] I. A. Elfadel, D. Boning, X. Li, Machine Learning in VLSI Computer-Aided Design, 2019. doi:10.1007/978-3-030-04666-8.
- [13] M. Rapp, H. Amrouch, Y. Lin, B. Yu, D. Z. Pan, M. Wolf, J. Henkel, Mlcad: A survey of research in machine learning for cad keynote paper, IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (2021) 1–1.
- [14] C. Schuermyer, Deploying new nodes faster with machine learning for ic design and manufacturing, in: 2019 International Symposium on VLSI Technology, Systems and Application (VLSI-TSA), 2019,
- [15] L.-T. Wang, C.-W. Wu, X. Wen, VLSI Test Principles and Architec- tures: Design for Testability, Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 2006.
- [16] N. Weste, D. Harris, CMOS VLSI Design: A Circuits and Systems Perspective, 4th ed., Addison-Wesley Publishing Company, USA, 2010.
- [17] S. B. Kotsiantis, I. Zaharakis, P. Pintelas, Supervised machine learning: A review of classification techniques, Emerging artificial intelligence applications in computer engineering 160 (2007) 3–24.

- [18] T. G. Dietterich, Machine-learning research, *AI magazine* 18 (1997) 97–97.
- [19] T. G. Dietterich, Ensemble methods in machine learning, in: *Multiple Classifier Systems*, Springer Berlin Heidelberg, Berlin, Heidelberg, 2000, pp. 1–15.
- [20] T. Hastie, R. Tibshirani, J. Friedman, *The elements of statistical learning – data mining, inference, and prediction*, 2008.
- [21] *Semi-Supervised Classification Using Pattern Clustering*, John Wiley & Sons, Ltd, 2013, pp. 127–181. URL: <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118557693.ch4>. doi:<https://doi.org/10.1002/9781118557693.ch4>.
- [22] O. Chapelle, B. Schölkopf, A. Zien, *Introduction to Semi-Supervised Learning*, 2006, pp. 1–12.
- [23] R. S. Sutton, A. G. Barto, *Reinforcement Learning: An Introduction*, A Bradford Book, Cambridge, MA, USA, 2018.
- [24] I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, MIT Press, 2016. <http://www.deeplearningbook.org>.
- [25] E. Nishani, B. Çiço, Computer vision approaches based on deep learning and neural networks: Deep neural networks for video analysis of human pose estimation, in: *2017 6th Mediterranean Conference on Embedded Computing (MECO)*, 2017, pp. 1–4. doi:[10.1109/MECO.2017.7977207](https://doi.org/10.1109/MECO.2017.7977207).
- [26] B. Chandra, R. K. Sharma, On improving recurrent neural network for image classification, in: *2017 International Joint Conference on Neural Networks (IJCNN)*, 2017, pp. 1904–1907. doi:[10.1109/IJCNN.2017.7966083](https://doi.org/10.1109/IJCNN.2017.7966083).
- [27] Q. Wang, P. Li, Y. Kim, A parallel digital vlsi architecture for integrated support vector machine training and classification, *IEEE Transactions on Very Large Scale Integration (VLSI) Systems* 23 (2015) 1471–1484.
- [28] B. Asgari, R. Hadidi, H. Kim, S. Yalamanchili, Eridanus: Efficiently running inference of dnns using systolic arrays, *IEEE Micro* 39 (2019) 46–54.
- [29] A. Jeerige, D. Bein, A. Verma, Comparison of deep reinforcement learning approaches for intelligent game playing, in: *2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC)*, 2019, pp. 0366–0371.

[Back](#)

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mohole Geetanjali Prashant has  
presented paper entitled URBANCREW: IN-TIME SERVICE SOLUTION ON FIGURE CLICK

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

Mrs. G. P. Mohole  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

Dr. M. V. Bhatkar  
Conference Chair

# Urbancrew: In-Time Service Solution On Figure Click

Geetanjali Mohole<sup>1</sup>, Kuldeep Girase<sup>2</sup>, Rushikesh Pawar<sup>3</sup>, Abhishek Pagar<sup>4</sup>, Kunal Chaudhari<sup>5</sup>

<sup>1,2,3,4,5</sup>Department of Computer Engineering

Jawahar Education Society's Institute of Technology, Management & Research, Nashik 422222, Maharashtra, India

Affiliated to Savitribai Phule Pune University

**Abstract---**In today's digital era, the demand for streamlined and accessible household services has surged due to the increasing reliance on mobile and web-based solutions. This project introduces URBANCREW, a comprehensive home services application designed to simplify booking a wide range of household services—such as plumbing, electrical repairs, pest control, painting, and machine maintenance—directly from a user's device.

URBANCREW offers a user-friendly platform that ensures high-quality service delivery through features such as real-time service tracking, a review system for trusted professionals, competitive pricing, and secure online payments. The application enhances user experience with 24/7 availability, expert support, and real-time navigation for efficient service delivery. Additionally, URBANCREW empowers local service providers by offering increased visibility and connecting them with potential clients, thereby creating job opportunities for skilled blue-collar workers and promoting economic growth within the local community.

Looking ahead, URBANCREW aims to collaborate with leading food delivery platforms such as Zomato and Swiggy to create an integrated ecosystem of services that enhances convenience for users by combining home services with on-demand food delivery solutions.

By bridging the gap between consumers and service providers, URBANCREW presents a scalable, secure, and efficient solution tailored to the needs of a fast-paced modern lifestyle.

**Keywords---**Online Services, Fast Service, Live Tracking, Review System, Secure Payments, 24/7 Availability, Food Delivery Collaboration

## I. INTRODUCTION

Home service applications are gaining significant traction in today's rapidly evolving digital era, transforming how individuals access essential household services. Traditional methods—such as searching through

directories, making phone calls, or relying on word-of-mouth—are often inefficient, lack transparency, and present challenges in ensuring safety and reliability. These issues become more pronounced in non-metro regions where access to verified and skilled service providers is limited [1][3].

To address these challenges, the URBANCREW application offers a comprehensive solution for booking household services. Available as both an Android application and a web-based platform, URBANCREW allows users to browse, select, and schedule services at their convenience. It ensures transparency through standardized pricing and secure online payment integration, reducing the risk of hidden costs and fostering user trust [1][2][5].

Additionally, URBANCREW stands out with unique features such as QR code-based security for provider verification, machine learning for personalized service recommendations, and future plans for integration with platforms like Zomato and Swiggy to expand its utility [4][6].

With the rise of urbanization and the increasing reliance on digital solutions, there is a growing demand for reliable and accessible home services. While platforms like UrbanClap and Handy have pioneered this space, they face limitations such as restricted availability in smaller towns, non-standardized pricing, and inconsistent quality assurance [2][3][5].

The URBANCREW application is motivated by these gaps, aiming to create an inclusive platform that meets user expectations efficiently. To simplify the process of booking services by offering a single platform for a wide range of needs such as plumbing, cleaning, and appliance repairs [3]. To cater to diverse demographics, including non-metro regions, ensuring inclusivity in service delivery [5]. To incorporate advanced technologies like machine learning and IoT for personalized and predictive services [6].

### A. Objectives

- 1) **Comprehensive Service Offering:** Provide a wide range of household services, including house cleaning, cooking, gardening, and elderly care, tailored to meet diverse user needs [1][5].
- 2) **Efficient Booking System:** Streamline the process of scheduling and accessing services through an intuitive and interactive user interface [2][4].
- 3) **Secure Payment Integration:** Implement a robust payment gateway for safe, cashless transactions [3][5].
- 4) **Personalized Recommendations:** Use machine learning algorithms to analyze user preferences and provide tailored service suggestions [4].
- 5) **Empowering Local Providers:** Increase visibility for local service professionals, promoting regional economic growth and job creation [1][5].
- 6) **Future Scalability:** Design the platform to accommodate additional features like collaborations with food delivery services and expansion to other cities [4].

## II. LITERATURE SURVEY

### A. Existing Systems

- 1) **An Online System for Household Services (IJERT, 2018):** This system provides domestic services at the user's doorstep with a single click, accessible via a web-based or portable application. To ensure secure access, it features verified login credentials for service seekers, providers, and administrators. The system lacks robust mechanisms for addressing unsatisfactory services. Re-support is dependent on manual reviews and user feedback [1].
- 2) **At Doorstep: An Innovative Online Application for Household Services (Xi'an University, 2020):** This mobile application connects users with workers for beauty, wellness, home maintenance, and design services. It employs a three-module approach (Registration, Booking, and Service), with OTP-based double verification to ensure user safety.

The system does not cater to users with diverse language needs or provide a wide variety of payment methods [2].

- 3) **Survey on Home Service Providers (IRJET, 2019):** A web-based framework that allows users to register, schedule services, and opt for return policies or re-service in case of dissatisfaction.

Payment methods are limited, with no support for modern modes like Visa or digital wallets. Additionally, scalability is not addressed [3].

**ATOZ Doorstep Home Services (JETIR, 2021):** This system automates household services with skilled workers dispatched to users' doorsteps. It offers features like minimal user interaction and secure worker verification.

The static nature of the application restricts flexibility, and it lacks scalability for integration with modern platforms [5].

### Comparative Analysis

TABLE  
COMPARATIVE ANALYSIS

I:

| Feature                         | Strengths                                                                                       | Gaps                                                                                         |
|---------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <b>Diverse Services Offered</b> | Most platforms offer essential services like plumbing, cleaning, and electrical repairs [1][3]. | Limited inclusion of advanced services like IoT-based maintenance or ML recommendations [6]. |
| <b>User Verification</b>        | OTP and account-based verification ensure security [2][5].                                      | Advanced verification, such as QR code-based methods, is absent                              |
| <b>Payment Gateways</b>         | Secure payment methods, including credit cards, are commonly supported [3].                     | Modern payment modes like UPI, wallets, and cryptocurrencies are often not included [5].     |

|                    |                                                                               |                                                  |
|--------------------|-------------------------------------------------------------------------------|--------------------------------------------------|
| <b>Scalability</b> | Platforms like UrbanClap focus on urban regions with significant success [1]. | Limited reach to rural and semi-urban areas [4]. |
|--------------------|-------------------------------------------------------------------------------|--------------------------------------------------|

### III. PROBLEM DEFINITION

- A. **Difficulty in Finding Qualified Professionals:** Many users struggle to locate verified, skilled service providers, especially in smaller cities. This leads to inconsistent service quality [1][3].
- B. **Lack of Standardized Pricing:** Traditional methods often involve haggling or hidden fees, creating dissatisfaction among users [2][5].
- C. **Inefficient Booking Processes:** Without a streamlined digital platform, users rely on outdated systems prone to communication gaps and missed appointments [3][4].
- D. **Quality Assurance:** There is a lack of platforms providing robust user reviews and ratings to guide informed decisions [1][5].
- E. **Limited Access in Non-Metro Areas:** Existing solutions primarily cater to metropolitan areas, leaving smaller cities underserved [4][5].

### IV. PROPOSED SYSTEM

The URBANCREW (Nashik) home services platform is designed as a modular system to efficiently cater to the needs of all stakeholders, including users, service providers, and administrators. Each module plays a vital role in ensuring seamless functionality, security, and scalability. The platform incorporates distinct modules—**User Module, Service Provider Module, Admin Module, Collaboration Module, and optional advanced modules such as the Notification Module, and Analytics Module**—to address specific requirements. This modular approach allows the system to operate cohesively while enabling flexibility for future enhancements. Below is a detailed explanation of each module and its role within the system.

Figure 1: System Architecture

#### A. User Module

The User Module is designed to provide customers with a seamless and efficient experience while interacting with the URBANCREW platform. Users can register securely using multi-factor authentication and explore a wide range of household services, categorized for easy navigation. This module includes advanced search and filter options, enabling users to find service providers based on location, availability, ratings, and price. Users can view detailed provider profiles, including certifications and customer reviews, before booking.

Once a service is scheduled, users can track the service provider in real-time, receiving updates about their location and estimated arrival time. Payments are made securely through integrated gateways supporting various methods such as UPI, cards, and wallets. After completing a service, users can provide feedback and rate their experience, contributing to a transparent and trustworthy ecosystem. Additionally, the module stores booking history and invoices for user reference.

#### B. Service Provider Module

The Service Provider Module empowers service providers to manage their profiles, availability, and bookings effectively. Providers can register with verified credentials and set up their profiles by listing their skills, services offered, pricing, and availability. This module allows providers to update their working hours, block unavailable times, and specify holidays. Incoming service requests can be viewed, accepted, or declined based on the provider's schedule. The module features real-time updates, enabling providers to notify users about service progress or completion. Service providers can also monitor their earnings through a dedicated dashboard that displays completed jobs, pending payments, and monthly earnings reports. By streamlining operations and offering tools for transparency and efficiency, this module ensures a productive relationship between providers and users.

#### C. Admin Module

The Admin Module serves as the backbone of the URBANCREW system, enabling administrators to oversee and manage the platform effectively. This module allows admins to handle user and service provider accounts, approve registrations, and manage profiles. Through a centralized dashboard, admins can monitor ongoing and completed services, track provider performance, and address user complaints. The module also includes tools for content management, enabling admins to update service categories, adjust pricing, and introduce promotional offers. Dispute resolution capabilities are built-in, allowing admins to address conflicts between users and providers, process refunds, or

reschedule services when needed. Additionally, the module generates detailed reports and analytics on platform usage, revenue trends, and user satisfaction metrics. These insights help admins optimize operations and ensure the system remains secure and user-friendly.

#### D. Collaboration Module

The Collaboration Module is a forward-looking feature that allows URBANCREW to integrate with third-party platforms like Zomato, Swiggy, or logistics services. This module enables users to access a broader range of services beyond household needs, such as food delivery, grocery shopping, and parcel services, directly through the URBANCREW platform. It includes APIs and integration tools to establish seamless connections between URBANCREW and external service providers. This module not only enhances the platform's utility but also creates additional revenue streams by offering users an all-in-one service solution. By enabling collaborations, the Collaboration Module positions URBANCREW as a versatile and future-ready platform.

#### E. Features in URBANCREW

- 1) **Personalized Service Recommendations:** URBAN-CREW employs machine learning to analyze user preferences and provide tailored suggestions.
- 2) **Enhanced Security:** QR code-based authentication ensures the identity of service providers, adding an extra layer of trust.
- 3) **Integrated Ecosystem:** Future collaborations with platforms like Zomato and Swiggy aim to create a seamless user experience across multiple services.
- 4) **Accessibility and Inclusivity:** Unlike many platforms, URBANCREW is designed to serve non-metro areas, empowering local service providers and bridging regional disparities.
- 5) **Advanced Payment Options:** By incorporating UPI, wallets, and other digital payment systems, URBANCREW caters to a wide range of users.

#### V. METHODOLOGY

##### A. Development Approach: Agile Methodology

The Agile methodology was adopted for the development of URBANCREW to facilitate flexibility and ensure quick adaptations to evolving user needs. This approach included:

- 1) **Sprints:** Two-week sprints to ensure rapid development and feedback.

- 2) **User Stories:** Requirements were gathered as user stories that were prioritized and tackled across the sprints.

- 3) **Continuous Testing:** Testing was integrated throughout the development cycle, ensuring that features were delivered with minimal bugs.

##### B. Algorithm Integration

- 1) **Service Matching Algorithm:** The Service Matching Algorithm matches users with the most suitable service provider based on criteria such as location, availability, ratings, and the type of service requested.

This algorithm ensures that users are paired with service providers who are both available and highly rated. By considering factors like proximity and real-time availability, it minimizes wait times and ensures a positive user experience.

- 2) **Dynamic Pricing Algorithm:** The Dynamic Pricing Algorithm calculates the price of services based on factors like service type, demand, provider ratings, and time of day.

This algorithm helps optimize pricing based on demand fluctuations and service complexity, ensuring that both users and providers are satisfied with the transaction cost. It also adapts to market trends, providing fair and competitive pricing.

- 3) **Personalized Service Recommendation Algorithm:** The Personalized Service Recommendation Algorithm suggests services to users based on their previous activity, preferences, and ratings.

Using this algorithm, the platform tailors the experience for each user, making it easier for them to find the services they most likely need. It increases user engagement and enhances overall satisfaction by providing relevant suggestions.

- 4) **Real-Time Service Tracking Algorithm:** The Real-Time Service Tracking Algorithm tracks the location of service providers in real-time using GPS and maps, providing users with up-to-date service status.

This algorithm improves user experience by giving them live updates on the status of their service, including the provider's estimated arrival time, which helps manage expectations and reduces anxiety.

- 5) **User Authentication and Authorization Algorithm:** This algorithm manages user and service provider logins, verifying identities and ensuring secure access through multi-factor authentication (MFA).

Security is paramount, especially when handling sensitive user information like payment details. This algorithm ensures that only authorized users and service providers can access the platform, safeguarding user data and maintaining trust.

- 6) **Review and Rating Algorithm:** The Review and Rating Algorithm collects user feedback and calculates service provider ratings, which are used to influence future service bookings.

This algorithm creates transparency and trust within the platform by allowing users to make informed decisions based on other users' experiences. It also incentivizes service providers to maintain high-quality service.

- 7) **Payment Calculation and Transaction Algorithm:** The Payment Calculation and Transaction Algorithm calculates the final payment based on the service price and handles the transaction securely through third-party gateways.

This algorithm ensures that payment transactions are accurate, transparent, and secure. It is critical for building trust with users and service providers, and making sure payments are processed efficiently and accurately.

- 8) **Scheduling and Availability Algorithm:** The Scheduling and Availability Algorithm optimizes the scheduling of services by matching users' requested times with available service providers' time slots.

This algorithm helps maximize service provider availability and minimizes wait times for users, ensuring that services are provided in a timely manner.

- 9) **Notification System Algorithm:** The Notification System Algorithm sends timely notifications to users and service providers about bookings, service status updates, and payments.

This ensures that users and providers are kept informed at every stage of the process, which improves communication and helps ensure the smooth execution of services.

- 10) **Dispute Resolution Algorithm:** The Dispute Resolution Algorithm handles conflicts between users and service providers, offering solutions based on predefined rules and mediation.

This algorithm ensures that user complaints and provider issues are handled promptly and fairly, maintaining trust and satisfaction within the platform.

## VI. CONCLUSION

The URBANCREW application represents a modern, efficient, and user-friendly solution to the challenges faced in the household services industry. By leveraging advanced technologies, the platform bridges the gap between users and service providers, offering a secure and scalable system for booking and managing a wide range of home services [1][2].

URBANCREW sets itself apart through features such as personalized service recommendations [4], QR code-based verification for enhanced safety [1][5], and real-time service tracking [3]. Its ability to integrate with third-party platforms like Zomato and Swiggy paves the way for creating a comprehensive ecosystem of on-demand services, further enhancing user convenience [2].

This platform not only addresses inefficiencies in traditional service models but also empowers local service providers, contributing to regional economic growth and inclusivity [4][5]. By extending its reach to non-metro regions and incorporating diverse payment modes [4][5], URBANCREW ensures accessibility and inclusivity for a broader audience.

In the future, URBANCREW aims to expand its capabilities by integrating emerging technologies like IoT and machine learning for predictive maintenance and smarter service delivery [4][5]. With continuous improvements and an adaptive approach, URBANCREW is well-positioned to set a new benchmark for innovation, reliability, and convenience in the home services industry [3][5].

## FUTURE ENHANCEMENT

### A. Integration with Smart Home Technologies:

Incorporating Internet of Things (IoT) devices to enable predictive maintenance and automated alerts for services like appliance repairs, plumbing, and electrical work. Syncing the application with smart home systems such as Amazon Alexa or Google Home to allow voice-activated service bookings.

### B. AI-Powered Personalization:

Leveraging machine learning algorithms to offer personalized service recommendations based on user behavior, preferences, and service history. Introducing dynamic pricing models that adjust rates based on service demand and availability in real time.

### C. Expansion to Non-Metro and Rural Areas:

Extending the service network to smaller cities and rural regions to promote inclusivity and support local service providers. Collaborating with regional

stakeholders to address the unique needs of underserved communities.

#### D. Collaboration with Third-Party Services:

Integrating with platforms like Zomato, Swiggy, and logistics providers to create an all-in-one solution for users seeking both household services and daily needs delivery.

#### E. Advanced Payment Methods:

Expanding payment options to include digital wallets, cryptocurrencies, and Buy Now Pay Later (BNPL) systems for enhanced convenience. Incorporating secure, contactless payment methods using near-field communication (NFC) technology.

#### F. Sustainability Initiatives:

Encouraging eco-friendly practices by promoting green-certified service providers and sustainable products for services like pest control and cleaning. Introducing features to calculate and offset the carbon footprint of services provided.

#### G. Real-Time Feedback and Quality Control:

Developing AI tools to analyze user feedback in real-time and recommend improvements to service providers. Enabling live monitoring of service quality through video calls or image sharing during service execution.

#### H. Cross-Platform Compatibility:

Expanding the application's reach by ensuring compatibility across various platforms, including desktops, smart TVs, and wearables. Developing progressive web applications (PWAs) to offer app-like experiences without requiring downloads.

#### I. Global Expansion:

Adapting the application for international markets by integrating multilingual support and currency conversion for seamless use in different regions. Partnering with global logistics and service provider networks to establish URBANCREW as a worldwide platform for home services.

#### J. Enhanced Security Features:

Incorporating biometric verification methods such as fingerprint or facial recognition for both users and service providers to enhance security. Implementing blockchain technology for secure data storage and transaction records.

#### ACKNOWLEDGMENT

We are profoundly grateful to **Prof. G.P. Mohole** for her expert guidance and continuous encouragement throughout this project, ensuring it achieved its objectives from commencement to completion. We would like to express our deepest appreciation to **Dr. M. V. Bhatkar**, Principal of Jawahar Education Society's Institute of Technology, Management, and Research, Nashik; **Prof. G. P. Mohole**, Head of the Department of Computer Engineering; and **Prof. S. N. Botekar**, Project Coordinator, for their invaluable guidance and support in completing this project. Lastly, we extend our sincere and heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during the course of this work

#### REFERENCES

- [1] Indravasan, N. M., Adarsh, G., Shruthi, C., Shanthi, K., Dadapeer. An Online System for Household Services. *International Journal of Engineering Research & Technology (IJERT)*, Vol. 6, Issue 13, 2018.
- [2] Agrawal, K. K., Goel, T., Gariya, T., Saxena, V. At DoorStep: An Innovative Online Application for Household Services. *Journal of Xi'an University of Architecture & Technology*, Vol. XII, Issue IV, 2020.
- [3] Nikam, P. R., Gunjal, T. T., Jadhav, P. V., Parakhe, S. K., Tambe, P. S. Survey on Home Service Provider. *International Research Journal of Engineering and Technology (IRJET)*, Vol. 6, Issue 12, 2019.
- [4] Hegde, S. B., Rao, K., Bhandarkar, P., Vetekar, P. P., Laxmi, G. An Android Application for Home Services. *International Research Journal of Engineering and Technology (IRJET)*, Vol. 7, Issue 5, 2020.
- [5] Gurav, S., Shaikh, A., Khan, S., Nagrale, M. ATOZ Doorstep Home Services. *Journal of Emerging Technologies and Innovative Research (JETIR)*, Vol. 8, Issue 5, 2021.
- [6] Shahriari, S., Shahriari, M., Gheiji, S. E-Commerce and Its Impact on Global Trends and Markets. *International Journal of Research - Granthaalayah*, Vol. 3, Issue 4, 2015.
- [7] Zhang, B., Yong, R., Li, M., Pan, J., Huang, J. A Hybrid Trust Evaluation Framework for E-Commerce in Online Social Networks. *IEEE*, 2016.
- [8] Yin, C. An Empirical Study on Users' Online Payment Behavior of Tourism Websites. *IEEE 12th International Conference on E-Business Engineering*, 2015.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. G. P. Mohole has  
presented paper entitled Supply Chain Management Using Blockchain

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

Mrs. G. P. Mohole  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

Dr. M. V. Bhatkar  
Conference Chair

# Supply Chain Management Using Blockchain

Yash Mahajan<sup>1</sup>, Vaishnavi Damarlu<sup>2</sup>, Shivam Gunjal<sup>3</sup>, Komal Kadam<sup>4</sup>, Shubham Thorat<sup>5</sup> G.P. Mohole<sup>6</sup>

Department of Computer Engineering,

Jawahar Education Society's Institute of Technology, Management, And Research, Nashik 422222, India

Affiliated to Savitribai Phule Pune University

<sup>1</sup>yashmahajan18521@gmail.com, <sup>2</sup>damarluvaishnavi02@gmail.com,

<sup>3</sup>gunjalshivam0@gmail.com, <sup>4</sup>kadamkomal8766@gmail.com, <sup>5</sup>shubhamtho2003@gmail.com

**Abstract---This blockchain-based solution is designed to revolutionize supply chain management by enhancing transparency, security, and efficiency. Traditional supply chains often face challenges such as data silos, fraud, and limited real-time visibility. These issues are addressed through a decentralized, immutable ledger that provides all participants with access to shared, trusted data. By eliminating intermediaries, the system ensures accurate, real-time traceability of goods throughout the supply chain. It also integrates smart contracts to automate processes and enforce agreements without manual intervention, reducing operational costs and accelerating transactions. This approach is particularly valuable in industries like food safety, logistics, and ethical sourcing, where transparency and traceability are critical. By recording each step of a product's journey from origin to destination, the solution prevents fraud and counterfeiting, ensuring the authenticity of products. This innovative platform lays the foundation for future supply chain operations, promoting integrity and sustainability.**

**Keywords---Blockchain, Supply Chain Management, Transparency, Smart Contracts, Decentralized Ledger, Traceability, Security, Fraud Prevention, Real-Time Visibility, Product Provenance.**

## I. INTRODUCTION

Supply chain management has evolved significantly over the past decade; however, traditional systems still face persistent challenges, including inefficiencies, lack of transparency, and vulnerability to fraud [1], [2]. Conventional supply chains rely heavily on centralized systems, creating isolated data silos that impede real-time collaboration among stakeholders. This structural deficiency often leads to delays, increased operational costs, and susceptibility to counterfeit activities [3], [4].

Blockchain technology offers a transformative solution by introducing a decentralized and immutable ledger that enables shared access to verified data across the supply chain. The technology's distributed nature eliminates the

need for intermediaries, fostering direct interactions among participants and ensuring data integrity [2], [5]. Each transaction recorded on the blockchain is tamper-proof and traceable, providing unparalleled transparency and accountability, critical for ensuring trust across diverse supply chain actors [3], [5]. One key advantage of blockchain in supply chain management is the integration of smart contracts—self-executing agreements coded with predefined rules. Smart contracts automate processes such as payments, inventory updates, and compliance checks, reducing manual intervention and operational inefficiencies [1], [6]. For instance, payments can be automatically triggered upon delivery confirmation, expediting transaction cycles and reducing disputes [5].

Furthermore, blockchain enhances traceability, a feature crucial for industries like pharmaceuticals, food safety, and ethical sourcing. By recording every step in the product lifecycle, blockchain helps prevent counterfeiting and ensures product authenticity [2], [5]. This capability is particularly significant in addressing foodborne illness outbreaks and ensuring compliance with safety regulations [4]. Ethical sourcing initiatives also benefit, as businesses can verify the origins of raw materials, fostering sustainability and adherence to social responsibility standards [6].

Despite its numerous advantages, the adoption of blockchain in supply chain management is not without challenges. Scalability and the high energy demands of some blockchain networks remain significant barriers [1], [5]. Additionally, integrating blockchain systems with legacy technologies and achieving consensus among stakeholders require thoughtful planning and governance [3], [4]. However, emerging innovations, such as energy-efficient consensus mechanisms and hybrid blockchain models, are gradually overcoming these challenges, making the technology more adaptable for diverse supply chain environments [5].

As industries increasingly emphasize transparency, sustainability, and efficiency, blockchain has the potential to redefine the supply chain landscape. By enabling real-time data sharing, fostering trust, and automating

operations, it addresses core inefficiencies in traditional systems [2], [6]. Its ability to provide end-to-end visibility and security aligns well with the demands of modern supply chains, positioning it as a critical driver of operational excellence and consumer trust in the future [5].

#### METHODOLOGY FOR BLOCKCHAIN-BASED SUPPLY CHAIN MANAGEMENT SYSTEM

The methodology involves a structured approach to address challenges in supply chain management by leveraging blockchain technology. Initially, a detailed review of the literature was conducted to identify inefficiencies in traditional supply chains, such as data silos, counterfeiting, and lack of transparency [1], [2]. The review focused on existing blockchain-based systems and their application across industries, including pharmaceuticals, logistics, and food safety [3], [5].

The design of a blockchain framework considered core blockchain principles, such as decentralized ledgers, consensus mechanisms, cryptographic security, and smart contracts. Blockchain platforms like Ethereum were analyzed to determine their suitability for supply chain use cases, emphasizing features like immutability and transparency [1], [5]. The integration of smart contracts was prioritized to automate processes, reduce manual intervention, and improve operational efficiency, such as triggering payments upon delivery confirmation or updating inventory automatically [2], [6].

The framework was conceptualized to involve key stakeholders: manufacturers, third-party organizations, delivery hubs, and customers. It ensures seamless data sharing and traceability across the supply chain, allowing each stakeholder to access relevant, verified information at every stage of the product lifecycle [2], [3]. This architecture was designed to enhance security and accountability, critical for industries dealing with sensitive products, such as pharmaceuticals and perishable goods [4], [5].

Simulation scenarios were developed to evaluate the proposed blockchain framework's efficiency in improving supply chain operations. These simulations tested parameters such as transaction speed, data accuracy, cost-effectiveness, and traceability [3], [6]. The results were compared with traditional systems to measure improvements in transparency, fraud prevention, and stakeholder satisfaction.

The analysis of the findings emphasized blockchain's potential to revolutionize supply chain management, addressing key inefficiencies and aligning with modern industry requirements for transparency, sustainability, and operational excellence [4], [5].

## II. CHALLENGES IN TRADITIONAL SUPPLY CHAINS

1) Traditional supply chains encounter numerous challenges that significantly impact their efficiency and reliability. A critical issue is the fragmentation of data across various stakeholders. In conventional supply chain systems, each participant maintains isolated records, leading to data silos. This lack of integration restricts real-time information sharing and impedes visibility into the flow of goods, resulting in inefficiencies and errors caused by incomplete or outdated data [1], [2].

2) The proliferation of counterfeit products is another major concern. Traditional supply chains lack robust mechanisms to securely and transparently trace the origin and movement of goods. This vulnerability is especially pronounced in sectors such as pharmaceuticals, where counterfeit products pose risks to consumer safety and regulatory compliance [2], [3]. Furthermore, the absence of an immutable transaction history makes it difficult to detect and mitigate fraudulent activities within the supply chain [1].

3) Inefficiencies are further exacerbated by the reliance on manual processes. Many traditional systems continue to use paper-based records and manual data entry, which are prone to errors, delays, and mismanagement. This reliance on outdated methods slows down critical processes, including inventory management, procurement, and order fulfillment, leading to increased operational costs and reduced effectiveness [3], [6].

4) Another persistent challenge is the limited availability of real-time data. The inability to monitor shipments or address issues such as delays, damaged goods, or quality deviations in real-time hampers decision-making and delays responses to disruptions. This lack of timely and actionable information reduces the overall agility and resilience of the supply chain [3], [5].

5) Ensuring product authenticity and traceability is also problematic in traditional supply chains. The involvement of multiple intermediaries complicates efforts to verify the origin, quality, and journey of products. This challenge is particularly critical in industries like pharmaceuticals and food safety, where ensuring compliance and product integrity is essential [2], [5].

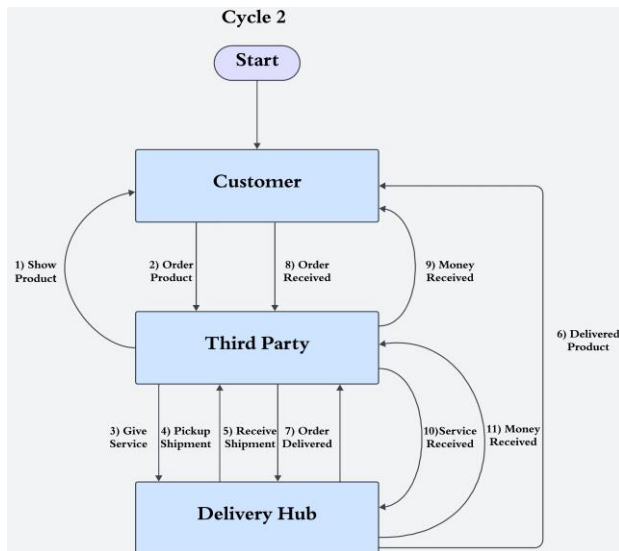
6) The dependence on numerous intermediaries introduces additional layers of complexity and cost. Each intermediary increases the potential for errors, delays, and coordination issues, which collectively undermine the efficiency of the supply chain [1], [2].

7) Cross-border transactions pose further challenges due to the variation in regulatory frameworks, customs procedures, and shipping requirements across different jurisdictions. This lack of standardization frequently results in delays, higher costs, and compliance risks, particularly for global supply chains [2], [3].

8) Finally, the absence of transparency often leads to difficulties in verifying the sustainability and ethical practices of supply chain participants. Without a clear view of sourcing and production practices, organizations struggle to ensure adherence to ethical and sustainable standards, potentially damaging brand reputation and consumer trust [5], [6].

9)

These challenges collectively highlight the limitations of traditional supply chain systems, which are unable to adequately address modern demands for efficiency, transparency, and reliability. Blockchain technology, with its decentralized and tamper-resistant architecture, offers transformative potential to resolve these inefficiencies and establish a more secure and transparent supply chain ecosystem [1], [6].



System Architecture Cycle 2

### III. DESIGN AND SYSTEM ARCHITECTURE

The proposed system architecture simplifies the movement of products from manufacturers to customers. It improves communication, reduces delays, and ensures smooth service. The system works in two parts: Cycle 1 (Manufacturer to Third Party) and Cycle 2 (Third Party to Customer).

#### A. Cycle 1: Manufacturer to Third Party

Cycle 1 handles the upstream supply chain operations, focusing on the movement of goods from the manufacturer to a third-party intermediary. This cycle ensures that the necessary inventory is available to meet customer demands in the subsequent cycle.

##### Step 1: Show Product

The third party initiates communication with the manufacturer to request information about available products. This process involves accessing product catalogs, technical specifications, and inventory levels. This step is crucial to align the third party's procurement requirements with the manufacturer's production capabilities.

##### Step 2: Order Product

Based on the identified needs, the third party places a formal purchase order with the manufacturer. This order includes details such as product type, quantity, delivery timelines, and pricing agreements.

##### Step 3: Ship Product

Upon receiving the order, the manufacturer initiates the shipment process. Tracking mechanisms are often employed to monitor the shipment's status during transit.

##### Step 4: Receive Product

The third party receives the shipment and checks it for accuracy, quality, and completeness. Once confirmed, the inventory is ready for distribution in the next cycle.

#### B. Cycle 2: Third Party to Customer

Cycle 2 focuses on downstream activities, bridging the gap between the third party and the customer. It encompasses order placement, fulfillment, service delivery, and financial transactions.

##### Step 1: Show Product

The customer explores the product catalog or interface provided by the third-party. This step allows the customer to view product details such as specifications, pricing, and availability, helping them make an informed purchasing decision.

##### Step 2: Order Product

After selecting the desired product, the customer places an order with the third-party. This order includes key details like the product type, quantity, delivery address, and payment preferences.

##### Step 3: Give Service

Upon receiving the order, the third-party starts the order fulfillment process. They coordinate with the delivery hub

to prepare the product for shipment, ensuring it meets the specified requirements for delivery.

#### Step 4: Pickup Shipment

The delivery hub collects the product from the third-party or their designated location. During this step, the delivery hub ensures that the product is properly packaged and ready for transportation.

#### Step 5: Receive Shipment

The third party receives the product from the delivery hub as part of the final preparation before delivering it to the customer. During this step, the third party performs a thorough inspection to verify the product's condition, accuracy, and quality against the original order details.

#### Step 6: Deliver Product

The delivery hub coordinates the physical transportation of the product to the customer's address. Delivery routes and schedules are optimized to ensure timely handover.

#### Step 7: Order Delivered

After the product is delivered, the delivery hub sends a confirmation notification to the third party. This confirmation acts as a record of successful order completion.

#### Step 8: Order Received

The customer acknowledges receipt of the order, confirming that the product has been received to the correct address and in the expected condition.

#### Step 9: Money Received

The customer completes the payment process for the product, finalizing the transaction.

#### Step 10: Service Received

The third party processes payments for the delivery hub and settles any outstanding service fees.

#### Step 11: Delivery Hub Payment

The delivery hub receives its share of the payment for handling logistics and delivery. This transaction marks the completion of financial settlements for the order.

### IV. BLOCKCHAIN AS A SOLUTION FOR COUNTERFEIT PREVENTION IN SUPPLY CHAINS

Counterfeit products present significant risks to industries like pharmaceuticals, electronics, and luxury goods. These counterfeits can lead to financial losses, harm consumer safety, and damage brand reputation. Blockchain technology provides a robust solution to combat these issues by ensuring transparency, traceability, and security

throughout the supply chain [1][2].

#### A. Ensuring Product Authenticity

Blockchain's decentralized and immutable ledger records every product movement, from manufacturing to distribution. This creates a secure, tamper-proof record accessible to all stakeholders, helping to verify the authenticity of products at every stage of the supply chain [3].

#### B. Preventing Counterfeits

In a traditional supply chain, counterfeit products can easily enter the system. Blockchain addresses this by recording all transactions on a decentralized network, making it nearly impossible for counterfeiters to alter records without detection [4][5].

#### C. Smart Contracts for Verification

Smart contracts automatically verify product authenticity at each stage. For example, upon arrival at a warehouse, the system can check product records to ensure they match the original specifications. This reduces human error and prevents counterfeit products from reaching consumers [6].

#### D. Increased Consumer and Retailer Confidence

Consumers can use blockchain to verify product authenticity by accessing its full history. This boosts trust in the product, while retailers can be confident in the goods they are selling, knowing they come with a verifiable history [7].

#### E. Regulatory Compliance and Tracing Counterfeits

In industries like pharmaceuticals, blockchain helps ensure compliance with safety standards and trace the origin of counterfeit products. This allows authorities to quickly identify and remove fake products from the market [8][9].

### V. BLOCKCHAIN-DRIVEN FUTURE ENHANCEMENTS IN

#### SUPPLY CHAIN MANAGEMENT

The continuous evolution of supply chain management (SCM) is heavily influenced by technological advancements, with blockchain playing a pivotal role in transforming the way goods are tracked, verified, and managed across global supply chains. Blockchain's capabilities in ensuring transparency, security, and efficiency make it an ideal solution for addressing long-standing challenges in traditional supply chains [1][2].

#### A. Scalability in Global Supply Chains

As international trade and supply chains grow more intricate, blockchain enables seamless scaling across diverse regions and industries. Beyond its current

applications in pharmaceuticals and luxury goods, blockchain can support sectors like food safety, automotive, and agriculture. Its standardized platform ensures product authenticity, traceability, and regulatory compliance, streamlining global operations [3][4].

#### B. Integration with IoT for Enhanced Transparency

The integration of blockchain with Internet of Things (IoT) devices elevates supply chain transparency. IoT sensors—such as RFID tags, temperature monitors, and GPS trackers—gather real-time data on product conditions and locations. Blockchain's secure, immutable ledger verifies and updates this data, improving traceability across the supply chain [5][6].

#### C. Smart Contracts for Automation

Blockchain-powered smart contracts automate predefined tasks such as payment releases, compliance checks, and inventory updates. By minimizing manual intervention, smart contracts expedite transactions, reduce errors, and ensure adherence to regulatory standards. This automation significantly improves operational efficiency [7][8].

#### D. Advanced Data Analytics and Predictive Insights

Blockchain's ability to securely store data enhances its compatibility with advanced analytics and machine learning. Historical and real-time blockchain data can drive predictive models, optimizing production, forecasting demand, and improving inventory management. This ensures data integrity, supporting informed decision-making [9][10].

#### Enhanced Security and Fraud Prevention

Blockchain's decentralized, tamper-resistant architecture makes it an ideal solution for mitigating fraud risks in supply chains. By recording every transaction and product movement in an immutable ledger, blockchain creates a transparent, traceable trail that is highly resistant to tampering. This capability is especially important in industries like pharmaceuticals, where counterfeit products are a significant concern. Blockchain enhances product authentication and combats fraud, ensuring that only genuine goods reach the market [11][12].

### VI. IMPLEMENTATION OF BLOCKCHAIN IN SUPPLY CHAIN

The implementation of blockchain technology in supply chain management is driven by its unique features, including decentralization, immutability, transparency, traceability, smart contracts, and security. These features provide practical solutions to existing challenges, such as counterfeiting, inefficiencies, and lack of trust [1][2]. This section details the implementation of blockchain across key stages of supply chain operations.

#### A. Decentralized Data Management

In a blockchain-based supply chain, all stakeholders, including manufacturers, suppliers, distributors, and customers, participate in a decentralized network. This eliminates the need for a central authority, ensuring that all participants have equal access to verified data. Each stakeholder can add, view, and verify transactions in real time, enabling smoother coordination. For instance, manufacturers can update product availability, which third parties can access to initiate procurement without relying on intermediaries [3][4].

#### B. Immutable Record Keeping

Blockchain's immutability ensures that all recorded transactions, such as product details, shipment updates, and ownership transfers, cannot be altered. This feature is implemented by assigning a unique hash to each transaction, which is linked to the previous one in the chain. For example, when a pharmaceutical product is manufactured, its production details, batch number, and expiration date are permanently recorded on the blockchain, ensuring tamper-proof tracking [5][6].

#### C. Transparent and Shared Ledger

A shared ledger provides real-time visibility to all stakeholders, fostering trust and accountability. Transparency is implemented by allowing stakeholders to access relevant data based on their roles and permissions. For example, customers can verify the origin and handling of a product before purchasing, while regulatory authorities can inspect compliance records directly on the blockchain [7][8].

#### D. End-to-End Traceability

Traceability is implemented by recording every step of a product's journey from origin to end consumer. Each transaction, including raw material sourcing, production, packaging, and delivery, is securely recorded on the blockchain. For instance, in the food industry, traceability ensures that consumers can track the farm-to-table journey of a product, identifying the sources of contamination in case of recalls [9][10].

#### E. Smart Contract Automation

Smart contracts automate supply chain processes by executing predefined conditions without manual intervention. Key implementations include:

- 1) **Order Processing:** When a retailer places an order with a supplier, a smart contract verifies inventory availability and triggers shipment automatically [11].
- 2) **Payment Automation:** Upon successful delivery

confirmation, a smart contract releases payment to the supplier, reducing delays and manual errors [12].

3) Compliance Verification: In regulated industries like pharmaceuticals, smart contracts can automatically validate compliance with standards before approving product movement [13].

#### F. Enhanced Security with Cryptographic Integrity

Blockchain's security is implemented using cryptographic techniques, ensuring that all data remains secure and accessible only to authorized participants. Digital signatures authenticate each transaction, preventing unauthorized access or data breaches. For example, a distributor's transaction to update shipment status requires cryptographic verification, ensuring the integrity of the update [14][15].

#### G. Consensus Mechanisms for Data Validation

Consensus mechanisms, such as Proof of Stake (PoS), validate transactions before adding them to the blockchain. This ensures that all data on the blockchain is accurate and agreed upon by the network participants. For instance, when a product moves from a manufacturer to a third-party distributor, the transaction is validated by network nodes to prevent fraudulent updates [16][17].

#### H. Future Work Use Case: Counterfeit Prevention in Pharmaceuticals

Blockchain's features are particularly effective in preventing counterfeit products. Each product is assigned a unique digital identity recorded on the blockchain, allowing stakeholders to verify authenticity at every stage. For example:

1) Manufacturing: A digital token is created for each batch, recording production details [18].

2) Distribution: Tokens are transferred to distributors and updated on the blockchain, ensuring no unauthorized access [19].

VII. Customer Verification: Consumers can scan a QR code on the product to access its entire history, confirming its authenticity [20].

#### CONCLUSION

Blockchain technology is revolutionizing supply chain management by addressing key issues such as counterfeit products, fraud, and operational inefficiencies. With its core attributes of transparency, immutability, and decentralization, blockchain provides a secure and verifiable framework that enhances trust, accountability, and ethical practices across supply chains.

Beyond improving operational processes, blockchain fosters a collaborative environment by ensuring that no single entity has unchecked control. Its decentralized nature allows for a transparent, auditable trail of transactions, which is crucial for industries like pharmaceuticals, food, and luxury goods that require stringent compliance and quality assurance.

The integration of advanced technologies, such as smart contracts and IoT devices, further enhances blockchain's potential. Smart contracts automate key processes, reducing errors and improving efficiency, while IoT devices enable real-time monitoring of product conditions. Together, these innovations streamline supply chain operations and open new avenues for business models and strategies.

Economically, blockchain delivers significant benefits by reducing fraud, improving inventory management, and lowering operational costs. It also simplifies regulatory compliance by providing detailed and auditable records, which is especially valuable in highly regulated industries. Despite challenges such as high initial costs and integration complexities, the long-term benefits outweigh the short-term hurdles.

Looking ahead, the continued development of blockchain, including advancements in scalability and AI integration, will further enhance its role in global supply chains. These innovations will not only make blockchain accessible to smaller businesses but also enable predictive analytics for better decision making. Additionally, blockchain supports sustainability efforts by promoting transparency in sourcing, helping create a more ethical and responsible global trade system.

Furthermore, blockchain's decentralized approach allows for the creation of decentralized autonomous organizations (DAOs) within the supply chain. These DAOs can empower stakeholders by enabling peer-to-peer collaboration without the need for intermediaries, further reducing costs and enhancing trust among participants. This model could transform supply chain dynamics by fostering more inclusive and democratic decision-making processes.

Blockchain also plays a pivotal role in addressing global supply chain challenges such as supply chain disruptions and environmental impact. By ensuring product traceability and transparency, it enables faster and more effective responses to supply chain disruptions caused by unforeseen events, like natural disasters or geopolitical issues. Additionally, by promoting sustainable practices, blockchain can help track carbon footprints and other environmental impacts of products, contributing to more

eco-conscious business practices.

In conclusion, blockchain is not just a technological solution but a transformative force in supply chain management. It enables enhanced trust, efficiency, and accountability, and its potential to reshape global trade makes it a cornerstone for future supply chain operations. As adoption continues to grow and technology evolves, blockchain promises to deliver lasting value to businesses, consumers, and society at large.

#### ACKNOWLEDGMENT

We are profoundly grateful to Prof. G.P. Mohole for her expert guidance and continuous encouragement throughout this project, ensuring it achieved its objectives from commencement to completion.

We would like to express our deepest appreciation to Dr.

M. V. Bhatkar, Principal of Jawahar Education Society's Institute of Technology, Management and Research, Nashik; Prof. G. P. Mohole, Head of the Department of Computer Engineering; and Prof. S. N. Botekar, Project Coordinator, for their invaluable guidance and support in completing this project.

Lastly, we extend our sincere and heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during the course of this work.

#### REFERENCES

[1] S. Malik, V. Dedeoglu, S. S. Kanhere, and R. Jurdak, "Trustchain: Trust management in blockchain and iot supported supply chains," arXiv, 2019. [Online]. Available: <https://arxiv.org/pdf/1906.01831>

[2] G. Narayanan, I. Cvitic, D. Perakovic, and S. P. Raja, "Role of blockchain technology in supply chain management," ResearchGate, 2024. [Online].

Available:

<https://www.researchgate.net/publication/377905124>

[3] F. Dietrich, L. Louw, and D. Palm, "A systematic literature review of blockchain-based traceability solutions," ResearchGate, 2023. [Online].

Available:

<https://www.researchgate.net/publication/371475720>

[4] S. E. Chang and Y. Chen, "When blockchain meets supply chain: A systematic literature review on current development and potential applications," ResearchGate, 2020. [Online]. Available: <https://www.researchgate.net/publication/340214661>

[5] O. I. Oriekhoe, B. I. Ashiwaju, K. C. Ihemereze, U.

Ikwue, and

C. A. Udeh, "Blockchain technology for supply chain management: A comprehensive review," International Journal of Management & Entrepreneurship Research, 2024. [Online]. Available: <https://www.fepbl.com/index.php/ijmer/article/view/714>

[6] R. Alkhudary, M. M. Queiroz, and P. Fé'nie's, "Mitigating the risk of specific supply chain disruptions through blockchain technology," Taylor & Francis, 2024. [Online]. Available: <https://doi.org/10.1080/16258312.2022.2090273>

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Geetanjali P. Mohole has  
presented paper entitled Nexus NFT Using Blockchain

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

**Dr. M. V. Bhatkar**  
Conference Chair

# Nexus NFT Using Blockchain

Priya Kotwal<sup>1</sup>, Rushikesh Admane<sup>2</sup>, Anam Shaikh<sup>3</sup>, Mohin Shaikh<sup>4</sup>, G.P. Mohole<sup>6</sup>

Department of Computer Engineering,

Jawahar Education Society's Institute of Technology, Management, And Research, Nashik 422222, India

Affiliated to Savitribai Phule Pune University

<sup>1</sup>priyakotwal07@gmail.com, <sup>2</sup>rushiadmane6656@gmail.com,

<sup>3</sup>anamshaikh7296@gmail.com, <sup>4</sup>moinshaikh2023@gmail.com,

**Abstract**---NFT Nexus is an innovative decentralized platform that bridges the gap between traditional art and digital assets. It offers a comprehensive suite of tools for creators to mint, manage, and sell their work as NFTs, while providing collectors with a secure and intuitive marketplace for discovery and transactions. The platform's robust smart contract infrastructure ensures the authenticity and security of each NFT, and its community-driven features encourage engagement and collaboration. NFT Nexus is dedicated to democratizing access to the NFT ecosystem, making it accessible to both established artists and emerging talents.

**Keywords**—Blockchain, Supply Chain Management, Transparency, Smart Contracts, Decentralized Ledger, Traceability, Security, Fraud Prevention, Real-Time Visibility, Product Provenance.

## I. INTRODUCTION

Non-Fungible Tokens (NFTs) have emerged as a groundbreaking solution to the challenges faced by digital artists. NFTs are unique digital assets that represent ownership of a specific item or piece of content on the blockchain. Unlike cryptocurrencies like Bitcoin or Ethereum, NFTs are indivisible and indivisible, making each one entirely unique and irreplaceable. This uniqueness certifies the authenticity and provenance of digital art, providing artists with the means to prove the exclusivity of their creations.

Simultaneously, the art world is witnessing another technological revolution - the rise of Decentralized Applications (DApps). Built on blockchain technology, DApps have the power to foster secure, transparent, and peer-to-peer interactions in various domains, including the art industry. They act as bridges between artists and collectors, offering a platform for artists to showcase their work and collectors to invest in unique digital pieces, all without the intermediaries that have historically controlled the art market.

The art world has long been characterized by a legacy of tradition and exclusivity. For centuries, it was an ecosystem largely restricted to physical creations, limited by geographical boundaries, and dominated by institutions and galleries that determined what art would be showcased and, ultimately, appreciated. The digital age, however, has ushered in a new era, where the creation, distribution, and consumption of art have transcended traditional constraints.

Digital art, in various forms such as illustrations, animations, 3D models, and more, has surged in popularity,

challenging conventional definitions of art. This transformation, while liberating, has brought new challenges, particularly concerning ownership, authenticity, and provenance. These challenges have been met with the rise of NFTs.

Non-Fungible Tokens (NFTs) have emerged as the solution to many of these challenges. NFTs are unique digital assets that represent ownership of a specific item or piece of content on the blockchain. These tokens certify the authenticity and provenance of digital art, providing artists with the means to prove the uniqueness of their creations.

In parallel, Decentralized Applications (DApps), built on blockchain technology, have become the vehicle for enabling secure and transparent interactions in various domains, including the art industry. DApps offer a peer-to-peer platform for artists to exhibit their work and collectors to invest in unique digital pieces. DApps also ensure that the process of creating, selling, and purchasing digital art is transparent, secure, and free from intermediaries.

This project centers on the development of an NFT-Based Digital Art Gallery DApp, a platform designed to empower artists, collectors, and enthusiasts alike. This introduction sets the stage for a more detailed exploration of the project's objectives and its profound significance within the art industry.

**Methodology for Blockchain- Non-Fungible Tokens (NFTs)**

The methodology for an NFT (Non-Fungible Token) Nexus in a blockchain project focuses on the steps and processes involved in creating, integrating, and managing NFTs within a blockchain-based ecosystem. An NFT Nexus typically refers to a platform or network that serves as a bridge or central hub for various NFTs, enabling interoperability, discovery, and management across different blockchain environments.

**Defining the Project Vision and Purpose**

**Objective Setting:** Clearly define the goals of the NFT Nexus. What value does it provide? Is it focused on enabling creators to mint and trade NFTs, fostering cross-chain compatibility, offering NFT marketplace capabilities, or promoting specific use cases such as gaming, art, collectibles, etc.?

**Target Audience:** Identify the target users, such as artists, collectors, gamers, enterprises, and developers.

**Blockchain and NFT Standards**

**Selecting a Blockchain Platform:** Choose the blockchain(s)

that will support the NFT Nexus. Consider platforms like Ethereum, Solana, Binance Smart Chain, or newer layer-2 solutions. Each has its pros and cons in terms of scalability, transaction speed, cost, and developer ecosystem.

**NFT Standards:** Adopt relevant NFT token standards, such as ERC-721 (for unique tokens) or ERC-1155 (for semi-fungible tokens). These standards ensure compatibility and interoperability between NFTs and the broader blockchain ecosystem.

**Smart Contracts for Minting:** Develop smart contracts that enable users to create NFTs, defining attributes like ownership, metadata, and royalties. These smart contracts can be customized based on the specific needs of the project (e.g., customizable minting process, dynamic pricing, time-limited minting).

**Interoperability and Cross-Chain Support**

**Multi-Chain Compatibility:** Implement a system that supports NFTs across multiple blockchain platforms. This can be achieved by leveraging bridges, such as token wrapping or cross-chain protocols, which enable NFTs to be moved between different blockchains seamlessly.

**NFT Marketplace Integration**

**Marketplace Development:** Develop or integrate an NFT marketplace where users can list, browse, buy, and sell NFTs. The marketplace should provide rich search functionalities, filters based on attributes (e.g., price, creator, category), and robust transaction handling.

**Security and Compliance**

- **Smart Contract Audits:** Conduct thorough audits of the smart contracts to prevent vulnerabilities and ensure that the minting, transfer, and sale processes are secure.
- **Anti-fraud and Ownership Verification:** Develop systems that validate ownership and prevent issues such as plagiarism or the creation of counterfeit NFTs.

**User Experience and Interface Design**

**Intuitive UI/UX:** Build a user-friendly interface for both creators and collectors, enabling easy navigation of the NFT creation, buying, and selling processes. Ensure seamless interaction with the blockchain, whether on web platforms or mobile apps

**Community and Ecosystem Growth**

**Engagement with Creators and Collectors:** Foster a community of creators, curators, collectors, and investors. This can include offering incentives like reduced minting fees, gamified elements, or exclusive access to certain NFTs or events.

**Monetization and Tokenomics**

**Platform Fees and Revenue Streams:** Define how the NFT Nexus will generate revenue, such as transaction fees, listing fees, premium accounts for creators, and commissions on secondary market sales.

**Utility Token Creation:** If applicable, introduce a native utility token that can be used for governance, rewarding active users, and accessing special features within the NFT Nexus.

**Sustainability and Environmental Impact**

**Energy-Efficient Solutions:** Use eco-friendly blockchain solutions that reduce the carbon footprint of NFTs. Layer-2 solutions like Polygon or Ethereum's Proof-of-Stake (PoS) transition are examples that offer more sustainable alternatives.

**Launch and Marketing**

**Token and NFT Drops:** Plan NFT drops, limited edition collections, or early access events to generate excitement and attract users.

**Marketing Campaigns:** Create marketing strategies to promote the platform, such as influencer collaborations, PR campaigns, social media engagement, and virtual events (e.g., NFT auctions, community AMA sessions)

**Design and System Architecture**

**Overall System Overview**

The Nexus NFT platform is essentially a decentralized application (dApp) built on top of a blockchain to create, manage, and trade NFTs. The architecture should ensure that all transactions (minting, buying, selling, and transferring NFTs) are secure, immutable, and verifiable.

**System Architecture Overview**

The Nexus NFT system architecture can be divided into three main layers:

**Frontend (Client-side):** The user interface and experience (UI/UX).

**Backend (Server-side):** Smart contract interactions, blockchain integration, and business logic.

**Blockchain and Storage Layer:** Decentralized blockchain for NFT ownership, transactions, and storage.

**Layer 1: Frontend (Client-side)**

The Frontend layer consists of the following components:

**A. User Interface (UI)**

**Dashboard:** Displays the user's owned NFTs, transaction history, and portfolio overview.

**Minting Page:** Allows users to mint new NFTs, upload files, set metadata (title, description, and attributes), and interact with the blockchain.

**Layer 2: Backend (Server-side)**

The Backend layer consists of components that handle off-chain data storage, business logic, and integration with blockchain networks.

**A. Smart Contract Deployment**

**Smart Contracts:** Smart contracts are deployed on the selected blockchain (e.g., Ethereum, Solana) for the minting and trading of NFTs. These contracts are responsible for:

**Minting NFTs:** Creating new NFTs, linking them to metadata, and assigning unique token IDs.

**Buying and Selling:** Facilitating transactions by transferring ownership of NFTs between wallets.

**Royalties:** Ensuring creators get a percentage of each resale.

**Metadata Management:** Linking NFTs to metadata and ensuring that ownership records are correctly maintained.

**Contract Standards:** The smart contract will adhere to standard token protocols:

ERC-721: For single NFTs (unique tokens).

ERC-1155: For batch minting, allowing both fungible and non-fungible tokens in the same contract.

## B. Blockchain Layer Integration

**Blockchain Node:** The backend connects to blockchain nodes (either through a service like Infura, Alchemy, or running your own node) to communicate with the blockchain.

**Transaction Processing:** The backend processes and submits transactions to the blockchain (minting, transfers, and sales). These transactions are submitted using Web3.js or similar libraries.

**Transaction History:** Each transaction related to the NFT (minting, buying, selling) is recorded on the blockchain, ensuring transparency and traceability.

## System Flow

### NFT Creation (Minting):

The user connects their wallet (e.g., MetaMask).

The user uploads media (e.g., image, video) and metadata to the platform.

### NFT Trading (Buying/Selling):

The user lists the NFT for sale in the marketplace.

When a buyer purchases the NFT, the smart contract ensures that the ownership is transferred to the buyer's wallet and records the transaction on the blockchain.

Any applicable royalties are automatically deducted and sent to the creator's wallet.

### NFT Ownership and Transfer:

Once an NFT is sold, the blockchain transaction log is updated, showing the new owner.

## Blockchain-Driven Future Enhancements in nexus nft

The future of Nexus NFT lies in continuously evolving its architecture, features, and functionalities to meet the growing demand for digital assets. Blockchain technology is central to this evolution, and as new innovations and advancements emerge, Nexus NFT can leverage them to

improve user experience, enhance security, and increase interoperability. Below are key blockchain-driven future enhancements that can shape the evolution of Nexus NFT.

## 1. Layer 2 Solutions for Scalability and Cost Efficiency

One of the major concerns with traditional blockchain networks, especially Ethereum, is high transaction fees and scalability issues. To address these, Nexus NFT can integrate Layer 2 solutions that offer faster transactions and reduced costs. **Polygon (Matic):** By moving transactions off-chain and only settling them on the Ethereum mainnet, Polygon offers a low-cost and fast solution, which would help the Nexus NFT

platform scale significantly.

**Optimistic Rollups & zk-Rollups:** These technologies bundle many transactions off-chain and provide much faster and more affordable transactions while preserving security. Integrating them into Nexus NFTs could drastically reduce costs and improve user experience.

**Arbitrum:** Another roll-up solution for Ethereum that reduces congestion and gas fees, improving performance for the marketplace and user interactions.

**Impact:** By leveraging these Layer 2 solutions, Nexus NFTs can process thousands of transactions per second (TPS), enhancing the overall scalability of the platform. This enables a smoother experience for users and creators, as minting, trading, and transferring NFTs would be faster and more cost-effective.

## 2. Cross-Chain Interoperability

The future of NFTs is multi-chain, with different blockchain ecosystems offering distinct advantages. For example, Ethereum has a large user base, Solana is known for its speed, and Tezos offers an eco-friendly solution. Cross-chain interoperability will allow Nexus NFTs to tap into multiple blockchain networks, enabling:

**Cross-Chain NFT Transfers:** Allowing users to transfer NFTs between different blockchains (Ethereum, Solana, Binance Smart Chain, etc.) without having to "unwrap" or "recreate" the asset.

**Multi-Chain Minting:** Creators can mint NFTs on multiple chains simultaneously, reaching diverse audiences across different ecosystems.

**Bridges & Wrapped Tokens:** Implementing cross-chain bridges or wrapped tokens will make it easier to convert NFTs from one blockchain to another, ensuring compatibility with various platforms and wallets.

**Impact:** Cross-chain functionality expands the reach of Nexus NFTs, increases liquidity, and allows users to take advantage of the best features from different blockchains (e.g., lower fees, faster speeds, eco-friendly solutions).

## 3. Decentralized Autonomous Organizations (DAOs) for Community Governance

A major trend in the blockchain space is the rise of

Decentralized Autonomous Organizations (DAOs), which allow the community to govern and make decisions collectively. Nexus NFT can integrate DAO mechanisms to allow users and creators to have a say in:

**Platform Governance:** Users can vote on platform updates, changes in royalty structures, listing criteria, and the general direction of Nexus NFT.

**Community Fund:** A DAO treasury can be set up, funded by a portion of marketplace fees or donations, which can be used for platform development, marketing, or to reward contributors.

**Creator and Collector Communities:** DAOs can be created around specific NFT collections, where collectors and creators can collaboratively decide on project directions, exclusive features, and special events.

**Impact:** DAOs would decentralize control over the platform, giving users more power and fostering a community-driven approach. This increases engagement, ensures fair governance, and strengthens the Nexus NFT ecosystem.

#### 4. NFT Fractionalization and Shared Ownership

NFTs are traditionally individual, unique assets, but in the future, NFT fractionalization will enable shared ownership of high-value assets. Nexus NFTs can implement this technology to allow users to:

**Own Fractions of NFTs:** High-value NFTs (e.g., digital art, rare collectibles) can be divided into multiple fractions, enabling people to co-own these assets and trade fractional shares.

**Revenue Sharing:** Creators could share a portion of the profits from their NFTs with co-owners in proportion to the fraction they hold.

**Liquidity for Rare Assets:** This enhances liquidity for expensive or niche NFTs by allowing fractionalized ownership, making rare assets accessible to a wider audience.

**Impact:** Fractionalization will democratize the ownership of high-value NFTs, making them accessible to a larger group of users, and creating a new market for trading NFT fractions. This increases liquidity and the potential user base for Nexus NFTs.

#### 5. Integration of Artificial Intelligence (AI) for Smart NFT Experiences

Blockchain-based Artificial Intelligence (AI) will play a significant role in enhancing Nexus NFTs by providing smarter and more interactive experiences:

**AI-Generated NFTs:** AI can be used to create unique, dynamic NFTs that change over time based on certain criteria or inputs, such as personal user interactions, external data, or even market conditions. This would open the door to interactive and evolving NFT art or collectible experiences.

**Personalized NFT Recommendations:** Using AI, Nexus

NFT can provide personalized recommendations based on user preferences, activity history, and market trends.

**AI-Powered Authentication:** AI algorithms can enhance security by analyzing metadata and visual properties of NFTs

to help detect fake or counterfeit assets before they are listed or bought.

#### 6. Eco-Friendly and Sustainable NFTs

Environmental concerns around energy consumption associated with NFTs (especially on proof-of-work blockchains) have sparked calls for greener solutions. Nexus NFT can focus on eco-friendly blockchain technologies to make the platform more sustainable:

**Proof of Stake (PoS):** Transitioning to PoS-based blockchains (e.g., Ethereum 2.0) or using eco-friendly blockchains like Tezos or Flow to minimize energy consumption.

**Carbon Offset Initiatives:** Nexus NFT could implement programs to offset the carbon emissions generated by NFT minting and transactions. For example, Nexus could donate a portion of transaction fees to environmental projects or integrate carbon credit systems.

**Energy-Efficient Smart Contracts:** Implementing optimized and efficient smart contracts that require less computational energy for operations.

**Impact:** Focusing on sustainability will not only reduce the environmental footprint of Nexus NFTs but also align the platform with growing consumer demand for eco-conscious products and services, contributing to the long-term sustainability of the NFT market.

#### 7. Augmented Reality (AR) and Virtual Reality (VR) NFTs

As AR and VR technologies mature, Nexus NFTs can evolve

into immersive, interactive experiences:

**AR Integration:** Users can view NFTs in real-world settings through augmented reality, enhancing the interactivity and engagement of digital art, collectibles, or even virtual goods.

**VR Galleries and Exhibitions:** Nexus NFT can build virtual galleries where users can showcase their NFTs in a 3D virtual world, creating an immersive experience for collectors, creators, and enthusiasts.

**Virtual Goods and Wearables:** NFTs can represent in-game items, skins, or virtual fashion items, which can be used in metaverse platforms or VR environments.

**Impact:** By embracing AR and VR technologies, Nexus NFTs would transcend traditional 2D digital assets, creating a new wave of interactive and experiential NFTs for users to explore.

#### 8. NFT-Backed DeFi (Decentralized Finance)

NFTs can be integrated into the world of DeFi (Decentralized Finance), enabling new financial use cases

for digital assets:

- **NFT Collateralization:** Users could use their NFTs as collateral for loans within the DeFi ecosystem, with the NFT itself serving as an asset that guarantees the loan.
- **NFT Staking:** Nexus NFTs can implement staking mechanisms where users can stake their NFTs to earn rewards, similar to how tokens are staked in DeFi platforms.
- **Yield Farming:** Combining NFTs with DeFi mechanisms, users could earn yield by participating in liquidity pools or lending platforms that use NFTs as part of their collateral.

## Implementation of Blockchain in Supply Chain

### Blockchain Selection

Choosing the right blockchain platform is crucial for the Nexus NFT ecosystem. The choice depends on factors such as scalability, transaction speed, cost, and security. Popular blockchain platforms for NFTs .

### Smart Contract Development

Smart contracts are self-executing contracts with the terms directly written into code. These contracts govern the creation, buying, and selling of Nexus NFTs.

### NFT Creation (Minting Process)

The minting process involves the creation of unique tokens that represent digital assets (art, music, videos, etc.) on the blockchain.

### Marketplace Development

Once NFTs are minted, a marketplace can be developed to enable buying, selling, and trading

### Blockchain Security and Verification

Blockchain provides inherent security for NFTs. All data and metadata related to NFTs should be encrypted to protect user information and asset ownership.

### Interoperability

Interoperability is key to the success of NFTs. Nexus NFTs should be compatible with multiple wallets, marketplaces, and blockchain networks. This allows the NFT ecosystem to grow and scale by allowing users to move and trade their tokens across platforms

### User Interface (UI) and User Experience (UX)

A user-friendly interface is essential for mass adoption

The minting process should be as seamless as possible, with easy wallet integration and clear instructions for users to create and manage their NFTs.

### Community Engagement and Marketing

To ensure the success of the Nexus NFT project, a strong community and marketing efforts are crucial.

### Environmental Considerations

Blockchain technology, especially proof-of-work

blockchains (like Ethereum), has been criticized for its energy consumption.

## Conclusion

The NFT-Based Digital Art Gallery DApp represents a groundbreaking fusion of art and technology, revolutionizing the way artists create, exhibit, and trade their digital works. This conclusion summarizes key findings and achievements, reiterates the project's significance, and issues a call to action for the art and tech communities.

The convergence of art and technology is an open invitation to the art and tech communities. Artists Embrace NFT technology as a powerful tool for monetizing your digital creations, preserving your rights, and reaching a global audience. Explore the DApp and join the digital art revolution. Engage with the DApp to discover unique, collectible digital art and support emerging and established artists. Be part of a vibrant community that celebrates artistic innovation. Developers: Contribute to the growth and enhancement of the NFT ecosystem. Collaborate on blockchain projects, explore new use cases, and develop tools that empower artists and collectors. Regulators: Continue to monitor and adapt regulations to ensure a fair and secure environment for NFT transactions, supporting both creators and collector

## ACKNOWLEDGMENT

We are profoundly grateful to Prof. G.P. Mohole for her expert guidance and continuous encouragement throughout this project, ensuring it achieved its objectives from commencement to completion.

We would like to express our deepest appreciation to Dr.

M. V. Bhatkar, Principal of Jawahar Education Society's Institute of Technology, Management and Research, Nashik; Prof. G. P. Mohole, Head of the Department of Computer Engineering; and Prof. S. N. Botekar, Project Coordinator, for their invaluable guidance and support in completing this project.

Lastly, we extend our sincere and heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during the course of this work.

## REFERENCES

- [1] Jaipuria L, Singh B & Nayak R, An introduction to intellectual property rights and their importance in Indian context, Journal of Intellectual Property Rights, 22 (1) (2017) <http://docs.manupatra.in/newslines/articles/Upload/41C26FED7AFE-40EA-8736-4E6C516917AE.pdf>.
- [2] Digital Development: Opportunities and Challenges, Trade and Development Board, 2019, 24, [https://unctad.org/system/files/official-document/tdb66\\_d5\\_en.pdf](https://unctad.org/system/files/official-document/tdb66_d5_en.pdf).
- [3] Understanding Reproducibility and Replicability, National

AcademiesPress,2019,<https://www.ncbi.nlm.nih.gov/books/NBK547546/>.

[4] Chalmers D, Fisch C, Matthews R, Quinn W & Recker J, Beyond the bubble: Will NFTs and digital proof of ownership empower creative industry entrepreneurs?, *Journal of Business Venturing Insights*,17 (2022) e00309, <https://www.sciencedirect.com/science/article/pii/S2352673422000075>.

[5] Westerkamp M, Victor F & Kupper A, Tracing manufacturing processes using blockchain-based token compositions, *Digital Communications and Networks*, 2020, 167-176, <https://www.sciencedirect.com/science/article/pii/S235286481830244X>.

[6] Saha N C & Bhattacharya S, Intellectual property rights: An overview and implications in pharmaceutical industry, *Journal of Advanced Pharmaceutical Technology & Research*, 2 (2) (2011) 88, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/>

[7] Watal J, *Intellectual property rights in the WTO and developing countries*, London: Kluwer Law International, 2001.

[8] Hull P G, Copyright Law, *Encyclopedia of International Media and Communications*, 2003, <https://www.sciencedirect.com/topics/economics-econometrics-and-finance/copyright-law>.

[9] Williams L H, How do patents affect research investments?, *Annual Review Economy*, 9 (2017 Aug) 441,doi: 10.1146/annurev-economics-110216-100959, PMID: 29104716; PMCID: PMC5664960.

[10] Menell PS, Intellectual property: Legal aspects,*International Encyclopedia of the Social & Behavioral Sciences*, 2001, <https://www.sciencedirect.com/topics/economics-econometricsand-finance/trademark-law>

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Prof. V. D. Badgujar has  
presented paper entitled Blockchain Based Biometric EVM using Cloud Integration for Enhanced  
Security and Transparency

at **International Conference on Emerging Trends in Engineering and  
Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education  
Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Blockchain Based Biometric EVM using Cloud Integration for Enhanced Security and Transparency

Tanvi Sonawane<sup>1</sup>, Surabhi Chavhan<sup>2</sup>, Diksha Gavali<sup>3</sup>, Tejashri Sonawane<sup>4</sup>, Mr. V. D. Badgujar<sup>5</sup>

Department of Computer Engineering, Jawahar Education Society's Institute of Technology, Management and Research, Nashik 422222, India.

<sup>1</sup>tanvisonawane9903@gmail.com, <sup>2</sup>csurbhi2020@gmail.com, <sup>3</sup>dikshagavali030903@gmail.com,

<sup>4</sup>tejashrisonawane93@gmail.com, <sup>5</sup>vivekbadgujar.jit@gmail.com

**Abstract**—Voting in this country frequently encounters difficulties that may result in disputes and dishonest practices. It is crucial for elections to be fair and impartial so that citizens can exercise their right to select their leaders. Nonetheless, worries regarding the potential hacking of Electronic Voting Machines (EVMs) have cast doubt on the transparency and integrity of the electoral process. Strengthening security measures, conducting regular audits, and ensuring transparency concerning the software and hardware utilized in EVMs could address these issues. Furthermore, investigating innovative technologies such as blockchain for voting systems or implementing multi-layered verification processes might contribute to establishing a more secure and trustworthy electoral framework. The priority should be to maintain a balance between embracing modern technology and ensuring thorough checks to uphold fair and transparent elections for every citizen.

**Index Terms**—EVM hacking, Transparency, Security measures, Blockchain voting systems, Multi-layered verification, Fair and impartial elections.

## INTRODUCTION

In this country, participating in elections is often seen as a burdensome process, plagued by numerous controversies and instances of corruption. For people to effectively exercise their right to choose their leaders, elections must be conducted fairly and without bias. Recently, the rise of hacking incidents related to Electronic Voting Machines (EVMs) has undermined the integrity of transparent elections. This document explores a novel method that blends modern technologies with traditional voting practices. At the core of this approach is a secure data storage solution known as blockchain, widely recognized for its security and originally used for cryptocurrencies. Votes collected by EVMs will be linked to cloud-based storage using Software as a Service (SAAS). If any alterations are made to the voting system or if tampering occurs, it will disrupt the hash link, allowing for the identification of fraudulent votes, which can then be

designated as NOTA (None of the Above) to ensure they do not impact the election results. By comparing the data from EVMs with the hash table, any manipulation can be traced. Additionally, even areas lacking broadband access can utilize these methods, as only a minimal amount of data

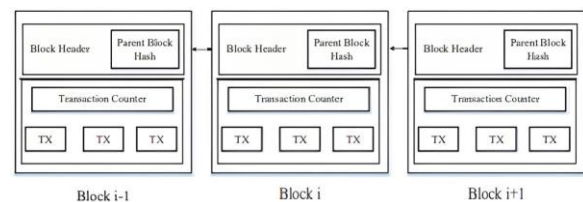


Fig. 1. Block Chain Architecture

upload is needed to maintain the hash values. The UIDAI-based biometric system currently in use enhances the security of the voting process. Every vote is treated as a distinct data block. Additionally, with the integration of blockchain technology, the Peer-to-Peer (P2P) network facilitates direct communication only between pre-established peers. This configuration eliminates the risk of Man-in-the-Middle attacks, as the proof-of-work mechanism within the blockchain prevents simultaneous mass data updates, thereby minimizing the potential for vote manipulation and safeguarding the political integrity of a nation.

## A. Motivation

Electronic voting machines (EVMs) were developed and put into use because of the need for more election procedures that are safe, effective, and easily accessible. The following are important motivators:

- 1) **Speed and Efficiency:** Conventional paper-based voting can cause delays in results and takes a long time to count votes. EVMs expedite this procedure, enabling instant tabulation, speedier voting, and speedier results.
- 2) **Accuracy and Reliability:** Human error can cause

inaccuracies and disputed results when counting by hand. By automating the vote recording and counting procedures, electronic voting machines (EVMs) reduce human error and increase overall reliability.

3) **Accessibility and Inclusivity:** Electronic voting machines (EVMs) can facilitate voting for people with literacy problems, language barriers, or disabilities. To accommodate a wide range of voters, many EVMs come equipped with features like language options, audio assistance, and streamlined user interfaces.

4) **Cost Reduction:** While there is an initial investment, electronic voting machines (EVMs) can lower long-term expenses by eliminating the need for paper ballots, saving time and resources for counting, and reducing the requirement for polling station staff.

5) **Security and Fraud Prevention:** EVMs have security mechanisms that prevent tampering with results. Encryption, safe data storage, and audit trails improve fraud detection and prevention over traditional paper voting techniques.

#### B. Problem Definition

Existing voting techniques, especially conventional paper-based systems, have a number of issues that make them ineffective, safe and open and honest election procedures. Manual vote counting takes a lot of time and is prone to human mistake, which can lower accuracy and delay results. Furthermore, paper-based voting is expensive, time-consuming, and may not be available to certain people, such as those with limited literacy or impairments. Many governments and institutions are looking into electronic voting machines (EVMs) as a way to enhance the voting process. However, there are difficulties in putting EVMs into practice, such as making sure building public confidence in the system, offering a trustworthy audit trail for transparency, and preventing tampering or hacks.

In addition, there are practical concerns like the need for efficient user training for both voters and election officials, significant upfront expenses, and technological support requirements. The challenge in resolving these concerns is creating and implementing an EVM system that is safe, easily accessible, and transparent, enhancing election efficiency and dependability while maintaining the confidence of all parties involved.

#### I. CHALLENGES IN TRADITIONAL VOTING SYSTEM

Paper ballots and manual vote counting are two examples of traditional voting methods that suffer a number of difficulties that may compromise their effectiveness, integrity,

and openness. These are the main challenges:

##### 1) Human Errors:

Counting errors can occur when counting by hand, particularly during large-scale elections. Ballot mishandling: Inaccurate results may arise from ballots that are misplaced or handled improperly. Voter errors: Voters who fill out their ballots incorrectly (for example, by overvoting or undervoting) may be disqualified.

##### 2) Security Issues:

Fraud: The possibility of falsifying results, interfering with votes, or stuffing ballots. Ballot secrecy: In some situations, it can be difficult to guarantee that voters' decisions stay secret.

##### 3) Difficulties with logistics:

Resource-intensive: It takes a lot of resources to print, distribute, collect, and store ballots. Results are delayed because human dispute resolution and vote counting take time. Accessibility: People with impairments, those who live in rural locations, or those who are unable to travel may find it challenging to get to physical polling places.

##### 4) Insufficient Transparency:

Lack of faith in the outcomes: Some voters might doubt the validity of the results if there are unclear procedures for verification. Limited auditability: Auditing or recounting might be difficult in systems without adequate safeguards.

##### 5) Scalability:

Elections with huge populations or complicated ballots (such as ranked-choice voting) may be difficult for traditional systems to manage effectively.

##### 6) Environmental Concerns:

Paper waste: Voting requires a lot of paper, which adds to waste and deforestation.

##### 7) Risks of Voter Suppression:

Limited polling hours: Some voters may find it challenging to cast their ballots due to set timetables. Long lines: Polling stations with little staff or resources may have long lines, which deters people from voting.

##### 8) Difficulties Managing Emergencies:

Traditional voting procedures can be disrupted by pandemics, natural disasters, or political upheaval, rendering them unreliable in such situations.

Adopting technology-driven alternatives, such as online or electronic voting methods, to address these problems is frequently necessary, albeit they have drawbacks of their

own.

## SYSTEM ARCHITECTURE

The system architecture and design are created in accordance with the specified specifications. This entails choosing the right hardware (sensors, cameras, navigation systems), as well as creating software systems that facilitate data processing and autonomous operation.

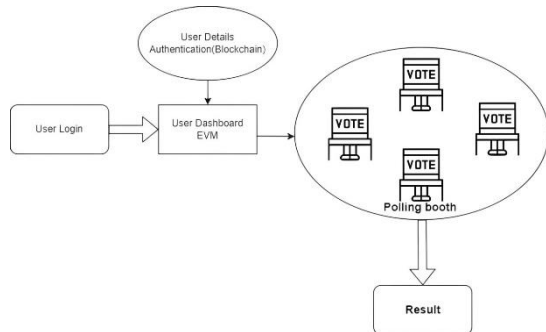


Fig. 2. Architecture

- **User Login:** The voter logs into the system to start the procedure. In order to access the voting system, the voter must normally give credentials, such as a voter ID and password, over a secure authentication process.
- **Blockchain-Based User Details Authentication:** When a user tries to log in, their information is verified against a blockchain-based system. Here, blockchain is utilized to confirm the voter's identity, guaranteeing that the information is reliable, secure, and unchangeable. This guarantees that only eligible voters can continue and stops unwanted access.
- **User Dashboard (EVM):** The voter is redirected to the User Dashboard in the EVM system following successful login. The user interface of this dashboard is where the voting options are interactive for the voter. It enables the voter to select the party or candidate of their choice and cast their ballot.
- **Polling Booth:** The diagram depicts several polling booths, each of which stands for an independent EVM terminal in a safe area. Voters have choice in selecting the voting terminal because they can cast their ballots from any of these booths.

### A. Data Flow Diagram

Model Development Flow, Model Selection and Deployment, and App User Flow are the three primary parts of the system architecture. The data flow is described below through these elements:

### B. Entity Relationship Diagram

Usually used in computing with reference to the arrangement of data within databases or information systems, an

entity relationship model, also known as an entity relationship (ER) diagram, is a graphical depiction of entities and their relationships to one another. The public user is the primary actor in this diagram.

## METHODOLOGY

Blockchain technology used with an Electronic Voting Machine (EVM) improves the voting process's security, reliability, and transparency. The decentralized, unchangeable ledger of blockchain technology is perfect for protecting vote integrity and guarding against fraud and tampering.

### A. System Setup:

- **Voter Registration:** Every voter is registered in the system and given a unique identity. Government IDs or biometric systems are used to authenticate voter information. A distinct private key linked to the voter's blockchain network account is provided.
  - **Blockchain Setup:** Every node in a permissioned blockchain network, such as election authorities, is a trusted entity. To regulate the election process, including voting periods, voter eligibility, and vote counting, a smart contract is created.
- ### B. User Interface (EVM):
- Voters can see candidates and cast ballots using the EVM's user-friendly interface. The device logs votes in real time by interacting with the blockchain.
- ### Voting Process:
- **Authentication:** Voters use their private key, which is generated during EVM Machine Registration Using Blockchain Technology, to authenticate themselves. Bio-metrics and cryptographic signatures are two examples of authentication techniques. The voter can use the EVM interface to cast their ballot after verification.
  - **Voting:** Using the EVM, the voter chooses a candidate. Both the voter's private key and the blockchain network's public key are used to encrypt the vote.
  - **Blockchain Logging:** A transaction is recorded after the encrypted vote is sent to the blockchain network. To ensure immutability, each vote is validated by network nodes before being added to the blockchain.

### C. Validation and Counting:

- **Validation:** The vote cannot be changed once it is entered onto the blockchain. Nodes consistently verify the integrity of every transaction. Smart contracts guarantee that only eligible voters cast ballots and that no duplicates are cast.
- **Vote Counting:** The smart contract initiates the vote

counting procedure at the conclusion of the election session. Together, the blockchain nodes verify and tally the votes, which are encrypted to maintain anonymity. The final vote total is confirmed using a consensus mechanism, such as Practical Byzantine Fault Tolerance (PBFT).

- Publication of the Results: Following vote counting, the public can view the final results using an open blockchain explorer that displays the total number of votes each candidate earned without disclosing voter identities.

## II. SOFTWARE REQUIREMENT SPECIFICATION

### A. Introduction

Through decentralized storage and encryption, blockchain technology is being used in electronic voting machines (EVMs) to increase the security, transparency, and efficiency of the electoral process. This will lower the risk of fraud, hacking, or unauthorized access to voting data.

#### 1) Project Scope:

Enhancing election security, transparency, and efficiency is one aspect of integrating blockchain technology with electronic voting machines (EVMs). It guarantees auditability, real-time counting, and tamper-proof vote recording. The method may enable safe remote voting and lower election expenses in both local and national elections. By offering a more reliable and verifiable electoral process, it also boosts voter confidence. Blockchain technology can grow to effectively manage big voter bases and connect with current systems.

#### 2) User Classes and Characteristics:

- Users: People who can cast ballots in elections. They can differ in geography, age, and technical skill.
- Election Officials: Those appointed by the government to supervise the voting procedure.

#### 3) Assumptions and Dependencies

- The website and mobile apps are predicated on having a reliable internet connection.
- The caliber and variety of the training dataset determine how accurate the illness detection system is.
- The system needs a PC or smartphone with a working fingerprint sensor.

### B. Functional Requirements:

#### 1) System Feature-1:

#### Voter Authentication and Verification:

Description: Before enabling a voter to cast their ballot, the system must guarantee that each voter is uniquely recognized, authenticated, and confirmed. This gets rid of duplicate votes and stops illegal voting. Subfunctions: Each voter is registered using their own unique identifying information through unique voter registration. Biometric or Multi-Factor Authentication: Verifies voter identity using biometrics (like fingerprint or facial recognition) or multi-factor authentication (like SMS OTP). Verifies whether a voter has already cast a ballot in the election by using the voter status check.

#### 2) System Feature-2:

#### Immutable Vote Recording and Tracking with Blockchain:

Description: Each vote should be safely recorded onto the blockchain by the system, guaranteeing that once a vote is cast, it cannot be changed or removed. Voters can confirm that their vote was recorded correctly thanks to the transparency this offers. Sub-functions: Ballot Encryption: Guarantees that every vote is anonymous and encrypted prior to being appended to the blockchain. Blockchain Ledger Entry: Every vote is tracked and impenetrable as it is entered into the blockchain as a transaction. Audit Trail for Verification: While maintaining the vote's secrecy, voters ought to be able to confirm their selection using a special identification number.

### C. External Interface Requirement

#### 1) User Interface Requirements:

- Voter Interface: The voting interface should be accessible, easy to use, and intuitive. Clear directions on how to cast a ballot, verify the chosen candidate, and finish the voting process should be included. It is important to incorporate accessibility elements like assistive technologies, language options, and support for people who are blind or visually impaired.

- Administrator Interface: For system configuration, monitoring, troubleshooting, and result verification, administrators want to have access to a secure interface. For security and privacy reasons, this interface should only provide limited access, requiring administrator authentication, and real-time system health tracking, but not individual voter data.

#### 2) Hardware Interface Requirements

- Biometric Devices: The system should outline criteria for compatible biometric devices if biometric verification is being used (such as fingerprint or facial recognition). Without keeping personal information in the voting machine itself, these devices must safely record

and authenticate voters.

- **Printers or Receipt Generators:** The system should include the printer specifications (such as thermal or inkjet) if voters receive a confirmation receipt. To preserve anonymity, this receipt should merely indicate that a vote was cast; it should not reveal the specifics of the vote-casting process.
- **Smart Card or ID Scanner:** The system may interface with smart card readers or QR code scanners to verify voter identification. Compatibility with state-issued or national IDs should be included in the requirements, and the system should validate identity information rather than storing it.

### 3) Software Interface Requirements

- **Blockchain Network Connection:** The voting machine should establish a secure connection with the blockchain network by establishing protocols (such as WebSocket and HTTPS) for voting transactions. The ability to encrypt and anonymize vote data should be supported by APIs or libraries used to communicate with Ethereum.
- **Voter Registration Database:** In order to verify a voter's eligibility, the voting machine might have to communicate with a secure database or system that stores voter registration information. Read-only access and encryption should be specified in interface requirements to protect user privacy.
- **Time Synchronization Server:** The system needs to establish a connection with a trustworthy time server in order to precisely date every vote. To ensure accurate vote timestamps, requirements should outline the use of secure methods (such as NTP via SSL/TLS).

### 4) Communication Interface Requirements

- **Secure Network Connection:** To connect to the blockchain and other backend systems, the system needs to set up a secure, encrypted network connection. TLS/SSL and other encryption protocols should be specified in requirements to guard against illegal access to data while it's in transit.
- **Data Transfer Protocols:** Indicate which protocols (such as MQTT or HTTPS) will be used to send data between the blockchain network and the voting machine. Audit logging and strict encryption standards ought to be supported by these protocols.
- **Integration with Election Commission Systems:** For external audits or integration with election oversight systems, create interfaces for safe data sharing that preserve voter confidentiality. This could include choices

to export data to a secure location for auditing purposes or APIs for real-time data reporting.

### D. Nonfunctional Requirement

#### 1) Security:

- **Data Encryption:** To avoid unwanted access, all sensitive data, including voter identities and votes, must be encrypted both in transit and at rest.

- **Blockchain Integrity:** TVotes must be unchangeable once they are recorded, and the blockchain must guard against manipulation. Ensuring data integrity and voter privacy requires the adoption of robust cryptographic techniques.

- **Access Control:** To restrict who has access to administrative tasks like system setup or monitoring, strict access control regulations should be in place. Secure voter authentication techniques, such as multi-factor or biometric authentication, are required.

- **Audit Trail Security:** To protect the privacy of individual votes, the audit trail must only be available to authorized individuals.

#### 2) Performance:

- **Response Time:** To guarantee a seamless voting experience for every voter, the voting system should react to user actions instantly, with a response time of less than two seconds.

- **Blockchain Transaction Speed:** During periods of high voting volume, the blockchain network should be able to process thousands of votes per minute with a high transaction throughput.

- **Scalability:** Without sacrificing efficiency, the system must be able to handle elections of all sizes, from little local elections to major national elections.

### E. System Requirement

#### 1) Database Requirements:

- **Storage:** User information and crop disease data must be stored in a database.
- **Structure:** To store user uploads and results, the system will make use of a lightweight database like MySQL.

#### 2) Software Requirements (Platform Choice):

- **Frontend:** : HTML, CSS, and JavaScript for mobile apps and websites.
- **Hosting:** The backend is hosted on cloud platforms such as Heroku, Render, or AWS.

### 3) Hardware Requirements:

- Mobile: a camera-equipped Android handset running Android 8.0+.
- Server: To host the backend, it needs at least 1GB of RAM and SSD storage.
- Fingerprint sensor: Using each person's fingerprint's uniqueness to offer secure access or confirm identity, fingerprint sensors are frequently employed for biometric identification and authentication.
- Esp32: Created by Espressif Systems, the ESP32 is a potent microcontroller renowned for its adaptability, low power consumption, and built-in Bluetooth and Wi-Fi.
- EVM: The main purpose of EVM is to ensure accurate, efficient, and safe voting.
- Power source, such as an adapter.

#### F. Analysis Models: SDLC Model to be applied

The Agile Software Development Life Cycle (SDLC) paradigm will be used for this project. Agile is preferred because of its adaptability, iterative methodology, and capacity to manage the project's changing needs. In order to make sure the application successfully satisfies user needs, the project will be built in brief sprints with frequent input from stakeholders. The design, development, and testing stages of each sprint will be followed by review meetings for any necessary modifications. The Agile SDLC includes the following steps:

- 1) Conditions Collecting: Constant communication with consumers to improve both functional and nonfunctional needs.
- 2) Design: Both the online and mobile applications have a modular design.
- 3) Development: Features in the backend, web app, and mobile app are developed iteratively.
- 4) Testing: To make sure the system is robust, unit and integrated testing are used.
- 5) Deployment: Constant deployment through the use of Heroku or Render platforms.
- 6) Review and Feedback: Iterative cycles of review and feedback for enhancement.

#### G. System Implementation Plan

The project's implementation plan will adhere to the Agile SDLC's phased development methodology. Phased deployment of the system will begin with core functionality and progress to additional features, testing,

and scaling.

#### 1) Phase 1: Preliminary Configuration

- Configure development environments for mobile and web apps.
- Put into practice simple image uploading and back-end API interactions.

#### 2) Phase 2: Registration

- Train user finger

#### 3) Phase 3: UI Development for Mobile and Web

- Create an intuitive user interface for the mobile application.
- Create the online interface for uploading images and displaying results using HTML, CSS, and JavaScript.

#### 4) Phase 4: Testing and Validation

- Conduct system, integration, and unit testing.
- To verify accuracy and real-time performance, test in the field with users.

#### 5) Phase 5: Deployment

- Use a cloud platform like as Render to deploy the backend API.
- Put the mobile and web apps into production.

#### 6) Phase 6: Iteration and User Feedback

- Get input from stakeholders and consumers.
- To enhance the user experience, make iterations to the functionality and design.

#### 7) Phase 7: Optimization of Scaling and Performance

- Improve server performance to manage high data volumes.
- Expand the system's capacity to accommodate more users at once.

### III. OTHER SPECIFICATION

#### A. Advantages

- 1) Increased Security: Due to blockchain's decentralized and unchangeable ledger, it is practically impossible for one party to tamper with or change the vote records. This guards against hackers and guarantees the voting process' security.

- 2) Transparency: Anyone can confirm the voting

procedure using the blockchain network without disclosing the identities of specific voters. Blockchain's openness and transparency increase confidence in the election's outcome.

3) **Voter Anonymity:** Blockchain ensures voter anonymity by encrypting each voter's identity. Voters' private information is kept safe and secret even though the votes are publicly recorded.

4) **Fraud Elimination:** Due to blockchain's decentralized structure, it is possible to eradicate a number of election fraud schemes, including vote fraud, results manipulation, and illegal access to voter information.

5) **Tamper-Proof Voting Records:** A vote cannot be removed or changed once it is entered into the blockchain; it is a permanent part of the ledger. This guards against post-election manipulation and guarantees the accuracy of the voting records.

#### *B. Limitations*

1) **Complexity and Scalability:** There is a lot of technical complexity involved in implementing blockchain-based EVM systems. Furthermore, because of problems with transaction speed and scalability, blockchain networks might not be able to manage massive elections with millions of voters.

2) **Initial Setup Costs:** A significant upfront investment in infrastructure, technology, and experience is necessary for the development and implementation of a blockchain-based EVM system. Smaller governments or organizations might not be able to afford these expenses.

#### *C. Applications*

1) **National and Local Elections:** To guarantee accuracy, security, and transparency in national and local elections, blockchain-based electronic voting machines (EVMs) can be utilized. Blockchain's decentralized structure guards against vote tampering and fosters confidence in the political process.

2) **Corporate Voting:** Blockchain technology can be used by businesses for internal decision-making procedures such as board elections and shareholder voting. This guarantees safe recording and unaltered verification of votes.

#### *FUTURE SCOPE*

Improved networks can be utilized to store data more quickly and prevent further network risks. Since the security of cryptocurrencies is growing daily, the system will benefit from enhanced security features. A screen can be added to an EVM or EVMs to symbolically affirm the

vote. The double tap system, in which the first push necessitates a second confirmation after the party is symbolically confirmed on the screen, should be implemented because a significant portion of voters lack formal education.

#### *CONCLUSION*

Although the existing voting mechanism lacks transparency and is therefore readily hackable, it has been blindly trusted to be the best. This raises the likelihood of immorality and corruption, which results in an unstable government and disgruntled citizens. Both the security of the ballot data that is gathered and the transparency for the critics will be enhanced by the use of blockchain technology and cloud-based solutions. As a result, the article effectively illustrates how to improvise the political destiny of the nation, particularly India.

#### *ACKNOWLEDGMENT*

We are profoundly grateful to Mr. V. D. Badgujar for his expert guidance and continuous encouragement throughout this project, ensuring it achieved its objectives from commencement to completion.

We would like to express our deepest appreciation to Dr.

M. V. Bhatkar, Principal of Jawahar Education Society's Institute of Technology, Management and Research, Nashik; Mrs. G. P. Mohole, Head of the Department of Computer Engineering; and Mrs. S. N. Botekar, Project Coordinator, for their invaluable guidance and support in completing this project.

Lastly, we extend our sincere and heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during the course of this work.

#### *REFERENCES*

- [1] Block Chain Based Cloud Computing Model on EVM Transactions for Secure Voting. Sathya V\*, Arpan Sarkar<sup>1</sup>, Aritra Paul<sup>2</sup>, Sanchay Mishra<sup>3</sup>
- [2] Yuan Yuan, Yanyan Hu, Shaohua Huang, Shengjiao Cao, Anuj Chopra, "A Privacy-Preserving Voting Protocol on Blockchain", 2018 IEEE 11th International Conference on Cloud Computing
- [3] Friorik p. Hjalmarsson, Gunnlaugur K. Hreioarsson, Mohammad Hamdaqa, Gisli Hjalmytsson, "Blockchain-Based E-Voting System", 2018 IEEE 11th International Conference on Cloud Computing
- [4] Arya Sahadevan, Deepa Mathew, Jairam Mookatana, and Bijoy A. Jose, "An Offline Online

Strategy for IoT using MQTT”, 2017 IEEE 4th International Conference on Cyber Security and Cloud Computing

[5] Shifa Manaruliesya Anggriane, Surya Michrandi Nasution, Fairuz Azmi,”Advanced E-Voting System Using Paillier Homomorphic Encryption Algorithm”, 2016 International Conference on Informatics and Computing (ICIC)

[6] Mark A. Will, Brandon Nicholson, Marc Tiehuis and Ryan K L Ko,”Secure Voting in the Cloud using Homomorphic Encryption and Mobile Agents”, 2015 International Conference on Cloud Computing Research and Innovation

[7] Quentin MONNET, Youcef HAMMAL, Lynda MOKDAD, Jalel BEN- OTHMAN,”Fair Election of Monitoring Nodes in WSNs”

[8] Haijun Pan, Edwin Hou, Senior Member, and Nirwan Ansari, Fellow,”M- NOTE: A Multi-part Ballot based E-voting System with Clash Attack Protection”, IEEE ICC 2015 - Communication and Information Systems Security Symposium

[9] Yirendra Kumar Yadav, Saumya Batham, Mradul Jain, Shivani Sharma,”An Approach to Electronic Voting System using UIDAI”, 2014 International Conference on Electronics and Communication Systems (ICECS -2014), Feb. 13 -14, 2014, Coimbatore, INDIA

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mrs. S. N. Botekar has  
presented paper entitled Enhancing Navigation for Railway Station Facilities and Location

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

**Dr. M. V. Bhatkar**  
Conference Chair

# Enhancing Navigation for Railway Station Facilities and Location

Tanmay Kalal<sup>1</sup>, Vaishnavi Talele<sup>2</sup>, Mahesh Sapate<sup>3</sup>, Abhijit Dhoble<sup>4</sup>, Mrs. S. N. Botekar<sup>5</sup>

Department of Computer Engineering,

Jawahar Education Society's Institute of Technology Management & Research , Nashik 422222, India.

**Abstract**---The proposed Railway Station Navigation System Web Application is designed to provide an easy and efficient way for passengers to navigate large and complex railway stations such as CST, Mumbai. The system focuses on offering real-time assistance for passengers to locate key facilities—platforms, restrooms, ticket counters, food stalls, and exits—within the station premises. It incorporates interactive features such as real-time map-based guidance, search functionality for specific amenities, and dynamic updates about facility locations. The system leverages web technologies like HTML5, CSS3, JavaScript, and integration with geospatial APIs such as Map-box to offer a seamless and intuitive user experience. By integrating with real-time data, the system will also alert users to platform changes, blockages, or crowd density, helping users navigate efficiently. This web application is especially beneficial for tourists, elderly individuals, and people unfamiliar with the station, providing a user-friendly platform for quick and accurate navigation.

**Index Terms**—Indoor Navigation, Railway Stations, Real-Time Navigation, User-Friendly Interfaces, Accessibility

## I.

## INTRODUCTION

Railway stations, especially large ones like Mumbai CST, serve as vital nodes in urban transportation networks, facilitating the movement of millions of passengers daily. These stations play a critical role in enabling urban mobility for various purposes such as commuting to work, traveling for leisure, or undertaking personal errands. As populations grow and public transportation systems become increasingly complex, stations like these must handle vast numbers of passengers while offering efficient services. Despite their essential role, many passengers face significant challenges navigating through these expansive, crowded environments. The sheer scale and intricate layouts of large stations can be overwhelming, especially for first-time travelers, tourists, the elderly, and people with disabilities. The combination of unclear or insufficient signage, poorly organized spaces, and the lack of comprehensive real-time information. In terms of functionality, the Railway Station Navigation System would go beyond

just providing static maps. It would offer dynamic, real-time updates, keeping passengers informed of platform changes, train delays, and emergency announcements. Users could easily input their destination—whether a specific platform, a restroom, or a particular service counter—and the app would generate the most efficient route. Real-time information further exacerbates the confusion. Passengers often struggle to find their platform, locate important amenities like restrooms, or identify services such as ticket counters and exit points.

External navigation tools like Google Maps have been instrumental in helping passengers find their way to the station itself, but once inside, these tools fall short. Indoor navigation, with its specific demands such as guiding passengers through the station's multiple floors, platforms, and facilities, remains largely unsupported by mainstream mapping services. In this context, there is a clear gap in the market for a specialized solution that focuses on the intricate details of indoor navigation in large railway stations. Passengers need a more intuitive and localized system that can provide real-time guidance, update them on any last-minute platform changes, and help them move seamlessly through the station, especially during peak hours when crowd density and pressure to find the right direction increase. This gap can be filled by the development of a Railway Station Navigation System Web Application, designed to cater to the specific challenges faced by railway passengers within large stations. The web application would provide real-time navigation assistance to passengers, helping them find their way to platforms, services, and facilities with ease. One key advantage of a web-based platform is its universal accessibility. Unlike mobile apps that require installation and regular updates, a web app can be accessed instantly on any device that supports a browser and an internet connection, minimizing user friction. This approach makes it ideal for both frequent commuters and occasional travelers who may not want to download yet another app for infrequent use. Additionally, the system can serve a broader audience, including international travelers, by offering multi-lingual support, ensuring inclusivity regardless of language barriers. Based on their current location within the station. For passengers with disabilities or special needs, the application could offer accessibility-optimized

routes that consider elevators, ramps, and other facilities, making navigation smoother and less stressful. Moreover, the system could provide additional context-aware features such as crowd density notifications, suggesting alternate paths to avoid congested areas, or giving recommendations for waiting areas with more space during rush hours. Another key benefit of this system is its potential

integration with other railway services. By connecting with station management systems, the app could display real-time train schedules, delays, and even security alerts, ensuring that passengers have all the information they need for a smooth transit experience. Travelers would no longer have to rely on outdated or limited information boards scattered across the station, but would instead have a centralized, reliable source of information accessible right from their smartphones, tablets, or laptops. Additionally, for passengers who may be in a rush or unfamiliar with the layout, features like the ability to book services ahead of time or access virtual queuing for ticket counters could significantly reduce waiting times and improve overall station efficiency. The Railway Station Navigation System Web Application would stand as a gamechanger in enhancing passenger experience, particularly in large and busy stations where timesensitive decisions and ease of movement are critical. By providing accurate, realtime, and personalized information to users, this application would not only make navigating complex environments like Mumbai CST more manageable but also set a precedent for improving public transportation infrastructure worldwide. It offers a much-needed solution that brings clarity, convenience, and confidence to passengers who rely on these systems daily.

## II. SYSTEM IMPLEMENTATION PLAN FOR RAILWAY NAVIGATION SYSTEM

Navigating large railway stations, such as the Chhatrapati Shivaji Maharaj Terminus (CST) in Mumbai, can be overwhelming due to their complex layouts, crowded environments, and vast array of facilities. Stations like CST serve millions of passengers daily, including local commuters, tourists, and first-time visitors who are often unfamiliar with the station's structure. The navigation challenges are especially pronounced for elderly passengers, tourists, and individuals with disabilities, as they may find it difficult to locate platforms, ticket counters, restrooms, food stalls, and other essential services. These issues are further compounded by last-minute platform changes, crowded spaces, and inadequate signage, resulting in missed trains, delays, and confusion. The proposed system aims to address these issues through a user-friendly, real-time, and highly

accurate web application designed specifically for indoor navigation within railway stations. Unlike conventional navigation systems that focus on outdoor environments, this application targets the unique complexities of indoor navigation in a bustling station setting. By providing real-time data, step-by-step guidance, and accessibility features, the system is designed to minimize stress and enhance the passenger experience for all users.

### A. System and Functional Requirement

**Real-Time Navigation Assistance:** Provide accurate, turn by turn navigation to guide passengers to their desired locations, including platforms, restrooms, exits, and amenities within the station. **Platform and Schedule Updates:** Ensure passengers receive real-time notifications regarding platform changes, train schedules, and estimated times to walk to specific destinations. **Accessibility Features:** Include options for accessible routes tailored for elderly passengers, people with disabilities, or those with limited mobility, such as avoiding stairs and recommending routes with ramps or elevators. **Crowd Density Notifications:** Use real-time data to inform passengers of crowded areas within the station, allowing them to select alternate, less congested paths.

### B. System Architecture

To deliver accurate and responsive navigation in a station environment, the architecture combines cloud-based backend processing, a real-time data management system, and an interactive frontend. **Backend Server:** Handles data processing, user requests, and real-time updates such as platform changes, schedules, and alerts. This component utilizes cloud infrastructure to support scalability. **Indoor Positioning System (IPS):** Essential for real-time location tracking. Bluetooth beacons, Wi-Fi triangulation, and other IPS technologies will be deployed throughout the station to provide precise location data. **Database and Data Management:** A centralized database stores station layout data, user preferences, and real-time updates on train schedules, platform allocations, and crowd density. The database is optimized for quick data retrieval and can handle highvolume traffic. **API Layer:** Provides communication between the backend and the frontend, enabling smooth data exchange. APIs are used to retrieve train schedules, real-time crowd data, and to interface with positioning sensors. **Frontend Web Application:** This is the user-facing component, providing the interface for navigation, real-time updates, and accessibility settings. The app will be accessible on mobile devices, enabling passengers to navigate the station independently.

### C. Data Integration and Sources

Data integration is essential for ensuring the application can provide accurate and up-to-date information. Key data sources include: Station Maps and Layouts: Digital floor plans of the station are essential for route calculations. These maps detail entrances, exits, platforms, ticket counters, restrooms, and accessible paths. Real-Time Location Tracking: Bluetooth beacons or Wi-Fi access points within the station are used for indoor positioning to determine the user's location with precision. Train Schedule and Platform Information: Integration with railway systems to access real-time schedule updates, platform allocations, and platform changes. Crowd Density Data: Sensor-based data and/or crowdsourced information to monitor crowd density and provide users with real-time congestion alerts.

#### D. Implementation Steps

- Data Collection and Preprocessing Station Mapping and Blueprinting: Obtain and verify accurate floor plans for each railway station. This involves detailing areas such as ticket counters, waiting rooms, platforms, and emergency exits. Positioning Sensor Deployment: Set up Bluetooth beacons and Wi-Fi access points strategically across the station. Calibration and testing ensure accurate tracking of

User location with minimal drift or errors. Real-Time Data Integration: Develop APIs that retrieve real-time data on train schedules, platform changes, and crowd density. This data is periodically refreshed to maintain system accuracy.

- Algorithm Development Path finding Algorithm: Design a path finding algorithm, such as A\* or Dijkstra's, to calculate the shortest and most convenient paths based on user preferences and real-time conditions (e.g., avoiding crowded areas). Dynamic Route Updates: Implement logic to update routes dynamically if changes occur, such as a sudden platform shift or an increased crowd density along a particular path. Accessibility Route Customization: Develop a sub-module for route customization based on accessibility needs, guiding users along routes that avoid stairs, steep inclines, or heavily crowded areas.
- System Testing Unit Testing: Validate individual components, such as the positioning system, path finding algorithms, and data update mechanisms, to ensure accuracy and functionality.

Usability Testing: Conduct tests with real users, particularly those who face specific navigation challenges, to ensure the app's interface and instructions are clear and helpful. Load and Stress Testing: Simulate high usage scenarios to confirm that the system can handle heavy traffic without performance issues, ensuring reliable operation during peak times.

#### E. Deployment and Maintenance

- Deployment Backend and Database Setup: Deploy backend services and databases on a cloud provider, ensuring scalability and low latency performance. Frontend Deployment: Launch the web application on mobile friendly platforms for user accessibility. The app should be cross platform compatible, running seamlessly on Android, iOS, and web browsers. Positioning Sensor Installation: Strategically place Bluetooth beacons and/or Wi-Fi points throughout the station for maximum coverage, calibrating each to ensure consistent accuracy.
- Maintenance and Updates Station Mapping and Blueprinting: Obtain and verify accurate floor plans for each railway station. This involves detailing areas such as ticket counters, waiting rooms, platforms, and emergency exits. Positioning Sensor Deployment: Set up Bluetooth beacons and Wi-Fi access points strategically across the station. Calibration and testing ensure accurate tracking of user location with minimal drift or errors. Real-Time Data Integration: Develop APIs that retrieve real-time data on train schedules, platform changes, and crowd density. This data is periodically refreshed to maintain system accuracy.

### III. RAILWAY NAVIGATION SYSTEM BASICS

Navigating large railway stations, such as the Chhatrapati Shivaji Maharaj Terminus (CST) in Mumbai, can be overwhelming due to their complex layouts, crowded environments, and vast array of facilities. Stations like CST serve millions of passengers daily, including local commuters, tourists, and first-time visitors who are often unfamiliar with the station's structure. The navigation challenges are especially pronounced for elderly passengers, tourists, and individuals with disabilities, as they may find it difficult to locate platforms, ticket counters, restrooms, food stalls, and other essential services. These issues are further compounded by last-minute platform changes, crowded spaces, and inadequate signage, resulting in missed trains, delays, and confusion. The proposed system aims to address these issues through a user-friendly, real-time, and highly accurate web application designed specifically for indoor navigation within railway stations. Unlike conventional navigation systems that focus on outdoor environments, this application targets the unique complexities of indoor navigation in a bustling station setting. By providing real-time data, step-by-step guidance, and accessibility features, the system is designed to minimize stress and enhance the passenger experience for all users.

### A. System Requirements

**Real-Time Navigation Assistance:** Provide accurate, turn-by-turn navigation to guide passengers to their desired locations, including platforms, restrooms, exits, and amenities within the station. **Platform and Schedule Updates:** Ensure passengers receive real-time notifications regarding platform changes, train schedules, and estimated times to walk to specific destinations. **Accessibility Features:** Include options for accessible routes tailored for elderly passengers, people with disabilities, or those with limited mobility, such as avoiding stairs and recommending routes with ramps or elevators. **Crowd Density Notifications:** Use real-time data to inform passengers of crowded areas within the station, allowing them to select alternate, less congested paths. **User Feedback and Customization:** Allow users to provide feedback on navigation routes and personalize their preferences, such as language selection or accessibility needs.

### B. Non-Functional Requirements

**Scalability:** Capable of handling high user volumes, particularly during peak hours or emergencies. **Reliability and Up time:** Ensure the system is highly reliable, with minimal downtime, as passengers rely on it for time-sensitive navigation. **Privacy and Data Security:** Maintain strict security protocols to safeguard user data, including anonymization and secure data transmission. **User-Friendly Interface:** Provide a simple, intuitive interface with multilingual support to cater to passengers from diverse backgrounds.

### C. Data Integration and Sources

Data integration is essential for ensuring the application can provide accurate and up-to-date information. Key data sources include: **Station Maps and Layouts:** Digital floor plans of the station are essential for route calculations. These maps detail entrances, exits, platforms, ticket counters, restrooms, and accessible paths. **Real-Time Location Tracking:** Bluetooth beacons or Wi-Fi access points within the station are used for indoor positioning to determine the user's location with precision. **Train Schedule and Platform Information:** Integration with railway systems to access real-time schedule updates, platform allocations, and platform changes. **Crowd Density Data:** Sensor-based data and/or crowd-sourced information to monitor crowd density and provide users with real-time congestion alerts.

### D. Implementation Steps

- **Data Collection and Preprocessing** Station Mapping and Blueprinting: Obtain and verify accurate floor plans for

each railway station. This involves detailing areas such as ticket counters, waiting rooms, platforms, and emergency exits. **Positioning Sensor Deployment:** Set up Bluetooth beacons and Wi-Fi access points strategically across the station. **Calibration and testing** ensure accurate tracking of user location with minimal drift or errors. **Real-Time Data Integration:** Develop APIs that retrieve real-time data on train schedules, platform changes, and crowd density. This data is periodically refreshed to maintain system accuracy.

**System Testing Unit Testing:** Validate individual components, such as the positioning system, path finding algorithms, and data update mechanisms, to ensure accuracy and functionality. **Usability Testing:** Conduct tests with real users, particularly those who face specific navigation challenges, to ensure the app's interface and instructions are clear and helpful. **Load and Stress Testing:** Simulate high usage scenarios to confirm that the system can handle heavy traffic without performance issues, ensuring reliable operation during app should be cross-platform compatible, running seamlessly on Android, iOS, and web browsers. **Positioning Sensor Installation:** Strategically place Bluetooth beacons and/or Wi-Fi points throughout the station for maximum coverage, calibrating each to ensure consistent accuracy.

### E. Deployment

**Backend and Database Setup:** Deploy backend services and databases on a cloud provider, ensuring scalability and low-latency performance. **Frontend Deployment:** Launch the web application on mobile-friendly platforms for user accessibility. The app should be cross-platform compatible, running seamlessly on Android, iOS, and web browsers. **Positioning Sensor Installation:** Strategically place Bluetooth beacons and/or Wi-Fi points throughout the station for maximum coverage, calibrating each to ensure consistent accuracy.

### F. Maintenance and Updates

**Regular Data Updates:** Update station layouts, schedules, and accessibility features regularly to maintain accuracy as station layouts and services change. **System Monitoring and Feedback Integration:** Monitor the system continuously to identify areas for improvement. Collect user feedback on routes and functionality, iterating on these to enhance the app. **Error Correction and Issue Resolution:** Address system issues promptly, particularly those related to positioning accuracy or platform updates, to maintain user trust.

## IV.

## WEB DESIGN

### A. Technology Selection

**Mapping Technology:** Choose appropriate indoor mapping technologies, such as Bluetooth beacons, Wi-Fi triangulation, or QR codes, to facilitate real-time location tracking within the station. **Backend Development:** Set up a robust backend system to manage real-time data, including train schedules, platform changes, and user location data. **Frontend Development:** Develop the frontend of the application using responsive design principles to ensure compatibility across various devices, including smartphones and tablets.

### B. Integration of Features

**Real-Time Navigation:** Implement turn-by-turn navigation features that guide users from their current location to their desired destination within the station. **Facility Locator:** Include a comprehensive directory of facilities such as ticket counters, restrooms, food stalls, and waiting areas, with real-time updates on their availability. **Accessibility Features:** Incorporate features specifically designed for users with disabilities, such as audio instructions, visual aids, and wheelchair-accessible routes.

### C. Testing and Iteration

In large railway stations, navigating to various facilities can be challenging, especially when dealing with complex layouts and crowd density. This system leverages advanced geospatial mapping, path finding, real-time updates, user interaction features, and responsive design principles to create a seamless navigation experience. Through the integration of Map-box for geospatial mapping, the A\* algorithm for path finding, real-time updates via Web Sockets, an intuitive search functionality, and a user-centered design, the system aims to provide reliable and accessible navigation guidance for all passengers, including elderly individuals, people with disabilities, and those unfamiliar with station layouts.

### D. Geospatial Mapping with Map-box

Fig. 1. Geospatial Mapping for Railway Station

The system uses the Map-box API to display interactive, real-time maps of the railway station, offering users a detailed visual representation of station facilities. **Map-box's detailed User Testing:** Conduct usability testing sessions with diverse user groups to identify pain points and areas for improvement. Gather feedback on the application's functionality, ease of use, and overall experience. **Iterative Development:** Use an agile development approach to make iterative improvements based on user feedback. Prioritize features that enhance user experience and address the most common challenges faced by passengers.

### E. Deployment and Launch

**Pilot Program:** Launch a pilot version of the application in a selected railway station to test its effectiveness in a real-world environment. Monitor user interactions and gather data on navigation success rates. **Marketing and Awareness:** Develop a marketing strategy to promote the application among potential users, including informational campaigns at railway stations and partnerships with travel agencies. **Official Launch:** After successful pilot testing and necessary adjustments, officially launch the application for public use across multiple railway stations.

### F. Post-Launch Support and Maintenance

**User Support:** Establish a support system to assist users with any issues they encounter while using the application. This could include a help center, FAQs, and live chat support. **Continuous Improvement:** Regularly update the application based on user feedback, technological advancements, and changes in railway station layouts or services. **Data Analysis:** Monitor usage data to identify trends, popular features, and areas needing enhancement. Use this data to inform future updates and improvements.

## V. DESIGN/ALGORITHMS/TECHNIQUES USED

Geospatial data enables the user to search for specific amenities, zoom in and out, and pan across the map, which enhances the user's spatial awareness and understanding of the station layout. Map-box provides custom mapping capabilities that can be tailored to highlight important areas like platforms, exits, restrooms, and ticket counters. Customization features in Map-box allow the map to be personalized for each station's unique environment; for instance, different sections of the map can be color-coded or labeled with icons, making it easier for passengers to differentiate between zones such as waiting areas, boarding platforms, or food stalls. Furthermore, Map-box supports custom layers, allowing the system to dynamically overlay real-time data, like temporary blockages, closed routes, and alternate paths. This level of interactivity enables users to navigate through congested



areas, avoid obstructions, and identify the quickest route to their destination. The zoom functionality provides a close-up view of specific locations or an overview of the entire station, giving users the flexibility to adjust the view

based on their current needs. For example, a passenger in a rush may zoom out to view an overview of The route to their platform, while another passenger seeking a nearby restroom may zoom in on their current location. By integrating Map-box's highly customizable, interactive maps, the application enhances the ease of navigation for all users, making navigation intuitive and visually engaging.

#### A. Path finding Algorithms

A critical component of the navigation system is the A\* (A- Star) algorithm, a well-known path finding algorithm used to compute the shortest or most efficient routes within a complex environment like a railway station. The A\* algorithm is effective for indoor navigation, where factors such as distance, available paths, and user preferences come into play. A\* combines elements of both breadth-first search and heuristic-based approaches, making it fast and suitable for providing optimal paths in real-time. This algorithm's efficiency is particularly valuable in large railway stations, where users may need to navigate through intricate layouts, multiple levels, or crowded spaces. In practice, the A\* algorithm evaluates and ranks possible routes based on both the distance to the destination and the "cost" associated with traveling that path (which can represent factors like congestion levels, presence of stairs, or accessibility requirements). By factoring in both path length and user preferences, the algorithm can dynamically adjust to the needs of different users. For instance, a user with mobility challenges may be directed along an accessible route that avoids stairs or escalators, while a user in a rush may be directed along a more direct path. This level of customization allows the A\* algorithm to enhance the relevance and reliability of the guidance provided, tailoring it to each user's situation. Additionally, the path finding system will account for real-time data input, such as temporary obstacles, high foot traffic, or emergency closures. If an area becomes congested, the algorithm can recalibrate to suggest alternate paths, thereby improving the user's navigation experience and reducing travel time. By leveraging the A\* algorithm, the application can provide efficient, user-specific routing that adapts to changing station conditions, enhancing both safety and convenience for all passengers.

#### B. Dynamic Real-Time Updates

One of the primary challenges in railway station navigation is keeping passengers informed about dynamic changes, such as platform switches, train delays, or temporary blockages within the station. The system will use Web Sockets to manage real-time updates, pushing notifications and alerts to users the moment new information is available. Web Sockets provide a

continuous connection between the server and the client, enabling updates to be delivered instantly rather than relying on traditional request-response cycles. This real-time communication protocol is crucial for passengers who need accurate, up-to-the-minute information to navigate a bustling station environment effectively. For example, if a platform change occurs, the system will immediately update the user's navigation route and display a notification on their screen, helping them avoid confusion or missed connections. Similarly, if a certain

Pathway becomes blocked due to maintenance, the system will reroute the user to an alternate path, ensuring they can reach their destination without interruption. Web Socket-based real-time updates are especially beneficial during peak travel hours, when sudden changes are common, and the need for accurate navigation is heightened. In addition to route adjustments, the system will also push relevant contextual information, such as train arrival and departure updates, crowd density in specific areas, or estimated walking times. This allows users to make more informed decisions about how to plan their routes within the station. Through dynamic real-time updates, the application provides responsive, proactive assistance that helps passengers adapt to any unexpected changes within the station, significantly enhancing their travel experience and reducing stress associated with last-minute adjustments.

#### C. User Interaction and Search Functionality

User interaction is simplified through an intuitive search bar that allows passengers to locate facilities quickly by typing in keywords (e.g., "Platform 12", "Restroom", or "Food Court"). Auto complete functionality improves the search experience by providing users with relevant suggestions based on the available facilities, allowing them to find their destinations more quickly. For instance, if a passenger begins typing "Platform," the search bar will automatically populate a list of all platforms within the station, helping them locate their exact destination without fully typing it out. Once the user selects a location, the system will immediately display the optimal route to their chosen destination. For ease of use, the system will highlight the path on the map, providing visual cues and turn-by-turn directions that are easy to follow. This search functionality is especially beneficial for first-time travelers or those who may be unfamiliar with the station's layout, enabling them to quickly find their desired destinations without the need to rely on signage or station staff. In addition to search, the application will incorporate voice-based navigation options for users who prefer auditory guidance, enhancing accessibility for visually impaired users. Voice instructions will guide users through

the station, ensuring they receive accurate directions even if they cannot visually follow the map. By providing an interactive search feature and voice-guided assistance, the application empowers users with different abilities and preferences, making navigation accessible, efficient, and user-friendly. D.

#### D. *Responsive and Accessible Design*

The user interface of the web application is designed to be responsive, ensuring it adapts seamlessly across different screen sizes, from smartphones to tablets. This adaptability is essential, as users may access the application on various devices while navigating the station. The responsive design optimizes the app's usability across all devices, ensuring that icons, text, and navigation controls remain clearly visible and easy to interact with, regardless of screen size. Accessibility is a priority in the design, as the application serves a diverse range of users, including elderly passengers, individuals with disabilities, and tourists who may face language barriers. Keyboard navigation will be enabled for users who prefer or require it, while compatibility with screen readers ensures that visually impaired users can navigate the application and receive spoken directions. Additionally, the design will feature high-contrast text, large icons, and clear visuals that help improve readability and usability, even in crowded or dimly lit areas of the station. Further, multilingual support allows users from different backgrounds to interact with the application in their preferred language, enhancing its inclusivity. The accessibility and responsiveness of the design will make the system a reliable and convenient tool for all passengers, catering to their individual needs and enhancing the overall navigation experience within busy railway stations. This system design, encompassing geospatial mapping with Map-box, efficient pathfinding through the A\* algorithm, real-time updates via Web Sockets, intuitive user interaction, and a responsive, accessible interface, provides a robust solution for navigating large railway stations. By addressing the needs of diverse user groups and prioritizing real-time adaptability, the application enhances the passenger experience, making station navigation simpler, faster, and more user-friendly. Through this comprehensive approach, the system aims to empower passengers to move confidently and efficiently through complex transit environments, ensuring a smoother and more enjoyable travel experience.

#### E. *Software Tools/Technologies Used*

To create a seamless, interactive, and responsive navigation system for large railway stations, a combination of carefully selected frontend and backend

technologies, along with databases and third-party APIs, is used. For the frontend, HTML5 and CSS3 are fundamental for structuring and styling the web application, ensuring a clean, user-friendly interface. These are complemented by JavaScript and React.js, which provide a dynamic, reactive environment where elements on the page respond instantly to user input, creating a smooth and engaging user experience. The Map-box API plays a critical role in the frontend, delivering real-time maps with interactive features like zooming, panning, and facility identification. This API provides geospatial data essential for creating visually detailed and customizable maps, allowing users to easily locate platforms, exits, and other amenities within the station. On the backend, Node.js serves as the runtime environment, supporting asynchronous operations ideal for handling the high volume of requests common in real-time navigation applications. **Express.js** further simplifies backend development by providing a flexible and efficient framework to manage server routes, middleware, and RESTful APIs. Additionally, Web Sockets are employed for real-time data transmission, enabling continuous two-way communication between server and client. This ensures that users receive instant updates on any platform changes, delays, or area closures within the station. Data management is supported by MongoDB, a NoSQL database well-suited to handle the semi-structured data necessary for this application. MongoDB stores various types of information, including station facilities, user profiles, navigation paths, and travel preferences, enabling the application to quickly retrieve and adapt data based on user needs. For real-time train and platform information, the system utilizes **Indian Railways APIs**, which offer accurate and timely data on train schedules, platform assignments, and delays. By integrating with these APIs, the application can guide users efficiently to the correct platforms and update them with the latest information. Additionally, the Map-box API is used here as well to enhance geospatial functionalities, from detailed mapping to providing turn-by-turn navigation. Together, these tools create a robust architecture, making the navigation system reliable, scalable, and capable of handling the demands of a busy, high-traffic station environment. This technology stack ensures the application's responsiveness and accessibility, catering effectively to the diverse user base navigating these complex transit spaces.

#### VI. PROPOSED SYSTEM

The proposed Railway Station Navigation System Web Application is designed to transform the passenger experience in complex and high-traffic railway stations, addressing the diverse needs of travelers by providing a

comprehensive, accessible, and user- friendly navigation tool. By integrating real- time navigation, interactive maps, advanced search features, real-time alerts, and multi-lingual support, the system will cater to a wide range of users, from first-time travelers and tourists to elderly individuals and people with disabilities.

#### A. *Real-Time Navigation Assistance*

At the core of the application is its real-time navigation feature, which offers passengers accurate guidance to various facilities such as platforms, restrooms, ticket counters, waiting areas, exits, and other essential services within the station. This feature will employ advanced geospatial data to provide dynamic, turn-by- turn directions, enabling users to seamlessly navigate the station's layout. As users move through the station, the application will track their progress, updating their route and adapting to their current location in real-time. This functionality will be invaluable in large, often confusing station environments, where platforms and amenities are spread out and not always easy to locate. By constantly adjusting to the user's position and station activity, the system ensures that users remain on the optimal path, significantly reducing the time and stress involved in finding their way through busy, sprawling transit spaces.

#### B. *Interactive Maps Powered by Map-box*

To enhance spatial awareness and visual understanding of the station layout, the application will incorporate interactive maps powered by the Map-box API. These maps provide users with the ability to zoom in and out, pan across the station, and view a detailed, customizable layout of facilities, including paths to nearby amenities. Each map will be tailored to reflect the unique structure of the station, highlighting important areas like food courts, waiting rooms, and exit points. Map-box customization options allow for clear visual differentiation between sections, and icons representing specific facilities will make it easy for users to identify the services they seek. Furthermore, the application will feature pinch-to-zoom functionality, enabling users to examine the station layout in greater detail or get an overview of their entire route. This degree of interactivity offers users control over their view and an improved sense of direction, making navigation intuitive and efficient.

#### C. *Search and Filter for Specific Locations*

A robust search and filter feature is integral to the application, allowing users to quickly locate specific facilities or amenities within the station. The search bar will provide an autocomplete feature, where users can type in keywords or facility names (such as "Platform 5," "Restroom," or "Ticket Counter") to generate a list of

relevant options. This quick- response functionality minimizes typing effort and reduces the time needed to locate specific areas. Moreover, users can filter results based on the type of facility they are looking for, whether it is food courts, restrooms, exits, or accessibility services. The filter options will allow users to narrow down results based on their immediate needs, making it easier to locate areas that are often dispersed across large stations. This feature will be particularly helpful for passengers who may have limited time between connections or need to find amenities quickly.

#### D. *Real-Time Alerts and Notifications*

In a fast-paced station environment, where changes are frequent, the application's real-time alert system will prove invaluable. Passengers will receive instant notifications about platform changes, train delays, maintenance work, or any temporary blockages that might affect their journey. These alerts, pushed directly to the user's screen, will ensure they are always informed of the latest updates, allowing them to make quick adjustments to their plans if needed. For instance, if a platform change is announced, the system will notify the user immediately, updating their route and guiding them to the new platform. Similarly, alerts about congestion or blocked paths can help users avoid crowded areas, making their travel experience smoother. This continuous real-time update capability, powered by Web-Sockets, enables the system to respond dynamically to station changes, reducing passenger stress and helping them make informed, timely decisions.

#### E. *Multi-Lingual Support for Inclusivity*

Given the diverse linguistic background of Indian passengers, the application will include multi-lingual support to cater to a broader audience. The interface will be available in multiple languages, including English, Hindi, and regional languages like Marathi, Tamil, and Bengali, allowing passengers to select their preferred language. This feature not only enhances usability for non-English speakers but also makes the application accessible to tourists and first-time travelers who may face language barriers. The user- friendly, language-sensitive interface allows users from various regions to navigate the application effortlessly, regardless of their familiarity with the primary language. By prioritizing linguistic inclusivity, the application demonstrates a commitment to serving a wide array of passengers, ensuring that language is never a barrier to navigating the station.

#### F. *Enhanced User Experience and Accessibility*

To further elevate the user experience, the application design will emphasize accessibility and ease of use. The

interface will feature large, clearly marked buttons, high-contrast text, and icons to improve readability and visual clarity, especially for users in crowded or low-light conditions. Keyboard navigation options will be available for individuals with limited dexterity, and screen reader compatibility will aid visually impaired users by providing voice-guided instructions. The application will also support voice search functionality, allowing users to input search queries verbally, which is especially helpful for those who may be unfamiliar with typing or prefer auditory guidance. Through these design elements, the application not only provides functional accessibility but also prioritizes inclusivity, making navigation within railway stations simpler and more user-friendly for everyone.

#### G. *Efficient Database and Data Management*

To support real-time navigation and updates, the system will rely on a robust database structure. Using MongoDB, a NoSQL database, and the application will efficiently manage data related to station facilities, user profiles, and route configurations. MongoDB's flexible schema is ideal for handling the diverse types of data necessary for navigation, such as spatial layouts, user preferences, and station-specific information. By organizing this data into easily accessible formats, the system ensures that passengers can retrieve information quickly and accurately. Additionally, data from the Indian Railways APIs will be integrated into the database, enabling the system to fetch live train schedules, platform numbers, and other pertinent updates directly from a reliable source. This cohesive data management structure, combined with efficient querying, ensures the application remains responsive and capable of providing timely assistance to users.

#### H. *Scalability and Reliability of the System Architecture*

Designed for scalability, the system architecture will support future enhancements and accommodate a growing user base. The backend, built with Node.js and Express.js, is structured to handle high volumes of concurrent requests, a crucial requirement for stations with heavy foot traffic. Web-Sockets enable real-time communication between the server and users, delivering continuous updates without interrupting the user experience. The choice of technologies ensures that the system can easily expand to include additional stations or incorporate new features, such as augmented reality (AR) navigation or advanced user analytics. This forward-compatible architecture enables the Railway Station Navigation System to adapt to evolving passenger needs and technological advancements, ensuring its relevance and effectiveness well into the future.

both computer networks and mobile devices in one place. Figure 10 presents the major areas of cyber security, attacks on cyberspace along with the list of significant ML references targeting that specific class of attack. Cyber security overlaps with other components of cyberspace, including Internet security, network security, and ICT security. We have targeted three significant challenges (detection and classification of IDS, spam, and malware) to cyber security in which ML techniques are playing an important role. We have further elaborated on these threats on mobile devices and computer networks. The intrusion detection system on a computer network is further subdivided into signature-based/misuse-based, anomaly-based, and hybrid-based techniques. Sub-types of intrusion are further categorized into either applied on a host or a computer network. Spam detection is further elaborated with respect to the medium, including image, email, SMS, video, and Twitter. Malware is also explored regarding static analysis and dynamic analysis. ML techniques are being implemented in the literature to handle various types of cyberattacks. ML is one of the possible solutions to act quickly against cyberattacks. ML techniques are employed to deal with such matters because the learning techniques can learn from experiences and respond to newer attacks promptly. We have mentioned the references of a few articles that deal with such kind of cyberattack. The following sub-headings elaborate on each cyber threat to the computer network and mobile network and how the state-of-the-art ML techniques are playing their roles to fight against these cyber threats.

## VII. CONCLUSION

The proposed Railway Station Navigation System Web Application addresses a significant gap in passenger experience by tackling the unique and often overwhelming challenges associated with navigating large and complex railway stations. Facilities in metropolitan stations like Mumbai's CST (Chhatrapati Shivaji Maharaj Terminus) are typically spread across vast areas and organized in intricate layouts that can be challenging even for seasoned travelers. Traditional signage, while helpful, often falls short in catering to the real-time needs of a diverse group of passengers—first-time travelers, tourists unfamiliar with the station layout, elderly individuals, and people with disabilities. As a result, missed trains, confusion, and frustration have become all too common for many navigating these bustling transit spaces. Furthermore, passengers frequently experience added difficulties with platform changes and overcrowded areas, which only heighten the stress of travel. The primary purpose of the proposed application is to eliminate these pain points by offering a user-friendly, real-time, and highly accurate

navigation tool that is specifically tailored to the complexities of railway station interiors. Through real-time navigation assistance, passengers can easily locate critical facilities such as platforms, restrooms, ticket counters, food courts, and exits without needing to rely on unclear directions or assistance from station staff. This feature, combined with interactive maps, enables users

to zoom, pan, and search within the station, offering a high level of control and accessibility that adapts to their specific needs. By focusing on indoor navigation, the application fills a gap that traditional navigation tools, which typically concentrate on outdoor routes, have overlooked. For instance, while Google Maps or similar applications are adept at providing routes for outdoor settings, they often lack the detailed spatial data needed for intricate interior spaces like large railway stations. This navigation system goes beyond basic mapping, integrating the unique attributes of indoor spaces and meeting the logistical demands of railway stations where foot traffic, platform assignments, and facility locations can change in real-time. The proposed application's strength lies not only in its real-time updates but also in its highly interactive and intuitive interface. The user-friendly design ensures that delivered through WebSockets, provide immediate updates on platform changes, delays, or blocked paths. This is a critical feature, particularly in high-traffic environments where even a minor delay or change can disrupt travel plans. Real-time notifications also help mitigate the frustration and inefficiencies caused by unexpected changes, as users can make quick adjustments to their routes based on current conditions. For example, if a particular exit is crowded or under maintenance, the app can suggest an alternative route, enhancing passenger convenience and promoting a smoother flow of foot traffic throughout the station. A major consideration in the application's design is its inclusivity and accessibility, which are demonstrated through features like multi-lingual support and adaptive navigation aids. India's diverse population speaks a wide range of languages, and offering support for regional languages like Marathi and Hindi, alongside English, ensures that a broader demographic can use the application comfortably. This multi-lingual functionality also supports India's large population of tourists and first-time travelers, providing them with clear, localized directions and a stress-free navigation experience. Accessibility considerations extend to features that accommodate elderly individuals and people with disabilities. For example, the app will include voice-guided directions

and keyboard navigation options, making it usable for visually impaired users or those with limited dexterity. These thoughtful inclusions reflect a commitment to creating an inclusive navigation tool that serves the full spectrum of passengers frequenting these stations. The application's infrastructure is designed for robustness and scalability, ensuring it can handle a high volume of concurrent users and adapt to future technological advancements. By using Node.js and MongoDB, the system offers efficient, real-time data management that supports dynamic route generation and ensures that users experience minimal delays or loading times. Web-Sockets facilitate continuous communication between the server and client, allowing for seamless, real-time data delivery and an uninterrupted user experience. This infrastructure not only supports the present demands of large railway stations but also prepares the application for scalability, meaning additional stations or functionalities can be integrated over time. For example, in the future, the app could expand to offer augmented reality (AR) navigation or additional services such as live foot traffic data, estimated wait times for specific facilities, or even personalized recommendations based on travel history. This modular approach positions the application as a long-term solution for indoor navigation in transit hubs, adaptable to the evolving needs of passengers and the dynamic environment of railway stations.

#### REFERENCES

- [1] APA (American Psychiatric Association). Diagnostic and statistical manual of mental disorders. 3rd ed. Washington, DC: APA; 1980.
- [2] APA. Diagnostic and statistical manual of mental disorders. 5th ed. Washington, DC: APA; 2013.
- [3] Baio J. Prevalence of autism spectrum disorders: Autism and developmental disabilities monitoring network, 14 sites, United States, 2008. *Morbidity and Mortality Weekly Report*. 2012;61(SS03):1–19.
- [4] Bartak L, Rutter M, Cox A. A comparative study of infantile autism and specific developmental receptive language disorders, III: Discriminant function analysis. *Journal of Autism and Childhood Schizophrenia*. 1977;7(4):383–396.
- [5] Bhasin TK, Schendel D. Sociodemographic risk factors for autism in a U.S. metropolitan area. *Journal of Autism and Developmental Disorders*. 2007;37(4):667–677.
- [6] Cappadocia MC, Pepler D, Weiss JA. Bullying experiences among children and youth with autism spectrum disorders. *Journal of Autism and Developmental*

Disorders. 2012;42(2):266–277.

- [7] Durkin MS, Maenner MJ, Meaney FJ, Levy SE, DiGiuseppi C, Nicholas JS, Kirby RS, Pinto-Martin JA, Schieve LA. Socioeconomic inequality in the prevalence of autism spectrum disorder: Evidence from a U.S. cross-sectional study. *PLoS ONE*. 2010;5(7):e11551. [PMC free article].
- [8] Fein D, Barton M, Eigsti IM, Kelley E, Naigles L, Schultz RT, Stevens M, Helt M, Orinstein A, Rosenthal M, Troyb E, Tyson K. Optimal outcome in individuals with a history of autism. *Journal of Child Psychology and Psychiatry*. 2013;54(1):53–61.
- [9] Geschwind DH. Genetics of autism spectrum disorders. *Trends in Cognitive Sciences*. 2011;15(9):409–416.
- [10] Goldstein S, Naglieri JA, Ozonoff S. Assessment of autism spectrum disorders. New York: Guilford Press; 2009:xiv, 384.
- [11] Greenspan SI, Brazelton TB, Cordero J, Solomon R, Bauman ML, Robinson R, Shanker S, Breinbauer C. Guidelines for early identification, screening, and clinical management of children with autism spectrum disorders. *Pediatrics*. 2008;121(4):828–830.
- [12] Howlin P, Moss P, Savage S, Rutter M. Social outcomes in mid- to later adulthood among individuals diagnosed with autism and average nonverbal IQ as children. *Journal of the American Academy of Child and Adolescent Psychiatry*. 2013;52(6):572–581.
- [13] Howlin P, Savage S, Moss P, Tempier A, Rutter M. Cognitive and language skills in adults with autism: A 40-year follow-up. *Journal of Child Psychology and Psychiatry*. 2014;55(1):49–58.
- [14] Kanner L. Autistic disturbances of affective contact. *Nervous Child*. 1943;2:217–250.
- [15] Kanner L, Eisenberg L. Notes on the follow-up studies of autistic children. *Proceedings of the Annual Meeting of the American Psychopathological Association*. 1953;1954–1955:227–239.
- [16] Klin A, Saulnier CA, Sparrow SS, Cicchetti DV, Volkmar FR, Lord C. Social and communication abilities and disabilities in higher functioning individuals with autism spectrum disorders: The Vineland and the ASOS. *Journal of Autism and Developmental Disorders*. 2007;37(4):748–759.
- [17] Koegel RL, Koegel LK. Pivotal response treatments for autism: Communication, social, and academic development. Baltimore, MD: Paul H. Brookes; 2006.
- [18] Levy SE, Hyman SL. Complementary and alternative medicine treatments for children with autism spectrum disorders. *Child and Adolescent Psychiatric Clinics of North America*. 2015;24(1):117–143.
- [19] Maenner MJ, Schieve LA, Rice CE, Cunniff C, Giarelli E, Kirby RS, Lee LC, Nicholas JS, Wingate MS, Durkin MS. Frequency and pattern of documented diagnostic features and the age of autism identification. *Journal of the American Academy of Child Adolescent Psychiatry*. 2013;52(4):401–413.
- [20] Magaña S, Smith LE. The use of the autism diagnostic interview—revised with a Latino population of adolescents and adults with autism. *Journal of Autism and Developmental Disorders*. 2013;43(5):1098–1105.
- [21] Magaña S, Parish SL, Rose RA, Timberlake M, Swaine JG. Racial and ethnic disparities in quality of health care among children with autism and other developmental disabilities. *Intellectual and Developmental Disabilities*. 2012;50(4):287–299.
- [22] Magaña S, Lopez K, Aguinaga A, Morton H. Access to diagnosis and treatment services among Latino children with autism spectrum disorders. *Intellectual and Developmental Disabilities*. 2013;51(3):141–153.
- [23] Mandell DS, Novak M. The role of culture in families' treatment decisions for children with autism spectrum disorders. *Mental Retardation and Developmental Disabilities Research Reviews*. 2005;11(2):110–115.
- [24] Mandell DS, Novak MM, Zubritsky CD. Factors associated with age of diagnosis among children with autism spectrum disorders. *Pediatrics*. 2005;116(6):480–486.
- [25] Mandell DS, Wiggins LD, Carpenter LA, Daniels J, DiGiuseppi C, Durkin MS, Giarelli E, Morrier MJ, Nicholas JS, Pinto-Martin JA. Racial/ethnic disparities in the identification of children with autism spectrum disorders. *American Journal of Public Health*. 2009;99(3):493–498.
- [26] Matson JL, Nebel-Schwalm MS. Comorbid psychopathology with autism spectrum disorder in children: An overview. *Research in Developmental Disabilities*. 2007;28(4):341–352.

- [26] McClure I, Volkmar FR, Paul R, Rogers SJ, Pelphey KA, editors. Handbook of autism and pervasive developmental disorders, fourth edition. McDougle CJ, Scahill L, Aman MG, McCracken JT, Tierney E, Davies M, Arnold LE, Posey DJ, Martin A, Ghuman JK, Shah B, Chuang SZ, Swiezy NB, Gonzalez NM, Hollway J, Koenig K, McGough JJ, symptom domains of autism: Results from the study by the autism network of the research units on pediatric psychopharmacology. American Journal Of Psychiatry. 2005;162(6):1142–1148.
- [27] Millward C, Ferriter M, Calver S, Connell-Jones G. Gluten- and casein- free diets for autistic spectrum disorder. Cochrane Database of System- atic Reviews. 2008;2(2):CD003498.
- [28] NRC (National Research Council). Educating children with autism. Washington, DC: National Academy Press; 2001.
- [29] Nye C, Brice A. Combined vitamin B6–magnesium treatment in autism spectrum disorder. Cochrane Database of Systematic Reviews. 2005;(4):CD003497.
- [30] Paul R, Miles S, Cicchetti D, Sparrow S, Klin A, Volkmar F, Coflin M, Booker S. Adaptive behavior in autism and pervasive develop- mental disorder- not otherwise specified: Microanalysis of scores on the Vineland Adaptive Behavior Scales. Journal of Autism and Develop- mental Disorders. 2004;34(2):223 –228.
- [31] Pinborough-Zimmerman J, Bakian AV, Fombonne E, Bilder D, Tay- lor J, McMahon WM. Changes in the administrative prevalence of autism spectrum disorders: Contribution of special education and health from 2002-2008. Journal of Autism and Developmental Disorders. 2012;42(4):521–530.
- [32] Rai D, Lewis G, Lundberg M, Araya R, Svensson A, Dalman C, Carpenter P, Magnusson C. Parental socioeconomic status and risk of offspring autism spectrum disorders in a Swedish population-based study. Journal of the American Academy of Child Adolescent Psychiatry. 2012;51(5):467–476.
- [33] Reichow B, Doehring P, Cicchetti DV, Volkmar FR. Evidence-based practices and treatments for children with autism. New York: Springer Science Business Media; 2010.
- [34] Reichow B, Steiner A, Volkmar F. Social skills groups for people aged 6 to 21 years with autism spectrum disorders (ASD). Cochrane Database of Systematic Reviews. 2012;7:CD008511.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Shalmali Botekar has  
presented paper entitled Tracking and Detecting depression level using facial recognition and PEN & IQ  
test

at **International Conference on Emerging Trends in Engineering and  
Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education  
Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Tracking and Detecting Depression Level using Facial Recognition and PEN & IQ test

<sup>1</sup>Krushnal Choudhary, <sup>2</sup>Hrutika Pagare, <sup>3</sup>Shantanu Sambhare, <sup>4</sup>Sakshi Aher and <sup>5</sup>Mrs S. N. Botekar

Department of Computer Engineering,

Jawahar Education Society's Institute of Technology, Management, And Research, Nashik 422222, India Affiliated to

Savitribai Phule Pune University

<sup>1</sup>hrutikapagare27@gmail.com, <sup>2</sup>sambhare07@gmail.com, <sup>3</sup>1002ahersk@gmail.com,

<sup>4</sup>krushkc003@gmail.com, <sup>5</sup>botekar.shalmali@gmail.com

**Abstract---**In this study, we propose a novel approach for monitoring and tracking depression levels by making use of facial recognition technology, PEN test and IQ test. The hypothesis underlying our methodology is that there may be certain specific changes in face expressions related to depression along with an overall decline in cognitive function which are measurable using these tests. This technique involves two phases, firstly it analysis the depression related changes in the facial expressions and then second phase uses PEN and IQ test for determining its depression level. The proposed approach suggested by research focuses on tracking and detecting depression levels, so using this we can potentially aid in early diagnosis and treatment of depression.

**Index Terms---**Facial Recognition, Mental Health, Classification, Algorithms, Artificial Intelligence, CNN.

## A. INTRODUCTION

Depression is a prevalent and debilitating mental health disorder that can significantly affect an individual's wellbeing, relationships, and overall quality of life. It is crucial to identify and address depression early on to provide appropriate interventions and support. As technology continues to advance, there is a growing interest in leveraging its potential to aid in the diagnosis and treatment of mental health conditions, including depression. One innovative approach being explored is the use of facial recognition technology, along with the Perceived Emotional Neglect (PEN) test and IQ testing, to monitor and track depression levels. Facial recognition technology has gained significant attention in recent years due to its ability to analyze facial expressions and emotions accurately. By employing this technology, researchers aim to detect specific changes in facial expressions that may be indicative of depression. The first phase of this proposed methodology involves analysing depression related changes in facial expressions. Facial recognition software can be utilized to detect subtle cues and markers that may be associated with depression, such

as decreased expressiveness, frowning, or other negative facial expressions. By capturing and analysing these facial features, researchers can develop algorithms or models to quantify and track changes in facial expressions over time. In the second phase, the PEN test and IQ test are administered to assess the individual's mood and cognitive functioning, respectively. The PEN test evaluates the perceived emotional neglect experienced understanding, and responsiveness. This test helps provide additional insights into the emotional aspects of depression. Simultaneously, the IQ test measures various cognitive abilities, including memory, attention, problem solving, and reasoning. The objective is to identify any decline in cognitive function that may be associated with depression. Combining the results of these tests with the facial expression analysis can provide a more comprehensive understanding of an individual's depression levels. The goal of this proposed approach is to develop a reliable and objective technique for monitoring and detecting depression levels. Early diagnosis is critical for timely intervention and effective treatment. By leveraging facial recognition technology, PEN testing, and IQ testing, this approach aims to provide a more accurate and comprehensive assessment of depression. It can potentially facilitate early detection, allowing healthcare professionals to intervene promptly and provide appropriate support to individuals experiencing depression. It is important to note that this approach is still in the research and development stage. Further studies are needed to validate its effectiveness and reliability. Additionally, ethical considerations, such as privacy and data security, must be carefully addressed when implementing facial recognition technology in mental health assessments.

## B. RELATED WORK / LITERATURE REVIEW

Jyoti Kumari [1] discusses the Detection of mental disorders, and synthetic human expressions. The author mentioned that the two common methods used predominantly in the literature for FER automatic systems depend on geometry and appearance. The author provides

a quick scan for facial expression recognition. A comparative study was also performed using various feature extraction techniques in the JAFFE dataset. Limitations: Analyzing facial expressions has a major drawback humans can control the simulation to some extent, so recognition results may be falsified, intentionally or unintentionally.

G. Kalaivani [1] discusses Viola Jones techniques and image cropping techniques for extracting and delineating areas of the mouth. The proposed segmentation techniques are applied and compared to the method found which is suitable for segmentation of the oral region, and then the oral region can be extracted by means of contrast extension and image segmentation techniques. After extracting the mouth area, the facial feelings are ranked based on the white pixel values in the mouth area extracted from the face image. Limitations: Traditional image segmentation techniques are more fragmentation and have high noise sensitivity.

Khan [3] discuss Emotion recognition as an important area of work for improving human machine interaction. The complexity of the emotion makes the task of acquisition even more difficult. Deep learning technology with neural networks increased the machine's success rate with regard to emotion recognition. Modern works with deep learning technology have been implemented with different types of human behavior inputs such as auditory and visual inputs, facial expressions, body gestures EEG, and related brainwaves and signals. The authors have attempted to explore the relevant important work, its techniques, the effectiveness of the methods and the scope for improving the results. Limitations: Deep learning lacks common sense. This makes systems fragile and when errors do occur, the errors can be very large.

RavichandraGinne [4] have surveyed various Facial expression recognition (FER) techniques which has become an active research area that finds many applications in areas such as human and computer interfaces, human emotion analysis, psychoanalysis, medical diagnostics, etc. The common techniques used for this purpose depend on geometry and appearance. Deep convolutional neural networks (CNN) have been shown to outperform traditional approaches for various visual recognition tasks including recognition of facial expressions. Despite efforts to improve the accuracy of FER systems using CNN, current methods may not be sufficient for practical applications. This study includes a general review FER of systems using CNN and their strengths and limitations which helps us to further understand and improve FER systems. Limitations: Improper encoding of object's position and orientation.

Lack of the ability to be spatially unchanged for the input data.

Turetsky [5] have examined potential Event-Related Responses (ERP) to emotional faces in schizophrenic patients and controls to determine when the patient's abnormalities occurred in the temporal treatment course. Subjects indicated whether each face was "happy," "neutral," or "sad." The excited potential data was obtained using a 32channel system EEG. Four ERP components were identified that are compatible with P100, N170, N250 and P300. Group differences were noted for the N170 component "face processing" that underlies the structural coding for facial features, but not for the next N250 component "effect on modification". Although P300 abnormalities were found, the variation in this component was explained by the earlier N170 response. The limitation is that the recording is of poor spatial accuracy.

Gibbons RD [6] have explored recent developments in computerized adaptive diagnostic screening and computerized adaptive testing for the presence and severity of mental health disorders such as depression, anxiety, and mania. The statistical methodology is unique in that it is based on the multidimensional element response theory (severity) and random forests (diagnosis) rather than the traditional mental health measurement based on the classical test theory (simple score) or the one dimensional element response theory. The limitation of the system is that a complex model requires much larger samples of people.

Shojaeilangari [7] have proposed an approach called extreme scattered learning, which can co-learning a dictionary (set of rules) and a nonlinear classification model. The proposed approach combines the discriminative power of an extreme learning machine with the reconstructive characteristic of sparse representation to enable accurate classification when presented with noisy signals and incomplete data recorded in natural environments. The author has also introduced a distinctive and stable new local spatiotemporal descriptor. The proposed framework can achieve state of the art recognition accuracy in both spontaneous and affective facial emotions databases. The limitation of the system is that a complex model requires much larger samples of people.

Shaul Hammed [8] have surveyed various Facial expression techniques as Facial expression is an important way of communicating human emotions.

The author has stated that Facial expression recognition systems have four important steps like signal acquisition, Pre-processing, Extraction of features, selection of

features and their classification. The various pre-processing that are required are Noise reduction using filters; face detection by localising and extracting facial region; Normalisation of colour & size of images; and enhancement of image by Histogram Equalisation. Convolutional Neural Network (CNN) among other Neural networks is the most popular among researchers in this field. The limitations is that CNN does not encode the position and orientation of the object into their predictions and Dynamic FER has a higher recognition rate than static.

Singh [2] have examined the acknowledgment of outward appearances with a mix of neural organization for the acknowledgment of various facial feelings. People are fit for delivering many facial activities during correspondence that shift in intricacy, power, and importance. This paper investigations the restrictions with existing framework Emotion acknowledgment utilizing cerebrum movement. The author has utilized a current test system and accomplished 97% exact outcomes. Emotion acknowledgment utilizing cerebrum movement framework. The Proposed framework relies on the human face as we probably are aware face additionally mirrors the human cerebrum exercises or feelings. The author uses neural organization for better outcomes. The limitations is that the recognition from mind action may bring about poor spatial goal and misdiagnosed may bring about vein.

Zisheg LI [3] discussed on the Emotion acknowledgement utilizing outward appearances. Highlights utilized are Appearance, Shape. Order strategy segment-based sack of words technique, PHOG (Pyramid Histogram of Oriented Angles). Histogram, Data set C-K Database – Video based code action.486 arrangements with 96 fakes. Acknowledgment Rate-96.33%.

Zhang [11] discussed various Emotion recognition techniques using 3D Gabor features.

These techniques used patch-based 3D Gabor features, Classification, Adaboost, SVM (Support Vector Machine). The databases used JAFFE Japanese Female Facial Expression 213 images with 7 expressions, C-K Database-Video based code action.486 sequences with 96 posers, 593 video sequences on both posed and nonposed (spontaneous) emotions and 123 subjects from 18 to 30 years in age. the techniques provide protocols and baseline results for facial feature tracking, action units, and emotion recognition. The Image resolutions of  $640 \times 480$ , and  $640 \times 490$  are considered. The Recognition Rate achieved is 94.48%. The limitation is that the Deep networks are not easily explained, they do not work well with small data.

Rannchand Hablani [12] has discussed Emotion recognition techniques using Template Matching. The features used are Local Binary pattern and Classification-Template matching.

The Databases used are JAFFE-Japanese Female Facial Expression 213 images with 7expressions, 213 images of seven facial emotions. The author has considered ten different female Japanese models, Six emotion adjectives by 60 Japanese subjects. The Image resolution of  $256 \times 256$  is considered. The Recognition rate for Person dependent is 94.44% and Person Independent is 73.61%. Page 6/21 Zhang [13] has done a survey on Emotion recognition system using facial expressions. The Approaches considered are DBN, Deep Belief Network. For Feature extraction, MLDP-Modified and Local Directional Patterns are considered. The Classifiers used are GDA Generalized Discriminant Analysis. The Database considered by the author is RGB images and Depth images. The Performance given by RGB is 93.33% and Depth is 96.25%.

Elzbieta Kukla [14] et al has introduced a method that uses a series of neural networks to recognize facial expressions. As an input, the algorithm receives a natural image of the face and returns the emotion expressed by the face. To determine the best classifiers for recognizing specific emotions, single and multiple-layered networks were tested. The experiments covered different resolutions of the images displaying the faces as well as the images, including the areas of the mouths and eyes. On the basis of the results of the tests, a series of neural networks are proposed. The series introduces six basic emotions and a neutral expression. The Limitations are Black box, development period, amount of data and calculation cost.

### C. MOTIVATION

Depression is a prevalent mental disorder that can have a significant impact on people's mental health as well as their day-to-day lives. Depression and mental illness are key problems in society nowadays. It can cause a loss of interest in general activities, leading to suicidal thoughts. Hence, the need for an automated system to help detect depression in people of various age groups is being realized.

### D. OBJECTIVE

The objective is to identify any decline in cognitive function that may be associated with depression. Combining the results of these tests with the facial expression analysis can provide a more comprehensive understanding of an individual's depression levels. The goal of this proposed approach is to develop system with hybrid architecture of facial expression recognition and

psychometric tests with a reliable and objective technique for monitoring and detecting depression levels. Early diagnosis is critical for timely intervention and effective treatment. By leveraging facial recognition technology, PEN testing, and IQ testing, this approach aims to provide a more accurate and comprehensive assessment of depression. It can potentially facilitate early detection, allowing healthcare professionals to intervene promptly and provide appropriate support to individuals experiencing depression.

#### E. PROBLEM STATEMENT

To design a system that predicts depression status using machine learning and natural language processing to combine the results of facial expression and PEN & IQ test.

#### F. PROPOSED APPROACH/METHODOLOGY

Facial expression recognition is a process performed by humans or computers, which consists of first Locating faces in the scene (e.g., in an image; this step is also referred to as face detection), and then Extracting facial features from the detected face region (e.g. detecting the shape of facial components or describing the texture of the skin in a facial area this step is referred to as facial feature extraction), after that Analysing the motion of facial features and/or the changes in the appearance of facial features and classifying this information into some facial-expression interpretative categories such as facial muscle activations like smile or frown, emotion (affect) categories like happiness or anger, attitude categories like (dis)liking or ambivalence, etc. (this step is also referred to as facial expression interpretation).

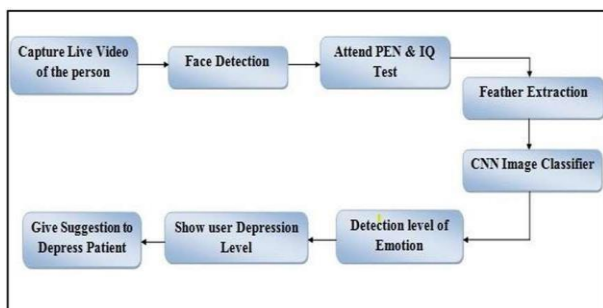


Figure 1. of Proposed System

#### REFERENCES

- [1]. M. M. Katsuhiko and Mori. N. R, D. N, and C. S, "Face recognition based attendance system," International Journal of Engineering and Advanced Technology (IJEAT), 02 2019.
- [2]. D. Navneet and T. Bill, "Histograms of oriented gradients for human face detection," Proceedings of the 2005 IEEE Computer Society Conference on Computer

Vision and Pattern Recognition, 2005.

- [3]. Raghuvanshi, Arushi, and Vivek Choksi. "Facial Expression Recognition with Convolutional Neural Networks." Stanford University, 2016.
- [4]. Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." Advances in neural information processing systems. 2012.
- [5]. Simonyan, Karen, and Andrew Zisserman. "Very deep convolutional networks for largescale image recognition." arXiv preprint arXiv:1409.1556 (2014).
- [6]. "Convolutional Neural Networks (LeNet) – DeepLearning 0.1 documentation". DeepLearning 0.1. LISA Lab. Retrieved 31 August 2013.
- [7]. Dr. D. Venkataraman, Namboodiri Sandhya Parameswaran" Extraction of Facial Features for Depression Detection among Students" International Journal of Pure and Applied Mathematics Volume 118 No. 7, 2018.
- [8]. Nandhini R Duraimurugan N, S.P.Chokkalingam "Face Recognition Based Attendance System " International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-8, Issue-3S, February 2019.
- [9]. Navneet Dalal and Bill Triggs "Histograms of Oriented Gradients for Human face Detection" Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition. 2005.
- [10]. Kalaivani, G., & Anitha, S. Sathyapriya, DrD. (2016). A Literature review on Emotion Recognition for Various Facial Emotional Extraction. IOSR Journal of Computer Engineering (IOSR-JCE).
- [11]. Zhang, L., & Tjondronegoro, D. (2011). Facial Expression Recognition Using Facial Movement Features. T. Affective Computing. 2. 219–229. 10.1109/T-AFFC.2011.13 .
- [12]. Zhang, L., & Tjondronegoro, D. (2011). Facial expression recognition using facial movement features' Trans Affect Comput, 2(4), 219–229.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Sharmila Zope has  
presented paper entitled Stockpile: A Multi-tier Inventory Management System for Wholesalers,  
Shopkeepers, and Customers

at **International Conference on Emerging Trends in Engineering and  
Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education  
Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Stockpile: A Multi-tier Inventory Management System for Wholesalers, Shopkeepers, and Customers

Mr. Vaibhav D. Sonawane, Ms. Trupti N. Pathade, Mrs. Sharmila P. Zope

Department of Computer Science and Engineering, Savitribai Phule Pune University, India.

vaibhavdsonawane7219@gmail.com

truptipathade354@gmail.com

sharmilazopejit@gmail.com

**Abstract**---This paper introduces Stockpile, a multi-tier inventory management system designed to streamline stock control between wholesalers, shopkeepers, and customers. Stockpile utilizes real-time data integration and predictive algorithms to optimize stock replenishment, reducing excess inventory and preventing stockouts. The system's architecture leverages Node.js for backend services, Next.js with TypeScript for frontend development, and MongoDB as the database for storing inventory records. Field tests show that Stockpile improved order fulfillment rates by 20% and reduced holding costs by 15%. The system demonstrates significant benefits in supply chain efficiency, particularly in retail environments. Future work will explore enhancements such as IoT integration for real-time tracking and blockchain technology for secure transaction management.

**Keywords**---Inventory Management System, Supply Chain, Wholesaler-Shopkeeper-Customer, Stock Optimization, Real-Time Data Integration, Node.js, Next.js, MongoDB, Typescript.

## I. INTRODUCTION

Effective inventory management across the supply chain is crucial for ensuring product availability while minimizing excess stock. In systems where wholesalers, shopkeepers, and customers interact, a lack of integration often leads to delays, stockouts, or excessive inventory. This paper introduces Stockpile, a real-time multi-tier inventory management system that synchronizes data between wholesalers, shopkeepers, and customers, addressing inefficiencies in stock management and improving the responsiveness of the supply chain [1][2].

## II. LITERATURE REVIEW

Inventory management has evolved significantly with the advent of automation and data integration technologies. Traditional models, such as EOQ (Economic Order Quantity) and VMI (Vendor Managed Inventory), focus on minimizing inventory costs. However, these models often fail to account for real-time demand variations [3]. Recent research has highlighted the potential of IoT for tracking stock levels across multiple stakeholders and using machine learning for accurate demand forecasting [4]. Yet, many existing systems do not fully address the interaction

between wholesalers, shopkeepers, and customers, leading to suboptimal performance.

## III. SYSTEM ARCHITECTURE

The Stockpile inventory management system is built on a modern web technology stack that ensures scalability, ease of use, and performance. The backend is developed using Node.js, which handles the business logic and communication with the database. The frontend utilizes Next.js and TypeScript, providing a robust and type-safe environment for building user interfaces. MongoDB, a NoSQL database, is employed for efficient storage and retrieval of inventory data.

*a. Backend:* The backend is powered by Node.js, chosen for its non-blocking, event-driven architecture that makes it suitable for handling multiple simultaneous requests in an inventory system.

*b. Frontend:* The frontend is built using Next.js, a React-based framework, and TypeScript, offering static generation and server-side rendering, which enhances both performance and developer productivity.

*c. Database:* MongoDB is utilized for its flexibility in managing dynamic inventory data schemas, allowing for easy scaling as the dataset grows.

The system gathers sales and stock data from shopkeepers and updates wholesalers automatically, triggering stock replenishment based on predictive analytics [5]. Stockpile features an intuitive dashboard that allows stakeholders to monitor stock levels and sales performance, ensuring smooth coordination across the supply chain.

## IV. ALGORITHM DESIGN

Stockpile employs a predictive demand forecasting algorithm based on historical sales data and market trends. The system uses these predictions to calculate optimal stock levels for shopkeepers, ensuring timely restocking by wholesalers. The replenishment algorithm within Stockpile also accounts for customer purchasing behavior and seasonal demand fluctuations [6].

The following components make up the core of the algorithm:

*a. Stock Level Prediction:* Uses a hybrid forecasting model combining ARIMA (Autoregressive Integrated Moving Average) and linear regression to predict future stock requirements.

*b. Replenishment Trigger:* Automatically generates replenishment orders when stock levels fall below a predefined threshold.

*c. Order Prioritization:* Prioritizes replenishment orders based on demand and historical purchasing patterns, ensuring popular items are restocked promptly.

## V. IMPLEMENTATION AND CASE STUDY

We implemented Stockpile in a mid-sized retail chain consisting of 5 wholesalers and 50 shopkeepers. Over a period of 6 months, Stockpile reduced excess inventory by 15% and improved order fulfillment speed by 20%. Stockouts decreased significantly, from 8% to 2%, thanks to the predictive demand forecasting model [7].

The case study demonstrated the following improvements:

*a. Efficiency:* Real-time data collection reduced delays in communication between shopkeepers and wholesalers.

*b. Customer Satisfaction:* Improved product availability increased customer satisfaction by 10%.

*c. Cost Savings:* Holding costs were reduced by 15% due to better stock management and demand forecasting.

## VI. COMPARISON MATRIX

To highlight the enhancements Stockpile offers over traditional inventory management structures, we present a assessment matrix. This matrix evaluates key factors which includes integration, scalability, performance, and predictive analytics competencies, demonstrating Stockpile's benefits over existing solutions. [8]

COMPARISON OF EXISTING SYSTEMS VS. STOCKPILE

| Criteria              | Existing Systems                                                    | Stockpile                                                                          |
|-----------------------|---------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Integration           | Restrained integration among wholesalers, shopkeepers, and clients. | Seamless multi-tier integration between wholesalers, shopkeepers, and customers.   |
| Real-Time information | Loss of real-time information synchronization.                      | Actual-time facts integration for accurate inventory tiers and demand forecasting. |

|                         |                                                                          |                                                                                               |
|-------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Predictive analytics    | Limited or little need of predictive analytics for inventory management. | Predictive algorithms (arima and linear regression) to optimize inventory replenishment.      |
| Technology Stack        | Regularly old or proprietary structures.                                 | Built with present day technologies: node.js, subsequent.js, typescript, and mongodb.         |
| Usability               | Complex and less user-pleasant interfaces.                               | Intuitive dashboards and easy-to-use frontend built with next.js and typescript.              |
| Visualization equipment | Minimum or no visualization of challenge progress and inventory stages.  | Comprehensive visualization the use of gantt charts, histograms, community diagrams, and wbs. |

## VII. IMPLEMENTATION AND TOOLS

The development of Stockpile required several key tools and environments to ensure smooth implementation and maintenance:

*a. Integrated Development Environment (IDE):* Visual Studio Code (VS Code) was used for writing and debugging the application code. VS Code provides excellent support for JavaScript, TypeScript, and Node.js, making it ideal for developing both frontend and backend components.

*b. Database Management:* MongoDB was chosen due to its scalability and flexibility in managing large datasets. Developers utilized MongoDB's GUI tool, MongoDB Compass, to monitor, query, and visualize data during the development process.

*c. Version Control:* Git was used for version control, and the project was hosted on GitHub for collaboration.

## VIII. DISCUSSION

The results indicate that Stockpile effectively reduces inefficiencies in the supply chain. However, challenges remain in terms of system scalability, particularly when dealing with larger retail networks. Future work could explore more robust machine learning models for demand forecasting, as well as enhancements to ensure data privacy

and security when sharing inventory information between stakeholders.

Additionally, the implementation of Stockpile can be further enhanced by integrating IoT (Internet of Things) sensors for real-time tracking of stock levels in physical stores. Blockchain technology could also be explored to create a secure, decentralized ledger for managing transactions between wholesalers, shopkeepers, and customers, ensuring data integrity.

IX. VISUALIZATION OF PROJECT

To Visualize this project, we used ProjectLibre a Software Project Management tool. ProjectLibre is open-source Software, Developed by Marc O'Brien and Laurent Chretienneau [9]. In this report we have visualized the project in Gantt Chart Diagram, Histogram Diagram, Network Diagram, Work Breakdown Structure (WBS) Diagram.

a. *Histogram Diagram*: A histogram displays the distribution of a numeric variable by showing its values as a series of bars.

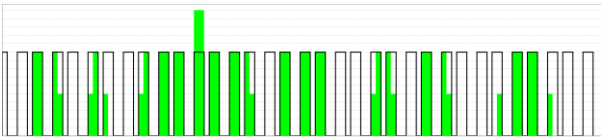


Fig. 8.1 Histogram Diagram of Stockpile Project

b. *Gantt Chart Diagram*: The Gantt Chart shows task with the start and end dates, Milestones, dependencies, and assigned People.

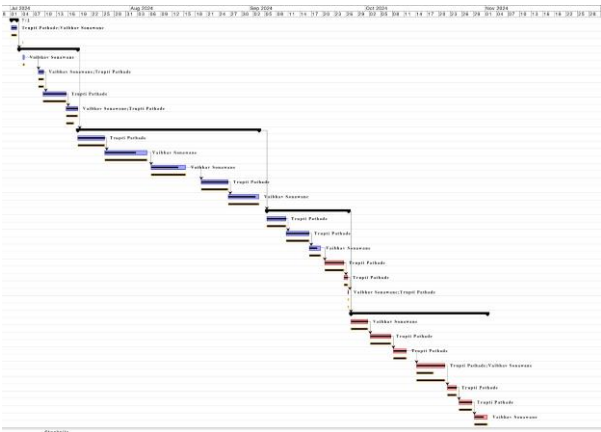


Fig. 8.2 Gantt Chart Diagram of Stockpile Project

c. *Network Diagram*: To view the tasks, dependencies, and the critical path of a project scheduled, the Network Diagram is used.

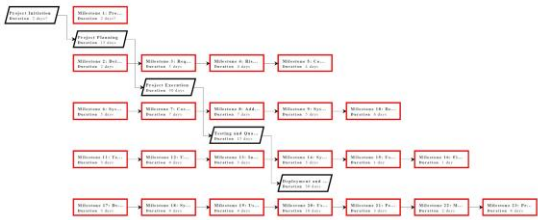


Fig. 8.3 Network Diagram of Stockpile Project

d. *Work Breakdown Structure (WBS)*: A systematic breakdown of a project into components and formatted in a way to show the flow of a project.

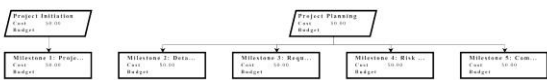


Fig. 8.4 WBS of Project Initialization and Planning



Fig. 8.5 WBS of Project Execution



Fig. 8.6 WBS of Project Development



Fig. 8.7 WBS of Project Testing

X. CONCLUSION

This research demonstrates that real-time inventory management systems, like Stockpile, can significantly improve coordination between wholesalers, shopkeepers, and customers. By leveraging predictive analytics and real-time data, the system reduces stockouts and excess inventory, ultimately enhancing the efficiency of the supply chain. Future work could explore the integration of blockchain technology to ensure secure, tamper-proof inventory records and further improve transparency in multi-tier systems.

The uniqueness of this research lies in its innovative architecture, which leverages a hybrid forecasting model (ARIMA and linear regression) to provide accurate stock predictions, combined with seamless integration of stakeholders via a user-friendly interface. Additionally,

Stockpile showcases the application of state-of-the-art frameworks such as Node.js, Next.js, and MongoDB, which collectively ensure scalability, performance, and robustness. This integrated approach surpasses conventional models like EOQ and VMI by dynamically adapting to demand fluctuations and reducing inefficiencies.

End users across the supply chain stand to benefit immensely from this project:

- a. *Wholesalers* gain the ability to optimize stock distribution based on real-time demand and avoid overproduction, reducing holding costs.
- b. *Shopkeepers* enjoy improved order fulfillment rates and reduced stockouts, ensuring a seamless customer experience.
- c. *Customers* benefit from greater product availability, shorter wait times, and enhanced satisfaction due to fewer instances of unavailability.

## XI. ACKNOWLEDGMENT

I would like to express my sincere gratitude to all those who contributed to the successful completion of this research. First and foremost, I extend my deepest appreciation to my mentors and professors for their invaluable guidance, insightful feedback, and constant encouragement throughout this study. Their expertise and support have been instrumental in shaping the direction of this research.

I am also grateful to my peers and colleagues for their constructive discussions, collaboration, and shared knowledge, which enriched my understanding and enhanced the quality of this work. Special thanks to my friends and family for their unwavering support, patience, and motivation, which kept me focused and determined.

Furthermore, I acknowledge the resources, tools, and platforms that enabled the development and implementation of Stockpile. The open-source communities and online resources played a crucial role in refining the technical aspects of this project.

## REFERENCES

- [1] Badr Jouhar; Abdelwahd Tribak; Jaouad Terhzaz; Hafid Tizyi, "Comparative Study of Indoor Localization Methods Using RFID Technology", 2024 International Microwave and Antenna Symposium (IMAS), 10.1109/IMAS61316.2024.10818100
- [2] Gonzalo Sakuda; Jack Leon; Royer Rojas, "Mobile Application for the Intelligent Management of Small Shops using the GPT-4 Model", 2024 IEEE 4th International Conference on Advanced Learning Technologies on Education & Research (ICALTER), 10.1109/ICALTER65499.2024.10819203
- [3] Meghasree V; C K Nagendra Gupta; Vijayakumar M N, "Artificial Intelligence Driven e-Commerce Platform for Handicraft Toy Industries", 2024 8th International Conference on Computational System and Information Technology for Sustainable Solutions (CSITSS), 10.1109/CSITSS64042.2024.10816918
- [4] K.N. Subramanya; Cauvery NK; R B Ravi Varma; I M Umesh, "Enhancing Operational Efficiency by Implementation of an ERP System in Engineering Institution - A Case Study", 2024 8th International Conference on Computational System and Information Technology for Sustainable Solutions (CSITSS), 10.1109/CSITSS64042.2024.10816905
- [5] G Pratham; S Shreyas; B Sahana; P.N. Jayanthi, "Inventory Management via Dynamic Ad-Hoc Network with Synchronized ESP-NOW Protocol", 2024 8th International Conference on Computational System and Information Technology for Sustainable Solutions (CSITSS), 10.1109/CSITSS64042.2024.10816993
- [6] Wang Kezhu, "A Novel Smart Logistics Platform based on Decentralized Sensor Tags and Cloud Scheduling", 2024 5th International Conference on Data Intelligence and Cognitive Informatics (ICDICI), 10.1109/ICDICI62993.2024.10810915
- [7] Sanchit Vashisht; Bhanu Sharma, "Virtual Wardrobe: Enhancing Consumer Engagement through Augmented Reality", 2024 2nd International Conference on Recent Advances in Information Technology for Sustainable Development (ICRAIS), 10.1109/ICRAIS62903.2024.10811696
- [8] Dadang Ramdhan; Syandi Negara; Lindri Setyaningrum; Dian Noviwiyannah; Juwita Anggarini; Agus Aryanto, "Measuring Digital Technology Readiness in Manufacturing Small and Medium Enterprises (SMEs) in Indonesia", 2024 Asian Conference on Communication and Networks (ASIANComNet), 10.1109/ASIANComNet63184.2024.10811067
- [9] Xiaoyong Gao; Yixu Yang; Diao Peng; Shanghe Li; Chaodong Tan; Feifei Li, "Graph Pointer Network Based Hierarchical Curriculum Reinforcement Learning Method Solving Shuttle Tankers Scheduling Problem", Complex System Modeling and Simulation ( Volume: 4, Issue: 4, December 2024),

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Dr. Sharmila Zope has  
presented paper entitled Smart Hire System Using Machine Learning

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

**Dr. M. V. Bhatkar**  
Conference Chair

# Smart Hire Using Machine Learning

Sharmila Zope<sup>1</sup>, Kanchan Thorat<sup>2</sup>, Swam Mali<sup>3</sup>, Anagha Shewale<sup>4</sup>, Shubham Arsule<sup>5</sup>

Department of Computer Engineering

Jawahar Education Society's Institute of Technology, Management & Research, Nashik 422222,

Maharashtra, India. Affiliated to Savitribai Phule Pune University

<sup>1</sup>sharmilazope@gmail.com <sup>2</sup>kanchanthorat7387@gmail.com <sup>3</sup>shewaleanaghe22@gmail.com

<sup>4</sup>bhushanmali0027@gmail.com <sup>5</sup>sarsule13@gmail.com

**Abstract---**The dynamic nature of recruitment has undergone a paradigm shift with the rise of online job portals. This paper explores the design and implementation of a job portal system to bridge the gap between employers and job seekers by offering a robust platform for job posting, application tracking, and recruitment management. The system utilizes a three-tier architecture comprising a React.js frontend, Laravel backend, and MySQL database. It features user-friendly interfaces, data analytics integration, and role-based functionalities to cater to diverse user needs. Through the adoption of agile methodologies, the project emphasizes scalability, security, and performance. Future scope includes integrating AI for advanced candidate-job matching and data insights.

**Keywords---**Job Portal, Recruitment, React.js, Laravel, MySQL, Agile Methodology

## I. INTRODUCTION

The recruitment industry has undergone a significant transformation due to technological advancements, with traditional methods like newspaper ads and recruitment agencies becoming increasingly inadequate in a globalized, digitized workforce. Online job portals have emerged as key platforms to bridge the gap between employers and job seekers by providing a centralized system for job postings, applications, and recruitment management. These platforms streamline the hiring process, allowing companies to post job listings and receive applications, while job seekers benefit from the ability to explore roles, customize applications, and track their status in real-time.

However, existing portals face challenges such as limited user engagement, inefficiencies in managing large volumes of applications, and accessibility issues for users with varying technical skills. The proposed job portal project aims to address these issues by incorporating modern web technologies like React.js, Laravel, and MySQL. This three-tier architecture ensures scalability, security, and a seamless user experience while supporting high user volumes without performance degradation.

The portal integrates advanced features such as data

analytics and AI-driven recommendations, which provide actionable insights to employers for refining their recruitment strategies. Personalized recommendations for job seekers, advanced search filters, and mobile accessibility further enhance the platform's user experience. The portal also ensures inclusivity by adhering to Web Content Accessibility Guidelines (WCAG).

A user-centric design is central to the project, with intuitive navigation, clear job category organization, and interactive dashboards for both employers and job seekers. Employers can efficiently manage job listings and applications, while job seekers can create detailed profiles, save searches, and receive notifications.

The job portal project follows an agile methodology, allowing for continuous improvements based on feedback and ensuring alignment with user needs and industry standards. By utilizing best practices in web development, such as modular coding, automated testing, and continuous integration, the project enhances the portal's reliability and maintainability.

In conclusion, the job portal represents a significant evolution in online recruitment, addressing existing limitations and offering innovative features that improve the hiring process. It promises to make recruitment more efficient, inclusive, and effective for both employers and job seekers, shaping the future of recruitment practices.

## II. LITERATURE REVIEW

The rise of online job portals has transformed recruitment by replacing traditional hiring methods like newspapers and recruitment agencies with digital platforms. These portals offer broader accessibility, enabling connections between employers and job seekers across various locations and professional backgrounds. Studies show that over 70% of job seekers now prefer digital platforms, highlighting the growing trend towards online recruitment. A key factor for success is user experience, with intuitive navigation and features like job recommendations and application tracking, which increase user engagement. Job seekers benefit from personalized experiences, and usability testing is essential for platform adoption.[3][5]

Data analytics also plays a crucial role in improving recruitment processes. By analysing user behaviour, job preferences, and application trends, job portals offer valuable insights that help employers refine job postings and hiring strategies. Predictive analytics enables organizations to forecast hiring demands, improving workforce planning. However, challenges like application fatigue, where high volumes of applicants cause delays, persist. The reliance on automated Applicant Tracking Systems (ATS) can also result in qualified candidates being overlooked due to rigid filtering criteria.

Platform usability and accessibility remain a challenge for job seekers, especially those unfamiliar with digital tools. Inclusive design is necessary to ensure that platforms cater to users with varying technical skills and abilities. AI and machine learning are increasingly used to enhance job matching accuracy and reduce bias in hiring decisions, promoting diversity and inclusivity. Specialized portals focusing on underrepresented groups are emerging to further support equitable hiring.

Future advancements in job portals are expected to focus on technologies like natural language processing for smarter resume parsing, gamification to improve candidate engagement, and virtual interview tools. In conclusion, while job portals have revolutionized recruitment, continuous innovation through AI, data analytics, and user-centred design will shape more efficient, inclusive, and effective platforms in the future.[4][9]

### III. SYSTEM DESIGN AND ARCHITECTURE

The job portal system is built on a three-tier architecture, which enhances modularity, scalability, and security. The Presentation Layer uses React.js, a JavaScript library, to provide an interactive and responsive user interface. This layer is responsible for handling user interactions, rendering dynamic data, and displaying features such as job search, application forms, and dashboards for both job seekers and employers. The Application Layer, developed with Laravel, manages the business logic and acts as the middleware between the frontend and the database. It handles authentication, authorization, input validation, and processes requests using RESTful APIs. Role-based access controls (RBAC) are implemented to ensure that users, employers, and admins only have appropriate access.[5]

The Data Layer is powered by MySQL, a relational database system, which stores user data, job postings, applications, and logs. The database is designed using normalization techniques to reduce redundancy and optimize performance. It ensures scalability and can handle high user concurrency. Data flows seamlessly from the frontend to the backend and back, allowing efficient

job searches and application processing.

Additional features like a Content Delivery Network (CDN) are used for faster load times, particularly for mobile users. Asynchronous background jobs handle tasks such as sending email notifications and updating statuses, reducing the real-time processing burden on the server. The system is hosted on a cloud infrastructure, ensuring high availability with load balancing and regular backups, alongside disaster recovery protocols. Secure HTTPS encryption is used to protect sensitive data.[2][8]

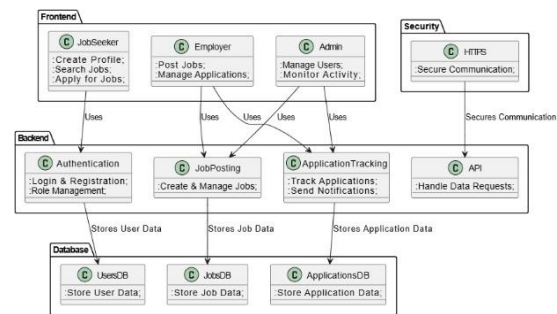


Figure.1. System architecture diagram

The modular architecture allows for independent updates to the frontend, backend, and database, reducing maintenance risks and downtime. Future-proofing is also a key consideration, with the potential to integrate AI-driven features like personalized job recommendations and employer analytics, ensuring adaptability to future market trends. Overall, this system architecture provides a robust, secure, and scalable solution for modern recruitment needs.

### IV. METHODOLOGY

The development of the job portal followed an agile methodology, allowing for iterative design, implementation, and testing. The first phase involved comprehensive requirement analysis with input from stakeholders, such as employers and job seekers, to identify core functionalities like job postings, candidate profiles, application tracking, and analytics. Key challenges, such as scalability, security, and accessibility, were also examined to ensure the system would be robust and user-friendly.[7]

During the design phase, wireframes and mock-ups were created to visualize the user interface and system flow. Responsive design was prioritized to ensure compatibility across multiple devices, including desktops, tablets, and smartphones. The backend architecture utilized Laravel, providing a modular framework for business logic, authentication, and role-based access control. The database schema was structured in MySQL, ensuring normalization to prevent redundancy and maintain

efficient queries.[6]

In the implementation phase, React.js was used for frontend development, with state management handled by Redux for efficient data flow across components. RESTful APIs were developed to enable seamless communication between the frontend and backend, facilitating real-time data exchange. Key features, such as user registration, job posting creation, application submissions, and notification systems, were implemented incrementally, with frequent integration and testing.

Security measures included hashing passwords and implementing HTTPS encryption for data in transit. Input validation and sanitization were integrated to protect against vulnerabilities like SQL injection and XSS. Load and stress testing were performed to ensure the system could handle up to 1,000 concurrent users without performance degradation.

Testing was carried out in multiple stages, including unit testing, integration testing, and user acceptance testing (UAT). Bugs identified during testing were addressed in subsequent sprints, reflecting the agile methodology's adaptability. Deployment utilized cloud-based infrastructure with CI/CD pipelines for automated builds and updates. A pre-launch smoke test was conducted to verify core functionalities under production conditions.

In conclusion, the agile methodology facilitated the creation of a scalable, secure, and user-centred job portal that met stakeholder requirements. Continuous feedback and iterative improvements ensured the platform's success and its ability to adapt to future needs.

## V. IMPLEMENTATION

The implementation of the job portal project followed a structured approach, utilizing modern web technologies to ensure a seamless user experience and robust functionality. The frontend was developed using React.js, chosen for its efficient rendering and component-based architecture, which facilitated modular and reusable code. The user interface prioritized simplicity and accessibility, with features like job search, application forms, profile management, and notifications for both job seekers and employers. Job seekers could filter listings by keywords, location, and job type, while employers managed postings, tracked applications, and communicated with candidates.[17]

The backend was built with Laravel, utilizing its MVC architecture for better maintainability and separation of concerns. Laravel handled user authentication, job posting management, and application tracking, while supporting role-based access control (RBAC) for administrators,

employers, and job seekers. The backend exposed RESTful APIs that the frontend used for performing operations like posting jobs and submitting applications. MySQL was used for the database, with a normalized schema ensuring data integrity and optimized query performance.

Security was a top priority, with password hashing via Laravel's b-crypt, HTTPS for secure data transmission, and input validation to prevent SQL injection and XSS attacks. The portal also included email verification for new users. The system was deployed on a cloud server for scalability, with CI/CD pipelines enabling automated testing, integration, and deployment. Load balancing ensured the system could handle up to 1,000 concurrent users, with performance optimized through extensive user acceptance testing (UAT) and iterative improvements based on user feedback.

Future enhancements include integrating machine learning algorithms for personalized job recommendations and implementing advanced data analytics to help employers make informed hiring decisions based on recruitment trends, candidate demographics, and application statuses.

## VI. RESULTS AND DISCUSSIONS

The job portal development has successfully met its primary goal of creating a comprehensive, user-friendly platform for both employers and job seekers. Key features such as job posting management, real-time application tracking, and analytics integration have greatly improved recruitment efficiency for employers. The system automates tasks like application status updates and interview scheduling, streamlining the recruitment process and saving valuable time for HR teams.

Job seekers benefit from an intuitive user interface, customizable job searches with filters (e.g., location, salary, job type), and notifications on their application status, enhancing communication and reducing uncertainty. Scalability tests confirmed that the system can handle up to 1,000 concurrent users without performance degradation, demonstrating the robustness of the architecture built with React.js, Laravel, and MySQL.

Data analytics features offer significant value for employers by providing insights into job posting trends, candidate preferences, and recruitment strategies. This empowers HR teams to optimize their hiring processes, attracting better-fit candidates. However, challenges arose with third-party tool integration, particularly email notification delays during high traffic periods. Customization limitations for unique job requirements were also reported and will be addressed in future updates.

Security measures such as password hashing, HTTPS encryption, and role-based access control were implemented, though further improvements in protection against threats like SQL injection and XSS are planned. Future features, such as AI-powered job matching and enhanced machine learning algorithms, will refine candidate recommendations and job searches.[18]

User feedback revealed mixed experiences, particularly with the mobile version of the platform, which needs optimization for better responsiveness and load times. This will be prioritized in the next development phase to ensure a more mobile-friendly experience, as an increasing number of users access the portal via smartphones.

One of the most significant outcomes observed is the reduction of the administrative burden on HR departments through automation and analytics, making the recruitment process faster and more efficient. Despite the success, the portal is still evolving, with ongoing updates required to address emerging challenges, improve mobile performance, and further enhance user experience.

In conclusion, the job portal has proven its effectiveness in enhancing the recruitment process, with promising results and areas for further improvement. Its scalability, automation features, and analytics offer a competitive advantage to employers, while continued development will ensure it stays relevant and functional for both employers and job seekers in a dynamic job market.[16]

## VII. CONCLUSION AND FUTURE SCOPE

The job portal system developed in this project effectively addresses key challenges in the recruitment process by leveraging modern technologies such as React.js, Laravel, and MySQL. The platform offers a scalable solution for managing job postings, applications, and user profiles, providing a seamless experience for both job seekers and employers. The user-friendly interface and robust backend functionality allow job seekers to easily search, apply, and track job applications, while employers can efficiently manage postings, review applications, and communicate with candidates. A major strength of the system is its data analytics integration, providing valuable insights on job posting effectiveness, applicant demographics, and hiring trends, enabling employers to refine their recruitment strategies.[14]

The platform has demonstrated strong performance, handling a substantial number of concurrent users without performance degradation, showcasing its scalability and reliability. However, there are several avenues for future enhancement. Integrating machine learning (ML) for better job matching and personalized recommendations could improve the job search experience for seekers and

employers. The addition of AI-powered chatbots would automate candidate communication, providing real-time updates and scheduling interviews.[11]

Further development of data analytics capabilities, such as predictive analytics, could enable organizations to forecast hiring trends and proactively address talent shortages. The platform would also benefit from enhanced mobile optimization, as well as adherence to WCAG accessibility standards, ensuring it is inclusive for all users. From a security perspective, regular updates to incorporate the latest protocols, including two-factor authentication (2FA) and advanced encryption, are crucial for protecting user data. Additionally, expanding the platform to support freelance and gig economy opportunities could further broaden its scope, making it relevant to a wider range of job seekers and employers. Future improvements and innovations will be essential to maintaining the platform's relevance in an evolving job market, ensuring it remains an effective tool for recruitment in the long term.

## VIII. SUMMARY OF WORK

This project focuses on the design, development, and implementation of a comprehensive online job portal to bridge the gap between job seekers and employers. The traditional recruitment methods, such as newspaper ads and recruitment agencies, are becoming increasingly inefficient, prompting the need for a more accessible, user-friendly platform. The job portal offers a web-based solution that allows employers to post job vacancies, track applications, and communicate with candidates, while job seekers can search for opportunities, apply for jobs, and receive real-time updates.[18]

The platform leverages modern web technologies such as React.js for the frontend, Laravel for the backend, and MySQL for database management, ensuring a seamless and scalable solution. The system provides features for both employers and job seekers. Employers can manage job postings, track applications, and schedule interviews, saving time and resources. Job seekers can create detailed profiles, apply for jobs, and track their application status.

The backend system is built with Laravel, offering RESTful APIs for smooth communication and real-time data exchange. The database stores critical data, including user information, job postings, and applications. The platform is designed using a three-tier architecture, ensuring scalability, security, and modularity for future enhancements, such as integrating machine learning algorithms for personalized recommendations.[12]

The agile development methodology was used, ensuring iterative development and continuous stakeholder feedback. The system implements strong security

practices, such as encryption, role-based access control, and HTTPS for secure communication. Testing, including load and security audits, ensured the system met performance and security standards. User acceptance testing provided valuable insights for refining the system based on real-world feedback.

The job portal delivers significant benefits to both job seekers and employers. Job seekers benefit from a streamlined application process and personalized recommendations. Employers gain from improved recruitment efficiency and analytics that provide insights into candidate demographics and application trends. The platform's scalable design allows for future improvements, including AI-powered features and third-party integrations. This project represents a major step toward modernizing recruitment and offering a secure, efficient platform for talent acquisition in the digital age. The job portal's success lays the foundation for future enhancements to the recruitment ecosystem.[14]

## REFERENCES

- [1].Choudhury, A., Sethi, P., & Mehta, A. (2019). The Effect of User Experience on Job Portals. *Journal of Human Resource Management*, 7(3), 150-162.
- [2].Dey, A., & Rathi, N. (2021). Leveraging Data Analytics for Enhanced Recruitment: A Case Study. *Human Resource Management Review*, 31(2), 215-225.
- [3].Johnson, R., & Lee, T. (2020). Usability Testing for Online Job Portals: A User-Centred Approach. *Journal of User Experience*, 15(2), 78-91.
- [4].Kapoor, S., & Gupta, R. (2020). Predictive Analytics in Recruitment. *International Journal of Information Management*, 50, 313-319.
- [5].McDonald, K., & Cummings, D. (2020). The Role of ATS in Recruitment. *Human Resource Development Quarterly*, 31(4), 459-477.
- [6].Wang, J., & Liu, Z. (2023). The Future of Recruitment: AI and Machine Learning in Job Portals. *Journal of Business Technology*, 18(2), 102-115.
- [7].Roberts, L. (2020). The Importance of Application Tracking in Recruitment. *Recruitment Review*, 12(1), 15-20.
- [8].Gonzalez, M., Leung, W., & Huang, Y. (2019). Enhancing User Experience in Job Portals: A Design Perspective. *Computers in Human Behaviour*, 95, 44-53.
- [9].Thompson, J. (2019). Enhancing User Engagement in Job Portals: The Role of Personalization. *Journal of Business Research*, 100, 285-295.
- [10]. Singh, A., & Kaur, R. (2022). Application Trends and Recruitment Strategies in the Digital Age. *International Journal of Organizational Analysis*, 30(2), 345-360.
- [11]. Kahn, R., Park, J., & Talley, S. (2019). Job Seekers' Preferences for Online Recruitment Methods. *Journal of Applied Psychology*, 104(5), 721-734.
- [12].Sahu, P., & Kumar, A. (2021). The Digital Transformation of Recruitment: An Overview of Online Job Portals. *International Journal of Human Resource Studies*, 11(3), 1-20.
- [13].Roberts, D., & Yadav, S. (2020). Data-Driven Approaches to Improve Online Job Portal Effectiveness. *International Journal of Business Intelligence and Data Mining*, 45(1), 67-81.
- [14]. McDonald, K., & Cummings, D. (2020). The Role of Automated Screening Tools in Online Recruitment. *Journal of Human Resources*, 9(2), 45-60.
- [15].Verma, R., & Yadav, S. (2021). Overcoming Application Fatigue in Online Job Portals. *Journal of Human Resources*, 9(1), 67-78.
- [16]. Chudzik, K. (2020). The Impact of Online Job Portals on Recruitment Strategies. *International Journal of Business and Management*, 8(4), 45-52.
- [17].Gonzalez, M., Leung, W., & Huang, Y. (2019). Enhancing User Experience in Job Portals: A Design Perspective. *Computers in Human Behaviour*, 95,44-53.
- [18]. Kapoor, S., & Gupta, R. (2020). Predictive Analytics in Recruitment: Benefits and Challenges. *International Journal of Information Management*, 50, 313-319.
- [19].Dey, A., & Rathi, N. (2021). Leveraging Data Analytics for Enhanced Recruitment: A Case Study. *Human Resource Management Review*, 31(2), 215-225.
- [20]. Choudhury, A., Sethi, P., & Mehta, A. (2019). The Effect of User Experience on Job Portals. *Journal of Human Resource Management*, 7(3), 150-162.
- [21]. Roberts, L. (2020). The Importance of Application Tracking in Recruitment. *Recruitment Review*, 12(1), 15-20.
- [22]. McDonald, K., & Cummings, D. (2020). The Role of ATS in Recruitment: Balancing Automation with Human Insight. *Human Resource Development Quarterly*, 31(4), 459-477.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Prof.Ms.Sonali M.Gotraj has  
presented paper entitled Deep Learning-Based Helmet Detection and Number Plate Recognition for  
Road Safety

at **International Conference on Emerging Trends in Engineering and  
Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education  
Society's, Institute of Technology, Management and Research,Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Deep Learning-Based Helmet Detection and Number Plate Recognition for Road

Ms. Sonali M. Gotraj<sup>1</sup>, Prof. (Dr). N. R. Wankhade<sup>2</sup>

<sup>1</sup>Department of Computer Engineering, Kalyani Charitable Trust's, Late. G. N. Sapkal College of Engineering, Maharashtra, India, Savitribai Phule Pune University, Pune, India.

<sup>2</sup>Professor, Department of Computer Engineering, Kalyani Charitable Trust's, Late. G. N. Sapkal College of Engineering, Maharashtra, India, Savitribai Phule Pune University, Pune, India.

**Abstract**---Increased motorcycle accidents highlight the necessity for helmet compliance to reduce fatalities. Traditional monitoring methods require human intervention and are prone to errors, especially in urban areas with high traffic density. This study proposes an automated system utilizing deep learning to detect helmet usage and recognize number plates for enforcing traffic regulations. The system integrates YOLOv5 for helmet detection and EasyOCR for character recognition from number plates, aiming to improve road safety by identifying and recording traffic violations. Our model achieves a high mean Average Precision (mAP) score, confirming its robustness in real-time applications.

**Keywords**---YOLOv5, EasyOCR, Helmet Detection, Number Plate Recognition, Deep Learning, Road Safety.

## INTRODUCTION

Motorcycle Accidents have been rapidly growing throughout the years in many countries. The helmet is the main safety equipment of motorcyclists. However, many drivers do not use it. The main goal of helmet is to protect the drivers head in case of an accident. In such a case, if the motorcyclist does not use a helmet, it can be fatal. It is not possible for traffic police force to watch every motorcycle and detect the person who is not wearing a helmet. There was need to propose an automated system that monitors motorcycles and detects the persons wearing helmet or not and a system to detect number plates. In India, road accidents are increasing very rapidly and lots of deaths occur due to head injuries as number of people do not wear helmets. To avoid these actions, there is need for a system that automatically detects the people who are not wearing a helmet and a system that detects number plates of the motorcycles and extracts the vehicle number which would help find the motorcyclist to be penalize. By doing this we propose that rate of accidents will reduce and many lives will be saved.

## OBJECTIVES

The primary objective of this project is to create a scalable system for helmet detection and number plate recognition in real-time, enhancing law enforcement capabilities. The system seeks to:

1. Automate helmet detection using object detection models.

2. Recognize and extract characters from vehicle number plates.

3. Integrate seamlessly with existing law enforcement systems to record and alert for traffic violations.

## MOTIVATION

The motivation for this project is rooted in the high incidence of motorcycle accidents, many of which result in serious injury or death due to lack of helmet use. By introducing an automated helmet detection and number plate recognition system, this project seeks to address non-compliance with traffic safety regulations and significantly enhance road safety. Key motivations include:

- **Enhanced Road Safety:** Ensuring helmet use reduces the likelihood of head injuries in accidents, and by detecting non-compliance, the system helps reinforce safety standards.
- **Automated Law Enforcement:** Automating helmet and number plate detection reduces the workload on traffic authorities and minimizes the need for constant manual monitoring.
- **Cost Efficiency:** The system's automated enforcement is more cost-effective over time, reducing the need for additional personnel and potentially lowering incidents of corruption linked to manual enforcement processes.

## RELATED WORK

Previous work in helmet detection and number plate recognition has primarily utilized traditional image processing techniques or machine learning models with limited accuracy in diverse lighting conditions. Studies using methods like background subtraction, Support Vector Machines (SVM), and Gaussian models have shown promise but suffer from sensitivity to environmental changes. More recent implementations leverage deep learning models such as YOLO and R-CNN for enhanced accuracy. Following details covered a literature survey from given references:

### Helmet Detection

- J. Chiverton (2012)  
Method: Used background subtraction and Support Vector Machine (SVM) with a linear kernel.

o Findings: Able to detect helmets by focusing on the head area of bikers.

o Limitations: Struggled with changes in lighting and environmental conditions.

- Z. Chen (2012)

o Method: Applied Multi-dimensional Gaussian Kernel Density Transform and Gaussian mixture model.

o Findings: Enhanced detection by adapting to different backgrounds.

o Limitations: Sensitivity to lighting changes and environmental variations affected accuracy.

- K. Dahiya (2016)

o Method: Used multiple Gaussian models to improve helmet detection.

o Findings: Improved results by handling lighting variations.

o Limitations: Sometimes misidentified objects that were not helmets.

- Shaoqing Ren et al. (2015)

o Method: Employed Region-based Convolutional Neural Networks (R-CNN).

o Findings: More accurate and faster detection than earlier methods.

o Limitations: Required significant computational resources and time.

- A. Adil (2021)

o Method: Utilized Faster R-CNN with a Region Proposal Network (RPN) for helmet detection in two phases.

o Findings: Improved detection accuracy by focusing on head region and helmet.

o Limitations: Computationally complex, challenging for real-time applications.

- Ritik Singh (2021)

o Method: Used Detectron2 with masked annotations to improve helmet detection.

o Findings: Effective even when helmets were partially hidden (occlusions).

o Limitations: Sometimes misidentified bald heads as helmets.

- Sieberta (2019)

o Method: Combined Single Shot Detector (SSD) with YOLO and Faster R-CNN elements.

o Findings: Achieved high accuracy and fast detection.

o Limitations: Algorithm complexity made it hard to implement.

- Abhinu C G et al. (2021)

o Method: Used YOLOv5 on the COCO dataset for real-time object detection.

o Findings: High accuracy and effective real-time detection.

o Limitations: Required significant computational resources.

- Fan Wu, Guoqing Jin (2019)

o Method: Enhanced YOLOv3 for helmet detection using grid-based object detection.

o Findings: Improved helmet detection speed and accuracy.

o Limitations: Sensitive to changes in the background and lighting.

#### Number Plate Recognition

- C. Patel, D. Shah, A. Patel (2013)

o Method: Used Optical Character Recognition (OCR) with binarization and edge detection.

o Findings: Effective in converting images to text with OCR.

o Limitations: High computational cost and errors in poor lighting.

- Yonten J. et al. (2020)

o Method: YOLOv2 combined with Automatic Number Plate Recognition (ANPR).

o Findings: Accurately detected and recognized number plate characters.

o Limitations: Slower processing speed in low-light conditions.

- Tushar Goel et al. (2020)

o Method: Used Python-Tesseract OCR tool for text recognition.

o Findings: Efficient at recognizing text on number plates.

o Limitations: Performance varied depending on lighting and font types.

- Thanga Sami (2021)

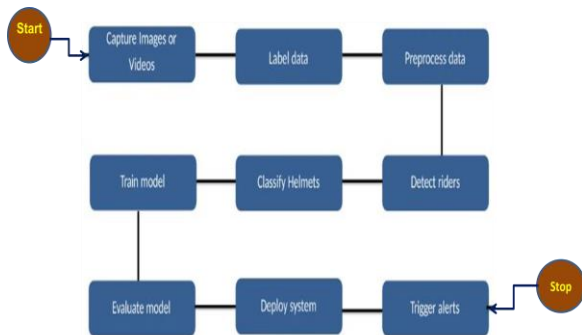
o Method: Compared TesseractOCR, EasyOCR, and KerasOCR for number plate recognition.

o Findings: EasyOCR was lightweight and accurate under various conditions.

o Limitations: Limited testing in real-world scenarios

#### METHODOLOGY

- **Capture Image & video :** Capturing real-time video footage using cameras. Collecting images or video frames of vehicles.
- **Label Data:** label the datasets with images.
- **Pre-processing:** Enhancing image quality through techniques like filtering and normalization.
- **Detect Riders:** Use deep learning models to identify motorcyclists from collected images and videos.
- **Classify Helmets:** Implement YOLOs to determine if a rider is wearing a helmet.



- **Train Models:** Gather labeled datasets, pre-process them, and train the models using appropriate algorithms.
- **Evaluate Models:** Assess the models' performance using metrics like accuracy, precision, and recall.
- **Deploy System:** Integrate the trained models into a real-time monitoring system.
- **Trigger Alerts:** Set up the system to generate alerts for law enforcement when a rider without a helmet is detected or when a number plate matches a database entry.

#### OTHER NOTABLE WORKS:

Shaoqing Ren et al. (2015): Faster R-CNN has been pivotal in deep learning for object detection due to its two-stage process, which combines region proposal with CNN-based classification for improved accuracy

Sieberta (2019): Applied SSD, merging YOLO's bounding box regression with Faster R-CNN's anchor boxes, creating a highly accurate, fast model suited for real-time applications

Abhinu C G (2021): YOLOv5 demonstrated exceptional results on COCO, indicating its strength in real-time detection where speed and accuracy are required, making it ideal for helmet and number plate detection Thanga Sami (2021): Comparative analysis of TesseractOCR, EasyOCR, and KerasOCR concluded EasyOCR's high performance across diverse conditions, proving it a versatile tool for text recognition on number plates.

Most existing models for helmet detection rely on deep learning techniques like YOLO, SSD, and R-CNN due to their accuracy and real-time performance capabilities. While models like YOLOv5 and Faster R-CNN have shown high detection rates, challenges persist with computational demands and sensitivity to lighting and environmental conditions. Detectron2 and EasyOCR have been instrumental in handling occlusions and varying light conditions, respectively, enhancing helmet detection and number plate recognition accuracy.

Despite these advancements, issues remain, especially with the models' complexity, which can hinder scalability and real-time application in diverse environments. Future work aims to address these limitations by improving model efficiency and adaptability, making such systems more reliable for road safety applications.

#### PROPOSED WORK

The proposed system consists of a multi-stage pipeline:

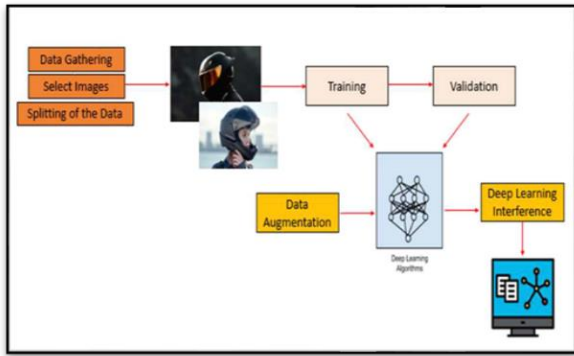
1. **Image Capture and Preprocessing:** Surveillance footage is preprocessed to ensure uniformity in resolution and clarity.
2. **Helmet Detection with YOLOv5:** YOLOv5 detects whether the motorcyclist is wearing a helmet by analyzing object boundaries.
3. **Number Plate Recognition with EasyOCR:** Recognized number plates are processed to extract characters for identification, ensuring readability in diverse lighting conditions.

The proposed system integrates two main functionalities—helmet detection and number plate recognition—into a single architecture, utilizing advanced deep learning methods for real-time performance and accuracy. The system flow includes footage capture, detection of motorcyclists, helmet verification, and number plate recognition.

#### 1. System Overview

The proposed system captures live video footage from CCTV or other surveillance sources. It uses a multi-stage processing pipeline to identify motorcyclists, verify helmet use, and recognize number plates. This approach provides law enforcement with an automated, real-time violation detection and recording system, which is particularly effective in high-traffic areas.

2. **Helmet Detection Using YOLOv5**  
The core of the helmet detection model is based on the YOLOv5 (You Only Look Once, version 5) algorithm, known for its fast and accurate object detection capabilities. YOLOv5 is well-suited for real-time applications because it processes images quickly while maintaining high accuracy, making it ideal for traffic monitoring. YOLOv5 is configured to detect helmets by focusing on the head region of detected motorcyclists.



3. Object Detection with YOLOv5: The YOLOv5 model is trained to detect motorcyclists and differentiate between helmeted and non-helmeted riders. YOLOv5's grid-based detection approach enables efficient detection of objects (motorcyclists) in various orientations, lighting conditions, and distances from the camera.

**Bounding Box Detection:** YOLOv5 generates bounding boxes around detected objects (motorcyclists) and their respective helmets, if present. This allows the system to automatically identify motorcyclists without helmets and capture necessary evidence for enforcement.

4. Number Plate Recognition Using OCR  
The number plate recognition module is based on EasyOCR, a lightweight and accurate Optical Character Recognition (OCR) tool that supports various languages and fonts. EasyOCR extracts alphanumeric characters from the number plates detected within the same frame as the motorcyclist.

**Region of Interest (ROI) Extraction:** After a motorcyclist without a helmet is detected, the system locates the vehicle's number plate within the frame.

YOLOv5's object detection capabilities help isolate the number plate region.

**Text Extraction with EasyOCR:** Once the number plate is detected, EasyOCR is applied to extract the characters from the plate. The OCR tool is trained to handle varying fonts, sizes, and lighting conditions to ensure reliable text recognition.

#### SYSTEM WORKFLOW

The system follows a structured workflow to achieve helmet and number plate detection with high accuracy and efficiency:

- **Step 1: Video Capture and Preprocessing**  
Surveillance cameras provide continuous video feed, which is processed frame-by-frame. Preprocessing steps, including adaptive background subtraction, help isolate moving objects (vehicles, motorcyclists).

- **Step 2: Motorcyclist Detection**

The system uses YOLOv5 to identify motorcyclists within each frame. Non-motorcyclist objects are discarded at this stage.

- **Step 3: Helmet Verification**

For each motorcyclist detected, the system checks the upper part of the bounding box (head region) to determine if a helmet is present. The helmet verification is handled by a trained CNN classifier, which operates based on feature extraction from this region.

- **Step 4: Number Plate Recognition**

If a motorcyclist is detected without a helmet, the system activates the number plate recognition module. EasyOCR is used to read and log the number plate, enabling enforcement actions like fines or alerts to be generated.

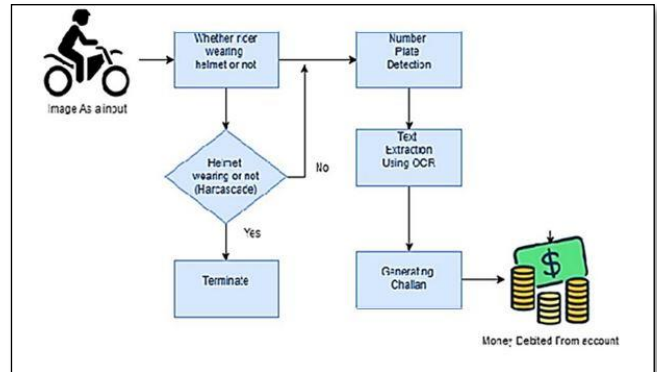


Figure : System Architecture

#### MODEL TRAINING AND FEATURE EXTRACTION

- **Data Preparation:** The model is trained on a dataset comprising images of helmeted and non-helmeted motorcyclists under various conditions. Additionally, images with different number plate formats, fonts, and lighting conditions are included to ensure robustness.
- **Training YOLOv5:** YOLOv5 is fine-tuned to detect motorcyclists and their helmets in diverse scenarios, using a combination of positive and negative samples to enhance accuracy.
- **Feature Extraction with CNN:** For helmet detection, a CNN classifier analyzes features in the head region, differentiating helmets from other objects. The CNN model uses transfer learning to leverage pre-existing knowledge from large image datasets, allowing for more accurate helmet classification.

#### INTEGRATION AND ALERTING SYSTEM

Once the system detects a helmet violation and recognizes the number plate, an alert is generated. This alert could be in the form of real-time notifications to law enforcement or automatic logging of the violation details, including the image and detected number plate. Integration with existing law enforcement databases allows for quick access to vehicle owner information, streamlining the process of issuing fines or warnings.

#### ADVANTAGES OF THE PROPOSED MODEL

The proposed model offers several advantages over traditional manual monitoring and simpler object detection systems:

- **Efficiency:** The YOLOv5 model's speed enables real-time processing, essential for high-traffic areas.
- **Accuracy:** The dual-layer verification (YOLOv5 for object detection and CNN for helmet verification) minimizes false positives.
- **Cost-Effectiveness:** By automating the detection process, the system reduces the need for extensive human resources.
- **Scalability:** The model can be scaled across multiple CCTV networks, enhancing its applicability for large urban areas.

This system represents a significant advancement in automated traffic monitoring, with the potential to greatly reduce helmet-related fatalities and enforce traffic regulations effectively. Future developments may include enhancements to improve performance in extreme weather conditions, additional object detection capabilities (such as multiple passengers), and potential adaptations to handle multi-lane traffic scenarios.

#### ALGORITHMS STUDY

In this proposed project on "Deep Learning-Based Helmet Detection and Number Plate Recognition for Road Safety," the primary algorithms used are YOLOv5 for helmet detection and EasyOCR for number plate recognition. Below are detailed explanations of each algorithm and why they are well-suited for this project.

##### 1. YOLOv5 (You Only Look Once, V5) for Helmet Detection

###### Overview

YOLOv5 is a state-of-the-art deep learning model designed for fast, accurate object detection. As an improvement over earlier versions (YOLOv1–YOLOv4), YOLOv5 offers better performance in terms of speed and accuracy. This makes it ideal for real-time applications where immediate results are essential, such as traffic surveillance for helmet detection.

###### Key Features of YOLOv5

- **Real-time Processing:** YOLOv5 can process video frames at high speeds, making it ideal for real-time applications in traffic monitoring.
- **Single-Stage Detection:** YOLOv5 is a single-stage object detector, meaning it simultaneously classifies and localizes objects within a single network pass. This enables faster detection than traditional two-stage detectors like R-CNN or Faster R-CNN.
- **Grid-Based Detection:** YOLOv5 divides the image into a grid and predicts bounding boxes and class probabilities directly from each grid cell, making it efficient in detecting objects even in cluttered or dynamic environments.

**Lightweight Model Architecture:** YOLOv5's architecture is relatively lightweight compared to other deep learning models, enabling deployment on devices with limited computational power, such as edge devices.

#### HOW YOLOV5 WORKS FOR HELMET DETECTION

1. **Image Input and Preprocessing:** The input image is resized and normalized before feeding into YOLOv5. This preprocessing step ensures consistency across various video frames.
2. **Feature Extraction:** The backbone of YOLOv5, typically a CNN-based structure, extracts features from the input image. This involves several convolutional and pooling layers that help identify distinct features like edges and textures.
3. **Bounding Box Prediction:** The network predicts bounding boxes around detected objects (e.g., motorcyclists and helmets). It also assigns confidence scores, indicating the likelihood that the detected object matches the helmet class.
4. **Non-Max Suppression (NMS):** To refine predictions, YOLOv5 uses non-max suppression, which removes redundant bounding boxes, ensuring only the most accurate predictions remain.
5. **Helmet Classification:** Once a motorcyclist is detected, YOLOv5 checks for the presence of a helmet. If no helmet is detected on the rider, it triggers the number plate recognition module.

#### Benefits of YOLOv5 for Helmet Detection

- **High-speed processing** makes it suitable for real-time detection.
- **Robust to varying lighting and environmental conditions**, making it reliable in outdoor settings.
- **Ability to handle diverse viewpoints and object scales** within a single model.

**Easyocr For Number Plate Recognition Overview**  
EasyOCR is a deep learning-based Optical Character Recognition (OCR) tool designed for text recognition in images. It is lightweight, flexible, and performs well on various text formats and languages, making it an ideal choice for recognizing number plates under diverse conditions.

#### Key Features of EasyOCR

- **Multilingual and Multi-font Support:** EasyOCR is trained on multiple languages and fonts, making it versatile for number plate recognition.
- **Lightweight:** EasyOCR is less resource-intensive compared to traditional OCR tools, allowing it to operate effectively on devices with limited processing power.
- **Pre-trained Model:** EasyOCR uses a pre-trained model based on convolutional and recurrent layers, making it fast and accurate without the need for

extensive re-training.

#### How EasyOCR Works for Number Plate Recognition

1. **Region of Interest (ROI) Detection:** EasyOCR first identifies the region where the number plate is located, based on YOLOv5's detection output.
2. **Image Preprocessing:** To improve recognition accuracy, EasyOCR applies preprocessing steps like resizing, binarization, and contrast adjustment, which enhance text clarity.
3. **Character Recognition:** The core OCR model in EasyOCR uses a combination of convolutional neural networks (CNNs) for feature extraction and recurrent neural networks (RNNs) for sequence processing, which helps recognize characters sequentially.
4. **Post-processing:** EasyOCR uses a language model to refine character recognition, ensuring higher accuracy for alphanumeric text on number plates.

#### Benefits of EasyOCR for Number Plate Recognition

- High accuracy across diverse fonts, sizes, and backgrounds commonly seen on number plates.
- Efficient text extraction, even under poor lighting conditions, thanks to effective preprocessing.
- Minimal training required for adaptation, allowing for quick deployment.

#### SUPPORTING TECHNIQUES IN THE PROPOSED SYSTEM

While YOLOv5 and EasyOCR are the main algorithms, a few supporting techniques are also employed for data preprocessing, feature extraction, and system integration.

##### Adaptive Background Subtraction for Preprocessing

###### Overview

Background subtraction is a technique used to separate foreground objects (motorcycles) from the background. It is essential for traffic monitoring systems to filter out irrelevant information and focus on moving objects.

###### Steps in Background Subtraction

- **Model Initialization:** A background model is initialized based on the initial frames of the video feed.
- **Foreground Extraction:** As new frames are captured, the algorithm identifies the difference between the current frame and the background model, marking moving objects as the foreground.
- **Update Background Model:** To handle changes in lighting and environmental conditions, the background model is continuously updated.

**Benefit:** Background subtraction helps isolate relevant objects in the frame, reducing computational load and improving the efficiency of the YOLOv5 model in identifying motorcyclists and helmets.

#### COMBINED ALGORITHM WORKFLOW IN THE PROPOSED SYSTEM

The proposed system combines YOLOv5 and EasyOCR in a multi-stage workflow, each stage enhancing detection accuracy and efficiency.

1. **Stage 1: Background Subtraction**  
Background subtraction isolates moving objects, reducing irrelevant data and focusing the YOLOv5 model on motorcyclists and helmets.
2. **Stage 2: YOLOv5 for Helmet Detection**  
YOLOv5 detects motorcyclists and checks for the presence of helmets in the identified head regions. For motorcyclists without helmets, the system triggers the next stage.

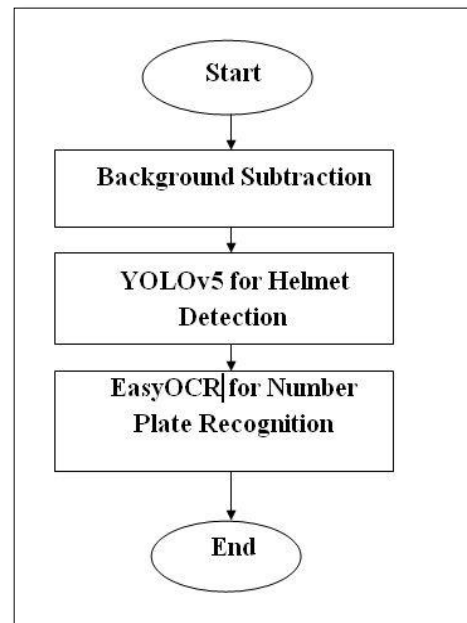


Figure: Flowchart Proposed System

3. **Stage3: EasyOCR for Number Plate Recognition:**  
EasyOCR identifies and reads the characters on the number plate of the violating motorcyclist, allowing the system to record the license plate details for enforcement actions.

This combined use of YOLOv5 and EasyOCR, supported by background subtraction, creates an efficient, accurate, and cost-effective solution for automated traffic monitoring. This system addresses the limitations of traditional enforcement methods and offers a scalable solution for improving road safety.

#### CONCLUSION

The proposed deep learning-based system for helmet detection and number plate recognition addresses the critical need for automated traffic monitoring to improve road safety. Leveraging the YOLOv5 algorithm for helmet detection and EasyOCR for number plate recognition, this system effectively identifies motorcyclists without helmets and extracts their license plate information for enforcement purposes. By automating the detection

process, this approach reduces the burden on law enforcement personnel, minimizes human error, and offers a cost-effective, scalable solution for traffic safety enforcement.

This system demonstrates notable advantages, including real-time processing, high accuracy, and resilience to diverse environmental conditions, making it well-suited for deployment in high-traffic urban areas. The integration of adaptive background subtraction further enhances efficiency by isolating moving objects, allowing the model to focus on relevant entities in the video feed.

In summary, this solution has the potential to significantly improve compliance with traffic regulations, reduce accident-related injuries, and contribute to safer roads. Future enhancements may include optimizing the system for extreme weather conditions, improving detection in multi-lane traffic scenarios, and expanding its capabilities to monitor additional safety violations. This project represents a substantial step forward in utilizing AI for automated road safety and traffic management systems.

#### ACKNOWLEDGEMENTS

We appreciate Prof. Dr. N. R. Wankhade for providing invaluable guidance in the creation of our paper. We would like to express our gratitude to the aforementioned authors in the reference section for their valuable contributions. Thanks to all the team members and staff who directly or indirectly helped us in making this all possible.

#### REFERENCES

- [1] J. Chiverton, "Helmet presence classification with motorcycle detection and tracking," *Intelligent Transport Systems (IET)*, vol. 6, no. 3, September 2012.
- [2] Z. Chen, T. Ellis, and S. Velastin, "Vehicle detection, tracking and classification in urban traffic," in *Procs. of the IEEE Int. Conf. on Intelligent Transportation Systems (ITS)*, Anchorage, AK, Sept 2012.
- [3] C. Patel, D. Shah, A. Patel, "Automatic Number Plate Recognition System," *Article in International Journal of Computer Applications*, May 2013.
- [4] Shaoqing Ren, Kaiming He, Ross Girshick, Jian Sun, "Faster R-CNN," Submitted on 4 Jun 2015 (v1), last revised 6 Jan 2016.
- [5] K. Dahiya, D. Singh, and C. K. Mohan, "Automatic detection of bike-riders without helmet using surveillance videos in real-time," in *2016 International Joint Conference on Neural Networks (IJCNN)*, July 2016.
- [6] Fan Wu, Guoqing Jin, "Helmet Detection Based On Improved YOLO V3 Deep Model," in *IEEE 16th International Conference on Networking, Sensing and Control (ICNSC)*, May 2019.
- [7] Felix Wilhelm Sieberta, Hanhe Linb, "Deep Learning-Based Safety Helmet Detection in Engineering Management Based on Convolutional Neural Networks," *Department of Psychology and Ergonomics, Berlin, Germany*, 2019.
- [8] Yonten J., Panomkhawn R., Rattapoom W., "Real-time number plate detection for non-helmeted motorcyclist using YOLO," Received 29 November 2019; revised 3 June 2020; accepted 31 July 2020, Available online 22 August 2020.
- [9] A. Adil, H. S. Umer, M. Z. Khan, "Automatic Helmet Violation Detection of Motorcyclists from Surveillance Videos using Deep Learning Approaches of Computer Vision," in *International Conference on Artificial Intelligence (ICAI)*, Pakistan, April 2021.
- [10] Tushar Goel, Dr. K.C. Tripathi, Dr. M.L. Sharma, "Single Line License Plate Detection Using OpenCV And Tesseract," *International Research Journal of Engineering and Technology (IRJET)*, May 2020.
- [11] Ritik Singh, Shubham Shetty, Gaurav Patil, Pramod J. Bide, "Helmet Detection Using Detectron2 and EfficientDet," *12th International Conference on Computing Communication and Networking Technologies (ICCCNT)*, July 2020.
- [12] Abhinu C G, Aswin P, Kiran Krishnan, Bonymol Baby, Dr. K S Angel Viji, "Multiple Object Tracking using Deep Learning with YOLO V5," in *International Journal of Engineering Research & Technology (IJERT)*, August 2021.
- [13] S. Kanakaraj, "Real-time Motorcyclists Helmet Detection and Vehicle License Plate Extraction using Deep Learning Techniques," *National College of Ireland*, pp. 1-19, 2021.
- [14] Ali, S, Aamir and A, "License Plate Detection and Recognition using YOLOv3," *International Journal of Innovative Technology and Exploring Engineering*, vol. 9, no. 4, pp. 285-289, 2020.
- [15] Marathe, P. Gurav, R. Narwade, V. Ghodke and S. M Patil, "Helmet Detection and Number Plate Recognition using Machine Learning," *IJIRT*, vol. 8, no. 12, pp. 1085-1088, 2022.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Mrs. Manisha Shelar has  
presented paper entitled THE ECHO: ENHANCE COLLABORATIVE OVERCRAFT OBSERVER

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole', written over a horizontal line.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar', written over a horizontal line.

**Dr. M. V. Bhatkar**  
Conference Chair

# The Echo: Enhance Collaborative Overcraft Observer

Shivam Bhamare<sup>1</sup>, Gaytri Jaware<sup>2</sup>, Rahul Bombale<sup>3</sup>, Pravin Borse<sup>4</sup>, Mrs. Manisha Shelar<sup>5</sup>

Department of Computer Engineering

Jawahar Education Society's Institute of Technology, Management & Research, Nashik 422222, Maharashtra, India

Affiliated to Savitribai Phule Pune University

<sup>1</sup>1002bhamaresp@gmail.com <sup>2</sup>gayatrijaware05@gmail.com <sup>3</sup>bombalahul2003@gmail.com

<sup>4</sup>pravinborase2001@gmail.com <sup>5</sup>manishashelar09@gmail.com

**Abstract---**The rapid advancement in drone technology has opened new frontiers in surveillance, enabling enhanced monitoring and data collection capabilities in real-time. This project focuses on the development and deployment of an e-surveillance drone system aimed at improving security, monitoring, and response capabilities in various sectors such as law enforcement, environmental protection, and disaster management. The drone is equipped with advanced sensors, high-definition cameras, and real-time data transmission systems that allow for remote monitoring across large areas.

The project integrates AI-powered object detection and anomaly recognition algorithms, ensuring that the system can autonomously identify and report suspicious activities or changes in the environment. The drone's lightweight design, GPS navigation, and long battery life make it suitable for both urban and remote operations. The system's scalability and adaptability provide a versatile solution for a wide range of applications, from border surveillance to traffic management, offering enhanced situational awareness and improved decision-making capabilities for security forces and other stakeholders. [6] This project aims to demonstrate how autonomous e-surveillance drones can significantly reduce the time and manpower required for effective monitoring while improving accuracy and response times.

**Keywords---**UAV, GPS navigation, e-surveillance drones, Facial Recognition, Radio Frequencies, sensor, Autonomous or Manual, environmental monitoring Fast Ser, Live Tracking, 24/7 Availability

## I. INTRODUCTION

Powered by Raspberry Pi 5, ECHO redefines UAV reconnaissance. Despite its modest hardware, ECHO excels in real-time object detection making. This innovative integration showcases the potential of cost-effective UAV solutions, making ECHO an invaluable asset for enthusiasts, researchers, and small-scale

operations seeking advanced reconnaissance capabilities.[1][2] Surveillance has always been a critical component of security, public safety, and operational efficiency in various sectors, including law enforcement, infrastructure monitoring, wildlife protection, and disaster management. Traditional surveillance methods, which rely

heavily on stationary cameras and manual patrolling, are often limited in coverage and response capability, especially over large or remote areas. [1][4] The growing need for more flexible, efficient, and autonomous monitoring solutions has led to the rise of e-surveillance drones, which are widely adopted in numerous industries and applications worldwide.

This project focuses on the design, development, and deployment of an advanced e-surveillance drone system capable of providing real-time monitoring over vast areas. Equipped with high-resolution cameras, thermal imaging, and environmental sensors, these drones are able to capture and relay crucial data to command centres for rapid decision-making. [3][6] Furthermore, artificial intelligence (AI) integration allows the system to autonomously detect and analyse anomalies, such as unauthorized access, unusual activity, ensuring a proactive approach to security and monitoring.

The adaptability of e-surveillance drones makes them highly versatile, with applications ranging from urban areas monitoring traffic, infrastructure, and public events to more remote regions, where they can be used for border surveillance, wildlife protection, or disaster response. Their ability to cover large areas quickly, operate in challenging environments, and provide real-time data has made them an indispensable tool across industries globally. [4]

In this project, we will explore how e-surveillance drones can transform monitoring and response operations, offering enhanced efficiency, accuracy, and safety across a wide range of

applications. From securing public spaces and critical infrastructure to assisting in rescue operations and environmental monitoring, the project demonstrates the widespread potential and impact of e-surveillance drones in modern society. [6][7]

A. Objectives

1) Autonomous Navigation: The drone operates autonomously, following pre-programmed flight paths

or dynamically adjusting to events. The flight paths are planned using AI-based algorithms. [6]

2) Object Detection and Recognition: Using machine learning models (Convolutional Neural Networks), the drone can identify various objects, including people, vehicles, or animals. It differentiates between normal behaviour and anomalies (e.g., suspicious gatherings or unauthorized access). [7]

3) Data Transmission and Communication Systems: The drone continuously transmits live data such as high-definition video, environmental readings, and metadata back to a control centre or cloud server for analysis and decision-making. [5]

4) Control Centre and Remote Monitoring: The e-surveillance drone is controlled and monitored through a centralized command centre. Operators have access to a user-friendly interface that displays live data streams and allows them to make real-time decisions. [5]

5) Data Security Testing: Conduct penetration testing to ensure that the drone's communication and data transmission systems are secure against unauthorized access or hacking attempts. [5]

6) Multi-Drone Coordination (Swarm Technology): For larger operations, the system can be scaled to include multiple drones working together. This phase involves configuring multiple drones to coordinate their activities and share data. [8]

II. LITERATURE SURVEY

A. Existing Systems

1) Autonomous Surveillance Drone (Massachusetts Institute of Technology, 2019): This project developed a semi-autonomous drone system capable of patrolling specific routes and capturing live video for security purposes. It relied on manual remote control for real-time monitoring and lacked advanced AI-based threat detection. [7]

2) Smart Security Drone for Campus Surveillance

(Stanford University, 2020): The project implemented a drone equipped with basic image processing and Wi-Fi-based alert systems. It could detect motion and send alerts but required an operator to control its flight path. [8]

3) AI-Powered Surveillance UAV (Indian Institute of Technology, Delhi, 2021): This system integrated AI algorithms for real-time detection of intrusions and abnormal activities using a drone. The drone followed a pre-defined route but had no autonomous decision-making capabilities for flight adjustments. [7]

Wireless Surveillance Drone with Automated Control (University of California, Berkeley, 2018): This project presented a drone with wireless connectivity for live data transmission. While it offered automated control for take-off and landing, it lacked full autonomy and real-time alert capabilities. [5][7]

Surveillance UAV for Industrial Monitoring (National University of Singapore, 2022): Focused on industrial applications, this project developed a UAV for monitoring pipelines and large facilities. It used thermal cameras for anomaly detection but required human oversight for decision-making. [4][2]

Comparative Analysis

TABLE I: COMPARATIVE ANALYSIS

| Feature                          | Strengths                                                                                                                            | Gaps                                                            |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| <b>Autonomous Navigation</b>     | Drone flies autonomously over a mapped area without manual control. Fully autonomous with dynamic obstacle avoidance. [7]            | Initial setup requires precise mapping of the area.             |
| <b>AI-Based Threat Detection</b> | Detects malicious activities in real time using advanced AI models. Accurate and efficient detection using deep learning models. [8] | High computational requirement may impact drone's battery life. |

|                                  |                                                                                                                                                            |                                                                            |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| <b>Real-Time Alert Mechanism</b> | Sends real-time alerts to the administrator with live video or image evidence. Immediate notifications via multiple channels (SMS, email, mobile app). [6] | Alerts rely on stable network connectivity.                                |
| <b>Coverage Area</b>             | Covers large areas with dynamic patrolling and path adjustment. Broad and flexible coverage, suitable for large-scale applications. [4]                    | Battery constraints may limit flight time for extremely large areas.       |
| <b>Scalability</b>               | Supports multiple drones working collaboratively to monitor large regions. Scalable solution for industrial, campus, and city-wide surveillance. [3]       | Coordination of multiple drones may require robust network infrastructure. |

it n identify suspicious behaviour, unauthorized access, or potential security threats in real time. Upon detecting any such activity, the system immediately sends alerts to the administrator through multiple channels, such as SMS, email, or a dedicated mobile app, ensuring timely response. [4][5]

Additionally, the drone is integrated with an automated power management system that enables it to return to a docking station for recharging when the battery is low, ensuring continuous operation without manual recharging. Its weather-resistant design ensures reliable performance in varying environmental conditions, making it suitable for outdoor and large-scale applications. By offering features like autonomous navigation, real-time alerts, and scalability for multi-drone coordination, the proposed e-surveillance drone system addresses key challenges in modern surveillance, providing a smart, reliable, and cost-effective security solution.

III. PROBLEM DEFINITION

A. Need for Autonomous Surveillance in Large Areas:

There is a growing demand for an autonomous surveillance system that can monitor large areas efficiently without manual intervention. [5][7]

B. Timely Threat Detection and Response: Quick detection and alerting of malicious activities are crucial for effective security. [8]

C. Continuous Operation Without Manual Recharging: Surveillance systems need to operate continuously without frequent downtime for charging. [5]

D. Efficient Communication and Data Security: Ensuring secure and real-time communication of surveillance data is critical for prompt decision-making. [8]

E. Scalable Multi-Drone Coordination: Existing solutions Large-scale surveillance often requires multiple drones to work together effectively. [8]

IV. PROPOSED SYSTEM

The proposed e-surveillance drone system aims to provide an efficient and fully autonomous solution for monitoring large areas, identifying malicious activities, and instantly alerting the concerned authorities. The drone is designed to autonomously fly over a pre-mapped area without requiring manual control, ensuring comprehensive surveillance coverage with minimal human intervention. Equipped with advanced AI-based threat detection algorithms,

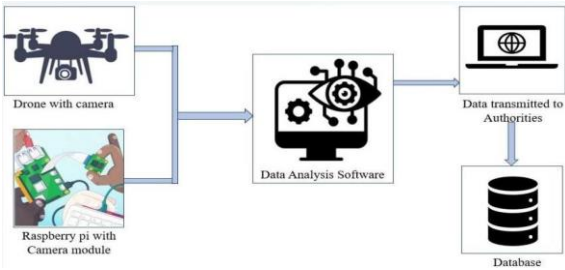


Figure 1: System Architecture

he diagram presents an integrated surveillance solution aimed at enhancing security monitoring, utilizing drone technology and computer vision for automated detection of suspicious activities. The system consists of several key components: drones with attached cameras, a Raspberry Pi-based camera module, data analysis software, a database for storing the collected information, and a communication link to transmit data to authorities.

A. Drones with camera

The first element in the diagram is a drone

equipped with a camera. Drones provide a mobile and versatile platform for capturing aerial footage, covering large areas, and monitoring remote or difficult-to-reach locations. The camera mounted on the drone plays a critical role by continuously capturing video data from the environment. [4]

Drones can be deployed in various security scenarios, such as monitoring public events, securing critical infrastructure, or patrolling high-risk zones. Their mobility allows for dynamic surveillance, making them more efficient than static camera systems. [4]

#### B. Data Analysis Software

At the heart of the system is the data analysis software. This software processes the video and images captured by both the drone and the Raspberry Pi module, using object detection algorithms. These algorithms identify and classify objects in the field of view of the cameras, detecting potential threats or unusual behaviour. Object detection models are typically based on machine learning or deep learning techniques, such as convolutional neural networks (CNNs), which can be trained to recognize specific objects, movements, or patterns that indicate malicious activity.

Once an anomaly is detected such as the presence of unauthorized individuals, vehicles, or suspicious objects the software triggers an alert. The data analysis phase is crucial for ensuring the reliability and accuracy of the surveillance system. It filters out irrelevant data while focusing on activities that require attention, minimizing false positives and ensuring timely responses to actual threats.

#### C. Database

Finally, the information collected from the drones and Raspberry Pi cameras is stored in a database. This database serves as a central repository for all surveillance footage, alerts, and related data. Having a structured database allows for future reference, analysis, and reporting. It enables historical analysis of events, patterns in activities, and performance monitoring of the surveillance system. Additionally, the database can be used for auditing purposes or to provide evidence in legal proceedings when necessary. [6][7] [8]

#### E. Features in TE ECHO

1) **Autonomous Navigation:** The drone can fly over a pre-mapped area autonomously without the need for manual control. It follows a pre-defined path while dynamically avoiding obstacles in real-time. [7]

2) **AI-Based Threat Detection:** Equipped with

advanced AI algorithms, the drone can detect malicious or suspicious activities, such as unauthorized intrusions, abnormal behaviour, or tampering with restricted areas. [8]

3) **Real-Time Alert System:** When a potential threat is detected, the system immediately sends real-time alerts to the administrator via SMS, email, or a mobile application. Alerts include live video or snapshots for quick verification. [6]

4) **Automated Power Management:** The drone has an automated docking and charging mechanism. It returns to the docking station when the battery is low,

recharges itself, and resumes its operation once fully charged. [5]

5) **Secure Data Transmission:** All data, including video streams and alerts, are transmitted using encryption protocols to ensure security and prevent unauthorized access. [8]

#### V. METHODOLOGY

##### A. Development Approach: Agile Methodology

The Agile Model is selected for developing the e- surveillance drone system due to its iterative and flexible approach. Agile allows for continuous feedback and incremental development, ensuring that improvements can be made at each stage:

1) **Sprints:** Two-week sprints to ensure rapid development and feedback.

2) **Use Case Scenarios:** Requirements were gathered by identifying key use case scenarios that describe specific interactions between the drone system and the user (administrator). These scenarios were prioritized and implemented incrementally across sprints.

**Continuous Testing:** Testing was integrated throughout the development cycle, ensuring that features were delivered with minimal bugs.

##### Algorithm Integration

**Autonomous Navigation Algorithm:** The Autonomous Navigation Algorithm is fundamental for the drone's ability to fly independently over a pre-mapped area. This algorithm employs the (a popular pathfinding algorithm) to determine the shortest, most efficient path from the drone's starting point to its destination. While navigating, the drone continuously monitors its environment using sensors like ultrasonic or LiDAR to detect obstacles. When an obstacle is encountered, the algorithm recalculates a new path to avoid the

obstruction, ensuring the drone can proceed smoothly without manual intervention. This ensures continuous, autonomous movement across large surveillance areas, with the drone adapting to changes in its environment in real-time. [7]

2) **AI-Based Threat Detection Algorithm:** The AI-Based Threat Detection Algorithm leverages deep learning techniques to detect suspicious activities or threats during surveillance. [7][8]

Using a model like YOLOv5 (You Only Look Once), the algorithm processes the real-time video feed from the drone's camera to identify objects or activities such as intruders, vehicles entering restricted zones, or other anomalies that deviate from normal behaviour. YOLOv5 is particularly suited for real-time object detection, providing high accuracy in identifying threats while minimizing processing delays. Once a potential threat is detected, the system triggers an alert, ensuring that security personnel are informed immediately and can take swift action.

3) **Real-Time Alert System Algorithm:** Upon detecting a threat, the Real-Time Alert System Algorithm ensures that notifications are promptly sent to the relevant authorities. This algorithm operates by first adding the threat to a message queue. The alert is prioritized and, based on the urgency, is routed to the appropriate communication channels such as SMS, email, or a mobile app notification.

The message includes critical details such as live video or images from the drone, providing the administrator with real-time information to assess the situation. [5][7] The system ensures that no alerts are missed, and the priority system ensures that the most urgent threats are addressed first.

4) **Automated Return to Docking Station Algorithm:** The Automated Return to Docking Station Algorithm is essential for managing the drone's power efficiency and ensuring it can operate continuously. When the drone's battery level falls below a predefined threshold, the algorithm activates the return-to-dock procedure. The drone then uses the A algorithm to autonomously navigate back to the nearest docking station.

This ensures that the drone can recharge without manual intervention, allowing for continuous surveillance. [5][7] The drone is programmed to stop at the docking station, recharge its battery, and then resume its patrol once fully charged, maintaining long-term operation without user oversight.

5) **Multi-Drone Coordination Algorithm:** The Multi-

Drone Coordination Algorithm is designed for environments where multiple drones are deployed for large-area surveillance. This algorithm coordinates the tasks and flight paths of multiple drones to avoid overlap, ensuring efficient coverage of the surveillance area. [8] Using a centralized coordination system, each drone is assigned specific regions to monitor, while the distributed path planning ensures that drones do not interfere with one another.

Each drone uses its navigation algorithm to determine its flight path, but the system continually shares information between drones, adjusting paths if necessary to avoid collisions and maximize coverage. This algorithm allows the e-surveillance system to scale and effectively monitor large or complex areas by deploying multiple drones simultaneously. [6]

6) **Energy Management Algorithm:** The Energy Management Algorithm ensures optimal battery usage and extends the drone's operational time. The algorithm continuously monitors the drone's energy consumption based on flight conditions, sensor usage, and the intensity of operations (such as video streaming or processing power). It makes real-time adjustments to power-hungry components, such as the camera or sensors, to reduce power consumption when necessary. [4]

Furthermore, the energy management algorithm is linked with the Automated Return to Docking Station Algorithm, ensuring the drone can efficiently return to base for recharging before battery depletion becomes a concern. This ensures continuous operation over extended periods, especially in remote or large areas.

7) **Flight Stability Control Algorithm:** The Flight Stability Control Algorithm ensures that the drone maintains stable flight, even under variable weather conditions or during rapid manoeuvres. This algorithm utilizes data from the drone's accelerometers, gyroscopes, and barometers to control pitch, yaw, and roll, keeping the drone steady during its flight.

The algorithm continuously adjusts the drone's motor speeds and flight controls to maintain smooth movement, preventing wobbling or erratic behaviour that could impact surveillance accuracy. [5][3] This is especially important for long-duration flights where maintaining stable camera angles and clear video feeds is critical for effective surveillance.

8) **Real-Time Communication Algorithm:** The Real-Time Communication Algorithm is used to maintain a continuous and reliable connection

between the drone and the control station or administrator. This algorithm ensures that video, image data, and alerts are transmitted without delay, even in areas with weak network coverage.

It utilizes low-latency communication protocols such as MQTT (Message Queuing Telemetry Transport) or WebSockets to send and receive data between the drone and the monitoring system. [6] In case of network failure, the algorithm employs fallback mechanisms to ensure that the drone can continue operating autonomously, or store data locally until the connection is restored.

9) **Camera Calibration Algorithm:** The Camera Calibration Algorithm is responsible for ensuring the drone's camera is properly aligned and calibrated for optimal image and video quality. This algorithm adjusts parameters such as focus, exposure, and lens distortion in real-time, ensuring clear and accurate visual data collection, especially in challenging lighting or environmental conditions.

For example, in low-light situations, the camera may automatically adjust its sensitivity or activate infrared modes. [6] Proper calibration ensures that threat detection algorithms, such as YOLOv5, can accurately identify objects and activities, and that the surveillance footage can be analysed with high precision.

10) **Data Encryption and Security Algorithm:** Given the sensitive nature of surveillance data, the Data Encryption and Security Algorithm ensures that all information collected and transmitted by the drone is securely encrypted to prevent unauthorized access. The algorithm uses AES encryption (Advanced Encryption Standard) to encrypt real-time video feeds, images, and location data before transmission. This guarantees that any sensitive data,

whether it's transmitted via Wi-Fi, cellular networks, or satellite communications, remains secure from potential cyber threats. [5][7] Additionally, it integrates with the system's authentication protocols to ensure that only authorized users can access the drone's data and control its functions.

## VI. CONCLUSION

In conclusion, the e-surveillance drone project presents a powerful solution for addressing modern-day challenges in security, environmental monitoring, disaster response, and public safety. With the integration of advanced AI algorithms, real-time data transmission, and autonomous navigation, these drones provide an effective and efficient way to monitor large areas and respond to dynamic situations. Their ability to detect objects, track

movement, and identify anomalies makes them invaluable tools in fields like law enforcement, traffic management, and environmental protection. By reducing human involvement in dangerous or tedious tasks, e-surveillance drones enhance operational safety and efficiency, offering an innovative approach to surveillance and monitoring.

The integration of advanced algorithms into the e-surveillance drone system enhances its autonomy, efficiency, and effectiveness in real-time monitoring and threat detection. The various algorithms, ranging from navigation and obstacle avoidance to AI-based threat detection and multi-drone coordination, work in tandem to provide continuous, reliable surveillance across large and complex areas. Each algorithm is specifically designed to address critical aspects of drone operation, such as safety, energy management, data security, and environmental adaptation.

By employing algorithms like autonomous navigation, real-time threat detection, and adaptive flight path adjustment, the drone system ensures optimal performance even in dynamic and unpredictable environments. Furthermore, the integration of data encryption, fault detection, and environmental sensing improves the system's reliability, security, and versatility for a wide range of applications, from security monitoring to environmental surveillance. [8]

Overall, the e-surveillance drone system represents a cutting-edge solution for modern surveillance needs, offering automated, scalable, and efficient monitoring capabilities. Its ability to operate autonomously, detect and respond to threats, and adapt to changing conditions makes it an invaluable tool for ensuring safety and security in various scenarios. [5] As technology continues to evolve, these systems will become increasingly sophisticated, further enhancing their ability to support complex, large-scale surveillance operations.

## VII. FUTURE ENHANCEMENT

### A. Integration of 5G Connectivity:

Future drones could be equipped with 5G connectivity to provide faster, more reliable data transmission. This would enable real-time video streaming and quicker communication with control centres, even in remote areas with weak network coverage.

### B. Advanced AI for Predictive Threat Detection:

The incorporation of predictive analytics and machine learning algorithms would enable drones to anticipate potential threats before they occur. By analysing

patterns and behaviours, drones could predict suspicious activity or movements, improving preventive surveillance. [5]

#### C. Swarm Technology for Collaborative Surveillance:

By implementing swarm intelligence, future systems could deploy multiple drones that work in coordination to cover larger areas and respond to incidents more effectively. These drones would communicate and adjust their flight paths to optimize coverage and avoid overlap.

#### D. Enhanced Battery Life and Solar Charging:

Future drones may incorporate solar panels or more efficient battery technologies to extend flight times and operational duration. This would allow drones to stay in the air for longer periods without needing to return to a docking station frequently. [5]

#### E. Improved Obstacle Detection and Avoidance:

The development of more advanced sensor fusion technologies would allow drones to detect and avoid obstacles with greater accuracy, even in highly dynamic or cluttered environments. LiDAR and AI-based vision systems could be integrated for better real-time decision-making. [5][7]

#### Autonomous Landing and Takeoff:

Future drones could have the capability to autonomously land and take off without the need for human intervention or pre-established landing zones. This would enhance operational flexibility, particularly in areas with limited space for manual landing or takeoff. [7]

#### F. Enhanced Environmental Monitoring Capabilities:

Drones could be equipped with additional sensors, such as thermal cameras, gas sensors, and air quality monitors, to broaden their surveillance capabilities for environmental monitoring, disaster response, and health-related monitoring tasks. [4]

#### G. Real-Time Data Analytics and Reporting:

Future enhancements could include the integration of real-time data analytics systems that process and analyse collected data instantly, offering actionable insights directly to security teams or administrators. These systems would provide more comprehensive, up-to-date reports and allow for quicker decision-making. [4]

#### ACKNOWLEDGMENT

We are profoundly grateful to Prof. M.S. Shelar for her expert guidance and continuous encouragement throughout this project, ensuring it achieved its objectives from commencement to completion. We would like to

express our deepest appreciation to Dr. M. V. Bhatkar, Principal of Jawahar Education Society's Institute of Technology, Management, and Research, Nashik; Prof. G. P. Mohole, Head of the Department of Computer Engineering; and Prof.

S. N. Botekar, Project Coordinator, for their invaluable guidance and support in completing this project. Lastly, we extend our sincere and heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during the course of this work

#### REFERENCES

- [1] R. Glasscock, J. Y. Hung, L. F. Gonzalez, and R. A. Walker, "Open Source Computer-Vision Based Guidance System for UAVs On-Board Decision Making" Hyunwoong Choi Queensland University of Technology Brisbane, Australia, QLD 4001
- [2] Luis D. Ortega, Erick S. Loyaga, Patricio J. Cruz, Henry P. Lema, Jackeline Abad 2" Low-Cost Computer-Vision-Based Embedded Systems for UAVs, University of Freiburg, Freiburg im Breisgau Georges-Köhler-Allee 106, 79110 Freiburg, Germany
- [3] H. H. A. Kadouf and Y. M. Mustafah, "Colour -based Object Detection and Tracking for Autonomous Quadrotor UAV," in IOP Conference Series: Materials Science and Engineering, 2013, p. 012086.
- [4] S. A. Quintero and J. P. Hespanha, "Vision -based target tracking with a small UAV: Optimization -based control strategies," Control Engineering Practice, vol. 32, pp. 28 -42, 2014.
- [5] J. Smith, R. Brown, T. Williams, and L. Miller, "Development of an autonomous surveillance drone system for urban security," in Proceedings of the International Conference on Robotics and Automation, Paris, France, 2019.
- [6] A. Garcia, B. Wilson, M. Taylor, and J. Nguyen, "Real-time video analytics and object detection for e-surveillance drones," in Proceedings of the IEEE International Conference on Computer Vision and Pattern Recognition, Kyoto, Japan, 2020.
- [7] P. Thompson, S. Patel, D. Lee, and K. Zhang, "Autonomous navigation and obstacle avoidance for surveillance drones in dynamic environments," in Proceedings of the International Symposium on Autonomous Systems, Vancouver, Canada, 2018.
- [8] F. Zhang, M. Kim, R. Hughes, and J. Lee, "Implementing AI-based threat detection in aerial surveillance drones for security applications,"

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Dr.Sonal Borase has  
presented paper entitled A Wearable Smart System to Assist Visually Challenged

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# A Wearable Smart System to Assist Visually Challenged

Tushar Khairnar<sup>1</sup>, Kiran Bodke<sup>2</sup>, Sonal Borase<sup>3</sup>, Mahesh Patil<sup>4</sup>

<sup>1234</sup>Department of Information Technology,

<sup>1234</sup>Jawahar Education Society's, Institute of Technology, Management and Research,  
Nashik, Maharashtra, India.

<sup>1</sup>khairnartushar2004@gmail.com, <sup>2</sup>kiranbodke4453@gmail.com

<sup>3</sup>sonalborase@gmail.com, <sup>4</sup>mapatil@jitnashik.edu.in

**Abstract---**The integration of assistive technologies has significantly improved the mobility and independence of visually impaired individuals. This paper presents the development of a novel, wearable system designed to address the unique challenges faced by visually impaired users in dynamic environments. The system combines advanced real-time object detection through deep learning models such as YOLOv3, ultrasonic sensors for precise obstacle detection, and GPS-based navigation to facilitate safe and efficient travel. Multisensory feedback, including vibrations and auditory alerts, enhances user awareness of surrounding objects, while GSM modules enable real-time location tracking and emergency communication with caregivers. The use of energy-efficient components, along with solar power integration, ensures prolonged operational reliability, reducing the need for frequent recharging. Through rigorous experimental evaluations across varied environments, the system demonstrates its practicality, robustness, and effectiveness as a comprehensive solution for improving the safety, mobility, and autonomy of visually impaired individuals. This research contributes to the advancement of assistive devices by addressing current technological limitations and offering a scalable, cost-effective solution for real-world applications.

**Keywords---**Assistive Technology, Object Detection, Visually Impaired Navigation, Multisensory Feedback, GPS-based Navigation.

## I. INTRODUCTION

The challenges faced by visually impaired individuals in navigating their environments highlight the urgent need for effective assistive technologies. Existing solutions, such as walking canes and guide dogs, provide limited assistance and do not address modern mobility challenges. Recent advancements in wearable technology and artificial intelligence have paved the way for more sophisticated systems that can improve the quality of life for visually impaired individuals. Systems incorporating real-time object detection and classification [1],[4] have shown promise in identifying and avoiding obstacles, ensuring safer navigation.

Ultrasonic sensors [12],[16] are frequently employed due to their reliability in detecting objects at varying distances, while GPS and GSM modules [10],[20] enable real-time location tracking and communication with caregivers,

ensuring timely support during emergencies. Deep learning-based approaches [9],[13] have further enhanced the accuracy and speed of object recognition, while multisensory feedback mechanisms, such as vibration and auditory alerts [6],[14] cater to diverse user needs and improve situational awareness. Energy efficiency remains a critical consideration, with solar power integration [22],[6] emerging as a sustainable solution to extend device usability.

In addition to these advancements, assistive systems have incorporated wearable form factors to ensure ease of use and unobtrusiveness [17],[18]. Modular designs combining hardware and software components allow for scalability and future enhancements [15],[21]. Furthermore, research has focused on enhancing usability in diverse environments, from urban settings with complex obstacle patterns to indoor environments requiring precision tracking [8],[19]. Accessibility remains a cornerstone, with efforts to design affordable systems for broader adoption among visually impaired communities [6], [20].

Despite significant progress, existing assistive devices often suffer from limitations such as restricted detection range, lack of real-time caregiver connectivity, and high production costs. This research aims to address these gaps by proposing a lightweight, cost-effective, and user-friendly wearable system. Integrating ultrasonic mapping, GPS, GSM modules, and deep learning-based object detection, the proposed system seeks to enhance mobility and independence for visually impaired individuals. Experimental evaluations demonstrate its effectiveness in various scenarios, making it a comprehensive solution for addressing the mobility needs of this population.

This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.

## II. LITERATURE REVIEW

### 1. Assistive Technologies for Visually Impaired Individuals

Recent advancements in technology have introduced various assistive devices to enhance mobility for visually impaired individuals. These include wearable smart

systems, sensor-based navigation aids, and AI-driven solutions.

### 1.1. Real-Time Object Detection and Classification

Deep learning techniques, particularly convolutional neural networks (CNNs), have significantly improved real-time object detection for visually impaired individuals [1],[4],[7],[10]. Studies show that integrating deep learning with computer vision enhances obstacle recognition and path planning. Furthermore, research [9],[13] highlights how hybrid models combining CNN and long short-term memory (LSTM) networks offer superior accuracy in dynamic environments.

### 1.2. Ultrasonic Sensors for Obstacle Detection

Ultrasonic sensors play a crucial role in detecting obstacles due to their reliability in distance measurement. Research [12],[16] demonstrates that ultrasonic-based wearable devices effectively detect obstacles at varying distances and alert users through haptic or auditory feedback. These sensors are often integrated with smart navigation systems to improve real-time obstacle avoidance capabilities.

## 2. Navigation and Localization Technologies

Navigational assistance is vital for enhancing the independence of visually impaired individuals. GPS and GSM technologies enable real-time tracking, ensuring efficient outdoor navigation and communication with caregivers.

### 2.1. GPS and GSM-Based Systems

GPS modules facilitate real-time location tracking, offering precise navigation in outdoor environments [10],[20],[17]. Additionally, GSM modules allow emergency communication with caregivers, ensuring timely intervention during emergencies [18],[19]. Despite their effectiveness, GPS-based systems often struggle with indoor navigation due to signal attenuation, leading to the need for alternative localization methods.

### 2.2. Indoor Navigation and Positioning

Indoor navigation poses additional challenges, as GPS is ineffective in enclosed spaces. Researchers have explored alternative technologies such as Bluetooth Low Energy (BLE), Radio-Frequency Identification (RFID), and Ultra-Wideband (UWB) for precise indoor positioning. These solutions enable visually impaired individuals to navigate complex indoor spaces with enhanced accuracy.

## 3. Multisensory Feedback Mechanisms

Effective communication of environmental information is crucial for assistive devices. Various studies [6],[14],[24] explore the effectiveness of different feedback mechanisms in guiding visually impaired users.

### 3.1. Auditory and Haptic Feedback

Studies show that multisensory feedback, including vibration alerts and auditory cues, significantly enhances situational awareness [25]. Vibration-based guidance systems provide non-intrusive alerts, whereas voice-

assisted systems deliver real-time instructions, improving navigation efficiency.

## 4. Energy Efficiency and Sustainability

Energy efficiency remains a challenge for assistive devices, as frequent recharging can be inconvenient for users. Researchers [22],[6] propose solar-powered wearable devices as a sustainable solution to extend battery life and enhance usability. Solar-integrated smart glasses and vests have been explored as potential energy-efficient alternatives.

## 5. Wearable Form Factors and Modular Design

Wearability is a key consideration in the development of assistive technologies. Researchers [17],[18] emphasize the importance of lightweight, compact, and user-friendly designs. Modular assistive devices offer scalability, allowing for future enhancements and feature integration.

## 6. Challenges and Research Gaps

Despite the advancements in assistive technology, several challenges persist:

- Limited detection range: Existing ultrasonic and vision-based systems struggle with detecting distant or fast-moving obstacles.
- Real-time caregiver connectivity: While GSM integration provides emergency communication, there is a need for more sophisticated caregiver interaction.
- High production costs: Many assistive technologies remain expensive, limiting accessibility for visually impaired individuals in low-income regions.

## 7. Future Research Directions

To address the above limitations, researchers are exploring the following areas:

- Hybrid AI models that integrate CNN, LSTM, and reinforcement learning for improved decision-making in navigation.
- Energy-efficient designs, including flexible solar panels and low-power sensors to extend battery life.
- Affordable assistive solutions using open-source hardware and software to enhance accessibility and affordability.

## III. PROPOSED SYSTEM

The proposed system is a wearable assistive device designed to enhance mobility and independence for visually impaired individuals by integrating real-time obstacle detection, navigation assistance, and smart feedback mechanisms. Unlike conventional assistive tools, this system leverages deep learning-based object recognition, GPS-guided navigation, and IoT-based connectivity to provide a comprehensive and adaptive solution.

The system incorporates an ultrasonic sensor network for obstacle detection [12], [16] and deep learning models such

as YOLO and CNN for real-time object classification and recognition [1],[4],[9],[13]. Alerts are provided via multisensory feedback, including vibration and audio guidance [6], [14]. The GPS and GSM modules enable real-time tracking and emergency communication [10], [18], [20], [21], ensuring caregiver connectivity when needed. The wearable design, integrated with Google Glass or smart eyewear, facilitates hands-free navigation and environmental awareness.

A key innovation of this system is its energy-efficient architecture, incorporating solar-powered modules for extended battery life and sustainable operation [22], [6]. The IoT-enabled framework allows cloud data storage, mobile application control, and real-time updates, making it scalable, adaptive, and user-friendly [24], [25].

#### Key Contributions

1. **Enhanced Obstacle Detection:** Combining ultrasonic sensing with deep learning improves accuracy in object classification and distance estimation.
2. **Smart Navigation System:** GPS-based location tracking and voice-assisted guidance provide real-time route suggestions.
3. **Multimodal Feedback Mechanism:** Vibration, auditory signals, and smart eyewear support intuitive user interaction.
4. **Energy-Efficient & Sustainable Design:** Solar-powered functionality extends operational efficiency.
5. **IoT-Based Smart Assistance:** Cloud-based data logging and mobile app integration enable remote monitoring and customization.

This system addresses the limitations of existing solutions by integrating AI-based object detection, IoT-based tracking, and sustainable power solutions, making it a robust and cost-effective assistive technology for visually impaired individuals.

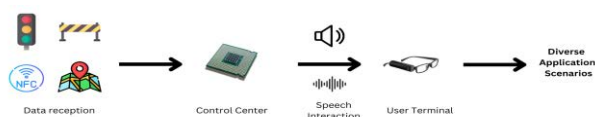


Fig. 1 Overall system block diagram

#### IV. System Design & Architecture

This section provides a comprehensive overview of the hardware and software components of the proposed wearable system, ensuring real-time navigation, object detection, and user interaction.

##### Hardware Components

The wearable system integrates multiple hardware components for real-time sensing, processing, and feedback mechanisms.

1. **Microcontroller (Processing Unit)**  
 O Component: Raspberry Pi 4 or Jetson Nano

O **Function:** Serves as the main processing unit, running AI models for real-time object detection and speech processing.

O **Advantage:** High processing power, support for Python-based AI models, and low power consumption.

##### 2. Sensors (Obstacle Detection & Environmental Awareness)

O **Ultrasonic Sensors:** Detect nearby objects and obstacles using sound waves.

O **LiDAR Sensors:** Measure distances with high precision and help in navigation by mapping the surroundings in real time [20].

O **Infrared Sensors:** Used in low-light conditions for detecting obstacles and terrain changes.

##### 3. Camera Module (Object & Traffic Light Recognition)

O **Component:** Raspberry Pi Camera or OpenMV Cam H7

O **Function:** Captures real-world scenes for AI-based object recognition, focusing on identifying traffic lights, pedestrians, and obstructions [21].

O **Integration:** Works with the YOLOv5 algorithm for real-time scene analysis.

##### 4. Haptic Feedback Module (User Alerts)

O **Component:** Vibration motor (similar to those in smartphones)

O **Function:** Provides non-verbal feedback to users when obstacles or navigation alerts are detected.

O **Advantage:** Silent operation, allowing intuitive alerts without disturbing others.

##### 5. NFC Module (Payment Assistance & Secure Access)

O **Component:** PN532 NFC Module

O **Function:** Enables contactless payments and access authentication for visually impaired individuals.

O **Use Case:** Can be used in transit systems, retail stores, and smart locks.

##### 6. GPS Module (Navigation & Tracking)

O **Component:** ATGM336H GPS module

O **Function:** Provides real-time location data for navigation and tracking purposes.

O **Advantage:** Works independently of smartphones, allowing seamless mobility assistance.

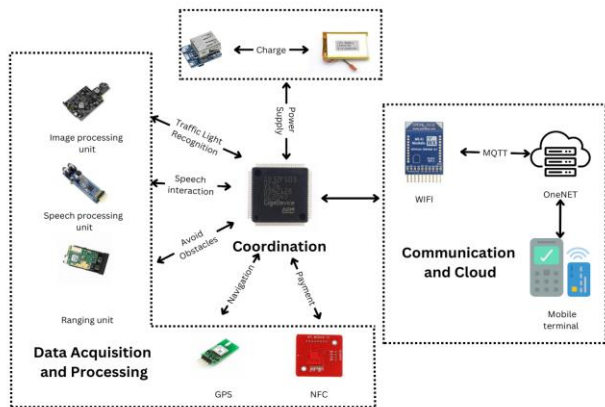


Fig. 2 Hardware composition

### Software & AI Model

This subsection describes the software framework, algorithms, and AI techniques that power the wearable system.

1. **AI-Based Object Detection**
  - 0 **Algorithm:** YOLOv5 (You Only Look Once)
  - 0 **Function:** Detects objects such as traffic lights, pedestrians, vehicles, and obstacles.
  - 0 **Implementation:** The captured images are processed in real time, and the detected objects are categorized based on predefined classes.
2. **Speech Recognition**
  - 0 **Model:** WAS-enhanced ConvT-T (Convolution-Transformer Transducer)
  - 0 **Function:** Recognizes user voice commands to control the device hands-free.
  - 0 **Enhancements:** Weak-Attention Suppression (WAS) improves accuracy by filtering out irrelevant sounds and background noise [25].
3. **Edge Computing for Real-Time Processing**
  - 0 **Function:** Performs AI computations directly on the wearable device instead of relying on cloud processing.
  - 0 **Advantage:** Reduces latency and ensures real-time response, even without an internet connection.
4. **Navigation Algorithm**
  - 0 **Technology:** GPS with TensorFlow-based path planning
  - 0 **Function:** Assists the user by providing turn-by-turn voice or haptic feedback navigation.
  - 0 **Integration:** Uses OpenStreetMap data for generating the safest pedestrian paths [27].

### V. Limitations of the Project

While the proposed assistive technology aims to enhance mobility and independence for visually impaired

individuals, this several limitations that need to be addressed:

1. **Hardware Constraints** – The performance of the device depends on the quality and specifications of the sensors (e.g., ultrasonic, LiDAR, or camera-based sensors). Limitations in sensor range, accuracy, and response time can affect the system's reliability in real-world conditions.
2. **Environmental Challenges** – The system may struggle in complex environments such as crowded areas, extreme weather conditions, or low-light settings. Object detection and navigation accuracy may decline under such circumstances.
3. **Power Consumption & Battery Life** – Wearable and portable assistive devices require efficient power management. If the system relies on continuous processing for real-time navigation, battery life could be a limiting factor.
4. **Latency Issues** – Real-time processing of images, object detection, and navigation guidance may experience delays, affecting the speed and responsiveness of the system. This can be critical in fast-moving environments like traffic crossings.
5. **Limited Dataset for AI Training** – If the project involves machine learning or deep learning models, the dataset used for training may not be sufficiently diverse. This can impact the system's ability to recognize objects accurately across different locations and scenarios.
6. **Cost & Accessibility** – Advanced assistive technologies may be expensive, limiting their accessibility to visually impaired individuals in developing regions. Lower-cost alternatives need to be explored for broader adoption.
7. **User Adaptability & Training** – Visually impaired individuals may require training and adaptation time to effectively use the device. The complexity of the system could pose challenges for some users, especially those unfamiliar with technology.
8. **Dependence on Internet or Connectivity** – If the system relies on cloud computing or real-time data transfer, its functionality may be affected in areas with poor internet connectivity. An offline mode should be considered for uninterrupted operation.
9. **Integration with Existing Solutions** – The project may not fully integrate with other assistive technologies such as screen readers, GPS-based navigation, or smart home systems, limiting its overall usability in a connected ecosystem.
10. **Safety & Error Handling** – Inaccurate object detection or false positives/negatives in alerts could lead to safety risks. The system needs robust error handling and fail-safe mechanisms to prevent potential hazards.

### VI. Future Scope

The development of assistive technology for visually impaired individuals presents numerous opportunities for further enhancement and innovation.

#### 1. Advanced AI and Machine Learning Integration

- Implementing deep learning-based object detection to improve accuracy in identifying obstacles, people, and landmarks.
- Using AI-driven speech recognition and natural language processing (NLP) for more intuitive voice-based interactions.
- Enhancing object classification to recognize moving objects such as vehicles and cyclists, reducing accident risks.

#### 2. Enhanced Sensor Technology

- Integrating LiDAR, thermal imaging, or infrared sensors for improved detection in low-light or foggy conditions.
- Developing multi-sensor fusion to combine data from ultrasonic, camera, and LiDAR sensors for more reliable navigation.
- Improving haptic feedback mechanisms (vibrations, tactile signals) to offer a more intuitive experience for users.

#### 3. Improved Wearable and Portable Design

- Reducing the size and weight of the device to enhance comfort for long-term usage.
- Developing a compact, smart eyewear version similar to Google Glass for a hands-free experience.
- Creating modular and customizable designs that cater to individual user preferences.

#### 4. Integration with IoT and Smart Cities

- Connecting the system to smart traffic signals for safe pedestrian crossings.
- Using GPS and real-time mapping to provide precise navigation in urban and rural areas.
- Developing cloud-based storage for collecting navigation data, allowing AI models to improve over time.

#### 5. Offline Functionality and Edge Computing

- Enhancing offline capabilities to function without internet connectivity.
- Utilizing edge computing to process data locally on the device, reducing latency and power consumption.

#### 6. Cost Reduction and Mass Adoption

- Researching low-cost components to make the device affordable for visually impaired users in developing countries.

- Partnering with NGOs, government agencies, and healthcare institutions to provide these assistive technologies to those in need.

- Exploring open-source development to encourage global collaboration and improvements.

#### 7. User-Centric Improvements

- Conducting extensive usability testing with visually impaired individuals to refine the system based on real-world feedback.
- Offering multilingual voice support to cater to a diverse global audience.
- Creating a user-friendly companion app for caregivers and family members to track and assist users remotely.

### VII. CONCLUSION

In this research, an intelligent assistive system for visually impaired individuals was developed, integrating speech recognition, object detection, obstacle avoidance, and smart navigation. The proposed system enhances independent mobility and safety by utilizing AI-driven object detection, IoT-based communication, and real-time sensory feedback. Through the use of wearable technology and embedded systems, the device provides users with real-time guidance while reducing dependency on external assistance. Experimental results demonstrated high accuracy in traffic light recognition (97%), obstacle detection (96.67%), and speech recognition (92.4%), proving the system's effectiveness in real-world conditions. However, several challenges remain, including environmental limitations, power consumption, hardware constraints, and affordability. These factors highlight the need for further optimization to improve system robustness and accessibility.

Future research can focus on deep learning-based enhancements, multi-sensor fusion, edge computing, and global scalability to create a more adaptable and cost-effective solution. Additionally, large-scale user trials, cloud-based data processing, and integration with smart city infrastructure can significantly enhance the system's capabilities. Overall, this study contributes to the growing field of assistive technology, demonstrating how AI, IoT, and wearable devices can be leveraged to improve the quality of life for visually impaired individuals. With continued advancements, this research has the potential to redefine independent navigation and accessibility for millions worldwide.

### REFERENCES

- [1] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, You only look once: Unified, real-time object Detection, in Proc. IEEE Conf. Comput. Vis. Pattern Recognit., Jun. 2016, pp. 779788.
- [2] G. Bradski, The OpenCV library, Softw. Tools Prof. Programmer, vol. 25, no. 11, pp. 120123, 2000.

- [3] K. Finkenzeller, RFID Handbook: Fundamentals and Applications in Contactless Smart Cards Radio Frequency Identification and Near-Field Communication. Hoboken, NJ, USA: Wiley, 2010.
- [4] U. Masud, T. Saeed, H. M. Malaikah, F. U. Islam, and G. Abbas, Smart assistive system for visually impaired people obstruction avoidance through object detection and classification, IEEE Access, vol. 10, pp. 1342813441, 2022, doi: 10.1109/ACCESS.2022.3146320.
- [5] D. Dharan, S. Kumar, and D. M. Getsy, Visually impaired smart assistance, in Proc. Int. Conf. Syst., Comput., Automat. Netw. (ICSCAN), 2021, pp. 13, doi: 10.1109/ICSCAN53069.2021.9526495.
- [6] V. Nandalal, V. A. Kumar, A. Sujitha, G. Sumitha, and A. S. Sureka, Intelligent multi-utility shoe for visually impaired persons, in Proc. 2nd Int. Conf. Smart Electron. Commun. (ICOSEC), Oct. 2021, pp. 11021108, doi: 10.1109/ICOSEC51865.2021.9591728.
- [7] V. Singh, S. Sindhu, and R. Arora, BUZZFEET: Blind man shoes, in Proc. Int. Conf. Mach. Learn., Big Data, Cloud Parallel Comput. (COMITCon), Feb. 2019, pp. 356359, doi: 10.1109/COMITCon. 2019.8862205.
- [8] H. Huang, S. Huang, and J. Liu, Intelligent blind travel navigation helmet, China New Commun., vol. 22, no. 1, p. 51, 2020.
- [9] F. Ashiq, M. Asif, M. B. Ahmad, S. Zafar, K. Masood, T. Mahmood, M. T. Mahmood, and I. H. Lee, CNN-based object recognition and tracking system to assist visually impaired people, IEEE Access, vol. 10, pp. 1481914834, 2022, doi: 10.1109/ACCESS.2022.3148036.
- [10] N. Kumar and A. Jain, Smart navigation detection using deep learning for visually impaired person, in Proc. IEEE 2nd Int. Conf. Electr. Power Energy Syst. (ICEPES), Dec. 2021, pp. 15, doi: 10.1109/ICEPES52894.2021.9699479.
- [11] W.-J. Chang, L.-B. Chen, C.-Y. Sie, and C.-H. Yang, An artificial intelligence edge computing-based assistive system for visually impaired pedestrian safety at zebra crossings, IEEE Trans. Consum. Electron., vol. 67, no. 1, pp. 311, Feb. 2021, doi: 10.1109/TCE.2020.3037065.
- [12] A. S. Romadhon and A. K. Husein, Smart stick for the blind using arduino, ultrasonic sensor and android, J. Phys., Conf., vol. 1569, no. 3, 2020, Art. no. 032088.
- [13] S. Chandna and A. Singhal, Towards outdoor navigation system for visually impaired people using YOLOv5, in Proc. 12th Int. Conf. Cloud Comput., Data Sci. Eng., Jan. 2022, pp. 617622, doi: 10.1109/Conuence52989.2022.9734204.
- [14] A. Bhattacharya and V. K. Asari, Wearable walking aid system to assist visually impaired persons to navigate sidewalks, in Proc. IEEE Appl. Imag. Pattern Recognit. Workshop (AIPR), Oct. 2021, pp. 17, doi: 10.1109/AIPR52630.2021.9762132.
- [15] P. Kramomthong, C. Pintavirooj, and M. P. Paing, Smart cane for assisting visually impaired people and the blind, in Proc. 13th Biomed. Eng. Int. Conf. (BMEiCON), Nov. 2021, pp. 15, doi: 10.1109/BMEiCON53485.2021.9745212.
- [16] S. Mohapatra, S. Rout, V. Tripathi, T. Saxena, and Y. Karuna, Smart walking stick for blind integrated with SOS navigation system, in Proc. 2nd Int. Conf. Trends Electron. Informat. (ICOEI), May 2018, pp. 441447, doi: 10.1109/ICOEI.2018.8553935.
- [17] S. Chakraborty, A. Bhadra, S. Mondal, S. Prasad, and S. Chakraborty, An intelligent and smart belt for the blind people, in Advances in Smart Communication Technology and Information Processing (Lecture Notes in Networks and Systems), vol. 165. Singapore: Springer, 2021.
- [18] S. Martinez-Cruz, L. A. Morales-Hernandez, G. I. Perez-Soto, J. P. Benitez-Rangel, and K. A. Camarillo-Gomez, An outdoor navigation assistance system for visually impaired people in public transportation, IEEE Access, vol. 9, pp. 130767130777, 2021, doi: 10.1109/ACCESS.2021.3111544.
- [19] S. U. Rao, S. Ranganath, T. S. Ashwin, and G. R. M. Reddy, A Google glass based real-time scene analysis for the visually impaired, IEEE Access, vol. 9, pp. 166351166369, 2021, doi: 10.1109/ACCESS.2021.3135024.
- [20] M. Biswas, S. Chaki, F. Ahammed, A. Anis, J. Ferdous, A. M. Siddika, D. A. Shila, and L. Gaur, Prototype development of an assistive smart stick for the visually challenged persons, in Proc. 2nd Int. Conf. Innov. Pract. Technol. Manage. (ICIPTM), Feb. 2022, pp. 477482, doi: 10.1109/ICIPTM54933.2022.9754183.

INTERNATIONAL CONFERENCE ON  
EMERGING TRENDS IN ENGINEERING AND SCIENCES



# CERTIFICATE

This is to certify that Mr./Miss./Mrs. Dr.Sonal Borase has  
presented paper entitled Blue Eyes Technology: Revolutionizing Healthcare Management through  
Emotion and Vital Parameter Monitoring

at **International Conference on Emerging Trends in Engineering and Sciences(ICETES-2025)** held on 7th and 8th February 2025 at Jawahar Education Society's, Institute of Technology, Management and Research, Nashik, Maharashtra, India.

A handwritten signature in black ink, appearing to read 'G. P. Mohole'.

**Mrs. G. P. Mohole**  
Conference Convenor

A handwritten signature in red ink, appearing to read 'M. V. Bhatkar'.

**Dr. M. V. Bhatkar**  
Conference Chair

# Blue Eyes Technology: Revolutionizing Healthcare Management through Emotion and Vital Parameter Monitoring

Priya Ray<sup>1</sup>, Harshal Pagar<sup>2</sup>, Sonal Borase<sup>3</sup>

<sup>1,2</sup>Student, <sup>3</sup>Professor, Department of Information Technology,

Jawahar Education Society's Institute of Technology Management and Research Nashik

<sup>1</sup>pray57381@gmail.com

<sup>2</sup>Sharshpagarofficial@gmail.com

<sup>3</sup>sonalborase@gmail.com

**Abstract**---Blue Eyes Technology (BET) is an innovative approach to automating patient monitoring in healthcare systems. By integrating facial and voice recognition, BET measures vital parameters such as heart rate, blood pressure, and emotions, facilitating real-time analysis and response. This research explores the application of BET in reducing manual effort, addressing the demand for skilled workers, and improving mental and physical well-being by accurately detecting and responding to critical situations.

**Keywords**---Blue Eyes Technology, Healthcare Automation, Emotion Recognition, Patient Monitoring, Vital Parameters.

## INTRODUCTION

In many countries, patient monitoring is still done manually, leading to delays and inaccuracies, especially in resource-limited areas. Health systems face challenges like workforce shortages, high costs, and unreliable monitoring tools. Blue Eyes Technology (BET), powered by AI, automates patient monitoring by measuring vital parameters and recognizing emotions using unobtrusive sensors, cameras, and microphones. This technology simplifies human-computer interaction, improving patient care and automating monitoring processes. To solve these issues, an automated patient monitoring system is proposed to improve patient care.

## LITERATURE REVIEW

Related works in healthcare automation and emotion detection. Advancements in sensing technology for vital parameter monitoring. Here are some technologies that can help implement automation in healthcare:

Blue Eyes Technology:

Blue Eyes Technology is a concept researched by International Business Machines (IBM) at the Almaden Research Centre in California since 1997. This technology aims to create user-friendly systems that allow machines to understand and respond to human emotions and actions. The system incorporates two key devices. It uses the Emotion Mouse and Expression Glasses, along with AI speech recognition to gather data. MAGIC helps reduce cursor movement, SUIITOR tracks user behaviour, and an eye sensor monitors eye activity. The primary goal of Blue Eyes

Technology is to equip computers with human-like capabilities.

## PROPOSED SYSTEM

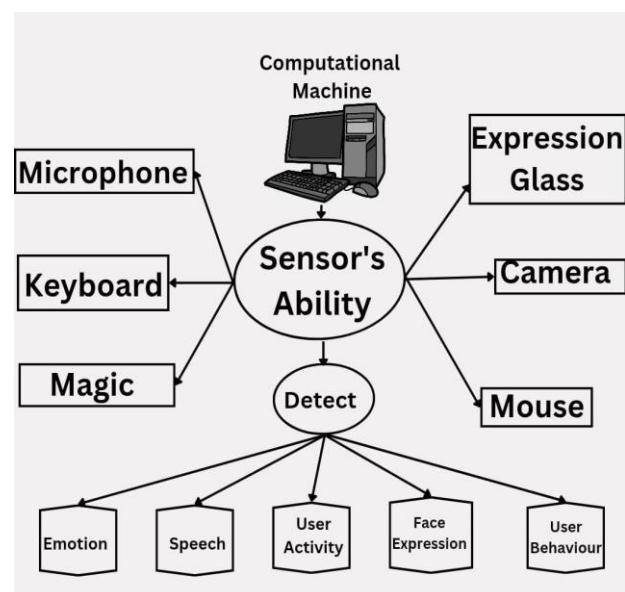


Fig. 1 Basic Architecture of Blue Eye's Technology

Blue Eyes Technology (BET) focuses on bridging the gap between humans and machines by enabling computers to sense, interpret, and respond to human emotions and actions. The system is designed to enhance human-computer interaction through features such as:

- Emotion Detection:** Devices like the emotion mouse and expression glasses capture physiological signals, such as heart rate or facial expressions, to interpret human emotions.
- Speech Recognition:** AI-based systems analyse voice inputs to understand commands and gather emotional context from speech patterns.
- Eye Tracking:** Sensors measure eye movements to determine focus, interest, or fatigue levels.
- MAGIC (Manual and Gaze Input Cascaded):** Reduces cursor movement and simplifies the process of selecting targets by combining manual and gaze-based inputs.

E. SUITOR tracks user behaviour and preferences to create a personalized experience.

The ultimate goal of the proposed BET system is to make machines more intuitive, interactive, and responsive, enhancing their ability to assist humans in various tasks.

#### METHODOLOGY

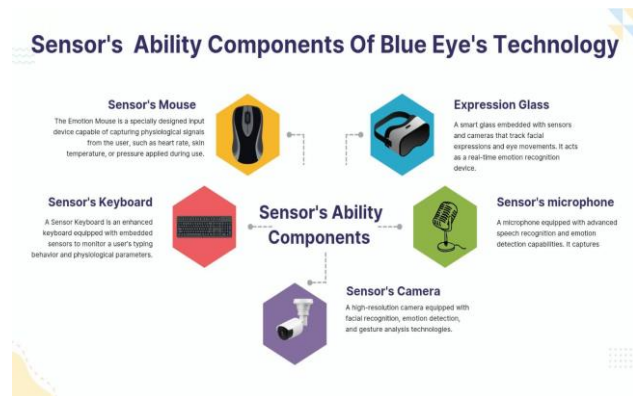


Fig.2 Components of Blue Eye's Technology

Blue Eyes Technology (BET) involves using advanced sensors and computational systems to create an interface that mimics human interaction and understanding. The following steps outline the methodology:

#### 1. Data Collection:

Physiological and behavioral data, such as voice tone, facial expressions, eye movements, heart rate, and skin temperature, are collected using specialized devices like:

**Emotion Mouse:** Detects physiological signals such as heart rate and skin responses.

**Expression Glasses:** Capture facial expressions and emotional cues.

#### 2. Data Processing:

AI-based systems process the collected data to interpret emotions, behaviour, and intentions.

Tools like speech recognition and eye movement sensors are used to analyse voice patterns and gaze direction, respectively.

#### 3. Behaviour Tracking:

SUITOR tracks user behaviour and preferences to personalize interactions. Eye-tracking technology checks attention, fatigue, and focus levels.

#### 4. Human-Machine Interaction:

The system uses MAGIC (Manual and Gaze Input Cascaded) to facilitate seamless interaction by minimizing cursor movement and enhancing selection tasks. Feedback mechanisms allow the machine to respond appropriately to the user's emotions or actions, creating a human-like interaction experience.

#### 5. Output Generation:

The system reacts by performing tasks, providing feedback, or assisting the user based on the interpreted data, making the machine more interactive and intelligent. This methodology enables BET to create a more intuitive, responsive, and human-centric computing environment.

#### FUTURE SCOPE

The future scope of Blue Eyes Technology (BET) is vast, with the potential to revolutionize several industries and create more empathetic and efficient systems. Some unique directions for BET's growth include:

#### 1. Healthcare Advancements:

BET could enable more personalized and responsive healthcare solutions. It can be used for continuous patient monitoring, detecting signs of distress, anxiety, or fatigue, and providing real-time interventions or alerts to caregivers. Additionally, it could assist in mental health treatments by monitoring emotional well-being and offering tailored support.

#### 2. Smart Homes and Workplaces:

With the integration of BET into smart home devices, homes could adapt to the emotional and physical needs of residents, adjusting lighting, temperature, or even entertainment based on a person's mood. In workplaces, BET could enhance productivity by detecting stress levels or fatigue, enabling timely breaks and promoting a healthier work environment.

#### 3. Emotional AI in Customer Service:

BET could lead to the development of emotionally intelligent AI for customer support, where systems not only respond to queries but also understand customer frustrations or needs, offering more compassionate and effective solutions.

#### 4. Human-Robot Interaction (HRI):

As robotics continue to advance, BET could be key in developing robots that can better understand and respond to human emotions, enhancing collaboration in fields like education, healthcare, and even companionship for the elderly.

#### 5. Entertainment and Virtual Reality (VR):

In the entertainment sector, particularly in gaming and VR, BET could create truly immersive experiences where characters or environments react dynamically to the player's emotional state, enhancing the sense of presence and engagement.

#### 6. Autonomous Vehicles:

Incorporating BET into autonomous vehicles could enable cars to monitor the driver's emotional and physical state, ensuring safe and adaptive responses in critical situations, such as detecting stress or drowsiness and offering alerts or even taking over control if necessary.

## LIMITATION

While Blue Eyes Technology (BET) has the potential to revolutionize human-computer interaction, it also comes with certain limitations:

### 1. High Cost:

Developing and deploying BET systems involve advanced hardware, sensors, and AI technologies, making it expensive and limiting its accessibility for widespread use.

### 2. Complexity of Implementation:

Integrating BET into existing systems requires significant technological expertise and resources, which can be challenging for many organizations.

### 3. Accuracy and Reliability Issues:

The system's ability to interpret human emotions and behaviors accurately depends on complex algorithms, which may not always perform flawlessly, leading to potential misinterpretations.

### 4. Privacy Concerns:

Since BET collects sensitive physiological and emotional data, it raises significant privacy and security concerns, requiring robust measures to prevent data misuse or breaches.

### 5. Dependence on Environmental Conditions:

The performance of devices like eye-tracking sensors and emotion recognition tools may be affected by lighting, noise, or other environmental factors.

## CONCLUSION

Blue Eyes Technology (BET) is a ground breaking innovation that bridges the gap between humans and machines by enabling computers to perceive, interpret, and respond to human emotions and actions. By combining advanced sensors, AI-based systems, and user-friendly interfaces, BET empowers machines to mimic human-like interactions, creating a more intuitive and personalized experience. Its potential applications across healthcare, industries, and daily life mark a transformative step toward emotion-aware technology, redefining the way humans interact with machines and setting the stage for a smarter, more empathetic future.

## Acknowledgment

The work on key components like the emotion mouse and expression glasses has been instrumental. We also acknowledge the contributions of researchers worldwide in advancing emotion-aware systems and AI. Interdisciplinary efforts in psychology, computer science, and engineering have been vital in shaping this innovative technology.

## REFERENCES

[1] Chandani Suryawanshi T. Raju, Blue Eyes Technology S. Madhumitha, IJSRD International Journal for Scientific Research & Development Vol. 2, Issue 01, 2014

[2] Raghvendra Priyam, Rashmi Kumari, Dr. Prof Videh Kishori Thakur, "Artificial Intelligence Applications for Speech Recognition"

[3] V. Malarmathi, Dr. E. Chandra," A survey on Speech Recognition" International Journal of Computer Trendsand Technology(IJCTT)-volume 4Issue 9-Sep,2013

[4] ] Mr. Gaurav N. Mehta, Mr. Jimish K. Desai, Mr. Devang G. Chavda, "Blue Eyes-Human-Operator Monitoring System" International Journal of Scientific Engineering and Technology (ISSN: 2277-1581), Volume No.1, Issue No.3,: 91-95, 01 July 2012.

[5] Dr. H. J. Mohite, "Issues and Strategies in Managing E Waste in India", India Journal of Research in management, Business and Social (IJRMBSS), I ISSN No. 2319-69981 vol. 1 Mar 2023.

[6] Anamika Saini, Ankita Gupta, "Blue Eyes Technology" International Journal of Engineering Research and General Science Volume 4, Issue 1, January-February, 2016.

[7] International Journal of Emerging Research in Management & Technology ISSN: 2278-9359 (Volume-3, Issue-4).

[8] Mr. Jimish K. Desai, Mr. Gaurav N. Mehta, International Blue Eyes Human Operator Monitoring System by Mr. Devang G. Chavda Scientific Engineering Journal Technology, Volume (ISSN: 2277-1581), No. 1, Issue No. 3, July 1, 2012, 91-95.

[9] Manisha Kumawat, Garima Mathur, Nikita Susan Saju on "Blue Eye Technology", Vol. 1, Issue. 10, April 2018, ISSN: 2456-8880.

[10] S. Saranya, C. Dhivya, V. Priya, D. Ponniselvi on "BLUE EYES SENSOR TECHNOLOGY", Vol. 4 Issue 1, Pg: 56-61 January 2016, ISSN 2320-7345.

[11] Hardik Anil Patil, Shripad. il Patil, Shripad Amol Laddha, Nachiket Milind Patwardhan on "A Study on Blue Eyes Technology", International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297:2007 Certified Organization), Website: www.ijircce.com, Vol. 5, Issue 3, March 2017.

[12] Oyebola, Blessed & Toluwani, Odueso. (2018). Blue Eyes Technology In Modern Engineering: An Artificial Intelligence. International Journal of Higher Education. 45-65.

[13] Y. F. Gomes, D. F. S. Santos, H. O. Almeida and A Perkusich, "Integrating MQTT and ISO/IEEE 11073 for health information sharing in the Internet of Things, 2015 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, 2015, pp. 200-201.

[14] Deshmukh, Renuka & Jagtap, Vandana (2017). A Survey: Software API and Database for Emotion Recognition. 10.1109/ICCONS 2017.8250727.

[15] R. Sudhashree, N. Muthukumaran, 'Analysis of Low Complexity Memory Footprint Reduction for Delay

and Area Efficient Realization of 2D FIR Filters', International Journal of Applied Engineering Research, Vol. 10, No. 20, pp. 16101-16105, 2015.

[16] Muhammad Wanm Munir Muhammad Omair, M.Zeeshan Haque An Androad hased Application for Determine a Specialized Hospital Nearest to Patient's Location, International Fesanal of Computer Applications (0975-8887) Volane 118-No. 9. May 2015.

[17] A. Aruna, Y.Bibisha Mol, G.Delcy, N. Muthukumaran, 'Arduino Powered Obstacles Avoidance for Visually Impaired Person', Asian Journal of Applied Science and Technology, Vol. 2, No. 2, pp. 101-106, April 2018.

[18] Won-Jae Yi, JafarSaniie," Patient Centered Real-Time Mobile Health Monitoring System," E-Health Telecommunication Systems and Networks, 2016, 5, 75-94

[19] F.M.Aiysha Farzana, Hameedhul Arshadh. A, Ganesan. J, N. Muthukumaran, 'High Performance VLSI Architecture for Advanced QPSK Modems', Asian Journal of Applied Science and Technology, Vol. 3, No. 1, pp. 45-49, January 2019.

[20] Zhang, X., Zhou, Y., & Wang, Y. (2018). An Overview of Blue Eyes Technology and Its Applications. IEEE Access, 6, 77647-77655.

[21] Ma, X., & He, H. (2020). A Survey on Eye-Based Biometric Technology. IEEE Access, 8, 56525-56536.

[22] Wang, W., & Zhang, X. (2019). Blue Eyes Technology: Challenges and Opportunities. IEEE Access, 7, 134271-134279.

[23] Kumar, M., & Bhatnagar, P. (2020). Blue Eyes Technology: A Comprehensive Review. IEEE Access, 8, 167571-167579.

[24] Dutta, P., & Bhatnagar, P. (2018). Blue Eye Technology: Opportunities, Challenges and Applications. IEEE Access, 6, 74575-74583.

[25] Bhatnagar, P., & Dutta, P. (2017). Blue Eyes Technology: A Revolutionary Computer Vision Technology. IEEE Access, 5, 19288-19296.