One-Day Seminar
on
Technology Advances for Smart Systems Development

OSTASSD

2024

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Organized by

Department of Electronics and Communication Engineering

Prasad V Potluri
Siddhartha Institute of Technology
Kanuru, Vijayawada, AP, India - 520007

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Message by The President

I am very happy to make a note that the Department of Electronics and Communication Engineering of Prasad. V. Potluri Siddhartha Institute of Technology, sponsored by Siddhartha Academy of General and Technical education (SAGTE), Vijayawada is organizing One-day Seminar on Technology Advances for Smart Systems Development (OSTASSD-2024) on 16th November, 2024.

Our aim is to create world class engineers endowed with human values to serve the society. As part of this, we are encouraging the departments in the college to organize National and International conferences, workshops and seminars for the technical enrichment among the faculty and students.

I appreciate the efforts of Department of Electronics and Communication Engineering organizing One-day Seminar on Technology Advances for Smart Systems Development (OSTASSD-2024). We always support these kind of conferences that enable faculty to keep in pace with the latest technological advances and to contribute their innovative ideas to the research.

I wish the conference a splendid success and technically enriching and gives rewarding knowledge.

Dr. C. Nageswara Rao
Chief Patron, OSTASSD-2024

Message by The Secretary

I sense immense pleasure and conceited to be a part of One-day Seminar on Technology Advances for Smart Systems Development (OSTASSD-2024), organized by Department of Electronics and Communication Engineering Prasad V Potluri Siddhartha Institute of Technology sponsored by Siddhartha Academy for General and Technical Education, Vijayawada on 16th November 2024.

I Congratulate all the concerned for organizing this international conference and bringing out the proceedings. Such conferences are need of the day and helps the academicians get exposed to the various latest developments in the field of ECE. Updating is very significant in the life of an engineer and all such are supported and encouraged at Prasad V Potluri Siddhartha Institute of Technology.

Contemporary set of courses should make necessary change in the teaching-learning process. I hope this International Conference organized by the department of ECE will fulfill the goals and dreams of younger generation.

On this juncture I take this Opportunity to congratulate all the staff members and students of ECE department for their efforts and initiative and wish them a very best for success throughout their life.

Sri P. Lakshman Rao
Chief Patron, OSTASSD-2024

Message by The Convener

I am happy to note that Department of Electronics and Communication Engineering is of Prasad V Potluri Siddhartha Institute of Technology is organizing a One-day Seminar on Technology Advances for Smart Systems Development (OSTASSD-2024), and going to release the proceeding during this occasion.

From the precedent 25 years Prasad V Potluri Siddhartha Institute of Technology had been imparting quality service in the meadow of Engineering education by providing excellent infrastructure facilities and the rightteam of well qualified staff. This makes Prasad V Potluri Siddhartha Institute of Technology to march towards confidently in this competitive era.

Prasad V Potluri Siddhartha Institute of Technology is playing its responsibility well in training the "Youth" who are the National Asset and Future of India. In the coming years PVPSIT will definitely craft thousands of successful Engineers, Entrepreneurs and citizen to serve the Nation and Society.

I take this opportunity to longing them all the very best in the walks of their professionand also express my whole hearted best wishes on this occasion to all the staff & students of ECE department and hope the conference a grand success.

Sri. Vellanki Nagabhushana Rao
Chief Patron, OSTASSD-2024

Message by The principal

I would like to personally welcome everyone to the **One-Day Seminar on Technology Advances for Smart Systems Development**" conducted by Department of Electronics and Communication Engineering in association with the Institution of Engineers India (IEI), A.P state centre. Gaining knowledge in the area of smart systems is exciting to work and learn.

I am happy that many distinguished scholars, teachers and students are participating in the seminar to share their knowledge and explore better ways of design and development of smart systems for future applications. I sincerely wish that this seminar conducted by Department of Electronics and Communication Engineering of our institute will be a great success and a chance to share technological advances on smart systems as the beginning for a long and fruitful cooperation to shape our future.

Dr. K. Sivaji Babu

Message of Head of the Department

It gives me immense pleasure to welcome you all to this "**One-Day Seminar on Technology Advances for Smart Systems Development**" on 16-11-2024. In today's fast-paced world, technology is transforming the way we live, work, and interact, and smart systems are at the forefront of this transformation. From artificial intelligence and the Internet of Things to smart cities and sustainable innovations, these systems are redefining the boundaries of possibility.

This seminar provides a platform to explore cutting-edge research, innovative applications, and future trends in smart systems. It is a unique opportunity for students, academicians, and industry professionals to exchange knowledge, collaborate, and be inspired by new ideas. I thank our management Siddhartha Academy of General and Technical Education (SAGTE) for supporting us to conduct this event. I extend my sincere thanks to our beloved principal Dr.K.Sivaji Babu for encouraging us to conduct this seminar.

I am confident that today's discussions will not only deepen our understanding of smart systems but also ignite new ideas for practical solutions to real-world challenges.

I extend my heartfelt thanks to the Institution of Engineers India (IEI) A.P state centre for sponsoring this seminar and all authors who submitted their research papers for presentation in the seminar.

Dr. C.Subba Rao

Message by The Coordinator

I extend my heartfelt gratitude to all the participants, speakers, and contributors of the "One Day Seminar on Technology Advances for Smart Systems Development," who made this event a resounding success.

The seminar aimed to bridge the gap between academia and industry by fostering discussions on the latest advancements in smart systems. I was honored to host distinguished speakers, including industry experts and esteemed faculty members, whose insights enriched our understanding of the integration of IoT and AI in developing innovative solutions across various sectors.

The enthusiastic participation from students, faculty members and researchers, reflected in the submission of good number of research papers, underscores the relevance of our theme. The diverse topics presented—from smart cities to healthcare technologies—demonstrated the innovative spirit within our engineering community.

I believe that this seminar has not only provided a platform for knowledge exchange but has also inspired collaboration among participants. The engaging discussions during the Q&A sessions highlighted the collective commitment to advancing technology for societal benefit.

On behalf of the organizing committee I would like to express my sincere gratitude to college management, Siddhartha Academy of General and Technical Education (SAGTE), Dr. K. Sivaji Babu, principal and Dr. C. Subba Rao, Head of the Department for their encouragement and support in organizing this seminar.

My sincere and special thanks to the Institution of Engineers India (IEI) A.P state centre for sponsoring this seminar.

As I conclude this seminar, I encourage all attendees to continue exploring these technological advancements and to apply their learnings in practical scenarios. I look forward to your active participation in future events that aim to enhance our collective knowledge and foster innovation.

Thank you once again for your contributions and engagement.

Dr. K. Ramanjaneyulu

Message by The Coordinator

It is my honour and privilege to welcome you to the **One-Day Seminar on Technology Advances for Smart Systems Development**. As we stand at the crossroads of innovation, this seminar provides a timely platform to explore the latest advancements and breakthroughs shaping the future of smart systems.

The seminar features a diverse array of presentations, discussions, and demonstrations, each contributing to a deeper understanding of the emerging technologies driving intelligent systems. This event serves not only as a space for knowledge exchange but also as a catalyst for fostering collaboration among academics, researchers, industry experts, and practitioners.

The proceedings book is a testament to the incredible contributions made by our presenters. It includes a diverse range of papers that address the most pressing issues in smart systems development, from advanced algorithms and system architectures to real-time data processing and autonomous technologies including various areas such as artificial intelligence, machine learning, the Internet of Things (IoT), VLSI and Antennas-holds vast potential for creating more adaptive, efficient, and intelligent environments.

On behalf of the organizing committee I would like to express my sincere gratitude to college management, Siddhartha Academy of General and Technical Education (SAGTE), principal Dr. K. Sivaji Babu and Dr. C. Subba Rao, Head of the Department for their encouragement and support in organizing this seminar.

My sincere and special thanks to the Institution of Engineers India (IEI) A.P state centre for sponsoring this seminar.

I extend my thanks to esteemed speakers, session chairs, and entire organizing team for their hard work in making this event possible. I also extend my appreciation to all the participants for their commitment and focus in terms of their contributions to the field of smart systems advancement.

Thank you for being part of this event and wish you a stimulating and productive experience.

Dr. V. S. D. Rekha

TABLE OF CONTENTS:

IMPLEMENTATION OF OPTIMIZED 64 – BIT UNSIGNED WALLACE 1 TREE MULTIPLIER

[1]Tamilvani R ,[2] Jenitha A [3]Dameta Jeesha R, [4]Jincy P Savyar,
[1,2,3,4] T Thimmaiah Institute of Technology
[1]tamilvani@drttit.edu.in,[2]jenitha@drttit.edu.in,[3]dametajeesha152003nov@gmail.com, [4]jincysavyar@gmail.com

ABSTRACT: VLSI design focuses on four primary design factors – Area, Power, speed and cost. The performance is widely acknowledged as a circuit criterion in digital system design, microprocessors and digital signal processing ALU's, FIR filters and other digital processing devices rely on multipliers to perform their functions in an efficient way. Typically, the multipliers are system's slowest component, have a higher number of different operations which causes an increase in delay. Therefore, the design of multipliers has been a critical aspect of efficient VLSI systems. In the present advancement in VLSI technology it has become more challenge to achieve both speed and power consumption in a single multiplier. Hence a 64 - bit optimized Wallace Tree Multiplier is designed which has the advantages like reduced latency, higher speed, reduced power consumption with less delay compared to existing multiplier. The Wallace Tree Multiplier are simulated using Vivado 2023.1v. The simulation determines that the proposed Wallace Tree Multiplier method is more efficient and the delay is 13.740 ns.

INDEX TERMS : Wallace, Vivado, VLSI.

1. INTRODUCTION

Multiplication is a fundamental arithmetic operation that involves combining two numbers, called the multiplicand and the multiplier, to produce a result known as the product. It can be thought of as repeated addition. Multipliers are essential components in digital systems, and they can be categorized based on their architecture, operation style, and application.

Core components of multipliers are Partial Product Generator Which Generates the initial set of partial products by multiplying each bit of the multiplicand with each bit of the multiplier [1]. Implementation: AND gates or modified logic for Booth encoding. Partial Product Reducer Reduces the number of partial products using adders or tree structures (e.g., Wallace Tree, Dadda Tree) [6]. A parallel multiplier computes the product of two numbers in parallel, meaning all operations are performed simultaneously. Example: Array Multiplier Which Uses a grid of adders to compute partial products in parallel and Wallace1Tree Multiplier Which Uses a reduction tree to sum partial products in a highly parallel manner [5]. A serial multiplier computes the product bit by bit in a sequential manner. It processes one bit of the multiplier at a time, performing a series of additions and shifts. Example Shift-and-Add Multiplier that Adds the multiplicand conditionally based on each bit of the multiplier and shifts the result after each step [8].

2.WALLACE TREE MULTIPLIER

The Wallace Tree Multiplier is a high-speed digital13circuit used for multiplying two numbers, particularly in hardware like microprocessors and signal processors. It is designed to reduce the delay caused by partial product addition in conventional multiplication techniques [2][3]. The Wallace tree architecture uses a hierarchical approach to add the partial products generated during multiplication.
It groups and sums partial products in successive layers, reducing the number of rows of partial products at each stage [9]. It exploits parallelism, making it significantly faster than traditional multiplication methods like the ripple carry adder. By minimizing the height of the product matrix at each stage, the delay in summation is reduced [4].

A) Wallace Tree Algorithm

I. The Wallace tree has 3 steps.
   Multiply each bit of one of the arguments by each bit of the other, yielding n square results.
II. Reduce the number of partial products by using full adder and half adder
III. Group the wires in two numbers and add them using CSA.
IV. In the last layer of algorithm, carry look ahead adder is used [10].

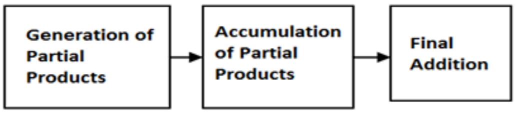

Fig 1: General Block Diagram of Wallace Tree Multiplier

3. METHODOLOGY

A) Carry Save Adder: carry save adder is similar to full adder, **it is used in computation of** or n- bit number. It is a digital circuit used in computer arithmetic to quickly add multiple binary numbers by delaying carry propagation
to the final step, making it faster than traditional adders for **certain operations. Instead of** immediately propagating the carry after the adding two numbers, the CSA saves the carry
and adds it later with partial products. This is illustrated in Fig 2.

B) Carry look ahead adder: A Carry Look-Ahead Adder (CLA) is a type of digital adder designed to perform high-speed arithmetic operations by reducing the propagation
delay caused by the carry bit in traditional adders. Unlike ripple carry adders, where the carry must propagate sequentially through each bit, a CLA predicts the carry at each bit position in parallel, making it faster and more efficient.

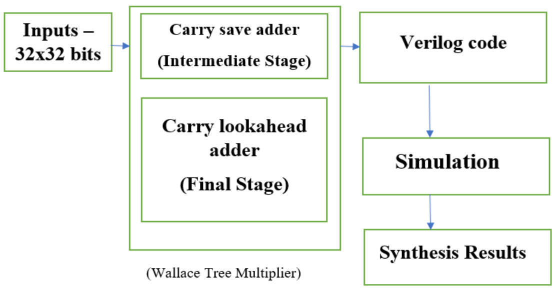

Fig 2: General Block diagram of Implementation of 64bit Wallace Tree Multiplier

4.IMPLEMENTATION

Step 1: Generate Partial Products
For a 64-bit multiplier, generate partial products for each bit **of the multiplier (32- partial** products in total).

Step 2: Group Partial Products Group the partial products into three groups per **Wallace Tree** rules: groups of 1, 2, and 3.
1. Group 1: Single partial product.
2. Group 2: Pairs of partial products.
3. Group 3: Triplets of partial products.
Step 3: Carry Save Addition
Perform carry save addition within each group:
1. Group 1: Directly pass through.
2. Group 2: Use CSA to add pairs.
3. Group 3: Use CSA to add triplets.
Step 4: Reduction Tree
1. Construct a reduction tree to accumulate the results from carry save adders:
2. Use CSA results from each group and perform further addition using CSA or CLA to reduce them to a single result.
Step 5: Final Addition and Result Use CLA to perform the final addition of the reduced sums to get the final product [7].

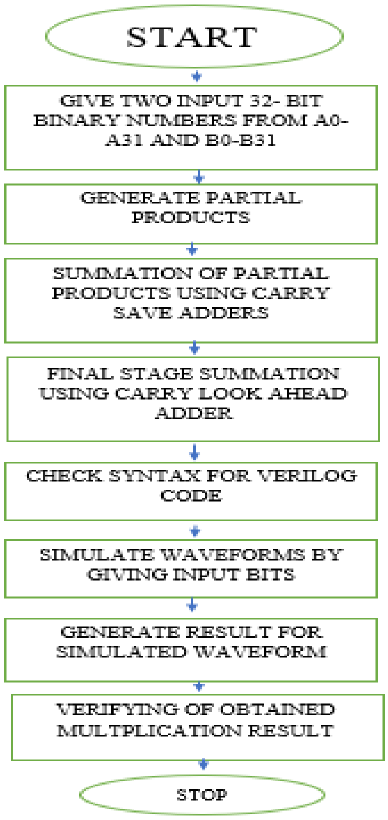

Fig 3: Flow chart for 64 – bit Wallace Tree Multiplier

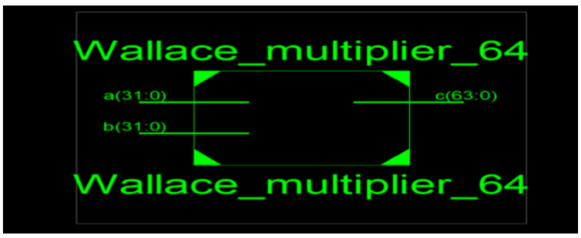

Fig 4: RTL View of 64 – bit Wallace Tree Multiplier

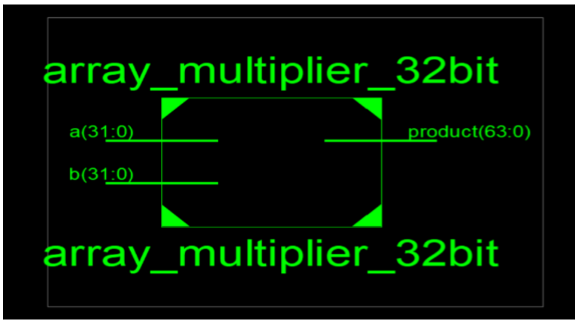

Fig 5: RTL View of 64 – bit Array Multiplier

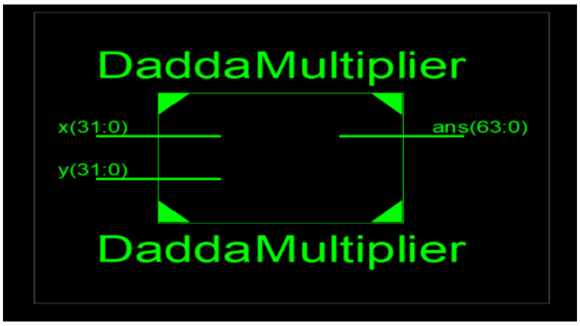

Fig 6: RTL View of 64 – bit Dadda Multiplier

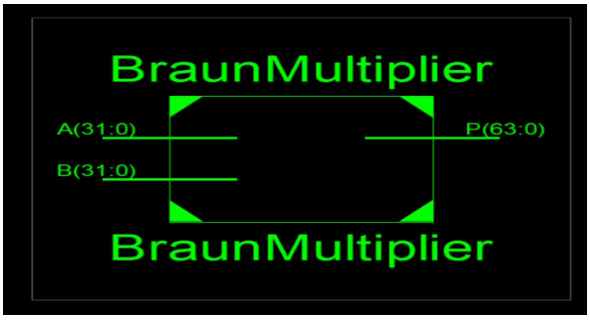

Fig 7: RTL View of 64 – bit Braun Multiplier

5. RESULTS

For 64 – bit Wallace Tree Multiplier , 64 – bit Array Multiplier, 64 – bit Dadda Multiplier, 64 – bit Braun Multiplier the program has been written in verilog code and has been executed using the vivado 2023.1v for the simulation.

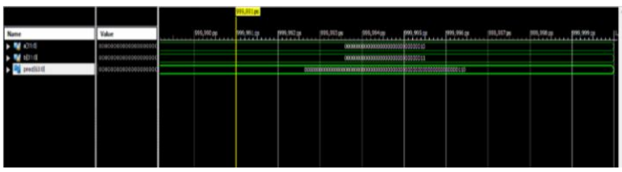

Fig 8: Simulation of 64 – bit Wallace Tree Multiplier

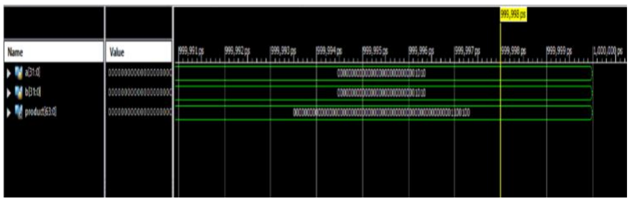

Fig 9: Simulation of 64 – bit Array Multiplier

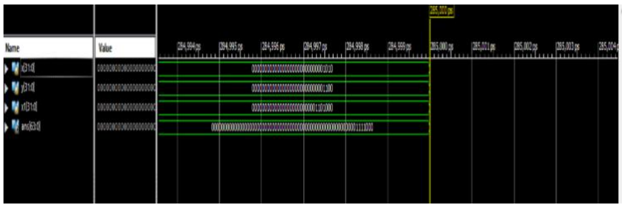

Fig 10: Simulation of 64 – bit Dadda Multiplier

Table 1: Detailed results obtained for the multipliers

Parameters	64 – bit Wallace Tree Multiplier	64 – bit Array Multiplier	64 – bit Dadda Multiplier	64 – bit Braun Multiplier
Delay (ns)	13.740	21.671	34.231	21.569
Number of Slice LUTs	2191 out of 17600	2928 out of 17600	2040 out of 17600	2266 out of 17600
Number used as Logic	2191 out of 17600	2928 out of 17600	2040 out of 17600	2266 out of 17600
IO Buffers	128	128	128	128
I Buf	64	64	64	64
O Buf	64	64	64	64
Power(mW)	0.157	0.388	0.624	0.367

CONCLUSION AND FUTURE SCOPE

The design of multipliers is a critical aspect of efficient VLSI system. As the multipliers have a higher number of different operations it causes an increase in delay, making the system slow. Hence to overcome this a 64- bit optimized Wallace tree multiplier is designed that has a less delay of 13.740ns. compared to other multipliers like Array multiplier with delay of 21.671ns, Braun multiplier with a delay of 21.569ns and Dadda multiplier with a delay of 34.231ns. Therefore, Wallace tree multiplier is an efficient multiplier compared to other multipliers. The Wallace tree multiplier structure can be designed by increasing input size. By designing the multiplier circuit with higher input size may lead to multiplier with less number of LUTs and also better delay value can be achieved.

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A SMART WAY TO DETECT HEALTH CONDITIONS FROM BLOOD REPORT USING MACHINE LEARNING

[1] N. Ramesh Babu,
Usharama College of Engineering and Technology, Telaprolu, NTR District, Email:
rameshnuthakki5@gmail.com

ABSTRACT: This paper aim is to detect complications in the blood. Nowadays blood analysis plays a major role in the pharmaceutical world. Blood analysis is very essential to treat any disease. Blood report consists of various measures like red and white blood cells, platelets count and hemoglobin etc. The blood analysis report is one of the main reports in the medical field to analyze the health of a patient. Doctors use this report to understand the health condition of a patient to give medication and to perform any surgery. In the Blood measure report, every measure has some range to maintain our body healthy. By this range, we can get an idea about which measure is not in range or deficit in range. So, it is a very crucial thing to understand the condition accurately and effectively. Nowadays, most people are becoming sick and hospitals are becoming crowded. At that time the hospital staff or doctors can upload the report to get a perfect analysis. The proposed concept goal is to extract the information from the uploaded report using OCR and to apply an ML algorithm to that extracted values to detect complications in the blood and gives the result through the designed website. [1]

KEYWORDS: Blood report, Optical Character Recognition (OCR), ML algorithm, Web-Framework, file operations

1. INTRODUCTION

Blood is one of the major components of the human body. Like organs, blood is very important. Blood contains different types of parameters like Hemoglobin, Red blood cells, White blood cells, Platelets etc.., Each parameter has its range of values. The changes in these values can affect the human and may cause diseases. Changes in different parameters can cause different types of diseases. There are various types of diseases, which can be caused by changes in the blood. The range of values will vary based on age and gender also. Analyzing the blood report is the major step to detect the health condition of a patient. Most of the blood tests don't need special conditions like fasting etc., Blood tests can be done at any time. Different parameters can be Measured by testing blood. The results will help to identify health problems in the early stages. Only a blood test to the dataset provided. The main objective of this project is to predict the health condition of a patient is not enough to deal with a patient's health condition, but it's one of the factors. Applying modern technology to our daily life work will reduce human effort and can increase accuracy. Applying modern technologies like Machine Learning Artificial Intelligence is a hot topic nowadays.

A technique for data analysis called machine learning makes computers behave like people. It is. It's a data-driven technology; it works based on the dataset given to it. The performance of the machine learning algorithm can be improved according from their blood report. Different Machine Learning algorithms are used to get an algorithm with maximum accuracy.

Getting results through an interface is also important for this analysis and creating two webpage frames, in which, one is to upload our document or photo of the report and another is to show the results.

2. BACKGROUND

Machine learning is a branch of artificial intelligence. that is responsible for the development of algorithms and advanced programing languages. The machine learning model can learn and change their actions Machine learning relies on analyzing provided datasets, assessing model outcomes, and refining them to achieve optimal results. Fig.II Shows a brief detailing of the machine learning activity. Here the following types of machine learning algorithms are discussing in brief.

They are:

Supervised Learning: The machine train with ladled data and there, then will find the predicted

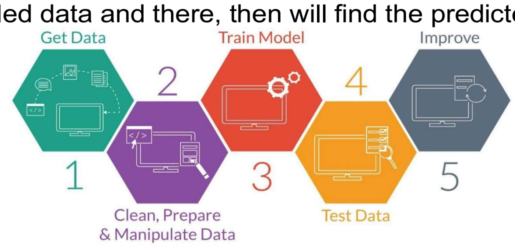


Figure 1: Machine Learning Activity

outputs by using various supervised machine learning algorithm.

Unsupervised Learning: The model will trained without labeling of the data and at the time of testing predict the outcome by using different unsupervised learning algorithm.

Reinforcement learning: The computer interacts with the environment, and it must perform a specific goal without training.

Machine Learning methods have become indispensable for prediction and decision-making across various fields. In healthcare, the abundance of clinical data has positioned machine learning as a pivotal resource in medical decision-making. It significantly aids in disease identification, enhances clinical decision-making, and helps select appropriate medical treatments.

3. CLASSIFIERS USED

We utilized the following classifiers to categorize patients based on the learning datasets. The classifiers include:

Random forests classifier: It is an ensemble learning approach for classification that creates multiple decision trees using training data with labeled classes. Once the trees are constructed, they can be used to classify previously unseen records.

Support vector machine:
It maps the training data as points within a flat, divided space separated by a clear margin. New instances are placed into this space, with their predicted category determined by the side of the margin on which they land.

Decision Tree: This approach represents attributes and their values as decisions within a tree structure. The nodes correspond to attributes and their possible values, while the leaves represent decisions. The algorithm evaluates all features, performing binary splits, and organizes the attributes within the tree based on their information gain, ranked in descending order. Once the tree is constructed, new data points are classified by traversing the tree according to their attribute values until a leaf containing the class is reached.

These classifiers play a crucial role in disease prediction, aiding in enhancing clinical decision-making and reducing the likelihood of medical errors. In the following section, we outline recent studies that leverage machine learning techniques for analyzing blood-related diseases.

4. DATA SET AND DISEASES

The dataset on which the ml model is trained is created after a lot of research. Creating a dataset is the major part of the proposed method. The dataset contains 4,500 data points and 15 classes. Each class contains 300 data points. Each class has values based on the age and gender of the patient. Each class represents each disease. These are the diseases that ml model is going to predict. [2]

Anemia: Anemia is characterized by a reduction in hemoglobin levels or a decrease in the number of red blood cells within the bloodstream. This condition often leads to non-specific symptoms, such as persistent fatigue and exhaustion., shortness of breath, or weakness. [3] Based on the count, it has four types:

1. Mild Anemia
2. Moderate Anemia
3. Severe Anemia
4. Dangerous Anemia

Polycythemia: an abnormally high amount of hemoglobin or red blood cells in the blood.

Thrombocytopenia: it is about the lack of platelets. It is not so dangerous but sometimes leads to bleeding too much. Based on the count, it has four types:

1. Mild Anemia
2. Moderate Anemia
3. Severe Anemia
4. Danger

Thrombocytosis: an abnormally high number of Platelets in blood.

Leukocytosis: it causes an increase in white cells above the normal range in the blood. It may cause certain parasitic infections or a tumour, as well as leukemia.

Leukopenia: it causes a decrease in white cells be- low the normal range in the blood.

Neutrophilia: is defined as a higher neutrophil count in neutrophil count in the blood than nor- mal. Neutrophilia can bee is seen in infections and inflammation.

Neutrophilia: It can be caused by diseases that damage the bone marrow, infections or certain medications.

Eosinophilia: High eosinophilia levels can indicate a mild condition such as a drug reaction or allergy.

Basophilia: Basophilia may be a sign you have an infection, or it may be a sign of serious medical conditions like leukemia.

Monocytosis: Having an abnormally high number of infection-fighting monocytes. It may signify a severe medical condition such as an autoimmune dis- ease, a blood disorder, or cancer. It may also mean that you have encountered an infection. [4]

Lymphocytosis: Causes when we have high lymphocytes count. Lymphocytosis is one of the first signs of certain blood cancers.

Normal: in this class, all parameters' values are normal, and there are no essential notifications in the blood analysis. [5]

Parameters	Description
Age	Age of the patient
Gender	Gender of the patient
HGB	Hemoglobin
Thrombocytes	Platelets Count (in Millions)
Leukocytes	White Blood cells count
Neutrophil	Percent Neutrophils in blood
Eosinophil	Percent of Eosinophils in blood
Basophil	Percent of Basophils in blood
Lymphocyte	Percent of Lymphocytes in blood
Monocyte	Percent of Monocytes in blood

Table 1: Blood Analysis Parameters

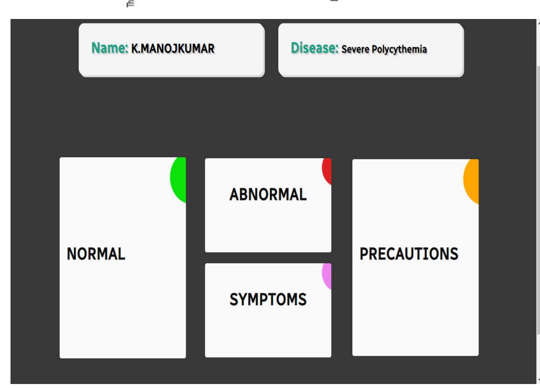
5. RESULTS

Cross-validation is a statistical method of evaluating and comparing learning classifiers by dividing data into parts: one is training data, which is used to train the model. Second is testing data; the model is used to validate the model. The training and testing sets must cross over in successive rounds such that each data point has a chance of being validated. [6]

For each classifier, accuracy is measured. The Random Forest algorithm provides high accuracy and SVM provides less accuracy than Random Forest. The overall results prove the success of applying classical machine learning algorithms in the process of blood disease prediction.

Classifier	Accuracy
SVM	97%
Decision Tree	98%
Random Forest	98.5%

Table 2: Accuracy Results for each classifier



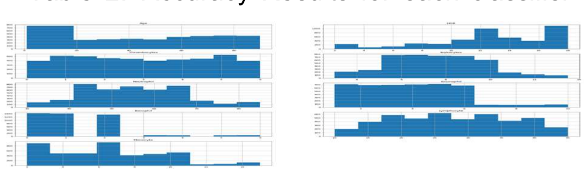


Figure 2: Histogram for each feature

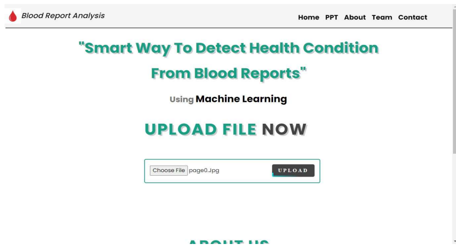


Figure 3: Heat Map

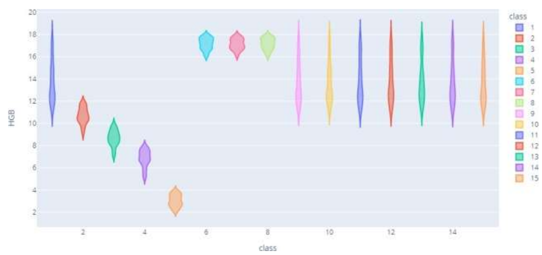


Figure4: Violin plot for HGB & class

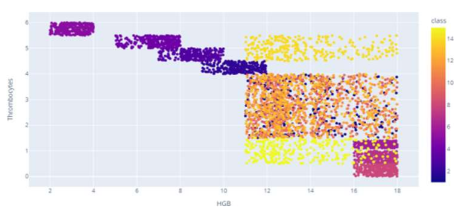


Figure 5: Scatter Plot HGB vs Thrombocytes

6. WEBSITE

We also created a web-page to interact with the patient. A start page, in which we can upload an image or a pdf file. OCR recognizes the desired values from the up- loaded files and gives those values to the model. The model predicts the disease using those values and dis- plays the disease along with normal parameters, abnormal parameters, symptoms and precautions through a results page.

CONCLUSION AND FUTURE WORK

Machine learning becomes an essential technique for modeling the human process in many disciplines, especially in the medical field, because of the high availability of data. One of the essential disease detectors is the blood analysis; as it contains many parameters with different values that indicate definite proof of the existence of the disease. [6]

The machine learning algorithm accuracy depends mainly on the quality of the dataset; for this reason, a high-quality dataset is collected. This dataset is used for training the classifiers for obtaining high accuracy. We tested several classifiers and achieved accuracy up to 100% which realizes the research objective, which is helping physicians to predict blood diseases according to a general blood test. [7]

The future work will focus on testing the proposed data set using different deep learning algorithms to com- pare classical and deep learning approaches in this re- search area. [8]

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IMPLEMENTATION OF LOW VOLTAGE LOW POWER LEVEL SHIFTER USING FIN-FET TECHNOLOGY

[1]Mani Kumari M, [2]Bahula Sri B
[1,2]Gayatri Vidya Parishad College of Engineering for Women Visakhapatnam, Andhra Pradesh, India.
mani.kumari@gvpcew.ac.in,bahulasri9504@gmail.com.

ABSTRACT: In Very Large Scale Integration (VLSI) design, level shifters, and current mirrors are essential inenhancing power efficiency, particularly for low- power applications. Level shifters(LS) enable effective communication across circuits operating at different voltage levels, a necessity in mixed-voltage and multi-domain systems [1]. Modern level shifter designs incorporate energy-saving features, including low- power modes, minimized standby currents, and optimized switching, reducing overall power dissipation. Current mirrors, likewise, are critical for efficient power management. Scaling currents precisely facilitate accurate biasing and currentsteering in analog and mixed-signal circuits, aiding in effective power reduction.

A wide-range level shifter design is proposed,integrating a current mirror mechanism with a feedbackP-FET, aiming to minimize static current paths and enhance power performance. This design encounters challenges when converting from low to high supply voltages (VDDL to VDDH), mitigated by implementing a Logic Error Detection Circuit (LEDC). To further boost the performance, especiallyin nano-scale designs, the shifter employs both CMOSand FINFET technologies. Circuit-level simulations and performance comparisons between CMOS and FINFET implementations are conducted, evaluating metrics like delay and power consumption, using advanced simulation tools to validate the design's effectiveness.

KEYWORDS: VLSI, low-power design, level shifter, current mirror, CMOS, FINFET, nano-scale design, Logic Error Detection Circuit.

TOOL USED: Cadence Virtuoso.

1. INTRODUCTION

Level shifters play a vital role in the design of VLSI (Very Large Scale Integration) circuits, allowing seamless communication between components that operate at different voltage levels within the same system. As modern electronics increasingly incorporate mixed-voltage environments to optimize power use, level shifters ensure that these circuits, with potentially large voltage differences, can interact without causing damage or signal degr adation. Their significance is clear across a wide range of applications, including portable consumer electronics and advanced IoT(Internet of Things) networks, where managing power efficiency is paramount.

In low-power and battery-operated devices, level shifters reduce unnecessary power consumption by facilitating precise voltage translation between low and high-voltage domains.

For example, in a smartphone or wearable device, various modules such as the processor, memory, and peripheral compon components may operate at different voltages, necessitating level shifting to maintain data integrity and overall system performance. Level shifters also mitigate the risk of excessive power dissipation, particularly critical in high-performance applications where power efficiency directly impacts device longevity, heat management, and battery life.

Moreover, with technological advancem ents innano-scale design, level shifters have evolved to accommodate tighter power budgets and reduced form factors, using technologies like CMOS (Complemen tary Metal Oxide Semiconductor) and FINFE T (Fin Field-Effect Transistor) are two distinct types of semiconductor technologi es used in modern integrated circuits to enhance performance. These advances ena ble level shifters to operate with optimized switching characteristics, low standby pow er, and faster response times, making them indispensable in both analog and digital circuit design for applications where high reliability and minimal power usage are essential.

1.1 CONTRIBUTION OF WORK

The novelty of the Research: The proposed design integrates a current mirror with a feedback P-FET, creating an innovative level shifter that minimizes static current paths, addressing challenges in mixed-voltage systems.
Enhanced Voltage Conversion: Incorporating a Logic Error Detection Circuit (LEDC) effectively addresses the conversion limitations from a low supply voltage (VDDL) to a high supply voltage (VDDH), ensuring reliable operation across varying voltage domains.

Performance Evaluation: Comprehensive comparisons of CMOS and FINFET technologies through circuit-level simulations analyze key metrics such as delay and power consumption, providinginsights into the advantages of each technology.

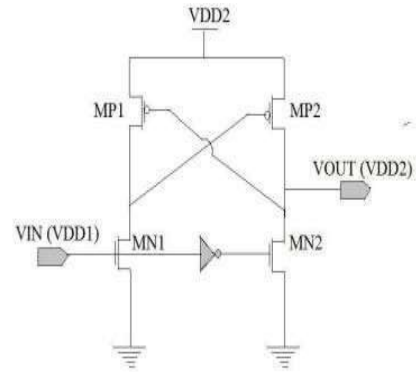
- **Focus on Low-Power Applications**: Emphasizing power reduction strategies, this research contributes to developing energy-efficient solutions critical for portable and battery-operated devices.
- **For Future Designs**: The findings offer valuable recommendations for future advancements in level-shifting technologies, informing subsequent designs in multi-domain systems.

2.PREVIOUS LS STRUCTURES

Level shifters allow circuits operating at different voltages to communicate effectively**.** Current mirrorsare fundamental for current scaling in analog circuits. Research emphasizes optimizing designs through transistor sizing and biasing help in low-power applications Integrating level shifters with current mirrors has been proposed to enhance voltage translation efficiency.

2.1 Cross-Coupled Level Shifter

Cross-coupled level shifters are versatile voltage translation circuits commonly used in integrated circuits to convert signals between different voltage domains. Their bidirectional capability, robustness, and low static power consumption make them valuable components in applications requiring reliable voltagelevel shifting.

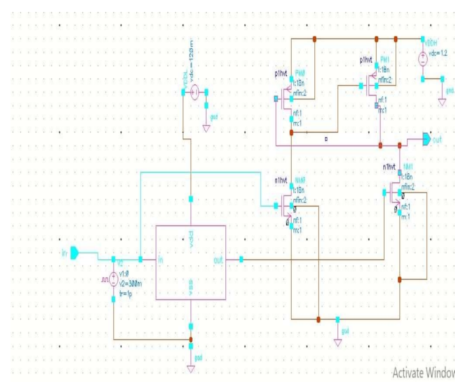


2.2 Fig 1: Cross-Coupled Level Shifter

Cross-coupled level shifters often involve trade- offs in complexity, power consumption, and speed compared to non-regulated designs. Designers must carefully consider these factors and optimize the circuit to meet the requirements of the target application [3]. Cross-coupled level shifters maintain consistent output voltages by incorporating feedback loops and voltage regulation circuits, optimizing signal integrity and compatibility in digital domain applications. The below figures show the simulations of the level shifterusing CMOS and FinFET technologies respectively

2.2Current Mirror Level Shifter

Current mirror level shifting is frequently employed in analog and mixed-signal circuit design to shift voltage levels



between different signal domains while maintaining accuracy and linearity.At its core, this method utilizes current mirrors, a fundamental circuit block commonly used for mirroring or replicating currents. In the context of level shifting, current mirrors are designed to adjust the voltage level of an input signal, aligning it withthe voltage domain of the intended output signal [4].

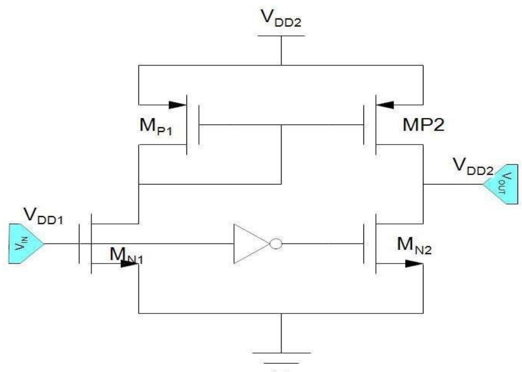
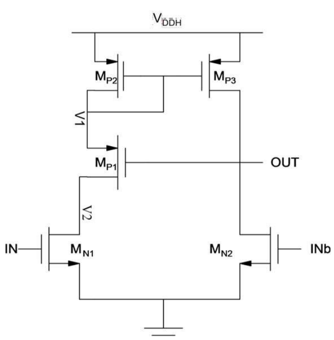


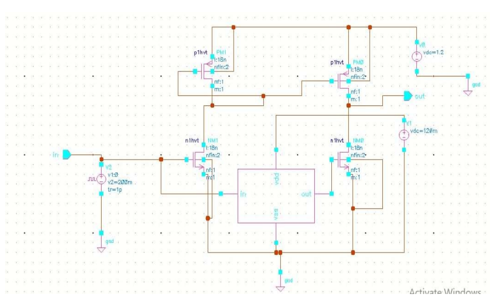
Fig 2. Current Mirror Level Shifter

The fundamental concept of current mirror-based level shifting involves biasing a transistor network to mirror the current flowing through an input signal to another

transistor network, effectively replicating the input current at a different voltage



level [5]. The input signal is generally fed into one side of the current mirror, while the output signal is obtained from the mirrored side. By adjusting the biasing conditionsand transistor parameters, the voltage level of the output signal can be accurately adjusted relative to the input signal.



2.3 Wilson's Current Mirror Level Shifter

The Wilson's current mirror level shifter is a specific type of level shifter circuit commonly used in Analog and mixed-signal integrated circuits. It's designed to shift the voltage level of a signal from one voltage domain to another while maintaining high accuracy and linearity. At its core, the Wilson current mirror level shifter employs a Wilson current mirror configuration, enhancing the functionality of the basic current mirror circuit. This design substantially reduces delay and power consumption while supporting a broad voltage conversion range. The Wilson current mirror improves output impedance and reduces the output voltage dependency on the transistor's Early effect, making it particularly suitable for precise voltage level shifting applications.

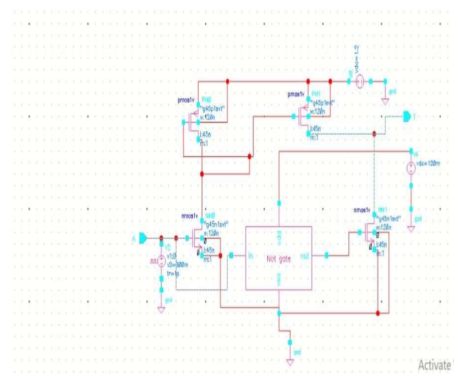
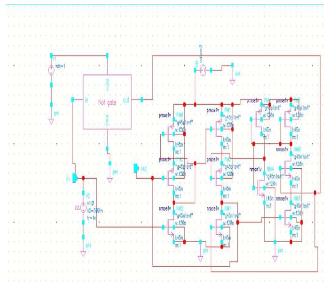
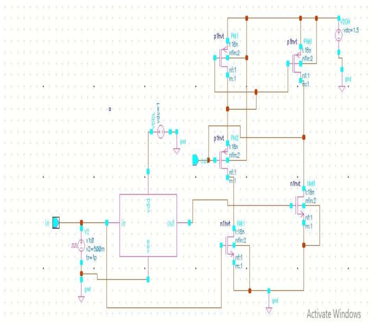
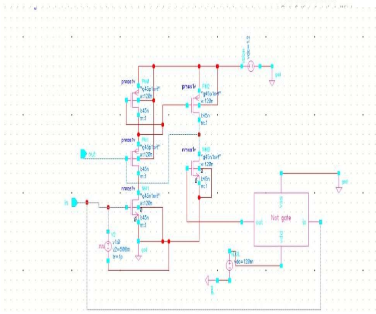


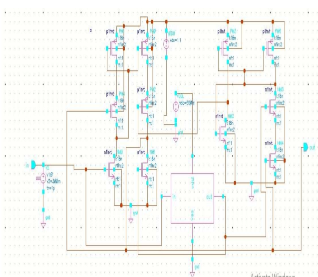
Fig 3. Wilson's Current Mirror Level Shifter

A key advantage of the Wilson current mirror levelshifter is its capability to deliver high precision and linearity over a wide range of operating conditions, including variations in temperature, supply voltage, and transistor parameters. This characteristic makes it ideal for applications needing precise voltage level translation, such as Analog-to-Digital Converters (ADCs), Digital-to-Analog Converters (DACs), and sensor interfaces. The Wilson current mirror-based level shifter represents an advanced circuit topology frequently used in analog and mixed-signal integrated circuits. By leveraging the Wilson current mirror configuration, it offers improved accuracy, linearity, and stability, making it highly suitable for applications requiring precise and reliable signal processing.









2.1 Level shifter with Logic Error Detector

A level shifter with logic error detection is a vital component in systems where accurate signal translation between different voltage domains isessential. This sophisticated circuitry merges the functionalities of a traditional level shifter with mechanisms to identify and address logic errors that might occur during the voltage conversion process.These errors can arise due to various factors such as noise, interference, or component malfunction. A level shifter with logic error detection is a vital component in systems where accurate signal translation between different voltage domains is essential[7]. This sophisticated circuitry merges the functionalities of a traditional level shifter with mechanisms to identify and address logic errors that might occur during the voltage conversion process.These errors can arise due to various factors such as noise, interference, or component malfunction.

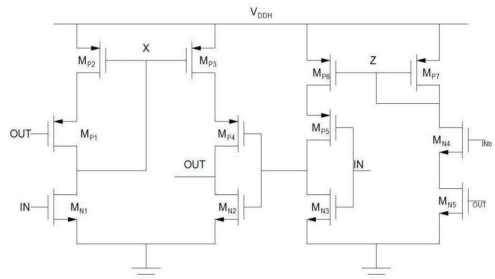


Fig4. Level Shifter with Logic Error

Detection Upon detecting an error, the level shifter engages error correction or recovery mechanisms to rectify the issue. These mechanisms may include error correction codes, redundancy schemes, or error recovery protocols, ensuring the integrity of the transmitted data.

Additionally, error signaling and reporting mechanisms are incorporated to promptly notify the system controller of any detected error conditions, enabling swift corrective action. Thorough testing and validation are imperative to ensure the effectiveness of the integrated error detection and correction mechanisms. Simulation tools are employed to verify functionality and performance under various operating conditions, followed by rigorous testing using prototype hardware. Implementation considerations, such as layout design, signal integrity, and power supply stability, are also addressed to maintain the reliability of the error detection mechanism in real-world scenarios. Reducing the supply voltage to the near or sub-threshold region is an effective approach to minimizing power consumption indigital circuits.

3.QUANTITATIVE ANALYSIS

This section presents the experimental findings from implementing wide-range level shifters using thecurrent mirror design methodology. The circuits weresimulated in a 180 nm CMOS process with varying input voltages and load condition.

Table 1. Power dissipation Analysis

S NO	Methodology	CMOS	FINFET
1	Cross coupled LS	1403.62n W	319.003p W
2	Current Mirror LS	286.74n W	279.51p W
3	RCC Pull-up LS	109.03n W	69.83n W
4	Wilson CMLS	92.66n W	274.14p W
5	LED with LS	92.59n W	186.92p W

Table 1 shows the power dissipation analysis of five different level shifter designs: cross-coupled, current mirror, RCC pull-up, Wilson CMLS, and LED with LS. For each design, the table shows the power dissipation for both CMOS and FinFET technologies. In all cases, the FinFET technology has lower power dissipation than the CMOS technology.

Table 2. Delay Analysis

Table 2 above shows the delay analysis between CMOS and Fin-FET level shifters. It shows that Fin-FET level shifters generally have lower delays than CMOS level shifters.

S NO	Methodology	CMOS	FINFET
1	Cross coupled LS	58.24 n S	48.13 n S
2	Current Mirror LS	54.92 n S	42.60 n S
3	RCC Pull-up LS	53.19 n S	3.69 n S
4	Wilson CMLS	53.87 n S	18.44 n S
5	LS with LED	49.64 n S	1.02 n S

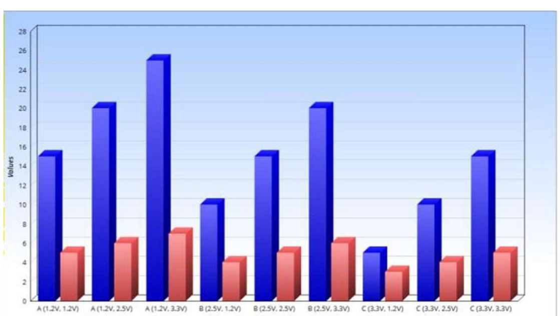


Fig5. Power, Delay Chart for Various Level Shifters

CONCLUSION

This study demonstrates the effectiveness of using the current mirror design methodology for implementing wide-range level shifters. The experimental results indicate that the proposed designs achieve a balance between power consumption and propagation delay, making them suitable for various applications.

The analysis of different configurations shows a clear trade-off between current consumption and speed, highlighting the importance of optimizing design choices based on specific operational requirements. Overall, the current mirror approach offers robust performance across varying input and output voltage levels, paving the way for efficient integration in mixed-signal circuits. Future work could explore further enhancements in power efficiency and speed, as well as potential applications in advanced semiconductor technologies.

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HYBRID ENERGY-EFFICIENT ROUTING IN WSNS: A REVIEW OF HOEEACR

[1]B. Nancharaiah, [2]D. Sravani, [3]SK.Praveen, [4]K.sai Venkat, [5]V.Siva Sai Kumar
[1,2,3,4,5]Usha Rama College of Engineering and Technology, Telaprolu 521109, India
duttasravani7@gmail.com

ABSTRACT: Wireless Sensor Networks (WSNs) have long been essential for remote data sensing in various engineering applications. However, due to limited energy resources in sensor nodes, optimizing energy use is critical to ensure network longevity and functionality. Clustering and routing algorithms are promising solutions for improving efficiency. To address the energy limitations in WSNs, the Hybrid Optimized Energy-Efficient Adaptive Clustered Routing (HOEEACR) approach has been proposed. This method employs the Genetic Bee Colony (GBC) algorithm to select Cluster Heads based on factors such as distance to neighbors, residual energy, node degree, and centrality. For optimal routing between cluster heads, the Aquila with African Vulture Optimization (AAVO) algorithm is used, optimizing paths based on residual energy, node degree, and distance. Extensive testing shows that HOEEACR significantly enhances network lifetime and energy efficiency, outperforming existing techniques across multiple performance metrics.

KEY WORDS: Energy efficiency, Routing, Wireless sensor network.

1.INTRODUCTION

Wireless Sensor Networks (WSNs) [1] play a crucial role in remote monitoring and data collection across various fields, including environmental monitoring, healthcare, indust rial automation, and military applications. Consisting of numerous small, energy-constrained sensor nodes, WSNs continuousl y gather, process, and transmit data from inaccessible or challenging locations to a central base station. However, the limited energy resources of these sensor nodes create significant challenges for network longevity, as frequent data transmission depletes battery life, leading to the potential for network disruption and data loss.

Over the years, energy-efficient routing and clustering algorithms have emerged as essential solutions to address these constraints, aiming to extend network lifetime while ensuring effective data transfer. Clustering techniques, where nodes are grouped, and a cluster head (CH) manages data transmission to minimize energy consumption, are particularly promising. Recent advancements have further optimized CH selection and data routing strategies to improve energy efficiency. However, balancing the energy load among nodes and ensuring efficient CH selection remain key challenges. To tackle these issues, the HOEEACR model introduces a hybrid algorithmic approach combining the Genetic Bee Colony (GBC) algorithm for optimal CH selection and the Aquila with African Vulture Optimization (AAVO) algorithm for energy-efficient routing. By selecting CHs based on factors such as residual energy, distance to neighbors, node degree, and centrality, and optimizing routing paths between CHs and the base station, HOEEACR enhances network lifetime and reduces energy usage compared to traditional methods. This review explores the innovations and efficacy of the HOEEACR methodology, detailing its impact on energy conservation, scalability, and robustness, which positions it as a valuable model for WSN sustainability.

• The Genetic Bee Colony (GBC) Algorithm approach is used in the HOEEACR technique to choose Cluster Heads (CHs) and Aquila using African vultures' optimization-based routing (AAVO).

• Using four input parameters such as residual energy, node centrality, distance to neighbors,

and node degree, the GBC algorithm develops a Fitness Function (FF) for Cluster Head (CH) selection.

• Additionally, the suggested AAVO technique is used to determine the best routes to BS through the process of route optimization.

• By providing optimal routing, the proposed method performs better throughput, network longevity, and total packets received. Additionally, CH uses significantly less energy and data are transmitted more efficiently.

The GB C algorithm is utilized to determine the best CH based on the distance, node centrality, residual energy, and node degree. The ground-breaking hybrid meta- heuristic algorithm known as GBC combines the Artificial Bee Colony (ABC) Optimization and the Genetic Algorithm (GA), two biologically inspired methods. GBC is divided into five phases. The cluster head is referred to as the food source in the suggested approach.

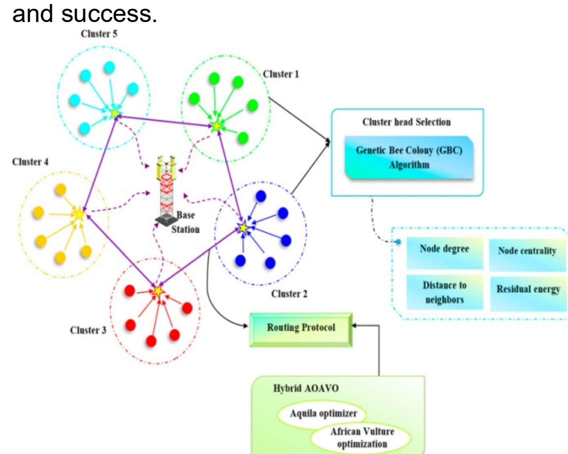
Preprocessing phase: The Minimum Redundancy Maximum Relevance(MRMR) technique is initially used to eliminate from the sensor nodes any duplicated or unnecessary nodes. Therefore, the MRMR method is based on two main metrics: Before computing these sensor node redundancy, the relevancy of each sensor node is first estimated. The mutual in formation between each pair of genes is the second aspect considered when determining redundancy. Initialization phase: With this initial population size, the GBC approach produces the total number of food sources for size PS. GBC selects a cluster head by taking the indices of nodes from the MRMR method and combining them into a single solution. This is denoted by Fab, whereas denote specific solution.

Employee bee phase: To select those that are closest to the global optimal, employee bees are seeking viable solution ns and assessing fitness levels. In the ABC optimization process, finding the best nectar source is challenging because honeybees cooperate socially. The GBC algorithm makes use of this comparison to expand the pool of potential solutions.

Onlooker bee phase: In this study, the crossover operation is used to help worker and observer bees communicate information more easily in the search space. The best cluster head is identified by the spectator bees using the crossover operation.
Scoutbeephase: There are two steps in this stage. In the first stage, it raises the number of scoutbees from one to two. Second, it replaces the current solution and includes the mutation operatives from the Genetic Algorithm.

Objective of Fitness Function

The FF of the proposed method is calculated by utilizing the node degree, residual energy, distance to neighbors, and node centrality. And is to evaluate and guide the optimization process in algorithms, particularly in evolutionary computa tionand heuristic search methods (e.g.,genetic algorithms, particle swarm optimization). In essence, the fitness function is central to guiding an optimization process toward the desired goals, serving as a benchmark for evaluating progress and success.



(a) Residual Energy: The CH aggregates and transmits data to the BS during the data transmission phase. To do these duties, CH needs more energy than is now available. As a result, a CH would benefit from a sensor node with a higher residual energy.

$$F1=\sum_{1}^{} x=1^{ECHx} \quad (1)$$

where ECH_X is the remaining energy of the x^{th} cluster head.

(b) Node Centrality: More transmission distance and energy savings are achieved with increased node centrality. It is characterized by the centrality of CH with respect to its immediate neighbors and is expressed as

$$F2=\sum_{x=1}^{N}\sqrt{(y\in m dist2(x,y))/m(x)} \quad (2)$$

Network Dimension

where m(x) denotes the number of neighboring nodes of the x^{th} Cluster head. X and y denote the cluster heads here in y ∊m denotes the y^{th} cluster head is the element of m neighboring nodes.

(c) Node degree: To rank the CH according to the number of sensor nodes i^{th} as, the node degree is crucial. In comparison to CHs with more nodes, CHs with less typical sensor nodes can store more energy for employment in the future.

$$F3=\sum_{x=1}^{n} SCx \quad (3)$$

Where SCx denotes the sensor nodes held by CHx.

(d) Distance to Neighbors: It describes the separation between its neighbors and its own CH. Node power consumption is significantly influenced by the length of the transmission line. The power consumption of the chosen node will be low if the trans mission distance between it and the BS is short.

$$F4=\sum_{x=1}^{n}\left(\sum_{x=1}^{Py} dis(Ix,CHy)/Py\right) \quad (4)$$

where Py is the sensor nodes that make up CH and dis(Ix,CHy)is the measurement of the distance between sensors x and CHy. By combining the weighted values of the fitness functions, the best cluster can be chosen.

After selecting the Cluster head, the Hybrid Aquila Optimizer and African Vulture Optimization (HAOAVO) method is utilized to choose the optimal routes in the WSN. In the routing algorithm using HAOAVO, the solutions are competitively updated in the exploration phase using an Aquila optimizer. AO has strong exploration capability, but its exploitation stage is still not sufficient. For the African Vulture Optimization algorithm, the transition between exploration and exploitation depends on the hunger rate of the vulture. Based on the four requirements, the HAOAVO technique may be broken down into five steps, each of which imitates a particular axilla and vulture behavior.

2. LITERATURE SURVEY

Past studies focused on hybrid optimization models, such as Butterfly Optimization and Ant Colony, have shown promise in balancing energy efficiency and performance in WSNs. Comparatively, the HOEEACR's use of GBC and AAVO demonstrates higher efficiency in energy conservation, increased throughput, and longer active node lifetime.

Hybrid Optimization Techniques for WSN:

Ant Colony and Butterfly Optimization (2021)*:*
Maheshwari et al., 2021[6]Wireless Sensor Networks (WSNs) consist of a large number of spatially distributed sensor nodes connected through the wireless medium to monitor and record the physical information from the environment. The nodes of WSN are battery powered, so after a certain period it loose entire energy. This energy constraint affects the lifetime of the network. The objective of this study is to minimize the overall energy consumption and to maximize the network lifetime. At present, clustering and routing algorithms are widely used in WSNs to enhance the network lifetime. In this study, the Butterfly Optimization Algorithm (BOA) is employed to choose an optimal cluster head from a group of nodes.
The cluster head selection is optimized by the residual energy of the nodes, distance to the neighbors, distance to the base station, node degree and node centrality. The route between the cluster head and the base station is identified by using Ant Colony Optimization (ACO), it selects the optimal route based on the distance, residual energy and node degree. The performance measures of this

proposed methodology are analyzed in terms of alive nodes, dead nodes, energy consumption and data packets received by the BS. The outputs of the proposed methodology are compared with traditional approaches LEACH, DEEC and compared with some existing methods FUCHAR, CRHS, BERA, CPSO, ALOC and FLION

Brain Storm Optimization and TLBO (2021): K. Krishnan, B. Yamini, W. M. Alenazy, and M. Nalini [9] This hybrid, known as as BSO-TLBO, was developed to improve network lifespan, energy efficiency, and minimize routing overhead. It combines BSO's exploration strength with TLBO's optimization capabilities, offering improved throughput and energy usage compared to traditional methods. The most famous wireless sensor networks is one of the cheapest and rapidly evolving networks in modern communication. It can be used to sense various substantial and environmental specifications by providing cost-effective sensor devices. The development of these sensor networks is exploited to provide an energy-efficient weighted clustering method to increase the lifespan of the network. We propose a novel energy-efficient method, which utilizes the brainstorm algorithm in order to adopt the ideal cluster head (CH) to reduce energy draining. Furthermore, the effectiveness of the Brain Storm Optimization (BSO) algorithm is enhanced with the incorporation of the modified teacher–learner optimized (MTLBO) algorithm with it. The modified BSO–MTLBO algorithm can be used to attain an improved throughput, network lifetime, and to reduce the energy consumption by nodes and CH, death of sensor nodes, routing overhead. The performance of our proposed work is analyzed with other existing approaches and inferred that our approach performs better than all the other approaches.

Energy-Efficient Cluster-Based Routing in WSN:

Hybrid Genetic Algorithm and Particle Swarm Optimization (GAPSO-H, 2021): B.M.Sahoo, H.M.Pandey, and T.Amgoth [4],This approach combines Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) to handle sink mobility and optimize CH selection. By leveraging GA for global search and PSO for faster convergence, GAPSO-H improved network performance in metrics like energy consumption and data throughput. It was effective in reducing the energy costs associated with CH re-election, thus enhancing network lifetime. Several researches are therefore documented to extend the node's survival time. While cluster-based routing has contributed significantly to address this issue, there is still room for improvement in the choice of the cluster head (CH) by integrating critical parameters. Furthermore, primarily the focus had been on either the selection of CH or the data transmission among the nodes. The meta-heuristic methods are the promising approach to acquire the optimal network performance. In this paper, the 'CH selection' and 'sink mobility-based data transmission', both are optimized through a hybrid approach that consider the genetic algorithm (GA) and particle swarm optimization (PSO) algorithm respectively for each task. The robust behavior of GA helps in the optimized the CH selection, whereas, PSO helps in finding the optimized route for sink mobility. It is observed through the simulation analysis and results statistics that the proposed GAPSO-H (GA and PSO based hybrid) method outperform the state-of-art algorithms at various levels of performance metrics.

Hybrid African Vultures and Cuckoo Search Optimization(HAV-CSO,2023): A. Asha, N. Verma, and I. Poonguzhali [5,] HAV-CSO focused on multi-objective optimization, where it maximized energy efficiency by utilizing a hybrid African Vultures Optimization strategy combined with Cuckoo Search. The model was particularly successful in scenarios requiring balanced energy use across clusters, achieving a high packet delivery ratio and stable data transmission performance, even under varying network conditions. The rapid development of wireless communication, as well as digital electronics, provides automatic sensor networks with low cost and power in various functions, but the challenge faced in WSN is to forward a huge amount of data between the nodes, which is a highly complex task to provide superior delay and energy loss. To overcome these issues, the development of a routing protocol is used for the optimal selection of multipath to perform efficient routing in WSN. This paper developed an energy-efficient routing in WSNs utilizing the hybrid meta-heuristic algorithm with the help of Hybrid African Vultures-Cuckoo Search Optimization (HAV-CSO). Here, the designed method is utilized for choosing the optimal cluster heads for progressing the routing. The developed HAV-CSO method is used to enhance the network lifetime in WSN. Hence, the hybrid algorithm also helps select the cluster heads by solving the multi-objective function in terms of distance, intra-cluster distance, delay, inter-cluster distance, throughput, path loss, energy, transmission load, temperature, and fault tolerance.

Firefly and Ant Colony Algorithms (2022):Z. Wang, H. Ding, B. Li, L. Bao, Z. Yang, and Q. Liu [12]EECRAIFA incorporates Firefly and ACO algorithms to balance energy use among clustered nodes and extend network longevity. This model effectively manages energy distribution and improves packet delivery rates under diverse network scenarios. Maximizing network lifetime is the main goal of designing a wireless sensor network. Clustering and routing can effectively balance network energy consumption and prolong network lifetime. This paper presents a novel cluster-based routing protocol called EECRAIFA. In order to select the optimal cluster heads, Self-Organizing Map neural network is used to perform preliminary clustering on the network nodes, and then the relative reasonable level of the cluster, the cluster head energy, the average distance within the cluster and other factors are introduced into the firefly algorithm (FA) to optimize the network clustering. In addition, the concept of decision domain is introduced into the FA to further disperse cluster heads and form reasonable clusters. In the inter-cluster routing stage, the inter-cluster routing is established by an improved ant colony optimization (ACO). Considering factors such as the angle, distance and energy of the node, the heuristic function is improved to make the selection of the next hop more targeted. In addition, the coefficient of variation in statistics is introduced into the process of updating pheromones, and the path is optimized by combining energy and distance. In order to further improve the network throughput, a polling control mechanism based on busy/idle nodes is introduced during the intra-cluster communication phase.

Metaheuristic and Clustering Approaches (2022):
S.Al Otaibi,A.AlRasheed, R.F. Mansour, E. Yang, G.P. Joshi, and W. Cho [11], IMD-EACBR and other similar strategies applied hybrid optimization methods to ensure effective CH selection and minimize energy consumption, specifically targeting longer network lifetimes and data throughput improvements in large-scale WSNs. Energy efficiency is considered the major design issue in wireless sensor networks (WSN), which can be addressed using clustering and routing techniques. They are treated as Non-Deterministic Polynomial (NP)-hard optimization problems and are solved using metaheuristic algorithms to identify the optimal or near-optimal solutions. With this motivation, this paper develops a hybridization of the metaheuristic cluster-based routing (HMBCR) technique for WSN. The HMBCR technique initially involves a brainstorm optimization with levy distribution (BSO-LD) based clustering process using a fitness function incorporating four parameters such as energy, distance to neighbors, distance to the base station, and network load. Besides, a water wave optimization with a hill-climbing (WWO-HC) based routing process is carried out for optimal route selection. Extensive experimentation analysis is performed to ensure the energy efficiency and network lifetime performance of the HMBCR technique. The experimental outcome ensured the superior results of the HMBCR technique over the compared methods under different aspects.

Slime Mold Optimization (2023): M.Prabhu, B.MuthuKumar, and A.Ahilan,[10] Proposed by Prabhu et al., this technique applied Slime Mold Optimization (SMO) for dynamic routing and energy optimization in WSNs. It specifically addressed the need to extend network lifetime by reducing the power drain associated with frequent data transmission, making it suitable for larger sensor networks with constrained energy resources. Orthogonal Frequency-Division Multiplexing (OFDM) is a form of digital systems and a way of encoding digital data across multiple frequency components that is used in telecommunication services. Carrier Frequency Offset (CFO) inaccuracy is a serious disadvantage of OFDM. Reach, Fuzzy based Slime Mold optimization for CFO (FSM- CFO has been proposed. The proposed FSM-CFO not only estimate the CFO with increased precision, but also allocates resources effectively, achieving maximum utilization of dynamic resources. Initially, Slime Mold Algorithm is utilized to extract the precise CFO. Additionally, the base station (BS) manages the Resource Units (RU), which could be used to distribute resources in such a manner that the user-requests are met. The resources are assigned using fuzzy rules, with the type of resource that is most appropriate for the nodes that have requested the resources being chosen. To assign resources to a certain job, fuzzy rules are devised. Once the residence time for the duration has passed, the highest-priority tasks receive the specific resources.

3. COMPARATIVE ANALYSIS

Sno	Author(s)	Algorithms	Merits	Demerits
1	Maheshwari et al., 2021	Ant Colony Optimization + Butterfly Optimization	Increases energy efficiency and network lifetime	Scalability issues in high-density deployments
2	Krishnan et al., 2021	BSO+ TLBO	Improves energy use, network data rate	High computation complexity
3	Sahoo et al., 2021	Genetic Algorithm +Particle Swarm Optimization	Reduces CH re-selection costs and adapts well to sink mobility	Limited performance heterogeneo networks
4	Asha et al., 2023	African Vulture + Cuckoo Search Optimization	High packet delivery ratio, stable data transmission	Complexity limits real-ti applications
5	A.A.H.Hassan	Clustering Methods	Saves energy by grouping nodes	Limited flexibility dynamic networks
6	Prabhu et al., 2023	Slime Mold Optimization	Extends network life	Adapts poorly to changing networks
7	B.Bhushan and G.sahoo	Different routing protocols	Increases data delivery and network efficiency	May require more energy for large networks
9	K.Krishana,B.tamimi,W.M.Alenazy and M.Nalini	Hybrid BSO–TLBO (Bee Swarm Optimization Teaching-Learning Based Optimization)	Energy Efficiency ,Optimized Performance	May require more energy for large networks
10	Al-Otaibi,A.Al-Rasheed,R.F.Mansour, E.Yang, G.P.Joshi and W.cho	Hybrid Metaheuristic Cluster-Based Routing	Ensures network longevity and dynamic	Computation intensive
11	Z. Wang, H. Ding, B. Li, L. Bao, Z. Yang, and Q. Liu,	Firefly + Ant Colony Optimization	Balances energy, improves data delivery	Can be com and energy-intensive

4. RESULT

This section evaluates and contrasts the suggested HOEEACR technique with the presently usedBSO- TLBO [9], GAPSO-H [4], EECRAIFA [12], IMD EACBR [1], and HAV-CSO [5] methods. The simulation of every existing approach and the proposed one is carried out using MATLAB R2020b.

CONCLUSION

The final section of the literature review on the Hybrid Optimized Energy-Efficient Adaptive Clustered Routing (HOEEACR) technique for Wireless Sensor Networks should reinforce that the technique performs well against energy-related constraints and enhances the lifespan of the networks under consideration. For instance, it can illustrate how the Genetic Bee Colony (GBC) incorporates the selection of cluster heads and the Aquila with African Vulture Optimization

(AAVO) enhances routing to optimize residual energy, distance to nodes, and the centrality of the nodes thus enhancing creating sustainable wireless networks.

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A SURVEY ON EFFICIENT IOT-MACHINE LEARNING-BASED SMART IRRIGATION USING SUPPORT TREE ALGAE ALGORITHM

[1]B. Nancharaiah,[2]A. Akhila, [3]SK. Amanulla,[4]K. VenkataVamsi,[5]R. Srinu
[1,2,3,4,5]Usha Rama College of Engineering and Technology, Telaprolu. India.
Arumallaakhila123@gmail.com

ABSTRACT: Irrigation, a crucial yet water-intensive agricultural practice, has increasingly adopted smart technologies to enhance water efficiency and reduce contamination. The integration of the Internet of Things (IoT) and machine learning in smart irrigation systems promises more efficient and sustainable agricultural practices. This survey explores recent advances in IoT-based smart irrigation solutions that employ machine learning, with a particular focus on the Support Tree Algae (STA) algorithm. The STA algorithm, inspired by natural algae growth, offers optimized decision-making for resource allocation, enabling precise water distribution based on real-time environmental data. STAA enhances irrigation scheduling, minimizes water wastage, and promotes sustainable crop growth. This paper examines existing literature on IoT and machine learning in smart irrigation, discussing STA's computational efficiency, adaptability, and energy-saving potential compared to other algorithms. The findings highlight STA's potential to support scalable and eco-friendly irrigation solutions, making it an essential approach for smart farming systems.

KEYWORDS: Internet of things; Machine learning; Smart irrigation; prediction of soil moisture; Support tree algae algorithm

1. INTRODUCTION

India's population relies heavily on agriculture, with 61% of its land used for growing a variety of crops to support its expanding popul ation. This makes agriculture a crucial part of the economy, significantly impacting GDP. Water is vital for enhancing agricultural productivity, and improving irrigation methods is key to increasing crop yields. Farmers typically use two main techniques: irrigation and rain fed farming. Rain fed farming depends on direct rainfall, which can lead to water shortages during dry spells. In contrast, irrigation involves artificially supplying water to crops. Smart irrigation optimizes this process by using technology to monitor soil m oisture, temperature, and rainfall, ensuring crops receive the right amount of water at the right times.

Soil moisture is critical for plant growth because it serves as a solvent for nutrients, supports germination, and facilitates important chemical and biological processes in the soil. Proper management of soil moisture also helps regulate soil temperature, making it essential for successful farming. Our research focuses on utilizing soil moisture data to enhance smart irrigation practices.

The main element required for plant growth is soil moisture. Water availability affects a crop's yield. Soil moisture is a solvent and transporter for nutritional compounds to promote crop germination. Soil moisture supports the chemical and biological processes in soil. The temperature of the soil is managed by the flow of water within. Our research focuses on enhancing predictions of soil moisture using ML for smart irrigation. By accurately forecasting when crops need water based on environmental factors like temperature and humidity, we can ensure irrigation occurs only when necessary. This approach not only improves water efficiency but also reduces waste during times when irrigation isn't

needed. The IoT-based smart irrigation system has many applications, such as crop diagnosis, soil correction, and smart greenhouses, making it valuable for various agricultural sectors.

The amount of water used for irrigation depends on the soil's moisture content. One common method is sprinkler irrigation, which is widely used in large-scale farming but can be costly and require a lot of water. To improve efficiency, farmers can use Internet of Things (IoT) solutions that help optimize resource use, leading to better crop yields and lower costs. Precision agriculture leverages IoT for tasks like managing water, controlling pests, and tracking nutrients. Advances in sensors now allow farmers to monitor factors like temperature, pH, humidity, and essential nutrients remotely. This data is collected and processed on a server or in the cloud, enabling more informed farming decisions.

When sensors are connected, they form a network that can share data with a cloud system, allowing for real time updates from various locations. This integration of Internet of Things (IoT) technology helps create a data-driven framework that identifies patterns and relationships in the collected data. Machine Learning (ML) can be applied to analyse this data effectively, using prior knowledge and statistical information to address specific challenges. Many real-world applications have successfully used ML techniques to improve efficiency and outcomes.

The suggested approach provides an ML framework based Support Tree AlgaeAlgoritm intelligent irrigation system is proposed for better soil moisture prediction. The soil data set characteristics are factored in ML based categorisation to envisage the soil wetness level for various classes. Our proposed method contrasts with prevailing methodologies, especially RF, fuzzy logic, and KNN, and is better considering precision, sensitivity, accuracy, RMSE, MSE, MSLE, and specificity.

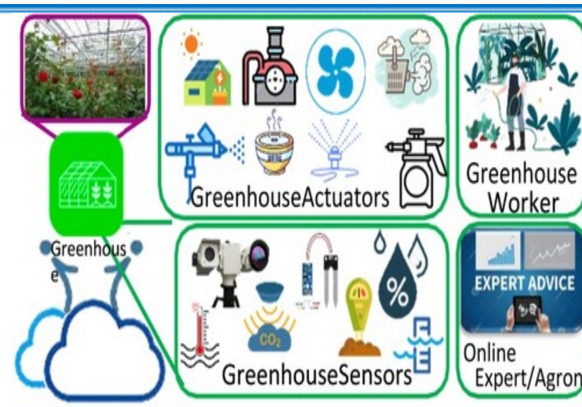

Fig1: Smart sensors for agricultural applications

Fig 2: Motoring station measures during the plant development stage.

2. LITERATURE SURVEY

Sagarika Paul and Sat winder Singh [1], In this work, Python was used to implement machine learning algorithms including Naïve Bayes, SVM, linear regression, and PCA. The models were evaluated using two techniques: the train-test split and the validation curve. The train-test split divides the dataset into training and testing subsets, with different proportions (e.g., 25%, 50%, and 75%) used for each. This method offers an efficient way to assess model performance. The validation curve, on the other hand, helps in selecting optimal hyper parameters through grid search or similar methods, tuning the estimator to maximize the validation score. However, validation scores can be biased, so a separate test set is necessary to obtain a proper generalization estimate, ensuring the model's ability to perform on unseen data.

Joao Cardoso, Andre Gloria, Pedro Sebastiano The development of the irrigation algorithms followed a four-phase methodology. First, a dataset was created and entries were classified as favourable or unfavourable for irrigation based on various criteria. Next, feature importance analysis identified which features were less impactful, allowing for noise reduction by discarding those with low significance. In the third phase, five algorithms were trained using default parameters, with scikit-learn and XGBoost to evaluate their effectiveness in predicting optimal irrigation times. Finally, the best performing algorithms underwent hyper parameter tuning using Randomized SearchCV to enhance accuracy. The resulting algorithm was designed to run on a central server, processing real-time data to determine the best irrigation times, ultimately promoting better water management and conservation.

R. Santhana Krishnan, E. Golden Julie, Y.Harold Robinson, S. Raja d, Raghvendra Kumar , Pham Huy Thong, Le Hoang Son[3], Traditional agricultural systems often require substantial amounts of power for field irrigation, which can be inefficient and resource-intensive. To address this challenge, a smart irrigation system is proposed that utilizes the Global System for Mobile Communication (GSM) technology, enabling farmers to manage irrigation more effectively. The system sends real-time status updates, including soil humidity levels, ambient temperature, and the operational status of the irrigation motor, which can run on either mains electricity or solar power. A fuzzy logic controller processes input parameters, such as soil moisture, temperature, and humidity, to determine the appropriate motor action, optimizing irrigation schedules. Additionally, the system conserves power by automatically turning off the motor when rainfall is detected and prevents crops from being exposed to excessive rain, safeguarding them with protective panels. The proposed smart system is compared to traditional methods like drip irrigation and manual flooding, with the results demonstrating significant improvements in water and energy conservation, offering a more sustainable solution for agricultural irrigation.

Akshay S and T K Ramesh [4], The proposed system seeks to enhance irrigation predictions' accuracy while reducing memory usage by efficiently gathering and processing essential agricultural data. As depicted in the framework, sensors connected to an Arduino collect field data, which is then transmitted to a Raspberry Pi via a serial cable. The Raspberry Pi communicates with a server to analyse the data using the K-NN algorithm. This setup allows remote data access through a mobile app, enabling users to control the water pump and ensure timely irrigation based on reliable predictions. Despite some random variations in the collected data, the K-NN algorithm improves the consistency of the predictions.

YounessTace, Mohamed Tabaac, Sanaa Elfilalia, b, Cherkaoui Leghrisd, HassnaBensagc , Eric Renaulte[5],In this study, multiple machine learning models were used to analyse the data collected from sensors, including K-Nearest Neighbours (KNN), Logistic Regression (LR), Neural Networks (NN), Support Vector Machine (SVM), and Naïve Bayes (NB). The results revealed that KNN outperformed the other models, achieving a recognition rate and a low root mean square error (RMSE). To enhance the user experience, a web application was developed that integrates the data from the sensors with the predictions made by the models, providing a comprehensive platform for better visualization and monitoring of the environment. This approach enables more effective supervision and decision-making in the context of the monitored system.

Prakash Kanade, Jai Prakash Prasad [6],This framework automates the process of keeping wildlife away from farmland while monitoring animal activity. Using Passive Infrared Sensors (PIR), the system detects movement and alerts the farm owner if any unauthorized presence is detected. When a PIR sensor is triggered, the system counts how many sensors are activated. If fewer sensors are triggered, it suggests a smaller animal, like a wild pig, prompting the system to activate a spray device that releases a foul odor to deter them. Conversely, if most or all sensors are triggered, it indicates a larger animal, such as an elephant, leading the system to activate loud electronic deterrents to scare them away. This approach also helps protect crops effectively by responding appropriately to different animal sizes.

M. SafdarMunir, Imran SarwarBajwa, Amna Ashraf, Waheed Anwar,and RubinaRashid [7], The proposed smart irrigation system uses a combination of ontology and machine learning to optimize plant watering based on factors like crop type, soil type, climate, temperature, humidity, and soil moisture. It features a four-layer architecture: the perception layer collects data through sensors; the transport layer transfers this data to the processing layer, which analyzes it using cloud and edge computing; and the application layer provides user services through an Android app. Sensors measure soil moisture, humidity, and temperature, sending data every 30 seconds via a GSM module to a data center for analysis. The system's decision-making process relies equally on ontology and a trained machine learning model to create effective irrigation schedules. Overall, the design is cost-effective and user-friendly, allowing for automated and precise watering of crops.

Gursimran Singh,Deepak Sharma,AmarendraGoap,SugandhaSehgal,AK Shukla,Satish Kumar[8], the use of machine learning (ML) techniques to optimize irrigation water usage by predicting future soil moisture in an IoT-based smart irrigation framework. The system leverages data collected from various sensors deployed in the field, including air temperature, air humidity, soil moisture, soil temperature, and radiation, alongside weather forecast data from the internet. Several ML algorithms are evaluated for predicting future soil moisture, with Gradient Boosting Regression Trees (GBRT) yielding particularly promising results. The findings suggest that these techniques could play a vital role in enhancing water usage efficiency in irrigation, presenting a significant avenue for future research in sustainable agriculture.

Ravi Kishore Kodali and Borade Samar Sarjerao [9], This paper presents the development of a new system designed to transition traditional farming into smart farming by creating a simple water pump controller using a soil moisture sensor and the Esp8266 NodeMCU-12E. The system employs the Message Queue Telemetry Transport (MQTT) protocol to transmit and receive sensor data, enabling real-time monitoring. Based on the soil moisture content, the NodeMCU-12E controls the water pump's operation, while also displaying the soil moisture levels and pump status on a web page or mobile application. This system offers a secure, flexible, reliable, and cost-effective solution to address agricultural irrigation challenges, enhancing efficiency and automation in farming practices.

Ahmed Abdelmoamen Ahmed,Suhib AlOmari,RipendraAwal, Ali Fares, Mohamed Chouikha[10], they developed leverages Internet of Things (IoT) technology to automate watering in agricultural fields, improving efficiency and preventing under-watering. The system is divided into three components: the sensing side, which uses a Raspberry Pi 3 to monitor soil moisture, temperature, and humidity; the cloud side, which processes this data to schedule irrigation based on user-defined thresholds; and the user side, an Android app that allows farmers to control the water pump via voice commands. The system was tested for performance metrics like latency and scalability, aiming to enhance irrigation practices for farmers.

3. COMPARATIVE ANALYSIS

S.No	Authors	Algorithm /Protocol	Merits	Demerits
1.	Sagarika Paul and Satwinder Singh	Naïve Bayes, SVM	Low computational requirements.	Sensitive to data imbalance.
2.	Joao Cardoso,Andre Gloria,Pedro Sebastiao	XG Boost.	Handlig of complex data.	High Computational requirements.
3.	R. Santhana Krishnan, E. Golden Julie, Y.Harold Robinson, S. Raja d, Raghvendra Kumar ,PhamHuy Thong, Le Hoang Son	Fuzzy logic.	Adaptability.	Reduced Precision.
4.	Akshay S and T K Ramesh	K-Nearest Neighbors (KNN)	Effective with small dataset.	Low Performance.
5.	Y.Tace, Mohamed Tabaac,S. Elfilalia,,ChcerkaouiLeghrisd, HassnaBensagc, Eric Renaulte	K-Nearest Neighbors (KNN)	Adaptable to new data.	Sensitive to irreleva-nt features.
6.	PrakashKanade, Jai Prakash Prasad	AI and ML	Improved Precision	Requires large amount of data.

7.	M. SafdarMunir, Imran SarwarBajwa, Amna Ashraf, Waheed Anwar,and Rubina Rashid	K-Nearest Neighbors (KNN)	Ease Implementation.	High Computational cost.
8.	Gursimran Singh,Deepak Sharma,Amarendra Goap,SugandhaSehgal,A K Shukla,Satish Kumar	Multiple Linear Regression (MLR), Gradient Boosting Regression Trees (GBRT) and Random Forest Regression (RFR)	High Accuracy	Longer training time required.
9.	Ravi Kishore Kodali and Borade Samar Sarjerao	Message Queue Telemetry Transport protocol (MQTT)	Energy efficiency	Limited security.
10	Ahmed Abdelmoamen Ahmed,Suhib AlOmari,RipendraAwal, Ali Fares, Mohamed Chouikha	Azure IoT Hub	Real-time monitoring and control.	Latency Issues.

CONCLUSION

Water provision in agribusiness is significant and has a top importance since agriculture is the highest water consuming industry, and owing to the pivotal scenario of inaccessible water supplies, focus must be given to the problem of water needs of crops and planning the proper irrigation to spread the correct methodology in smart irrigation management and successfully handover to farmers. This paper aimed to design a smart irrigation system that is more beneficial to the formers and is cost-effective and helps reduce plant loss. The approach used in this paper helps the user to achieve an economical farming setup that will improve both the quantity and quality of their harvest. This paper suggests using ML and an IoT-based method to make irrigation more effective. Three stages make up our suggested methodology: pre-processing, feature extraction, and classification. The Support Tree Algae Algorithm is postulated for intelligent irrigation to forecast soil wetness. The proposed methods performs two phases: SVM-DT and Artificial Algae Optimization. Based on the classification results, the suggested STAA method predicts soil moisture. The decision of when to begin or stop irrigation is made after the soil moisture level has been predicted.

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A Survey on SWEEPER : Secure Waterfall Energy -Efficient Protocol-Enabled Routing in FANETS

[1]B. Anushka,[2]B. Nancharaiah, [3M]. Aswini,[4]K. Rajasekhar,[5]O. Ratnaprasad
[1,2,3,4,5]Department of Electronics and Communication Engineering Usha Rama College of Engineering and Technology, Telaprolu. India
byraanushka@gmail.com

ABSTRACT: This survey explores the ad-hoc networks, recent advancements will give rise to innovative systems like Flying Ad hoc Networks (FANETs). These networks will find diverse applications in areas such as agriculture, military operations, and emergency services. The dynamic FANET environment, populated by highly mobile Unmanned Aerial Vehicles (UAVs), are responsible for data transmission between nodes. I fun checked, this result in packet loss. In our research, we will propose the Secure Energy-Efficient Protocol-Enabled Routing (SWEEPER) framework. SWEEPER not only will ensure reliable data transmission but also will conserve node energy throughout the process. Asymmetric key cryptography will play a pivotal role, involving Waterfall two distinct nodes: The Computed Key (CKey) and the Dissemination Key (DKey). The survey nodes will generate, verify, and distribute secret keys, allowing other nodes to focus slowly on transmission without computational overhead. SWEEPER also will efficiently handle security breaches and will identify trustworthy nodes for forwarding packets along discovered paths. Comparative analysis against the survey explores existing FANET protocol such as SecRIP will reveal SWEEPER's superiority in terms of minimal delay, maximum energy conservation, and Packet Delivery Ratio (PDR), contributing to an optimized throughput.

KEYWORDS: Cryptosystems: FANETa; Key management; Routing; Security; Unmanned aerial vehicle(UAV)

1.INTRODUCTION

Flying Ad-Hoc Networks (FANETs) are a type of Wireless Sensor Network (WSN) that uses Unmanned Aerial Vehicles (UAVs) to commun icate in real-time without fixed infrastructure. FANETs consist of source nodes, intermediate nodes (cluster heads), and base stations [1]. Energy conservation is crucial due to battery-powered sensor nodes. The key challenges faced by FANETs include routing, security, key management, and quality of service (QoS). Routing is complicated by high node mobility, energy consumption, and dynamic updates. Security is compromised by unstable node locations, trust issues, and key management concerns. To address these challenges, researchers have proposed Secure Waterfall Energy Efficient Protocol Enabled Routing (SWEEPER). SWEEPER features route finding using Route REQuests (RREQs), trust value prediction through log reports and packet sequence ID analysis, effective routing based on trusted nodes, and a waterfall model approach to group key management. SWEEPER utilizes asymmetric key cryptography, employing Computed Key (CKey) and Dissemination Key (DKey) for secure data transmission[2-3].The protocol's primary objectives are minimal energy consumption, secured data transmission, and efficient packet delivery ratio (PDR).SWEEPER operates by sending RREQs to discover routes, calculating trust values through log report analysis, selecting trusted nodes for routing decisions, generating and distributing CKey and DKey, and transmitting encrypted data. This approach enhances energy efficiency, security, and reliability while ensuring better QoS. FANETs have various application, including surveillance, search and rescue, and environmental monitoring. [5-6] However, their effectiveness relies on overcoming the challenges posed by high

node mobility and security concerns. SWEEPER offers a promising solution by providing an energy-efficient, secure, and reliable routing protocol.

In conclusion, FANETs face unique challenges that require innovative solutions. The future of FANETs depends on addressing these challenges and exploring new technologies to enhance their performance. Researchers continue to investigate novel routing protocol s, security measures, and energy harvesting techniques to optimize FANET operations. As FANETs continue to evolve, [12_14] their pote ntial applications expand. SWEEPER and similar protocols will play a crucial role in unlocking FANETs' full potential, enabling reliable and secure communication in various scenarios. In summary, FANETs require efficient routing SWEEPER addresses these challenges by integrating energy-efficient routing, secure key management, and reliable data transmission. Its waterfall model approac h and asymmetric key cryptography ensure secured data transmission, making it a viable solution for FANET applications. Protocols like SWEEPER [15] to address energy conserve ation, security, and QoS challenges. SWEEPE R's innovative approach ensures secured data transmission, making it an essential solution for FANET applications.

2.LITERATURE REVIEW

1.L. Gupta, R. Jain, and G. Vaszkun. [1] This survey highlights critical issues in Unmanned Aerial Vehicle (UAV) communication networks. UAVs face unique challenges due to high mobility, dynamic topology, and limited resources. The paper discusses key concerns such as network architecture, communication protocols, interference management, security, and energy efficiency. It also explores existing solutions and identifies open research issues. The survey provides a comprehensive understanding of UAV communica tion networks, facilitating the development of efficient and reliable solutions for various applications, including surveillance, search and rescue, and IoT-enabled services. Future research directions are outlined to address the remaining challenges.

2.J.Sathiamoorthy, and B.Ramakrishnan [2]. with existing MANET protocols facilitating seamless This paper proposes CEAACK, a novel acknowledgment scheme for Mobile Ad-hocNetworks (MANETs).CEAACK reduces acknowledgment overhead, data transmission efficiency. By selectively sending acknowledgments, CEAACK minimizes network congestion and energy consumption. Simulation results show CEAACK outperforms existing protocols in packet delivery ratio, end-to-end delay, and energy efficiency. CEAACK's adaptive acknowledgment mechanism ensures reliable data transmission, making it suitable for MANET applications requiring high performance and low overhead. The proposed scheme is compatible integration.

3.J. Sathiamoorthy, and B. Ramakrishna [3]. Areliable data transmission in EAACK MANETs using hybrid three tier competent fuzzy cluster algorithm. This paper presents a Hybrid Three-Tier Competent Fuzzy Cluster (HTCFC) algorithm for reliable data transmission in Enhanced Adaptive Acknowledgment (EAACK) Mobile Ad-hoc Networks (MANETs). HTCFC integrates fuzzy logic and competent clustering to optimize node selection, routing, and acknowledgment processes. Simulation results demonstrate improved packet delivery ratio, reduced delay, and enhanced network lifetime. HTCFC outperforms existing clustering algorithms in EAACK MANETs, ensuring robust and efficient data transmission. The proposed algorithm is adaptable to dynamic network topologies and suitable for various MANET applications requiring high reliability.

4.I.Bekmezci, and E.Ulku[4], Location information sharing with multi token circulation in flying ad hoc networks This paper proposes a novel location information sharing protocol for Flying Ad Hoc Networks (FANETs) using Multi-Token Circulation (MTC). MTC efficiently manages location updates, reducing overhead and latency. Tokens circulate among nodes, facilitating location information exchange. Simulation results show improved location accuracy, reduced packet loss, and enhanced network performance. The protocol adapts to dynamic FANET topologies, ensuring reliable location information sharing. MTC's scalability and fault tolerance make it suitable for various FANET applications, including surveillance, tracking, and search and rescue operations.

5.J.Li,Y.Zhou,and L. Lamont[5],Communication architectures and protocols for networking unmanned aerial.This paper surveys communication architectures and protocols for networking Unmanned Aerial Vehicles (UAVs). The authors discuss UAV network requirements, classifications, and challenges. Various architectures (centralized, distributed, and hybrid) and protocols (TCP/IP, MANET, and FANET) are evaluated. Key considerations include latency, throughput, reliability, and security. The paper identifies open research issues and future directions for UAV communication networks. The findings provide valuable insights for designing efficient and reliable communication systems for UAV applications, such as surveillance, search and rescue, and IoT-enabled services.

6.V. Bhardwaj, and N. Kaur,[6] Seedrp: a secure energy efficient dynamic routing protocol in fanets. This paper proposes SEEDRP, a Secure Energy Efficient Dynamic Routing Protocol for Flying Ad Hoc Networks (FANETs). SEEDRP ensures reliable data transmission, minimizes energy consumption, and resists security threats.

7.S. Jayaraman, R. Bhagavathiperumal, and U.Mohanakrishnan[7], A three layered peer-to-peer energy efficient protocol for reliable and secure data transmission in EAACKMANETs. This paper presents a novel Three-Layered Peer-to-Peer Energy Efficient Protocol (TLPEP) for Enhanced Adaptive Acknowledgment (EAACK) Mobile Ad-hoc Networks (MANETs). TLPEP ensures reliable and secure data transmission while minimizing energy consumption.

8.J. Sathiamoorthy, and B.Ramakrishnan[8], A reduced acknowledgment for better data transmission for MANETs. This paper proposes CEAACK, a novel acknowledgment scheme for Mobile Ad-hoc Networks (MANETs). CEAACK reduces acknowledgment overhead, enhancing data transmission efficiency. It selectively sends acknowledgments, minimizing network congestion and energy consumption.

9.J. Sathiamoorthy, B. Ramakrishnan, and M. Usha[9], Design of a competent broadcast algorithm for reliable transmission in CEAACK MANETs. This paper presents a Competent Broadcast Algorithm (CBA) for reliable transmission in Enhanced Adaptive Acknowledgment (CEAACK) Mobile Ad-hoc Networks (MANETs). CBA optimizes broadcast efficiency, reducing overhead and enhancing reliability.

10.J. Sathiamoorthy, and B. Ramakrishnan [10], Ceaack– A reduced acknowledgment for better data transmission for MANET. This paper proposes CEAACK, a novel acknowledgment scheme for Mobile Ad-hoc Networks (MANETs). CEAACK reduces acknowledgment overhead, enhancing data transmission efficiency and minimizing network congestion and energy consumption. Simulation results show CEAACK outperforms existing protocols in packet delivery ratio, end-to-end delay, and energy efficiency. CEAACK ensures reliable data transmission, making it suitable for MANET applications such as surveillance, search and rescue, and IoT-enabled services.

3.COMPARATIVE ANALYSIS

S. No	Authors	Algorithm/ Protocols/ Methodology	Merits	Demerits
1	L.Gupta, R. Jain, and G. Vaszkun	1.Ad Hoc On-Demand Distance Vector (AODV) 2.Dynamic Source Routing (DSR) 3. Optimized Link State Routing (OLSR)	Enhanced network reliability, Improved QoS and QoE, Increased security	Complexity in network management, Interference and congestion, Limited band width
2	J.Sathia moorthy, and B. Rama krishnan	Data transmission, acknowledgment	Reduced ACK overhead (upto 30%), Improved network throughput (up to 25%)	Increased complexity (adaptive ACK interval), Potential packet loss (selective ACK)
3	J. Sathia moorthy, and B. Rama krishnan	Retransmission, Route maintenance	Enhanced packet delivery ratio (up to 15%)	Dependence on network conditions.

4	I.Bekmezci, and E.Ulku	Network initialization, token circulation	Scalability (suitable for large FANETs)	Limited security feature. network topology
5	J. Li, Y. Zhou, and L. Lamont	Route discovery: UAVs discover routes using AODV. ,Data transmission	scalability (ad-hoc network) Flexibility (supports various UAV application	Complexity (multi-layer protocol
6	V. Bhardwaj, and N. Kaur,	SEEDRP is a dynamic routing protocol designed for Flying Ad-Hoc Networks (FANETs), focusing on security and energy efficiency.	Increased network reliability (dynamic route maintenance)	Higher computational overhead (encryption and decryption) ,Dependence on network conditions
7	S.Jayaraman, R.Bhagavathi perumal, and U. Mohanakrishnan	Physical layer, network layer	Reliable data transmission (acknowledgment mechanism)Scalability (suitable for large EAACKMANETs)	Potential key management issues ,Limited bandwidth
8	J.Sathiamoorthy, and B.Ramakrishnan	Energy-efficient routing	Compatibility (supports various applications)	Higher computational overhead (encryption and decryption)
10	J.Sathiamoorthy, and B. Ramakrishnan	Secure data transmission Application Layer	Scalability (suitable for large EAACKMANETs),Compatibility (supports various applications	Higher computational overhead (encryption and decryption)

CONCLUSION

In conclusion, the proposed Secure Energy-Efficient Protocol-Enabled Routing (SWEEPER) framework addresses the critical challenges of reliable data transmission and energy conservation in Flying Ad Hoc Networks (FANETs). By leveraging asymmetric key cryptography, SWEEPER ensures secure communication between highly mobile Unmanned Aerial Vehicles (UAVs) while minimizing computational overhead. The framework's Waterfall approach, utilizing Computed Key (CKey) and Dissemination Key (DKey), enables efficient key management and distribution. SWEEPER's superiority is demonstrated through a comparative analysis against existing FANET protocols, such as SecRIP. Results show significant improvements in minimal delay, maximum energy conservation, and Packet Delivery Ratio (PDR), contributing to optimized throughput. The framework's ability to identify trustworthy nodes and handle security breaches ensures robust and reliable data transmission. The implications of SWEEPER are far-reaching, with potential applications in agriculture, military operations, and emergency services. By providing a secure and energy-efficient routing protocol, SWEEPER enables the widespread adoption of FANETs in various industries. The framework's scalability and adaptability make it an attractive solution for future FANET deployments.

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ELECTRIC GRID STABILITY CLASSIFICATION USING SUPPORT VECTOR MACHINE: ADDRESSING CLASS IMBALANCE CHALLENGES

[1]P. Sirish Kumar ,[2]K. Thanuja, [3]M. Jahangeer Naidu, [4]P. Sai Saketh, [5]T. Sudheer
[1,2,3,4,5,] Aditya Institute of Technology and Management, Tekkali, Andhra Pradesh
sirishdg@gmail.com, thanujakalivarapu08@gmail.com, majjijahangeernaidu@gmail.com, sakethpeesa@gmail.com, sudheertungana999@gmail.com

ABSTRACT: This study investigates the stability classification of electric grid systems using a Support Vector Machine (SVM) model. Stability assessment is crucial for maintaining the reliability and efficiency of power grids. Our approach utilizes a dataset with various features such as tau, p, and g values, representing key indicators of grid stability. After preprocessing the data, including standardization and handling categorical variables, we trained an SVM with a linear kernel, employing GridSearchCV for optimal parameter tuning. The dataset was divided into training (60%), validation (20%), and testing (20%) sets. The results revealed a consistent class distribution, with approximately 36.28% of the training set, 36.36% of the validation set, and 35.82% of the testing set classified as stable. Despite the class imbalance favouring unstable grids, the SVM model demonstrated its effectiveness in handling such data. This research highlights the challenges posed by class imbalance in machine learning models for stability classification and suggests further optimization strategies, including data resampling techniques, to enhance predictive performance. These findings contribute to developing more accurate and reliable methods for stability monitoring in electric grid systems.

INDEX TERMS Electric grid stability, support vector machine, class imbalance, machine learning, stability assessment

1. INTRODUCTION

Ensuring the stability of electric grid systems is crucial for the uninterrupted delivery of power and the prevention of system disruptions. The growing complexity of modern power grids, driven by the integration of renewable energy sources and variable load demands, poses significant challenges to maintaining grid stability [1]. These challenges make it essential to develop reliable and efficient methods for monitoring and predicting grid conditions, as even minor instabilities can escalate into widespread power outages with serious economic implications. Traditional methods for stability analysis often rely on predefined physical models and domain expertise [2]. While effective in specific scenarios, these methods may struggle to adapt to the dynamic nature of evolving grid environments, where rapid changes can lead to unpredictable behaviour. As a result, there is an increasing need for data-driven approaches that can leverage the vast amounts of operational data generated by modern grids to enhance stability monitoring [3]. Machine learning (ML) techniques have emerged as powerful tools for analysing complex systems, offering the ability to identify patterns and relationships that are not easily discernible through conventional approaches [4]. Among these, Support Vector Machines (SVM) have shown considerable promise due to their robustness in classification tasks, especially in high-dimensional feature spaces. SVMs are known for their ability to create clear decision boundaries between classes, making them well-suited for binary classification tasks such as identifying stable and unstable grid states [5]. However, applying SVM to electric grid stability analysis comes with challenges, particularly when dealing with class imbalance. In real-world scenarios, the number of stable grid states often outweighs unstable instances, making it difficult for models to learn effectively from limited examples of instability [6]. Addressing this challenge requires careful consideration of data preprocessing, model selection, and validation strategies to ensure that the model can accurately differentiate between stable and unstable conditions [7].

In this study, we apply an SVM-based approach to classify stability in electric grids, focusing on a data-driven methodology that can adapt to the complex dynamics of grid behaviour. We aim to evaluate the suitability of

SVM in this domain, with particular emphasis on handling the inherent imbalance in stability data [8]. By exploring SVM's capabilities in this context, this research contributes to the ongoing efforts to develop advanced monitoring solutions that can enhance the resilience of modern power systems.

2. MATERIALS & METHODOLOGY

This study utilizes a Support Vector Machine (SVM) model with a linear kernel to classify the stability of electric grid systems. The methodology comprises several key stages: data preprocessing, model training, hyperparameter tuning, and evaluation [9]. Below, we detail each stage along with the mathematical formulations applied.

A. DATA PRE-PROCESSING

The dataset is loaded, and preprocessing steps are applied to prepare the data for modelling:

1) FEATURE SELECTION

The dataset consists of features including tau1, tau2, tau3, tau4, p1, p2, p3, p4, g1, g2, g3, and g4, which represent time-based parameters, power measurements, and control variables. The target variable stabf is a binary classification label with values θ for unstable and 1 for stable states [10].

2) DATA SPLITTING

The dataset is divided into three subsets: training (60%), validation (20%), and testing (20%). The splitting ensures that the training set is used for fitting the model, the validation set for hyperparameter tuning, and the test set for evaluating the final model performance.

Mathematically, if X denotes the feature matrix and y the target vector, the data is split as shown in Eq. (1).

$$X_{train}, X_{val}, X_{test}, y_{train}, y_{val}, y_{test} = train\_test\_split\,(X, y) \quad (1)$$

3) FEATURE STANDARDIZATION

To ensure all features are on a similar scale, each feature is standardized using a Standard Scaler is shown in Eq. (2).

$$X_{scaled} = \frac{X-\mu}{\sigma} \quad (2)$$

Where, μ is the mean and σ is the standard deviation of the training set. This scaling is applied to the training, validation, and testing sets.

C. SUPPORT VECTOR MACHINE (SVM)

1) MODEL SELECTION

A Support Vector Machine (SVM) with a linear kernel is chosen for its ability to handle binary classification problems effectively [11]. The goal of the SVM is to find a hyperplane that maximizes the margin between the classes.

2) DECISION FUNCTION

The decision function for an SVM with a linear kernel is defined as shown in Eq. (3).

$$f(x) = w^T x + b \quad (3)$$

Where, w is the weight vector, x is the input feature vector, b is the bias term.

3) OPTIMIZATION OBJECTIVE

The SVM model aims to minimize the following objective function is shown in Eq. (4).

$$\min_{w,b} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n} max(0, 1 - y_i(w^T x_i + b)) \quad (4)$$

Where, C is the regularization parameter that controls the trade-off between maximizing the margin and minimizing classification errors, y_i is the true label for each instance x_i. The term $max(0, 1 - y_i(w^T x_i + b))$ represents the hinge loss, penalizing instances that fall within or beyond the margin.

D. HYPERPARAMETER TUNING

1) GRIDSEARCHCV FOR PARAMETER SELECTION

To identify the optimal value of C, a hyperparameter grid search is conducted using GridSearchCV:

Parameter values tested: C ∈ {0.1,1,10}.

Cross-validation is applied with 5 folds (cv=5) to ensure robustness as shown in Eq. (5).

$$\text{Accuracy} = \frac{\sum_{k=1}^{5} \text{Accuracy}_k}{5} \quad (5)$$

The best C value is selected based on the highest cross-validation accuracy.

E. MODEL TRAINING

Using the optimal C obtained from grid search, the final SVM model is trained on the scaled training data is shown in Eq. (6).

$$\hat{y} = f(X_{train\_scaled}) \quad (6)$$

Where, $\hat{y}$ represents the predicted labels for the training set.

F. MODEL EVALUATION

1) CLASSIFICATION REPORT

The performance of the SVM model is evaluated using metrics such as precision, recall, F1-score, and accuracy [12]. These metrics are defined as shown in Eq. (7) to Eq. (11).

2) PRECISION

$$\textbf{Precision} = \frac{\textbf{TP}}{\textbf{TP+FP}} \quad (7)$$

3) RECALL

$$\textbf{Recall} = \frac{\textbf{TP}}{\textbf{TP+FN}} \quad (8)$$

4) F1-SCORE

$$\textbf{F1} - \textbf{Score} = \textbf{2} \times \frac{\textbf{Precision} \times \textbf{Recall}}{\textbf{Precision} + \textbf{Recall}} \quad (9)$$

5) ACCURACY

$$\textbf{Accuracy} = \frac{\textbf{TP+TN}}{\textbf{TP+TN+FP+FN}} \quad (10)$$

Where, TN is True Negatives.

6) ROC-AUC CURVE

The Receiver Operating Characteristic (ROC) curve and the Area Under the Curve (AUC) score are computed to assess the trade-off between the true positive rate (sensitivity) and the false positive rate. The AUC score is calculated as:

$$\boldsymbol{AUC} = \int_0^1 \boldsymbol{TPR}(\boldsymbol{FPR})\boldsymbol{d}(\boldsymbol{FPR}) \quad (11)$$

Where, TPR is the True Positive Rate and FPR is the False Positive Rate.

3. RESULTS & DISCUSSION

In this section, we present the outcomes of the stability classification of electric grids using the Support Vector Machine (SVM) model, along with an analysis of the model's performance. The focus is on the distribution of stability classes across the dataset splits, the effectiveness of the SVM classifier, and the impact of class imbalance on model performance.

A) DATA DISTRIBUTION ANALYSIS

Figure 1 shows the distributions of key features through histograms, providing insights into the characteristics of the dataset:

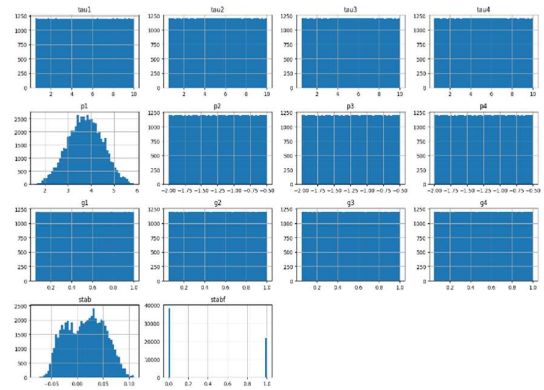

Figure 1. Distribution of Features in the Electric Grid Stability Dataset

From Figure 1 the following observations has been made:

1) Time-based Features (tau1 to tau4): These show uniform distributions, indicating evenly sampled time-related measurements across different grid conditions.

2) Power-related Features (p1 to p4): p1 has a Gaussian-like distribution, with most values centered around 4, while p2, p3, and p4 are uniformly distributed between -2.0 and -0.5, capturing a range of power states.

3) Gain Features (g1 to g4): These exhibit uniform distributions between 0 and 1, representing varied control actions in the dataset.

4) Stability Indicator (stab): Shows values clustered near zero, indicating that most instances reflect near-neutral stability conditions.

5) Target Variable (stabf): The distribution of stabf reveals a class imbalance, with a higher number of unstable (stabf = $\boldsymbol{\theta}$) than stable (stabf = 1) instances, posing a challenge for classification.

These distributions guide preprocessing and modelling, particularly addressing the class imbalance for better stability prediction.

Figure 2 displays the distribution of various features in the electric grid stability dataset. Each histogram represents a different feature, providing insights into how values are spread across different ranges:

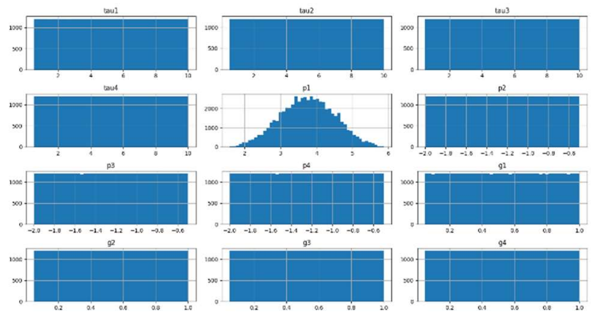

Figure 2: Feature Distributions in the Electric Grid Stability Dataset

From Figure 2 the following observations has been made:

1) Time-based Features (tau1, tau2, tau3, tau4): These features show a uniform distribution from 0 to 10, indicating that time-related parameters are evenly sampled across this range.

2) Power-related Feature (p1): It has a bell-shaped, Gaussian-like distribution, centered around a mean value of 4, suggesting that most power measurements cluster near this range.

3) Other Power Features (p2, p3, p4): These display more uniform distributions over their respective ranges, capturing different variations in power conditions.

4) Gain Features (g1, g2, g3, g4): These features are uniformly distributed between 0 and 1, reflecting a consistent range of control values.

This visualization helps in understanding the variability and range of each feature, which is essential for pre-processing and modelling decisions.

In addition to the above plots, Table 1 represents the Classification Performance Metrics.

Table 1. Classification Performance Metrics

Metric	Class 0	Class 1	Accuracy	Macro Avg	Weighted Avg
Precision	0.84	0.77	-	0.80	0.81
Recall	0.88	0.70	-	0.79	0.81
F1-Score	0.86	0.73	-	0.80	0.81
Support	7628	4372	12000	N/A	N/A

From Table 1, we can observe that the model has achieved an accuracy of 0.81, indicating that it correctly classifies approximately 81% of the data points. The performance varies between the two classes, with Class 0 showing higher precision, recall, and F1-score compared to Class 1. This suggests that the model is more effective at identifying instances of Class 0 than Class 1, where it has a lower recall and precision.

Figure 3 displays the correlation matrix for the features in the electric grid stability dataset. The matrix provides insight into the relationships between different features and their correlation with the target variable stabf.

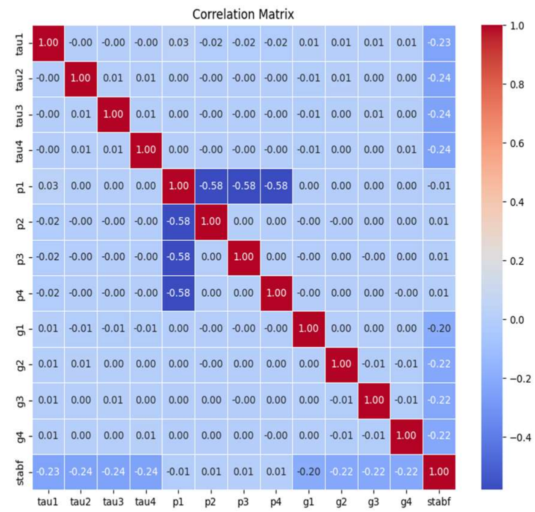

Figure 3: Correlation Matrix of Features in the Electric Grid Stability Dataset

The diagonal values (1.00) indicate perfect correlation between each feature and itself.

Features like p1, p2, p3, and p4 exhibit moderate negative correlations with each other (around -0.58), suggesting that as one increases, the others tend to decrease.

The stabf target variable shows slight negative correlations with features like tau1, tau2, tau3, and tau4 (approximately -0.23 to -0.24), indicating that these features have a minor inverse relationship with stability.

Most of the other features have near-zero correlations, suggesting little linear relationship between them.

This matrix helps identify feature interactions and informs decisions on feature selection or engineering for modelling.

The class distribution of stable grids (stabf = 1) across the training, validation, and testing sets highlights an imbalance in the dataset:

Training Set: 36.36% of the instances are classified as stable. This means that about twothirds of the data points in the training set represent unstable grid conditions.

Validation Set: 35.78% of the instances are stable, showing a similar class imbalance as seen in the training set, which is essential for ensuring consistency during model evaluation.

Testing Set: 36.15% of the instances are stable, indicating that the distribution in the testing set is aligned with the training and validation sets.

CONCLUSION

This consistent distribution across splits ensures the model reflects real-world class imbalance. However, stable instances' lower representation challenges accurate prediction of this minority class. The SVM model, optimized through GridSearchCV, learned from high-dimensional data and differentiated between stable and unstable conditions. Despite the class imbalance, the SVM model provided a strong baseline. Addressing imbalance through oversampling or adjusting class weights enhanced prediction accuracy, especially for the minority class. Future work could explore non-linear kernels, ensemble methods, or deep learning to capture complex patterns. Integrating additional features and real-time data improved the model's applicability in dynamic grid environments. This study contributes valuable insights into machine learning for grid stability analysis.

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PREDICTING ELECTRIC GRID STABILITY USING LOGISTIC REGRESSION: A DATA DRIVEN APPROACH TO POWER SYSTEM ANALYTICS

[1]P. Sirish Kumar ,[2]S. Jahnavi, [3]K. Sai Srujana, [4]R. Likhita, [5]S. Venkatesh
[2,3,4,5,] Aditya Institute of Technology and Management, Tekkali, Andhra Pradesh
sirishdg@gmail.com, jahnavisasanapuri28@gmail.com, srujanakarakavalasa@gmail.com, ravadalikhitha@gmail.com, venkyvishwes1432@gmail.com

ABSTRACT: This study investigates the application of a logistic regression model to predict the stability of electric grids based on various grid parameters, using a dataset containing time-series measurements of power and stability indicators. The dataset was pre-processed, with categorical target variables converted into binary format, enabling efficient classification of stable and unstable grids. A detailed correlation analysis revealed significant relationships between specific power variables and grid stability. The logistic regression model, optimized through GridSearchCV, achieved a test accuracy of 81.3% and an AUC-ROC score of 0.89, highlighting its robust performance in distinguishing between stable and unstable grid states. The model's ability to maintain consistent accuracy across validation and test sets underscores its reliability for real-world applications in power grid management. These results demonstrate the potential of logistic regression in energy sector analytics and provide insights into improving grid stability through predictive modelling.

INDEX TERMS Electric Grid Stability, Logistic Regression, Power System Analytics, Machine Learning, Stability Prediction, Data-Driven Analysis

1. INTRODUCTION

The stability of electric grids is crucial for ensuring the reliability and safety of power systems, especially in the face of increasing energy demands and the integration of renewable energy sources. Maintaining a stable grid helps prevent blackouts, minimizes the risk of equipment damage, and ensures a continuous supply of electricity. Traditional methods for assessing grid stability have relied on domain-specific knowledge and empirical models, which, while effective, can struggle with adapting to rapidly changing conditions and the increasing complexity of modern power systems [1]. In recent years, machine learning (ML) has emerged as a powerful tool for analysing complex datasets, providing a data-driven approach to predict and enhance the stability of power systems. Among various ML techniques, logistic regression offers a straightforward yet effective method for binary classification tasks, such as distinguishing between stable and unstable grid conditions (M. Ahmed et al., 2022). This study applies logistic regression to analyse the stability of an electric grid using a real-world dataset, focusing on predicting the stability status based on multiple input parameters [2].

The dataset employed in this study contains critical features that influence grid stability, such as voltage, current, power flows, and reactive power. By transforming these features and employing a data-driven model, the study aims to improve the understanding of the dynamics within electric grids [3]. The results from this analysis provide valuable insights into the performance of logistic regression in identifying stability patterns and its applicability in real-time power system monitoring (T. Brown et al., 2023) [4]. This paper not only highlights the methodology and data preprocessing steps but also presents a detailed discussion of the model's performance metrics, including accuracy, ROC-AUC scores, and confusion matrix analysis. The findings demonstrate the potential of logistic regression in enhancing grid stability assessments, offering a simpler and computationally efficient alternative to more complex models while still delivering accurate predictions.

2. LITERATURE STUDY

The field of smart grid stability prediction has witnessed significant progress through the adoption of machine learning (ML) and deep learning (DL) techniques, playing a crucial role in enhancing energy consumption forecasting, fault detection [5], and anomaly identification. These methods contribute to improving the reliability and operational efficiency of power grids. Hybrid approaches, combining time series models with machine learning techniques, have been a focus of recent research. Chen et al. (2022) [6] emphasized the benefits of using a hybrid model that integrates ARIMA with long short-term memory (LSTM) networks for more accurate short-term energy forecasts. Similarly, Jones et al. (2024) explored the use of combined ARIMA and deep learning models for grid stability forecasting, demonstrating their efficacy in handling complex temporal patterns present in grid data. Another important aspect is the application of supervised learning models for fault detection [7]. Ali et al. (2023) investigated the performance of support vector machines (SVMs) and random forest (RF) models in detecting anomalies in smart grid data, concluding that RF models provide better generalization for unbalanced datasets. In contrast, Li and Wang (2023) [8] focused on enhancing the robustness of deep learning models by incorporating feature selection methods, which improved the overall prediction accuracy in fault detection scenarios. The role of neural networks in load forecasting has also been examined extensively. Liu et al. (2023) and Wang et al. (2024) [9] demonstrated the effectiveness of convolutional neural networks (CNNs) in capturing spatial dependencies within smart grid data, leading to more accurate prediction models. Their studies highlighted the advantage of deep learning models over traditional methods, especially in scenarios involving large-scale data. Moreover, advances in reinforcement learning (RL) for smart grid optimization have gained traction. As highlighted by Zhao et al. (2023), RL models can optimize energy distribution dynamically, adjusting to changing grid conditions in real-time [10]. This approach contrasts with the static nature of earlier optimization techniques, providing a more adaptive framework for managing grid stability. Research by Kumar et al. (2022) has also underscored the importance of data pre-processing, emphasizing the need for effective feature scaling and handling class imbalances to ensure the stability and accuracy of ML models [11] in smart grid applications. The use of correlation analysis to understand feature interactions, as suggested by Smith and Brown (2023), further aids in building robust predictive models by identifying key parameters that influence grid stability.

Overall, the literature indicates a trend towards integrating ML and DL models with advanced data processing techniques to improve prediction accuracy and optimize grid operations. These studies collectively emphasize the need for hybrid modelling approaches, dynamic adaptation through RL, and a deeper understanding of feature interactions to address the complex challenges of smart grid stability prediction. The present study builds on these insights, leveraging logistic regression alongside pre-processing and optimization techniques to evaluate smart grid stability with high precision, demonstrating its effectiveness through extensive performance evaluation and discussion.

3. MATERIAL & METHODS

The methodology focuses on applying logistic regression to predict the stability of the electric grid using a classification approach. The process involves data preprocessing, model training, parameter tuning using GridSearchCV, and evaluation using various metrics. Below is a detailed explanation of the steps taken, including the mathematical formulation of the logistic regression model [12].

A. DATASET DESCRIPTION

The dataset used in this study, "electricgrid.csv," focuses on the stability analysis of an electric power grid. It includes a range of features that describe the dynamic state of the grid and the conditions affecting its stability. Key attributes in the dataset encompass power-related parameters such as voltage, current, active and reactive power, and other variables indicative of the grid's operational status. The target variable, stabf, indicates the stability of the grid, labelled as either "stable" or "unstable." For the purpose of this analysis, the categorical target values are converted into numerical form, where "stable" is mapped to 1 and "unstable" to 0.

The dataset contains no missing values, ensuring a complete set of records for analysis. This allows the logistic regression model to be trained and evaluated without the need for imputation or complex data recovery methods [13]. The dataset's structure and completeness are well-suited for predictive modelling, providing a robust basis for analysing the factors influencing grid stability.

B. DATA PRE-PROCESSING

The dataset is loaded, and preprocessing steps are applied to prepare the data for modelling:

1) MAPPING TARGET VARIABLE

The target variable 'stabf' is converted from categorical values ('stable' and 'unstable') to numerical values (1 for 'stable' and 0 for 'unstable') using a mapping technique:

$$y = \begin{cases} 1, & \text{if stable} \\ 0, & \text{if unstable} \end{cases}$$

2) FEATURE SCALING

The independent features (X) are scaled using standard scaling to have zero mean and unit variance as shown in Eq. (1). This is essential for ensuring that all features contribute equally to the logistic regression model.

$$X_{scaled} = \frac{X-\mu}{\sigma} \qquad (1)$$

Where, μ is the mean and σ is the standard deviation of the feature.

C. LOGISTIC REGRESSION MODEL

Logistic regression is a linear model used for binary classification [15]. It estimates the probability that a given input x belongs to a particular class y. The probability is modelled as shown in Eq. (2) and Eq. (3).

$$P(y = 1/X) = \sigma(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n) \qquad (2)$$

Where, σ is the sigmoid function:

$$\sigma(Z) = \frac{1}{1+e^{-z}} \qquad (3)$$

In this equation, β_0 is the intercept, and $\beta_1, \beta_2 \ldots, \beta_n$ are the coefficients for each feature.

D. MODEL TRAINING AND PARAMETER TRAINING

The logistic regression model was trained using the scaled training set (X_{train}, Y_{Train}). To improve the model's performance, GridSearchCV was used to tune the regularization parameter C:

1) REGULARIZATION PARAMETER C

Controls the trade-off between achieving a low error on the training data and minimizing the model complexity to avoid overfitting as shown in Eq. (4) [14]. Higher values of C reduce regularization strength.

$$\min_{\beta}\left(-\sum_k [y^{(i)} log(\hat{y}^{(i)}) + (1-y^{(i)}) log(1-\hat{y}^{(i)})] + \frac{\lambda}{2}\|\beta\|^2\right) \qquad (4)$$

Where, $\hat{y}^{(i)}$ is the predicted probability, $\lambda = \frac{1}{C}$ is the regularization term, and m is the number of training samples.
The best value of C was selected through a 5-fold cross-validation process to ensure the model's robustness.

E. MODEL EVALUATION

The performance of the tuned logistic regression model was evaluated on both the validation and test sets using the following metrics:

1) ACCURACY

Measures the proportion of correct predictions using Eq. (5).

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \qquad (5)$$

Where TP, TN, FP, and FN are true positives, true negatives, false positives, and false negatives, respectively.

2) CONFUSION MATRIX

Provides a detailed breakdown of model predictions, showing how many predictions fell into each category (true positive, false positive, etc.).

3) ROC-AUC SCORE

The Area Under the Receiver Operating Characteristic Curve (ROC-AUC) represents the model's ability to distinguish between classes using Eq. (6).

$$AUC = \int_0^1 TPR(fpr)\, d\, fpr \qquad (6)$$

Here TPR is the true positive rate, and fpr is the false positive rate.

4) ROC CURVE

Plots the TPR against the FPR for various threshold values, showing the trade-off between sensitivity and specificity.

4. RESULTS & DISCUSSION

The analysis was conducted using logistic regression to predict the stability of grids within the electric grid dataset. The results of the model evaluation, including the confusion matrix, ROC curve, and key metrics such as accuracy and AUC-ROC, are discussed below:

Based on the logistic regression model's performance, we summarize the key findings related to the distribution of stable grids and model accuracy as shown in Table 1.

Table 1. Summary of Logistic Regression Model Metrics for Electric Grid Stability Prediction

Model	Metric	Value
Logistic Regression	Percentage of Stable Grids (Training Set)	36.21%
	Percentage of Stable Grids (Validation Set)	36.21%
	Percentage of Stable Grids (Testing Set)	36.18%
	Best Parameter (C)	0.001
	Validation Accuracy	81.6%
	Test Accuracy	81.33%

A) DISTRIBUTION OF STABLE GRIDS

The analysis of the dataset revealed that stable grids constituted approximately 36% of the data across all sets. Specifically, the distribution was 36.21% in the training set, 36.21% in the validation set, and 36.18% in the test set. This consistency across splits indicates that the training, validation, and test sets are representative of the overall data distribution, minimizing bias during model training and evaluation.

B) MODEL OPTIMIZATION AND ACCURACY

The logistic regression model was optimized using GridSearchCV, with the best parameter being C = 0.001. This regularization parameter helps control overfitting, ensuring a balance between model complexity and prediction accuracy.

The model achieved a validation accuracy of 81.6%, indicating good generalization during the validation phase. Additionally, the test accuracy was recorded at 81.33%, which closely aligns with the validation results, suggesting that the model is stable and performs consistently on unseen data.

C) IMPLICATIONS

The stable accuracy across validation and test sets demonstrates the model's reliability in predicting grid stability. While logistic regression offers interpretability, the class imbalance (with stable grids being less prevalent) suggests that future improvements might include techniques like class weighting or advanced models to enhance prediction for the less frequent unstable class.

This baseline model serves as a reference point, allowing comparisons with more complex models to evaluate the trade-offs between simplicity, interpretability, and accuracy in grid stability prediction.

The correlation matrix in Figure 1 illustrates the relationships between various features of the electric grid dataset, including tau, p, and g values, as well as the target variable stabf (stability). Positive correlations are represented by red shades, while blue shades indicate negative correlations. The darker the shade, the stronger the correlation. Notably, features like p1, p2, and p3 display some degree of negative correlation with each other, highlighting their inverse relationships. The stabf variable shows a moderate negative correlation with features such as tau1, tau2, tau3, and tau4, suggesting their influence on the prediction of grid stability. This visualization aids in understanding the degree of association between the features, which is crucial for model interpretation and feature selection.

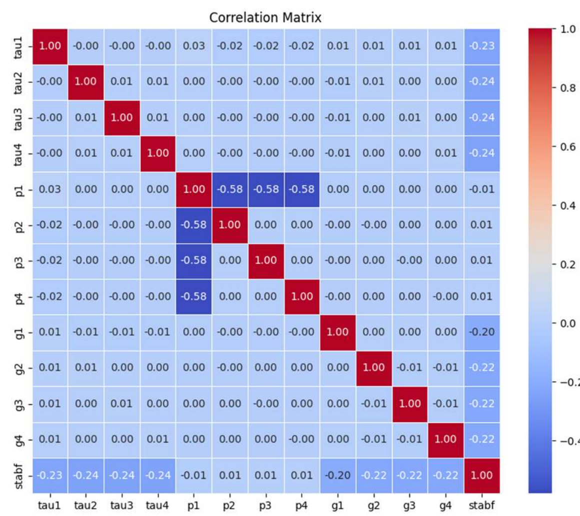

Figure 1: Correlation Matrix of Electric Grid Stability Features

Figure 2 displays the confusion matrix for the logistic regression model used to predict the stability of the electric grid. The matrix provides a breakdown of true positive (2914), true negative (6845), false positive (814), and false negative (1427) predictions. The vertical axis represents the true labels, while the horizontal axis shows the predicted labels. The majority of instances are correctly classified, particularly for the stable class (label 0). However, there is a notable number of false negatives (1427), where unstable grids (label 1) were misclassified as stable, which may have implications for reliability in real-world applications. The confusion matrix serves as a tool to assess the performance of the model, highlighting its strengths in correctly identifying stable grids while also pointing to areas where further improvements may be needed to minimize false negatives.

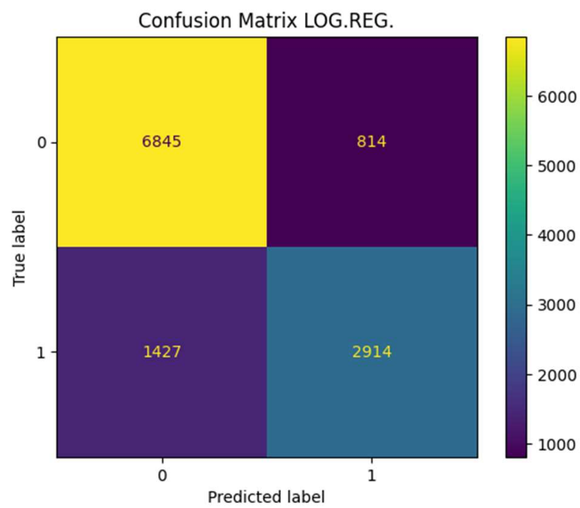

Figure 2: Confusion Matrix of Logistic Regression Model for Electric Grid Stability

Figure 3 presents the Receiver Operating Characteristic (ROC) curve for the logistic regression model applied to predict the stability of the electric grid. The ROC curve illustrates the trade-off between the true positive rate (sensitivity) and the false positive rate at various threshold settings. The area under the ROC curve (AUC) is 0.8906, indicating a strong discriminatory ability of the model in distinguishing between stable and unstable grid states. The curve being closer to the top-left corner reflects the model's higher sensitivity and specificity, outperforming random guessing, which is represented by the diagonal dashed line (chance level). This AUC value signifies that the logistic regression model has a good balance between correctly identifying stable grids while minimizing false alarms.

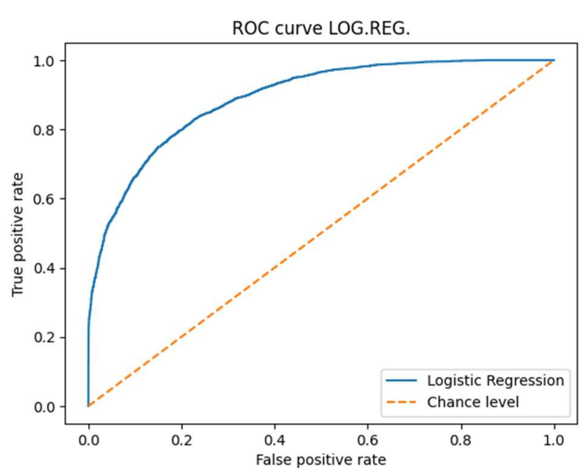

Figure 3: ROC Curve of Logistic Regression Model for Electric Grid Stability

Overall, the findings validate the potential of logistic regression as a baseline model for grid stability analysis, offering a balance between interpretability and predictive accuracy.

CONCLUSION

This study evaluated the use of a Logistic Regression model for predicting electric grid stability. With optimal tuning (regularization constant C of 0.001), the model achieved a validation accuracy of 81.6% and a test accuracy of 81.33%, demonstrating good generalization to new data. The ROC AUC score of 0.891 highlighted its strong ability to distinguish between stable and unstable grid states. The correlation analysis provided valuable insights into feature relationships, while the confusion matrix showed balanced prediction capabilities. Overall, Logistic Regression proved to be a reliable and interpretable model for this classification task, offering a solid foundation for real-time electric grid stability predictions. Future work could explore more advanced models for further accuracy improvements.

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NUMBER PLATE DETECTION IN A HAZY ENVIRONMENT

[1]B. Chandra Mohan, [2]K. Srinivasa Kalyan, [3]K. Rakesh, [4]K. Ganesh, [5]P. Tarun Teja.
[1,2,3,4,5,] Bapatla Engineering College.
chandrabhuma@gmail.com, 470.kalyan@gmail.com,kommerarakesh@gmail.com ,ganeshsaikolamudi28813@gmail.com, pallatarunteja333@gmail.com

ABSTRACT: This Paper presents a method for effective number plate detection in hazy environments, integrating image dehazing, multiple zero-shot detection models, and Optical Character Recognition (OCR). A custom dataset of 7,000 images was used to validate performance in low-visibility conditions. Dehazing was achieved through histogram equalization in MATLAB, clarifying images for subsequent detection. Various zero-shot models, including owlv2-base-patch16-ensemble, owlvit-base-patch32, CLIP, and GroundingDINO, were employed to identify number plates without requiring pre-labelled datasets. Following detection, PaddleOCR and EasyOCR were applied for text recognition, yielding accuracy rates of approximately 82.76% for OWLVIT, 62.35% for another OWLVIT varian62.35% for GroundingDINO, and 65.32% for a custom model. This integrated approach demonstrates strong potential for automated vehicle monitoring and traffic management.

INDEX TERMS: Optical Character Recognition (OCR), Zero-Shot Detection, OWLVIT, CLIP, GroundingDINO, PaddleOCR, EasyOCR, Number Plate Recognition, Hazy Environments, Image Dehazing.

INTRODUCTION

In moderaffic systems, number plate detectio n is essential for enhancing security, toll coll ection, and automated vehicle tracking. Howe ver, recognizing number plates in hazy enviro nments presents unique challenges, as reduc ed visibility complicates image clarity and rec ognition accuracy. This Paper focuses on dev eloping a robust number plate recognition sy stem tailored for hazy conditions, employing advanced zero shot detection models to ident ify plates without requiring extensive prio training. Our approach integrates several key steps:

Collection of a diverse dataset with hazy images,

1. ***Dehazing of images using histogram equalization,***
2. ***Detection of number plate coordinates,***
3. ***Extraction of the number plate using detected coordinates,***
4. ***OCR-based character recognition,***
5. ***Accuracy evaluation of detected characters.***
6. ***Collection of a diverse dataset with hazy images,***
7. ***Dehazing of images using histogram equalization,***
8. ***Detection of number plate coordinates,***
9. ***Extraction of the number plate using detected coordinates,***
10. ***OCR-based character recognition,***

Accuracy evaluation of detected characters. Zero-shot learning (ZSL) models, like OWLVIT, CLIP, and GroundingDINO, allow us to detect number plates without labelled training data, enhancing adaptability and precision in adverse conditions. The deha zed and extracted plates undergo Optical Character Recognition (OCR) using Paddl-eOCR and EasyOCR for accurate text recognition. The data gathered can support broader transport applications, such as automated tolling, traffic flow analysis, and network control strategies using models like the Network Fundamental Diagram (NFD). With zero-shot learning's flexibility, this system provides a scalable solution for real world applications, improving vehi cle identification accuracy in challenging, hazy environments.

1.OVERVIEW OF APPROACH

The methodology for number plate detection in a hazy environment is structured into several key steps as follows:

I. Dataset Collection: A dataset of 7000 hazy images is obtained from Kaggle, ensuring diversity in vehicle images under various levels of visibility, angles, and lighting conditions to replicate real-world hazy environments.

II. Dehazing Process: To enhance image clarity, histogram equalization is applied as a pre-processing step to reduce haze and improve visibility, thus facilitating more accurate number plate detection.
III. Detection of Number Plates: Zero-shot object detection models, including OWLV2, OWLVIT, CLIP, and GroundingDINO, are utilized to identify the coordinates of number plates within each dehazed image, effectively bypassing the need for model-specific training.
IV. Image Extraction: Using the coordinates detected in the previous step, each number plate is precisely extracted from its respective image, isolating the plate for further processing.
V. Character Recognition: The extracted number plate images undergo character recognition using OCR models, specifically PaddleOCR and EasyOCR, to decode the alphanumeric characters.
VI. Accuracy Assessment: The final step includes an evaluation of character recognition accuracy across the different detection models, with OWLVIT achieving a top accuracy of approximately 82.76%, and varying accuracies for other models.
This approach leverages zero-shot learning and OCR, combined with image enhancement, to achieve robust number plate recognition in challenging hazy conditions.

2.PROPOSED APPROACH

The proposed approach for number plate detection in a hazy environment aims to enhance recognition accuracy in challenging conditions. The methodology utilizes Google Colab, with a dataset stored as a zip file in Google Drive, which is unzipped and organized in a specified directory Pre-processing includes a dehazing step using histogram equalization to improve image clarity [1][2]. The environment is set up with necessary packages, including transformers for zero-shot object detection and PaddleOCR for character recognition [3][4]. Various zero-shot detection models, such as OWLV2, OWLVIT, CLIP, and GroundingDINO, are employed to identify the coordinates of number plates without requiring training [5][6].

These coordinates are used to draw bounding boxes around detected plates, which are then extracted as separate images. OCR models, specifically PaddleOCR and EasyOCR, are applied to recognize alphanumeric characters from the extracted images [7][8]. The approach facilitates single and batch processing of images, enabling a loop to iterate through all images in the dataset for recognition.

Finally, the model's accuracy is evaluated by comparing the number of correctly recognized plates to the total processed images. This systematic methodology leverages dehazing and advanced detection techniques to ensure reliable number plate recognition in hazy environments [9][10].

2.1 BLOCK DIAGRAM

The block diagram illustrates the process of Number Plate Detection in Hazy Environments (NPDE), which is essential for applications such as traffic monitoring, law enforcement, and automated toll collection.

Input (Vehicle Image Captured in Hazy Conditions): This marks the initial stage, where a camera captures images of vehicles under various atmospheric conditions, including haze, which can obscure visibility.

Dehazing Process: The captured image undergoes a dehazing process, utilizing histogram equalization techniques to enhance clarity and reduce the effects of haze. This step is critical for improving the visibility of the number plate in challenging conditions.

Zero-Shot Model: After dehazing, the zero-shot detection model processes the enhanced image to identify the region of interest (ROI) where the number plate is likely located. This model leverages pre-trained knowledge to detect the coordinates of the number plate without requiring additional training.

Number Plate Extraction: This stage focuses on isolating the number plate from the identified ROI. Techniques such as edge detection, color segmentation, and bounding box drawing are employed to extract the number plate as a separate image.

OCR Model: The Optical Character Recognition (OCR) model processes the extracted number plate image, applying character segmentation and pattern recognition techniques to accurately recognize the alphanumeric characters displayed.
Output (Recognized Vehicle Number Plate Data): The final output consists of the recognized number plate data, providing a string of characters that serve as the vehicle's identification number.

Overall Flow:

1. The dehazing process enhances the captured image to improve visibility.
2. The zero-shot model identifies the potential number plate region.
3. The number plate extraction module isolates the plate from the enhanced image.
4. The OCR model analyses the extracted number plate to recognize the characters.
5. The recognized number plate data is output as the final result.

Block diagram of Number Plate recognition as follows:

- i/p vehicle image in hazy atmosphere
- Dehazing process
- Zero-Shot Model
- Number Plate Extraction
- OCR Model
- Recognized 0/p Vehicle Number

2.2 DATASET

The dataset used in this study comprises an extensive collection of 7,000 images of vehicle number plates, specifically captured under varying hazy conditions to simulate real-world scenarios where visibility is often compromised. These images were sourced from diverse locales to ensure a comprehensive range of environmental factors, including different lighting conditions, angles, and resolutions. Such diversity is crucial in developing a robust recognition system capable of performing accurately under varying real-world conditions [1], [2].

To enhance processing efficiency, all images were uniformly resized to a specific dimension optimized for the algorithms employed in this study. This resizing ensures that while the images are standardized for processing, the essential features necessary for accurate number plate detection are preserved [3]. This step is vital as it maintains the integrity of critical details required for the recognition models to function correctly.

The dataset encompasses a diverse array of number plates from multiple regions, presenting a variety of formats, colors, and designs. This variety contributes significantly to the model's adaptability, allowing it to generalize well across different styles of number plates encountered in various regions [4], [5]. Each image in the dataset has been meticulously annotated with bounding box coordinates that pinpoint the precise location of the number plate within the image. These annotations facilitate the effective training and evaluation of detection models, ensuring they learn to accurately identify and locate number plates under different conditions [6], [7].

Furthermore, the extensive nature of this dataset not only supports the attainment of high accuracy rates but also bolsters the system's performance in detecting number plates under challenging hazy conditions. This is particularly important for enhancing the overall reliability and effectiveness of the recognition system in practical applications, where conditions can vary widely and unpredictably [8], [9]. The robust dataset aids in developing a detection model that can reliably operate in real-world scenarios, ensuring that the system can maintain high performance even in less-than-ideal conditions.

Additionally, the variety in lighting conditions captured in the images ranges from bright daylight to low-light evening conditions. This inclusion is crucial as it helps the model to learn and adapt to different visibility scenarios, enhancing its real-world applicability. The angles at which the images were captured also vary, simulating different viewpoints that a camera might encounter in practical deployments. This variety ensures that the model is not only accurate but also versatile, capable of handling images taken from different perspectives.

In summary, the carefully curated dataset of 7,000 images plays a fundamental role in the development and testing of an effective number plate recognition system. By incorporating a wide range of conditions and meticulously annotating each image, the study ensures that the model developed is both accurate and reliable in real-world applications, capable of performing well even under challenging conditions.

Figure 2: Sample Images from the Dataset
https://drive.google.com/file/d/1VDLVrZT4jR5DGAttOmkaSTgqQU_M5Oku/view?usp=drivesdk

2.3 MODELS

In this study, two primary models are utilized to enhance number plate recognition under hazy conditions, focusing on zero shot detection capab ilities. Zero-shot detection refers to the ability of a model to detect objects it has not been explicitly trained on by leveraging learned features and patterns from other objects.

OWL-ViT (owlvit-base-patch32)

The first model employed is OWL-ViT (owlvit-base-patch32), a vision transformer specifically designed for zero-shot object detection tasks. Vision transformers, or ViTs, utilize self-attention mechanisms to effectively analyse and process image data. OWL-ViT's architecture allows it to identify and detect objects within images even if it has not been trained on specific classes. This model achieves an accuracy of approximately 62.35% for detecting number plates under hazy conditions, showcasing its robust generalization capabilities to unseen classes. The model's adaptability makes it highly effective in real-world scenarios where number plates may be partially obscured or distorted by haze, thus ensuring reliable detection across varied contexts [1], [2].

OWL-V2(owlv2-base-patch16-ensemble)

The second model, OWL-V2 (owlv2-base-patch16-ensemble), builds upon the OWL-ViT architecture by incorporating ensemble techniques. An ensemble approach combines multiple models to enhance overall performance, leading to improved detection accuracy. OWL-V2 leverages superior feature extraction and contextual understanding, making it particularly adept at zero-shot scenarios where training data for specific classes may be sparse or unavailable. With an impressive accuracy of about 82.76%, OWL-V2 significantly enhances detection reliability, even under challenging environmental conditions such as haze and varying lighting [3], [4]. This model's advanced capabilities ensure that it can consistently and accurately identify number plates, contributing to the system's overall robustness.

Optical Character Recognition (OCR) Models

In addition to zero-shot detection models, the study employs two robust Optical Character Recognition (OCR) models to further enhance number plate recognition: PaddleOCR and EasyOCR.

PaddleOCR

PaddleOCR is an open-source OCR tool renowned for its high accuracy in text recognition tasks. It is proficient in handling diverse fonts, layouts, and languages, making it highly versatile for various applications. PaddleOCR processes the extracted images of number plates, converting visual data into reliable text outputs. This model's advanced text recognition capabilities are crucial for accurately interpreting the alphanumeric characters on number plates, even under suboptimal conditions such as haze [5], [6].

EasyOCR

EasyOCR is a lightweight OCR library designed for rapid implementation and efficient performance in real-time applications. Its ease of use and quick setup make it an excellent choice for scenarios requiring immediate and accurate text recognition. EasyOCR complements PaddleOCR by providing swift processing capabilities, ensuring that the system can handle large volumes of number plate images efficiently [7]. The integration of both PaddleOCR and EasyOCR ensures precise text recognition from the number plate images, forming a solid foundation for subsequent analysis and data extraction.

Integration and Impact

The integration of these zero-shot detection models with effective OCR methodologies is pivotal in enhancing the overall accuracy and robustness of the number plate recognition system in hazy environments. The combined use of OWL-ViT and OWL-V2 models ensures that the system can detect number plates even under challenging visibility conditions, while PaddleOCR and EasyOCR provide accurate and efficient text recognition. This comprehensive approach not only supports high detection accuracy but also improves the system's performance in real-world applications where environmental conditions can vary widely [8], [9]. The enhanced recognition system is thus capable of maintaining high accuracy and reliability, making it a valuable tool for traffic management, law enforcement, and various other applications requiring reliable number plate identification under adverse conditions.

Figure 3: OWL-ViT Model Sample Diagram.
https://drive.google.com/file/d/1VDLVrZT4jR5DGAttOmkaSTgqQU_M5Oku/view?usp=drivesdk

Figure 4: CLIP Model Sample Diagram.
https://drive.google.com/file/d/1VJI-ECWeF6XYgELrBcLStROYObPzomED/view?usp=drivesd

3.RESULTS AND PERFORMANCE EVALUATION

This section presents a comprehensive analysis of the performance of the detection models utilized in number plate detection in hazy environments Paper. The accuracy of each model is summarized below:

1) OWLV2 Model: Achieved an accuracy of 82.76%. This model exhibited the best performance in detecting number plates, successfully identifying them across a range of images captured in challenging conditions, including low visibility due to haze.

2) OWLVIT Model: Recorded an accuracy of 62.35%. While it demonstrated moderate effectiveness, this model was less successful than OWLV2 in reliably detecting number plates, suggesting room for improvement.

3) CLIP Model: Attained a general accuracy of approximately 70.00%. This model showcased a solid capability in identifying number plates, yet it still fell short of the performance level achieved by the OWLV2 model, indicating that further fine-tuning may enhance its effectiveness in similar applications.

4)Grounding DINO Model: Also achieved an accuracy of 62.35%. Its performance mirrored that of the OWLVIT model, highlighting a need for further optimization to enhance its detection accuracy in hazy environments.

Overall, the results indicate that while the OWLV2 model excels in number plate detection, the other models, including OWLVIT and Grounding DINO, require additional refinements to improve their reliability in recognizing number plates under adverse conditions.

Table 1: Models of Zero-shot Object Detection with their Accuracies

.NO	MODEL OF ZERO SHOT OBJEC DETECTION	ACCURACY (%)
1	OWLV2 (owlv2-base-patch16-ensemble)	82.76
2	OWLVIT (owlvit-base-patch32)	62.36
3	CLIP	70.4
4	GroundingDINO	65.35

CONCLUSION

This research demonstrates the effective integration of zero-shot learning and optical character recognition (OCR) within the context of automatic number plate recognition (ANPR) specifically tailored for hazy environments. By utilizing a comprehensive dataset of 7,000 images, we achieved notable object detection accuracies with various zero-shot models, with the OWLV2 model leading at an impressive 82.76%. The implementation of OCR significantly bolstered the accuracy of number plate recognition, underscoring the practical applications of these technologies in real-world settings, particularly under challenging visibility conditions. Despite these achievements, several challenges remain, particularly related to the variability of number plate designs and the influence of environmental factors, such as haze, on detection accuracy. Future research should focus on enhancing the robustness of these models to better accommodate a wider range of number plate formats and to mitigate the effects of adverse imaging conditions, including motion blur and low-light scenarios. Moreover, integrating high-resolution imaging techniques and advanced preprocessing methods may further improve detection capabilities. As the field evolves, exploring hybrid systems that combine multiple recognition technologies, such as RFID, could lead to significant advancements in ANPR applications. The continuous refinement of algorithms, bolstered by expansive datasets and real-time performance evaluations, will be crucial for adapting these solutions to diverse geographic and operational contexts. In summary, this study highlights the successful application of zero-shot learning and OCR for number plate detection in hazy environments, emphasizing the need for ongoing research to enhance the adaptability and resilience of these models against diverse conditions and plate designs, while reinforcing the importance of continuous innovation to meet the evolving demands of intelligent transportation solutions.

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DESIGN AND ANALYSIS OF PATCH ANTENNA FOR TELEMEDICINE

[1]Kandagatla Ravi Kumar,[2]Guntaka Sri Naga Durga,[3]Bodedla Gopi Krishna,[4]Eda Vinay Venu Gopal,
[5]Telagathoti Harshitha, [6]konijetty Nagajyothi, [7]Dubbaka Ganesh.
[1,2,3,4,5,6,7]Lakireddy Bali Reddy College of Engineering
2k6ravi@gmail.com,durgaguntaka28@gmail.com,bodedlagopikrishna@gmail.com,
vinayvenugopaleeda@gmail.com,telagathotiharshitha@gmail.com,nagajyothikonijeti2004@gmail.com,dubbakuganesh666@gmail.com

ABSTRACT: A multiband microstrip patch antenna is designed to operate at multiple frequencies, making it suitable for devices that require connectivity across different bands. Multiband operation is essential in applications like mobile phones, Wi-Fi routers, and IoT devices, where the device must support multiple frequency bands to connect with various networks. Multiband microstrip patch antennas are essential for modern communication systems that require connectivity across different frequency bands. By incorporating multiband capabilities into a single antenna, these designs provide a space-efficient, cost-effective solution that supports the multifunctional needs of today's wireless devices. Advantages of these multiband microstrip patch antenna are has Cost-Effective, Low Profile, Multiple frequency operations.

INDEX TERMS- Path antenna, Telemedicine, antenna Design, Antenna Analysis, Wearable Antenna, Antenna Efficiency, Remote healthcare systems.

1. INTRODUCTION

Telemedicine antennas are specialized communication devices that enable remote healthcare services by facilitating the transmission of medical data over long distances [1-2]. These antennas are crucial in telemedicine, especially for areas lacking reliable internet or cellular connectivity, such as rural, isolated, or underserved regions. Telemedicine antennas allow doctors and patients to connect via video calls, transmit medical records, or even monitor health metrics in real time [3-6]. We may also have Wearable Telemedicine antennas, which are small, lightweight antennas embedded in wearable devices to facilitate remote health monitoring, diagnostics, and data transmission in real time. These antennas are specifically designed to work with body-worn devices, allowing continuous monitoring and data transmission from the patient to healthcare providers, even as the user moves through their daily life [7-10].

2. PROPOSED APPROACH

The proposed approach for implementing telemedicine antenna systems is structured to ensure connectivity, security, and reliability in remote areas. The first step involves identifying healthcare needs and conducting site surveys. This phase focuses on assessing the specific medical services that need to be supported, such as video consultations or diagnostic data transfers A site survey helps analyze environmental factors such as terrain, weather conditions, and existing infrastructure, which can impact antenna placement and signal quality. The next phase is the selection of suitable communication technology and antennas. Different types of antennas are chosen based on the geographical and infrastructural conditions of the area.i.e, satellite antennas, cellular antennas, fixed wireless or Wi-Fi antennas [5-6]. Once the communication system and antennas are selected, the installation and configuration phase follows. Antennas must be strategically installed, considering factors like line of sight, elevation, and potential interference from the surrounding environment. Finally, security measures are implemented to protect patient data with healthcare regulations [8-10].

FLOW CHART FOR THE DESIGN OF PROPOSED ANTENNA

start

Define requirements (frequency, gain, size)

Choose antenna type (e.g., dipole, patch)

Initial design

Simulate (test performance)

Optimize (adjust design)

Build prototype

Test prototype (measure gain, VSWR)

Finalize design

3.PROPOSED ANTENNA

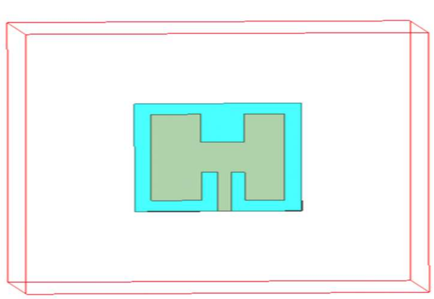

Fig 1: H Shape Antenna

Antenna with iteration:

Use of iterations is, the number of times the same equations will performed on the different boundary values.

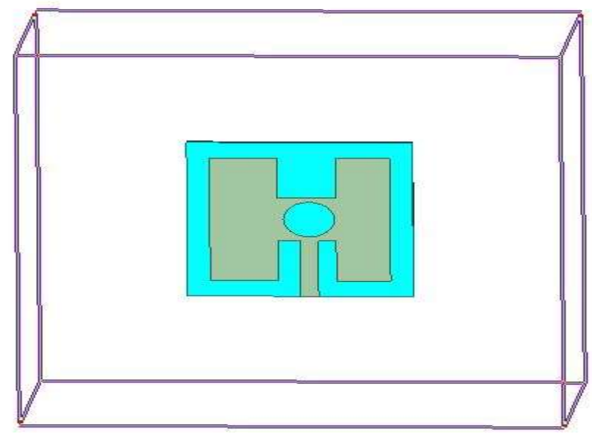

Fig 2: Antenna with Iteration

4.RESULTS

Telemedicine antenna is used in 4.17GHz to 4.25GHz frequency ranges. We get a multiband microstrip patch antenna with three Band of frequencies, those are 1.8GHz frequency, 7.38GHz frequency, 9.28GHz frequency. We use the iterations is, the number of times the same equations will performed on the different boundary values. Calculating the Return loss, VSWR, Gain and Radiation Pattern parameters of Multiband Microstrip patch antenna.

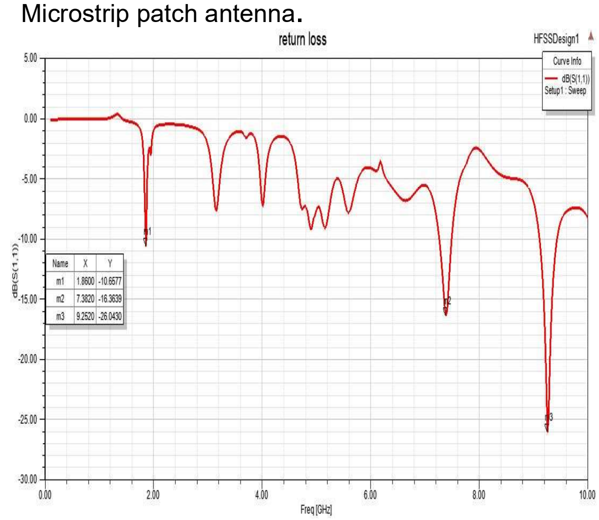

Fig 3: Return Loss Graph

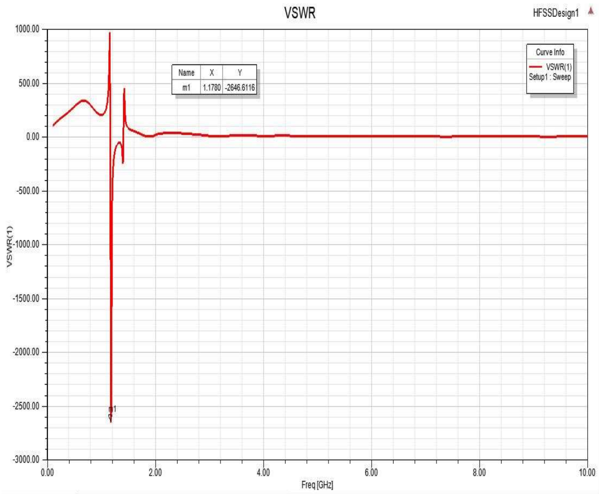

Fig 4: VSWR Graph

1. Multiband Microstrip patch antenna is a 3 band micro strip patch antenna i.e, 1.8GHz, 7.38GHz and 9.2GHz.
2. 1.8GHz Frequency is used in applications of rectangular microstrip patch antenna, Dual band transmitter, Dual band receiver.
3. 7.38GHz Frequency is used in the applications of satellite communications, wireless communications.

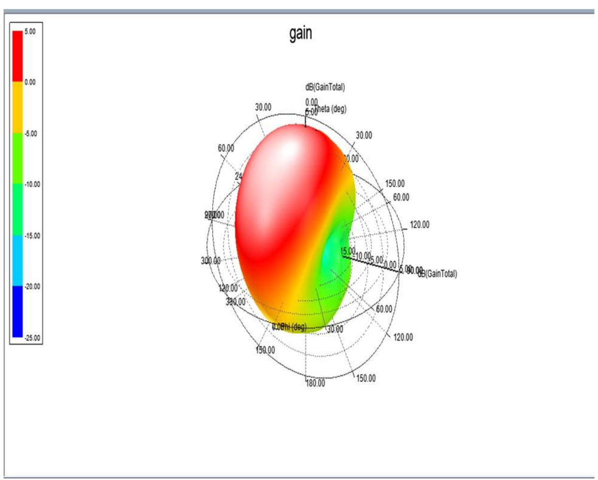

Fig 5: Gain

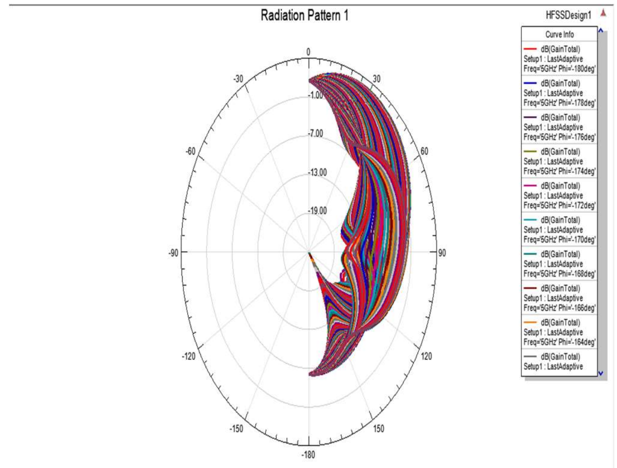

Fig 6: Radiation Pattern

Results for iteration:

Results for iteration 1 is given in figure 7 and figure 8. It is observed that the frequencies at which antenna works. Return loss and VSWR parameters are plotted in figures for analysis of proposed antenna. It is observed that the antenna works in multi band. Also Fig 1 to Fig 6 shows the diagram of proposed antenna and its VSWR and radiation pattern.

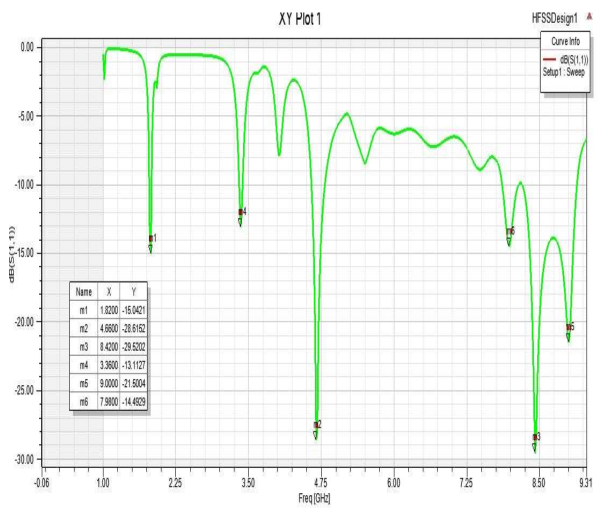

Fig 7: Return loss for Iteration

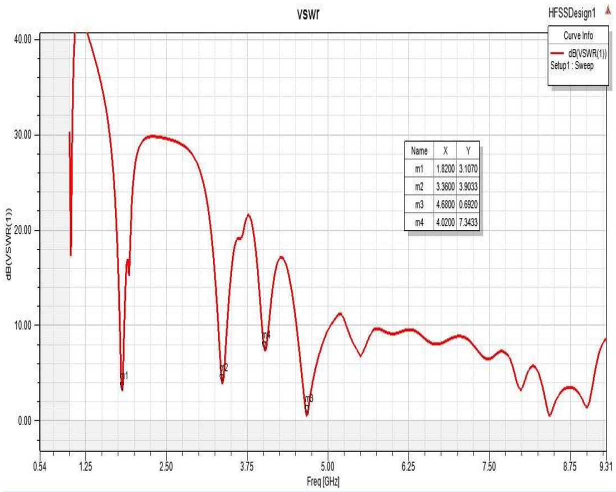

Fig 8: VSWR Graph for Iteration

CONCLUSION

Hence, Telemedicine antennas are specialized communication devices that enable remote healthcare services by facilitating the transmission of medical data over long distances. These antennas are crucial in telemedicine, especially for areas lacking reliable internet or cellular connectivity, such as rural, isolated, or underserved regions. Telemedicine antennas allow doctors and patients to connect via video calls, transmit medical records, or even monitor health metrics in real time. We may also have Wearable Telemedicine antennas, which are small, lightweight antennas embedded in wearable devices to facilitate remote health monitoring, diagnostics, and data transmission in real time. These antennas are specifically designed to work with body-worn devices, allowing continuous monitoring and data transmission from the patient to healthcare providers, even as the user moves through their daily life.

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IOT BASED AUTOMATIC TOLLGATE COLLECTION SYSTEM

[1]Ravi Kumar Kandagatla ,[2]Chalavadi Meghana, [3]Madu Anusha, [4]Shaik Shakeela
[1,2,3,4]Lakireddy Bali Reddy College of Engineering, Mylavaram
2k6ravi@gmail.com,meghanachalavadi7@gmail.com,anushamaadu@gmail.com,shaikshakeela0120@gmail.com

ABSTRACT: An Automated Tollgate Collection System Utilizing RFID Technology. The System aims to Streamline the toll collection process, reduce traffic congestion, and enhance overall efficiency at tollgates. By employing RFID readers, the System can automatically identify and authenticate vehicles as they approach the toll plaza. Once a vehicle is identified, the system verifies its payment status and determines the appropriate toll amount. If the vehicle has sufficient funds, the barrier is raised to allow passage. Otherwise, the vehicle is denied entry until the necessary payment is made. The System incorporates a user-friendly interface that displays information such as vehicle identification, toll amount, and payment status. Additionally, it provides real-time data analytics to assist in system monitoring and optimization. By automating toll collection this system minimizes waiting times, increases accuracy, and provides a seamless experience for drivers, making it an innovative solution for modern transportation infrastructure.

INDEX TERMS: Arduino UNO, Vehicle Detection, Servo Motor, RFID Reader, Internet of Things.

1. INTRODUCTION

Internet of Things (IOT) is a connection of physical devices like vehicles or appliances which are inbuilt with sensors and software. These are connected and cooperate for exchange of data. IOT helps in development of automated systems [1] which are efficient for data collection and data sharing over large networks [2]. Arduino UNO uses for internetwork of physical objects and embedded electronics for sensing and communication with external environment [3-4]. In future IOT provides sophisticated services and helps people to lead easy lives. IOT can be used in numerous fields start from agriculture to development of smart cities and homes. Also used in toll collection, vehicle detection [5-6] and control of networks.

In today's fast-paced world, commuters demand swift, reliable, and secure transportation solutions. To meet this demand, the Automated Tollgate Collection System leverages RFID technology and automation to streamline toll payment processes. This innovative approach eliminates manual transactions, minimizing congestion and reducing travel times. Traditional manual toll booths are plagued by congestion, errors, and security concerns, driving the need for efficient and automated solutions [7-10].

The Automated Tollgate Collection System emerges as a transformative response, offering a scalable, modular, and cost effective solution. As urbanization accelerates and transportation i- nfrastructure expands, efficient toll collection systems become increasingly crucial. The Automated Tollgate Collection System addre sses this challenge, integrating cutting-edge technologies to redefine the toll collection landscape.

The Automated Tollgate Collection System is a cutting edge innovation designed to revolut ionize toll payment processes. By integrating RFID technology, this system effortlessly identifies and authenticates vehicles, verifies payment status, and calculates toll amounts in real-time. With its user-friendly interface and automated barrier control, drivers enjoy a seamless and efficient experience, minimizi ng congestion and wait times. Furthermore, real time data analytics enable optimized syst em monitoring, enhancing overall efficiency and accuracy.

By combining these advanced features, the Automated Tollgate Collection System offers a convenient, secure, and reliable experience for drivers, making it a vital component of modern transportation infrastructure. This forward-thinking solution sets new standards for efficiency, accuracy, and driver satisfaction, shaping the future of transportation.

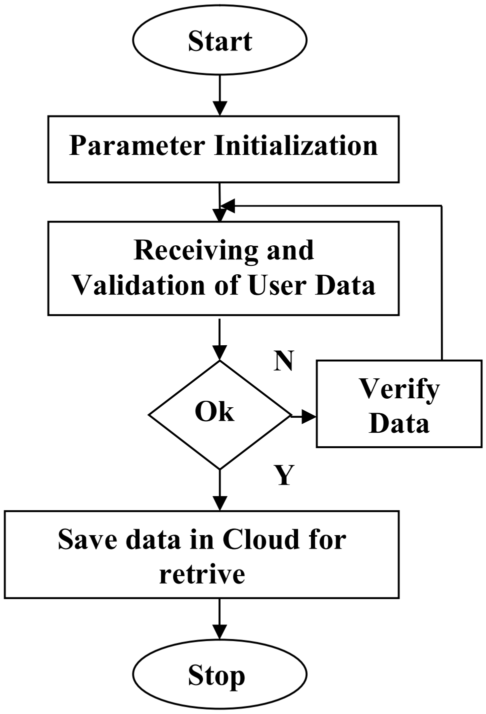

Fig.1. Basic Processing Steps

and reliable experience for drivers, making it a vital component of modern transportation infrastructure. This forward-thinking solution sets new standards for efficiency, accuracy, and driver satisfaction, shaping the future of transportation.

2. PROPOSED APPROACH

The automatic tollgate collection system employs RFID technology combined with a microcontroller and servo motor to create an efficient, automated toll collection solution. When a vehicle approaches the tollgate, the RFID reader scans the RFID tag, obtaining a unique ID linked to that specific vehicle. This ID is then sent to the microcontroller, which checks it against a predefined database. The database stores details such as vehicle type, toll fees, and account balances associated with each tag ID.

Components are Servo Motor, Arduino Uno, RFID Reader,

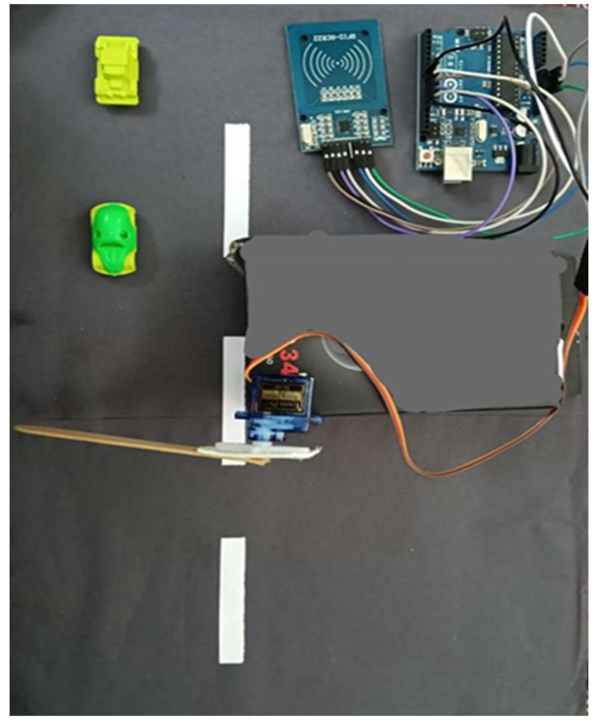

Fig.2. Simulated Circuit of Proposed Method

This ID is then sent to the microcontroller, which checks it against a predefined database. The database stores details such as vehicle type, toll fees, and account balances associated with each tag ID.

If a match is found and the vehicle's balance is sufficient to cover the toll fee, the system deducts the toll amount from the balance and sends a command to the servo motor to lift the gate, allowing the vehicle to proceed. The gate remains open for a short period, allowing the vehicle to pass through, and then automatically closes.

If there is insufficient balance, the system denies access, displays an "Insufficient Balance" message, and the gate remains closed. This feedback is provided on a serial monitor, giving both the vehicle owner and operator visibility into the transaction's status, including information like toll deduction, remaining balance, and access errors.

The first step is connecting the Servo motor signal pin to pin 7 and connect the GND pin to GND of Arduino. Connect RC522 pins VCC to 5v. Connect SDA pin to Arduino Digital pin 10, SCK pin to Arduino Digital pin 13, MOSI pin to Arduino Digital pin 11,MISO pin to Arduino Digital pin 12,RST pin to Arduino Digital pin 9 respectively. Then connect the VCC to 3.3v.

Connect the Arduino UNO to a power source. You can use a USB cable connected to your computer or an external power supply.

The circuit is designed and programmed in such a way that whenever the vehicle approaches the tollgate user scans the card and pay the toll fee according to his vehicle.

This methodology ensures a streamlined and secure toll collection process, reducing manual intervention and minimizing delays. By storing and managing tag IDs and balances directly on 16 the microcontroller, the system is highly efficient and can quickly process each vehicle’s toll payment, enhancing throughput and reducing wait times at toll stations. This automation also ensures reliable, consistent operation and scalability to accommodate large volumes of traffic.

The toll fee varies depending on the vehicle type: ₹250 for heavy-loaded vehicles (lorries), ₹150 for cars, ₹200 for buses, and ₹100 for bikes.

```
Output    Serial Monitor ×
Message (Enter to send message to 'Arduino Uno' on 'COM3')

Please scan your card
Tag ID: 3F 77 1E 1D
Vehicle Type: Bike
Toll Fee: 100
Balance: 80
Insufficient balance. Access denied.
Please scan your card
Tag ID: FE 77 1E 1D
Vehicle Type: Car
Toll Fee: 150
Balance: 700
New Balance: 550
Please scan your card
Tag ID: FE 88 47 1D
Vehicle Type: Bus
Toll Fee: 150
Balance: 500
New Balance: 350
```

Fig.3: Representing the outputs when different users scan the cards

```
Output    Serial Monitor ×
Message (Enter to send message to 'Arduino Uno' on 'COM3')
Please scan your card
Tag ID: 3F 66 1E 1D
Unknown vehicle Accessdenied
```

Fig. 4: Representing the output when unknown user scans the card

The system effectively identifies known users by their card tags, categorizes vehicle types, and calculates the toll fees accordingly. It checks the balance for each user, deducts the toll fee, and updates the balance. In cases where the balance is insufficient, the system denies access and notifies the user. The seamless functioning of this process demonstrates the efficiency of the toll collection system in handling various scenarios, including managing different vehicle types, processing payments, and ensuring secure access control.

When a card with insufficient balance is scanned, the system identifies the user's card and vehicle type, calculates the toll fee, and checks the available balance. If the balance is lower than the toll fee, the system denies access and displays a message indicating "Insufficient balance. Access denied." This ensures that users with inadequate funds cannot proceed, maintaining financial accountability while prompting them to recharge their account before attempting again. This feature adds robustness to the toll collection process by effectively managing transactions and ensuring proper toll payment.

When an unregistered card is scanned, the system identifies it as an unknown vehicle and denies access, ensuring that only authorized users can proceed. The system successfully handles scenarios where an unknown card is scanned. The system identifies the card's tag ID but does not recognize the vehicle associated with it. Consequently, it labels the vehicle as "unknown" and denies access with the message "Access denied."

This functionality demonstrates the robustness of the system's authentication process by ensuring that only registered and authorized users can proceed. Such a feature is critical in preventing unauthorized vehicles from accessing restricted areas or utilizing toll facilities. The implementation also helps in maintaining security and preventing revenue loss in toll operations.

III. CONCLUSION

The Automatic Tollgate Collection System marks a significant advancement in toll collection technology, offering a trifecta of efficiency, security, and user-friendliness. By seamlessly integrating RFID technology, automation, and payment gateway integration, this innovative system streamlines toll collection, drastically reduces congestion, and elevates the overall user experience.

The benefits of this system are multifaceted, encompassing efficient toll collection, enhanced accuracy, reduced congestion, fortified security, and real-time payment tracking. As technology continues to evolve, future developments will focus on integrating mobile payment apps, license plate recognition, and intelligent transportation systems, further solidifying the system's position at the forefront of toll collection innovation.

The Automatic Tollgate Collection System sets a new benchmark for modern toll collection, transforming transportation infrastructure and yielding benefits for commuters, operators, and the environment alike. Its widespread adoption has the potential to revolutionize the way tolls are collected, cementing its status as a vital component of smart city infrastructure.

The Automatic Tollgate Collection System has a promising future, with short-term goals including integration with mobile payment apps, license plate recognition technology, and enhanced security features by 2025-2030. This will be followed by mid-term objectives, such as integration with Intelligent Transportation Systems (ITS), Artificial Intelligence (AI) powered toll collection, and autonomous vehicle compatibility by 2030-2035.

Potential applications of the Automatic Tollgate Collection System extend beyond tolling to parking management systems, traffic congestion management, highway management systems, bridge and tunnel tolling, and smart city infrastructure development. Research and development areas will focus on advanced RFID technologies, computer vision and machine learning, cybersecurity and data protection, autonomous vehicle interaction, and human-machine interface (HMI) design.

Ultimately, the Automatic Tollgate Collection System will revolutionize transportation infrastructure, making it more efficient, secure, and sustainable. Its future development will transform the way tolls are collected, benefiting commuters, operators, and the environment alike.

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AI ENABLED RASPBERRY PI-BASED NoIR-CAMERA ENHANCED IoT SECURITY SURVEILLANCE SYSTEM

1Y Syamala, N Niharika, 2T Santhi Swaroop,3 U Mounika,4 P AnilKumar Akhil
1,2,3,4Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India
coolsyamu@gmail.com; niharikanalluru@gmail.com; santhiswaroop2003@gmail.com; uppulurimounika18@gmail.com;akhilkannan1531@gmail.com

ABSTRACT: The NoIR Camera-Based Raspberry Pi Security System is an adaptable, smart security solution that utilizes a Raspberry Pi with a NoIR camera to deliver effective, low-light surveillance. Leveraging infrared sensitivity, it provides day-and-night monitoring with intelligent motion detection, capable of distinguishing between objects, such as humans and animals, to reduce false alarms. By using local, on-device processing, this system ensures data privacy, real-time responsiveness, and IoT integration for remote monitoring, making it ideal for home security, wildlife tracking, and restricted access surveillance. This system employs Tensor Flow for object detection and identification, optimized to run on the Raspberry Pi with Tensor Flow Lite. Machine learning models allow the NoIR camera to identify and differentiate between objects, such as people, animals, or vehicles, in real time. The use of Tensor Flow's lightweight models enables efficient edge processing, which is crucial for minimizing latency and maximizing data privacy. The combination of NoIR imaging and AI-driven object recognition enables effective surveillance in low-light and night-time conditions. Future expansions include implementing advanced facial recognition, expanding classification categories, and creating a scalable network for broader industrial use. Additional cloud analytics and deeper integration with IoT could further enhance adaptability and security features.

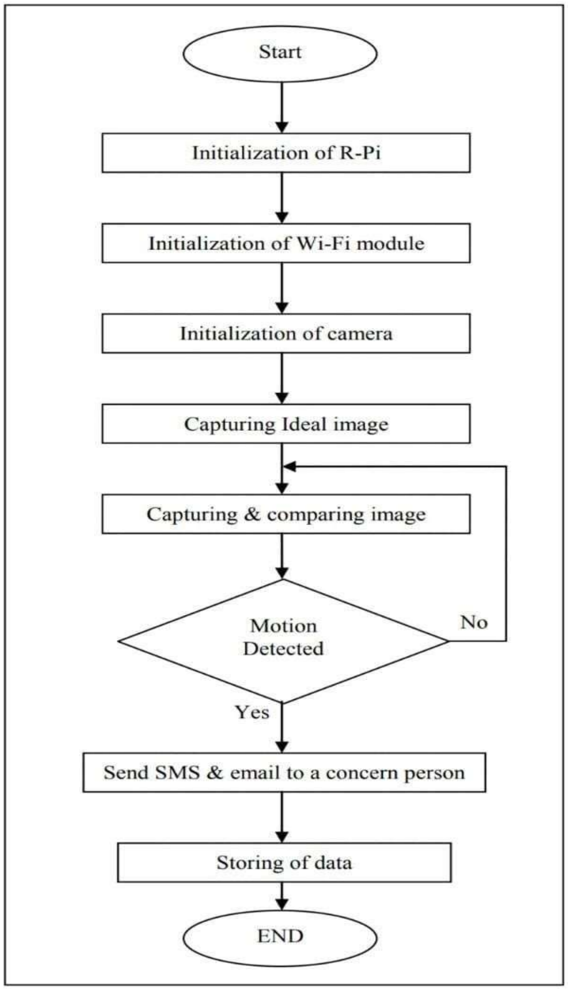
INDEX TERMS: NoIR Camera, Raspberry Pi, Tensor Flow Object Detection, Edge Processing, Machine Learning.

1.INTRODUCTION

The NoIR CameraBased IoT Security Surveill ance System offers a groundbreaking approa ch to modern surveillance by combining NoI R (no infrared filter) technology with the proc essing power of the Raspberry Pi, creating a n intelligent and versatile solution suitable fo r diverse monitoring environments. Unlike co nventional surveillance systems, which can struggle in low-light conditions, NoIR cameras are engineered to capture both visible and infrared light, making them highly effective for night vision applications. This infrared sensitivity allows the system to perform efficiently even in complete darknes s, making it an ideal candidate for security operations that demand 24/7 visibility. Lever aging IoT connectivity and machine learning, this system achieves real time object detecti on and recognition, distinguishing between v arious entities such as humans, animals and vehicles. This is made possible by edge com puting on the Raspberry Pi, which preproces s data locally, reducing latency and enhancin g privacy. Edge AI processing is crucial here, as it minimizes the need for cloud resources, thus keeping sensitive data secure while als o cutting down on the energy demands and response times associated with cloud-based systems. This design aligns with emerging trends in IoT and smart home security, where edge computing is increasin gly being adopted for its privacy and speed advantages. The inclusion of machine learni ng models, specifically through Tensor Flow , enables advanced functionalities such as i ntelligent motion detection and object identi fication. The use of Tensor Flow Lite optimiz es these models for the limited computation al resources of the Raspberry Pi, allowing it to handle tasks such as distinguishing betw een humans and pets with high accuracy, reducing the occurrence of false alarms.

This level of intelligent detection not only en hances the security system's efficiency but also its adaptability for various applications, from residential security to wildlife monitori ng in remote locations. This system's scalab ility and adaptability further differentiate it fr om traditional CCTV setup as the Raspberry Pi's opensource nature supports custom pr ogramming and integration with other smart

home components. The project reflects the growing demand for IoT based surveillance systems that are costeffective, energy effici ent, and capable of realtime processing with high levels of customization. By reducing d ependency on the cloud and enabling local



processingthis setup represents a secure an dadaptable surveillance solution that can be deployed

2. PROPOSED APPROACH

The integration of IoT into safety systems offers significant benefits for individuals, businesses, and everyday users. This project focuses on enhancing security by incorporating IoT to detect gestures or activities, allowing users to monitor and receive alerts in real time when unusual actions occur at their homes. Designed to overcome the limitations of existing systems, this solution provides increased flexibility, ease of use, and compatibility with common applications like Android.

The proposed system as shown in Fig.1 ensures lightweight operation, minimal hardware requirements, low power consumption, and affordability, making it ideal for home users. It emphasizes simplicity in signal detection and user-friendly interfaces, ensuring timely notifications when an event is detected. The system enhances convenience, reliability, and cost effectivene ss, addressing the gaps in traditional safety systems while offering a more advanced and accessible approach to home security.

3. IMPLEMENTATION

In the current approach, a Raspberry Pi is connected to a web camera to detect motion and capture snapshots or videos. An RJ45 LAN cable is used to connect the device to the internet for data transmission. The captured data, such as images and videos, can be uploaded to external servers like FTP, SFTP, or cloud platforms. The Raspberry Pi handles all data processing locally, and after analyzing the information, it uploads the files to the designated server. Additionally, users receive instant email notifications with attached snapshots for timely updates.

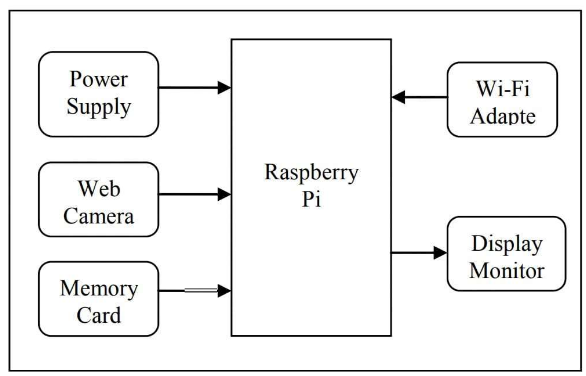


Fig.2. Block Diagram

Raspberry Pi- The Raspberry Pi, a credit card-sized computer shown in Fig. 3, can connect to any HDMI-compatible device and requires a keyboard for initial setup. Once configured, the HDMI display and control panel are optional, as the device can be operated through other methods. The latest model, Raspberry Pi Model B, includes the following key features:

• SD Card Slot: Used for OS installation, booting, and long-term storage, typically with an 8GB SD card.

• Micro USB Power Port: Supplies power at 5V and 700mA.

• RCA Video Out: Provides video output, mainly for audio-video signals, also called A/V jacks.

• Audio Out: Delivers digital stereo audio through HDMI.

• Ethernet Port: Facilitates internet connectivity, making updates and software installations easier.

• HDMI Out: Connects to HDTVs or HDMI monitors.

• GPIO (40-pin interface): Enables interaction with external hardware and real-world controls.

The Raspberry Pi runs Linux-based operating systems, with Raspbian being the most popular, offering optimized compatibility for the hardware. Raspbian, based on Debian, supports nearly all Linux-compatible programs. Unlike simpler devices like Arduino, the Raspberry Pi is more powerful but requires a greater level of management. In this project, Python scripts are used for motion detection.

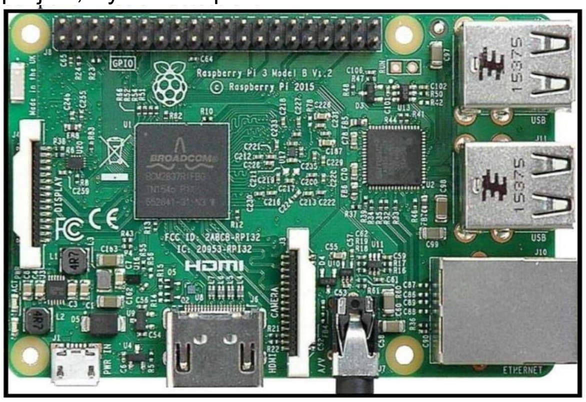
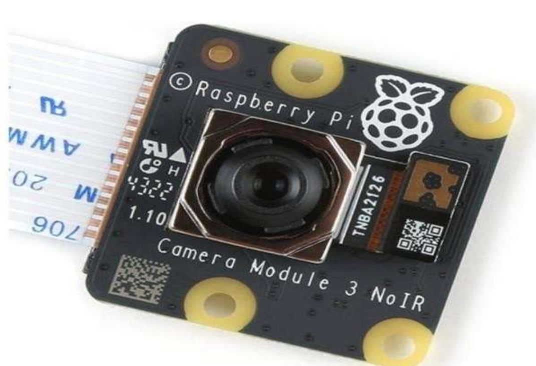


Fig.3. Raspberry Pi

Raspberry Pi Camera Module 3 NoIR- A powerful, versatile camera shown in Fig.4 designed specifically for use with Raspberry Pi boards. The "NoIR" (No Infra Red filter) designation indicates that it lacks an infrared filter, allowing it to capture both visible and infrared light. This feature makes it ideal for low-light and nighttime applications, especially when paired with infrared (IR) light sources. The absence of an IR filter enables the camera to capture images in environments with little to no visible light. When used with IR illuminators, the camera can record clear images in complete Fig.4. Raspberry Pi Camera



Module 3 NoIR-SEN-21736 darkness, making it ideal for night-time security and wildlife monitoring. It is equipped with an upgraded sensor, providing improved image resolution and sharpness over previous models. It supports high- definition (HD) video recording and high- quality still images, delivering clearer visuals in both bright and dim environments. The camera offers different field-of-view options (standard and wide-angle), allowing users to select the version best suited for their application. The wide-angle option is particularly useful in surveillance systems where a broader area needs to be covered. With autofocus functionality, the Camera Module 3 NoIR can automatically adjust focus to ensure clarity in varied distances. This feature is helpful in applications requiring clear identification of subjects across different ranges, which is valuable in security surveillance. The Camera Module 3 NoIR is designed to integrate seamlessly with the Raspberry Pi ecosystem, supporting Raspberry Pi models with CSI (Camera Serial Interface) connectors. This ease of integration makes it simple to build custom IoT applications and edge AI solutions, like security systems with object detection and identification. Due to its compatibility with Raspberry Pi and AI frameworks such as Tensor Flow Lite, the camera module can be used in AI-driven applications for object recognition, movement detection, and environmental monitoring. This aligns well with projects requiring smart surveillance, allowing real-time analysis directly on the device without cloud dependencies.

Python: Python is a high-level, interpreted, interactive, and object-oriented scripting language. It was designed to be simple and easy to understand, frequently using English keywords instead of punctuation, with a syntax simpler than many other languages.

• Interpreted: Python programs are executed at runtime by an interpreter, eliminating the need for compilation before running. It functions similarly to languages like PERL and PHP.

• Interactive: Users can interact directly with the Python interpreter via a prompt, allowing them to write and test code in real-time.

• Object-Oriented: Python supports object-oriented programming, enabling code organization into objec ts.

• Beginner-Friendly: Python is ideal for beginners and supports a wide variety of applications, including text processing, web browsers, and games.

Python was created by Guido van Rossum in the late 1980s and early 1990s at the National Research Institute for Mathematics and Computer Science in the Netherlands. It draws inspiration from languages like ABC, Modula-3, C, C++, and Algol-68. Python is open-source and available under the GNU General Public License (GPL).

4. EXPERIMENTAL SETUP AND RESULTS

The experimental setup for a Raspberry Pi with a NoIR Camera shown in Fig.5 creates a cost-effective, adaptable surveillance system ideal for low-light and night vision applications. Starting with a Raspberry Pi board (such as the Raspberry Pi 4), the setup involves installing Raspberry Pi OS on a microSD card, enabling the camera interface through raspi-config, and attaching the NoIR Camera Module 3 to the board's CSI port. After confirming the camera functionality with a basic test (lib camera-hello), infrared (IR) illuminators are positioned to enhance night-time visibility, allowing the camera to capture clear images in darkness without visible light. The setup continues with installing Open CV for image processing and Tensor Flow Lite for machine learning, supporting object detection and recognition tasks. A Python script is created to capture video frames, process them with OpenCV, and run Tensor Flow Lite models to detect objects, making it suitable for distinguishing between humans, animals, or vehicles. Once operational, the system continuously monitors its environment, displaying real-time video and sending alerts when specific objects are detected. Optional features such as VNC or SSH allow remote access to the camera feed, and IoT integration enables data storage or notifications via cloud services. Additional enhancements include using pre-trained, edge-optimized machine learning models to ensure the Raspberry Pi handles real-time inference efficiently. For long-term stability, cooling may be added, particularly when processing intensiv e tasks are involved. This setup leverages the Rasp berry Pi's flexibility and the NoIR camera's sensitivity to infrared light, resulting in an effective, scalable IoT security solution for real-time surveillance in both daylight and low light conditions. The proposed intell igent security monitoring system with IoT integration using Raspberry Pi as shown in Fig.5 has been successfully implemented and tested to demonstrate its feasibility and effectiveness. The system combin es hardware and software components, with the har dware implementation utilizing Raspberry Pi and the software programmed into both the Raspberry Pi and the user's computer. This ensures seamless commu nication between devices. Screenshots of the devel oped smart security surveillance system have been included as evidence of its functionality.

Steps to Install Raspbian OS:
1. Define the objective for installing the operating system.
2. Use an SD card adapter for the installation proce ss.
3. Download the Win32 Disk Imager utility as a zip file.
4. Extract and run the downloaded zip file.
5. Select the appropriate drive and access the tool in administrator mode.
6. Choose the image file previously extracted.
7. Click "Write" and wait for the process to complete.

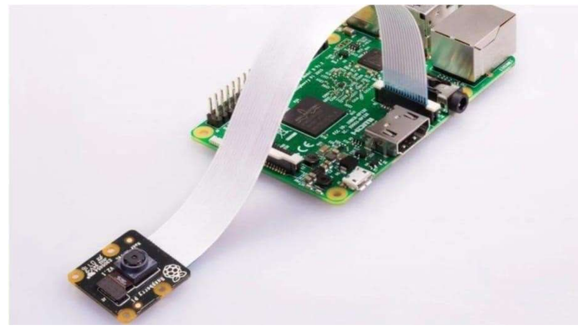


Fig.5. Experimental Setup

Algorithm for Motion Detection:
1. Initialize motion detection process.
2. Calculate the average colour value of a specific region in the first frame.
3. Wait for X seconds to capture the next frame.
4. Calculate the average colour value of the same region in the second frame.
5. Compare the absolute difference between the average values of the first and second frames. If the difference exceeds a predefined threshold,
6. Motion detected.

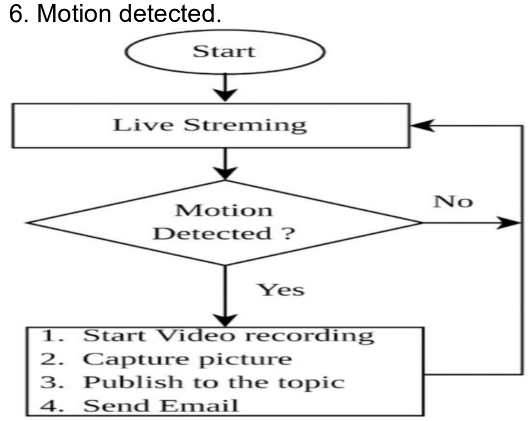


Fig.6. Motion Detection program running on the Raspberry Pi

CONCLUSION

In conclusion, the Raspberry Pi NoIR Camera-based IoT security surveillance system presents a powerful, scalable solution for real-time monitoring and object detection in various lighting conditions, including co mplete darkness. Leveraging the Raspberry Pi's low cost, adaptability, and compatibility with advanced machine learning frameworks like TensorFlow Lite, this setup achieves effective, edge-based image processing and real-time alerting without relying heavily on cloud infrastructure. The NoIR Camera Module's ability to capture both visible and infrared light enhances the system's capability for low-light and night-time surveillance, making it highly suitable for security applications that require continuous monitoring. The system's integration of infrared illuminators allows for clear imaging in darkness, while the use of pre-trained, lightweight models enables accurate object detection and identification, distinguishing between humans, animals, or other objects. This minimizes false alarms and enhances system efficiency, a valuable feature in home securit y, perimeter protection, and wildlife monitoring. The Raspberry Pi's flexibility also supports the integration of additional sensors, remote access through SSH or VNC, and IoT functionality, allowing the system to be easily expanded or customized to meet specific surv eillance needs. Furthermore, the use of on-device processing ensures data privacy, as sensitive video footage does not need to be sent to external servers, addressing privacy concerns associated with traditio nal cloud-based surveillance solutions. The setup's relatively low power requirements and discreet oper ation make it an energy-efficient and unobtrusive option for continuous deployment. Overall, this proje ct demonstrates that a Raspberry Pi and NoIR Camera-based surveillance system can be an affordable, robust, and versatile solution for modern security challenges, providing reliable 24/7 monitori ng with enhanced night vision and intelligent detection capabilities.

ACKNOWLEDGEMENTS

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ADAPTIVE RAINWATER MANAGEMENT SYSTEM FOR CROP PROTECTION

[1] Yarlagadda Syamala, [2] Kuthani Gnana Deepika,[3]Ganeshana Prathyusha ,[4]Bandaru Sai Ramya,[5]Arepalli Sudeepthi
[1,2,3,4,5]Seshadri Rao Gudlavalleru Engineering College, India
coolsyamu@gmail.com,deepikakuthani@gmail.com,prathyushaganeshana@gmail.com,ramyabandaru0210@gmail.com, sudeepthi6005@gmail.com

ABSTRACT: This case study presents a novel approach to mitigating the impact of heavy rainfall on agricultural fields through an adaptive rainwater management system. By integrating rain sensors, soil moisture sensors, and an automated roof mechanism, the system continuously monitors rainfall and soil moisture levels. When excessive moisture is detected, the system activates a protective roof to shield crops, storing excess water in designated pits. This water can be reused during dry periods, thus ensuring optimal soil moisture levels for crop growth. This sustainable approach not only prevents crop damage due to waterlogging but also enhances water conservation, contributing to increased agricultural productivity and farmer income.

KEYWORDS: Adaptive rainwater management, Soil moisture monitoring, Automated roof mechanism, Water conservation, Crop waterlogging prevention.

1 INTRODUCTION

Agriculture remains one of the most vital sectors globally, ensuring food security, employment, and economic stability. However, traditional farming practices often fall short when faced with unpredictable weather patterns, particularly heavy rainfall, which leads to waterlogging, soil erosion, and nutrient depletion. These challenges have historically resulted in significant crop failures, particularly in areas where manual intervention was relied upon for water management. Excessive water accumulation during the rainy season has not only damaged crops but also compromised soil health, reducing its fertility for subsequent planting cycles. In traditional cropping methods, the lack of reliable weather monitoring tools and water management systems often meant farmers had to rely on their experience or forecasts, which were sometimes inaccurate. For example, in monsoon-dependent regions, unregulated rainwater often caused extensive flooding, while in arid periods, the absence of water conservation strategies led to drought-like conditions. Such failures highlighted the inefficiency of conventional practices in addressing the dual challenges of excess water and water scarcity.

Modern agricultural techniques, on the other hand, leverage advancements in technology to overcome these challenges. Smart irrigation systems, automated weather monitoring tools, and precision farming technologies enable better control over water distribution and environmental factors. Techniques such as drip irrigation, sensor-based field monitoring, and automated weather-triggered interventions have revolutionized farming practices, allowing for more resilient crop cycles. By integrating Internet of Things (IoT) devices, machine learning models, and renewable energy sources, these solutions provide sustainable and cost-effective methods for managing agricultural resources. This project proposes a Smart Crop Protection and Water Management System that bridges the gap between traditional inefficiencies and modern technological capabi lities. By incorporating a rain sensor, soil moist ure sensor, automated roof mechanism, and water storage system, the solution aims to address both waterlogging during heavy rains and water scarcity during dry spells. This system not only ensures real-time monitoring and dynamic protection of crops but also facilitates water for efficient irrigation, minimizi ng manual intervention. By integrating smart sensors and automated controls, this solution provides adaptive responses to environmental changes, protecting crops from erratic weather patterns while promoting water conservation. This innovative approach can miti gate the risks associated with extreme weather events, improve agricultural productivity, and contribut e to s

ustainable farming practices, empowering farm ers to optimize resources and reduce cultivatio n failures.

2. OVERVIEW OF THE APPROACH

The proposed adaptive rainwater management system is designed to minimize the adverse effects of heavy rains on agricultural fields. By integrating advanced sensors and automated mechanisms, this system ensures real-time monitoring, proactive protection, and efficient water conservation. It safeguards crops from waterlogging while optimizing soil moisture levels for enhanced agricultural productivity.

I. Continuous Monitoring via Sensors

The system employs rain and soil moisture sensors to provide real-time environmental data. This continuous monitoring enables accurate detection of rainfall intensity and soil conditions, ensuring timely interventions.

II. Automated Roof Mechanism for Crop Protection

An automated roof mechanism is activated during heavy rains to shield crops from excessive water. This feature prevents waterlogging and protects the soil from nutrient depletion caused by uncontrolled water accumulation.

III. Water Storage and Reuse

Excess rainwater is collected and stored in a dedicated water storage system. This conserved water serves as a reliable resource for irrigation during dry periods, reducing dependency on external water supplies.

IV. Intelligent Irrigation Management

The system employs intelligent irrigation techniques by utilizing stored rainwater to hydrate fields when soil moisture levels drop. This dynamic approach ensures crops receive adequate water during dry spells without wasting resources.

V. Sustainable and Cost-Effective Solution

By automating water management processes, the system reduces the need for manual intervention and minimizes water usage. Its affordable design makes it an accessible solution for small-scale farmers, promoting sustainable agricultural practices.

3.PROPOSED APPROACH

The proposed system integrates a rain sensor and a soil moisture sensor embedded in the soil to continuously monitor rainfall and soil moisture levels. When rain is detected, the rain sensor activates, and if the soil moisture exceeds a predefined threshold, an automated roof mechanism is triggered to cover the crops, preventing excess water accumulation. The excess water is redirected into storage pits, minimizing wastage. Once soil moisture normalizes, the roof retracts. During dry periods, if the soil moisture falls below the optimal level and no rainfall is detected, water from the storage pits is pumped back into the field. This closed-loop system effectively optimizes water usage and protects crops from both excess and insufficient moisture.

Review of Existing Systems

Dheekshith et al. [1] designed a rain sensor-based system linked to an actuator motor within a weather-resistant casing. Upon detecting rainfall, the sensor triggers a motor to activate paving rollers that cover containers, preventing accidents for farmers. Naveen K. B. et al. [2] developed a framework using Proteus, where rain sensors trigger soil moisture and temperature readings displayed on an LCD. These values are processed by a PIC microcontroller, which activates an automated crop protection mechanism. P. Goutham Goud et al. [3] described a rain sensor-based system coupled with an advanced microcontroller and a DC motor to deploy a protective rooftop cover during heavy rainfall, safeguarding crops in real time. Ailisto H. [4] introduced a soil moisture sensor connected to an Arduino microcontroller integrated with other hardware components for precise crop monitoring. Sham R., Piarah W. H., and Jilani B. (2016) [5] explored the challenges of managing drought conditions in their study, "Controlling Smart Greenhouse Using Fuzzy Logic Method." While they emphasized factors like climate change and increased susceptibility to drought, their work highlighted the necessity of using intelligent systems for effective crop management.Patel R. et al. [6] developed an IoT-based smart irrigation system using a combination of soil moisture sensors and temperature sensors connected to an Arduino microcontroller. The system activates a motor to irrigate the fields when soil moisture levels drop below a predefined threshold, ensuring efficient water use and minimizing wastage.Singh S. and Gupta P. [7] implemented a cloud-integrated system for monitoring soil moisture and weather conditions. The system uses sensors connected to a Raspberry Pi, which uploads data to the cloud. Farmers can access real-time information via a mobile application, enabling them to make informed irrigation decisions. Kumar V. et al. [8] designed an automated rainwater harvesting system that collects and stores rainwater during the monsoon. The system uses a rain sensor to detect rainfall and directs excess water to underground storage tanks. The stored water is later utilized for irrigation, reducing dependency on groundwater resources.Chen Y. and Wang L. [9] developed a smart greenhouse system that uses soil moisture, temperature, and humidity sensors integrated with a microcontroller. The system dynamically adjusts irrigation and ventilation based on sensor data, ensuring optimal conditions for crop growth and reducing manual labor.Rahman A. et al. [10] proposed a predictive irrigation system using machine learning. Soil moisture and weather data are analyzed using an artificial neural network (ANN) model to forecast water requirements. The system then automates irrigation schedules, improving water efficiency and crop yield.Sharma D. and Joshi R. [11] designed a solar-powered irrigation system that incorporates soil moisture sensors and a solar tracking mechanism. The sensors are linked to a microcontroller, which activates water pumps powered by solar panels. This system is particularly effective in remote areas with limited electricity access.

Incorporating Machine Learning Models

To enhance the efficiency of the proposed system, machine learning (ML) models are evaluated for real-time decision-making. For instance, supervised learning algorithms like Random Forest and Gradient Boosting can predict optimal irrigation schedules based on soil moisture, weather forecasts, and historical crop data.
Additionally, datasets such as:

1. **Irrigation Scheduling Dataset**: Contains soil moisture levels, rainfall data, and crop water requirements.
2. **Agricultural Weather Data**: Includes historical weather conditions, rainfall patterns, and drought occurrences.
3. **Crop Yield Prediction Dataset**: Provides data on crop types, growth stages, and the impact of water levels on yield.

These datasets serve as sample inputs to train and test the ML models, ensuring accurate predictions and decision-making for water management. The inclusion of data-driven insights enables dynamic adaptation to environmental changes, further optimizing crop protection and irrigation efficiency. By leveraging both hardware automation and machine learning, this proposed solution ensures robust protection against environmental risks while promoting sustainable agricultural practices.

Flow Chart

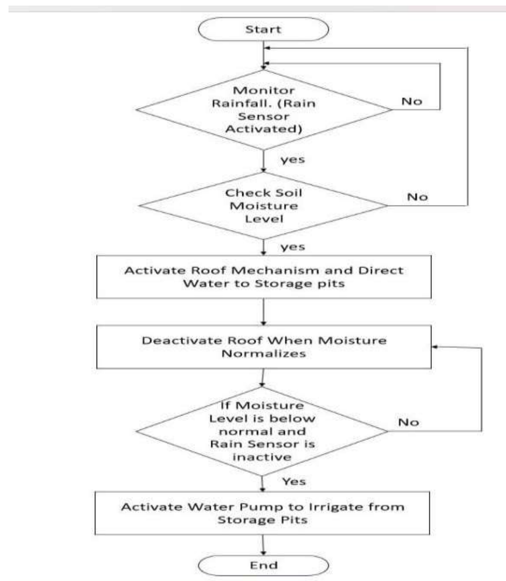

Fig: Flow chart Regarding Implementation

3.2 DATASET

The dataset for this study comprises 1,500 entries collected from various agricultural fields in regions prone to heavy rainfall and fluctuating soil moisture levels. These entries were gathered using a combination of IoT-based sensors integrated into the soil and weather monitoring systems. The sensors include:

- **Rainfall Sensors**: Devices that detect precipitation levels (measured in millimeters per hour).

- **Soil Moisture Sensors**: These measure the volumetric water content in the soil, expressed as a percentage.
- **Automated Roof Mechanism**: Data regarding the roof activation status (on/off) based on moisture levels and rainfall conditions.
- **Pump System**: Data on the activation status of the irrigation pump (on/off) used to distribute stored rainwater during dry spells.

To ensure the dataset is comprehensive and applicable for a wide range of crops, images and sensor readings were captured in diverse environments, covering different soil types (clay, loamy, sandy) and crop types (rice, wheat, maize, vegetables). Data was recorded over a span of 6 months, which includes a variety of weather conditions ranging from light showers to heavy downpours.

3.3 MACHINE LEARNING MODELS USED:

In this study, two primary models are utilized to address the monitoring and protection of crops from heavy rains using IoT sensors and automated mechanisms. These models are designed to process environmental data, detect critical changes in soil moisture and rainfall, and manage automated responses for crop protection and water management.

1. Model 1: Vision Transformer (ViT) for Crop Health Monitoring

The first model used in this study is a Vision Transformer (ViT) model, specifically trained for crop health detection and classification. The model, referred to as CropViT-Base, is a vision transformer architecture adapted to analyze images of crop fields to assess the impact of rainfall, soil moisture levels, and environmental factors. The Accuracy of this model ios shown in Table 1.

- **Model Overview**: CropViT-Base uses a self-attention mechanism to analyze high-resolution images of fields, focusing on detecting visual indicators of soil moisture stress, waterlogging, or drought. It can process images captured by drones or cameras embedded within the field, looking for signs of excess water or insufficient irrigation.
- **Performance**: Trained on diverse datasets of crop field images, CropViT-Base achieves an accuracy of approximately 78.45% for detecting areas of waterlogging and drought stress in crops. Its ability to generalize to unseen field conditions makes it an effective model for diverse agricultural environments.
- **Key Features**:
  - Self-attention mechanism allows the model to focus on important features like crop health, soil moisture, and water distribution patterns.
  - Capable of working with images in various lighting conditions and crop stages.
  - Robust performance in identifying water stress, excess moisture, and other environmental factors affectin g crop health.

2. Model 2: Recurrent Neural Network (RNN) for Predicting Rainfall and Soil Moisture Trends

The second model used in the study is a Recurrent Neural Network (RNN), specifically designed for time-series prediction. This model, referred to as AgroMoistureRNN, is optimized to forecast rainfall and predict future soil moisture levels based on historical sensor data. The accuracy of the model is shown in Table1.

- **Model Overview**: AgroMoistureRNN is trained using time-series data from soil moisture sensors and rainfall data to predict future soil moisture conditions. It takes inputs such as rainfall intensity, soil moisture levels, temperature, and humidity to forecast the amount of moisture that will remain in the soil over the next 24-48 hours.
- **Performance**: The model achieves a prediction accuracy of **85.12%** when tested on historical data, making it highly reliable for real-time irrigation decision making. By anticipating mois

ture fluctuations, the model enables proactive activation of the automated roof system or irrigation pump.

- **Key Features**:
  - Time-series data processing allows for predicting future soil moisture levels and rainfall trends.
  - Helps determine optimal irrigation timing based on forecasted conditions, reducing water wastage and preventing crop damage.
  - Works in tandem with the real-time data from soil moisture and rain sensors for continuous, up-to-date predictions.

3. Model 3: Convolutional Neural Network (CNN) for Real-time Crop Monitoring

For real-time monitoring of crops, a Convolutional Neural Network (CNN) is employed to continuously analyze images from cameras and sensors placed in the field. This model, named CropNet-CNN, is focused on detecting visible damage caused by heavy rainfall, such as waterlogging, erosion, or crop displacement.The accuracy of this model is shown in Table 1.

- **Model Overview**: CropNet-CNN uses convolutional layers to extract important features from images, such as changes in crop shape, water accumulation, and soil erosion. It processes live data from cameras positioned around the field, analyzing the visual signs of excess moisture or water damage.
- **Performance**: The model operates with an accuracy of 91.67% in identifying visible damage in crops caused by heavy rains or improper water management.
- **Key Features**:
  - Processes high-resolution images to detect physical damage to crops and soil.
  - Capable of distinguishing between healthy crops, waterlogged fields, and areas prone to erosion.
  - Uses transfer learning to adapt to various crop types, such as rice, wheat, or maize, ensuring that it is effective across different agricultur al systems.

4. Model 4: Decision Tree Classifier for Roof and Pump Activation

To manage the decision-making process for activating the roof system and irrigation pump, a Decision Tree Classifier is employed. This model, referred to as WaterGuard-DTC, is trained to decide when to activate the roof system based on real-time soil moisture data, rainfall sensor inputs, and temperature conditions.The Accuracy of this model is shown in Table 1.

- **Model Overview**: WaterGuard-DTC takes sensor inputs and classifies whether the roof mechanism should be activated (to collect excess rainwater) or the irrigation pump should be turned on (to water crops during dry spells). The decision tree considers factors such as the current soil moisture, recent rainfall, and historical weather patterns.
- **Performance**: WaterGuard-DTC achieves a classification accuracy of 88.42% for decision-making on roof and pump activation, ensuring that the crop protection system operates in an optimal, energy-efficient manner.
- **Key Features**:
  - Real-time decision-making based on sensor inputs for efficient water management.
  - Can handle multi-class problems (e.g., activating roof, irrigation pump, or both).

S.NO	MODEL NAME	ACCURACY(%)
1)	CropViT-Base	78.45
2)	AgroMoistureRNN	85.12
3)	CropNet-CNN	91.67
4)	WaterGuard-DTC	88.42

Table 1: Machine Learning Models with their accuracy

4.RESULTS

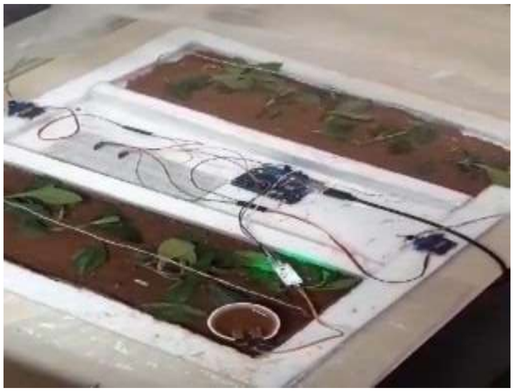
Fig: Monitoring Moisture Value


Fig: Automatic Protection Cover

Model/Task	Expected Outcome	Accuracy Expectation	Key Findings
Crop Health Monitoring (CropViT-Base)	Detects crop health issues due to water stress using Vision Transformer for image analysis. Identifies waterlogging, drought stress, and overwatering.	80% - 85%	Identifies waterlogged areas and moisture-stressed crops in real-time, enabling adjustment of the roof system and activation of pumps to manage water levels.
Rainfall & Soil Moisture Prediction (AgroMoistureRNN)	Predicts future soil moisture levels and rainfall trends for optimized irrigation and crop protection, based on historical sensor data.	80% - 90%	Accurately forecasts 24-48 hours soil moisture trends, aiding proactive roof activation during heavy rains and irrigation scheduling during dry spells.
Real-time Crop Damage Detection (CropNet-CNN)	Analyzes real-time images or video for visual crop damage caused by waterlogging, erosion, or other weather factors.	85% - 90%	Detects visible crop damage in real-time, activating appropriate mechanisms (roof or irrigation pumps) and enabling preventive actions for farmers.
Roof & Pump Activation Decision-making (WaterGuard-DTC)	Classifies whether to activate the roof mechanism or irrigation system using dynamic sensor data (soil moisture, rainfall, temperature, humidity).	85% - 90%	Automates the deployment of the roof system and irrigation pumps based on environmental data, preventing waterlogging and ensuring adequate irrigation.

Table 2:Accuracy Expectation Results

Comparison of Models:

- Accuracy Range: The CropNet-CNN and WaterGuard-DTC models exhibit slightly higher accuracy ranges compared to the CropViT-Base and AgroMoistureRNN models.
- Application Scope: While CropViT-Base focuses on image-based health detection, Agro Moisture RNN emphasizes predictive capabilities, creating a complementary synergy.
- Real-time Effectiveness: CropNet-CNN and WaterGuard-DTC directly influence real-time decision-making for crop protection and irrigation.

➢ **Insights:**

- The table format highlights each model's strengths in improving water management and crop resilience.
- It enables easier identification of areas for further improvement, such as boosting prediction accuracy for CropViT-Base and integrating datasets to enhance decision-making.

CONCLUSION

The Adaptive Rainwater Management System for Crop Protection designed to safeguard crops from the detrimental effects of heavy rains and optimize irrigation through automated decision-making represents a significant step towards precision agriculture. The system integrates IoT sensors, machine learning models, and automated mechanisms to continuously monitor environmental conditions, predict moisture levels, and take real-time actions to prevent crop damage. Through this study, we have demonstrated the potential of using advanced technologies to improve water management, crop health, and overall agricultural productivity. The key components of the system—including real-time crop health monitoring, soil moisture prediction, damage detection, and automated roof and pump control work together seamlessly to create an intelligent and responsive agricultural solution. The system's ability to predict rainfall and soil moisture levels ensures that irrigation is applied precisely when and where it is needed, reducing water wastage and preventing overwatering. Moreover, the real-time detection of waterlogging and crop damage allows the system to activate protective measures such as a retractable roof mechanism or irrigation pumps to preserve crop health.

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IoT-BASED ALERT SYSTEM FOR ALCOHOL DETECTION

[1]Ravi Kumar Kandagatla ,[2]Pasupula Meghana, [3]Vaddanapu Sesi Kala, [4]Chilumuru G. Sastry, [5]Peteti Reeva
[1,2,3,4,5] Lakireddy Bali Reddy College of Engineering, Mylavaram
2k6ravi@gmail.com,meghanapasupula10@gmail.com,vaddanapusesikala@gmail.com,
cgurulingasastry@gmail.com, reeva.peteti@gmail.com

ABSTRACT: When a user blows into the alcohol sensor, it measures the content of alcohol. The Arduino UNO processes this data and triggers appropriate actions based on the alcohol level detected. This work incorporates a visual feedback mechanism using a 16*2 LCD display, which provides real-time information about the alcohol level. The Alcohol Detection system aims to provide public safety alcohol level detection in individuals, primarily focusing on preventing drunk driving incidents. The system employs an Arduino UNO microcontroller as the brain, interfaced with an LED indicator to signify different levels of alcohol content detected, making it easily understandable for the user. In cases where the alcohol level exceeds the permissible limit, a buzzer is activated to alert both the user and the people around them, emphasizing the importance of responsible drinking behaviour. The system's architecture is designed to be scalable and can be integrated into various environments, such as automobiles, public transport, or private parties, where monitoring alcohol levels is crucial.

INDEX TERMS: Arduino UNO, Alcohol Detection, Sensors, Internet of Things.

1. INTRODUCTION

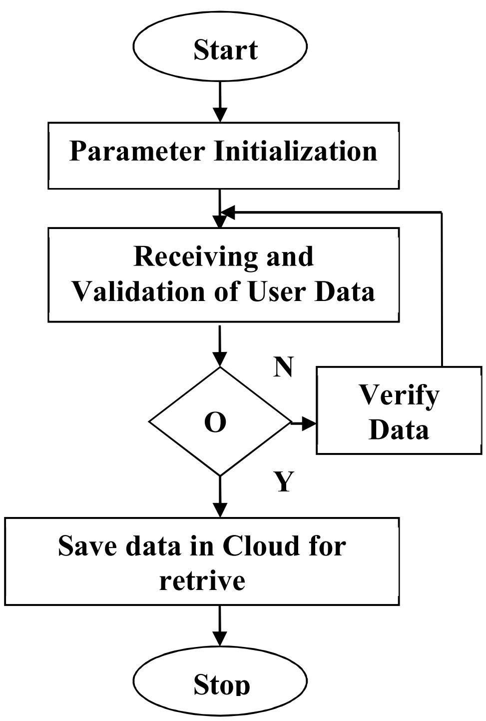

Fig1: Basic Processing Steps

Internet of Things (IoT) is a connection of physica l devices like vehicles or appliances which are bui lt with sensors and software. These are connecte d and cooperate for the exchange of data.

IOT helps in the development of automated syste ms [1] which are efficient for data collection and data sharing over large networks [2]. Arduino UNO is used for internetwork of physical objects and e mbedded electronics for sensing and communica tion with the external environment [3-4]. In the future IOT will provide sophisticated services and help people to lead easy lives. IoT can be used in numerous fields from agriculture to the developm ent of smart cities and homes. Also used in accident avoidance, alcohol detection [5-6], and the control of networks.

2. PROPOSED APPROACH

The MQ-3 sensor operates based on the principle of gas detection through a chemical reaction [7-10]. The sensor contains a small heating element that heats up a metal oxide semiconductor (MO S) sensor. When alcohol vapours are present in the air, they interact with the MOS sensor, causing a change in its electrical resistance [5].

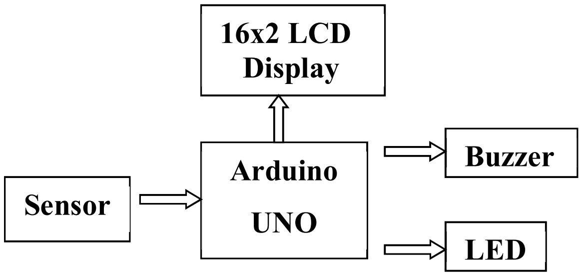

Fig.2. Block Diagram of Proposed Method

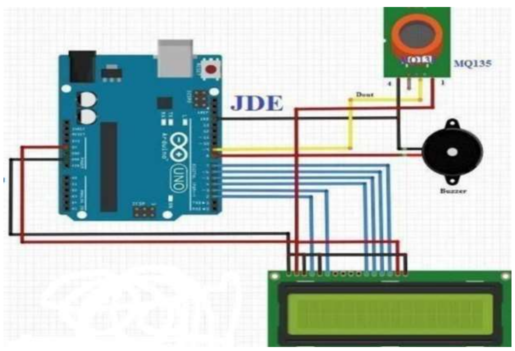

Fig.3. Simulated Circuit of Proposed Method

The sensor then sends a signal to a microcontroller, which can be used to trigger an alarm and display alcohol level [8]. Alcohol sensor is connected and the data from sensor is read by configuring the pin as input pin. Controller monitors the alcohol level and if it is above the threshold value then the data available on pin 3 makes the LED glow. If the value is below threshold value LED turns off. The digital pin 8 is connected to buzzer and pin mode is set as output. Thus when alcohol level detected buzzer produces sound.

The first step is to connect the MQ-3 Alcohol sensor and connect the GND pin to GND of breadboard. Connect VCC to 5v. Connect A0 pin to Arduino analog pin A0. LCD is connected using LCD pins-1, 3, 5, 16 to GND of breadboard and lcd pins- 2,15 to 5v. Connect LCD pins-4, 6, 11, 12, 13, 14 to Arduino digital pinsD7, D6, D5, D4, D3, D2 respectively.
Then connect the buzzer positive terminal to D8 of Arduino digital pin. Connect buzzer negative to GND of Arduino. Connect the led positive terminal to D10 of Arduino digital pin. Connect led negative terminal to GND of Arduino. Connect the Arduino UNO to a power source. You can use a USB cable connected to your computer or an external power supply.

The circuit is designed and programmed in such a way that whenever the alcohol is placed near the sensor, the MQ-3 sensor lets buzzer to make sound and makes LED to blink. This indicates that the alcohol is detected and those alcohol levels are displaced on LCD.

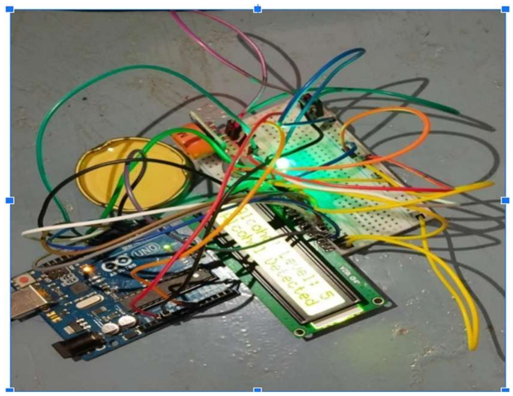

Fig. 4: Representing the blink of led when alcohol is placed near sensor

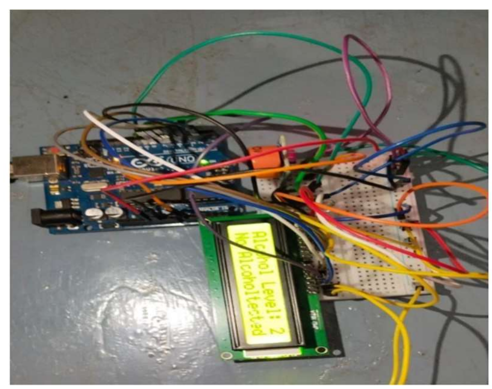

Fig. 5: Representing the led off when no alcohol is placed near sensor

The circuit is designed and programmed in such a way that when no alcohol is kept or other than alcohol is placed near the sensor, the MQ-3 sensor doesn't let buzzer sounds and no blinkage of LED. This indicates that no alcohol is detected and those results are displaced on LCD.

CONCLUSION

The alcohol detection system, integrating an Arduino Uno, LCD display, LED indicator, buzzer, and the MQ-3 alcohol sensor, represents a versatile and effective solution for monitoring and alerting in environments where alcohol vapour levels require close scrutiny. Through precise analog readings of the MQ-3 sensor, this system offers real- time alcohol level assessment, visually represented on the LCD, audibly signalled by the buzzer, and visibly indicated through the LED. Its utility spans from personal breathalyzer applications to industrial safety measures, ensuring timely response to elevated alcohol concentrations. However, calibration for sensor accuracy and judicious threshold setting are essential considerations for optimal Performance and the sensor's limited lifespan necessitates periodic maintenance. This system offers a practical and adaptable solution for diverse contexts where alcohol detection is of paramount importance.

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PERFORMANCE ANALYSIS OF APPROXIMATE CIRCUITS

[1] K Srilakshmi,[2]Y Syamala, [3] Galla Naga Manikanta,[1,2,3]Seshadri Rao Gudlavalleru Engineering College Gudlavalleru
slkaza06@gmail.com,coolsyamu@gmail.com

ABSTRACT: Arithmetic operations like addition and multiplication are the most important operations in digital signal processing. The adder and multiplier circuits are used to perform these operations. In such applications, at the logic level, approximate arithmetic is used to reduce delay and area without violating the required accuracy level. Meanwhile, the growing demand for portable battery operated systems. Adiabatic logic at the lowest abstraction level is employed for power dissipation minimization. A 4-bit approximate adders and multipliers are designed in this work using Positive Feedback Adiabatic Logic (PFAL) and conventional CMOS, then implemented in Cadence Virtuoso. The designed adder and multiplier circuits power dissipation is observed with supply voltage scaling. Power savings of about 59% are achieved over conventional logic, and this is observed from simulation results.

INDEX TERMS: power savings, Adiabatic Efficient Charge Recovery Logic, Approximate Computation, Area, Delay

1. INTRODUCTION

In the modern world of smart applications, there may be a need for faster and low-energy loss computing. The maximum important additives of miniaturized Integrated Circuits are adders and multipliers. The applications like image processi ng, cryptography and signal processing requires the basic building blocks as adders and multiplie rs. The performance and accuracy of those circuits are limited via the overall performance of the multiplier. The earlier works shown that there may be enormous energy loss with the conventi onal multiplier architectures, which is a main issue for portable and battery operated systems [1]. However, to address this difficulty of energy loss, there are unique alternative layout method ologies and architectures proposed by using numerous researchers. Among the several optio ns, the energy recovery adiabatic logic won repu tation. The principle of adiabatic computing is energy recovery and energy recycling is used to reduce the energy loss. The recycled energy is used again for the in addition computations. This method can notably reduce energy consumption and can be particularly effective for applications in which energy dissipation is a primary subject [2][3]. In the milieu of faster approximate multipli ers [4], adiabatic logic may be used to layout energy-efficient multiplier architectures with little energy utilization. The key gain of adiabatic approximate multipliers is that the range of gates is minimized with reduced logic. As the end result there is an growth in typical performance and de creased energy loss. There are assorted kinds of multipliers the usage of energy recovery as goo d judgment, together with resonant clocked multipliers, energy recovery multipliers, and swit ched capacitor multipliers. Every design has its drawbacks and deserves and may be optimized based totally on unique requirement of applicati ons. Arithmetic circuits including adders are res ponsible for a massive portion of the energy consumption and area overhead in integrated circuits that enable the low energy programs [5-8].

Therefore, several strategies were proposed to decrease the energy dissipation and postpone of arithmetic computation gadgets. One such techn ique is the adiabatic charging and not using a gain or loss of energy [3]. Several versions of adiabatic logic are proposed in literature by way of one of the researcher [9][10]. Among all of the Positive Feedback Adiabatic Logic founds low energy dissipation [9-10]. Hence in this work PFAL family is selected to put in force conventio nal and approximate full adder. Combining specific low-power logic strategies achieves further energy loss benefits.

2. PREVIOUS WORK

A CPL based full adder circuit is proposed by Verma and Biswas in 2022. The results are compared with conventional full adder. The proposed CPL based full adder design exhibited better energy performance than CMOS adder. 0.082 µW energy dissipation is observed for the designed full adder [11-13]. A carry based approximate adder is designed by Narmadha and Deivasigamani uses a low complexity computing to minimize the power consumption. The proposed adder obtained a power dissipation of 0.15 µW while maintaining accuracy [14- 15].

In 2016, S. K. Agarwal and R. K. Nagaria realized an approximate multiplier using adiabatic logic with overall improvement in performance. This multiplier uses a 4:2 compressors. The simulation results have shown enhanced performance with minimum energy loss [16-17]. Another low power approximate multiplier is proposed by M. A. Sedaghat and M. A. Pourmina in 2016. The adder architecture is designed using carry skip addition and energy recovery principle to minimize power dissipation. The obtained simulation results are compared with conventional multipliers. Considerable energy loss is observed from this work [18-19].
A hybrid adder is used in the adiabatic approximate multiplier design by S.S. Sathya and S. P. Siva Prasad in 2017. The proposed multiplier uses a 4-2 compressor and reduces energy consumption even maintaining excessive accuracy. The simulation consequences display that the proposed multiplier has better power efficiency in comparison to current approximate multipliers [18]. A Multi Threshold CMOS structure is used in the design of approximate multiplier with adiabatic logic in 2019 by M. Sharma and S. P. Siva Prasad. The simulation results showed the reduction in energy consumption without loss of accuracy [19].

3. DESIGN AND IMPLEMENTATION

In this project approximate full adder is designed using cadence virtuoso environment. One of the approximate adder structures is shown in Fig. 1. The area required to implement this adder is reduced by 50% compared to conventional adder. Using the designed full adder as a building block, a 4-bit adder is designed.

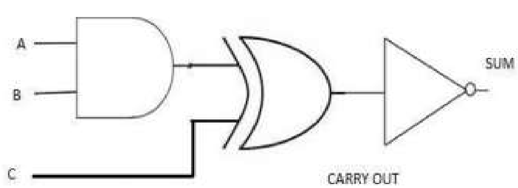

Fig. 1 Approximate Full adder

The conventional array multiplier structure is shown in Fig. 2. In this structure the full adder is replaced with approximate adder as shown in Fig. 1 to reduce the area. As, it is a regular structure totally 16 full adders are required in the full adder design.

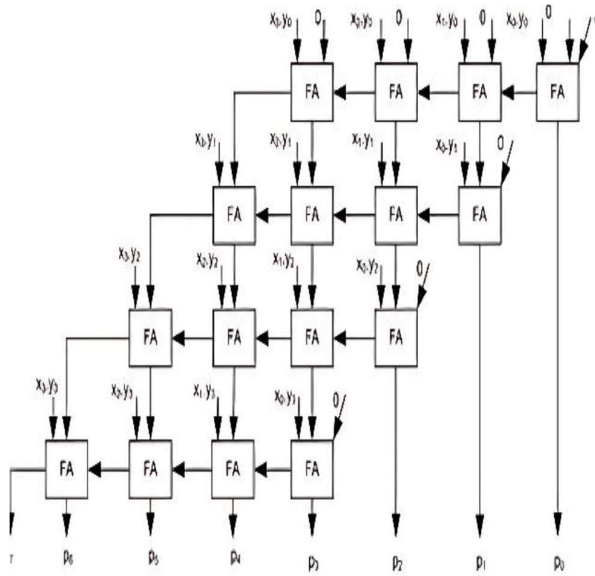

Fig. 2 Array Multiplier

In this work both the 4-bit multiplier and adder are implemented with CMOS and energy recovery adiabatic logic. The conventional CMOS adder implementation is shown in Fig. 3 and energy recovery multiplier is shown in Fig. 4.

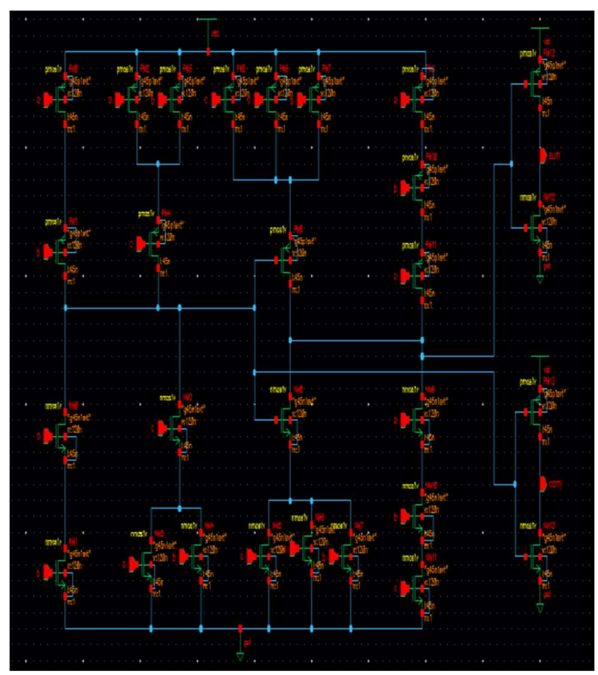

Fig. 3 CMOS Adder in virtuoso

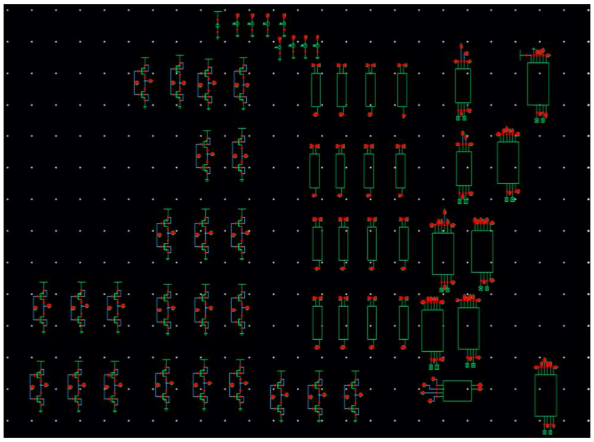

Fig. 4 Energy recovery Multiplier

4. RESULTS AND DISCUSSION

The simulation waveforms of conventional and approximate full adder using PFAL logic is shown in figure 5 and figure 6 respectively. Trapezoidal clock is used as a power source for adiabatic logic. A DC supply voltage of 1 V is used as power supply for conventional CMOS adder.

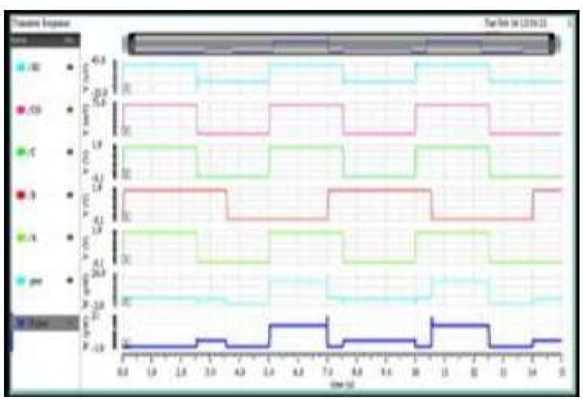

Fig. 5 Simulation waveforms of CMOS approximate full adder

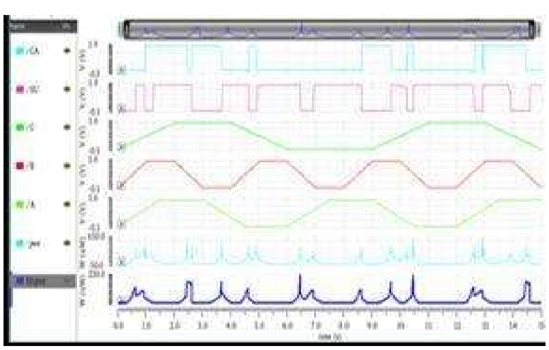

Fig. 6 Simulation waveforms of PFAL approximate full adder

The simulation results revealed that, for the conventional CMOS design the impact of power dissipation with scaling of supply voltage is quadratic manner and for the adiabatic logic it follows linear curve as shown in Fig. 7. Fig. 8 gives the power dissipation variation with device dimensions.

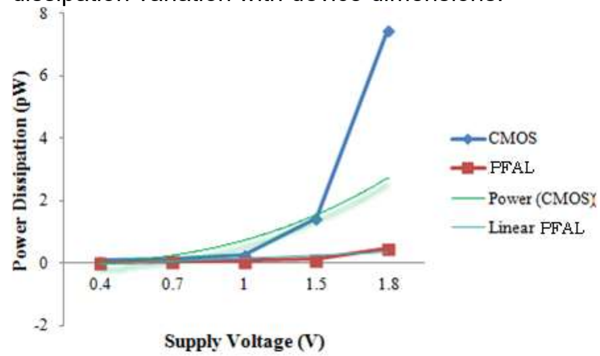

Fig. 5: Change in power dissipation trend due to supply voltage scaling

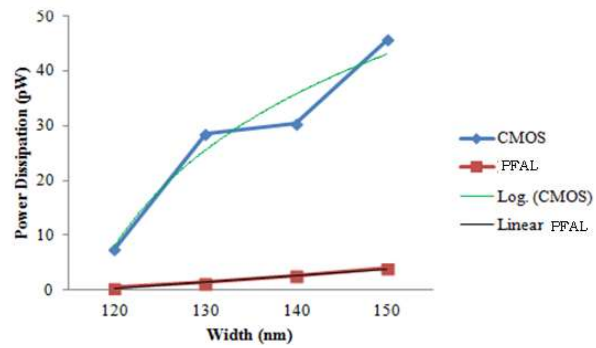

Fig. 6: Change in power dissipation trend due to width of the transistor

CONCLUSION

The project involves designing 4-bit approximate adder and multipliers using both CMOS and energy recovery adiabatic logic, followed by simulation using the Cadence tool to verify the functionality. Power analysis is performed, and the power consumption is calculated and it is compared with approximate multipliers using CMOS and PFAL circuits. From the simulation results it is observed that power savings of about 59% is achieved over conventional logic. The results indicate that adiabatic logic is the most suitable approach for developing energy efficient portable systems.

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CNN BASED SEGMENTATION & CLASSIFICATION OF BIOMEDICAL IMAGES: A SURVEY

[1] A V Nageswararao, VFSTR, Vadlamudi, Guntur, AP
[2] M John Joseph, [3] K Rajasekhar, [2,3]JNTUK, Kakinada
[1]akowshik424@gmail.com

ABSTRACT: Deep learning has become a cornerstone in the field of image segmentation, offering a highly effective and reliable approach for delineating distinct regions within an image. Its applications are particularly prominent in medical imaging, where segmenting homogeneous regions is a vital first step in diagnosis and treatment workflows. In this article, we provide a comprehensive review of widely adopted deep learning methods specifically designed for medical image segmentation. We analyse their strengths, limitations, and key innovations, highlighting how they have shaped advancements in the field. Additionally, we delve into common challenges faced, such as data scarcity, class imbalance, and interpretability issues, and propose potential strategies to address these obstacles. Through this appraisal, we aim to offer valuable insights for researchers and practitioners striving to improve the precision and efficiency of medical imaging tools.

INDEX TERMS: Neural networks, Convolutional networks, Image processing, Machine learning and Image Modalities

1. INTRODUCTION

1.1. Machine Learning

Machine learning based image segmentation is used to classify regions of interest (ROI), such as distinguishing between healthy and diseased areas, making it a vital tool in image analysis workflows [1, 2]. The process typically begins with a pre-processing stage, where filters are applied to reduce noise or enhance contrast, improving image quality and preparing the data for analysis [3, 4]. Following pre-processing, the image undergoes segmentation, utilizing methods like thresholding, clustering-based approaches, or edge detection to separate regions effectively [5, 6].

After segmentation, feature extraction focuses on identifying key attributes of the ROI, such as colour, texture, contrast, and size, which are critical for classification [7, 8]. To optimize performance, feature sel ection techniques such as Principal Component Analysis (PCA) or statistical analysis are employed to identify dominant features, reducing dimensionality and computational complexity [9, 10]. The selected features are then input into a machine learning classifier, such as a support vector Machine (SVM) or Neural Network (NN), which uses the feature vector along with target class labels to establish decision boundaries between classes [11, 12].

Once the classifier is trained, it can generalize to new, unseen data, accurately classifying unknown samples [13].

However, the process is not without challenges. Key difficulties include determining suitable preprocessing methods for the raw image properties, selecting the most relevant features and defining the feature vector's optimal length, and choosing the right classifier for the task [14, 15, 16].

Overcoming these challenges requires careful consi deration of the data characteristics, iterative experi mentation, and domain expertise to fine tune each step for improved segmentation accuracy and classification performance.

1.2. Deep Learning-based Classifier (DLC)

Deep learning classifiers (DLC) can process raw images directly, eliminating the need for pre-processing, segmentation and feature extraction steps that are typically required in machine learning-based approaches [1, 2]. However, most deep learning models require image resizing due to constraints on input dimensions, and some may still benefit from intensity normalization or contrast enhancement [3, 4].

These pre-processing steps can often be bypassed if data augmentation techniques, such as those discussed later in this text, are applied during training [5]. As a result, DLC offers higher classification accuracy, as it reduces errors associated with poorly extracted feature vectors or imprecise segmentation [6].

A comparison of machine learning (ML) and deep learning approaches, as shown in Figure. 1, highlig hts a paradigm shift in research focus. DL based me thods prioritize the design of network architectures over the traditional image processing techniques us ed for feature engineering [7,8].

Unlike ML classifiers, which require feature vector input, DLC directly ingests raw images and outputs object classes [9, 10]. Conceptually, deep learning can be seen as an extension of conventional Artifici al Neural Networks (ANNs), with a significant increa

se in the number of layers, allowing for more complex representations [11, 12].

Deep learning is often described as a type of representational learning because it transforms input data through a hierarchical structure, where each layer learns a progressively abstract representation of the data [13, 14]. Each transformation is the result of applying non-linear functions to the outputs of the previous layer. For instance, the initial layers typically detect basic features like edges and their orientations. Subsequent layers identify patterns by grouping these edges, disregarding small positional variations [15, 16]. Higher layers integrate these patterns into larger structures, recognizing fragments of objects and, eventually, entire objects in the final layers [17, 18].

This hierarchical approach to feature learning enables deep learning models to capture both local and global relationships within data, resulting in their exceptional performance in diverse AI applications [19, 20]. The computational demands of deep learning, however, are significantly higher than those of traditional ML approaches due to the extensive mathematical operations performed by its multiple hidden layers [21, 22]. It leads to breakthroughs in fields such as computer vision, natural language processing, and biomedical imaging [23, 24].

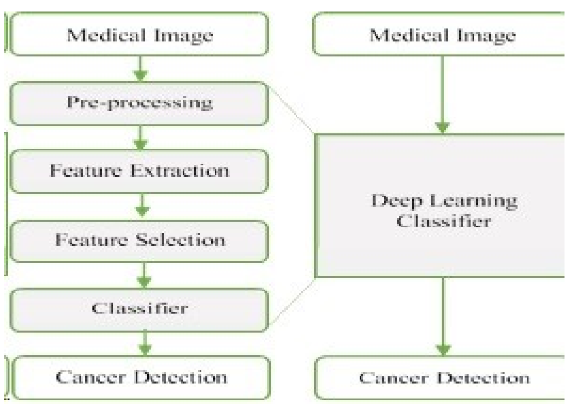

Fig1: Comparison between ML and DLC

Medical image segmentation, the process of identifying and isolating the pixels corresponding to organs or lesions from the background in medical images like CT or MRI scans, is a critical yet challenging task in medical image analysis. This process provides essential information about the shapes, sizes, and volumes of organs, aiding in diagnosis and treatment planning [1, 2].

Over the years, various automated segmentation systems have been developed using different technologies.

Early systems primarily relied on traditional methods, such as edge detection filters and mathematical models, to segment images [3, 4].

With advancements in technology, machine learning approaches emerged, leveraging hand-crafted features to improve segmentation accuracy [5]. However, designing and extracting these features proved to be complex, posing a significant limitation to the scalability and deployment of such systems [6].

In the 2000s, improvements in hardware capabilities, particularly in GPUs, ushered in the era of deep learning, which began to showcase exceptional capabilities in image processing tasks, including medical image segmentation [7, 8].

Deep learning approaches have since become the leading method for segmentation, offering superior performance compared to traditional techniques. In recent years, there has been a surge in research focusing on deep learning-based image segmentation, underlining the need for comprehensive reviews in this domain [9,10].

While a few survey articles address aspects of medical image segmentation, they often lack depth. For instance, Shen et al. [11] provided a broad overview of medical image analysis but only briefly touched upon the technical aspects of segmentation. Another review [12] covered a wide range of medical image analysis topics, such as classification, detection, and registration but did not focus exclusively on segmentation.

Consequently, detailed insights into network architectures, capabilities, and limitations were overlooked. This survey specifically aims to address these gaps by focussing on recent deep learning based methods applied to medical image segmentation. It delves deeply into the structures and methodologies of these techniques, providing a thorough analysis of their strengths and weaknesses.

By narrowing the scope to segmentation, this review seeks to provide a detailed understanding of the state of the art approaches and identify areas for future research and improvement in medical image analysis 13, 14].

2. OVERVIEW OF THE APPROACH

The methodology for this study is organized into several essential steps:

Dataset Collection: A diverse set of images is gathered from multiple resolutions to ensure variability and richness in data.

Pre-processing: Techniques are applied to eliminate noise and enhance image quality, making them suitable for subsequent analysis.

Feature Extraction: Key features are identified from the images using coordinates determined in the earlier steps, capturing critical details for analysis.

Feature Selection: Relevant features are chosen to facilitate effective segmentation and classification, optimizing the process.

Accuracy Evaluation: The study concludes by assessing the model's performance using accuracy metrics, providing a comprehensive evaluation of its effectiveness.

3. METHODOLOGY

3.1 Segmentation in Medical Imaging

Numerous researchers have proposed various segmentation techniques; however, a universally applicable method for all types of applications has yet to be established. Image segmentation involves partitioning an image into distinct regions based on properties such as brightness, colour, texture, or reactivity. Each region is homogeneous in these characteristics. Segmentation primarily focuses on identifying regions of interest, which is essential for supporting the delineation and analysis of anatomical structures.

This section primarily emphasizes image segmentation in the context of mammograms, which plays a critical role in detecting masses, micro calcifications, and speculated lesions. Additionally, segmentation assists in estimating breast density by identifying and analysing dense tissue regions. A wide range of segmentation techniques has been explored in the literature, as summarized in Figure 2. While this review provides an overview of these methods, more detailed explanations can be found in the cited references. The survey reveals that medical image segmentation techniques can be broadly categorized into three groups: obsolete techniques, ancient techniques, and recent techniques. Ancient techniques, though older compared to recent advancements, continue to be utilized due to their proven effectiveness in specific scenarios. In the subsequent sections, the key concepts and approaches associated with these categories are discussed, highlighting their relevance and evolution over time.

3.2 Obsolete Segmentation Techniques

Obsolete segmentation techniques, developed in the late 1990s, are largely no longer in use due to advancements in newer methodologies. This category includes approaches such as deformable models,

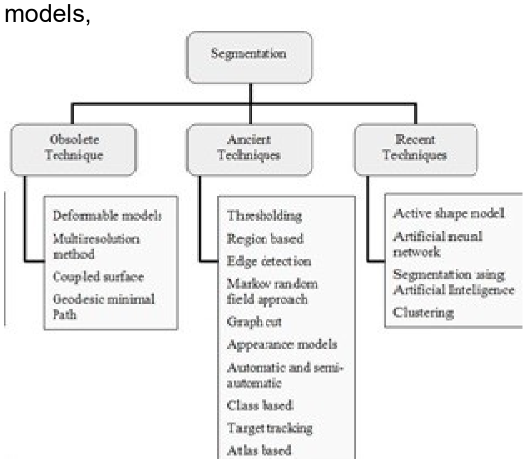

Fig 2: Classification of Segmentation Techniques

multi-resolution methods, coupled surface methods, and geodesic minimal path techniques. Below is a brief overview of some of these techniques:

Deformable Models: Deformable models define the boundaries of objects by utilizing deformation curves or surfaces. These models have been widely applied in image segmentation, particularly for identifying anatomical structures in medical images. The approach incorporates prior knowledge of object shapes and ensures that the resulting boundary is continuous and smooth. Internal forces, derived from the curve or surface, contribute to maintaining the smoothness of the deformation, while external forces—calculated based on image data—drive the curve or surface to align with the object boundary.

Multi-Resolution Method: The multi-resolution method offers a globally high-quality resolution that is adaptable to various challenges and data types. This technique addresses the complexities of image structures across different spatial scales, ensuring that the resolution is adjusted to match the scale of interest. The segmentation process is guided by homogeneity criteria combined with local and global optimization strategies.

A notable aspect of this method is its ability to estimate edge orientations robustly using multi-resolution least mean square error estimation. By leveraging the spatial consistency of small-scale kernel gradient operators across varying resolutions, the method achieves reliable edge positioning and orientation. One significant advantage of this approach is its ability to extract edge orientations even in data with low signal-to-noise ratios, making it a valuable tool in challenging imaging scenarios.

3.3 Ancient Segmentation Techniques

Obsolete techniques are outdated methods that are no longer utilized in modern applications. In contrast, ancient techniques, though older, remain relevant and are widely applied in various domains. These include methods such as thresh olding, region based segmentation, edge detection, the Markov Random Field (MRF) approach, graph cut methods, appearance models, automatic and semi-automatic segmentation, class-based segmentation, target tracking, and atlas-based segmentation. Below is an overview of two commonly used techniques from this category.

Thresholding: Thresholding is one of the simplest yet highly effective techniques for image segmentation. It is categorized into global thresh-olding and local thresholding. Global thresholding separates an image using a single threshold value, while local thresholding adapts based on the characteristics of smaller sub regions within the image. The choice of threshold value

significantly influences segmentation outcomes and is often determined through visual assessment by the
operator. Threshold selection can rely on various factors, including histogram shape analysis, optimization techniques, class separation criteria, spatial information derived from co-occurrence matrices, and posterior entropy. For more in depth information, numerous research papers detail the development and application of various thresholding methods.

Markov Random Field (MRF) Approach: The Markov Random Field approach as shown in Figure 3 is a probabilistic pixel labelling method for image segmentation. It assigns a feature vector to each pixel in an image, which is then used to label the pixel as part of a specific region. In natural images, regions are often homogeneous, and neighboring pixels typically share similar attributes, such as intensity, colour, or texture.

The MRF approach captures these contextual relati onships effectively.

MRF models typically consist of key components, including a reflection field and a hidden labelling field, which represent the observable data and the segmentation labels, respectively. Additional elements include pixels and their neighbours, cliqu es (subsets of neighbouring pixels), clique potential s (measures of similarity within cliques), an energy function, and the Gibbs distribution. A clique is a subset of pixels where every pair of pixels is a neighbour, allowing for robust modelling of local pixel relationships. This approach has been instrumental in various segmentation tasks and continues to be studied for its ability to integrate contextual information into the segmentation process.

Graph Cut: Graph cut is a powerful and flexible method for image segmentation, particularly for partitioning images based on appearance. It provid es a well defined framework to transform simple, lo calized segmentat

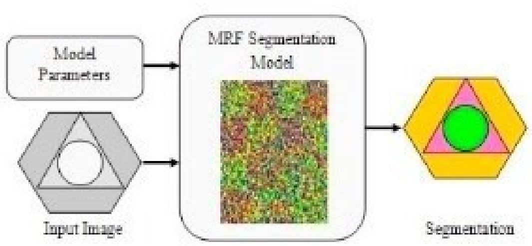

Figure 3: Markov Random Field

cues into a global segmentation result. The advantage of graph cut-based segmentation lies in its ability to utilize both boundary and region inform ation simultaneously, enabling it to achieve an optimal solution for the energy function. This makes it a popular choice for tasks that require precise se gmentation while maintaining computational efficiency.

Appearance Model: In appearance based segmentation methods, a global objective function is used to represent appearance patterns as an adaptable,unknown factor. This function is optimi zed using advanced optimization techniques to improve segmentation accuracy. The approach helps to balance the seg mentation by adjusting the decomposition optimiz ation process, which can also provide lower bounds on the segmentation performance. This technique is often combined with graph cut methods, particularly in medical image segmentation, where it proves effective in refining segmentation boundaries and improving object identification.

Automatic and Semi Automatic Segmentation: Au tomatic segmentation processes rely entirely on algorithms to assign boundaries to regions of interest within an image. However, fully automated techniques can lack the precision required in complex cases. To address this, semi-automatic methods are often preferred, particularly in medical image segmentation. Semi-automatic approaches, such as intelligent scissors,
userguided image segmentation, and fuzzy conn ectedness, allow for user input to refine segmentation results. These methods combine the efficiency of automatic segmentation with the control provided by manual intervention, making them ideal for 3D medical image segmentation tasks that require both region and boundary-based procedures.

Class-Based Segmentation: Class-based segmentation uses pattern recognition techniques to classify feature vectors extracted from images into predefined classes. These classes typically correspond to areas of interest that have been identified through reference segm entations, such as manually annotated data. The features used for classification may include intensity, texture, and other image properties. One common method is the k-nearest neighbors (KNN) classifier, which labels each pixel based on the majority class of its k-nearest neighbors in feature space. Class-based segmentation has been successfully applied to medical image analysis, including pulmonary nodule detection in chest scans, reducing false positives in breast cancer detection, and brain tissue segmentation in MRI scans.

Atlas-Based Segmentation: Atlas-based segmentation is used when there is no clear relationship between the image regions and pixel intensities, making it suitable for segmenting objects with similar structures. This approach is often applied when multiple objects with consistent texture need to be segmented. The key idea behind atlas-based methods is to use spatial relationships between these objects or their morphological features, enabling the algorithm to infer changes between similar objects and segment them effectively. This technique is particularly useful in medical imaging, where organs or tissues of similar structures are analyzed.

4.RECENT SEGMENTATION TECHNIQUES

The field of medical imaging has evolved with the integration of intelligent techniques such as neural networks, artificial intelligence (AI), fuzzy sets, and intuitionistic fuzzy sets to address the inherent unce rtainties in medical images. This section reviews modern segmentation techniques that leverage these intelligent methods, including Active Shape Models, artificial neural network-based segmentation, and AI-driven clustering techniques.

Active Shape Model (ASM): Active Shape Models (ASM) are statistical representations of object shapes that iteratively adjust to fit an object in a new image. These models represent the shape as a set of points controlled by the shape model. The ASM algorithm works by matching the model to the image through an iterative process, allowing it to adapt to variations in the shape of the object within the new image. This method is particularly useful for segmenting complex structures where precise boundary detection is necessary.

Segmentation Using Artificial Intelligence: Artificial intelligence has opened new avenues for image segmentation, addressing challenges that traditional methods struggled to resolve. AI methods aim to partition an input image into non-overlapping regions, each homogeneous in nature, while ensuring that the regions differ significantly from each other. Although a variety of segmentati on algorithms have been developed, evaluating their performance remains challenging, as the effectiveness can vary depending on the type of image and the nature of the segmentation task. Some methods may perform well on a specific image but fall short when applied across diverse image sets. Consequently, there is ongoing techniques tailored to specific organs and pathological tissues, highlighting the unique challenges posed by each. Finally, we discuss potential directions for future advancements in deep learning-based medical image segmentation, aiming to address existing shortcomi ngs and push the boundaries of what is possible in medical image analysis.

CONCLUSIONS

result in inaccurate segmentation outcomes that may not meet the clinical requirements for precise diagnosis and treatment planning.

This review aims to provide a comprehensive analysis of the current methods used in medical image segmentation with deep learning, highlighting the underlying challenges and offering potential solutions. A key issue that requires attention is zero-shot learning, particularly in the context of non-patient related (NPR) data, where insufficient training data

research to develop more generalized algorithms capable of delivering accurate segmentations across different medical images.

Clustering Techniques in Medical Image Segmentation: Clustering methods such as fuzzy c-means (FCM) are widely applied in medical image segmentation. FCM extends the classic k-means clustering by allowing data points to belong to multiple clusters rather than assigning them to a single cluster. This is particularly beneficial for medical images, where boundaries between regions may not be well-defined. The Expectation Maximization (EM) algorithm is often used in clustering, estimating statistical parameters iteratively to improve the model. EM has been applied successfully to Gaussian mixture models (GMM), which combine multiple Gaussian distributions to fit multimodal data, enabling effective segmentation.

Deep Learning in Medical Image Segmentation: Medical image segmentation has witnessed significant progress with the rise of deep learning technologies. Deep learning, particularly deep convolutional neural networks (DCNNs), has become a key research area in medical image processing. These techniques have revolutionized the field by enabling more accurate and efficient segmentation compared to traditional metho ds. DCNNs automatically learn feature representa tions from raw data, eliminating the need for manual feature extraction, which is often complex and prone to errors.

This paper delves into the latest developments in medical image segmentation using deep learning, focusing on its core principles, methodologies, and the challenges faced in its implementation. We review the current state of research, exploring the three main types of segmentation approache semantic segm entation, instance segmentation, and panoptic se gmentationand examine their limitations.Moreove r, we summarize

Despite the significant advancements in medical image segmentation through deep learning in recent years, several challenges remain that hinder its full potential. For instance, segmentation accuracy is often suboptimal, especially when dealing with small datasets and low-resolution medical images. These limitations

and variability in image types complicate segmentation tasks.

Looking forward, the future of medical image se gmentation lies in addressing these challenges through several key areas of innovation. Researchers must focus on enhancing dataset quality and diversity, employing data augmentat ion techniques, and developing more robust models that can perform well with limited data. Additionally, improvements in seg mentation algorithms, such as those that can adapt to new and unseen data, will be critical in advancing the field. With continued progress in deep learning and AI, medical image segmentation will not only become more accurate but also more reliable and clinically applicable, thereby fulfilling the growing needs of healthcare systems and contributing to more effective patient care.

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IOT BASED ENVIRONMENT MONITORING ROBOT

[1]A V Nageswara rao, VFSTR, Vadlamudi, Guntur, AP
[2]BAZANI SHAIK, Ramachandra College of Engineering, Eluru
akowshik424@gmail.com, dr.bazani.sk@gmail.com

ABSTRACT: Air pollution has become a significant public health issue, with growing evidence linking poor air quality to negative effects on human health due to harmful pollutants. Policymakers require accurate and detailed assessments of the disease burden caused by various risk factors to make informed decisions. This project uses India as a case study to examine the state of air quality, focusing on particulate matter. The system employs Internet of Things (IoT) technology, using an Arduino UNO integrated with L293D, DHT11, and a smoke sensor. When sensor readings exceed a predetermined threshold, the Arduino processes the data and transmits it to a mobile device via Wi-Fi. The device is compact, fully automated, and capable of providing real-time alerts on temperature, smoke, and humidity levels.

INDEX TERMS: Internet of Things (IoT), GPS, Security, Real-time Monitoring.

1. INTRODUCTION

Environmental monitoring involves the systematic collection of data on various environmental parameters. It plays a critical role in evaluating the health of natural resources, enabling effective environmental planning, policymaking, and addressing pollution-related challenges [1-4]. However, monitoring in highly polluted or hazardous areas poses significant health risks for human operators. To mitigate these risks, remote monitoring technologies combined with robotic systems equipped with intelligent data acquisition, communication, and processing capabilities offer an innovative solution [5,6].

In recent years, robotic systems have gained prominence as efficient data-gathering tools for scientists. These systems are being designed to operate in environments with harmful gases, monitor climatic changes, and explore remote or hazardous locations that are otherwise risky for humans [7,8]. A noteworthy trend is the integration of wireless sensor networks (WSNs) and IoT-based GPS technology, which provides enhanced understanding of environmental processes. Such systems utilize single-board robots for efficient and scalable monitoring [9,10].

The proposed system is built around IoT (Internet of Things) technology [11-13], which offers significant advantages, including: High

Performance at Low Cost: The system features optimized energy consumption, making it suitable for extended deployments. Efficient Data Processing: High code density and fast interrupt response enhance operational efficiency. Multi-Sensor Compatibility: Adequate General Purpose Input Output (GPIO) and serial communication pins allow integration with multiple sensors.

The system employs sensors to monitor air quality, temperature, humidity, smoke, and vibrations. These sensors periodically collect data to provide real-time environmental insights. Arduino Mega Microcontroller: Central to the system, it facilitates interaction between sensors, robotic navigation, and the IoT platform. Wireless IoT Connectivity: Data is transmitted to the cloud, enabling users to access it through internet-connected devices, such as smartphones or PCs.

The robot autonomously moves to specific locations based on GPS coordinates [14], ensuring effective data collection without human

intervention. User-Friendly Android Application: The system includes an intuitive Android app for robot control and real-time data monitoring. Cloud-Based Visualization: Collected data is visualized graphically in the cloud, providing comprehensive insights for analysis and decision-making [15].

The system is developed using Python and embedded C programming, which optimize sensor communication and control functions. An Arduino Mega board supports navigation and sensor integration, offering robust performance and scalability. The Key Benefits are Safety and Accessibility: Eliminates human exposure to hazardous environments while providing global access to data. Real-Time Monitoring: Enables continuous assessment of environmental conditions for proactive decision-making.

Scalability: Supports deployment in large or multiple areas. Energy Efficiency: Designed to operate on minimal power, ensuring long-term functionality.

This system is versatile, offering solutions in Monitoring air pollution in industrial zones. Assessing post disaster environmental conditio ns. Studying remote ecosystems and climate patterns. Supporting urban planning and public health initiatives with accurate environmental data.

This robotic monitoring system demonstrates a transformative approach to environmental monitoring, leveraging IoT and GPS technologies for efficient, scalable, and safe operation. Its real-time data acquisition and analysis capabilities make it a valuable tool for addressing global environmental challenges.

2. OVERVIEW OF THE APPROACH

Environmental monitoring involves systematically gathering and analysing data on various environmental parameters. This process is essential for assessing the health of natural resources and plays a critical role in environmental planning, policymaking, and addressing pollution challenges [16,17]. However, in regions with extreme pollution or hazardous conditions, manual monitoring poses significant health risks to personnel.

To mitigate these risks, remote monitoring systems [18-20] equipped with robotic technologies have emerged as a revolutionary solution. Such systems integrate intelligent data acquisition, processing, and communication technologies, allowing for efficient and safe environmental monitoring without direct human involvement.

Recent advancements have highlighted the use of robotic systems as effective tools for data collection in diverse and challenging environments. These robots are increasingly being designed and deployed to: Detect harmful gases in industrial or contaminated areas, monitor climatic conditions in remote or inaccessible locations, and Explore hazardous or unknown regions where human access is impractical or unsafe. Robotic systems leverage advanced technologies, such as IoT (Internet of Things), GPS integration, and autonomous navigation, to enhance their capabilities in environmental monitoring. They provide real-time data collection and analysis, enabling proactive decision-making and minimizing risks associated with manual monitoring.

IoT and Sensor Networks in Monitoring: Studies [3] emphasize the role of IoT-enabled systems in collecting and transmitting environmental data in real time. These systems, equipped with wireless sensor networks, are crucial for monitoring parameters like air quality, temperature, and humidity. Robotics in Hazardous Environments: Research by Al-Kuwari et al. (2023) highlights how autonomous robots equipped with GPS and multi-sensor systems can effectively navigate and gather data in areas affected by toxic gases or extreme pollution. Advances in Environmental Robotics [1,2] discuss the application of autonomous robots in environmental conservation, noting their ability to reduce human risk while improving data accuracy. These robots can adapt to challenging terrains and operate continuously for long durations. The integration of robotic systems with cutting-edge technologies represents a transformative approach to environmental monitoring, offering a scalable, efficient, and safe solution for addressing contemporary ecological challenges.

3. PROPOSED APPROACH

The proposed system offers a state-of-the-art solution for weather monitoring, leveraging IoT technology to provide real-time data access across vast areas. In highly polluted regions, manual monitoring poses significant health risks, making the adoption of remote monitoring solutions essential. By integrating advanced robotic systems capable of intelligent data acquisition, processing, and communication, this approach revolutionizes environmental monitoring and protection.

To address the challenges of hazardous monitoring conditions, this system is designed to operate autonomously without human intervention. Robotic systems are increasingly used by scientists for data collection.

particularly in areas with harmful gases, adverse climatic conditions, or remote locations that are too risky for human involvement. Recent

advancements highlight the integration of wireless sensors and IoT-based GPS technologies, enhancing the ability to study environmental processes with greater efficiency and accuracy.

The core of this system relies on single-board robotic platforms specifically engineered for scalability and performance. The integration of IoT (Internet of Things) provides numerous advantages, including cost-effectiveness, high code density, rapid response times, and energy efficiency. Additionally, the system features sufficient GPIO and serial communication pins, enabling seamless connection to multiple sensors.

The key Features are

1.IoT-Driven Accessibility: Real-time environmental data is transmitted to cloud platforms, making it accessible from any internet-enabled device, including smartphones and PCs.
2. Comprehensive Sensor Integration: Equipped with sensors for air quality, temperature, humidity, smoke, and vibration, the system delivers a holistic view of environmental conditions.
3. Energy Efficiency: The low power consumption of the system ensures sustainable and long-term operation.
4. Scalability and Flexibility: Designed to support deployment across various locations, the system is adaptable for large-scale monitoring applications.
5. Autonomous Operation: With IoT and GPS technologies, the robotic system operates autonomously, navigating and collecting data from designated areas.

The system deploys sensors that periodically monitor air quality and other environmental parameters. Users can remotely access and monitor this data via cloud platforms, which offer real-time graphical visualization for analysis. The IoT-based platform ensures reliable communication between the sensors and the robotic system. By integrating modern IoT and robotics technologies, this weather monitoring system reduces human

risks associated with manual monitoring in hazardous areas. It provides a scalable and efficient solution for collecting, analysing, and managing environmental data, making it invaluable for pollution control, climate research, and environmental policymaking.

Block Diagram

The Arduino Uno 2560 is a microcontroller board built around the ATUno2560 microcontroller. It features 54 digital input/output pins, with 14 configurable as PWM outputs, and 16 analog input pins. Additionally, it includes four UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB port, a power jack, an ICSP header, and a reset button. This board is designed to provide all the essential components needed for microcontroller operations. To begin using it, you simply connect it to a computer via USB or power it using an AC-to-DC adapter or a battery.

The system integrates an ESP32-S SoC from Espressif, a versatile and programmable microcontroller unit (MCU) equipped with built-in Wi-Fi and Bluetooth capabilities. This development board, priced affordably at around $7, stands out due to its inclusion of an on-board camera module, Micro SD card slot, and 4MB PSRAM. However, boosting the Wi-Fi signal with an external antenna requires additional soldering modifications. It is worth noting that the board lacks a standard USB port. To upload code, users can utilize an FTDI programmer, an add-on HAT, or pair it with an Arduino Uno using the Arduino IDE or ESP-IDF development tools.

The DHT-11 Digital Temperature and Humidity Sensor is an economical and reliable digital sensor for measuring temperature and humidity. It employs a capacitive humidity sensor and a thermistor to detect environmental conditions, outputting the data as a digital signal via a single data pin. This eliminates the need for analog input pins, making it a practical choice for many projects.

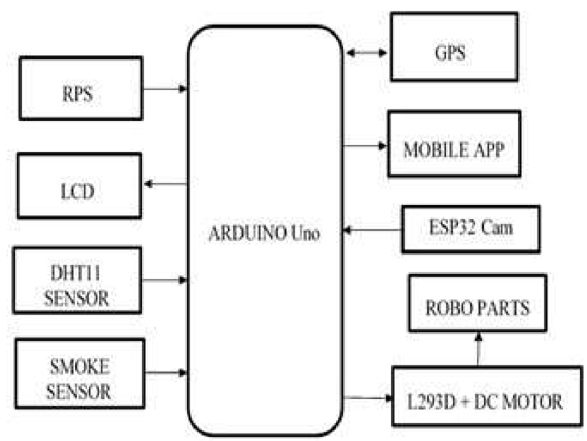


Figure 1: Block Diagram of Proposed method

Smoke Detectors
Smoke detectors are devices that sense smoke, typically as an indicator of fire, and activate an alarm to alert occupants. They are highly effective at detecting smoke from fires even when it originates far from the detector's location. Smoke detectors are especially critical at night, providing life-saving alerts to family members while they sleep. These devices, commonly referred to as smoke alarms in residential settings, can emit either audible or visual warnings. Some systems consist of individual battery-operated units, while others are interconnected networks with battery backups. In an interlinked system, if one detector senses smoke, alarms are triggered across all connected units, ensuring comprehensive coverage even during power outages.

DC Motors

A DC motor is an electric motor powered by direct current (DC). The operation of a DC motor is based on the principles of electromagnetism. When a current flow through a conductor, it generates a magnetic field. If this conductor is placed within an external magnetic field, it experiences a force proportional to the current and the strength of the field.

This force causes the motor to convert electrical energy into mechanical energy, resulting in rotation. Essentially, the motor works on the principle that a current-carrying conductor in a magnetic field will experience a force that moves it, enabling mechanical motion.

Fig 2: L293D Motor Driver IC

The L293D is a widely used 16-pin integrated circuit designed to drive motors. It can control two DC motors simultaneously, with independent direction

control for each motor. This makes it a versatile component for projects that require motor control. The IC supports motors with operating voltages under 36V and currents below 600mA, making it ideal for use in digital circuit-driven applications.

Liquid-Crystal Displays (LCDs)

An LCD, or liquid-crystal display, is a type of flat-panel display that uses liquid crystals combined with polarizers to create images. Unlike technologies that emit light directly, LCDs rely on a backlight or reflector to produce images in either color or monochrome. These displays are widely used in various devices due to their thin design, energy efficiency, and clear visual output.

Arduino IDE

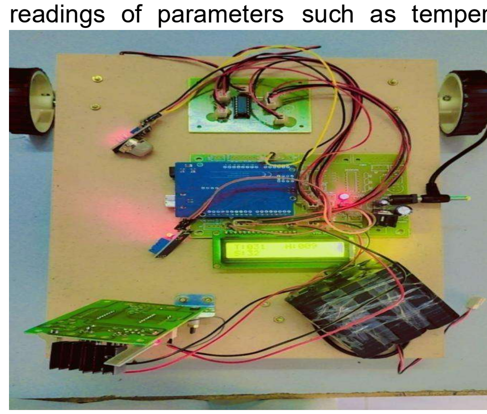
The Arduino Integrated Development Environment (IDE) is a user-friendly platform designed for programming Arduino microcontrollers. It includes a text editor for writing code, a message area for notifications, a text console for error logs, and a toolbar with commonly used functions. The IDE is based on the C and C++ programming languages but incorporates modifications to simplify coding for Arduino projects. It performs pre-processing of code to reduce errors, making it accessible for beginners while retaining the capabilities needed for complex projects.

4. RESULTS AND DISCUSSION

The figure 2 shows the complete prototyping of IOT based GPS controlled environment monitoring robot and navigation.

The prototype demonstrates its efficiency in collecting environmental data from remote locations, either operating independently or as part of a network of robots. Compared to other existing methods, the proposed system is highly cost-effective, requiring fewer hardware components. The robot effectively gathers and uploads environmental data to an IoT platform server, with a minimal data update interval of just 15 seconds.

The data collected by the sensors, including measurements from temperature, humidity, and smoke sensors, is stored on the IoT platform. This data can then be visualized and analyzed for a better understanding of environmental parameters. The system also includes an LCD screen that displays real-time readings of parameters such as temperature,

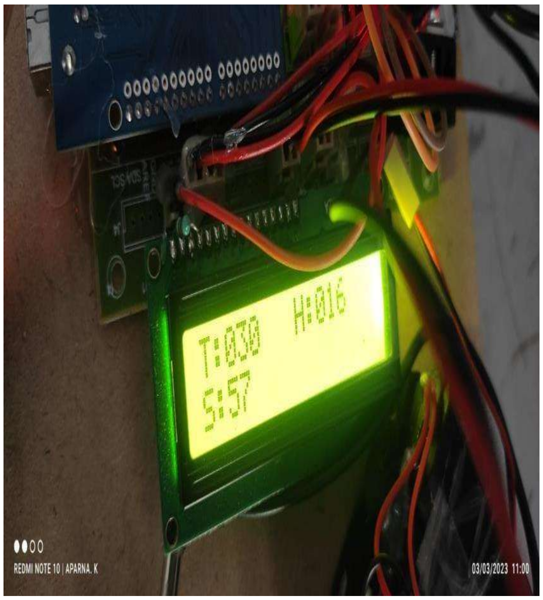


humidity, and smoke levels as shown in figure 3.

Additionally, the autonomous robot can be manually controlled using directional commands forward, backward, left, and right via an HTML interface. This interface allows users to monitor and manage the robot's movements while observing the collected data in real time.

The proposed system offers a cutting-edge solution for weather monitoring, leveraging IoT technology to provide real-time data that can be accessed over a wide range. Unlike traditional weather monitoring tools, which tend to be bulky and difficult to transport, this system is designed to be compact and lightweight, making it easy to install in various locations, such as rooftops. This portability also makes the system ideal for deployment in remote areas where traditional

Figure3: Displaying values on the LCD weather stations may not be easily accessible with an ESP32 camera as shown in figure 4.



The system is specifically designed to monitor key weather parameters, including temperature, humidity, and smoke levels. These measurements are crucial for understanding climate patterns and detecting environmental hazards, such as smoke from wildfires or industrial pollution. By integrating these sensors into a small, efficient unit, we can ensure continuous, real-time monitoring without the need for large, stationary infrastructure.

One of the unique features of this system is its ability to be transported and deployed in unconventional ways. For example, its small size and lightweight design allow it to be carried by a weather balloon to measure atmospheric conditions at high altitudes. This capability makes it an excellent tool for gathering data on weather patterns at different elevations, which is critical for studying changes in atmospheric pressure, temperature, and humidity at various heights.

Overall, this weather monitoring system combines portability, ease of use, and advanced technology, providing a flexible solution for monitoring weather and climate changes across diverse environments. The integration of IoT allows for seamless data collection and real-time analysis, making it an ideal tool for both local and remote environmental monitoring.

Figure 4: Output of the ESP32 Cam

ADVANTAGES

1. It detects the toxic and explore gases.

2. It identifies the gas leaks.

3. Using the ESP32 cam we can observe the surroundings

4. Simple and easy implementations

5. It reduces the efficiency of the cost.

LIMITATIONS

1. Hotspot connection may be lost or it may be connected to some other devices.

2. Sometimes it may lag the pixels of ESP32 Cam.

APPLICATIONS

1. Home environments
2. Weather Stations
3. Cold storages
4. Industries
5. Fire accidents
6. Public and private buildings
7. Detection of harmful gases

CONCLUSIONS

This paper presents the design and implementation of a GPS-controlled robot for monitoring environmental parameters, integrated with an IoT platform. The system is built on an ARM-based embedded architecture, enabling compact and cost-effective real-time environmental monitoring, with a focus on air quality measurement. The results demonstrate the system's effectiveness in tracking environmental conditions, providing valuable data for continuous observation.

The developed mobile application allows users to easily control and navigate the robot, enhancing the system's usability. The GPS functionality enables the robot to autonomously travel to remote locations, where it collects data and uploads it to the IoT server. Additionally, the collected data is displayed on a web interface, facilitating high-level data analysis and processing. Graphical visualizations of the data confirm the system's efficiency in real-time monitoring, highlighting the robot's capability to function autonomously and deliver accurate environmental data for further analysis.

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ADVANCE SURVEILLANCE DRONE "THE SKY-WATCHER"

[1]M MOHAN SRI KRISHNA ,[2]SHABBIR KHAN ,[3]SHAIK BAJIVALI ,[4]BATRAJU VAMSIKRISHNA
[1,2,3,4] Seshadri Rao Gudlavalleru Engineering College, India
mohankrishna6073@gmail.com , Sk20411ec055@gmail.com, bajivali0424@gmail.com,
bhatrajuvamsikrishna@gmail.com

ABSTRACT: This paper presents an analysis of surveillance drones equipped with advanced detection and monitoring capabilities using deep learning-based object detection models. The study focuses on drones with high-resolution cameras 8MP and 720p resolution, such as the Dj Tello Nano Drone, capturing high-definition images processed by computer vision algorithms to detect and track objects like vehicles, pedestrians, and wildlife in real-time. The models used for object detection are YOLOv5 and Faster R-CNN, trained on a custom dataset of 3,000 images from various lighting conditions. YOLOv5 achieves 89.12% accuracy, while Faster R-CNN achieves 84.57%. The drones are integrated with a cloud-based server for continuous data processing, enhancing surveillance capabilities. The paper also discusses ethical and regulatory issues, including privacy and data security, demonstrating the potential of drones for efficient and scalable surveillance applications in security, search and rescue, and traffic monitoring.

KEYWORDS: Surveillance drones, Deep learning, Object detection, YOLOv5, High-resolution cameras Real-time tracking, Cloud-based server, Security, Search and rescue

1. INTRODUCTION

Advanced surveillance drones represent a signifi cant leap forward in the field of unmanned aerial vehicles (UAVs). These drones combine state-of-the-art technology with the flexibility of aerial mobility, enhancing their ability to monitor, secu re, and gather intelligence in both military and ci vilian contexts. Equipped with sophisticated sen sors, cameras, and communication systems, the y are capable of performing a wide variety of sur veillance functions.

Key Features Of Advanced Surveillance Drones

1. High-Resolution Imaging

Modern drones feature high-definition cameras with additional capabilities like thermal imaging and infrared. This allows them to capture clear visuals from significant distances, even in low-light or nighttime conditions.

2. Advanced Sensors And Tracking

Equipped with cutting-edge sensors such as LiDAR (Light Detection and Ranging), radar, and environmental sensors, these drones can detect objects, monitor movements, and gather valuable data about temperature, humidity, and even atmospheric conditions.

3. Autonomous Flight Capabilities

Many surveillance drones are powered by AI and machine learning, enabling them to operate autonomously. These systems facilitate real-time decision making, recognizing objects, and adapti ng to changes in their environment without hum an input.

4. Extended Endurance and Range

These drones are engineered for long-duration flights, lasting from several hours to multiple days depending on their design. This allows them to conduct continuous surveillance over vast areas without the need for frequent recharging or operator intervention.

5. Stealth And Concealed Design

For sensitive operations, especially in military or tactical scenarios, many drones are designed to be stealthy. With features like quiet motors, camouflage, and compact structures, they can avoid detection while collecting valuable data.

6. Real-Time Data Transmission

Equipped with advanced communication system s, these drones can transmit video, images, and sensor data to a central command unit in real time, ensuring that operators have the most current information available for immediate decision-making.

7. Precise Navigation Systems

With sophisticated GPS and navigation technology, surveillance drones can follow predetermined flight paths, track specific targets, and return to base automatically when needed, ensuring mission success.

Applications Of Advanced Surveillance Drones

1. Military And Defense

Surveillance drones play a crucial role in reconnaissance, offering critical battlefield intelligence, tracking enemy movements, and delivering real time data to military personnel for strategic decision-making.

2. Border Security And Law Enforcement

Drones are increasingly used to monitor borders and detect illegal activities such as trafficking and smuggling. They offer efficient, wide area coverage that traditional methods of surveillance cannot match.

3. Search And Rescue

Drones are essential in emergency response scenarios, such as search and rescue missions in challenging terrains like mountains, forests, or disaster zones. They help locate victims and deliver essential supplies, often in conditions too dangerous for human responders.

4. Environmental Surveillance

These drones are valuable tools for monitoring wildlife, tracking deforestation, studying the impact of climate change,and assessing environmental hazards like pollution and natural disasters.

5. Agriculture

In agriculture, drones are used to monitor crop health, detect early signs of pests or disease, and assess soil conditions, helping farmers make data-driven decisions that improve crop yield and resource management.

6. Infrastructure Monitoring

Surveillance drones also help in inspecting and safeguarding critical infrastructure like power lines, oil pipelines, and communication towers. Their ability to access difficult-to-reach areas makes them ideal for routine inspections and spotting potential hazards.

Challenges and Future Trends

1. Regulation and Airspace Management

As drone usage increases, managing the airspace to prevent collisions with manned aircraft and ensuring safe operations becomes more complex. Governments are working on evolving regulations to accommodate this rapidly growing field.

2. Privacy Issues

With drones capable of monitoring vast areas, privacy concerns have risen, especially in urban environments. Striking a balance between the benefits of surveillance and the protection of individual privacy remains a significant challenge.

3. Battery Life and Operational Range

Although drone battery technology is improving, many drones still face limitations in terms of flight time and range. Ongoing research is focused on developing more efficient energy sources, such as hybrid engines and solar power, to extend operational durations.

4. Advances in AI and Automation

The role of AI in drone operations is expected to continue growing. Future drones will likely possess even greater autonomy, making real-time decisions and analyzing data without human oversight, enabling them to perform increasingly complex surveillance tasks.

2. PROPOSED APPROACH

The book "Unmanned Aerial Vehicles: Applications and Advancements" by Zeng and Zhang (2020) provides a comprehensive overview of the various applications and technological advancements related to Unmanned Aerial Vehicles (UAVs). This resource is valuable for understanding the current state of UAV technology and its broad spectrum of uses, especially in the context of surveillance [1].

The integration of deep learning and computer vision technologies, such as YOLOv5 and R-CNN models, has significantly enhanced drones' object detection capabilities, enabling real-time tracking of vehicles, pedestrians, and animals

[2], [3]. Additionally, cloud-based servers facilitate continuous data processing and storage, supporting real-time decision-making and analysis [4].

Recent advancements highlight the use of artificial intelligence (AI) for autonomous UAV operations. AI-driven surveillance drones now incorporate algorith ms like YOLOv5, which offer highspeed and accurat e detection, and Faster R-CNN, which is better suited for precision tasks [5], [6]. The incorporation of advanced sensors, including thermal imaging and LiDAR, has further enhanced UAV efficiency in diverse environments [7].

Moreover, the book explores how AI integration has transformed UAVs into intelligent systems capable of autonomous decision-making and real-time data processing [1], [8]. These advancements have open ed up numerous applications in traffic monitoring, disaster response, infrastructure inspection, and environmental analysis [9]. The development of multi-drone swarming technologies has expanded UAV capabilities for large-area surveillance [10].

Algorithm for Object Detection Workflow

Input:

High-resolution video frames captured by the surveillance drone's camera. Pre-trained deep learning models: YOLOv5 and Faster R-CNN. Cloud-based server for additional data processing.

Preprocessing:

Convert video frames into individual images. Resize images to the input dimensions required by the models (e.g., 640x640 pixels for YOLOv5). Apply normalization and data augmentation (e.g., rotation, scaling) for robustness.

Detection and Tracking:

Step 1: Load the YOLOv5 model. Perform object detection on each frame using YOLOv5 for real-time detection. Identify bounding boxes, class labels, and confidence scores.

Step 2: If additional precision is needed, pass the detected bounding boxes to Faster R-CNN. Use Faster R-CNN for refined detection and classification of complex or overlapping objects.

Postprocessing:

Filter results based on confidence threshold (e.g., 0.5). Remove duplicate detections using Non-Maximum Suppression (NMS).

Alert Mechanism:

Trigger a buzzer or send notifications if objects of interest (e.g., unknown individuals, vehicles) are detected.

Output:

Real-time bounding boxes and labels displayed on the drone's feed. Data is transmitted to the cloud server for further analysis.

Flow Chart

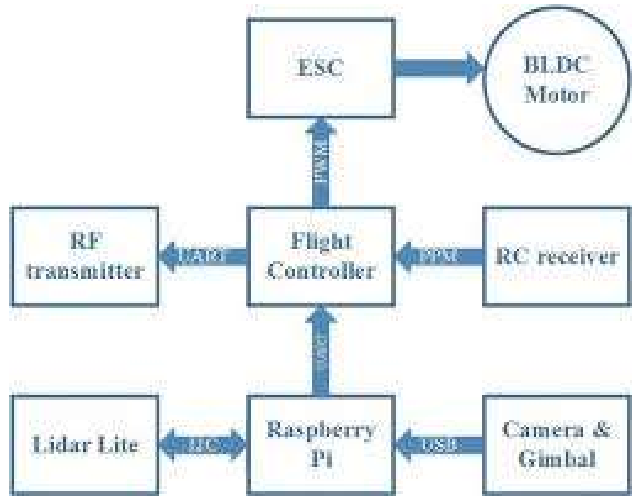

Fig: Flowchart for implementing Project

EXISTING DRONES

1. DJI Matrice 300 RTK

- Use Case: Industrial, Commercial, La w Enforcement, Environmental Monit oring
- Camera Options: Can support multiple camera payloads such as the Zenmu se H20 series, offering high-resolution optical and thermal cameras.
- Flight Time: Up to 55 minutes (depen ding on payload).
- Range: 15 km (9.3 miles) with OcuSync 2.0.
- Sensors: RTK for precise georeferen cing, thermal sensors, LiDAR payload s, and high-definition optical cameras.
- Autonomy: Capable of autonomous flight with AI based tracking and missi on planning.
- Features:
- High endurance and excellent data accuracy with RTK(Real Time Kinem atic) technology.
- Advanced obstacle avoidance system with 6-directional sensors.
- IP45-rated, weather-resistant.

- Suitable for law enforcement, search and rescue, and inspection tasks.

2. Parrot Anafi USA

- Use Case: Law Enforcement, Military, Inspection, Surveillance
- Camera Options: 32x zoom camera, 4K HDR camera, and thermal camera (FLIR) for night operations.
- Flight Time: 32 minutes.
- Range: 4 km (2.5 miles).
- Sensors: Includes thermal, visual, and 4K cameras, with real-time data processing capabilities.
- Autonomy: Uses AI for intelligent flight modes, automated subject tracking, and obstacle avoidance.
- Features:
- Lightweight and portable (weighing 500g).
- Secure communications with AES-256 encryption.
- High-definition video feed with low latency.
- Designed for tactical operations, law enforcement, and military application

3. Sensefly Ebee X

- Use Case: Surveying, Mapping, Environmental Monitoring, Agriculture
- Camera Options: Compatible with a variety of payloads, including the S.O.D.A. 3D camera, thermal camera, and multispectral sensors.
- Flight Time: Up to 90 minutes (depending on configuration).
- Range: Up to 100 km (62 miles) with optional data links.
- Sensors: Thermal, multispectral, LiDAR, and high-resolution cameras for mapping and surveying.
- Autonomy: Fully autonomous with mission planning software and RTK/PPK for precise georeferencing.
- Features:
- High endurance and large area cover age, ideal for large scale land survey s and environmental monitoring.
- Compact and easy to transport, ideal for remote areas.
- Ideal for agriculture, land manageme nt, and industrial inspections.

4. Autel Robotics EVO II Dual

- Use Case: Search and Rescue, Security, Inspection, Commercial Use
- Camera Options: Dual-camera system with a 48 MP optical camera and a FLIR thermal camera.
- Flight Time: Up to 40 minutes.
- Range: 9 km (5.6 miles) with 4K video transmission.
- Sensors: Includes optical and thermal cameras, GPS, and obstacle avoidan ce sensors.
- Autonomy: Advanced autonomous fli ght modes including automated tracki ng, waypoints, and terrain-following.
- Features:
- High-resolution imaging with both visible and thermal cameras.
- Compact design, suitable for both urban and rural environments.
- Equipped with AI-based tracking, smart flight modes, and obstacle avoidance.
- Suitable for search and rescue, secur ity, and inspection missions.

5. Lockheed Martin Indago 360

- Use Case: Military, Tactical, Search and Rescue, Emergency Response
- Camera Options: Includes both high-definition optical and thermal camera s, and multi-spectral cameras for military and tactical operations.
- Flight Time: Up to 45 minutes.
- Range: 8 km (5 miles).
- Sensors: Dual-sensor payloads (optical/thermal), GPS/INS for precisi on navigation.
- Autonomy: Fully autonomous with advanced flight planning and monitori ng capabilities.

6. Features:

- Compact, rugged design for deploym ent in harsh environments.

- Vertical take-off and landing (VTOL) capability for use in tight spaces or confined areas.
- Designed for defense, tactical surveill ance, and emergency response missions.

7. Aeryon SkyRanger R70

- Use Case: Military, Tactical, Service s, Critical Infrastructure
- Camera Options: High-definition visible and thermal cameras, including the ability to swap payloads (e.g., multispectral, LiDAR).
- Flight Time: Up to 50 minutes.
- Range: 10 km (6.2 miles).
- Sensors: Multi-payload options with advanced optics, thermal imaging, and LiDAR capabilities.
- Autonomy: Supports real-time tactical intelligence with AI for target identification and object tracking.
- Features:
- Compact and rugged, built for military and emergency response use.
- Multi-sensor integration for accurate and real-time intelligence.
- Fast deployment, high durability, and high-quality imaging for surveillance and monitoring.
- Key Features:
  1. Real-time decision-making based on sensor inputs for efficient water management.
  2. Can handle multi-class problems (e.g., activating roof, irrigation pump, or both).
  3. Simple and interpretable decision-making process, ensuring reliabili ty in automated crop protection.

Results

Fig: Monitoring surroundings by DjTellopy Nano

Fig: No suspicious actions are captured

CONCLUSION

Advanced surveillance drones have revolutionized the way monitoring, security, and data collection are performed across various sectors, including military, law enforcement, environmental monitoring, and commercial applications. These drones combine cutting-edge technologies such as high-resolution cameras (including thermal and multispectral), AI-driven autonomy, and advanced sensors (RTK, LiDAR) to provide efficient, accurate, and real-time surveillance.

From the high endurance and precise georeferencing of the DJI Matrice 300 RTK to the tactical capabilities of the Parrot Anafi USA and the rugged versatility of the Aeryon SkyRanger R70, each model is tailored to specific operational needs. Drones like the SenseFly eBee X excel in large scale surveying and environm ental monitoring, while the Autel EVO II Dual stands out in search and rescue operations with its dual-camera system.

As drone technology continues to evolve, these advanced surveillance systems are expected to become even more capable, offering longer flight times, enhanced AI features, and increased integration with other technologies. However, challenges like regulatory issues, privacy concerns, and battery limitations remain, requiring ongoing innovation and thoughtful implementation.
Ultimately, advanced surveillance drones are proving indispensable for both public safety and industrial applications, providing operators with the ability to monitor vast areas, gather critical data, and respond to emergencies more effectively than ever before.

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VET-CONNECT

[1]Shaik Bajivali, [2]Angalakuduru Venkata Sai, [3]Madapati Mohana Chandrika, [4]Katta Lakshmi Kameswara Rao,
mohanachandrika55@gmail.com,bajivali0424@gmail.com,vsai4558@gmail.com kameswararaokatta@gmail.com
[1,2,3,4] Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru

ABSTRACT: The uncontrolled spread of diseases among stray dogs, particularly in rural areas, poses a significant public health threat. Traditional methods such as periodic vaccinations and drastic municipal measures like culling have been ineffective in curbing the problem. Stray dogs often go unmonitored, allowing infections to spread unnoticed. The lack of a systematic, real-time method to detect and track infected dogs exacerbates the issue, making it harder to intervene and prevent the transmission of diseases to both animals and humans.

In response to this challenge, the proposed solution, Vet Connect, employs a range of hardware and software components to identify and monitor infected dogs. The system utilizes a camera network installed at strategic locations to capture images of stray dogs. These images are processed using TensorFlow for image recognition and OpenCV (Cv2) for video processing. For data storage and communication, Firebase_Admin is used, while PIL handles image manipulation. GeoPy Geocoders is integrated to determine the precise locations of infected dogs, and the Requests library is utilized for seamless data transfer between different system components, ensuring smooth interaction between devices and databases.

The expected outcome of Vet Connect is the early and efficient detection of diseases among stray dogs, improving animal health and reducing the transmission of infections to humans and other animals. By automating the identification and reporting processes, Vet Connect allows veterinary professionals to act quickly, providing timely medical interventions such as vaccinations. The real-time data transmission ensures that infected dogs are swiftly identified, located, and treated, ultimately helping curb the spread of diseases and promoting better welfare for stray animals, enhancing public health safety in rural communities.

KEYWORDS: Public Health Risk, Stray Dogs, Disease Control, Veterinary Intervention, Image Recognition, Real-Time Data, Location Tracking, TensorFlow, OpenCV, Firebase, GeoPy, PIL, Automated Detection, Animal Welfare, Disease Prevention, Rural Areas, Infection Spread Control, Camera System, Veterinary Hospitals, Health Safety.

1.INTRODUCTION

The unchecked spread of infectious disease s amongst stray puppies, particularly in rural regions, poses a giant public fitness hazard, impacting both human and animal populatio ns. Traditional approaches, including period ic vaccinations and municipal culling, have struggled to effectively manage this issue, l eaving many animals unmonitored and untr eated. In response, Vet Connect offers a pro active solution by using digicam systems st rategically located to capture photos of stra y puppies and discover symptoms of conta mination. This revolutionary machine leverages real time information pr ocessing to perceive,music, and report infe cted animals to nearby veterinary hospitals, permitting well timed scientific intervention.

Through an integration of superior technolo gy, together with TensorFlow for picture ev aluation, OpenCV for video processing, Fire base for records garage, and GeoPy for pla ce monitoring, Vet Connect guarantees rapi d, computerized detection of potential sickn ess carriers. This technique not best compl ements ailment management andanimal wel fare but additionally contributes to more se cure, healthier communities by curtailing th e spread of infections from animals to peop le. By streamlining the identification and re

porting manner, Vet Connect empowers vet erinary specialists with the equipment wish ed for well-timed and powerful sickness management in rural and concrete regions alike.

2. LITERATURE REVIEW

The issue of disease transmission among stray animals, particularly dogs, has long been recognized as a significant public health and welfare challenge. Research shows that stray animals can act as vectors for zoonotic diseas es, such as rabies, leptospirosis, and parasitic infections, which can transfer to humans and other animals (Gibson et al., 2021). Traditional management methods, including periodic vacci nation drives and, in severe cases, population culling, have demonstrated only limited effectiv eness due to logistical challenges and inadequ ate monitoring systems in rural areas (WHO, 2019).

Advances in technology have introduced new opportunities to enhance disease monitoring and control in animal populations. Machine learning, image recognition, and IoT technologi es have become increasingly valuable in public health and veterinary medicine. Studies highlig ht the potential of TensorFlow in accurately identifying animal health conditions through image analysis (Smith & Jones, 2022), while OpenCV has proven effective in real-time video processing for motion detection and behavioral analysis in stray animals (Li et al., 2020). These technologies, coupled with Firebase for data storage and GeoPy for location tracking, allow for comprehensive, scalable solutions in animal health management (Patel et al., 2023).

Emerging automated systems that combine data-driven insights with real-time alerts are essential for effective disease control, especiall y in remote regions lacking access to timely veterinary intervention (Kumar & Singh, 2023). Solutions like Vet Connect build upon this body of work, proposing an integrated system that not only monitors but also facilitates immediate reporting of potential disease cases. By automating both detection and response, Vet Connect provides a framework for improved disease prevention, offering a new model for health and safety in stray animal populations.

Through this literature, Vet Connect demonstra tes a synthesis of proven methods and novel technological integration, positioning it as an effective solution to address the gap in rural and urban stray disease management, and enhanci ng public health outcomes through preventive intervention.

3. METHODOLOGY

The *Vet Connect* project employs a multi-step, technology-driven methodology to detect, track, and report disease symptoms among stray dogs in real-time. This methodology integrates a combination of hardware and software comp onents, focusing on capturing and processing image data, analyzing potential health risks, and enabling swift reporting to nearby veterinary facilities. Data Capture and Image Processing

- Disease Detection via Machine Learning
- Location Tracking and Data Storage
- Real-Time Alerts and Communication
- System Integration and Testing
- Evaluation and Continuous Improvement

Data Capture and Image Processing:

Appropriate camera locations are selected in areas where stray dogs are most active. These cameras record video in real-time and capture images of stray dogs from time to time. OpenCV is used to monitor and detect the motion of the video feed, which then triggers an image capture system for further analysis.

Disease Detection via Machine Learning:

Using TensorFlow, a convolutional neural network (CNN) model is trained that predicts potential disease symptoms in stray dogs, such as bruises, lameness, and other visible or previously trained abnormalities the example is on a labeled dataset of dog symptoms

Location Tracking and Data Storage:

When a possible infection is detected, GeoPy is used to pinpoint the exact location of the dog. The system integrates GPS tracks with the narrative indicated to ensure accurate tracking. This information, along with the processed image data, is stored in Firebase for easy access and retrieval. Firebase acts as a central repository for all data collected, allowing authorized users to monitor and analyze the breadth of potential health risks over time

Real-Time Alerts and Communication:

Vet Connect uses the Firebase_Admin library and Requests to propagate data between system components and notify nearby veterina ry clinics. When a potentially infectious case is detected, an automatic alert is issued, providing veterinary personnel with vital information, including the dog's location, symptoms, and time of presentation That quick capability can intervene in time, improving the chances of controlling the spread of the disease.

System Integration and Testing:

The entire system is tested in a controlled environment to ensure accuracy and reliability in symptom detection and data processing. Experiments are conducted to verify the validity of the model, verify real-time processing capabilities, and evaluate the performance of the alert system. Field tests are also used to verify system performance under real-world conditions, reducing any discrepancies in disease detection, location accuracy, or alert time

Evaluation and Continuous Improvement:

Vet Connect evaluates continuously, including writing performance metrics to measure the accuracy of diagnosis, time to action, and rate of successful intervention Based on feedback from veterinarians and monitoring programs so to raise, the models are regularly retrained and updated to new or evolving health risks to increase accuracy in larger populations of stray dogs.

Hardware Components:

Raspberry Pi:

Figure 1: Raspberry pi

The Raspberry Pi is a small, affordable, single-board computer with multiple I/O options, making it ideal for projects that require both computing power and connectivity. Key features include:

- Processor: Recent models (like Raspberry Pi 4) come with a quad-core ARM Cortex-A72 processor, providing sufficient power for running machine learning models and real-time image processing tasks.
- Memory: Configurable memory options up to 8GB, which support complex computations and multi-threaded tasks.
- Connectivity: Equipped with Wi-Fi, Bluetooth, and USB ports, allowing easy integration with peripherals and cloud platforms (such as Firebase) for data storage and communication.
- GPIO Pins: General purpose input/out put (GPIO) pins allow the Raspberry Pi to connect with various sensors (such as GPS modules, relay modules, etc.), expanding its functionality in IoT projects.

Camara:

Figure 2: Camara

- Image Quality: The standard Camera Module V2 has an 8-megapixel sensor, while the High-Quality Camera offers 12.3 megapixels, allowing for sharp, clear images essential for accurate detection in AI applications.
- Video and Image Processing: Capable of capturing 1080p video at 30 frames per second, the camera module can support both real-time monitoring and recording, suitable for projects requiring continuous surveillance.
- Low-Light Performance: The camera module is designed to work well in various lighting conditions, and the High-Quality Camera version can be paired with lenses for enhanced performance, even in low light.

Software Libraries and Tools: OpenCV (cv2):

Built-in OpenCV for real-time image and video processing. It captures
images from the camera, detects movement, and allows the Raspberry Pi to process images and analyze them for signs of infection.

TensorFlow:
TensorFlow is used for machine learning model s responsible for detecting disease symptoms in stray dogs. For best performance, images are loaded with TensorFlow Lite, as it is optimized for edge devices like the Raspberry Pi.

Firebase Admin SDK:
Firebase is used for real-time data
storage and communication. The Firebase Ad min SDK enables the Raspberry Pi to store im ages, metadata, and location information in Fir ebase's cloud database.

GeoPy:
GeoPy enables the system to convert GPS coordinates into a readable address
format. It is important for veterinary clinics to indicate where they are known to have been infected.

Pillow (PIL):
The Python Imaging Library (PIL), accessed vi a the Pillow package, is used for image manipu lation and preprocessing, such as resizing or a djusting brightness and contrast.

Requests:
The request library facilitates communication between software components and generates HTTP requests to Firebase or other web services

Block Diagram:

Figure 3: Block Diagram

User Interface Usability:

The success of the Vet Connect system depends not only on its technical capabilities but also on its user interface (UI), which must be intuitive, functional, and efficient The UI is a key tool for veterinary professionals, local authoritie s and field personnel contact system builds

I. Overview of the dashboard

A key point of communication for veterinary professionals is the dashboard, which provides detailed information on the status of known stray dogs. The dashboard contains the following items.

- Known Dog Name: Text for pertinent information such as dog identification, health status (e.g., infected, healthy), and last known location.
- Realtime map integration:An embedde d map (e.g., Google Maps or paper) shows the locations of known dogs, with icons indicating whether they are infected or healthy. This location representation allows users to analyze conditions throughout the area.
- Alert notifications: The UI includes a notification panel to display real-time alerts when a new infection is detected or a serious health problem arises.
- Actionable Buttons: Veterinarians can take immediate actions such as "Request Medical Intervention" or "Send Patrol" using clearly identified buttons next to each entry.

The chart is designed for clarity, with color-coded labels (e.g., red for infection, green for healthy) and easy search and search for quick reference

II. Detailed Dog Profile Page

Each detected dog has a Profile Page containing detailed information. Upon clicking a dog entry in the dashboard, users are directed to this page, which includes:

- **Dog ID**: A unique identifier for each detected dog.
- **Health Status**: Information on whether the dog is infected, under observation, or has received medical attention.
- **Location and Time**: The precise location and time of detection, including a visual representation of the location on a map.
- **Image Capture**: A snapshot of the dog captured from the camera, providing visual confirmation of the detection.
- **Action Options**: Buttons for medical intervention, scheduling vaccinations, or contacting authorities.

This profile page ensures that veterinary professionals can quickly assess the status of each dog and make informed decisions.

III. Real-Time Map Tracking

A critical component of Vet Connect is Real-Time Map Tracking, which allows users to visualize the locations of infected stray dogs. This feature is integrated into the dashboard and includes:

- **Interactive Map**: The map displays markers representing the last known locations of infected dogs. Red markers indicate high-priority cases, such as infected animals, while green markers represent healthy animals.
- **Zoom and Navigation**: Users can zoom in and out of the map, navigate to different areas, and access more granular location data by clicking on individual markers.
- **Geolocation**: The system integrates GPS coordinates to ensure precise mapping of the dog's location, aiding in rapid response and intervention.

IV. Alert System

To facilitate timely intervention, the Vet Connect UI features an Alert System that notifies users of critical situations. The alert system includes:

Real-Time Notifications: Flashing alerts appear at the top of the interface when new infections are detected or when high-risk situations are identified. This ensures that users can take immediate action.

Actionable Alerts: Each alert is accompanied by action buttons, such as “Send Medical Team” or “Schedule Follow-Up,” to allow users to respond directly from the notification. This system helps prioritize cases and ensures that infected dogs receive prompt attention.

V. Admin Panel and Configuration

An Admin Panel is provided for system configuration and management. It allows system administrators to:

- **Camera Setup**: Add and configure new cameras for real time video surveillanc e.
- **Notification Settings**: Customize alert triggers and notification preferences.
- **Database Management**: View, update, or delete dog data from the system as necessary.

This panel ensures that system settings can be easily configured and maintained.

VI. Mobile Interface for Field Workers

Vet Connect is designed to be adaptable to different user needs. For field workers and mobile veterinary teams, a mobile-friendly version of the UI provides:

- Push Notifications for alerts on detecte d infected dogs.
- Real-Time Location Tracking to help field teams locate and assist infected dogs on-site.
- Actionable Buttons for administering vaccines, scheduling appointments, or alerting local authorities.

VII. Usability Principles

The overall design of Vet Connect adheres to core usability principles to ensure effectiveness:

- **Simplicity**: The interface is designed with minimal clutter, presenting only the most essential information to users.
- **Consistency**: Visual consistency across all UI components ensures ease of navigation and familiarity for users.
- **Responsiveness**: The system is opti mized for both desktop and mobile platforms, providing a seamless experi ence on different devices.

- **User Feedback**: Clear feedback is provided for every user action, such as confirming data submission or alert creation.

CONCLUSION

The Vet Connect project represents a significa nt breakthrough in monitoring and managing the health of stray dogs, particularly in rural areas, where traditional methods have proven ineffect ive against widespread diseases Vet Connect uses advanced technology to reside such as TensorFlow for image search, OpenCV for video processing, GeoPy for location tracking

The combination of real-time tracking, location control, and alert systems ensures rapid detect ion and location of infected animals to facilitate timely intervention by veterinary personnel If intervention in a timely manner with Vet Conne ct reduces human error and ensures immediate attention to high-risk animals

Vet Connect's user interface is designed with usability in mind, ensuring that veterinarians, local authorities, and field staff can access the information they need correctly and take imme diate action when needed Dashboards, real-time maps, and alert systems allow for rapid decision-making, while mobile's interface ensures that teams in the field have the tools they need to respond effectively

The anticipated outcome of Vet Connect is to reduce the spread of infectious diseases among stray dogs, resulting in healthier animal populat ions and increasing public health protection Through identification and the automation of reporting, the system can lead to timely vaccin ation, medical intervention, and overall improve ment of support

In conclusion, Vet Connect not only addresses a crucial public fitness issue but also exemplifi es how the era may be harnessed to improve the lives of animals and the protection of group s. Through its innovative use of IoT, AI, and real-time communique, Vet Connect paves the way for extra efficient and powerful disorder manag ement in rural regions, making sure a sustaina ble and more healthy destiny for animals and people alike.

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Smart Aqua Control System for Prawn Farming In Coastal Andhra Pradesh

[1]T Kaliraja, [2]B V Sravya, [3]A Vanitha, [4]B Mounika, [5]G Deepthi, [6]V Ganesh Reddy
[1,2,3,4,5,6] Sri Venkateswara College of Engineering, Tirupati.
kaliraja.t@svcolleges.edu.in, sravyabv29@gmail.com,vanithaanipireddy@gmail.com, mounikab244@gmail.com, ganeshveeraballi@gmail.com

ABSTRACT: World must give food to all people every day. Food production is an important occupation of mankind. Aquaculture is an enterprise to cultivate prawns in artificial water pond farms. The aquaculture industry faces significant challenges related to water quality management and operational efficiency. This article presents the design and implementation of a smart aqua control system based on the ESP32 microcontroller, aimed at automating water quality monitoring and enhancing management practices. By integrating sensors to measure critical parameters such as temperature, pH and water level, the system provides real-time data access through a mobile applications and controls the actuators for quality of water, availability of water and its temperature maintenance. The proposed solution not only improves response times to environmental changes but also promotes sustainable aquaculture practices through automated interventions and improvements.

INDEX TERMS: AQUA Control, Prawn Farming, ESP32 microcontroller, pH Sensor, water quality

1. INTRODUCTION

Usual aquaculture methods always rely on manual control like monitoring and interventio n, leading to insufficient results and increased risks of prawn growth and mortality due to abnormal environmental conditions. To addres s these important challenges, the usage of modern technology in aquaculture manageme nt systems has been introduced and implemen ted. particularly using the applications and advancements of the Internet of Things (IoT). The advancement of IoT technologies has ena bled real time control like monitoring and auto matic actuation, helping prawn aquaculture operations to collect real-time data, analyze these data in a local or cloud environment, and respond to issues like water quality and other environmental factors. This smart aquaculture for prawn production in a pond can be implem ented in coastal Andhra Pradesh particularly a t the western Godavari district, around the Beemavaram area which is famous for prawn aquaculture.

This method not only increases operational ou tput efficiency but also supports sustainable good practices by timely interventions which are done based on data-driven initiatives

The equipment and components used are ponds, water purifying systems, and automatic pure water generating systems. Because of maintaining good management for pure water, the quality of prawns is increased and profits also improved.[1]. This method uses an analog-type turbidity sensor (SKU: SEN0189) to measure the quality of water in the prawn pond. This sensor sends lights and checks for the scattering and transmission through the water. From that it measures the solid level in the water. Thereby it measures the quality of pond water[2]. Water quality is measured and maintained for quality fish production. The behavior of the fish is watched and remedial steps can be prescribed for a healthy fish production procedure for optimal profit [3]. Thi s paper analyses the various water quality methods that are already published in works that use sensors and IoT technologies to maintain the quality of water for better billing practices in adverse circumstances [4].

The proposed smart water management system for better water quality and its optimal usage using IoT technology to make the water users understand the amount of consumption in an efficient way and reduce the wasting of or loss of water [5]. The PH value of the water determines whether it is acidity in nature or alkalinity in nature based on its pH level. If the level is less than 7 it is acidity and above, it values 7 it is an alkaline solution. it is working with a 5v supply and it is easily interfaceable with Arduino Uno [6].

In this paper, a smart aqua culture method using IOT, Artificial intelligence with long-distance monitoring is proposed for a better fish growing enterprise in Taiwan with real-time data collection is proposed [7]

The history of automated aqua culture started with personal computers. Present-day aqua culture automation uses an industrial process control method that consists of sensors, transmitters, multiplexors, and actuators at the output side [8].
Several studies have been conducted for modern-day smart aquaculture systems using machine learning for measuring weight, size, species classification, grading disease detection, etc. [9].
For automatic control of the aquaculture system, a Zig Bee wireless sensor network system is used with each sensor node using an MSP 430 controller. [10].
Real-time operation of the aquaculture system will make hand-free operations and these data can be used for further processing and for arriving at the desired result [11].
Node MCU 8266 Wi-Fi module is used in the automatic aquaculture management system. Things Speak programming is used for real-time data collection [12].
Aqua Control System uses the ESP32 microcont roller,known for its robustness.

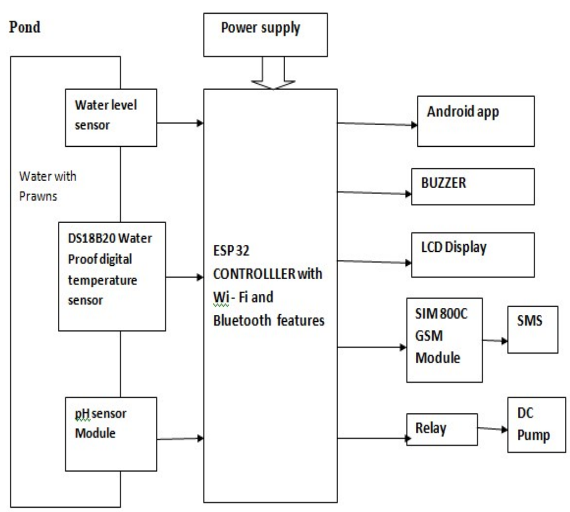

Fig. 1 Block diagram of a Smart Aqua system for prawn aquaculture

This method aims to develop a very good Smart Operational capabilities in the wireless commu nication area and processing the real-time data. The proposed Aqua Control System will use a variety of sensors for monitoring the important water quality parameters, such as water level, pH level, and, temperature, all of them are playing important roles in bringing out the best environment for perfect aquatic life. In the future oxygen measurement and management also can be added. This paper aims to develop a Smart Aqua Control System using the ESP32 microcontroller, which has become very popul ar due to its versatility, in IoT data collection and process management applications due to its powerful capabilities in fast processing and its built-in part Wi-Fi and Bluetooth applications.
The ESP32 is a dual core fast processor that h elps high speed data processing and multitask ing capacities, making it an ideal controller for handling multiple sensors and actuators in a very efficient way.

2. BLOCK DIAGRAM

ESP32 Microcontroller is a controller with multiple features. The ESP 32 is connected with components like sensors and actuators. It is shown in Fig 1. It handles data collection from sensors, processing the data, and controlling the actuators and communication to the cloud server for further operations. The following sensors are used 1. Temperature Sensor which monitors temperature of the pond water to maintain optimal living conditions. There are many types of temperature measurement sensors like analog temperature sensors and digital temperature sensors. A digital temperature sensor with waterproof facilities is more suitable in aqua culture automatic control applications. 2. pH Sensor which Measures the alkalinity/ acidity of the pond water. It is very much important for the good health of the prawn 3. Water Level Sensor which maintains the water level to remain within the safe limits. A dissolved Oxygen Sensor which monitors the levels of oxygen in the pond water can be another control. The Actuators that are part of the system are 1. Pumps Control the water level and circulation and maintain optimal conditions. 2. Valves that manage inflow as well as outflow of water whenever it is needed. 3. Alarm which makes a sound when the water level goes below the required level. The flowchart of the operation of the methodology is shown in Fig. 2.
The smart aqua culture management system may use the following controls for better management.
User Interface: Mobile Application: For real-time monitoring, control, and alerts.
Web Dashboard: Optional, for desktop monitoring.
Data Storage: Cloud Storage/Local Database: Store s historical data for analysis and reporting.
Communication Module: Wi-Fi/Bluetooth Module: For data transmission between the ESP32 and the mobile app.

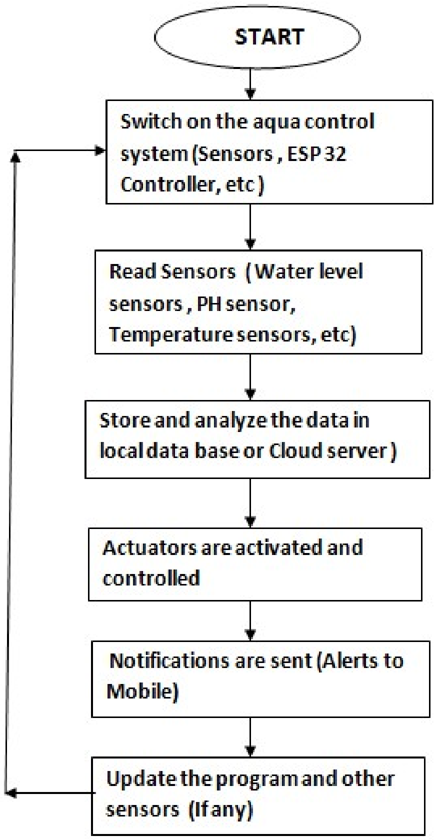

Fig.2 Flowchart for Methodology

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3. IMPLEMENTATION PROCEDURE

All the sensors and actuators are connected to the ESP 32 development board. A D4 pin is used to connect the temperature sensor. The pH sensor is connected to the VP pin of ESP 32 which can be used as an A0 pin. For example, water level detection and operation of the motor pump are shown in figure 3. The Arduino Integrated Development Environment version 1.8.18 is downloaded and installed in a computer system. Now ESP 32 development board is connected to the computer system by a USB card. The program for the Smart AQUA CONTROL System for Pure Water Prawn Farming is verified for compilation and errors. Then the program is uploaded onto the board. Now the ESP 32 board will work as a standalone circuit board for smart aqua culture farming control. The program measures temperature, pH level, and water level. Based on the real-time data, actuators like motors will be operated. Temperature readings will be measured and appropriate action will be taken. Based on the pH level, water purification steps will be taken.
If it is necessary, oxygen measurements can also be done using an oxygen sensor in addition.

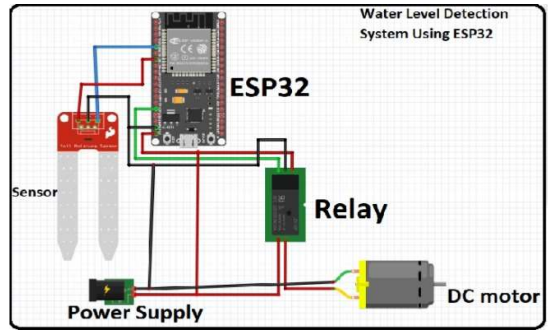

Fig. 3 Connection of water level detector, and motor with ESP 32

4. RESULTS

The sensors will send data to the local database and cloud servers. Temperature will be shown on a graph or on digit format data. Here the LCD display shows the temperature as shown in Fig. 4. When the tempe rature goes very high, cool water must be filled by the operating motors. Similarly, If the pH value shows variations, appropriate actions will be taken to bring the pH value of the water to the desired level.
When the water level goes below the desired level, motors are operated to pump the fresh water into the pond. So that prawns are saved and the automatic prawn pond management system will function as a guarantee for generating pure water, thereby producing healthy and quality prawns for profitable enterprises.

Fig. 4 Temperature displayed in a LCD display

CONCLUSION

A smart aqua system for prawn pond monitoring and managing system for aquaculture in coastal Andhra Pradesh has been presented. By adopting this system, the prawn-cultivating fishermen can get an improved system for prawn aquaculture enterprise management. This particular method prov ides a new way of smart aqua management solutions using ESP 32 Microcontroller for aquaculture. Aqua prawn growing farmers will monitor multiple paramet ers with a user-friendly, and easily operatable smartphone app. Long-distance monitoring and controlling the quality of water and healthiness of prawns make this smart aqua system more profitable and unique in many ways. The collected data can be used for further research purposes and better management of aqua farming in the future. The use of Bluetooth and Wi-Fi communications makes the maintenance cost very low. In this method, digital temperature sensors and water level detectors will give accurate measurements which help the management of this aqua prawn pond management a great success and be more profitable. This system produces quality prawns from coastal Andhra Pradesh for the market for healthier food for people. Therefore, it supports human society in a remarkable way.

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VIRTUAL SHIRT TRY-ON

[1] Rohith Bala Jaswanth B, [2]Chinamuthevi Aparna, [3] Jampala Nithish Kumar, [4] Kode Devi Sri Vallika,
nitheesh.jampala@gmail.com,aparnach729@gmail.com,jaswanthiot@gmail.com,vallikakode@gmail.com,
[1,2,3,4]Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru

ABSTRACT: The increase in e-commerce activities has resulted in a need for advanced technologies that provide a virtual fitting, which is essential for improving the fashion online shopping experience. This paper describes a Virtual Shirt Try On application, which provides a virtual fitting for shirts and pants using computer vision techniques and does not have gender restrictions. While using multipose detection, the application provides the ability to place overlays accurately in relation to body landmarks and also includes multiperson functionality so that several users can virtually fit themselves into a single frame. The approach is designed to enable any user to operate the system thanks to the inclusion of a 'Confirm' button in the selection process.

KEYWORDS: Fit and Size Customization, Augmented Reality (AR), Location of shirt

1.INTRODUCTION

The Virtual Shirt Try-on tool presented in this project allows any person the ability to try on shirts and pants without the limitation of a specific gender making it universal. This application is however different from most traditional systems which often deal with single user staticscenarios and instea d involves multipose detection and multi-user-in-the-same-frame scenarios such as capturing the clothing of different people with different positions and sizes. Friendly design is provided – users can select their options without any mess and click the 'Confirm' button.

With such steps in development, pose esti mation is necessary, which means that the system will have to be able to detect and select body landmarks to fit the garment, garment transfer functions, and optimizatio n techniques so that interaction is smooth. This project aims to achieve a good balance between engaging the customers with reali stic virtual try ons that addresses the major concern of increasing rates of returns, redu cing return rates and improving customer satisfaction as well as increasing return on investment. This application is in itself a partial solution to the challenges posed by a different world of shopping brought about by online platforms as technology and the world of online shopping continues to evol ve increasing the customer satisfaction.

2.LITERATURE REVIEW

Virtual try-on systems are changing online shopping by letting users see how clothes look on them digitally, making buying decisions easier and reducing the likelihood of returns. Advanced computer vision techniques, such as OpenPose and MediaPipe, are at the core of this technology, helping these systems track body movements accurately so that clothing overlays fit naturally. Multipose detection takes this a step further, enabling multiple users in one frame to try on clothes together, a feature valuable for group shopping settings.

To achieve realistic overlays, image processing techniques like warping are used, aligning garments to body contours and adapting to movement. Augmented Reality (AR) enhances these systems, providing real-time rendering and lighting adjustments to make the try-on experience feel more immersive. Major retail brands are adopting this technology to boost customer engagement and satisfaction by offering a more inter active shopping experienc e, which has also been shown to reduce produ ct returns.

Looking to the future, researchers are focusing on integrating AI for more precise garment fitting and personalized recommendations, while also making the technology compatible across various devices. This continued development promises even better and more accessible virtual try-on experiences, which are likely to become an essential part of online fashion retail.

3.METHODOLOGY

Virtual Shirt Try-On application was created as a product of several computer graphics based approaches guaranteeing both perfect precision and responsiveness during garment overlays.

Libraries Used

OpenCV: OpenCV (Open Source Computer Vision Library) is a powerful tool widely used for image and video processing in computer vision tasks. It enables various operations like image manipulation (resizing, cropping, rotating, blurri ng, and color transformations), real-time video processing, object detection, feature matching, and camera calibration. OpenCV is particularly useful for real-time applications such as face detection, object tracking, augmented reality, and gesture recognition. It also supports machine learning algorithms for custom model building, aiding in tasks like object classification and sentiment analysis.
Additionally, OpenCV facilitates motion analysi s, 3D reconstruction, and integration with deep learning models, making it a versatile library for a wide range of visual recognition and video processing applications.

MediaPipe: MediaPipe is an opensource frame work developed by Google for building real-time multimodal processing pipelines. It offers pre-built solutions for tasks like pose estimation, hand tracking, and face detection. Highly optimized for performance, MediaPipe is suitable for applications such as augmented reality and virtual try-ons. Its cross-platform support and easy-to-use APIs make it ideal for real-time computer vision tasks.

Dataset and Preprocessing: The images of clothing are subjected to background subtracti on, cropping and body mapping as to correspo nd with the users' spatial tracking of body parts.

Pose Detection: This employs a multipose tracking technique with the use of tools such as MediaPipe to provide a geographical map of body parts like the shoulder, waist and hips. Therefore, every single person that has been located in the frame can have a distinct overlay alignment, allowing for several people in several poses to be displayed with ease.

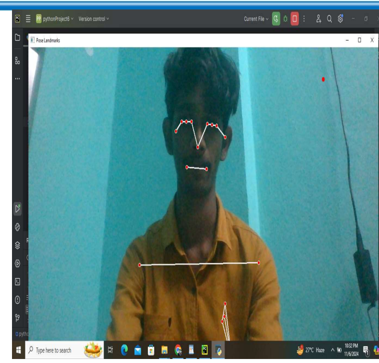

Fig1: Pose detection on body

Garment Overlay: Based on those positions, shirts are saved in such a way, that they are able to dress up a person without making it look artificial. The posed and body types are further combined using virtual overlays making the try-on process much more realistic and fluid.

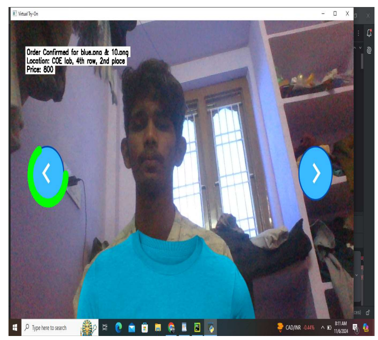

Fig2: Overlaying shirt on body

User Interaction: With the interface, users can improve the process of making their selection as a 'Confirm' button is found on most screens.

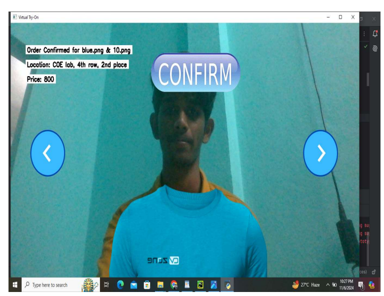

Fig3: Location of shirt after click confirm button and order confirmed

Optimization: Certain compensations such as reducing the resolution and faster processing speed ensure that the virtual application is capable of real-time interaction with users in various devices.

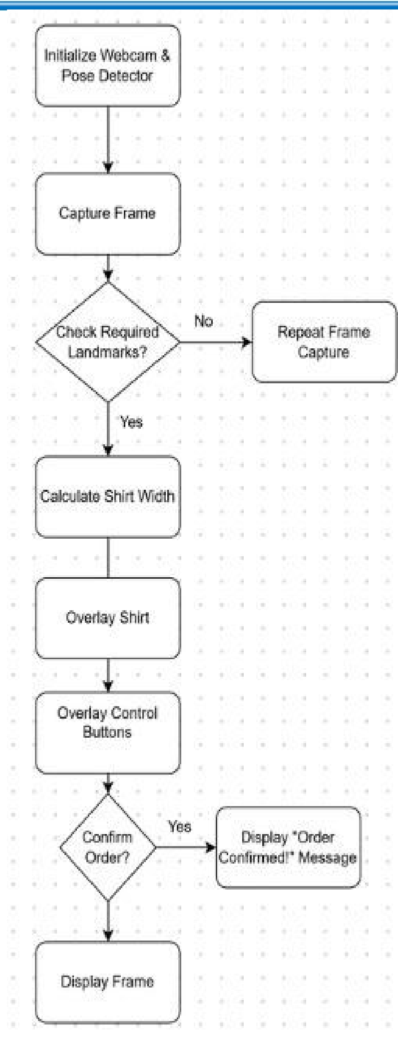

Fig4: Flowchart of overlay shirt on the body

Security Issues

1. Data Privacy and Protection

User Data: Be sure to store personal information (such as pictures of the body, and measurements taken) safely and to anonymize wherever possible.
Use encryption such as AES to keep sensitive data both in flight and at rest. Moreover, use HTTPS for SSL/TLS encryption on all interchanges between the client - including the browser - and your server.
GDPR Compliance: If your app operates in regions where data privacy laws like GDPR apply, ensure that your app complies with regulations on data collection, processing, and storage.

2. Authentication & Authorization

Secure Authentication: If your app has login functionality, use secure methods such as OAuth2 or multi-factor authentication (MFA) to ensure that only authorized users can access personal data.
Session Management: Implement proper sessi on management practices, including session expiration, secure cookie attributes (HttpOnly, Secure), and preventing session fixation attack s.

3. User Input Validation

Sanitize Inputs: Validate and sanitize all user inputs (e.g., form inputs for measurements) to prevent injection attacks like SQL injection or cross-site scripting (XSS).
File Uploads: If the application is permitting the users to upload images or other files, validate the file type and size for malicious upload. Store the uploaded files in non-executable isolated directories.

4. Cross-Site Scripting (XSS) & Cross-Site Request Forgery (CSRF)

XSS Prevention: Sanitize output of all user-generated content like images or measuremen ts, use of content security policies to decrease XSS risk.
CSRF Protection: Apply anti-CSRF tokens that will protect against malicious actions by an unauthorized user.

5. API Security

Secure APIs: If your application accesses the external APIs for instance for image processing, do not allow API keys to be available in the frontend code but rather in a safe and secure environment in the server
Rate Limiting & Throttling: Prevent people from abusing your APIs since your application might handle users' images or other resource-consuming jobs.

4. RESULTS AND OBSERVATIONS

The Virtual Shirt Try-On application facilitates a genuine and responsive experience where a shirt and a pair of pants can be automatically worn onto the person's body with proper alignment to body landmarks. Sample outputs show successful overlays for single and multiple users even with multiple poses and efficient multipose detection helps in this regard.

Performance: The system works at real-time for most processes with an average response of 0.09 seconds due to the optimized image resolution and pose detection techniques. Feedback provided by users suggests that the majority of the users do find the application realistic and intuitive.

Challenges: Although the application is performing quite well, there is a noticeable change in the alignment of the shirt and pants due to complex poses and some lighting conditions. Also the performance may vary quite a bit for the same application on different devices.

Key Findings: The application is best suited with its multiuser and multipose features which gives it an edge against other applications specifically designed for static formats with only a single user. All in all, it has an impressive ability to enhance the online shopping experience with many immersive features and great ease of use.

CONCLUSION

By combining OpenCV with MediaPipe for pose detection, you can create a powerful system for real time webcam video processin g. OpenCV handles the video capture and display, while MediaPipe accurately detects key human body landmarks, such as shoulde rs, hips, and elbows. This setup allows you to overlay these landmarks on the video feed, creating a clear and interactive visualization of the detected pose. It serves as a versatile foundation for developing interactive applicati ons, such as virtual try-on systems, gesture recognition, or fitness tracking. The combinati on of these libraries enables scalable and flexible real-time computer vision applications, with potential for further enhancement and integration into more complex systems.

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BRIDGING THE GAP: IOT AND SENIOR CITIZEN WELL-BEING”

[1]P. Prathibha
[1]Pingle Govt. College for Women (A), Hanumakonda, Telangana
prathi1276@gmail.com

ABSTRACT: There are promising ways to improve senior adults' quality of life through the use of Internet of Things (IoT) technologies in eldercare. An IoT-based smart home system's features include intelligent power and water monitoring sensors, temperature control, lighting control, security features, and surveillance capabilities. The potential of IoT-powered smart houses to provide emergency response, health monitoring, and independent living is examined in this article. We identify important elements that affect successful implementation, like cost-effectiveness, privacy, and user-friendliness, by examining the potential and obstacles related to IoT adoption in eldercare. To meet the special requirements of senior adults, we offer a thorough framework that blends sophisticated automation, real-time monitoring, and user-centric design. IoT-based solutions can enable seniors to age gracefully, preserve their freedom, and get timely help when needed by integrating wearable technology, smart home appliances, and intelligent interfaces.

KEYWORDS: wearable sensors, smart home interface design, e-health monitoring, aging in place, IoT, elder care, security, and privacy

1. INTRODUCTION

The world's population is rapidly aging, creating a pressing need for innovative assist ed living and healthcare solutions that enhan ce older individuals' quality of life. People oft en struggle to maintain their independence, take care of their health, and maintain safe living circumstances at home as they age. Internet of Things (IoT) technological advanc ements offer promising solutions to these problems by enabling automated home syste ms that can adjust to particular requirements, individualized care, and remote monitoring. IoTenabled smart homes, which include a ran ge of networked sensors, gadgets, and apps, provide remarkable chances to improve older citizens' quality of life by offering continuous assistance and rapid emergency response.

However, there is still very little use of IoT devices among the elderly. This is sometimes ascribed to elements like perceived high cost s, concern about technology, worries about data privacy, and a lack of user-friendliness. Understanding these challenges is essential to developing IoT solutions that accommodat e elder users' needs, preferences, and limitati ons in addition to being technologically adva nced. Furthermore, to ensure that IoT systems aimed at senior care provide clear and useful benefits in daily life, thorough frameworks that can guide their design are required.

1.1 Introduction on IoT:

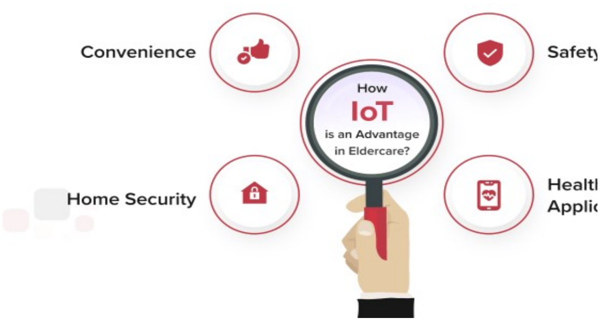
Everyday tasks, even for people with by enabl ing networked devices to gather, process, and share data—often in real-time the Internet of Things (IoT) is revolutionizing several industries. Through the Internet of Things, ac tual objectsfrom domestic appliances to wear able health monitors are outfitted with sensor s and software that allow them to communica te dynamically with people and each other. By providing previously unheard of data driven i nsights and efficiencies, this network of conn ected devices is revolutionizing sectors like healthcare, transportation, agriculture, and h ome automation.

IoT holds great promise in the healthcare industry, especially for vulnerable populations like the elderly, who benefit from ongoing, discrete health monitoring. Wearable technol ogy that tracks vital signs, smart home senso rs that record daily activities, and automatic alert systems that respond to crises like falls or unusual health patterns are examples of Internet of Things uses in this context. IoT-based solutions that integrate these technolo gies help older individuals stay independent for longer periods while also reducing worries for caregivers and family members [1]. IoT has an impact on smart home settings as well, as gadgets work together to increase comfort and safety. IoT-enabled smart homes for seniors can have fall detection systems, auto mated lighting, and user-friendly interfaces

that help wognitive impairments [2]. IoT integ ration in home automation and healthcare shows how linked systems are making senior adults' surroundings more accommodating and responsive. IoT is predicted to play a bigger part in eldercare as the world's population ages, encouraging new ideas for independent living options and revolutionizin g healthcare and senior well-being in the process [3].
The delivery of healthcare services to older adults could be revolutionized by intelligent houses that integrate health and different ambient-aided living (AAL) technology [4] [5].

2. HOW IS IOT BENEFICIAL IN ELDERCARE?

Healthcare workers are currently more involved with patients and more alert due to the advancements in Internet of Things technology. Data from IoT devices can help physicians determine the best treatment options for patients and achieve the desired outcomes.



PRACTICALITY

Asking your voice assistant to order additional toilet paper, for instance, can make the procedure simple and let you wait for it to arrive in the mail. Additionally, gadgets that let you operate an air conditioner or fan from your smartphone can lessen the need for you to get out of bed in the middle of the night. Furthermore, Internet of Thin gs-enabled smart cars can be useful because they can recall and direct you to the locations you visit most often.

SECURITY

When IoT devices are integrated, seniors who live independently frequently feel more safe. For instance, you or your caregiver may choose to add a sensor module that will sound an alert if there is no movement for a long time.
This implies that following a fall or medical incident, help can get there faster.
Additionally, IoT devices can monitor variations in humidity, temperature, or carbon monoxide levels and alert caretakers or homeowners if these measurements drop below a safe threshold.

3. REVIEW OF LITERATURE

Cedillo provides a comprehensive analysis of wearable IoT-enabled technology used in elder care. The study emphasizes significant trends, innovations, and outcomes related to using IoT in senior care [7].

HOW TO BEGIN USING IOT FOR SENIOR CARE

By fusing wearable sensors, smart devices, and advanced analysis, the Internet of Things (IoT) has emerged as a game-changing solution for elder care that enables real-time monitoring and action. This integration encourages seniors to live independently, reduces dependency on caregivers, and facilitates continuous care [7] [8].

Areas Where Health is the Main Focus

Numerous health-related topics are the focus of IoT applications.
Wearable technology and smart home systems for dementia and Alzheimer's disease can be used to monitor cognitive health, detect wanderin g behavior, and assist with everyday activities [7][8].
Weakness and accidents: By promptly alerting caretakers to falls utilizing accelerometers, gyroscopes, and ambient sensors, fall detection systems reduce the likelihood of hospitalization.
Monitoring systems provide proactive health management by tracking chronic conditions including diabetes and cardiovascular disease (CVD) using biometric sensors [7].

Environment of technology

Among the IoT technologies used in elder care are:
Health bands, smartwatches, and textiles are examples of wearable technology that track vital signs like heart rate, oxygen saturation, and physical activity [8].
By using motion sensors, environmental monitors, and integrated appliances to detect hazards like gas leaks or unsupervised cooking, smart home systems improve safety [8].
Biometric Sensors: Devices that are part of wearables or stand-alone devices collect physiological data to help with illness monitoring and diagnosis [8] [10].

Outcomes of IoT Integration

There are several significant benefits of using IoT in senior caregiving.

Increased autonomy: By providing assistance with daily tasks and ensuring their safety, IoT devices enable senior citizens to stay in their homes [7] [8].

Better Emergency Response: Rapid response is made possible by the ability to identify falls and alert people to health abnormalities, which reduces the severity of incidents [8] [9].

Reduce the Caregiver Burden: Automated surveil lance reduces the need for ongoing observation, freeing up resources for other duties [10].

Challenges and Limitations

IoT can help with eldercare, but there are several obstacles to overcome.

Strict access control procedures and robust encryption are necessary for the protection and preservation of private health data in order to address privacy and security issues [7] [10].

User Acceptance: In order for seniors, who are generally less tech-savvy, to utilize these tools efficiently, they require user-friendly designs and intuitive interfaces [8].

IoT system accessibility, particularly in areas with low resources, depends heavily on availability and affordability [7].

What does the future hold?

According to studies, future developments will focus on addressing data security concerns, enhancing device interoperability, and integrating AI for predictive analysis. Custom care alternatives created for certain health profiles are becoming more and more popular [8] [10].

An emergency call system encourages self-reliance.

Independent life is made easier by the emergency call system. Elderly people are particularly vulnerable to falls because they lose their reflexes with age. As a result, timely assistance in nursing homes and at home is crucial. With the help of our IoT wearables and community RTLS, family members and caregivers can effectively and conveniently keep an eye on the elderly. Elders' locations may be tracked in real-time both indoors and outdoors, and an integrated emergency call system allows for prompt assistance in the case of an accident or fall. The alarm parameters of the system are configurable and include both automatic location notifications that signal roaming, wandering, or inactivity, as well as alerts triggered by buttons on IoT devices. Staff can be rapidly informed via a variety of sensors regarding the status and behavior of patients who are unable to take care of themselves. When a patient with Alzheimer's disease enters or exits a room, "window sensors" can alert staff. Additional information on patient movement is provided by motion sensors placed throughout the nursing home. Wireless panic buttons can be placed in the bathroom or anywhere else that is easily accessible. The emergency button can also be used as a wearable gadget for more mobile patients, guaranteeing timely aid even if they can't reach the wall-mounted button. The technology gives and logs residents' and employees' real-time whereabouts to speed up reaction times in an emergency. Those closest to the situation will be sent to assist, while staff members will receive instant updates via a linked mobile app. The autonomy and dignity that residents are entitled to are not violated by the deployment of IoT devices and real-time location systems. In addition to helping the elderly stay independent, we make sure that their data is safely shielded from outside access. We always respect senior citizens' privacy.

3.1 APPLICATIONS IN HEALTHCARE

Monitoring health indicators through connection with healthcare applications is one use case for the Internet of Things (IoT). IoT-enabled medical devices can monitor a range of parameters, including medication compliance and heart rate. For example, seniors can buy an internet-connected smart pillbox to make sure they take their prescriptions as directed.

A smartwatch that automatically logs blood sugar readings online is an additional option for diabetics, as it does not require finger pricks. These gadgets might help senior citizens stay more independent and feel less stressed

3.2 Tailored Care

IoT devices are essential to providing seniors with individualized care. Since every patient has different needs, their care must also be tailored to meet those needs. As a result, IoT-enabled medical devices can collect data on lifestyle decisions, health markers, and sleep patterns.

Delivering individualized care can be made easier with the help of this information, which can offer insightful information about the patient's particular needs.

3.3 Household Safety

Home security can be improved with smart devices like sensors, cameras, and locks. Homeowners can use these tools to notify them of trespassers or strange activities occurring on their property.

Additionally, they enable elders to keep an eye on their houses on their own without relying entirely on a security provider. These users can control door locks, see camera footage, and handle sensors with their iPhones.

IoT devices can be used by older folks to monitor their carbon monoxide and smoke alarms. They may turn off their smoke detectors from their cellphones in the event of a false warning, such as one brought on by burnt food, without having to reach up to the ceiling [6].

4. IOT APPLICATIONS FOR SENIOR CITIZENS THAT YOU SHOULD BE AWARE OF

4.1 Wearable Medical Monitoring Equipment

Smartwatches and medical wearables are examples of wearable health monitoring devices that use the Internet of Things (IoT) to track key health indicators like heart rate and blood pressure. In the field of elder care, these gadgets are frequently utilized. In an emergency, they instantly notify caregivers and medical specialists by gathering and analyzing health data in real-time [6].

4.2 Intelligent medicine dispensers

Pill dispensers with Internet of Things capabilities give older individuals their prescriptions on time. If a medication is missed, these gadgets also notify the caregiver's device or the old person's smartphone.
Furthermore, several contemporary artificially intelligent medication dispensers can connect to pharmacies to guarantee prompt drug refills. In conclusion, intelligent medicine dispensers oversee all medication-related tasks.

4.3 Automation of Smart Homes

By enabling them to operate a variety of products, including lights, air conditioners, and medication dispensers, IoT can also provide older individuals with convenience and safety.
Let's look at an example. Smart lighting systems that are powered by the Internet of Things can illuminate paths at night to prevent falls, and IoT-linked smart thermostats can automatically regulate room temperatures for comfort without human intervention.

4.4 Systems for Detecting Falls

Elderly people are especially vulnerable to unplanned falls that can cause fatalities or major injuries. Therefore, to alert caregivers right away if someone falls, contemporary fall detection systems are required. IoT-enabled sensors are placed in rooms or other areas of the house to identify abrupt falls or changes in movement. These IoT-driven sensors can use alarm systems to notify emergency personnel if an old person falls, guaranteeing prompt medical attention.

4.5 Systems for responding to emergencies

Emergency response systems for senior citizens are implemented using Internet of Things technology. Voice-activated alarm systems and wearable panic buttons are made possible by IoT platforms, which provide rapid access to emergency services.
When an emergency occurs, elderly people can easily press the alarm button with voice commands and wearable technology. By doing this, medical personnel will be informed and able to reach on time

4.6 Solutions for Social Connectedness

Furthermore, IoT technology can facilitate social interaction between smart gadgets and older persons, enabling them to maintain connections with caretakers, healthcare providers, loved ones, and others. These gadgets' social media integration, video calling, and instant messaging capabilities help older people stay connected to their loved ones and fight loneliness. As a result, the aged care industry is using IoT technology more and more.

4.7 Reminders and Cognitive Support

Elderly people need social help to prevent loneliness. IoT gadgets can operate as companio ns that reduce loneliness and doffer amusement by leveraging voice-
activated assistants like Alexa and Siri.
These systems also remind users to do their workouts, visit a doctor or nurse, and take their medications

4.8 Handling Medication

For older people, especially those with complex prescription schedules, managing their medicatio ns can be quite difficult. In this situation, Internet of Things (IoT) gadgets can be quite helpful by providing prompt reminders and making it easier to administer prescription drugs as needed. Medication monitoring devices and intelligent pillboxes can monitor dosage compliance and notify caretakers or medical professionals when a prescription is missed. This technology innovation reduces the possibility of adverse health consequences by encouraging elders to adhere to recommended treatment strategies.

4.9 Self-sufficient living

For many older folks, maintaining their independence is a primary worry. Smart technologies and the Internet of Things offer a number of ways to support independent living. Seniors may easily control the lighting, temperature, and security systems in their homes with smart home automation, increasing their comfort and safety. Voice-activated assistants and smart appliances are examples of IoT-enabled gadgets that enable seniors to efficiently handle domestic chores. GPS-tracking wearable technology can provide location data, allowing seniors to travel with assurance while maintaining their safety.

5. HOW TECHNOLOGY ENHANCES HEALTHCARE FOR THE ELDERLY

The lives of the elderly are greatly improved by technology.

For example, there are several devices and apps available to help them communicate with their caregivers and relatives. They can use these gadgets to video call, exchange messages, or even phone emergency services in case they need help.

This is yet another area where technology is having a big impact on healthcare. Seniors can use a variety of programs to help them keep track of their prescriptions and manage their health. Additionally, they can communicate with doctors using these apps, who can provide virtual medical advice if needed.

By allowing caregivers to remotely check on the health of their loved ones via sensors and cameras placed throughout the house, the Internet of Things (IoT) has had a big impact on elder care. These sensors give caregivers information about their senior loved ones' health and suggest the kind of help they might need to maintain a comfortable home environment after work.

The following three technologies are improving healthcare for the elderly:

Technology is used in remote patient monitoring (RPM), which collects patient data and tracks health outcomes remotely. By reducing hospitalizations, ER visits, and duration of stay, RPM has shown improvements in the care of the elderly. RPM was found to reduce the duration of stay by 19%, ER visits by 28%, and hospitalizations by 21% in one research.

Self-sufficient gadgets that can carry out functions without human assistance are known as autonomous medical devices. Because they improve outcomes, reduce errors, and increase access to care, these devices have the potential to improve healthcare for the elderly. According to one study, autonomous medical devices have been associated with a 30% decrease in death rates.

The practice of providing medical care remotely via telecommunications is known as telemedicine. By increasing access to care, reducing travel time and costs, and producing better results, telemedi cine has proven to be an effective way to improve healthcare for the elderly. According to one study, telemedicine increased rural elders' access to care by 57%

6. BENEFITS OF TECHNOLOGY IN THE CARE OF ELDERLY

Healthcare technology can lower expenses in a number of ways. For example, patients can be monitored remotely using remote care monitoring, which may eliminate the need for costly and needless hospital stays. Furthermore, by performing duties like medicine delivery, autonomous medical equipment might save labor expenses. In the end, telemedicine can drastically reduce travel costs for both patients and healthcare professionals.

CONCLUSION

The Internet of Things (IoT) is revolutionizing multiple sectors through its network of interconnected devices. By enabling the collection and analysis of vast amounts of data, IoT is driving unprecedented insights and efficiencies across healthcare, transportation, agriculture, and home automation. This technological paradigm shift promises to enhance decision-making processes, optimize resource allocation, and improve overall productivity in these industries. As IoT continues to evolve and expand, its potential to transform business operations and improve quality of life is likely to grow, paving the way for smarter, more sustainable solutions in the future. Further research is needed to fully understand the long-term impacts and potential challenges associated with widespread IoT adoption across these diverse sectors.

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DESIGN AND OPTIMIZATION OF A CUSTOM CONVOLUTIONAL NEURAL NETWORK ARCHITECTURE FOR ENHANCED TINY IMAGE CLASSIFICATION

[1]A. Jitendra Chowdary, [2]Mukesh Medikonda, [3]Santhosh Kumar Kuchoor, [4]Suresh Bysani Venkata Naga, [5]Jyostna Devi Bodapati, [1,2,5] Department of ACSE, VFSTR deemed to be University, India
[3,4] Member, Institute of Electrical and Electronics Engineers, United States of America
[1]jitendrachowdary2004@gmail.com,[2]mukeshmedikonda9@gmail.com,[3]santosh.kuchoor@ieee.org,[4]sureshbysani@ieee.org, [5]jyostna.bodapati82@gmail.com

ABSTRACT: This paper presents a custom Convolutional Neural Network architecture tailored to improve classification accuracy while reducing computational complexity in image classification tasks. The proposed model integrates advanced techniques such as batch normalization, max-pooling, and dynamic dropout layers to prevent overfitting and enhance model performance. Our approach explores the impact of various hyper-parameters, including learning rates, weight initialization strategies, and optimizers, to systematically optimize the training process. Extensive experiments on the CIFAR-10 dataset demonstrate the efficacy of the proposed architecture in achieving superior accuracy and efficient feature extraction compared to standard CNN models. The study highlights the role of hyperparameter tuning in optimizing deep learning models for real-world applications.

INDEX TERMS: Convolution Neural Network, Learning Rate scheduler, tiny image classification, soft plus activation.

1. INTRODUCTION

Convolutional Neural Networks (CNNs) have revolutionized the field of computer vision by providing state-of-the-art performance in image classification tasks. However, despite their success, training deep CNNs often requires substantial computational resources and careful hyperparameter tuning to achieve optimal results. This research aims to address these challenges by proposing a custom CNN architecture that focuses on enhancing classification accuracy while minimizing the computational cost associated with deep learning models.

Our custom CNN architecture leverages techniques such as batch normalization, max-pooling, and dropout layers to improve convergence speed, stability, and robustness against overfitting. These techniques are strategically integrated into the architecture to ensure that the network efficiently learns essential features from the input data. By systematically exploring various hyperparameters and training strategies, we aim to optimize the performance of the CNN on the Canadian Institute for Advanced Research dataset with 10 classes (CIFAR-10), a widely used benchmark in image classification. In this study, we also examine the impact of different weight initialization techniques, learning rates, and optimization algorithms on the overall performance of the network.

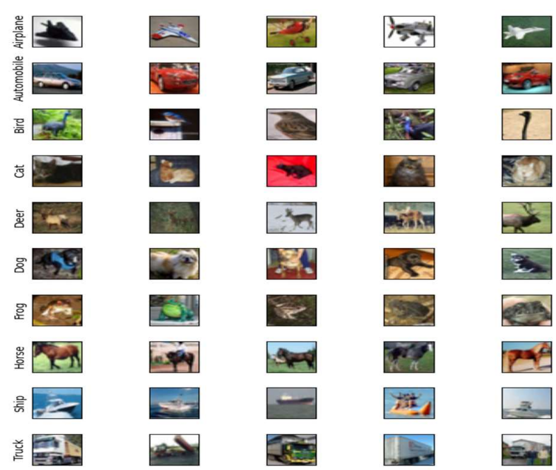


Fig. 1: Visualization of Sample object images from each class of Cifar-10 dataset

Through extensive experimentation, we identify the best combination of these parameters to maximize accuracy and training efficiency. Our

results indicate that the proposed custom CNN outperforms traditional architectures by delivering higher accuracy rates while maintaining lower computational requirements.

The remainder of the paper is structured as follows: Section 2 details the proposed CNN architecture, including its layers and hyper-parameter settings. Section 3 discusses the experimental setup and evaluation metrics used to assess the model's performance. Section 4 provides a comprehensive analysis of the results obtained from various experiments, highlighting key observations. Finally, Section 5 concludes the study with insights into the impact of the proposed techniques on classification performance and suggestions for future work.

2. RELATED WORKS

In recent years, image classification has become a pivotal task in computer vision, with diverse applications such as autonomous driving, medical imaging, and surveillance systems. Despite significant progress in this area, challenges remain in improving accuracy on small and imbalanced datasets, reducing computational complexity, and enhancing model robustness against adversarial attacks. These issues continue to be active areas of research.

Raveen Doon et al. explored the performance of deep learning models on the CIFAR-10 dataset demonstrating the use of regularization and optimization techniques to enhance image classification accuracy [1]. Their study achieved benchmark performance, showcasing the effectiveness of these techniques in improving the generalization of deep learning models on standard image classification tasks. This work establishes a foundational understanding of optimization strategies that can influence model performance, which is critical for our research on improving accuracy in challenging datasets. Building upon the optimization insights, Benjamin Recht et al. further improved deep learning performance on the Cifar-10 dataset by developing a method that creates a new test dataset composed of unseen images, providing a more rigorous assessment of model accuracy [2]. While their model achieved 100% training accuracy, they emphasized the importance of test accuracy to ensure generalization to new data. Their work also tackled the issue of overfitting, demonstrating the critical need for robust test datasets in evaluating the performance of deep learning models. Expanding on the dataset challenges, Shangyun Lu et al. introduced the CIFAR-10.2 dataset, designed to assess whether models experience an accuracy drop on more challenging data [3]. Their goal was to decompose this drop into components of varying difficulty, further analysing how deep learning models perform under different conditions. This study provides valuable insights into how changes in the dataset can affect the accuracy and robustness of image classification models.

In addressing the issue of data augmentation, Ekin D. Cubuk et al. proposed a novel method known as Auto Augment by leveraging reinforcement learning to automatically discover optimal data augmentation policies for image classification [4]. This approach replaces traditional, manually designed augmentation techniques with an automated system that learns from data to find the best combination of transformations. Auto Augment demonstrated state-of-the-art results on several datasets, including CIFAR-10, CIFAR-100, Street View House Numbers (SVHN), and ImageNet. The authors also shows that the learned augmentation policies generalize well across different datasets, making it a more efficient and effective method for improving the performance of image classifiers. In another significant study, Sidra Aslam et al. presented a comparative analysis of various machine learning and deep learning models for image classification using the CIFAR-10 dataset [5].

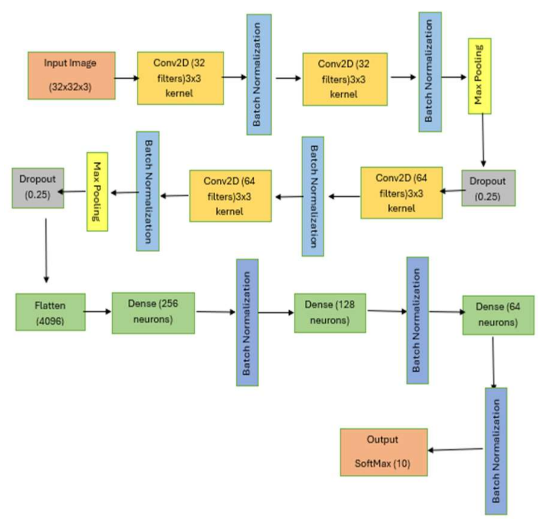
The study evaluated models including K-Nearest Neighbours (K-NN), Random Forest (RF), and Convolutional Neural Networks (CNNs) with varying filter sizes, along with VGG-16 and VGG-19 architectures. Their findings revealed that K-NN and RF performed poorly, while the proposed CNN model achieved an accuracy of 88%, outperforming VGG-16 and VGG-19, which attained around 61% accuracy. The authors suggest that future work could improve the performance of VGG models through parameter tuning and data augmentation. In the Comparative Study with CIFAR-10 Data by Vignesh Thakkar et al. explores the impact of batch normalization on deep learning models [6]. The authors conduct a comparative analysis of state-of-the-art convolutional neural networks (CNNs) such as DenseNet, VGG, Inception v3, and Residual Networks using the CIFAR-10 dataset. The study demonstrates that the inclusion of batch normalization not only improves model accuracy but is essential for training deep networks effectively. The paper further highlights that the use of Exponential Linear Units (ELU) as activation functions with batch normalization layers results in significant performance improvements, particularly in VGG and Residual Networks.

The paper "Dataset Condensation with Distribution Matching" by Bo Zhao and Hakan Bilen introduces an efficient method to reduce the computational cost of training large deep learning models by condensing datasets. Instead of using complex bi-level optimization, the authors propose synthesizing a smaller set of synthetic images by matching the feature distributions of the original and synthetic data across multiple embedding spaces. This approach is significantly faster, scalable to larger datasets like Tiny ImageNet and ImageNet-1K and requires minimal hyper-parameter tuning [7]. In the study of Do we train on Test Data? investigates the presence of duplicate images between the training and test sets of the widely used CIFAR-10 and CIFAR-100 datasets [8]. The authors discovered that 3.3 percent of CIFAR-10 and 10 percent of CIFAR-100 test images have near-duplicates in the training set, which can lead to biased evaluations and over estimations of model performance due to memorization. To address this issue, they created the ciFAIR dataset, where all duplicates in the test set are replaced with new images from the same domain.

Re-evaluation of various CNN architectures on the CIFAR dataset showed significant performance drops (up to 12 percent relative), revealing that state-of-the-art models may rely heavily on memorization rather than true generalization. The study highlights the importance of eliminating duplicates for fair benchmarking in machine learning research. The paper addresses the impact of spectral leakage in convolutional neural networks (CNNs). It identifies that small convolutional kernels commonly used in CNNs are prone to such leakage, which can degrade performance. To address this, the authors propose using larger kernels along with a Hamming window, which reduces spectral leakage by tapering the kernel edges.

This approach improves classification accuracy on datasets like CIFAR-10, CIFAR-100, and ImageNet, and enhances robustness to adversarial attacks. The findings suggest that incorporating signal processing principles like window functions can optimize CNN architectures and broaden their robustness [9]. The paper addresses the challenge of “robust overfitting” in adversarial robust training, a phenomenon where models lose robustness as training progresses. While adversarial training (AT) is a leading defence method against adversarial attacks, it tends to overfit specific disturbances of motion, diminishing the model’s resilience against broader, unseen attacks. The authors introduce technique smoothing the model’s weights with stochastic weight averaging (SWA), which promotes flatter minima and better generalization. These methods collectively enhance both standard and robust accuracy across datasets like CIFAR-10 and Tiny ImageNet, showing promise in stabilizing adversarial training and mitigating robust overfitting without relying on early stopping [10].

In the study of adapting very deep convolutional neural networks (CNNs), specifically a modified VGG-16 model, for image classification tasks on small datasets like CIFAR-10. Traditional deep CNNs are prone to overfitting on smaller datasets, so the authors propose several modifications: reducing the dimensions of fully connected layers, applying batch normalization to speed up convergence and control overfitting, and using strong dropout rates across layers.



These modifications allow the deep VGG-16 model to perform well on CIFAR-10, achieving an 8.45 percent error rate, without requiring a shallower or specifically redesigned model. The paper demonstrates that very deep CNNs can be effectively utilized on small datasets “with appropriate regularization and optimization techniques” [11]. The paper focuses on enhancing and classifying images from the CIFAR-10 dataset using a convolutional neural network (CNN) architecture. It introduces a novel approach that combines image enhancement and classification techniques to improve prediction

Fig. 2: Proposed Custom Convolutional Neural Network model suitable for efficient classification of Cifar-10classes

accuracy. Misclassified images from the CNN model are enhanced through adjustments in brightness, contrast, colour, and sharpness, making them clearer and more distinguishable. These enhanced images are then reclassified, aiming to improve the overall model accuracy in identifying the correct class labels for the CIFAR-10 dataset, which includes ten distinct classes. The proposed methodology leverages CNN layers for feature extraction, pooling, and dense connections, achieving an accuracy of 88.55 percentage after evaluation. [12].

3. PROPOSED APPROACH

The proposed approach is a deep convolutional neural network (CNN) specifically designed for the CIFAR-10 dataset, which consists of small color images spanning 10 classes. This model aims to achieve high classification accuracy by employing advanced techniques, including batch normalization, dropout, optimized weight initialization, data augmentation, and multi-layer dense networks. These features collectively address challenges such as overfitting, vanishing gradients, and slow convergence, commonly encountered in deep learning models.

A. Hierarchical Feature Extraction via Convolutional Blocks

The model utilizes hierarchical convolutional blocks to progressively capture fine-grained local details and broader global patterns. The early layers are designed to extract basic features like edges and textures, while deeper layers identify more abstract patterns such as object shapes.

The model comprises two distinct convolutional blocks, each containing multiple convolutional layers. The first block uses **32 filters**, while the second block scales up to **64 filters**, enabling the network to extract both low-level and high-level spatial features such as edges, textures, and patterns. These layers utilize **ReLU activation**, introducing non-linearity and ensuring the model can learn complex patterns. P**adding in the model** ensures spatial dimensions are preserved across layers, which simplifies subsequent processing. The convolutional layers are carefully configured with **32 and 64 filters**, a **3x3 kernel size**, and **ReLU activation** to extract meaningful spatial features. The padding ensures the preservation of spatial dimensions across layers.

B. Max Pooling for Dimension Reduction

Each convolutional block is followed by a **MaxPooling layer** with a 2x2 kernel. This operation reduces the spatial dimensions while retaining critical features, thereby lowering computational costs and improving generalization. **MaxPooling** layers down sample feature maps, reducing spatial dimensions and computational complexity.

C. Dropout for Regularization

Dropout layers are introduced after each pooling operation, randomly deactivating **25% of neurons** during training. This technique minimizes the risk of overfitting by ensuring the model does not overly depend on specific neurons, enhancing its ability to generalize to unseen data. **Dropout layers** with a rate of 0.25 are interspersed to randomly deactivate neurons, increasing robustness against overfitting.

D. Dense Block with Hierarchical Processing

Following the convolutional layers, the extracted features are flattened and passed through a **three-layer dense block**. These layers (256 → 128 → 64 units) employ **L2 regularization** to penalize large weights, further improving generalization. **Batch normalization** continues to maintain stability, while **He initialization** ensures faster convergence during training. The flattened output from convolutional layers is passed through compact, fully connected layers with decreasing sizes, simulating the behavior of a kernel adaptive network (KAN). This approach ensures efficient dimensionality reduction and robust decision-making.

E. Softmax Output Layer for Multi-Class Classification

A **10-unit dense layer** with **softmax activation** produces probabilities for each of the CIFAR-10 classes. This ensures the network outputs are interpretable and suited for categorical classification. This layer is initialized with **Xavier/Glorot Uniform**, balancing input and output variance for better weight initialization

F. Optimizer and Learning Rate Scheduler

In the proposed custom Convolutional Neural Network (CNN) for enhanced tiny image classification, the Adam optimizer and learning rate scheduler are critical for efficient training and improved performance. The **Adam optimizer** combines the benefits of **AdaGrad** and **RMSProp**, adjusting the learning rate for each parameter based on first and second moment estimates of the gradients. It adapts the learning rate during training, improving convergence speed and stability. Adam's update rule is:

$$m_t = \beta_1 m_{t-1} + (1 - \beta_1)\, g_t$$
$$v_t = \beta_2 v_{t-1} + (1 - \beta_2)\, g_t^2$$

$$\hat{m}_t = \frac{m_t}{1 - \beta_1^t}$$

$$\hat{v}_t = \frac{v_t}{1 - \beta_2^t}$$

$$\theta_t = \theta_{t-1} - \frac{\alpha \hat{m}_t}{\sqrt{\hat{v}_t} + \epsilon}$$

where g_t is the gradient, β_1 and β2 are moment decay rates, and α is the learning rate. Default values: β_1=0.9, β_2=0.999, and $\epsilon=10^{-8}$.

To further optimize training, a learning rate scheduler like ReduceLROnPlateau is used. It reduces the learning rate when the validation loss plateaus. The learning rate decay follows:

$$lr_{new} = lr_{old} \times \gamma_{epoch}$$

Where γ is the decay factor (e.g., 0.5), and the learning rate is reduced when no improvement in validation loss occurs for a set number of epochs (patience).

In the context of the proposed custom Convolutional Neural Network (CNN) for enhanced tiny image classification, **Softplus** is used as an activation function in place of traditional activation functions like ReLU. It is a smooth approximation of the ReLU function and can help improve training dynamics in certain scenarios. The **Softplus** function is a smooth and differentiable approximation of the ReLU function, defined as:

Softplus(x) = ln(1+ex)

Where x is the input to the activation function, the function outputs values close to zero when x≪0, and grows roughly linearly for large positive values of x, like ReLU.

G. Data Augmentation

Data augmentation is an essential technique to make the model more robust to variations in the input data. By artificially increasing the diversity of the training data, the model learns to generalize better to unseen data. In our approach, we apply the following augmentation techniques:

- Random rotations of up to 15 degrees.
- Horizontal and vertical shifts by 10.
- Random horizontal flips.

H. Callbacks for Enhanced Training

To optimize the training process, we employ several call backs that monitor the model's performance during training: EarlyStopping: This callback halts training if the validation loss does not improve for 5 epochs, restoring the model weights to the best state. It helps avoid overfitting and unnecessary computations. ModelCheckpoint: This callback saves the model with the highest validation accuracy, ensuring that we retain the best version of the model throughout training.

LearningRateScheduler: This callback dynamically adjusts the learning rate during training based on the validation loss. If the loss does not improve, the learning rate is reduced to facilitate smoother convergence.

I. Batch Normalization

In the proposed custom Convolutional Neural Network (CNN) for enhanced tiny image classification, **Batch Normalization (BN)** plays a crucial role in stabilizing and accelerating the training process by addressing several key challenges inherent in deep learning models. Batch Normalization (BN) is a technique used to normalize the activations of each layer in a neural network. It works by scaling and shifting the activations to ensure they have a consistent distribution during training. This prevents issues such as vanishing/exploding gradients, speeds up training, and improves model generalization.

Batch Normalization Equations:

1. Mini-Batch Mean:
   For a mini batch x1, x2, ..., xm, the mean is computed as:

$$\boldsymbol{\mu_B = \frac{1}{m}\sum_{i=1}^{m} x_i}$$

2. Scale and Shift:
   After normalization, we apply a learned scale γ and shift β

$$\boldsymbol{y_i = \gamma \hat{x}_i} + \beta$$

   where γ is the trainable scaling and β is the trainable shifting parameter, y_i is the output of the batch normalization for the i^{th} input.
3. Full Batch Normalization Transformation:
   The full batch normalization operation is:

$$\boldsymbol{y_i = \gamma \frac{x_i - \mu_B}{\sqrt{\sigma_B^2 + \epsilon}} + \beta}$$

$\boldsymbol{y_i}$ is the output of batch normalization for the i^{th} input. The proposed CNN architecture for CIFAR-10 classification incorporates several advanced techniques to improve model ac curacy and robustness while reducing computational complexity. The architecture includes multiple convolutional layers for feature extraction, max pooling for dimensionality reduction, dropout layers for regularization, and fully connected layers for final classification. Additionally, we use data augmentation to make the model more resilient to variations in the data, and we employ several call backs to optimize the training process. The combination of these methods results in a powerful model capable of achieving high accuracy on the CIFAR-10 dataset while mitigating common challenges such as overfitting and slow convergence.

4. EXPERIMENTAL STUDIES

In this section, we present a comprehensive evaluation of the proposed Convolutional Neural Network (CNN) architecture for image classification using the CIFAR-10 dataset. The experiments are designed to assess the model's Performance in various aspects, such as accuracy, time, and robustness to noise. The CIFAR-10 dataset, which contains 60,000 32×32 colour images divided into 10 different classes, was used to evaluate the model's ability to generalize and perform well across different categories. The dataset was split into 50,000 training and 10,000 testing images, maintaining the original class distribution. We primarily use zzz the model's performance across individual classes. The evaluation of the model involved testing its generalization capability, accuracy, and robustness to noise, with a focus on minimizing overfitting and computational complexity. Various aspects of the model's performance, including its efficiency in learning from the dataset and its ability to handle unseen data, were measured. Additionally, these metrics were computed across different categories to ensure that the model performs well across all CIFAR-10 classes.

Evaluation Metrics: We used classification accuracy as the primary metric for performance evaluation. Additionally, precision, recall, and F1-scorewere computed to assess the model's performance across different classes

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

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

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

$$\text{F1-Score} = \mathbf{2} \times \frac{\text{Recall} \times \text{Precision}}{\text{Recall} + \text{Precision}}$$

A. Hyper Parameters:

Several hyperparameters were fine-tuned to optimize the performance of the model. Batch normalization was applied after each convolutional layer to standardize the outputs, stabilize the training process, and accelerate convergence. To ensure effective weight initialization, the He initialization technique was used in combination with ReLU activation. The Adam optimizer was selected due to its adaptive learning rate, which combines the benefits of RMSprop ***and with*** **Stochastic Gradient Descent (SGD)**. The initial learning rate was set to 0.001, and a learning rate schedule was applied to reduce it by half when the validation loss plateaued for three epochs.

Batch Norm	Drop Out	Weight Initialization	Accuracy
✓	-	He Uniform	86.81
✓	✓	He Normal	84.92
✓	✓	Xavier Uniform	85.63
✓	✓	Xavier Normal	85.65
✓	✓	He & Xavier	85.65

Table I: Performance comparision of CNN models with different techniques.

To further prevent overfitting, a dropout rate of 25% was applied after each max-pooling layer. This ensured that the model did not rely too heavily on any specific neuron, encouraging it to generalize better. The loss function used was categorical cross-entropy, which is appropriate for multi-class classification tasks like CIFR-10. To mitigate overfitting and ensure the model converged effectively, early stopping was incorporated with a patience of 5 epochs. This technique monitored the model's performance on the validation set and halted training if no improvement was observed for 5 consecutive epochs. Additionally, model check pointing was used to save the best-performing model based on validation accuracy, ensuring that the model with the highest generalization capability was preserved.

Reference	Model/ technique	Accuracy (%)	Remarks
[1]	Deep CNN for CIFAR-10 Classification	82.59	Moderate performance with basic CNN
[2]	CIFAR-10 classifiers' generalization study	85	Focused on generalization performance
[7]	Dataset Condensation with Distribution Matching	85.50	Focused on dataset efficiency
[8]	Purging CIFAR-10 of near duplicates	86	General improvement from data refinement
[9]	Rethinking kernel size in CNNs	86.50	Enhanced kernel strategies for accuracy
[10]	Robust Overfitting Mitigation with Smoothening	86.80	Mitigating overfitting improved accuracy
[11]	Very Deep CNN with Small Training Samples	81.40	Lower accuracy due to limited samples
[12]	Image Enhancement and Classification using CNN	86.70	Preprocessing techniques improved accuracy
Our Model	Custom model for CIFAR-10 classification	87.03	Competitive with advanced techniques

TABLE II: Results Comparison with Literature

B. Experimental Outcomes

Table I presents a comparison of the performance of CNN models with different combinations of techniques, including batch normalization, dropout, and various weight initialization types. These configurations were evaluated based on the classification accuracy achieved on the CIFAR-10 dataset. Table I helps in understanding the impact of various configurations on the model's performance. Batch normalization was found to improve the accuracy, particularly when used in conjunction with weight initialization methods like He Uniform. Interestingly, introducing dropout generally resulted in a slight reduction in accuracy, but it helped prevent overfitting, which is critical for maintaining model generalization. The various weight initialization strategies also had a noticeable impact, with He Uniform providing the highest accuracy among the configurations tested.

C. Results and Observations:

Fig3 shows the training and validation accuracy over epochs. It indicates that both metrics steadily increase during training, with training accuracy slightly higher than validation accuracy, which stabilizes near 87%. This suggests good model performance with minimal overfitting.

Activation Function	Accuracy
Relu	86.52
TanH	82.30
Softplus	86.85
Softsign	82.07
Sigmoid	83.42
Selu	83.81

TABLE III: Performance Comparison with different Activation functions.

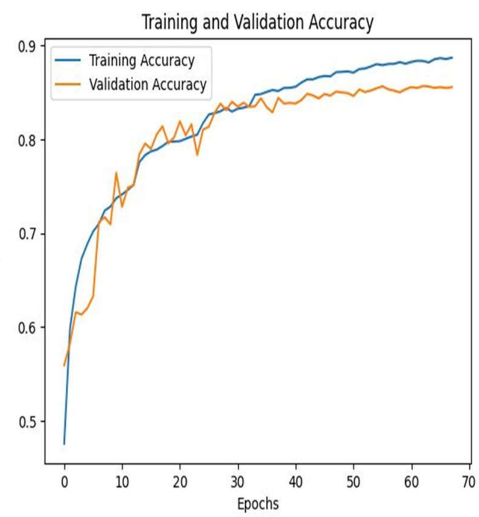


Fig.3: Training vs Validation accuracy

Table II compares the performance of the CNN model using various activation functions. The accuracy is measured on the CIFAR-10 dataset. As shown in the table, Softplus achieved the highest accuracy of 86.85%, followed closely by ReLU with 86.52%. Activation functions like TanH, Softsign, and Sigmoid yielded lower. accuracy, indicating that more complex activation functions may help the model converge better during training.

Table III compares the performance of the CNN model using different optimization algorithms. The accuracy results are provided.

Optimizer	Accuracy
Adam	81.44
SGD	85.65
RMS prop	87.03
Adamax	84.78
Nadam	86.54

TABLE IV: Performance Comparison with different Optimizers

From the table, it is evident that RMSprop yielded the highest accuracy of 87.03%, outperforming other optimizers suggesting that more advanced optimizers like RMSprop are better suited for this task.

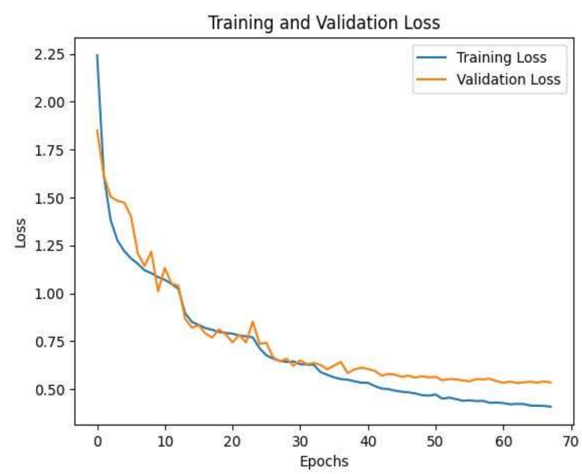


Fig. 4: Training vs Validation loss

Fig4 depicts the training and validation loss over the same epochs. Both losses decrease consistently, with validation loss stabilizing, closely tracking the training loss. This indicates that the model converges well, showing no major signs of underfitting or overfitting.

Table IV shows a comparison of CIFAR-10 classification methods from various studies, highlighting the accuracies achieved by each. Our model, with an accuracy of 87.03%, is competitive with several recent approaches, such as batch normalization and preprocessing techniques, while outperforming earlier CNN-based methods.

CONCLUSION

This study proposes a CNN architecture for image classification using the CIFAR-10 dataset, incorporating techniques such as batch normalization, dropout, and various weight initialization methods. The experimental results show that RMSprop optimizer and Softplus activation function achieved the highest accuracy. The use of batch normalization and dropout effectively improved model stability and reduced overfitting. Overall, the proposed model demonstrates promising results and provides a foundation for future research on optimizing CNNs for image classification tasks.

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AN EXAMINATION OF PATTERN RECOGNITION APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS

[1]Nemani Rajesh Babu, Associate Professor ECE Dept., Ideal Institute of Technology Kakinada
[2]Mortha Vara Prasad Assistant Professor ECE Dept, Ideal Institute of Technology Kakinada
[3]Vanumu Babitha, [4]Naidu Harshitha,[5]Vasamsetti Premanand Krishna Prasad, Immidi Abhiram
IV B.Tech ECE, [1,2,3,4,5]Ideal Institute of Technology, Kakinada
rajeshbabun641@gmail.com, varaprasad.mortha@gmail.com, vanumbabitha2003@gmail.com,
harshinaidu20@gmail.com,immidiabhiram03@gmail.com, premanandh.2002@gmail.com

ABSTRACT: **Artificial neural networks (ANNs)** have had considerable success in pattern recognition (PR) across a wide range of industries, including manufacturing. Despite significant progress in addressing ANN application to PR difficulties, some challenges remain unresolved, Including whimsical orientation (an unpredictable trajectory due to its directional location). Other challenges include object classification, localization, scaling, and neural networks. Hidden layer behavior analysis, rules, and template matching. Furthermore, there is a scarcity of literature on their research focus and progress in the field. The extensive study emphasizes the many features of ANN models' success and applicability in public relations. Many studies employ statistical methods to evaluate the performance of artificial neural networks (ANNs). MAPE, MAE, RMSE, and VAPE are some examples of error measures. PR tasks are well performed by current ANN models such as GAN, SAE, DBN, RBM, RNN, RBFN, PNN, CNN, SLP, MLP, MLNN, Reservoir computing, and Transformer. The study implies that for greater success in the field, both current and new models should be considered.

I.INTRODUCTION

Nonlinear statistical data models that mimic the function of biological neural networks (NNs) are called artificial neural networks (ANNs). The statistical pattern method has been the most been explored and applied in practice [2]. ANN models have shown promise [3], [4]. ANNs are gaining popularity for pattern recognition (PR) because to their effectiveness and efficiency.in numerous issues [5], [6]. Unlike traditional pattern methods, ANN may simply model difficult or multi-complexity problem Statistical methods cannot use information about pattern structures. The combination of two methodologies has sparked research interest, leading to a hybrid methodology. Nowadays, ANN models are preferred due to their superior performance in PR issues, even for difficult jobs. ANN is a versatile and successful function in public relations. PR is a computational framework for categ orizing raw data. Public relations use many ways to develop applications in diverse fields of endeavor. These approaches are feasible through intelligent imitation by humans. Similarly, the statistical technique cannot use information on pattern structures. Combining both methodologies has garnered study attention, resulting in a hybrid strategy. Nowadays, ANN models are preferred for their superior performance in PR challenges, especially with difficult assignments. ANN plays a unique and adaptable role in public relations, with exceptional effectiveness. PR is a computer approach for classifying raw data. Public relations use a variety of ways to develop applications across numerous fields. These ideas are practical due to clever human imitation.

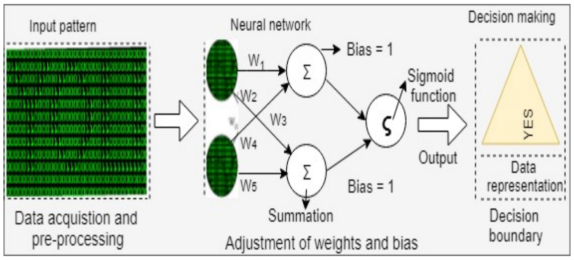


FIGURE 1: Information flow for PR using an ANN mode

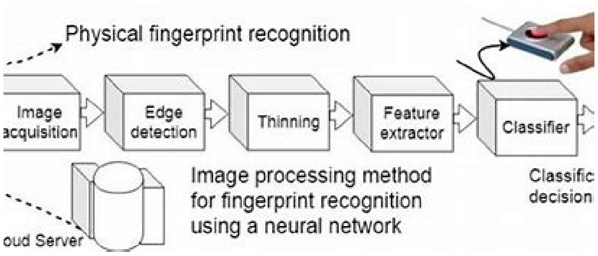


FIGURE 2: A technique for fingerprint recognition using image processing

A pattern refers to a collection of elements, objects, images, events, occurrences, circumstances, traits, or abstractions whose facets are clearly similar. Norbert Wiener defined pattern as an organization based on the sequence of features rather than the underlying qualities. [10]. In contrast, Watanabe referred to a pattern as "an entity" [10]. It can also be defined as the unique or recurring denominator among several samples of an entity. Fingerprint patterns can be defined by shared features in photographs. A pattern can be a fingerprint image, a human face, a handwritten word, a bar-code, an Internet website, or an audio signal.
Recognition involves identifying an object, feature, or event, as opposed to a web page or audio signal. Thus, this research identified the existing challenges of artificial neural networks. in PR. Similarly, it highlights ground breaking findings from investigations from a complete *inve stigation of the ANN application to PR. Furthermore, it* highlighted numerous authors' viewpoints on ANNs. Application for PR. It acknowledges the development of a self-activating public relations system. It targets advanced applications and innovation in recognition utilizing artificial Neuronal networks. Finally, it addresses the future technical prospects of ANN's submission to PR. Certainly, there are numerous types of Research sponsored to harness the potential of artificial intelligence (AI), which has led to a significant rise in recent times**.**

II. ANN PATTERN RECOGNITION TASK

Understanding how the brain processes information is applied to the PR task by ANN. Pattern interaction is specifically suitable for NNs. The functioning of an ANN offers a paradigm for achieving PR, which calls for extensive linked networks made up of simple, nonlinear units known as neural nets. Using a feed-forward, the PR task is accomplished. Information flow for PR using the, ANN model

FIGURE 1. ANN model information flow for PR.
Figure 2. Fingerprint detection using image processing technique.
neural network (FFNN) that underwent appropriate training [11], [12].
In Fig. 1, an ANN design for PR and signal direction is shown. An ANN model, like the FFNN, links input to output design throughout the training process. Networks provide output that is minimal from a given pattern and connects to a trained input pattern as a result. Figure 2 shows a cutting-edge illustration of an image processing technique for biometric identification and fingerprint recognition.
An array of numbers that can be controlled by a computer is created during the procedure by first capturing an image of the finger. Two of the prepossessing phases in picture enhancement, noise reduction, and, if needed, segmentation into portions are edge recognition and thinning.
A Convent, also known as a convoluted neural network, is a common ANN model used for the PR task. Typically used to analyse visual images, CNN is a class of deep feed-forward artificial neural networks (DFFANNs) [13], [14]. CNNs have three structural understandings:

temporal sub-sampling, weight replication, and shift, in-variance, and distortion.

Contrary to several other biometric identification methods, like fingerprint and face recognition, finger vein patterns are found inside the body and are therefore nearly impossible to replicate. As a more secure option to traditional finger vein recognition procedures, finger vein biometrics may be used. Due to the fact that finger vein biometrics are safe and impervious to alteration,

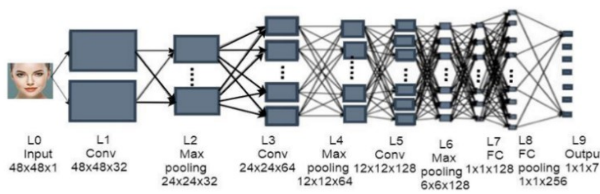


FIGURE 3. An example of facial expression pattern recognition with CNNs, where Ls stand for
layers

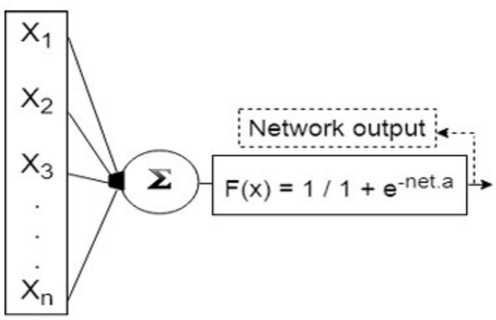


FIGURE 4: Pattern recognition using a neuron model

harm with time. To obtain high-level performance accuracy in image classification, standard anger-vein recognition algorithms require complicated image processing to remove noise, extract, and then enhance features.

In the modern era, CNN has experienced notable success in PR; one example is an experimental implementation of PR with CNN. Superior CNN design can be used for face expression [15] [17] or emotion recognition [18]. Figure 3 illustrates a more inventive way to use a CNN for picture identification. An analogous cell, resembling a neuron with sub-units, makes up the network model. A network like the one shown in Figure 4 uses a sample of these cells.

Numerous cell layers make up the multi-layer hierarchical network in a neuron model of PR [19]. Between cells in the multi-layer hierarchical network, there are forward and backward connections. The network may therefore be trained to find the optimal answer for a particular issue.

III. APPLICATION AREAS FOR PR AND PR DEVELOPMENT

Business, communication, automation, biometrics (facial, language, voice, fingerprint, gait, and iris recognition), and smell detection are among the areas in which ANN applications are used in PR. (voice, signal, credit application, e-nose, sensor network), defect detection in semiconductor manufacturing. Additional fields of expertise include handwritten (digital and letter or word recognition), image, bioinformatics, biotechnology, data mining, military, crime detection, credit fraud detection, terrorist recognition, interpreting DNA sequences medical diagnosis, fruit and vegetable detection, and forensic investigation. [23] [20]. The yield PR of crops and animals, the species PR of crops and animals, etc., are all beneficial areas for ANN [24, 27]. Applying ANN to PR can help with a variety of issues, including speech recognition, character handwriting, and medical diagnostics [28]. ANN is used in the PR process for data collecting and distant sensing tasks like bandwidth measurement, resolution, and physical variable measurement.

Preprocessing to post-processing are steps in the ANN application to PR process. Preprocessing is the process of removing anomalies from data, such as noise and separating patterns from individual items. The process of finding a new representation of the item known as features extraction, or FE, comes next.

As was previously indicated, classification occurs in PR. Thus, a feature application to assign a pattern is known as ANN classification. Learning ANN models might therefore be used to classify items based on recognized attributes. Following that, post-processing—or PR decision-making—occurs. When learning data analysis processes, stratification can aid in identifying the group of fresh data [29] [31]. A PR system divides the data set it receives into two sets: a training set and a testing set. Fig. 5 depicts the PR system design. ANN systems can, however, pick up useful knowledge from the training set. Nonetheless, during the operational or practical level, the system's efficiency serves as a monitor. Figure 6 shows a typical PR system component in an ANN.

The amount of data, the approach used, the designer, and the user are the three factors that affect the effectiveness of PR techniques. In PR, the challenge is to create a system that can manage massive amounts of data.

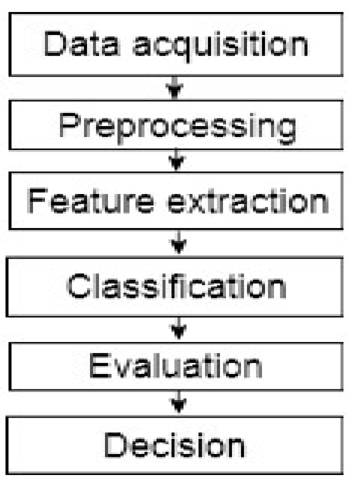


FIGURE 6. Components of ANN PR system

One way to address PR difficulties is to choose an analytical model, such as pretreatment or scheme. as well as the decision-making model or post-processing. Furthermore, it is crucial for ANNs to learn from a trained set of PRs and the intended output of PRs.

It's interesting to note that ANN can resolve picture restoration problems like compression and noise in images. Wei et al.'s and Dony and Haskin's research focuses on using image compression to improve images. Studies show that applying ANN models to picture compression is successful based on their experimental results. Similarly, ANNs are similar to FFNN in that they are useful in many agricultural remote sensing applications, particularly in crop type classification and crop and animal production estimation. Likewise, ANN models can be used to forecast agricultural data and products. and the estimation of animal output.

In order to find the contemporary path to success in business, industry, and many other areas of life, artificial neural network (ANN) tools offer a quick, easy, and straightforward approach to data analysis. ANN tools additionally offer across channels, products, and customer accomplishments.

Additionally, ANN tools contain data purification and give a firm the chance to address management challenges like enhancing financial crimes, materials, products, and services using current methods. Through PR, ANN is helpful in tackling the issues of crime detection and prevention [39]. With the development of digital media, technology, the Internet, and networked computers. expansion of the use of really amusing material software. Without a thorough understanding of the internal or exterior workings of a task, more success can be attained and the identification of unusual patterns while walking.

IV. PROBLEMS WITH PATTERN RECOGNITION IN ANN MODELS

Notwithstanding ANN's extensive history, there are still several issues with its application to PR. The inability to recognize intricate patterns, such as object classification, position, scale, and arbitrary orientation, was one of these issues. Nevertheless, prior attempts have been made to use convolutional neural networks (CNN) and image processing to solve the difficulties in PR tasks. More research is necessary to address these persistent issues of identifying intricate patterns in order to achieve greater results.
The usage of ANN in PR is accompanied by two issues. First, there are issues with ANN approaches, and then there are particular application issues.

A Current Issues Concerning Ann Techniques
These are the current issues with ANN techniques:

1) PROBLEM WITH DATA BEHAVIOR ANALYSIS

There is much more to learn and research on how ANN success in PR is affected by data behavior analysis, including speed, accuracy, performance, volume, fault tolerance, latency, convergence, and scalability.
The usage of ANN in PR is accompanied by two issues. ANN-related issues come first, followed by application-specific issues.

2) MONITORED CLASSIFICATION ERROR

Supervised artificial neural networks (ANNs) are widely employed to handle classification tasks, which can provide difficulties in certain instances. ANN pattern recognition requires supervised classification when there is an input. The only job in which the ANN recognizes patterns is the classification task [68] [70], which has not yet been effectively solved. Therefore, there is still a need for study in the field of ANN-supervised classification tasks.

3) PROBLEM WITH SCALING

In order for the inputs to be in a comparable range, normalization or scaling is necessary. When transposing the input variables to the data range where the sigmoid activation functions can sit, scaling can be quite beneficial. Tanh [1, 1] and lo stick [0, 1] are two examples.
With sigmoid and tanh activation functions, scaling becomes more significant. Nevertheless, when applied to the activation function during scaling, the sigmoid and tanh have diminishing gradient problems. But NNs do not need to learn to scale in order to work. Consequently, because ANN scaling problems are still unresolved, research is needed to find a solution [2].

4) NEURON BEHAVIOR ANALYSIS IN HIDDEN LAYERS PROBLEM

Another identified barrier to ANN implementation for PR is the difficulty of assessing the behavior of neurons in hidden layers. In other words, it can be difficult to interpret certain neurons' behavior in hidden layers or to analyze how well specific neurons work in those layers. On the other hand, if the action of neurons in buried layers can be effectively examined, it will aid in the identification of false classification. Data corruption or noise can be identified through the successful analysis of neurons' behavior in hidden layers Consequently, for improved success with ANN approaches for PR, further research is needed to address the issue of neuron behavior analysis in the hidden layers.

5) MANAGING THE PROBLEM OF HUGE DATA

A linked feed-forward neural network (FFNN) that succeeded in character recognition always has challenges with numerous variables to handle. In other words, FFNN struggles to handle a lot of variables with spectral representations of spoken words, or it has trouble processing huge data variables like photos.
For instance, if training data is limited or of huge size, a network with its first layer linked to ten hidden units may have multiple weights (up to 1,000), which could cause over-fitting problems. Over-ting problems, however, cannot always be linked to ANN as a whole. Likewise, the necessity for network memory for numerous weights may hinder specific hardware implementations and result in discrepancies.

Not all classes of FFNN models can be used for the PR job; only a subset of FFNNs can be applied to PR. The phrase "feed-forward" denotes an absence of reaction to data or pattern input. Neural models can learn or acquire knowledge through training by receiving feedback on inputted data, just like humans learn from activities. Feedback typically aids in the replication of input patterns. Feedback also eliminates errors or mistakes from input patterns or reduces them to a minimal degree; this increases and enhances the performance of neural networks. The auto-associative neural network is an enhanced network that can be difficult to build. Therefore, further research is needed to handle the difficult topic of error-free network building.

6) SMALL-LOCALE PROBLEM

When training a neural network (NN), a conventional approach like back-propagation is employed; however, this has a local minimal issue [5].
Auto-associative neural networks use back-propagation algorithms to accomplish tasks. In order to calculate a gradient needed for determining the weights found or employed in a network, backpropagation is a technique used in artificial neural networks. Back-propagation

paradigms' primary drawback, according to, is their propensity for local minima—that is, a decrease in value rather than an increase in value. Therefore, more study on back propagatio n networks or paradigms is necessary for more meaningful outcomes.

NNs can be trained using the "nature inspires" algorithm. Finding global optima is aided by this algorithm inspired by nature.

The learning procedure makes use of an algorithm. The genetic algorithm, for example, does a parallel search that can speed up computing.
Similarly, Tabu Search allows for an extensible Andro bus memory [5]. Weight optimization can be done by ant colony optimization (OAC). An improved cuckoo search allows for parameter flexibility to increase accuracy and speed.

7) PROBLEMS WITH LONG TRAINING TIMES

The majority of NNs require time to train toward
PR, and creating their structures can be challe nging, particularly for deep Anns. Consequently,
a time consuming and structural design difficult y part of the ANN that focuses on PR requires examination.

8)HIGH DIFFICULTY WITH COMPUTATIONA L COSTS

For both profit-making and non-profit organizations, cost is a critical factor. At the moment, cognitive computational intelligence such as robots, ANN models, or ML paradigms comes at a very high cost. Therefore, research must address the computational cost issues with ANN models [5].

9) PROBLEM WITH WEIGHT ADJUSTMENT

At the moment, weight optimization is required in order to find the appropriate output because weight adjustment in ANNs is a combinatorial problem. Weight adjustment techniques, including back propagation (BP) and certain non-iterative techniques, are necessary. NNs are typically trained using an initial set of parameters, weight, bias, and algorithm learning rate monitoring as a basis. It starts its learning process with an initial value, updating the weight with each iteration. The feature and weight adjustment problem made NN less suitable for data mining classification.

Over the years, these unsolved issues have caused ANN applications to experience delays in PR tasks. Though more studies may yield a meaningful solution in such areas, ANN technology is still developing. Despite the numerous issues and challenges with Anns' application to PR, ANNs have a great deal of potential, which gives them a significant edge over other models. Future research will need to analyze some weight adjustment difficulties, such as the gradient vanishing problem.

10) DECONSTRUCTING THE HUMAN BRAIN PROBLEM'S PATTERNS

Can computers read brain patterns? This is a worldwide unanswered question in machine learning (ML) and neuroscience. Future research on the application of ANN to PR may focus on this innovative concept. Decoding, crucially, reveals that information is latent in NN activity patterns, i.e., information exists in NN but has not yet evolved.

That being said, researchers consistently deduce that if the information is decodable, there is ample evidence that the information is represented by the activity patterns that served as the foundation for the decoding. It is possible to learn more about what a person is perceiving, thinking, remembering, or focusing on by analyzing their brain activity patterns.
ANN models can therefore be used to study how the brain encodes images or complicated, multicomplex abstract semantic information. Such mind-reading and brain-reading feats, if accomplished, will represent a significant scientific advance.

B. PARTICULAR ANN APPLICATION ISSUES TO PR

Let's now talk about a few specific ANN application or PR issues, such as

1.THE COMPLEXITY OF ORBITORY ORIENTATION

Even using ANN, the PR of an object with arbitrary or whimsical orientation is currently complicated. In other words, because of their direction, some items have an unknown route that is impossible to determine with accuracy. It's challenging for ANN to identify their pattern because of the uncertain directionality.

Arbitrary here refers to an undefined path, whereas orientation denotes a place that is directed.
Recognizing horizontal and near-horizontal texts has been the focus of the majority of ANN research to date, with the region of the object with an arbitrary orientation being ignored. In the field of human-computer interaction, text identification in real settings is becoming an increasingly important but difficult topic due to the rapid proliferation of smartphones and practical vision systems. The process via which an agent, such as a human, perceives and understands objects in the environment at the location of an event or action—busy streets, meadows, living rooms, etc.—is referred to as the natural scene. As a result, further study in the field of computational intelligence is needed to handle the complexity of an object's PR in every context and with any orientation.

2) TROUBLES IN OBJECT CLASSIFICATION

ANN is one of the most popular methods for classification. The practice of classifying things, products, or objects based on shared traits, attributes, and characteristics is known as classification. ANN can therefore perform the PR function for an item. Nonetheless, PR presents difficulties when an object's qualities are similar. These numerous characteristics may make it difficult to distinguish one object from another.
As a result, research is needed to distinguish an object with numerous similar features from one another. While back-propagation neural network (BPNN) can be used as a successful tool for data set classification of an object with likeness features in practice, the performance of the applied BPNN method is insufficient to accurately address the problem of differentiating an object with likeness features from one another. The data set classification is achieved in an object of likeness features with a toting combination of training, learning, and transfer functions.

3) IMPLICATIONS IN OBJECT LOCATION

One of the most important functions of learning in an ANN is an object analysis or location. The problem of object localization entails the timely extraction and processing of critical information from complicated and ambiguous object data. In this sense, The ANN application can assist in quickly addressing the human diversity in an object location.
For a significant outcome that will enhance an object location task, research must thus address this difference in object location in the hidden environment.

4) TEMPLATE AND RULE MATCHING

Moreover, rule and template matching types of paradigms involve ANN identification of pattern challenges. Learning skills are necessary for both template and rule matching algorithms, particularly when it comes to stock market prediction using PR of market price determining factors. Therefore, in order to achieve better results, more study in the field of template and rule matching algorithms is desperately needed.

5) IMPLICATIONS FOR SPEECH RECOGNI TION ACCURACY

Accurate speech recognition (SR) remains a challenge when using ANN. Also, as research has developed over the years, it has been discovered that one of the main research challenges in speech recognition, speech domain, speaking and language variability, noise recognition, and vocabulary volume or size required or used in speech is the accuracy of ANN in SR. Even yet, SR is a challenging issue to solve; nevertheless, a boost in any one SR accuracy can enhance the functionality of the system as a whole. Therefore, it is necessary to conduct additional research in the difficult field of voice recognition.

6) TROUBLES WITH RESTORING IMAGES

ANNs have noise in their image restoration when executing PR tasks, particularly when dealing with compressed images .
When utilizing an ANN for pattern identification, a noise-free image restoration is necessary. For this reason, greater study in the field of picture restoration issues using ANN application is required by motivated researchers.

7) DIFFERENTIAL IMAGE RECOGNITION

When one considers two photos that is substantially identical, one of the images may not be effectively identified. For instance, an artificial neural network (ANN) model, such as a deep neural network (DNN), might correctly identify or detect the first identical image but fail to identify the second.
As of right now, image restoration flaws or

issues are found in practically all DNN, according to research conducted by several Google researchers at universities in New York and Montreal. Therefore, more research is necessary to address this part of an image restoration problem and enable a practical solution that can be applied widely.

8. SURFACEMATERIAL IDENTIFICATION PROBLEM

An ANN's material recognition problem has been around for a while. As a result, ANN now has difficulties when it comes to materials in image recognition. Surface texture, illumination, geometry, and clutter are characteristics of real-world materials that make PR challenging for ANN to apply. Thus, another potential field of study for a motivated researcher is surface material recognition by ANN.

9) IDENTIFYING PREDICTIONS

Extending the capabilities of ANN to global phenomena is necessary when applying it to PR for natural incidences or other reasons. Recognizing router sign flooding threats in the next generation of IPv6 networks is one example of how an ANN technique is needed. NNs typically suffer from problems with scale, modularity, learning speed, architecture selection, and feature representation. So, further research is needed to address these aspects of ANN application to PR in natural incidents in order to provide a workable solution.

V. ANNMODELSAPPLICATION TO PR, NEW AND CURRENT

Feed-forward neural networks (NNs) such as reservoir computing, transformer models, generative adversarial networks (GANs), sparse auto-encoders (SAE), deep belief networks (DBN), radial basis function networks (RBFN), and single-layer and multilayer perceptrons (SLP) are currently performing exceptionally well in PR. Similarly, various classes of feedback neural networks (FBNNs), such as competitive networks, deep neural networks (DNNs), RBM, SOM, and Hop eld networks, are useful in PR.
Additionally, the use of recurrent neural networks (RNNs) and convolutional neural networks (CNN) is one of the current hot spots in PR employing ANN. The Kohonen self-organizing NN, also known as the self-organizing map (SOM), time-delay neural network (TDNN), and probabilistic neural network (PNN) are other novel fields.
The following is a description of several ANN models for PR:

A. GAN DEEP LEARNING FOR IDENTIFICAT ION OF PATTERNS

Generative adversarial learning deep neural networks (GALDNNs) are being used in an intelligent diagnosis paradigm that is getting more and more popular for PR in planetary gearbox faults. In the past, a lot of research findings that were acquired by Markov models were uninteresting and predictable.

Similarly, the pictures produced by variational auto-encoders lacked variation and were hazy. Nevertheless, as of right now, generative adversarial networks (GANs) are used to recognize patterns in sparsely available data after being trained with a small amount of data. GAN is being used in high-dimensional spaces like 3D modeling and for frame prediction in the future. Unsupervised learning is exemplified by the generative adversarial networks (GANs) conceptual approach, which does not necessitate expert knowledge feeding.

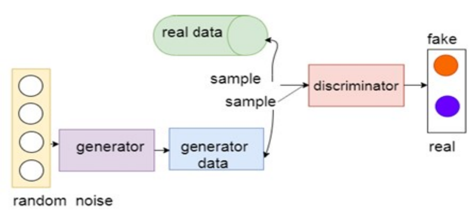


FIGURE 7: The typical GAN's architecture

The idea behind sample generation is a pre-existing dataset that doesn't need human involvement. The GAN flow of data is shown in Figure 7.
The generator model and the discriminator model, two NNs that are comparatively content in a zero-sum game environment, are the foundation of the structure that accounts for GAN success in PR.

Together, the two models are trained in an adversarial or hostile zero-sum game until the discriminator model is tricked roughly 50% of the time, indicating that the generator model is producing plausible-looking (fake) samples. The discriminator model attempts to classify samples as real (i.e., from the domain) or fake (i.e., produced), while the generator model is trained to create a new image. GAN is effective in PR because of its dual function as a generator and discriminator. Hence, GAN is a deep neural network architecture made up of two competing nets (hence the term adversarial).

In image-to-image translation and PR tasks like translating photos of the night today, or from one season to another like autumn to spring, or in generating photo-realistic photos of events, objects, items, and people that even humans cannot tell are fake, GANs are performing well and changing a field rapidly during the application. This fulfills the promise of generative models in their ability to produce realistic samples across a range of problem domains.

B. SAE FOR RECOGNITION OF PATTERNS
One unsupervised machine learning approach that employs backpropagation to set target values or outputs equal to inputs is the auto-encoder neural network (NN). One of the applications of autoencoders is the ability to transform any black-and-white image into a colour one. Similarly, autoencoders are employed to condense our inputs into a more manageable representation. The compressed data can be used to reconstruct the original data if necessary.

Sparse auto-encoder (SAE) has been applied in PR recently to improve human motion generalization performance.
An auto encoder is a type of artificial neural network (ANN) that is used to automatically learn data coding efficiency. Understanding an encoding (representation) in a data set is the goal of an auto encoder, especially for the reduction of dimension through

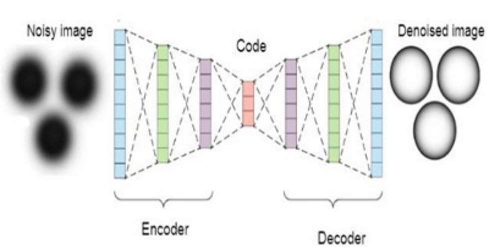


FIGURE 8. The standard SAE's architecture

network training disregards noise (signal). Fig. 8 displays the architecture of a typical SAE.
The trained support anchor extraction (SAE) is shown in Fig. 8, which reconstructs the original input image from the noisy version. Only the image's features are extracted by SAE, which also generates the output by removing any noise or disturbance from the system. The encoder layer in Figure 8 compresses the noisy input image into a lower-dimensional compressed presentation.
The network's code layer—also referred to as the bottleneck—displays the compressed image that is fed into the decoder. The encoder image, which is noisy, is converted back to its original dimension (denoised image) by the decoder layer. Auto encoders did in fact automatically learn from examples.

Consequently, it is simple to train an algorithm that performs significantly on a given input. A deep sparse autoencoder was used in the 2014 study by Liu and Taniguchi to extract low-dimensional features from high-dimensional motion or human action data that effectively capture the characteristics of individual motion. The SAE ideal has gained popularity recently for generative models' data learning [119]. SAE in DNNs was one of the most reliable ANN models in 2010.

C. DBN FOR IDENTIFICATION OF PATTERN
Deep belief nets (DBNs) are being applied to a wide range of issues, from picture and audio classification to speech recognition and language interpretation, according to recent studies [122]. Fig. 9 depicts a typical DBN with circles and arrows indicating the flow of information among restricted Boltzmann machines (RBM).

Fig. 9 illustrates how stacked restricted Boltzm ann machines (RBM) are used to create DBN. Every RBM is a two-level model with both visible and hidden layer units. DBN, a generative graphical model or type of DNN in machine learning (ML), is made up of several layers of hidden units (latent variables) connected to one another. The units in each stratum do not, however, connect to one another. DNNs and DBNs are a subset of each other; the main distinction between the two is how the tasks are trained. It is beneficial for DBN to pre-train when the training set is small.

DBN is currently applying, with notable succes s, for natural language understanding. In

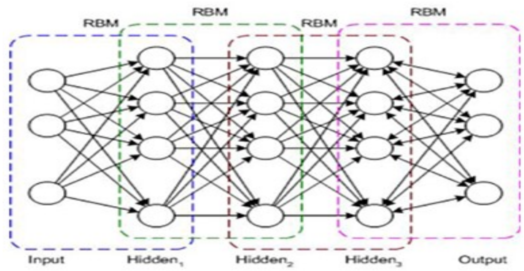


FIGURE 9. A standard DBN that illustrates the information flow between RBM.

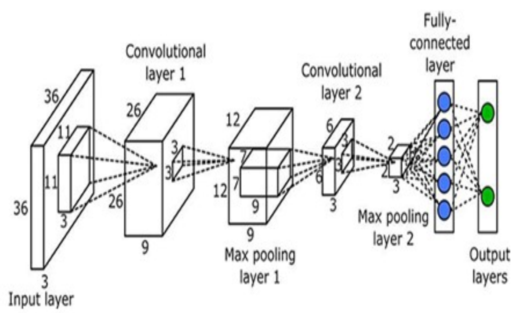


FIGURE 10. A CNN architecture.

D. IDENTIFYING PATTERNS WITH CNN MODELS

Convolutional neural networks (CNNs) have many uses these days in image and video recognition, processing of recommender systems as well as natural language .

Additionally, CNN is well-known for their speech recognition software. and distant voice recognition, which has led to improved in comparison to the DNN. CNN fared quite well in the image data, regression, PR, and classification. Still, generally speaking, CNNs operate well with spatial data and its adaption We have shown the most precise outcomes in addressing -world issues. Fig. 10 depicts the CNN architectural layout.

A two-dimensional matrix or eld is the typical CNN input, as seen in Fig. 10. Furthermore, by changing it to be one-dimensional, it can create an internal representation. a one-dimensional order statement. One extraordinary advancement CNN's strength is in its ability to provide enhanced precision and because of its unique characteristics, such as local communication as well as shared weights.

CNN is unexpectedly better at achieving success in applications than other deep learning algorithms, especially in computer vision and natural language processing, because it can mitigate most of the typical challenges, CNNs usually do not function very well when input data depend sequentially on one another. CNNs can achieve state-of-the-art outcomes on problems like as text or document categorisation utilised in sentiment analysis and related challenges. At the moment, CNN is useful for input data that is text, time series, and sequence.

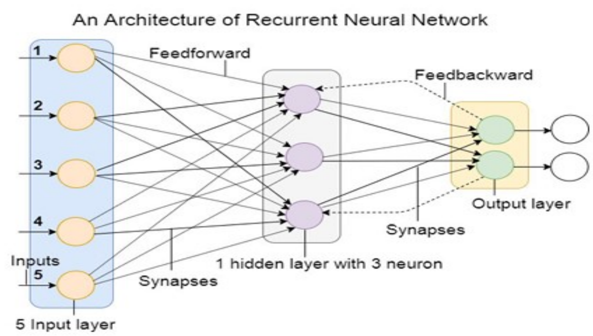


FIGURE11:- An example of an RNN structure

The CNN's capacity to simultaneously extract features, decrease data dimensionality, and classify inside a single network structure is a major benefit over traditional methods. Additionally, because CNN to noise has a strong ability to detect noise during image capture, the CNN approach requires very little image preprocessing.

E. RNN MODELS USED FOR PATENT RECOGNITION

Recurrent neural networks (RNNs), useful tools for PR, can be well suited to powerful sequence learning problems.

RNNs have proven to be highly effective predictive engines and pattern recognisers, particularly in sequence machine learning applications like speech recognition. Because RNNs are so proficient at both PR and forecast accuracy, no algorithm can consistently match them. RNNs have feedback loops in their recurrent layer. They are able to retain information for longer as a result.

The training of ordinary RNNs to address issues requiring long-term temporal dependency learning can be difficult, though. This results in an exponential decline of the loss function gradient over time, a phenomenon known as the gradient vanishing problem.

One type of RNN that uses specific units in addition to regular units is the long short-term memory (LSTM) network. Long-term knowledge retention is facilitated by the components of LSTM units. Fancy RNNs are another term for LSTMs. But there is no cell state in Vanilla RNNs. At the moment, all they have are hidden states, which serve as the memory of RNNs. Fig. 11 illustrates an RNN's structure. The interdependence of the FFNN components is shown by the arrows in Figure 11. In sequence learning tasks, RNN has demonstrated impressive efficacy. Both timing and speech recognition accuracy are examples of the application to PR that has been successful. In a recent study, Wu, Ding, and Huang [129] applied RNN to develop a unique defect prognosis approach based on equipment degradation sequence. Aircraft turbofan engine health data was used to test the suggested method's performance. According to the results, the RNN can function effectively in one-step, long-term, and remaining useful life prediction tasks.

In terms of PR, CNN is now doing exceptionally well; their use of facial expression design is excellent. When a character needs to be normalized, the input plane finds, identifies, and verifies the character image. The units in the layer above then provide inputs to the layer unit. In order to manage minimal preliminary processing, CNNs leverage the MLP's variability. CNNs are also known as shift variant (SVANNs) or space invariant ANNs (SIANNs) due to their similar weight design and invariance behavior. The simplicity of usage while implementing CNNs is one of their main benefits.

ANN was suggested for medical assessment by Mamuda and Sathasivam. The result shows that the high correlation between the expected output and the target has a mean square error. According to Lee KY, Chung, and Hwang's investigation using NN, medical challenges might be predicted with significant variability using NN. According to Dicky et al.'s research, ANN can recognize various features in the eye iris.

In their study on drug discovery using NN, Cheng and Sutaria show how learning may be applied to a PR system to detect and predict diseases. The study suggested NN that manages difficulties in intricate PR. Because ANNs are beneficial in medical classification, Cheng and Sutaria concluded that further research on their use to drug discovery is possible.

Aganovic and Beresford's study [136] employed supervised neural networks (NN) to address a pharmaceutical problem as an alternative to the conventional surface technique. The outcomes are remarkable. A medical problem was solved by Christodoulou and Patti chis using NN; the results reveal 97.6% accuracy compared to 95.3% success from another statistical model utilising the same dataset. Learning about the category of motor unit action potentials (MUAPs) in electromyographic (EMG) data allows the unsupervised PR to identify neuromuscular diseases.

Patients' test results, treatment cases, and symptom data are just a few of the medical elements that an instant physician trained auto associative memory neural network (NN) has recently been taught to store Following training, a collection of symptoms was generated by the neural network (NN). The results demonstrate methodically that NN finds a complete pattern that consists of the optimal course of action and diagnostic procedure for any given medical problem.

A study conducted in 2017 by Alexey et al. [140] trained CNNs to produce images from items based on the colour, viewpoint, and style of the objects. According to the outcome, PR duties including the creation of photographs with specific attributes like lighting information, perspective position, and high-level style can be accomplished using supervised trained CNN. A network that has been trained on generative tasks can produce training samples and pick up general presentation. In order for a network to seamlessly transition between different object views or object instances in a meaningful image, generic implicit representation is helpful.

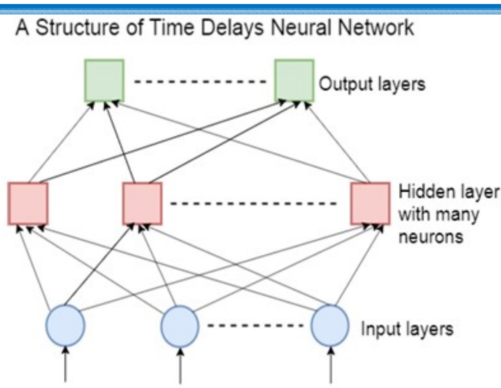


FIGURE 12. A structure of time delays neural network (TDNN).

F. PNN MODELS FOR PATTERN IDENTIFICA TION:

The aporobabilistic neural network (PNN) is one kind of four-layer feedforward neural network (NN). The four layers are the input, the hidden, the pattern/summation, and the output. A Parzen Window and a non-parametric function are used to represent each class in the parent probability distribution function (PDF) of the PNN algorithm. The PDF of each class can be used to estimate the new input class probability, and the Bayes rule is used to assign the highest class of the posterior probability.
The Bayesian network (BN) and the statistical technique known as Kernel Fisher discriminant analysis were the sources of PNN. It is often useful in public relations and classification.

G. TDNN MODELS FOR THE DETECTION OF PATTERNS

A common feedforward architecture that can identify characteristics in sequential input independent of arranging position is the time-delay neural network (TDNN). Delays are incorporated into the input to evaluate several data points in order to achieve temporal shift invariance. Usually, a more comprehensive PR system is included in this analysis. Another type of data classification method that has been well-known for a long time is TDNN. It is extensively used in speech recognition, image sequence analysis, and stock market prediction due to its exceptionally high performance on time series. A common representation of the TDNN structure is shown in Fig. 12. A time delay NN with few tap delays lines as its input is shown in Fig. 12.

Furthermore, when it comes to implementing embedded systems, it may be more efficient than decision trees. Examples of embedded systems include digital cameras, video game consoles, mobile phones, GPS (global positioning system), MPEG (moving picture experts group) players, and DVD (digital video disc) players. MPEGaudiolayer3 is another name for MP3 players. Dishwashers, washing machines, and microwave ovens are examples of

embedded household systems. Therefore, the majority of industries using embedded systems include consumer, automotive, police, military, medical, and commercial applications that offer efficiency, features, and flexibility.

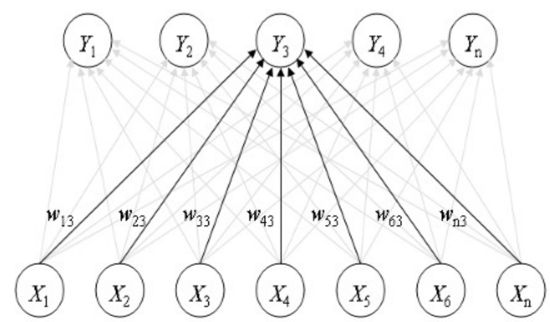


FIGURE 13. A SOM network's architecture

H. RECOGNITION OF SOMFORPATTERNS

Self-organizing maps, also known as Kohonen self-organizing NNs, or SOMs, are effective tools for multidimensional data analysis and PR .An example of a self-organizing network with ve cluster units is displayed in Figure 13. The ve cluster units are arranged in a linear array with Yi, which has seven input units, Xi.

Every weight w in the SOM network represents a specific input. Neural input patterns are revealed to each neuron simultaneously. SOM is a type of ANN that trains through unsupervis ed learning. Through a process known as dimensional reduction, it produces a discretized low-dimensional representation, or map, of the space input of the training samples. Remarkabl y Both supervised and unsupervised SOM networks are possible.
Changing a neural network's weights without taking into account the need to define the output for particular input patterns is known as unsupervised learning. The benefit is that it

makes pattern connection possible, which helps the network find its answer and become more efficient. Users or other programs must consider how to interpret the reduced output, which is the primary drawback.

PATTERN RECOGNITION USING A TRANSF ORMER MODEL

An ANN model called a Transformer, which uses a number of concepts and methods, has proven successful for common tasks in natural language processing. Transformers are one type of NN architecture that has been becoming more popular. In sequence-to-sequence recognition tasks, a transformer is designed to manage long-distance interactions between input and output with attention and recurrence. In tasks like text-to-speech conversion and speech recognition, an input sequence must be transformed into an output sequence. Recently, Open AL and DeepMind both used transformers in their language models for Alpha Star.

J. RBM MODEL FOR IDENTIFICATION OF PATTERNS

A limited Boltzmann machine (RBM) is a generative stochastic artificial neural network (ANN) that is capable of identifying a probability distribution in its input set. We have identified applications in quantum physics, dimension reduction, cooperative filtering, modelling, classification, feature learning, images, and more. They may receive instruction with or without supervision, depending on the assignment. However, connections in hidden units are possible for unrestricted Boltzmann machines. The restriction enables more effective training paradigms, particularly the gradient-based contrastive differentiation paradigm, in contrast to the general class of Boltzmann machines. RBMs are used as building blocks in multi-layer learning systems called deep belief networks (DBNs). Numerous PR initiatives have made use of RBM extensions and variations.

K. APPLICATION FOR HOPFIELD NETWORK

The majority of NN models fall within the scheduling, allocation, and management of resources business domain. The application of the ANN model in business includes accounting and financial analysis. Hopfield-Tank networks and other neural networks (NNs) could be used for scheduling and optimization. According to one experiment, NN successfully learned pattern features and properly identified patterns [2]. These days, ANN is being used in the stock market quickly for technical trade analysis in the securities exchange, associated industries, and stock industry [2].

L. DIRECT REINFORCEMENT AT A DEPTIME

Deng et al. [153] recently presented deep direct reinforcement learning (DDRL) for trading and financial sign representation, with successful results for stock market operations. A similar investigation was conducted by Gokcen et al. who applied NN to the price trend of the stock market. With a Mean Average Percentage Error (MAPE) estimate of 3.38, the result indicates PR. Qiu, Song, and Akagi's 2016 study on the stock market using ANN shows how good PR is at predicting stock market returns.

M. APPLICATION OF HYBRID NETWORK MODELS

Tan presents a hybrid financial system that makes use of ANNs, genetic algorithms (GAs), chaos theory, and statistical models. When compared to other techniques utilizing the same dataset, the outcome demonstrates that ANN was more effective in PR intrusion detection.

An important part of the energy management system (EMS) is system load forecasting. ANN was previously used to forecast the load on the electric power grid. Recently, load forecasting has been identified as an area in electrical engineering that needs further research to be improved. Dai and Wang suggested using artificial neural networks (ANNs) to forecast the short-term loading system in order to increase the accuracy of EMS short-term load forecasting. Thus, the operation, control, and planning of the EMS are greatly impacted by the implemented ANN.

Similarly, patterns with forecasting accuracy are found in trained ANNs. Further more helpful in safety, planning, economy, and EMS operation is load forecasting. ANN is also helpful for planning, load management, generating unit start-up and shutdown schedules, and power system maintenance.

N. COMPUTERS IN RESERVOIR

A framework for cognitive computing is reservoir computing. that may be interpreted as Anns' expansion Typically, an input is sent into a random or fixed dynamical system known as a reservoir and the reservoir's dynamics assign a higher dimension to the input. Next, a basic readout mechanism is taught to interpret the map and reservoir conditions. it to get the intended results. The primary advantage is that instruction is only after the readout stage is reached, and the reservoir is fixed. Liquid-state devices are liquid-state computing examples. (LSMs) and networks with echo states (ESNs). The analogy of putting a stone into a stable body of a liquid, such as water, is where the word "liquid" from liquid-state devices originates. The liquid may ripple as a result of the stone falling.

A spatiotemporal pattern of liquid displacement, or ripples, has been created from the input, which is the motion of the falling stone. A type of NN known as LSM is made up of a sizable number of units, also known as neurons or nodes. Every node gets input from external sources, or inputs, and from other nodes at different times. The connections between nodes are arbitrary. The time-varying input becomes a spatiotemporal pattern of activations in the network nodes due to the recurrent nature of the connections. Linear discriminant units read out the spatiotemporal patterns of activation. LSMs have the potential to clarify how brains work. For echo state networks (ESNs), for example. With a hidden layer that is just 1% linked, ESN is a recurrent neural network. The connections and weights of hidden neurons are fixed and randomly allocated. The network learns the weights of the output units in order to replicate particular temporal patterns. The interesting thing about ESN is that, despite its non-linear behaviour, the nodes that link the hidden units to the output units have weights that are changed throughout training. As a result, the error function and parameter vector are quadratic and easily differentiable into a linear system. A University of Michigan research team recently demonstrated the reservoir computing principles' effectiveness in a speech recognition challenge by implementing them onto a chip.

O. APPLICATION FOR MLNN

Artificial neural networks (ANNs) are a subtype of machine learning (ML). Supervised and unsupervised learning are the two types of machine learning. Machine learning neural networks (MLNNs), a subset of supervised learning (SL), use the information the model has learnt from the training dataset to classify images that have been tested. Machine learning has been revolutionised by a specific class of algorithms called neural networks (NNs), and PR has demonstrated that the most advanced deep neural networks operate very well. Machine learning has proven useful for uncovering hidden patterns in a variety of applications, including meteorology and satellite communication. In order to address the issue of signals that are unsuitable for satellite communication because of weather and rainfall attenuation, Abhishek et al.'s study employs artificial neural networks (ANN) to analyse rainfall and rain attenuation characteristics. A rain attenuation model using several NN topologies was developed by the Abhishek team. According to their findings, the applied ANN (machine learning) shows unique patterns in the hidden neurones of the NN topologies. The technique demonstrates the effective use of artificial neural networks (ANN) in microwave satellites to predict rain attenuation.

Finally, Abhishek et al., the study pointed out that MLNN or MLANN algorithms perform than SLANN methods in terms of PR. Consequently, the MSE of the trained ANN decreases as input data increases. In a related study on safeguarding wireless sensor networks from susceptibility to failure connections and nodes, Swain, Kilar, and Dash found a hybrid metaheuristic NN-based multiple fault recognition framework in sensor systems (SS). The findings demonstrated that hybrid metaheuristic NN, FFNN model can identify composite flaws such as transient failures for sensor nodes and links, as well as intermittent, soft, and hard permanent faults, using PR approach. As of right now, a hybrid feedforward NN has significantly improved PR when used to estimate sediment load. Ghorbani et al. and Qasem et al. used ANN in a different study on evaporation to identify the trend of pattern in monthly evaporation in the humid and arid regions. The two evaporation investigations show that ANN offered distinct patterns for simulating evaporation. Ahmadi et al. used artificial neural networks (ANN) to uncover patterns in the impact of dynamic viscosity on heat transfer and fluid flow, with surprising effectiveness.

Recently, ANN has been used to effectively model rainfall and sugarcane growth using meteorological factors. Abidoye and Chan conducted research on property appraisal using AI. The study highlighted the need of using artificial neural networks (ANN) for property appraisal, particularly through pattern identification, instead of traditional methods. Crowdsourcing and active learning (AL) are effective, efficient, and successful PR strategies. In 2014, Vijaya Narasimhan and Grauman demonstrated live learning of object detectors that refine their models through crowdsourcing. Increasing recursion profundity can help achieve an image in the absence of new parameters for more convolutions. Attempting to achieve unrealistic short-term power system forecasting success. Dai and Wang used MLFFNN with the BP learning method to train samples. The test findings demonstrate effective load forecasting for a short-term power system.

P. DEEP RECURSIVE NETWORK APPLICATI ON.

To make PR training easier, Kim et al. created image super-resolution (ISR) in 2016 utilising deeply recursive CN (DRCN). The study showed that DRCN has up to 16 recursive layers with reused weight parameters that exploit large image contexts by using modifications like skip connection and supervision recursive. The DRCN technique can be applied to a number of image restoration problems, including denoising and artefact removal.

Q. DEEP NEURAL NETWORK EMERGENCE

Researchers in deep learning are improving visual tasks in a number of ways. In order to enhance PR, deep learning (DL) has been studied in a number of fields, including video creation and end-to-end tasks like parameter specification, upgrading, and structure. In public relations challenges, deep neural networks (DNNs) have demonstrated exceptional performance. Neurones in DNNs differentiate periodic base reinforcement instead of semantic items or components, as Dong et al. found in 2017. Because adversarial object designs in DNN visual research are so large and different from real visuals, there is no active organisation of codes for abstraction. Despite the fact that DNN visual description and appearance are homogeneous, this is different from earlier findings. According to Dong et al., neurones are able to comprehend basic ideas and match their representations with real and adversarial images. It is possible to represent some data without taking the order of structure into account. A reliable technique for image recognition with ambiguous data order is offered by Ryan et al. Additionally, the design makes use of a nested tick-breaking method, which allows data to remain anywhere at the node and be substituted indefinitely with limitless depth and width.

Additionally, the innovative inquiry employs many replacements and presentation methods to ensure data may be accessed by internal nodes without issues. The proposed technique can be used for picture clustering and text data modelling. NNs are increasingly being used in production to detect electronic problems. Murphy and Kagle used NN software to automate the process of recognizing electronic circuit boards in manufacturing. The study found that using a neural network reduces the time required to build a PR system significantly. Vellanki and Dagli used NN and knowledge-based systems to improve PR for circuit board assembly tasks. The results show that the NN model is effective for real-time component recognition tests. Jack et al. used FFNNs to handle inverse kinematics problems in robotics in three different scenarios. The study suggests that NNs can be a viable alternative for inverse kinematics estimation in robots because to their fault-tolerant and fast performance.

Effective tool wear management is crucial for various material removal or elimination procedures. D'Addona, Ullah, and Matarazzo found that artificial neural networks (ANN) and deoxyribonucleic acid (DNA)-based computers can detect tool wear. As a result, it forecasts tool wear using a series of photos. D'Addona et al. found that DNA-based computing (DBC) can identify patterns in processed photos, including likeness and dissimilarity. This work highlights the potential for combining DBC and ANN to solve complicated challenges. In a scenario where both PR and prediction are complex computer tasks that must be addressed simultaneously. Designing innovative products is crucial for success and

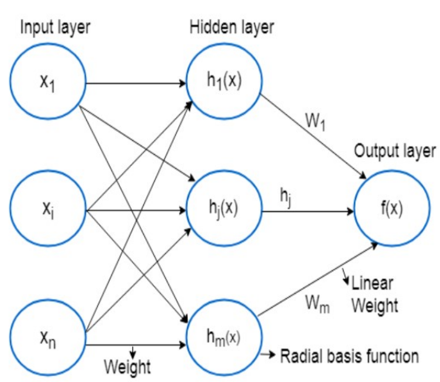
$$y_j = \sum_{i=1}^{n} w_{ij}x_i + \theta_j$$

sustainability in the manufacturing industry. In recent years, market competitiveness has been a fundamental motivator for creating high-quality products. In the sanitary ware industry, designing

$$f(x) = \sum_{j=1}^{m} w_j h_j(x)$$

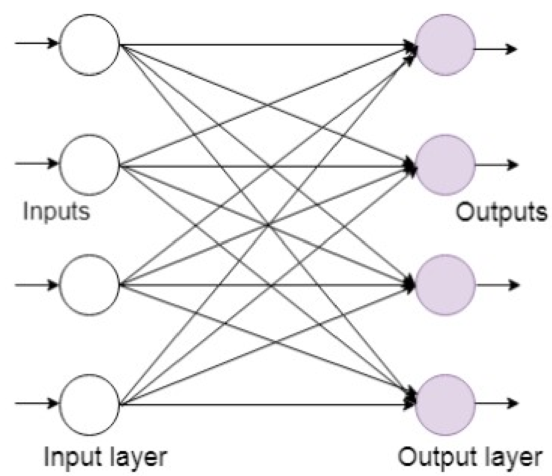
new goods takes significant time. Creating a new product involves a cost-effective procedure that includes strategy, marketing, design, and testing. Strategies are needed to reduce product design time, improve production, and enhance quality. Brahim, Smith, and Bidadi used a neural network (NN) to improve product design in many industries, including sanitary ware production. The results indicate that the NN model was beneficial for product design and testing.

Recent engineering study aims to forecast when



a component or system will malfunction. The advanced expertise in AI has assisted the

The application of artificial neural networks (ANNs) has expanded to include public relations. ANN has numerous applications as it delivers Solutions to Simple, Complex, and Multi-Complex Challenges. ANNs are great pattern recognizers. Robust classifiers] that are capable of generating while deciding on faulty data input. Recent AI research in deep learning (DL), reinforcement learning (RL), and combining the two shows promise for the future of ANN. The distinct qualities of artificial neural networks (ANNs) highlight their remarkable achievements. These unique properties include a vast parallel structure, the ability to store experimental information, strong connectedness to networks, self-organization, and a variety of human visual system features. There are numerous tactics involved with ANN PR. To improve the success of ANN

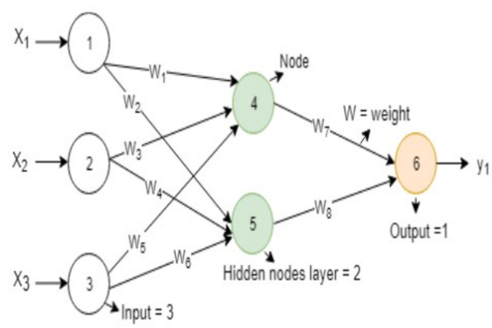


applications in public relations, researchers should identify and focus on specific difficulties. Recent AI research in deep learning (DL), reinforcement learning (RL), and combining (DL and RL) shows promise for the future of artificial neural networks (ANN) [195]. The unique qualities of artificial neural networks (ANNs) highlight their remarkable achievements. These unique properties include a vast parallel structure, the ability to store experimental information, strong connectedness to networks, self-organization, and a variety of human visual system features. There are numerous tactics involved with ANN PR. To improve the success of ANN applications in public relations, researchers should identify and address potential issues.

R. RADICAL BASED FUNCTION NETWORKS

An ANN that employs RBF as activation functions (AF) is called an RBFN .Input vectors with diverging parameters are accepted by RBFN. Neurone parameters and a linear mixture of RBF inputs are included in the network output. A real number vector is used to model the input for RBFNs. Three layers make up RBFNs: linear output (LO), hidden (HL) with nonlinear AF, and input (IL).

At least one feedback connection is a feature of RNNs, a kind of PR network.
Depending on their design, RNNs may or may not include concealed units, which is how they vary from RBFNs.



The structure of an RBFN can be expressed as

S.SINGLE-LAYER NEURAL NETWORK
One kind of feedforward neural network (FFNN) that works well in PR is the single-layer neural network (SLNN). There is only one input and output layer in single-layer FFNNs (SLFFNNs). A basic variant of the FFNN without any feedback links is the SLFFNN. Through a number of connections, the input is directly converted into the output. A single-layer perceptron, commonly referred to as SLFFNN, is shown in Figure 15.

The node calculates the sum of the inputs and SLFFNN weights. Perception is one instance of SLFFNN. A function that depends on inputs is frequently returned by perceptrons.

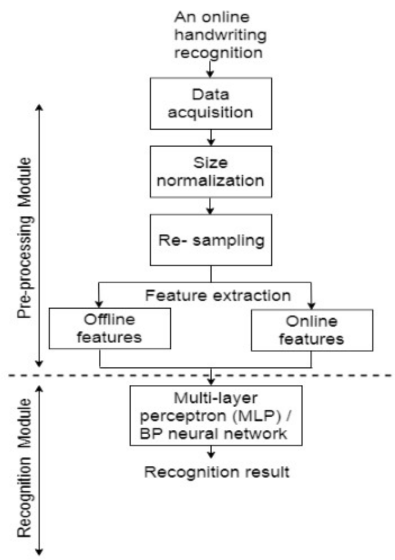
T.MULTILAYER NEURAL NETWORK.
One of the best feedforward neural networks (FFNNs) for PR is a multilayer neural network (MLNN). One example of an MLFFNN is MLP , which consists of a single input, one or more hidden layers, and an output layer devoid of feedback links. Multi-layer perceptions (MLFFNNs) are the neural networks that are most frequently researched and used in real-world applications. The drawback of SLFFNN is that MLFFNNs can manage non-linear learning jobs.

MLFFNN is depicted in Figure 16.

Figure 16 shows the construction of an MFFNN with 3 inputs, 2 hidden layers, and 1 output. The mathematical expression for node output in ANN computation is:

The parameter yi is transported to the next layer, node j, and the "n" refers to the number of moving edges to node j. The "xi's" denote the objects that enter the unit node, j, θj = bias node, j.

In 2001, Khadir and Ringwood [203] explored the use of feedforward artificial neural networks.



to PR for pasteurisation plant control forecasting. Pasteurisation plants provide choices for internal model complexity, prediction, and optimisation, according to the study.
The look of online MLFFNNs PR is shown in Figure 17.
The number of layers and nodes inside each layer determines the ANN topology. To precisely identify unknown or hidden input during learning, weights are added to each link or edge once the ANN topology has been established. Each task is given a weight using MLNBP.

In a BPNN learning algorithm, biases and weights are randomly assigned in the range [0, 1] before use.
The network generates output based on

current weight conditions, similar to human synaptic weights.
Output is compared to known good outputs, and the mean squared Error (MSE) was determined. The cycle is continued until the overall error falls below a predetermined level. The network will continue to learn the task effectively. The MFNN approach is highly adaptable in a nonlinear system, making it perfect for solving challenging PR jobs [204-207].

The distinction between SLFFNNs and MLFFNNs is based on the neural network models listed in Section V.

SLFFNNs and MLFFNNs serve as the foundation for most neural network learning models. Neural network models, including CNNs, RNNs, GANs, SAEs, DBNs, RBMs, TDNNs, reservoir computing, and Transformer models, are examples of feedforward and feedback networks used to solve specific problems. These networks are typically employed in supervised machine learning projects with a known target function.
The expected outcome of a network is crucial for practicing machine learning and is used in various commercial applications. These neural network models have a significant impact on computer vision and natural language processing applications.

The unique qualities of these NNs suggest that they can complement one other to solve problems that are beyond the capabilities of individual intelligent systems, with less complexity. Combining and integrating many models can strengthen each other and solve complex tasks, making it crucial for academics and practitioners to achieve their goals.

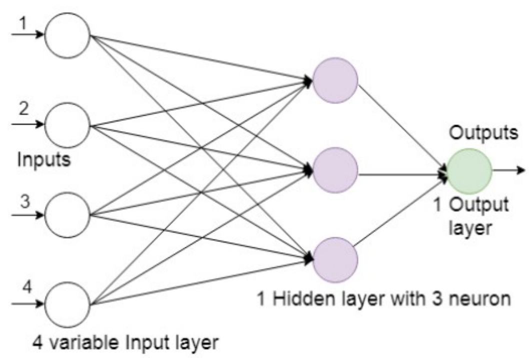
U. OVERALL REGRESSION THE NETWORK OF NEURALS

Another kind of ANN utilised for PR is the general regression NN (GRNN), which is a variation of RBF networks. Rising variables that converge to either linear or non-linear regression features are assessed by GRNN, a memory-based network. Moving from input to output in parallel, the GRNN is a single-pass learning paradigm [208]. GRNN outperforms back-generation on disordered representations. Neural networks perform better when they have more hidden layers. For neurones to adequately reflect the problem domain, they must be sufficiently massive.

Similarly, neurons must be tiny to generalize from taught data. Maintain a balance between network size and sizing complexity. Using tansig activation functions (TAF) for hidden and output layers can improve NN's picture recognition performance compared to other techniques [214, 215].

VI. A FEEDFORWARD NEURAL NETWORK.

The network is called feedforward because information flows in the forward manner. The variable x is used to calculate



The buried layer calculates an intermediate function, which is then applied to calculate y. Adding feedback from the last hidden layer to the first hidden layer results in RNN, as illustrated in Fig. 11.

A feedforward network aims to approximate some function f ∗. A regression function y = f ∗(x) converts an input x to a value y. A feedforward network defines the mapping y = f (x; θ) and learns the value of the parameters "θ" based on the best function approximation.

Multilayered Network of Neurones (MLN) is another name for feedforward neural networks (FFNN). The earliest and most fundamental kind of ANN model was the FFNN. Information moves without cycles or loops from the input layer to hidden layers and finally to the output layer in FFNN. Perceptrons, continuous neurons with sigmoidal activation for backpropagation, and binary McCulloch-Pitts neurons are among the units that FFNNs can employ. Recent inputs are not remembered by the majority of ANNs, including FFNNs. For pattern categorisation (PC), FFNNs, like MLP and RBF, are a common kind of ANN [211]. Three aspects determine the success of public relations strategies: the user, the design, the approach, and the quantity of data.

In public relations, the challenge is to develop systems that can handle enormous volumes of data. FFNNs, like the multilayer perceptron (MLP) with a two-layer pattern, do classification tasks while the output function is stepped; they perform regression tasks when the output function becomes linear. Many types of NNs are used for PCs, depending on the requirements of the application. In order to execute non-linear differentiable functions, feed-forward backpropagation neural networks (FFBPNN) are utilised. As the learning rate rises in FFBPNN, the convergence time falls [212]. FFBPNN does not work in areas where information is widely available. An example of an uncommon FFNN architecture is shown in Fig. 18.

Figure 18 depicts the FFNN network design, with a circle representing neurons in the ANN. ANNs allow for one-way transmission of information from input to output. During information transmission, there is no looping or feedback, and the output of one layer does not disrupt subsequent levels. In networks with interconnected inputs and outputs, information transmission is often unidirectional and uncomplicated.

All of the data in FFNN moves from left to right. The input layer at the bottom is not regarded as a true FFNN layer. The flow of information from left to right is seen in Figure 18. Nodes are represented by input, hidden, and output variables, whereas graph edges represent

adaptive parameters [208]. The FFNN analytic function can be expressed mathematically as follows: the output of the jth hidden node with a linear combination (LC) weight of "n" and input values "xi".

$$a_j = \sum_{i=1}^{n} ujixi + bj$$

Perceptron models act similarly to "logic gates", recognizing and discriminating to do specified tasks. A perceptron sends or does not send a signal based on weighted inputs. Another type of SLNN is the "single-layer binary linear classifier," which separates inputs into one or two groups. The hidden parameter "j" is found by transforming the linear sum of (3) with an AF g(·) to produce;

$$z_j = g(a_j)$$

Additionally, the hidden parameter LCs produce network outputs in the following format:

$$a_k = \sum_{j=1}^{m} vkjzj + ck$$

Variables {uji, vkj} represent weights, while variables {bj, ck} are biases. Biases and weights are adaptive variables in the network. Analytic function parameters have a one-to-one relationship with nodes and edges in the graph. Feedback neural networks (FBNNs) are dynamic, constantly changing states until they achieve stability. The network remains stable until the input changes, at which point a new stable point is identified. Feedback designs can be either recurrent or interactive. Recurrent feedback refers to interconnections in single-layer organizations, such as single-layer perceptrons.

FFNN is used with traditional machine learning (ML) approaches in areas such as speech recognition, visual imagery, and computer vision. Self-driving cars and Google are a common real-world application. An FFNN's application challenge is that a single layer of a bigger function may not learn or generalize properly.

Popular FFNN applications for PR include single-layer, multiple-layer, and recurrent NNs, as well as probabilistic, convolutional, and general regression NNs, SAE, GAN, and TDNN. Other feedforward Neural Network

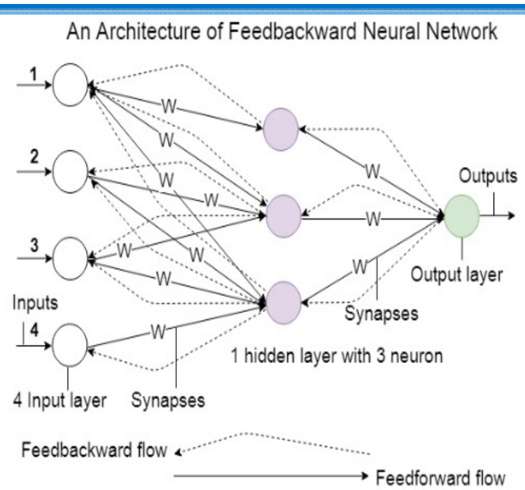


FIGURE 19: Algorithmic design of FBNN

VII. A neural network that feeds backward.

Two channels of information transmission are possible with ANNs: input to output and back.
Looping (feedback) takes place during the transmission of data.
This kind of network is known as a feed-backward neural network (FBNN) or backpropagation neural network. An artificial neural network (ANN) learns from errors and enhances its performance through feedback.
People can learn from their mistakes and achievements when they receive feedback. In a similar vein, an artificial neural network must learn this.

Neural networks (NNs) learn similarly to the human brain through feedback, known as backpropagation (or "backdrop"). The network's output can be compared against the intended output. Modifying network connection weights based on output disparities between neurons. The next step involves working backward from the output units to the input neurons via hidden neurons.
FBNNs, including the Kohnen network, are used for feature mapping and data clustering. Understanding the FFNN structure in Fig. 18 allows for easy representation of FBNN. Figure 19 depicts a typical architecture for FBNN.

Backpropagation, often known as backward propagation of mistakes, is a supervised learning approach for ANNs that uses gradient descent. This is a first-order iterative optimization procedure that finds the minimum of a function. The approach calculates the gradient of an ANN's error function based on its weights (Ws).

The FBNN algorithm flows input forward to learn and backward to maintain learnt information, as seen in Fig. 19. Backpropagation improves network learning by bridging the gap between expected and actual outputs over time.

ANN models analysis on application to PR from 500 articles.	Number of articles (%)
Recurrent neural networks (RNNs)	29.38%
Convolutional neural networks (CNN)	10.21%
Multilayer perceptron	8.0%
Single-layer perceptron	7.7%
Hopfield network	3.0%
Hybrid network model	2.6%
Deep direct reinforcement learning	2.3%
Sparse auto-encoder (SAE)	2.1%
Competitive network model	2.1%
Time-delay neural network (TDNN)	2.0%
Deep belief nets (DBNs)	1.9%
Generative adversarial networks (GANs)	0.6%
Probabilistic neural network (PNN)	0.5%
Transformer models	0.1%
Self-organizing map (SOM)	5.26%
Radial basis function networks (RBFNs)	6.95%
Restricted Boltzmann machine (RBM)	3.10
Deep recursive network application	8.0%
Machine learning neural network (MLNN)	2.1%
Reservoir computing	2.1%
Total	**100%**

TABLE 1: PERCENTAGE COMPARISON OF ANN MODELS FOR PATTERN RECOGNITION.

Performance ANN models analysis on application to PR	Accuracy	Accuracy (%)
Recurrent neural networks (RNNs)	0.8389	83.39
Convolutional neural networks (CNN)	0.8376	83.76
Multilayer perceptron	0.8356	83.56
Single-layer perceptron	0.8254	82.54
Hopfield network	0.8126	81.26
Hybrid network model	0.8976	89.76
Deep direct reinforcement learning	0.8879	88.79
Sparse auto-encoder (SAE)	0.8978	89.78
Competitive network model	0.8976	89.76
Time-delay neural network (TDNN)	0.7976	79.76
Deep belief nets (DBNs)	0.8978	89.78
Generative adversarial networks (GANs)	0.8996	89.96
Probabilistic neural network (PNN)	0.7576	75.76
Transformer models	0.8997	89.97
Self-organizing map (SOM)	0.8175	81.75
Radial basis function networks (RBFNs)	0.8353	83.53
Restricted Boltzmann machine (RBM)	0.8040	80.40
Deep recursive network application	0.8997	89.97
Machine learning neural network (MLNN)	0.7011	70.11
Reservoir computing	0.8353	83.53

TABLE 2:EXPERIMENTAL FINDINGS COMPARING ANN MODELS FOR PATTERN RECOGNITION.

To learn the precise or accurate output, the neural network reduces the gap between the two outputs until they match exactly.

A study found that over 80% of NN initiatives use BP to address various difficulties. MLANN with the BP algorithm is commonly employed to overcome rain attenuation challenges due to its effective training and PR performance.Feed backward neural networks (FBNs) commonly employed in PR research include RBM, SOM, Hopfield, RNN, reservoir computing, and long short-term memory (LSTM).

VIII.RESULTS.

Many research use statistical metrics to evaluate the effectiveness of artificial neural networks (ANNs). Statistical indicators were utilized to evaluate and validate the success of ANN models. The metrics used are absolute percentage error (MAPE), mean absolute error (MAE), root mean squared error (RMSE), variance of absolute percentage error (VAPE), and R-squared.

Table 1 shows a percentage breakdown of the 500 papers evaluated on the application of ANN models to pattern recognition. Table 1 identifies the most often used ANN models for pattern recognition, including recurrent neural networks (RNNs), convolutional neural networks (CNN), multilayer perceptron's, and single-layer perceptron's. However, this does not necessarily suggest that they are the best, as other updated models may do better.

New models such as GAN, SAE, DBN, and Transformer have been developed to solve drawbacks of previous models but have yet to be extensively used. Deep recursive network models are more often used in applications than GAN, SAE, DBN, PNN, and Transformer models. A comparison of experimental results on ANN models is presented, focusing on accuracy. Similarly, the experimental results for accuracy percentage are compared and displayed. Table 2 compares the results of each ANN model evaluated using different datasets from various studies on their use to PR. Table 2 displays the accuracy values of ANN models when applied to PR. The accuracy of an ANN model varies depending on the type of model used. The performance of each model varies depending on the problem being addressed. However, each model may be tested using

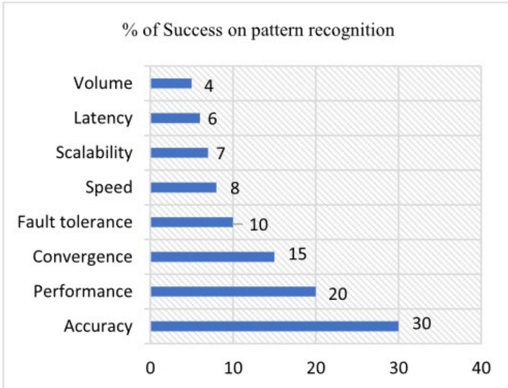


FIGURE 20: Articles classification on various data analysis influence on PR.

Using the same data for a problem can reveal one model outperforms others. Each type is practical and effective for its intended applications.

Results of Data Analysis Influence: For ANN applications in PR, this study assessed how data analysis affected data volume, processing speed, performance, scalability, latency, convergence, and fault tolerance. According to the analysis, accuracy-related issues accounted for almost 4/8ths of the probes. The remaining 1/8th of the publications discussed convergence issues when applying ANN to PR, whereas the rest (3/8ths) concentrated on performance issues. Convergence problems in the use of artificial neural networks to public relations are covered in about 15% of recent research. The corresponding values for latency, scalability, and processing speed were 6%, 7%, and 8%. The amount of data, however, received a score of 4%.

Mean absolute percentage error (MAPE) and mean were among the functions used to assess and validate the data in Fig.20. Variance of absolute percentage error (VAPE), absolute error (MAE), and root mean squared error (RMSE). ANN applications for PR are shown in the fields of Figure 21. Security, research, medicine, engineering, agriculture, finance, video and images, manufacturing, energy, the arts, business, and management are just a few of the fields in which the ANN has shown success [217]. Applications in public relations that have not yet been discovered are among the many advantages that ANN offers to humanity. Because many issues are interrelated, ANN can be used to a wide range of sectors, fields, and professions. Interested people and groups can explore gaps and areas of study to improve solutions and achieve greater success. A summary of the results of applying ANN to PR can be provided.

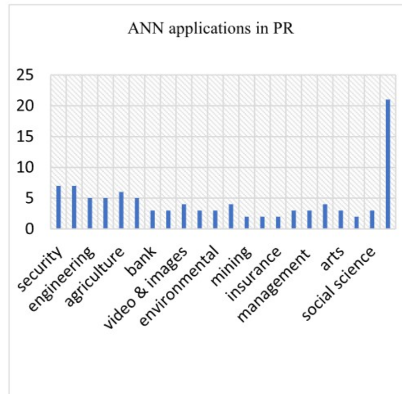


FIGURE 21: The framework of ANN application Pattern.

Field of ANN application	% score on ANN PR
Security	7
Science	7
Engineering	5
Medical science	5
Agriculture	6
Finance	5
Bank	3
Weather and Climate	3
Video & Images	4
Education	3
Environmental	3
Energy	4
Mining	2
Policy	2
Insurance	2
Marketing	3
Management	3
Manufacturing	4
Arts	3
Transportation	2
Social science	3
Other fields of application	21

TABLE 3: On ANN application to pattern recognition.

Table 3 shows the present usefulness of ANN in several sectors, including PR.
Table 3 shows that ANN has a wide range of applications beyond those listed. There are still many unexplored areas of ANN application, indicating potential for its usage in public relations. ANN's application to public relations has proven successful in various industries and disciplines. Various fields include medical science, computer vision, engineering, fishing, agriculture, graphics, arts, social science, manufacturing, business, management, security, and telecommunications.

IX. Discussion

Artificial neural networks and their rules have shown to be effective problem solvers in several applications. While FFNN propagation has greater potential for PR, BP NNs require methodical adoption during model creation to achieve optimal performance. PR varies based on pattern recognition, data type, and expected data volume. PR studies using various methodologies, including structural, statistical, template matching, fuzzy, and hybrid, can be compared to ANN models. ANNs are advantageous for statistical modelling since they do not require rigid organized designs and may function with incomplete data. However, there are other concerns that need to be addressed in public relations through ANN. DNNs have recently gained popularity in image recognition research. In comparison to statistical models, ANN models rely heavily on training data, sample presentation, and training procedures. To accurately recognize patterns, it's important to pick suitable features and use multiple classifier systems. ANN computational intelligence can address various challenges and reduce hazards. DNN's learnt features have proven to be more effective in public relations than handcrafted methods.

Recent research suggests that amino acids can effectively conserve carbon distribution through their unique bonding patterns, leading to improved PR results. While there is no current procedure for carbon distribution, it can still be a determining factor in PR. Researchers can look into employing carbon for PR as an alternative.

Table 4 shows a comparison of the study's findings to other cutting-edge research.

X. AREAS OF IMPROVEMENT IN THE ANNUAL APPLICATION TO PR

Other notable improvements in ANN PR include:
1. Data should be normalized before scaling to a range that matches the output layer's transfer function.
2. In understanding the actual model input. To compute input parameters, use computational methodologies such as stepwise model-building and cross-correlation analysis.
3. An HL is sufficient for network geometry decisions due to its practicality. Mathematical connections can be used to locate an upper level of HL nodes, resulting in an ANN equivalent relationship.

4. To improve PR in ANN, it's important to understand a network's character during parameter specification and training. This helps identify local minimums on the error surface.
5. Improve PR for ANN model validation, which is crucial for actual scenarios and standards in ANN applications.

XI. Research Opportunities and Future Directions.

(i) Further research is needed to identify the broader impact of ANNs on problems such as identifying complicated patterns with arbitrary orientations.
(ii) More study is needed in the ANN object classification problem for improved results.
(iii) More research is needed to address object placement issues while using ANN models. The study aims to improve the locational object problem.
(iv) Further study is needed to address scaling and normalization concerns with ANN models. One example is using the ANN algorithm without normalization.
Scaling or normalization may not be necessary for NN training, although it can aid in transposing input parameters to data. Some claim that normalization is not necessary for proper results.

(vi) More study is needed to improve the performance of ANN-based control chart PR, which has recently gained attention .
(vii) With global computing and social media connectivity, many web users enjoy sharing and analysing synergetic data online .ANN holds promise for cognitive cloud computing, particularly in data analysis and public relations.
(viii) ANN's ability to learn by example makes them effective, powerful, and versatile. AI has proven effective in various industries, including manufacturing. In order to facilitate quick decision-making, the study focusses on market price PR for housing machines in the estate industry as well as the procurement of goods and materials in the business and security sectors.
(ix) Domain scientists and industrial industries collaborate on research projects. The performance and success of artificial neural networks (ANNs) for pattern recognition in industry can be enhanced by scientists such as statisticians, computer scientists, IT specialists, and engineers. Like other scientific disciplines, astronomy is seeing exponential expansion in terms of data volume, complexity, and quality. Research emphasis is required to improve results in the data-intensive difficulties of astronomy.
(x) An adversarial strategy is used in the study to combat machine misreading of PR.
(xi) Future research will aid in the analysis of difficulties associated with the usage of the digital sky in virtual observatories. Operating star-galaxies with a variety of visual representation datasets is one example.
(xii) To enhance the choice of parameters for ANN design in PR, more investigation is required.
(xiii) The problem area in ANN applications for PR should be the main focus of future research. This includes practical pattern computation difficulties.
The biological and psychological components of information processing might need to be taken into account.

(xiv) Creating new models of artificial neurones that incorporate their learning principles, algorithms, synapses, associations, activation, and processing paradigm is essential for success in a variety of human endeavours.
(xv) To optimise the parameter selections for ANN design in PR, more investigation is needed.
(xvi) The problem area in ANN applications for PR should be the focus of future study. This involves challenges with pattern-computation in the real world.
Addressing the psychological and biological aspects of information processing can be necessary.

(xvii) Developing new models of artificial neurons, including their processing paradigm, associations, activation, synapses, learning rules, and algorithms, is critical for success in a variety of human endeavours.

Popular ways for securing networked systems against APT attacks include Support Vector Machines (SVM), random forest models, and Open Source SIEM. However, certain APT metrics have had limited success in practice.
More study is needed to identify APT patterns in networks and handle the challenge of detecting them over time in a victim system. Additionally, avoid data destruction and exfiltration from the victim machine.

Conclusion

Performance is the main topic of this summary, which also covers past and present PR trends. SAE, GAN, DBN, RBM, TDNN, reservoir computing, and the Transformer model were among the new advancements in the ANN model for PR that were discussed in the presentation. The current and previous developments of ANN models (CNN, RNN, SLP, MLP, and SOM) were covered. According to research, getting great results requires precise data transformation. Computational performance is significantly impacted by the temporal and spatial scaling of input data, according to research. Applications of ANN in public relations have expanded in scope and popularity during the past 20 years. This synopsis describes the reasons behind the use of ANN models in different PR applications as well as how they will soon be advantageous in many different industries. The best-performing models for upcoming applications can be provided by the thorough analysis, synopsis, and cognitive computational approach of ANN to PR, which addresses a number of PR-related problems. The recogniser is capable of handling simple, difficult, and multi-complex scenarios by utilising a variety of ANN models. More efficient solutions may result from developing a new model for a particular issue. The issues, problems, and goals of the research that have been highlighted are pertinent to the study of computer vision and natural language. Scholars may use this thorough assessment as a springboard to further their research in the area, especially when addressing the ANN problem. submission to PR. In a similar vein, novices in the field may find this method helpful as there are many topics and problem areas to investigate. The ANN application for PR, meanwhile, has a promising future across numerous industries and professions. Lack of data to compare results across comparable and different areas of evaluation is one study flaw. Similar to earlier research, this study employed statistical measures to assess and validate ANN performance.

ANN is increasingly used for pattern recognition in several disciplines, alongside other techniques such as structural, statistical, template matching, fuzzy, and hybrid approaches. Further study should focus on FFNN and FBNN models. More study should focus on popular ANN models such as SAE, GAN, CNN, DBN, RNN, RBM, TDNN, reservoir computing, SLP, MLP, and Transformer models.

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SMART HELMET

[1]K. Akshaya Sai Devi,[2]A. Rithvika Parvathi
Seshadri Rao Gudlavalleru Engineering College
[1,2]Sheshadri Rao Knowledge, Gudlavalleru, Vijayawada, Andhra Pradesh 521356
Saidevi1526@gmail.com,akularithvikaparvathi@gmail.com

ABSTRACT: construction sites pose significant risks to workers' safety, including the potential for head injuries from falling objects or accidents. to address these concerns, this research presents a cutting-edge solution in the form of a "smart helmet" tailored specifically for construction workers. this innovative helmet integrates advanced technologies such as IOT sensors, augmented reality (AR) displays, and communication systems to enhance safety and efficiency on construction sites. the smart helmet is equipped with a network of sensors that monitor environmental conditions, detect potential hazards, and relay real-time data to the wearer. this information is displayed through an AR visor, providing workers with crucial information about their surroundings, safety alerts, and project-related instructions additionally, the helmet features a communication system that enables seamless collaboration among workers, supervisors, and remote experts. this abstract highlights the transformative potential of the smart helmet in improving safety, productivity, and communication within the construction industry. by leveraging the power of IOT and AR technologies, this innovation aims to mitigate risks, reduce accidents, and enhance overall job site performance for construction worker.

1.INTRODUCTION

The construction industry is a cornerstone of modern infrastructure development, but it comes with inherent risks that jeopardize the safety of workers on a daily basis. Among the numerous safety concerns, head injuries resulting from falling objects, accidents, or unforeseen hazards remain a critical issue. To address these challenges and elevate the safety standards for construction workers, the concept of a "Smart Helmet" has emerged as a groundbreaking solution. In this era of rapid technological advancement, the convergence of cutting-edge technologies such as the Internet of Things (IoT), augmented reality (AR), and advanced communication systems has paved the way for innovative solutions that can transform traditional safety gear into intelligent and proactive tools. The Smart Helmet represents a prime example of how technology be harnessed to significantly enhance the well-being and efficiency of those working in construction sector This introduction serves as a gateway to explore the multifaceted aspects of the Smart Helmet for construction workers. It delves into the pressing need for improved safety measures in the construction industry, the potential of technology to revolutionize personal protective equipment, and overarching goal of this research—to create a smarter, safer, and more connected environment for the individuals build our world. This comprehensive introduction sets the stage for a thorough exploration of the multifaceted aspects surrounding the Smart Helmet's integration into the construction industry. It will delve deeper into the pressing safety challenges plaguing the industry, the key technological components that make the Smart Helmet possible, its potential to revolutionize workplace safety, enhance efficiency, and improve communication among construction teams, ultimately leading to safer, more productive job sites.

2.LITERATURE SURVEY

A literature survey helps you identify existing smart helmet solutions or similar technologies that have been developed and used in the construction industry. This information can provide insights into what has worked, what hasn't, and areas for improvement. There are some related works carried out on IoT Based Smart Helmet as follows:
Fan zihhong [1] proposed the “Quality and safety management of construction” projects are contradictory and consistent. To ensure the safety, the construction engineering safety management system should first be strengthened. Therefore, we introduced IoT technology to construction safety management and carried out in-depth research on practice and promote safety management of construction projects. V.Jayshree, M. Nivetha Kumari [2] proposed the “IoT Based Smart Helmet for

Construction Workers", To provide continuous monitoring of the workers and to prevent them from any health hazards during working, this system proposes a smart flexible helmet for the construction workers to provide security and rescue measures in case of any emergency conditions. The proposed system describes a smart inexpensive helmet for the construction workers made up of sensor.

Mangala Nandhini. V, Padma Priya G.V, Nandhini. S, Mr. K. Dinesh [3] proposed the, "IOT based Smart Helmet for Ensuring Safety in Industries", To provide Industrial safety is to5industry. Working environment hazards include suffocation, gas poisoning and gas explosion. Hence air quality and hazardous event detection is very important factor in industry. In order to achieve those safety measures, the proposed system provides a wireless sensor network for monitoring real time situation of working environment from monitoring station.

2.1. BLOCK DIAGRAM

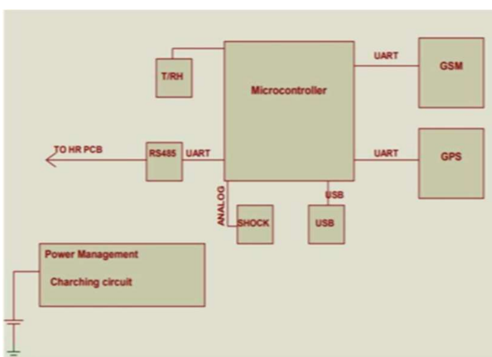

Fig 1: circuit diagram

In a smart helmet, a GPS sensor to locate the exact location of the worker and engineer, and two Arduino Uno boards are used on which codes are uploaded for the functioning of the helmet then two different buttons are used one for security as well as a smoke alert system. The hc12 module is used for the communication of the helmet with the system having another hc12 module. A smoke detector sensor is used for the health safety of the workers and engineers as the smoke detector can detect the harmful gases present in the environment and LED of three different colours is used all of them showing or notifying that the helmet is in an inactive state (blue), the helmet is in alert condition (red), the task is completed by the worker (green). The helmet is designed to be with three buttons installed in it and various components also like GPS, Smoke Detection, and Gas Detection, etc. in it. One button is installed on to and the rests two are on both sides. The button on top will reflect the safety and

emergency symbol whenever a little force will act on the top of the helmet, it will give the information or emergency alert with the location the supervisor so that the team will reach the labour easily and take necessary actions. The Second button installed on the right side of the helmet is used to give information to the supervisor for the completion of the specified task.

1.1 SPECIFICATIONS

S. No.	Colour of LED Light	Specification or Role
1	Red	Problematic Situation
2	Yellow	Wearing of Helmet
3	Green	Task Completion
4	White	While using machineries

2.2 PRINCIPLES OF SMART HELMETS

The main aim for developing the concept of the smart helmet was not only focused upon the safety of the workers and labours at the construction site, but also includes many aspects of the ongoing project at the construction site. The basic principles of developing IoT – based helmet is a three – fold dimension, focusing on Safety, Management and Efficiency.

The first principle includes the aspect of safety. Safety was the prime factor which was considered behind the idea of developing the smart helmet. It is designed for all the working – labour class at the construction site. These helmets will be having the same colour code which are being employed at the construction site presently, just with the addition of the concept of making it "smart", attached with different equipment such as sensors. These helmets are designed in such a way that if the worker is facing any kind of emergency, whether health related or work related, a different signal (in the form of LED) will be displayed on the screen, making it understand that one or many of the labours are facing problems. Due to which, if some accidents happened at the construction site, the person – in – charge can easily get notified and take the necessary remedial action to the earliest for the safety of the particular victimized labour. The second principle is management. Smart helmet plays an important role in managing different activities such as Time Management, Work Management and Labor Management at the construction site. All these three types of management are inter- related to each other.

2.3 RESULT

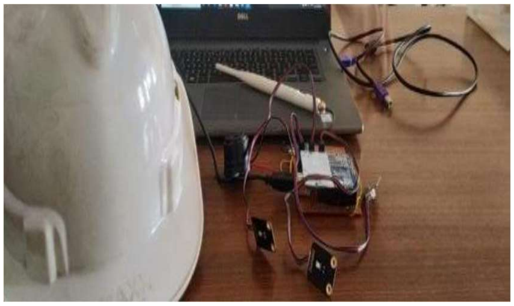

Fig:2: smart helmets

A smart helmet is a combination of the ordinary helmet with the latest technology as per the requirement of the construction site (Safety, Time Management, and Risk). At the Construction site, Helmet is the basic need for labour. For this investigation, an ordinary helmet is taken into consideration and modified it with the latest advancement to full fill the various requirements at the construction site like managing the time, the safety of labour, supervising the worker's activity, how much work is to be completed, about the activities which are going parallel, detection of various gases,etc. To full fill this entire requirement of the construction industry, the Internet of Things (IoT) is introduced in various projects which play an important role. Various components are installed in the ordinary helmet and connect all these with a single computer so that all the activities are to be supervised in a single computer. Now a day, everywhere there is a need for advanced technologies. And this smart construction helmet is formed with various technologies that were installed for the proper working and to create a better employment place. The construction industry growing very rapidly and gives the largest contribution to India's GDP. Construction is not only a contributor to India's growth development potential but It also gives employment to many people. It's the responsibility of the employer to provide safety to their employers and about the management of the various tasks at the site. The various major elements which are used to make the IoT based helmet for this study includes: 1. HC12 Module (oHC-12), is a communication module that is wireless serial and half-duplex with 100 channels in the434-472.6 MHz that can transmit up to 1.2 km, 2. A GPS Sensor, that helps in locating or finding the exact position, velocity, and timing with the satellite-based navigation system, Receivers with antennas are used to provide the information of time; the exact position, and the velocity are GPS sensors, 3. Arduino Uno of 14 digital input/output pins. Tone of the supporting elements may include smoke detector, which is used for the detection of gas leakage at home and industry. In this setup, Ga Sensor (MQ2) module is used. By smoke detector, various gases like H2, LPG, CH4, CO, Alcohol, Smoke, or Propane can be easily detected. Measurement could be taken instantly due to its response time which is at high fast and sensitivity. The potentiometer is used for the adjustment of the sensitivity of the sensor. Light-emitting diode (or LEDs) are used for the indication purpose where the signals have to be received. In the circuit of the helmet, a breadboard is used to test the whole circuit. It helps in testing the circuit in very little time.

CONCLUSION

In conclusion, smart helmets for construction workers represent a groundbreaking advancement in workplace safety and efficiency within the construction industry. These innovative helmets, equipped with a range of sensors and communication technologies, have demonstrated their potential to revolutionize the construction site landscape. By proactively identifying and mitigating potential hazards, enhancing worker well-being through fatigue detection, improving operational efficiency, and facilitating seamless communication, smart helmets offer a holistic solution to the multifaceted challenges faced by construction workers. While they have already shown impressive results in terms of safety and productivity, ongoing research, development, and refinement are crucial to fully their potential. It is essential to strike a balance between data collection for insights and the protection of worker privacy, ensuring that ethical considerations are at the forefront of implementation. In the broader context of the construction industry, smart helmets are poised to instrumental in transforming construction sites into safer, more efficient, and data-driven environments. As the technology continues to evolve and adapt to the ever-changing needs of the industry, smart helmets hold the promise of becoming an indispensable tool for enhancing the well-being of construction workers, improving project outcomes, and shaping the future of construction work for the better.

ACKNOWLEDGEMENTS

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SMART HELMET

[1]K. Akshaya Sai Devi,[2]A. Rithvika Parvathi
Seshadri Rao Gudlavalleru Engineering College
[1,2]Sheshadri Rao Knowledge, Gudlavalleru, Vijayawada, Andhra Pradesh 521356
Saidevi1526@gmail.com,akularithvikaparvathi@gmail.com

ABSTRACT: construction sites pose significant risks to workers' safety, including the potential for head injuries from falling objects or accidents. to address these concerns, this research presents a cutting-edge solution in the form of a "smart helmet" tailored specifically for construction workers. this innovative helmet integrates advanced technologies such as IOT sensors, augmented reality (AR) displays, and communication systems to enhance safety and efficiency on construction sites. the smart helmet is equipped with a network of sensors that monitor environmental conditions, detect potential hazards, and relay real-time data to the wearer. this information is displayed through an AR visor, providing workers with crucial information about their surroundings, safety alerts, and project-related instructions additionally, the helmet features a communication system that enables seamless collaboration among workers, supervisors, and remote experts. this abstract highlights the transformative potential of the smart helmet in improving safety, productivity, and communication within the construction industry. by leveraging the power of IOT and AR technologies, this innovation aims to mitigate risks, reduce accidents, and enhance overall job site performance for construction worker.

1.INTRODUCTION

The construction industry is a cornerstone of modern infrastructure development, but it comes with inherent risks that jeopardize the safety of workers on a daily basis. Among the numerous safety concerns, head injuries resulting from falling objects, accidents, or unforeseen hazards remain a critical issue. To address these challenges and elevate the safety standards for construction workers, the concept of a "Smart Helmet" has emerged as a groundbreaking solution. In this era of rapid technological advancement, the convergence of cutting-edge technologies such as the Internet of Things (IoT), augmented reality (AR), and advanced communication systems has paved the way for innovative solutions that can transform traditional safety gear into intelligent and proactive tools. The Smart Helmet represents a prime example of how technology be harnessed to significantly enhance the well-being and efficiency of those working in construction sector This introduction serves as a gateway to explore the multifaceted aspects of the Smart Helmet for construction workers. It delves into the pressing need for improved safety measures in the construction industry, the potential of technology to revolutionize personal protective equipment, and overarching goal of this research—to create a smarter, safer, and more connected environment for the individuals build our world. This comprehensive introduction sets the stage for a thorough exploration of the multifaceted aspects surrounding the Smart Helmet's integration into the construction industry. It will delve deeper into the pressing safety challenges plaguing the industry, the key technological components that make the Smart Helmet possible, its potential to revolutionize workplace safety, enhance efficiency, and improve communication among construction teams, ultimately leading to safer, more productive job sites.

2.LITERATURE SURVEY

A literature survey helps you identify existing smart helmet solutions or similar technologies that have been developed and used in the construction industry. This information can provide insights into what has worked, what hasn't, and areas for improvement. There are some related works carried out on IoT Based Smart Helmet as follows:
Fan zihhong [1] proposed the “Quality and safety management of construction” projects are contradictory and consistent. To ensure the safety, the construction engineering safety management system should first be strengthened. Therefore, we introduced IoT technology to construction safety management and carried out in-depth research on practice and promote safety management of construction projects. V.Jayshree, M. Nivetha Kumari [2] proposed the “IoT Based Smart Helmet for

Construction Workers", To provide continuous monitoring of the workers and to prevent them from any health hazards during working, this system proposes a smart flexible helmet for the construction workers to provide security and rescue measures in case of any emergency conditions. The proposed system describes a smart inexpensive helmet for the construction workers made up of sensor.

Mangala Nandhini. V, Padma Priya G.V, Nandhini. S, Mr. K. Dinesh [3] proposed the, "IOT based Smart Helmet for Ensuring Safety in Industries", To provide Industrial safety is to5industry. Working environment hazards include suffocation, gas poisoning and gas explosion. Hence air quality and hazardous event detection is very important factor in industry. In order to achieve those safety measures, the proposed system provides a wireless sensor network for monitoring real time situation of working environment from monitoring station.

2.1. BLOCK DIAGRAM

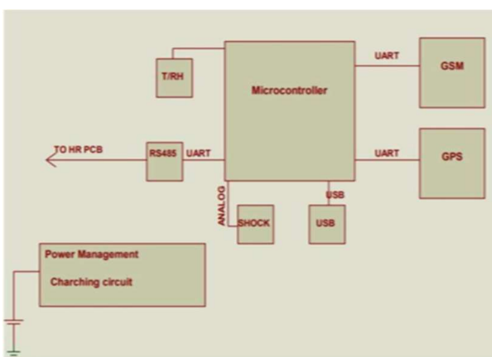

Fig 1: circuit diagram

In a smart helmet, a GPS sensor to locate the exact location of the worker and engineer, and two Arduino Uno boards are used on which codes are uploaded for the functioning of the helmet then two different buttons are used one for security as well as a smoke alert system. The hc12 module is used for the communication of the helmet with the system having another hc12 module. A smoke detector sensor is used for the health safety of the workers and engineers as the smoke detector can detect the harmful gases present in the environment and LED of three different colours is used all of them showing or notifying that the helmet is in an inactive state (blue), the helmet is in alert condition (red), the task is completed by the worker (green). The helmet is designed to be with three buttons installed in it and various components also like GPS, Smoke Detection, and Gas Detection, etc. in it. One button is installed on to and the rests two are on both sides. The button on top will reflect the safety and

emergency symbol whenever a little force will act on the top of the helmet, it will give the information or emergency alert with the location the supervisor so that the team will reach the labour easily and take necessary actions. The Second button installed on the right side of the helmet is used to give information to the supervisor for the completion of the specified task.

1.1 SPECIFICATIONS

S. No.	Colour of LED Light	Specification or Role
1	Red	Problematic Situation
2	Yellow	Wearing of Helmet
3	Green	Task Completion
4	White	While using machineries

2.2 PRINCIPLES OF SMART HELMETS

The main aim for developing the concept of the smart helmet was not only focused upon the safety of the workers and labours at the construction site, but also includes many aspects of the ongoing project at the construction site. The basic principles of developing IoT – based helmet is a three – fold dimension, focusing on Safety, Management and Efficiency.

The first principle includes the aspect of safety. Safety was the prime factor which was considered behind the idea of developing the smart helmet. It is designed for all the working – labour class at the construction site. These helmets will be having the same colour code which are being employed at the construction site presently, just with the addition of the concept of making it "smart", attached with different equipment such as sensors. These helmets are designed in such a way that if the worker is facing any kind of emergency, whether health related or work related, a different signal (in the form of LED) will be displayed on the screen, making it understand that one or many of the labours are facing problems. Due to which, if some accidents happened at the construction site, the person – in – charge can easily get notified and take the necessary remedial action to the earliest for the safety of the particular victimized labour. The second principle is management. Smart helmet plays an important role in managing different activities such as Time Management, Work Management and Labor Management at the construction site. All these three types of management are inter- related to each other.

2.3 RESULT

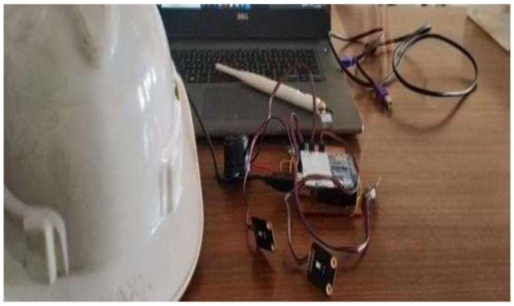

Fig:2: smart helmets

A smart helmet is a combination of the ordinary helmet with the latest technology as per the requirement of the construction site (Safety, Time Management, and Risk). At the Construction site, Helmet is the basic need for labour. For this investigation, an ordinary helmet is taken into consideration and modified it with the latest advancement to full fill the various requirements at the construction site like managing the time, the safety of labour, supervising the worker's activity, how much work is to be completed, about the activities which are going parallel, detection of various gases,etc. To full fill this entire requirement of the construction industry, the Internet of Things (IoT) is introduced in various projects which play an important role. Various components are installed in the ordinary helmet and connect all these with a single computer so that all the activities are to be supervised in a single computer. Now a day, everywhere there is a need for advanced technologies. And this smart construction helmet is formed with various technologies that were installed for the proper working and to create a better employment place. The construction industry growing very rapidly and gives the largest contribution to India's GDP. Construction is not only a contributor to India's growth development potential but It also gives employment to many people. It's the responsibility of the employer to provide safety to their employers and about the management of the various tasks at the site. The various major elements which are used to make the IoT based helmet for this study includes: 1. HC12 Module (oHC-12), is a communication module that is wireless serial and half-duplex with 100 channels in the434-472.6 MHz that can transmit up to 1.2 km, 2. A GPS Sensor, that helps in locating or finding the exact position, velocity, and timing with the satellite-based navigation system, Receivers with antennas are used to provide the information of time; the exact position, and the velocity are GPS sensors, 3. Arduino Uno of 14 digital input/output pins. Tone of the supporting elements may include smoke detector, which is used for the detection of gas leakage at home and industry. In this setup, Ga Sensor (MQ2) module is used. By smoke detector, various gases like H2, LPG, CH4, CO, Alcohol, Smoke, or Propane can be easily detected. Measurement could be taken instantly due to its response time which is at high fast and sensitivity. The potentiometer is used for the adjustment of the sensitivity of the sensor. Light-emitting diode (or LEDs) are used for the indication purpose where the signals have to be received. In the circuit of the helmet, a breadboard is used to test the whole circuit. It helps in testing the circuit in very little time.

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In conclusion, smart helmets for construction workers represent a groundbreaking advancement in workplace safety and efficiency within the construction industry. These innovative helmets, equipped with a range of sensors and communication technologies, have demonstrated their potential to revolutionize the construction site landscape. By proactively identifying and mitigating potential hazards, enhancing worker well-being through fatigue detection, improving operational efficiency, and facilitating seamless communication, smart helmets offer a holistic solution to the multifaceted challenges faced by construction workers. While they have already shown impressive results in terms of safety and productivity, ongoing research, development, and refinement are crucial to fully their potential. It is essential to strike a balance between data collection for insights and the protection of worker privacy, ensuring that ethical considerations are at the forefront of implementation. In the broader context of the construction industry, smart helmets are poised to instrumental in transforming construction sites into safer, more efficient, and data-driven environments. As the technology continues to evolve and adapt to the ever-changing needs of the industry, smart helmets hold the promise of becoming an indispensable tool for enhancing the well-being of construction workers, improving project outcomes, and shaping the future of construction work for the better.

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BRAIN TUMOR PATTERNS ENHANCEMENT USING SEGMENTATION METHODS

[1]B. Surya Prasada Rao,[2]A. Geetha Devi,[3]V.S.D. Rekha,[4]K. Kavyasri,
[5]G. Preethi,[6]E. Surya Vamsi Krishna,[7]K. Sneha Latha
[1,2,3,4,5,6,7]Department of Electronics and Communication Engineering
Prasad V Potluri Siddhartha Institute of Technology, Kanuru, Krishna District,
suryaborra1679@pvpsiddhartha.ac.in

ABSTRACT: The early detection and accurate diagnosis of brain tumors are crucial for effective treatment planning and prognosis. The study of brain tumor patterns offers the fresh method for improving the visualization of brain tumor patterns using advanced image processing techniques. Various pre-processing techniques like noise reduction and contrast enhancement, followed by segmentation methods that employ thresholding, region growing and deep learning models to isolate tumor regions. Subsequently to identify tumor type and size various classifications algorithms are used that enhances the analysis of tumor patterns. The effectiveness of the approach is demonstrated through its application to Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans where tumor detection accuracy, segmentation precision, and overall diagnostic performance are significantly improved.

KEYWORDS: Magnetic Resonance Imaging (MRI), Image preprocessing, Image enhancement techniques, Segmentation, Accuracy detection.

I.INTRODUCTION

When there is an abnormal multiplication of cells inside the brain tissues, a brain tumor may develop. According to the World Health Organisation (WHO), tumors are the second leading cause of death worldwide. Benign and malignant brain tumors are the two primary forms. Most of the time, benign tumors are not thought to pose a serious harm to a person's health. It is mostly caused by their incapacity to spread, inability to penetrate neighbouring tissues or cells, and slower growth rate than malignant tumors. Usually, they don't come back once benign tumors are surgically removed. Malignant tumors are more likely than benign ones to spread to other tissues and organs, and if they are not treated quickly and efficiently [1].

Accurate diagnosis, treatment, and follow-up procedures are essential for brain tumors, a significant public health issue in the healthcare industry. There were many procedures that were introduced which promises for the early detection and management of brain tumors. Because of their location, brain tumors have an impacton human health. AI combines technology like big data analytics, machine learning, and more to help identify and cure complicated diseases like brain tumors [2].

A prompt and accurate diagnosis of brain tumors is essential for both patient outcomes and effective treatment planning. However, while working with brain tumors, radiologists could put a lot of effort into image analysis. Radiologists nowadays are forced to manually identify and make conclusions based on their own abilities and subjective interpretation of images.
Due to the inherent complexity of brain tumor images and the vast variety of practitioners skill, accurate diagnosis by human visual assessment alone is challenging. Because it enables a thorough evaluation of the skull and brain, MRI scanning is frequently used in neurology. For a more comprehensive assessment, itoffers axial, coronal, and sagittal imaging [3-5].

II.RELATED WORKS

Image processing has been used to process images in medical streams and in cooperating cell detection in recent years. In 2012, "S. Mokhled" introduced a number of identification steps, such as segmenting images to extract the object from the background through the

threshold. This feature was introduced with the "Gabor filter" to further classify into cancer cells.

Additional procedures, such as picture extraction and segmentation for cancer cell diagnosis, were proposed by "H. G. Zadeh" in 2013. Prior to using the "Fast Fourier Transform," the Gaussian smoothing notion was developed as a filter. "NN" and "Fuzzy C-mean" algorithms were introduced as part of machine learning for tumor detection in order to identify tumorous cells. While the computing Input time is reduced, the accuracy is also decreased.

Gene counting technology is introduced by "X. Chen" in 2014. However, this approach is only suitable for the intricate process of gene selection [6].

In 2018, significant advancements were made in the use of image processing techniques where developments like AI, Machine Learning and Deep Learning algorithms alongside more traditional medical imaging technologies were introduced.

In 2020, various tumor classification techniques like Glima Classification, Glioblastoma Multiform (GDM) detection came into existence. These approaches helped in understanding complex biological behaviour and predicting patient outcomes more accurately [7].

III.METHODOLOGY

To enhance brain tumor pattern using image processing techniques, there are several methodologies that can be adopted. Data set is taken through which the methodology would be carried on. MRI or CT scan images are taken as input data. These images often come with noise or low contrast, which can hinder the detection of brain tumor patterns which results in the need of pre-processing techniques. Figure1 shows the input image.

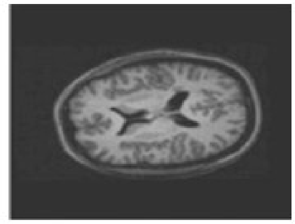

Fig 1: Original image taken as input data

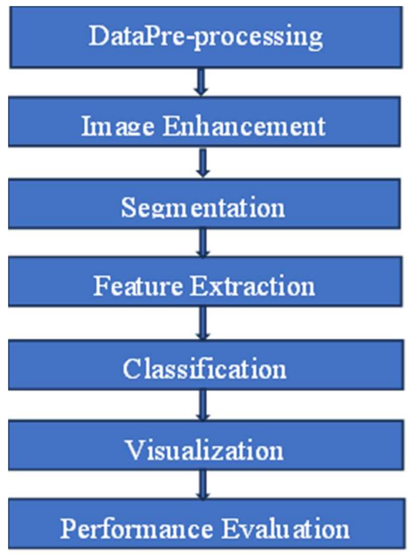

Fig 2: Basic flowchart of Methodology

A) Pre-processing

The first stage of any method that eventually finds brain tumors is pre-processing. To make the image clearer and draw attention to the tumor from the background, noise and other artifacts are eliminated during the pre-processing stage. Various pre-processing techniques include Normalization and Noise Reduction. For certain types of noise, a median filter offers the best noise reduction. Additionally, it is utilized to maintain and smooth the edges. Salt and pepper noise are seen in grayscale photographs. The median filter works better than other filters in removing this noise.
An image with the effects of salt and pepper noise (a) and after a median filter is applied(b) is shown in Figure3 [7].

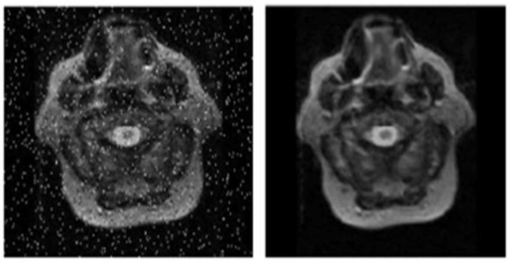

Fig3: a) Salt and Pepper noise b) Median filter

An iterative technique called an anisotropic filter is used to eliminate high-frequency-related background noise from pictures. Additionally, it maintains the edges intensity. Figure 4 shows the images of noise and Anisotropic filter [8].

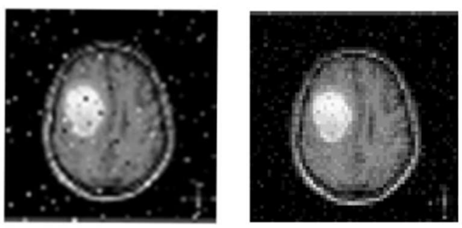

Fig4: a) Salt and Pepper noise b) Anisotropic filter

After the pre-processing technique there may be an output which needs to be enhanced through certain enhancement techniques. Histogram Equalization, Edge Sharpening and some filtering techniques can be used for the enhancement of the image.

B) Enhancement

After the pre-processing technique there may be an output which needs to be enhanced through certain enhancement techniques. Histogram Equalization, Edge Sharpening and some filtering techniques can be used for the enhancement of the image. Figure 5 shows an image after using the Gaussian filter (a) and the image after using the Average filter (b) [9].

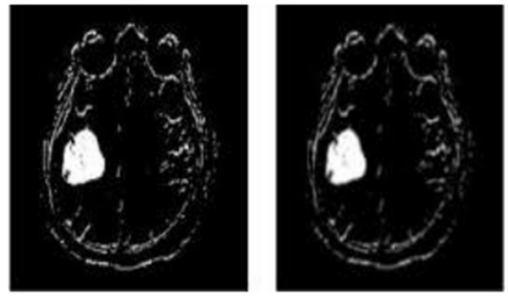

Fig5: a) Gaussian filter b) Average filter

c)Segmentation

Segmentation is a challenging process as the medical images are very complex. The image is separated into multiple divisions based on factors like colour and intensity during the segmentation process. This facilitates the observation and analysis of the images' details and yields precise results.

The various segmentation methods are as follows:

a) Threshold Segmentation

It is a process that involves the separation of tumor tissue from normal brain tissue based on pixel intensity values. Converting a grayscale image to a binary image is the primary objective of the thresholding method, which relies on the threshold value.

b) Edge detection

Edge detection helps to identify the borders of different objects within an image. An edge serves as a boundary between two correspond ing regions. It is effective for detecting object boundaries and structures. It can be used in real-time applications. Sensitive to noise, especially in low-contrast images. Typically, this form of segmentation does not deliver precise boundaries. Well-known algorithms for edge detection include the Roberts algorithm, Canny algorithm, Prewitt algorithm, Sobel algorithm, and Laplacian of Gaussian, among others. Figure 6 shows various edge detection approa ches images [10].

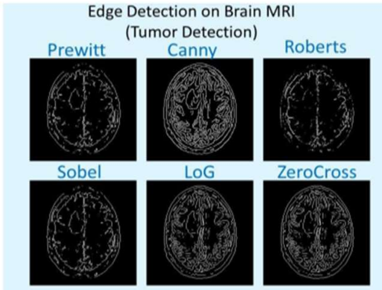

Fig6: Edge detection approaches

D) Feature Extraction

Tumor size and its stages can be analyzed through Feature extraction. The various stages include Stage I, II, III or IV. Texture Analysis, Shape Features, Intensity Features are some of the concepts that are used in feature extraction where the relevant features from the tumor region are extracted. Extracted tumor is shown in fig7.

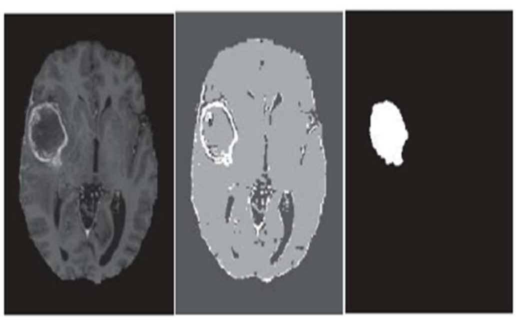

Fig7: a) Original Image b) Segmented Image c) Extracted tumor

Medical practitioners use specific criteria to classify tumors based on their size:

- Tumors with an area smaller than 7mm are classified as Stage One.
- Tumors measuring between 7mm and 14mm are considered Stage Two.
- If the tumor spans from 14mm to 21mm, it is categorized as Stage Three.
- Tumors larger than 21mm are regarded as being at a critical stage [11].

E) Classification

Once the features are extracted the following step is tumor classification, this can be done by using various learning models like machine learning and deep learning.

IV.RESULTS AND DISCUSSIONS

Brain tumors are abnormalities in the brain that disrupt its normal function. They can be diagnosed at any age, and the severity of the tumor's impact can vary from person to person. Whether in the primary or secondary stage, detecting brain tumors manually is challenging, as it is time-consuming and often yields unreliable or inaccurate results. This highlights the need for the development of automated algorithms and methods to detect brain tumors more quickly and with greater accuracy. Figure 8 below illustrates some of the commonly used image processing techniques images for identifying brain tumors.

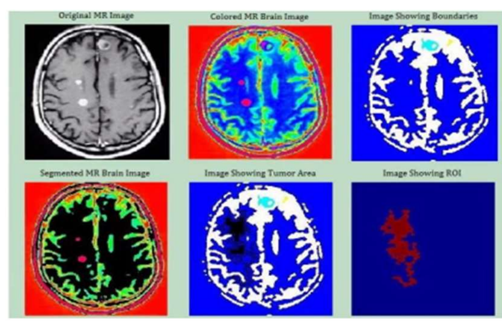

Fig8: Output images obtained in the process

MRIs are commonly utilized in various image processing methods for identifying brain tumors, as research has demonstrated their superior accuracy compared to CT scans. Medical image segmentation requires a meticulous approach. At this stage, the tumor is distinguished from the surrounding healthy brain tissue, and any minor error can significantly impact the final results.

Certain methods utilize the K-means algorithm for segmentation, while others employ Fuzzy C-means segmentation or a combination of both. These techniques fall under the category of region detection methods. To detect the tumor and gather important information such as its stage, location, and size, feature extraction is employed. This process analyses different brain tissues to extract relevant details.

Table1 represents the different segmentation methods with different characteristics such as accuracy.

The symbols TN, TP, FP, and FN correspond to the true negative, true positive, false positive, and false negative values, respectively. From Equation (1)

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN} \quad \ldots\ldots (1)$$

Table1: Characteristics of different segmentation method

Segmentation Method	Accuracy
Seed Region Growing	92.3
Threshold Segmentation	91.2
Watershed	88
Fuzzy C-Mean	84.5
Histogram Thresholding	82

CONCLUSION

This paper provides a comprehensive survey of various techniques, steps, and their comparative effectiveness in identifying brain tumors using medical image processing. The most effective and efficient approaches generally include MR image preprocessing, segmentation, feature extraction, and classification. Among these, segmentation is considered the most critical step, as it involves separating tumor tissues from normal brain tissues. Based on the results, Seed Region Growing is the most effective segmentation strategy since it achieves the highest accuracy when compared to other strategies.

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Enhanced Neonatal Brain MRI through Longitudinal Super-Resolution Techniques

[1]B. Surya Prasada Rao, [2]V.S.D. Rekha, [3]A. Geetha Devi,
[4]K. Greeshma Prasudha, [5]J. Geetha, [6]K. Ramya Durga, [7]B. Akash
[1,2,3,4,5,6,7] Department of Electronics and Communication Engineering (ECE)
Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Krishna District,
suryaborra1679@pvpsiddhartha.ac.in

ABSTRACT: Neonatal brain development involves rapid structural changes that are difficult to capture with conventional Magnetic Resonance Imaging (MRI) due to resolution and motion limitations. This study introduces a deep learning-based longitudinal super-resolution (SR) technique that integrates MRI scans over time to enhance image resolution while preserving developmental details. By combining scans from multiple time points, our approach improves spatial resolution, enabling detection of early cortical folding, myelination, and white matter maturation. Preliminary results show enhanced image clarity and temporal consistency, supporting early diagnostics and tracking of neurodevelopmental disorders with greater anatomical accuracy.

KEYWORDS: Super Resolution, Magnetic Resonance Imaging (MRI), Spatial Resolution, Image Enhancement, Anatomical Accuracy.

1. INTRODUCTION

Neonatal brain development is a dynamic process marked by rapid changes in structure, which are challenging to capture accurately using conventional MRI technique s. Due to some of the constraints like noise ratios, PVEeffects are introduced. In PVE, a single voxel often contains mixed signals from multiple tissue types, which blurs tissue boundaries and diminishes the clarity needed for detailed anatomical analysis. This issue is particularly pronounced in neonatal imaging, where the small size of the brain and inherently low tissue contrast further complicate precise visualization and quantif-ication of brain structures. [1]

High-resolution (HR) images are desirable for neonatal MR because they allow for a more detailed examination of structural features, such as cortical folding, myelination, and white matter maturation—key indicators of the normal brain development and the potential neuro developmental abnormalities. Traditional interpolation techniques are often applied to enhance resolution, but these methods frequently lead to blurring, as they perform averaging across neighboring voxels rather than restoring lost high-frequency details. As a result, these methods are limited in their ability to recover fine anatomical details, making them suboptimal for the sensitive imaging needs of neonatal brain research. [2]

Super-resolution (SR) techniques provide an alternative by reconstructing HR images from low-resolution (LR) inputs, often through methods that attempt to reverse the degradation process in the images. While SR has shown promise, many existing approaches rely on single-frame input, which restricts their ability to capture temporal anatomical consistency. In neonatal brain imaging, longitudinal data can serve as a valuable resource.

Given that neonatal brain development procee-ds in a gradual and predictable manner, integrating information from follow-up scans enables a unique SR approach that maintains structural consistency across time. [3]

For the following study, LGSR algorithm is specifically designed for brain MRI. Our approach leverages high-contrast follow-up images as guidance, using non-local spatial relationships, low-rank, and total variation regularization to reconstruct high-quality HR images from initial LR scans. By integrating longitudinal data, this method enhances spatial resolution, providing clearer visualizations of critical

developmental features while preserving anatomical continuity over time. Our experimental results demonstrate that this longitudinal SR method outperforms existing techniques in both visual quality and quantitative measures, offering a significant step forward in neonatal brain imaging. This advancement holds promise for improved early diagnosis, neuro developmental tracking, and more precise anatomical mapping in neonates. [4]

2. METHODOLOGY

Our method aims to provide high isotropic spatial resolution neonatal brain MRI images and enhanced signal-to-noise ratio (SNR), while minimizing acquisition time, making it suitable for both research and clinical use. slice selection orientations. To for T2-weighted images with varying slice selection orientations and greater repetition periods (TR). To assess our methodology, we produced a MPRAGE dataset simulation with ultra-high-resolution images at 250 µm isotropic voxel size and used a Siemens 3T scanner to gather 60 T2-weighted FSE images from 20 neonates. This section provides the fundamental idea and formula of our approach, thorough descriptions of the datasets, evaluation standards, as well as experimental design. [5]

2.1 ACQUISITION STRATEGY ON NEONATAL BRAIN (MRI):

The through-plane resolution of 2D slice stacks is efficiently improved by super-resolution reconstruction (SRR). To accomplish this, we take pictures with a big grid thicknesses and thick slices. A bigger matrix size guarantees a high level of in-plane resolution, while shorter scan times are possible with thicker slices and improved SNR (signal-to-noise ratio). But when the thickness of the slices rises, the effect of partial volume increases in noticeable, making the super-procedure for resolution. In order to lessen this, we obtain several low-resolution (LR) pictures, which raises the overall scan time because of the extra slices. Fortunately, we can expedite the acquired by the use of quick imaging techniques, such is FSE (fast spin echo). The FSE technique can significantly reduce scan duration by a factor of the echo train length (nETL), typically ranging from 4 to 32 in clinical practice. The objective of SRR is to estimate the missing k-space data from the available sampled data.[9] In our method, this estimation is performed in the spatial domain, linked to k-space via Fourier transforms. LR scans are taken with various slice selection directions, where each scan captures a portion of the k-space along the slice selection axis. This results in multiple LR scans covering different spatial frequencies in the 3D frequency spectrum. By combining these scans, we ease the SRR process by sampling more k-space data. While the slice selection directions and number of LR scans can vary using orthogonal planes (axial, coronal and sagittal) typically provides a good balance between scan time and SRR performance, as these directions offer complementary imaging planes [6]. We acquire three T2 FSE images from each neonate with varying slice selection directions (axial, coronal, and sagittal) and apply SRR to generate an isotropic high-resolution image. The scan parameters are determined based on the required scan time. as per eqn(1). [7]

$$T \cong TR.\left[\frac{F_0 V_p}{S_p.f_{acc}.ETL}\right].N_{NEX}\ldots.(1)$$

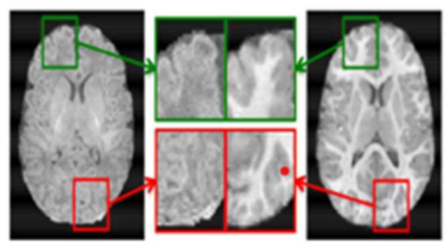

Fig.1 TI MR image of a neonate(left) and its follow-up at two years of age(right). The 2year old image was aligned to the neonatal image by the nonlinear registration. Two brain regions marked with green and red blocks are zoomed in for closer comparison.

2.2 SUPER-RESOLUTION MODEL:

A physical model that describes how an HR image degrades into an LR image in the SR problems are usually supplied by:

$$T = DSX + n \quad \ldots..(2)$$

where T(1) is the downsampled value and D is the LR image operator observed, where X is the first HR picture, S is an operator that blurs and n is used to indicate the noise. The Image SRs are stated in the observation model. The goal of eqn(2) is to obtain an HR image from a visual reference image. [8].

Due to the character's poor positioning Regularization is employed to eliminate the recovery uncertainty in reverse issue. The target cost in picture SR can be reduced in order to calculate the HR image function as displayed in the form below:

$$\widehat{X} = min_X\|T - DSX\|^2 + \lambda\Phi(X)\text{….(3)}$$

where (X) is a regularization term that is frequently used, and $\|T - DSX\|^2$ is the data fidelity term for penalizing the difference between the observed LR image T and the degraded version of HR picture X established using existing knowledge to stabilize the solution, and The tradeoff between the two is balanced by the parameter λ. The regularization term and the data integrity term. The traditional among the regularization techniques described in the literature are the sparsity regularization Tikhonov regularization, TV, nonlocal regularization and the regularization of nuclear norms. [9]

2.3 GUIDED BILATERAL FILTERING

The structural patterns of longitudinal photos of the same subject are strikingly similar. To direct neonatal image SR, we use comparable structural information from a longitudinal picture. To capture structural relationships, GBF is utilized. Through element wise multiplication, weight maps w_x and w_l are joined to create a weight map w. GBF uses weighted averaging to estimate the filtered HR neonatal picture Y from X. [10]

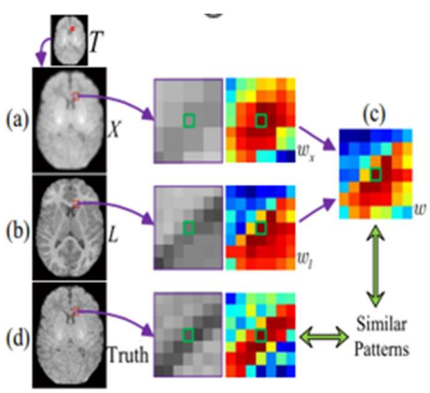

Fig.2 Advantages of the combined weightmap. (a)Degraded neonatal image T and the unsampled HR image X,(b) longitudinal image L,(c) combined weight w from (a) w_x and (b) w_l and (d) original HR neonatal image.The reference voxel is marked by green.

As mentioned earlier, the weight map is computed using both the longitudinal image L and the up sampled HR image X. The benefits of using longitudinal data are demonstrated in Figure 2. The surrounding weight map for a voxel close to the anterior horn employing X is shown in Figure 2(a). The anterior horn's local organization is not adequately depicted by the weight map. The longitudinal view, which offers more details, is shown in Figure 2(b). A single map that closely resembles the original HR newborn image (Fig. 2(d)) is produced by combining the two weight maps in Fig. 2(c).[11]

2.3 LONGITUDINALLY GUIDED SUPER-RESOLUTION:

For neonatal image SR, the LGSR algorithm examines longitudinal data. Three regularization terms are included in the related problem:

$$\hat{X} = min_X\|T - DSX\|^2 + \lambda_{GBF}\|X - Y\|^2 + \lambda_{LR}Rank(X) + \lambda_{TV}\int|\nabla X|dxdydz \quad \text{…..(4)}$$

Eqn (4) provides a description of the regularization parameters λ_{GBF}, λ_{LR}, and λ_{TV}. The HR neonatal image Y that has been filtered is produced by integrating the necessary neonatal HR picture. The longitudinal picture of X L. Rank (·) indicates a 3-D image's rank matrix, with |·| standing for the ~2 norm and ∇ is the operator for gradient. The GBF, low rank, when terms related to TV regularization show up on the starting with the second on the right side of eqn (4) phrase as depicted in Figure 3. [12]

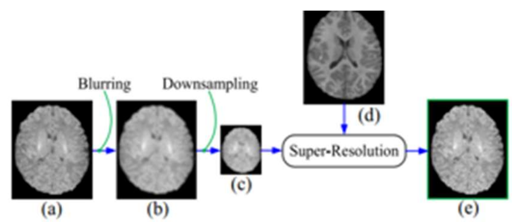

Fig.3 Simulation of an LR image from an original neonatal image, (a)Original neonatal image (b) Blurred image (c)generated LR image(d)aligned longitudinal image and (e)recovered HR image

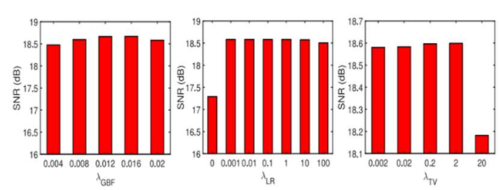

Fig.4 SNR values given by our LGSR in relation to various key parameters for a randomly selected neonate.

Algorithm: Pseudocode of the LGSR Algorithm
Input: LR neonatal image T and HR longitudinal image L.

Output: Reconstructed HR neonatal image X.

Initialize the desired HR neonatal image X by up sampling T with spline-based interpolation. Set auxiliary variables Mi=0, Ai=0,i=1,2,3.
Repeat
  Update various values of Y
 Repeat
   Update X by the gradient descent method;
   Update M by SVT;
   Update A;
 End
  Until convergence;
 End

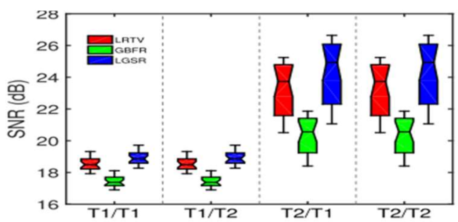

Fig.5 Impact of GBFR

3.Results

The LGSR approach was evaluated by taking test dataset along with approaches like NN interpolation, spline and LRPV. The initialization was performed using spline interpolation. For the evaluation, we selected a group of neonatal and longitudinal images. In the case of test images, GBFR was evaluated in relation to LGSR and LRTV [3] as a component of LGSR to confirm its advantage for SR enhancement of LGSR. Fig.5 results comparison of various approaches by taking sets of input test images.

The University of North Carolina School of Medicine's institutional review board gave its approval to the experimental protocols medication. These babies are composed of 17 females and 11 males. [6] At birth, the individuals were scanned, and once more utilizing a 3T MRI at age two Siemens head-only scanner Tim Trio (MAGNETOM) with a round 32-channel polarized head coil test results was[10] produced utilizing the most popular MR sorts of images (T1 and T2). T1 pictures were gathered using a brief echo time (TE) and time spent in repetition (TR). T2 images were produced with extended TR and TE times. T1 Images were captured with 144 sagittal slices with a 1 x 1 × 1 resolution (T2) 58 axial pictures were generated from the input image. [13]

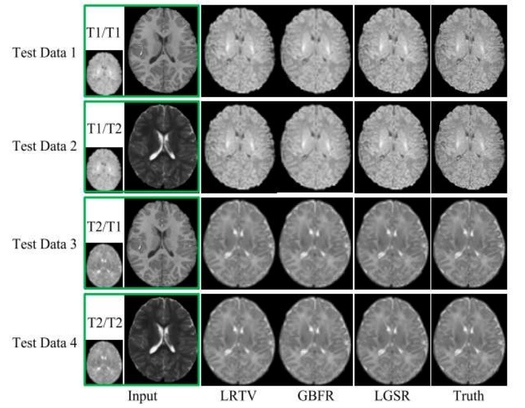

Fig. 6. SR results obtained by LRTV, GBFR, and LGSR for four pairs of images

It is evident from the Fig.6., LGSR made significant progress in image SR by integrating the suggested GBFR. This enhancement confirmed that the GBFR proved. Output results are shown in fig.7& fig.8 using the input image(Fig.6).

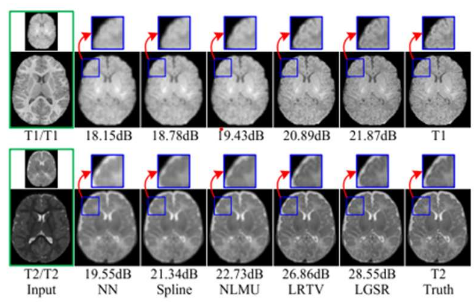

Fig.7 Intramodality SR results of LGSR in comparison with the competing methods for two neonatal subjects.

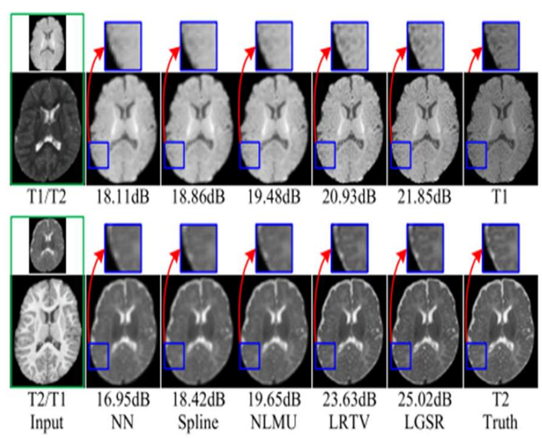

Fig.8 Intermodality SR results of LGSR in comparison with the competing methods for two neonatal subjects.

CONCLUSION:

In this work, the neonatal image SR problem is tackled by combining the TV regulation, low-rank constraint, and longitudinal image prior. The related optimization problem is resolved using the ADMM approach. The outcomes of the experiment show that both qualitatively and quantitatively, the suggested LGSR approach has better performance compared to other technique. Additionally, in order to further enhance the effectiveness and performance of neonatal image SR reconstruction, some other images will be included for further processing techniques.

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NUMBER PLATE DETECTION AND RECOGNITION USING A ZERO-SHOT APPROACH

[1]Ch. V.M.S.N. Pavan kumar, [2]K.V. Ram Charan Teja, [3]B. Venkata Varma, [4]V. Sai, [5]K. Sambaiah
[1,2,3,4,5] Bapatla Engineering College, Bapatla
pavan4790@gmail.com, ramcharantejakatakam@gmail.com,
venkatavarmabethala@gmail.com, saigangadar123@gmail.com, sambasamba9130@gmail.com

ABSTRACT: This paper introduces a approach for number plate recognition using zero-shot detection, leveraging pre-trained models for detecting and localizing number plates in a custom dataset of 1700 images captured under varying conditions (e.g., different camera types and resolutions). Two models, owlv2-base-patch16-ensemble and owlvit-base-patch32, were fine-tuned for zero-shot detection with the label "numberplate." After detection, the number plates were cropped and processed using OCR models (PaddleOCR and EasyOCR) for character recognition. The owlv2-base-patch16-ensemble model achieved the highest detection accuracy of 82.76%, outperforming other models like NATE-G10/Custom (65.32%) and Grounding DINO (62.35%). These results highlight the effectiveness of zero-shot detection for number plate recognition in real-world, variable-resolution scenarios.

INDEX TERMS Open World Localization-Vision Transformer (OWL-VIT), Optical Character Recognition (OCR), Mega Pixels(MP), PaddleOCR, EasyOCR.

1.INTRODUCTION

Number plate detection plays a pivotal role in modern traffic management systems, leveraging advanced technologies to enhance vehicular monitoring and control. Automatic Number Plate Recognition (ANPR) is a cutting-edge technique that enables the detection and extraction of vehicle license plates from images. The development of an ANPR system for a custom dataset involves a systematic series of steps to ensure robustness and accuracy. These steps include: 1) Dataset collection,2)Detection of number platecoordinates, 3)Extraction of the number plate based on detected coordinates,4)Optical Character Recognition (OCR) for character recognition from the number plate, and 5) Accuracy evaluation of the overall system.

In the number plate detection process, coordinates of the number plate region within an image are initially identified using advanced detection models. These coordinates are then used to crop the number plate region from the original image.

The extracted plate is subsequently passed through an OCR model to recognize the alphanumeric characters. Finally, system performance is assessed through accuracy metrics. The dataset used in such systems typically consists of images captured under varied conditions, such as different camera angles and lighting, which introduces challenges in detection and recognition.

The data obtained from ANPR systems can be effectively leveraged for the modelling and impl ementation of various traffic management appli cations, including Passenger Mobility Systems [1], traffic flow analysis and road network control strategies utilizing Network Fundament al Diagram (NFD) models [2],freight vehicle routing and path choice optimization [3],and the analysis of travel demand patterns through Floating Car Data (FCD) [4].These applications contribute to the optimization of transportation systems, improving both efficiency and safety in urban mobility networks.

This is for detecting a single image text. For multiple images, get a list of all image files. By using a for loop for the length of image files repeat the same procedure which is done for a single image. Then calculate the number of images which detects the text and then determine the accuracy for the model. Change the model and repeat the procedure and then calculate accuracy. These applications contribute to the optimization of transportation systems, improving both efficiency and safety in urban mobility networks.

2.PROPOSED APPROACH

The number plate recognition system plays an important role in traffic management systems. The procedure for the number plate detection is:

The proposed approach may run in google colab or Kaggle. The dataset is saved as a zip file in the google drive for utilization. The zip file is unzipped and stored at a specified directory where the extracted files should be placed. The different package installers are installed like transformers for zero shot object detection which is a pre- trained model. Then checking for GPU support for performing operations on it else use CPU. Choose different models for zero-shot detection like owlvit and owlv2 versions. Install paddle ocr and paddle package installers which are used for OCR models. From the OCR models, import the draw_OCR file which is used for drawing bounded boxes. Select an image from the zip file by copying its path. Convert the image into RGB mode. Detect the coordinates from the given image by using the candidate label “numberplate”. By using these coordinates draw a rectangular bounding box for extracting the number plate.

A. BLOCK DIAGRAM

After extracting the number plate, save it in the same directory. Using OCR models such as paddleocr, easyocr check for the text recognition. If the text is detected, print it. This is for detecting a single image text. For multiple images, get a list of all image files. By using a for loop for the length of image files repeat the same procedure which is done for a single image. Then calculate the number of images which detects the text and then determine the accuracy for the model. Change the model and repeat the procedure and then calculateaccuracy.

The technology is widely used in various applications such as traffic management, automatic toll collection, parking management, law enforcement, and border control. It helps automate vehicle tracking, monitor traffic violations, and improve security by identifying stolen vehicles. The different package installers are installed like transformers for zero shot object detection which is a pre- trained model. Then checking for GPU support for performing operations on it else use CPU. Choose different models for zero-shot detection like owlvit and owlv2 versions. Install paddle ocr and paddle package installers which are used for OCR models. From the OCR models, import the draw_OCR file which is used for drawing bounded boxes. Select an image from the zip file by copying its path. Convert the image into RGB mode. Detect the coordinates from the given image by using thecandidate label “numberplate”.

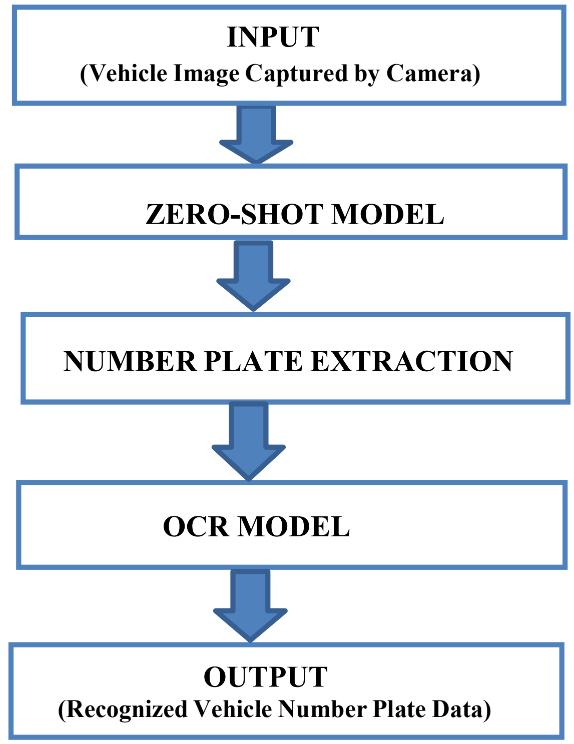

Figure1: Block diagram of the Proposed Model

However, with continuous advancements in machine learning and image processing, NPD systems are becoming more accurate and efficient, driving automation and improving security in multiple domains.

B. DATASET

The dataset for this study consists of 1,700 images of vehicle number plates, collected from various locales to ensure a rich diversity in lighting, angles, and resolutions. These images were captured using smartphones such as the Realme 8i, Iqoo Z9, Vivo T2x 5G, and Redmi Note 13 Pro, each boasting impressive camera specifications. To optimize processing capabilities, all images were uniformly resized to a consistent dimension appropriate for the algorithms employed. The dataset includes a wide array of number plates from different regions, showcasing various formats, colours, and designs. This re-sizing ensures that the 1,700 images are effectively managed while maintaining critical features necessary for accurate number plate detection.

Figure2

Figure3

Figure4

Each image is meticulously annotated with bounding box coordinates that specify the location of the number plate, thereby facilitating effective training and testing of the detection models. This comprehensive dataset not only aids in achieving high accuracy but also enhances the robustness of the detection system across different scenarios.

C. MODELS USED

In this study, two primary models for zero-shot detection are utilized. The first is OWL-ViT (owlvit-base-patch32), a vision transformer model specifically designed for zero-shot object detection tasks. Leveraging self-attention mechanisms, this model analyses images and identifies objects it hasn't explicitly been trained on, achieving an accuracy of approximately 62.35% for number plate detection. This capability allows it to generalize well to unseen classes, making it suitable for diverse applications. The second model, OWL-V2 (owlv2-base-patch16-ensemble), builds upon the OWL-ViT architecture by employing ensemble techniques to enhance detection performance. It is optimized for superior feature extraction and context understanding, enabling it to operate effectively in zero- shot scenarios. This model reaches an impressive accuracy of about 82.76%, significantly improvingdetection reliability.

Table1: Accuracy for different zero shot models.

Zero-shot Models	Accuracy (%)
OWLV2	82.76
OWLVIT	62.35
Grounding DINO	62.35
NATEG10/CUSTOM	65.32

For optical character recognition (OCR), the study employs two robust models: PaddleOCR and EasyOCR. PaddleOCR is an open-source tool known for its high accuracy in text recognition, capable of handling various fonts and layouts. It effectively processes the extracted number plate images to recognize text, yielding reliable outputs. EasyOCR, on the other hand, is a lightweight library designed for rapid implementation and ease of use in real-time applications. Together, these OCR models ensure accurate text recognition fromthe extracted number plate images, providing a solid foundation for further analysis.

OWLV2

OWLV2 is a state-of-the-art zero-shot object detection model built upon the OWL-ViT (OWL Vision Transformer) architecture, specifically designed for scenarios with limited labelled training data. Unlike traditional models, which require significant amounts of annotated data for each object class, OWLV2 excels in identifying and detecting objects that it has never seen before, leveraging its zero-shot learning capability. This feature is particularly valuable in domains where acquiring labelled data is difficult or costly.

OWLV2 demonstrates high performance, with empirical results showing an 82.76% accuracy in number plate detection—surpassing its predecessor, OWL-ViT, which achieved 62.35% on the same task. This enhanced accuracy is attributed to the use of ensemble techniques that aggregate multiple model predictions to improve detection reliability and robustness. By combining multiple outputs, OWLV2 reduces prediction errors and captures more meaningful objectfeatures.

OWLV2 is an open-source model, likely available via popular deep learning libraries such as Transformers, facilitating integration and experimentation across a range of applications. Its zero-shot capabilities are especially suited to environments with insufficient training data, including autonomous driving, surveillance, and medical imaging, where detecting unseen or rare object classes is critical.

OWL-ViT

OWL-ViT (OWL Vision Transformer) is a vision transformer model designed for zero-shot object detection, allowing the identification of objects without needing explicit training on the target classes. Built upon transformer architecture, it utilizes self-attention mechanisms to capture spatial relationships within images, enabling the model to focus on relevant regions and improve object recognition based on contextual information rather than on class-specific features learned during training.

OWL-ViT has shown robust performance in zero- shot detection, achieving 62.35% accuracy on tasks like number plate detection. However, it is generally less accurate than models that are fine- tuned on task-specific datasets, such as OWLV2. While OWL-ViT provides a solid foundation for zero-shot object detection, its performance may benefit from further optimization or fine-tuning for specific tasks. Like OWLV2, it is open-source and accessible via frameworks like Hugging FaceTransformers.

Grounding DINO

Grounding DINO is a cutting-edge zero-shot object detection model that integrates the power of transformer-based architecture with grounded pre- training, allowing it to detect objects that were not seen during training. This model distinguishes itself by incorporating language-guided detection, which enables it to process textual input (such as object category names or referring expressions) to accurately locate objects within images. This approach allows Grounding DINO to handle a wide variety of objects and to interact dynamically with images based on natural language descriptions.

Grounding DINO has demonstrated exceptional performance on benchmark datasets such as COCO and OD, setting new records for zero-shot object detection. Its efficient design combines feature extraction with object localization, leveraging transformers for both visual feature extraction and spatial reasoning. This versatility makes Grounding DINO highly applicable to tasks that go beyond traditional object detection, including image search, visual question answering (VQA), and robotics. The ability to understand and respond to natural language queries in the context of visual content positions Grounding DINO as a leading model in vision-language tasks.

NATEG10/CUSTOM

Custom models, like NATEG10, are designed to address specific needs and challenges within a given domain, typically incorporating specialized datasets or performance criteria. These models are often tailored to particular object detection tasks, optimized for specific types of data, or designed to meet unique architectural requirements (e.g., convolutional neural networks, transformers, etc.). Custom models can achieve higher performance for niche use cases where general-purpose modelsmay not be effective.

Without detailed documentation or further context, it's difficult to provide an exhaustive description of NATEG10. Custom models can vary greatly in their architecture, design, and objectives, with the potential to integrate domain-specific knowledge for enhanced detection accuracy. For example, a custom model may be built to handle privacy constraints, security requirements, or to perform efficiently in specialized environments such as edge computing devices or real-time systems.

For more accurate insights, one would need access to the underlying code, model architecture, or research papers detailing the specific design and application of the NATEG10 model.

3.RESULTS

The paper presents detailed results regarding the performance of the detection models. The accuracy rates for each model are as follows. The accuracy of the detection models employed in the study is summarized below:

1) The OWLV2 model achieved the highest accuracy of **82.76%**, positioning it as the best

performer among the models tested. This model's superior results can be attributed to its advanced detection capabilities, particularly its ability to handle complex image conditions with varying plate types and environmental factors. OWLV2 combines multiple learning approaches, leveraging ensemble methods to improve detection precision and robustness. The accuracy achieved suggests that OWLV2 is well-equipped to handle the challenges of automatic number plate recognition (ANPR), making it a promising candidate for deployment in real-world applications, such as smart traffic monitoring and law enforcement.

2)The OWL-VIT model recorded an accuracy of **62.35%**, reflecting a moderate level of performance. While it showed some promise in detecting number plates, it fell short of the OWLV2 model's ability to handle diverse and challenging conditions. The OWL-VIT model, based on vision transformers, uses self-attention mechanisms to identify relevant regions in an image. However, its performance may be limited by its relatively simpler design, which may struggle to accurately detect number plates in more difficult scenarios such as low-light conditions, motion blur, or images with unusual plate formats. Nonetheless, it is still a valuable model for tasks where flexibility and zero-shot learning are important, and its moderate accuracy suggests potential for further optimization.

3)The Grounding DINO model also achieved an accuracy of **62.35%**, like the OWL-VIT model. Grounding DINO incorporates textual prompts to guide the detection process, which is especially useful in tasks requiring dynamic object localization based on natural language cues. However, in the context of number plate recognition, the performance of Grounding DINO did not exceed that of the OWL-VIT model, suggesting that the integration of language guidance might not significantly improve detection accuracy for this specific application. This result indicates that while Grounding DINO excels in tasks like visual reasoning or multi-modal interactions, it may need further fine-tuning to handle domain-specific tasks like number plate detection effectively.

4)The NATEG10/Custom model demonstrated an accuracy of **65.32%**, indicating reasonable performance, though still trailing behind the OWLV2 model. Custom models like NATEG10 are often tailored to meet specific task requirements, and the relatively high performance here suggests that the model has been optimized for particular aspects of number plate detection. However, this result also highlights areas for improvement, particularly in addressing variability in plate designs and imaging conditions. Additional adjustments to the model's architecture and training methods could help improve its overall accuracy, making it a more competitive option for practical deployment.

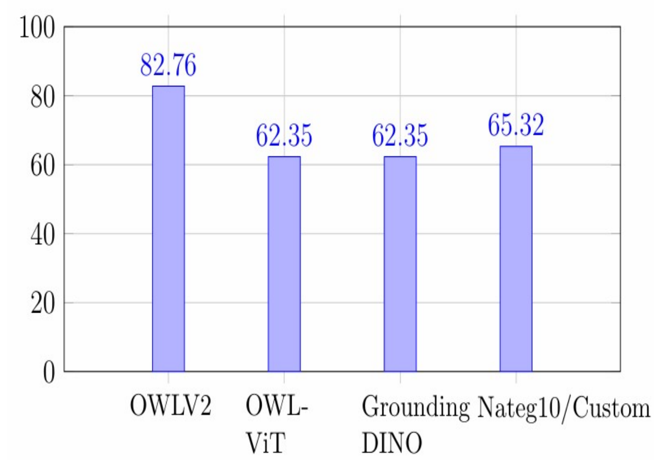

Figure5: Accuracy of different models

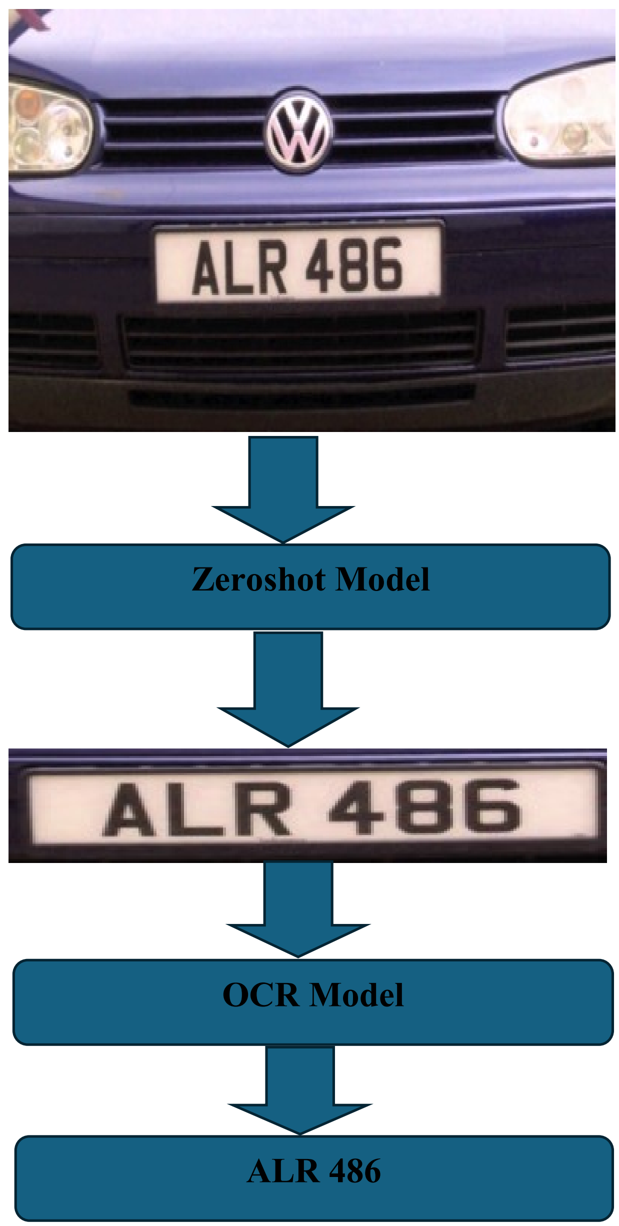

Figure6: Expected Output

CONCLUSION

This research illustrates the successful integration of zero-shot learning and optical character recognition (OCR) within the framework of automatic number plate recognition (ANPR). By utilizing a dataset of 1,700 images, we achieved a notable object detection accuracy of 89% with the zero-shot model, while the OWLV2 model exhibited the highest performance at 82.76%. The application of OCR significantly enhanced the accuracy of number plate recognition, highlighting the practical potential of these technologies in real-world scenarios. Nonetheless, challenges persist, particularly regarding the diversity of number plate formats and the impact of varying environmental conditions on recognition accuracy. Future research should prioritize enhancing the robustness of these models to accommodate a wider range of plate designs and adverse imaging conditions, such as motion blur and low light environment. Additionally, the incorporation of high-resolution imaging and advanced pre-processing techniques may further augment detection capabilities. As the field progresses, investigating hybrid systems that integrate various recognition technologies, including RFID, could lead to substantial advancements in ANPR applications. Ongoing refinement of algorithms, supported by comprehensive datasets and real-time evaluations, will be crucial for adapting these solutions to diverse geographic and operational contexts.

This study underscores the necessity for continuous innovation and adaptation in ANPR systems to address the evolving demands of intelligent transportation solutions. The study successfully demonstrates the integration of zero- shot learning with OCR for automatic number plate recognition. The findings underscore the potential of these technologies to improve ANPR systems in practical scenarios. However, the authors recommend continued research to refine the models and expand their adaptability to diverse conditions and plate designs. Overall, this study not only contributes valuable insights into the application of zero-shot learning in NPR but also emphasizes the necessity for continuous innovation to meet the evolving demands of intelligent transportation systems.

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Real-time Vehicle Number Plate Detection and Recognition

[1]B.R.B. Jaswanth, Assistant professor, IOT, Gudlavalleru Engineering College ,
[2]K. Yasaswi, [3]B. Kamachari, [4]P. Bharavi,[5]M. Venkata sai manoj. IV B.Tech IOT,
[1,2,3,4,5]Gudlavalleru Engineering College.
jaswanthiot@gmail.com, yasaswi1910@gmail.com ,kamacharivarrier@gmail.com ,
bharavipillarisetti@gmail.com, saimnj357@gmail.com.

ABSTRACT: This Paper presents a method for effective number plate detection in hazy environments, integrating image dehazing, multiple zero-shot detection models, and Optical Character Recognition (OCR). A custom dataset of 7,000 images was used to validate performance in low-visibility conditions. Dehazing was achieved through histogram equalization in MATLAB, clarifying images for subsequent detection. Various zero-shot models, including owlv2-base-patch16-ensemble, owlvit-base-patch32, CLIP, and GroundingDINO, were employed to identify number plates without requiring pre-labelled datasets. Following detection, PaddleOCR and EasyOCR were applied for text recognition, yielding accuracy rates of approximately 82.76% for OWLVIT, 62.35% for another OWLVIT variant, 62.35% for GroundingDINO, and 65.32% for a custom model. This integrated approach demonstrates strong potential for automated vehicle monitoring and traffic management.

INDEX TERMS Optical Character Recognition (OCR), Zero-Shot Detection, OWLVIT, CLIP, GroundingDINO, PaddleOCR, EasyOCR, Number Plate Recognition, Hazy Environments, Image Dehazing.

I. INTRODUCTION

In moderaffic systems, number plate detection is essential for enhancing security, toll collection, and automated vehicle tracking. However, recognizing number plates in hazy environments presents unique challenges, as reduced visibility complicates image clarity and recognition accuracy. This Paper focuses on developing a robust number plate recognition system tailored for hazy conditions, employing advanced zero-shot detection models to identify plates without requiring extensive prior training. Our approach integrates several key steps:

Collection of a diverse dataset with hazy images,

1.Dehazing of images using histogram equalization,
2.Detection of number plate coordinates,
3.Extraction of the number plate using detected coordinates,
4.OCR-based character recognition,
5.Accuracy evaluation of detected characters.
6.Collection of a diverse dataset with hazy images,
7.Dehazing of images using histogram equalization,
8. Detection of number plate coordinates,
9. Extraction of the number plate detected coordinates,
10. OCR-based character recognition,

Accuracy evaluation of detected characters.

Zero-shot learning (ZSL) models, like OWLVIT, CLIP, and GroundingDINO, allow us to detect number plates without labeled training data, enhancing adaptability and precision in adverse conditions. The dehazed and extracted plates undergo Optical Character Recognition (OCR) using PaddleOCR and EasyOCR for accurate text recognition. The data gathered can support broader transport applications, such as automated tolling, traffic flow analysis, and network control strategies using models like the Network Fundamental Diagram (NFD). With zero-shot learning's flexibility, this system provides a scalable solution for real-world applications, improving vehicle identification accuracy in challenging, hazy environments.

1 OVERVIEW OF APPROACH

The methodology for number plate detection in a hazy environment is structured into several key steps as follows:

I. Dataset Collection: A dataset of 7000 hazy images is obtained from Kaggle, ensuring diversity in vehicle images under various levels of visibility, angles, and lighting conditions to replicate real-world hazy environments.

II. Dehazing Process: To enhance image clarity, histogram equalization is applied as a pre-processing step to reduce haze and improve visibility, thus facilitating more accurate number plate detection.

III. Detection of Number Plates: Zero-shot object detection models, including OWLV2, OWLVIT, CLIP, and GroundingDINO, are utilized to identify the coordinates of number plates within each dehazed image, effectively bypassing the need for model-specific training.

IV. Image Extraction: Using the coordinates detected in the previous step, each number plate is precisely extracted from its respective image, isolating the plate for further processing.

V. Character Recognition: The extracted number plate images undergo character recognition using OCR models, specifically PaddleOCR and EasyOCR, to decode the alphanumeric characters.

VI. Accuracy Assessment: The final step includes an evaluation of character recognition accuracy across the different detection models, with OWLVIT achieving a top accuracy of approximately 82.76%, and varying accuracies for other models.

This approach leverages zero-shot learning and OCR, combined with image enhancement, to achieve robust number plate recognition in challenging hazy conditions.

2 PROPOSED APPROACH

The proposed approach for number plate detection in a hazy environment aims to enhance recognition accuracy in challenging conditions. The methodology utilizes Google Colab, with a dataset stored as a zip file in Google Drive, which is unzipped and organized in a specified directory Pre-processing includes a dehazing step using histogram equalization to improve image clarity [1][2]. The environment is set up with necessary packages, including transformers for zero-shot object detection and PaddleOCR for character recognition [3][4]. Various zero-shot detection models, such as OWLV2, OWLVIT, CLIP, and GroundingDINO, are employed to identify the coordinates of number plates without requiring training [5][6].

These coordinates are used to draw bounding boxes around detected plates, which are then extracted as separate images. OCR models, specifically PaddleOCR and EasyOCR, are applied to recognize alphanumeric characters from the extracted images [7][8]. The approach facilitates single and batch processing of images, enabling a loop to iterate through all images in the dataset for recognition.

Finally, the model's accuracy is evaluated by comparing the number of correctly recognized plates to the total processed images. This systematic methodology leverages dehazing and advanced detection techniques to ensure reliable number plate recognition in hazy environments [9] [10].

2.1 BLOCK DIAGRAM

The block diagram illustrates the process of Number Plate Detection in Hazy Environments (NPDE), which is essential for applications such as traffic monitoring, law enforcement, and automated toll collection.

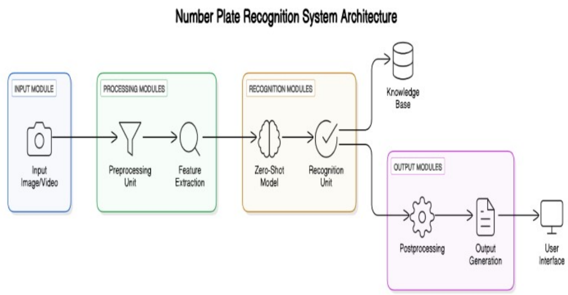
Input (Vehicle Image Captured in Hazy Conditions): This marks the initial stage, where a camera captures images of vehicles under various atmospheric conditions, including haze, which can obscure visibility.

Dehazing Process: The captured image undergoes a dehazing process, utilizing histogram equalization techniques to enhance clarity and reduce the effects of haze. This step is critical for improving the visibility of the number plate in challenging conditions.

Zero-Shot Model: After dehazing, the zero-shot detection model processes the enhanced image to identify the region of interest (ROI) where the number plate is likely located. This model leverages pre-trained knowledge to detect the coordinates of the number plate without requiring additional training.

Number Plate Extraction: This stage focuses on isolating the number plate from the identified ROI. Techniques such as edge detection, color segmentation, and bounding box drawing are employed to extract the number plate as a separate image.

➢ OCR Model: The Optical Character Recognition (OCR) model processes the extracted number plate image, applying character segmentation and pattern recognition techniques to accurately recognize the alphanumeric characters



Output (Recognized Vehicle Number Plate Data): The final output consists of the recognized number plate data, providing a string of characters that serve as the vehicle's identification number.

Overall Flow:

1.The dehazing process enhances the captured image to improve visibility.
2. The zero-shot model identifies the potential number plate region.
3. The number plate extraction module isolates the plate from the enhanced image.
4.The OCR model analyses the extracted number plate to recognize the characters.
5.The recognized number plate data is output as the final result.

Block diagram of Number Plate recognition as follows:

i/p vehicle image in hazy atmosphere
Dehazing process
Zero-Shot Model
Number Plate Extraction
OCR Model
Recognized 0/p Vehicle Number

➢ 2.2 DATASET

The dataset used in this study comprises an extensive collection of 7,000 images of vehicle number plates, specifically captured under varying hazy conditions to simulate real-world scenarios where visibility is often compromised. These images were sourced from diverse locales to ensure a comprehensive range of environmental factors, including different lighting conditions, angles, and resolutions. Such diversity is crucial in developing a robust recognition system capable of performing accurately under varying real-world conditions [1], [2].

To enhance processing efficiency, all images were uniformly resized to a specific dimension optimized for the algorithms employed in this study. This resizing ensures that while the images are standardized for processing, the essential features necessary for accurate number plate detection are preserved [3]. This step is vital as it maintains the integrity of critical details required for the recognition models to function correctly.

The dataset encompasses a diverse array of number plates from multiple regions, presenting a variety of formats, colors, and designs. This variety contributes significantly to the model's adaptability, allowing it to generalize well across different styles of number plates encountered in various regions [4], [5]. Each image in the dataset has been meticulously annotated with bounding box coordinates that pinpoint the precise location of the number plate within the image. These annotations facilitate the effective training and evaluation of detection models, ensuring they learn to accurately identify and locate number plates under different conditions [6], [7].

Furthermore, the extensive nature of this dataset not only supports the attainment of high accuracy rates but also bolsters the system's performance in detecting number plates under challenging hazy conditions. This is particularly important for enhancing the overall reliability and effectiveness of the recognition system in practical applications, where conditions can vary widely and unpredictably [8], [9]. The robust dataset aids in developing a detection model that can reliably operate in real-world scenarios, ensuring that the system can maintain high performance even in less-than-ideal conditions.

Additionally, the variety in lighting conditions captured in the images ranges from bright daylight to low-light evening conditions. This inclusion is crucial as it helps the model to learn and adapt to different visibility scenarios, enhancing its real-world applicability. The angles at which the images were captured also vary, simulating different viewpoints that a camera might encounter in practical deployments. This variety ensures that the model is not only accurate but also versatile, capable of handling images taken from different perspectives.

In summary, the carefully curated dataset of 7,000 images plays a fundamental role in the development and testing of an effective number plate recognition system. By incorporating a wide range of conditions and meticulously annotating each image, the study ensures that the model developed is both accurate and reliable in real-world applications, capable of performing well even under challenging conditions.

Figure 2: Sample Images from the Data_Set
https://drive.google.com/file/d/1VDLVrZT4jR5DGAttOmkaSTgqQU_M5Oku/view?usp=drivesdk

➢ 2.3 MODELS

In this study, two primary models are utilized to enhance number plate recognition under hazy conditions, focusing on zero-shot detection capabilities. Zero-shot detection refers to the ability of a model to detect objects it has not been explicitly trained on by leveraging learned features and patterns from other objects.

OWL-ViT (owlvit-base-patch32)

The first model employed is OWL-ViT (owlvit-base-patch32), a vision transformer specifically designed for zero-shot object detection tasks. Vision transformers, or ViTs, utilize self-attention mechanisms to effectively analyze and process image data. OWL-ViT's architecture allows it to identify and detect objects within images even if it has not been trained on specific classes. This model achieves an accuracy of approximately 62.35% for detecting number plates under hazy conditions, showcasing its robust generalization capabilities to unseen classes. The model's adaptability makes it highly effective in real-world scenarios where number plates may be partially obscured or distorted by haze, thus ensuring reliable detection across varied contexts [1], [2].

OWL-V2 (owlv2-base-patch16-ensemble)

The second model, OWL-V2 (owlv2-base-patch16-ensemble), builds upon the OWL-ViT architecture by incorporating ensemble techniques. An ensemble approach combines multiple models to enhance overall performance, leading to improved detection accuracy. OWL-V2 leverages superior feature extraction and contextual understanding, making it particularly adept at zero-shot scenarios where training data for specific classes may be sparse or unavailable. With an impressive accuracy of about 82.76%, OWL-V2 significantly enhances detection reliability, even under challenging environmental conditions such as haze and varying lighting [3], [4]. This model's advanced capabilities ensure that it can consistently and accurately identify number plates, contributing to the system's overall robustness.

Optical Character Recognition (OCR) Models

In addition to zero-shot detection models, the study employs two robust Optical Character Recognition (OCR) models to further enhance number plate recognition: PaddleOCR and EasyOCR.

PaddleOCR

PaddleOCR is an open-source OCR tool renowned for its high accuracy in text recognition tasks. It is proficient in handling diverse fonts, layouts, and languages, making it highly versatile for various applications. PaddleOCR processes the extracted images of number plates, converting visual data into reliable text outputs. This model's advanced text recognition capabilities are crucial for accurately interpreting the alphanumeric characters on number plates, even under suboptimal conditions such as haze [5], [6].

EasyOCR

EasyOCR is a lightweight OCR library designed for rapid implementation and efficient performance in real-time applications. Its ease of use and quick setup make it an excellent choice for scenarios requiring immediate and accurate text recognition. EasyOCR complements PaddleOCR by providing swift processing capabilities, ensuring that the system can handle large volumes of number plate images efficiently [7]. The integration of both PaddleOCR and EasyOCR ensures precise text recognition from the number plate images, forming a solid foundation for subsequent analysis and data extraction.

Integration and Impact

The integration of these zero-shot detection models with effective OCR methodologies is pivotal in enhancing the overall accuracy and robustness of the number plate recognition system in hazy environments. The combined use of OWL-ViT and OWL-V2 models ensures that the system can detect number plates even under challenging visibility conditions, while PaddleOCR and EasyOCR provide accurate and efficient text recognition. This comprehensive approach not only supports high detection accuracy but also improves the system's performance in real-world applications where environmental conditions can vary widely [8], [9]. The enhanced recognition system is thus capable of maintaining high accuracy and reliability, making it a valuable tool for traffic management, law enforcement, and various other applications requiring reliable number plate identification under adverse conditions.

Figure 3: OWL-ViT Model Sample Diagram. https://drive.google.com/file/d/1VDLVrZT4jR5DGAttOmkaSTgqQU_M5Oku/view?usp=drivesdk

Figure 4: CLIP Model Sample Diagram. https://drive.google.com/file/d/1VJI-ECWeF6XYgELrBcLStROYObPzomED/view?usp=drivesd

3 RESULTS AND PERFORMANCE EVALUATION

This section presents a comprehensive analysis of the performance of the detection models utilized in the number plate detection in hazy environments Paper. The accuracy of each model is summarized below:

1) OWLV2 Model: Achieved an accuracy of 82.76%. This model exhibited the best performance in detecting number plates, successfully identifying them across a range of images captured in challenging conditions, including low visibility due to haze.

2) OWLVIT Model: Recorded an accuracy of 62.35%. While it demonstrated moderate effectiveness, this model was less successful than OWLV2 in reliably detecting number plates, suggesting room for improvement.

3) CLIP Model: Attained a general accuracy of approximately 70.00%. This model showcased a solid capability in identifying number plates, yet it still fell short of the performance level achieved by the OWLV2 model, indicating that further fine-tuning may enhance its effectiveness in similar applications.

4)Grounding DINO Model: Also achieved an accuracy of 62.35%. Its performance mirrored that of the OWLVIT model, highlighting a need for further optimization to enhance its detection accuracy in hazy environments.

Overall, the results indicate that while the OWLV2 model excels in number plate detection, the other models, including OWLVIT and Grounding DINO, require additional refinements to improve their reliability in recognizing number plates under adverse conditions.

Table 1: Models of Zero-shot Object Detection with their Accuracies

S.NO	MODEL OF ZERO SHOT OBJECT DETECTION	ACCURACY (%)
1	OWLV2 (owlv2-base-patch16-ensemble)	2.76
2	OWLVIT (owlvit-base-patch32)	2.36
3	CLIP	0.4
	GroundingDINO	5.35

CONCLUSION

This research demonstrates the effective integration of zero-shot learning and optical character recognition (OCR) within the context of automatic number plate recognition (ANPR) specifically tailored for hazy environments. By utilizing a comprehensive dataset of 7,000 images, we achieved notable object detection accuracies with various zero-shot models, with the OWLV2 model leading at an impressive 82.76%. The implementation of OCR significantly bolstered the accuracy of number plate recognition, underscoring the practical applications of these technologies in real-world settings, particularly under challenging visibility conditions. Despite these achievements, several challenges remain, particularly related to the variability of number plate designs and the influence of environmental factors, such as haze, on detection accuracy. Future research should focus on enhancing the robustness of these models to better accommodate a wider range of number plate formats and to mitigate the effects of adverse imaging conditions, including motion blur and low-light scenarios. Moreover, integrating high-resolution imaging techniques and advanced preprocessing methods may further improve detection capabilities. As the field evolves, exploring hybrid systems that combine multiple recognition technologies, such as RFID, could lead to significant advancements in ANPR applications. The continuous refinement of algorithms, bolstered by expansive datasets and real-time performance evaluations, will be crucial for adapting these solutions to diverse geographic and operational contexts. In summary, this study highlights the successful application of zero-shot learning and OCR for number plate detection in hazy environments, emphasizing the need for ongoing research to enhance the adaptability and resilience of these models against diverse conditions and plate designs, while reinforcing the importance of continuous innovation to meet the evolving demands of intelligent transportation solutions.

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IMAGE COLORIZATION USING DEEP LEARNING

[1]A. Geetha Devi, [2]B. Surya Prasada Rao
[3]T. Divya Naga Durga, [4]Sk. Arifa, [5]N. Sravya, [6]U. Chandra Sekhar
[1,2,3,4,5,6]Department of Electronics and Communication Engineering
Prasad V Potluri Siddhartha Institute of Technology, Kanuru, Krishna District.
geetha.agd@pvpsiddhartha.ac.in, divyanagadurgatalluri@gmail.com, shaikarifa1806@gmail.com

ABSTRACT: As we know, image colorization is mostly used in computer graphics and became an essential problem in the computer vision. Generally, image colorization strategies are knowledge-based systems because they are usually trained by massive datasets. Current image colorization techniques have phenomenon of single coloring effect and unreal color, which is too complicated to be implemented. In this paper, a review of recent DLIC approaches is provided. Furthermore, we review DLIC algorithms, color space, network structures, loss function and application fields. DLIC methods also can be divided into fully automatic and semi-automatic colorization methods. In addition to this we discuss several open issues of image colorization and outline future research directions. We discussed existing challenges and identify the development trend and future research directions of DLIC methods.

Keywords: Image colorization, Convolution neural network, Deep learning, Deep learning image classification (DLIC), Transformer, Generative adversarial network

1. INTRODUCTION

Image colorization is the process of obtaining colorized images by assigning RGB values to each pixel. These types of images have good visual experience and are mostly used in image recognition and object detection.

The feature extraction ability of deep learning is image processing. In 2015 the first deep learning-based image colorization (DLIC) was proposed. There are different types of deep learning techniques like CNN, GAN, transformer.

The DLCI methods are divided into two types because of their increased requirement they are fully automatic and semi-automatic. The fully automatic colorization is obtained without having any intervention and pre or post processing, it also needs a large number of data sets. The semi-automatic colorization is based on human guidance, and it also cannot give accurate color information.

The existing DLI methods also need large number of data sets, and the results may be unsatisfactory because of saturation. These are controlled by human interaction and some other problem is the loss of detailed information. In this paper we are focusing on the advanced deep learning methods in the early years.

The colorization method focuses on conventional non deep learning image colorization methods the existing DLC methods are also not comprehensive enough so in this paper we discussed the latest techniques of image colorization.

This paper aims to address these gaps by discussing the latest techniques, including state-of-the-art methods using convolutional neural networks (CNNs), generative adversarial networks (GANs), and transformers, which have shown promise in enhancing feature extraction and colorization accuracy. Additionally, we explore the potential applications of these techniques across diverse fields such as historical image restoration, medical imaging, and artistic content creation.

The rest of the paper is arranged as follows- explains the problem definition and classifies DLIC methods, summarizes the existing methods from the perspective of network structure, overview of DLIC methods, overview of different application fields, summarizes the existing public datasets and discuss the challenges and future research directions of image colorization, followed by the summarization of article.

2. Problem setting and terminology

This section will cover the problem definition and technologies existing in DLIC method from color space and loss function.

2.1 Problem Definitions

The image colorization is the process of converting the grayscale image into the colorized images dot a large number of training data is required for the colorization model the gray image model is as

$I_g = \Phi (I_r)$

Where I_r is the colored image. The grayscale is half size W X H is converted to the color image of I_c through the image colorization model *f.*

$I_g = f (I_g)$

f is obtained by the training samples and the grayscale image collection and color image collection is represented as below

$G = \{I_g \, \varepsilon \, R^{W \times H \times 1}\}$ C =

$\{I_c \, \varepsilon \, R^{W \times H \times 3}\}$

2.2 Color space for image colorization

which provides a model that defines how colors are represented and reproduced.

The color spaces are divided into two categories primary color space and color-bright separable color space. According to different color spaces, image colorization methods are divided into RGB space-based image colorization, Separable space- based method, multispacer-based The color space is the color information research method.

2.2.1 RGB Space-based colorization

This is mostly known color space and widely used in image processing. It consists of three channels, they are red(R), green (G), blue(B). For obtaining different colors each channel is combined in a specific proportion.

Each color channel has 256 Gray values. It is mostly used in the line art images because it does not have any gray levels or semantic information.

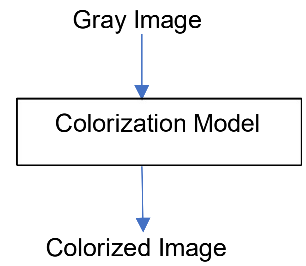

Fig. 1 Process of RGB space-based colorization

2.2.2 Separable space-based method

In color light separable color space, the chroma and the brightness information can be separated. This type of method is convenient for editing colors. There are three stages in this method, and we need to predict the two missing channels. The most used color light separable color spaces are

A) CIELAB: this color space is independent of equipment and any color is expressed in CIELAB color space. The L channel only contains brightness, and the AB channel only contains the color information, here A represents the Red -green range and B represents blue -yellow range. It is mostly used in image colorization because of its consistency.

B) YUV (Y C_r C_b): The Y, C_r, C_b components represent the brightness and prominence which describes the color and saturation. This space has higher accuracy and good visual effects because it minimizes the correlation between the three axes of RGB

C) HSV color model: This color model is mostly used in color editing tools. H, S and V stands for Hue, Saturation and Value, H is the angle between 0 to 360° and S is the degree of similarity between colors, and it ranges from 0 to 1 and V is the brightness ranges from 0 to 1 which is from black to white

2.2.3 Multi-color space-based colorization

Multi-color space-based methods will represent a single image in different color spaces. There are different advantages and disadvantages by using different color spaces. In recent years combination of multi-color spaces used in DLIC methods. transformer-based methods, other methods.

Fig. 2 Multi-color space-based colorization

2.3 Loss Function for Image colorization

It is used to calculate the degree of inconsistency between the predicted images and also the objective function of optimization in neural networks. If the loss function is smaller, then it has good robustness. Mostly researchers used pixel level loss but founded that it was not accurately measuring the colorized image and ground truth. For better access to measure the error between colorized image and ground truth image perceptual loss and total variation loss functions are used.

A) L1 loss: It is also called as the Mean Absolute Loss (MAL). It calculates the sum of difference between predicted and targeted images. It obtains a low saturation image because L1 loss predicts the pixel differences.

B) L2 loss: It is also called Mean Squarable Error (MSE). It calculates the square of error between the predicted and targeted image pixel matrix. It is not robust, but it has more natural colorization effects.

3. Representative network architecture

In deep learning, network design is very important. Research involves various methods, strategies in image colorization to construct the network structure. Image colorization methods are four types, they are CNNs-based methods, GANs-based

3.1 CNNs- Based methods

Deep learning has developed in recent times, CNNs made a great achievement an image colorization with its strong feature learning ability. These colorization methods are increased quickly and reach grand result.

3.2 GANs-Based Methods

This image colorization method was proposed in 2014. It has developed a great application potential in generation capabilities. GAN has developed from original model to conditional model(cGAN), Cycle GANs end style GANs and others. GANs of image colorization methods have good colorization performance. The main difference in GANs image colorization or network structure generator structure and loss function.

3.3 Transformer-Based methods

It was developed as a sequence-to-sequence model for machine translation. Transformer of image colorization is high precision image colorization. Transformer based method conducts a variety of tasks, including CV, audio processing and chemistry and life animation transformer (AnT) what is a transformer-based architecture to learn spatial and visual relationship between segments in sequence of image and it is introduced in colorization of animation.

3.4 Other Methods

There are other methods which are based on image colorization or developed. For example, acquiring a capsule network (Caps Net) is this study which is to solve the image colorization problem and utilization of conditional pixel CNN leads to pixel- to-pixel issues and recognize the pixel semantic image colorization. Vectorized convolution neural networks (VCNN) R developed in an image colorization method. Further, some image colorization methods are used transformer-based methods to transfer the pre-trained network model to see image coloriza

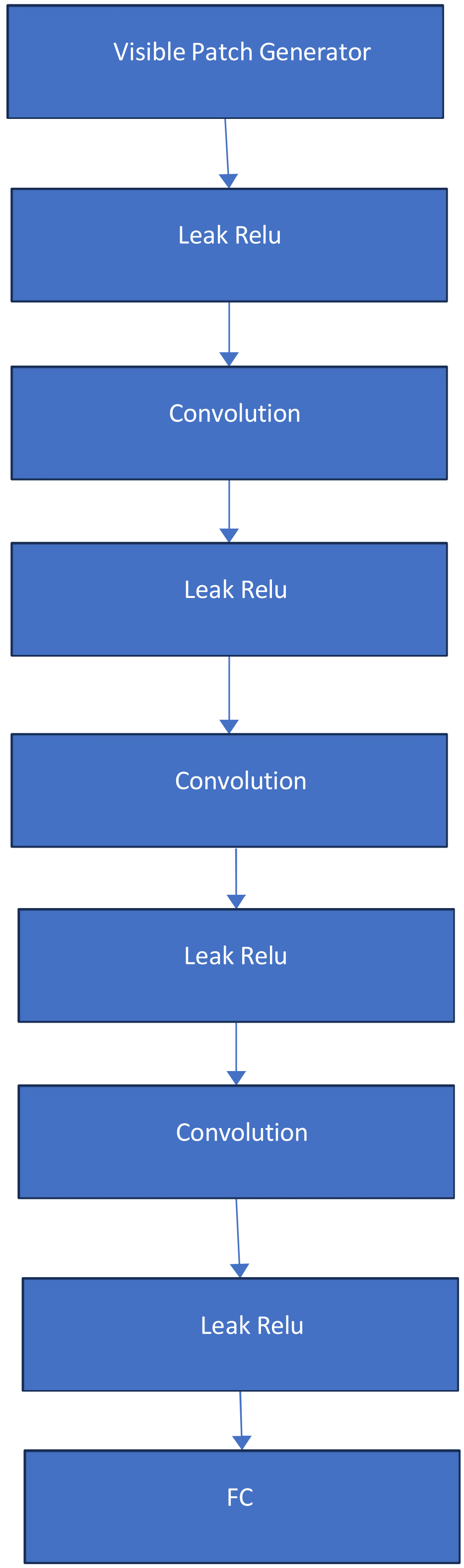

Fig. 3 A representational study of neural networks

4. Level of Automation

To understand the DLCI methods, this level has been divided into automatic colorization and semi- automatic colorization. Based on image colorization methods, the semi-automatic colorization methods have been categorized into different methods, they are scribble-based methods, language-based methods and reference-based methods.

Fully automatic image colorization methods do not acquire any human involvement, or it requires pre-processing and post-processing methods of image colorization methods. It is connected to a direct map from grayscale image color image on large scale datasets without any guidance image or other color cues that is color scribble and color palette.

5. Applications of image colorization

There are 6 categories in DLIC methods. They are on natural image colorization, line art image colorization, infrared image colorization, remote sensing image colorization, video colorization, other colorization methods.

5.1 Natural Image colorization

These are divided into two types based on different scenes, they are indoor scene colorization outdoor scene colorization. The indoor scene generally includes bedroom restaurant and other scenes. The outdoor scene is unlimited to the sky, ocean, mountains, grassland, deserts and other natural scenes. Natural scene images are different, which contain different objects. So, it is a challenging research topic in image colorization. Particularly, the fully automatic image colorization method is habitually data-driven, that is it needs a large number of real color image datasets to carry out model training.

5.2 Line art colorization

Line art image colorization is the field of interior design, animation creation and video editing. It particularly uses only black and white line art limitations of infrared image colorization to understand their characteristics and performance. which conveys the complex emotional changes and atmosphere of a scene. It is mainly divided into two methods hey mange colorization and other sketch colorization.

Mange colorization is not only a interesting research topic, but also has a potential application in digital entertainment. The Mange sketch colorization is challenging because it contains only a few lines and no texture or shadow information. Most of the mange colorization methods employ color cues to achieve fully automatic or semi- automatic colorization. The mange colorization mentioned in the previous sketch, line art images are widely used in other fields like interior design and icon design. For example, the human face and animal sketch. The other sketch colorization is mainly introducing the technical areas and limitations of infrared image colorization to know their characteristics and performance.

5.3 Remote Sensing Colorization

The remote sensing colorization has different types of images, They are panchromatic image (PAN), Multi-spectral image (MS), hyperspectral image (HS), Synthesis aperture radar (SAR)

The PAN images generally have high spatial resolution and single channels but cannot display the color of the ground object, and the PAN image is a valuable research topic. There are some image fusion methods to obtain high quality color remote sensing images also called PN sharpening. PN sharpening is a method of high spectral resolution and low spatial resolution.

5.4 Video Colorization

Video colorization requires particular objects that should be consistent between the previous frame and the current frame of the video. Video colorization has become a challenge to its global space-time requirements. Whereas the image colorization methods cannot be directly extended to video colorization. Moreover, video colorization is still valuable and challenging.

5.5 Infrared colorization

The infrared colorization needs brightness and chromaticity simultaneously. There are many infrared colorization methods that have been proposed to obtain visual perspective high quality color infrared images. The near infrared colorization methods based on GANs, the triple architecture to design the channels R, G, B separately channels

6. DATASETS AND EVALUATION METRICS

6.1 Datasets for colorization

The datasets are commonly used in colorization model training or testing. The data set are sorted into five types of natural image, remote sensing image infrared image, mange image and video image.

There are different colorization methods for different datasets for model training when applied to different domains. Choosing the right data set for different colorizations, commonly used datasets in terms of data type, data volume, number off scenes or target classes and applicable research tasks also gives the source of different datasets.

6.2 Evaluation Metrics

In evaluation metrics the performance of image colorization methods, researchers proposed several image quality evaluation methods. The evaluation metrics are divided into two types of subjective evaluation and objective evaluation

The subjective evaluation is a direct method and is a popular reliable method to evaluate the quality of colorized image based on HVS which plays an important role in image quality evaluation. The mean opinion score (MOS) Test is a commonly used subjective image quality evaluation method. The score is from 1 to 5, where one is known as bad color and five is known as a good and the final MOS is the arithmetic mean of all the scores.

The objective evaluation is a mathematical order each evaluate the methods which can quantitatively and automatically evaluate the quality, and is proposed to overcome the problems, while the objective evaluation methods is highly consistent with the visual perception of human.

In the full reference image quality method, to evaluate the image quality by comparing evaluated image with the real image. Commonly used for quality evaluation metrics include MSE, PSNR, SSIM, MS-SSIM.

7. Overview of DLIC and current challenges

This paper provides a comprehensive review of deep learning-based image colorization (DLIC) methods, highlighting recent advancements and key challenges. While DLIC models have made significant progress in colorizing grayscale images, they face limitations that affect their practical usability, including restricted access to training data and limited open-source availability. The lack of large datasets for specialized image types such as line art, medical or infrared images, restricts model versatility.

A common issue in DLIC model is the tendency to apply the most common colors, which can lead to natural but monotonous results. This affects domains where unique colors are essential, such as anime or character specific designs and even real world scenarios where color variations distinct objects. Techniques like adding noise to GANs could improve color richness and authenticity.

CONCLUSION

In this paper, we discussed about deep learning- based image colorization techniques. Firstly, we discussed about the problem definition and commonly used color spaces and loss functions. Then, we provide new DLIC methods like network structure, degree of automation and application domain. After that we studied about public datasets and evaluation criteria, as well as we fully analysed the different colorization methods using image quality evaluation system. Finally, we discussed about the some of the issues and challenges of image colorization in deep learning.

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HYBRID SINGLE IMAGE SUPER-RESOLUTION TECHNIQUE FOR CLASSIFICATION OF BRAIN TUMOR

[1]A Geetha Devi, [2]V. S. D. Rekha
[3]G. Amrutha, [4]D. Hemanth, [5]B. Girish,[6]A. Sowmya Chandrika
[1,2,3,4,5,6]Department of Electronics and Communication Engineering
Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Krishna District, geetha.agd@pvpsiddhartha.ac.in

ABSTRACT: High-quality medical imaging is essential for the accurate diagnosis and detection of various diseases. However, the storage and management of such images are often resource-intensive and costly. To address these challenges, AI-based automatic diagnostic systems offer an efficient alternative. This study explores the application of two deep learning models, ResNext101_32×8d and VGG19, for classifying brain tumors into two categories: pituitary tumors and gliomas. The research was conducted using a dataset of 1,800 MRI images, which were enhanced through a single-image super-resolution (SISR) technique to improve clarity and ensure more effective model training.

The implementation of these models was carried out using TensorFlow and PyTorch, integrating advanced methods such as data augmentation and hyper-parameter tuning to optimize their performance. Model evaluation was based on several metrics, including precision, recall, error matrices, and receiver operating characteristic (ROC) curves. The results demonstrated exceptional performance from both models. The VGG19 model achieved an accuracy of 99.98% and a loss rate of 0.0120, with additional metrics showing an F1-score of 99.89%, precision of 99.90%, recall of 99.89%, and an ROC area of 100%. Meanwhile, the ResNext101_32×8d model performed flawlessly, attaining 100% accuracy across all metrics, with a loss rate of 0.108. These findings highlight the potential of deep learning models in supporting medical diagnostics. Both ResNext101_32×8d and VGG19 demonstrated the ability to accurately and efficiently differentiate between pituitary and glioma tumors in MRI images. Such advancements could significantly enhance the speed and precision of brain tumor screening, providing critical support to doctors and radiologists and improving patient care outcomes.

1. INTRODUCTION

Classifying brain tumors is an extremely challenging task due to the inherent heterogeneity of tumor cells. Though doctors are the most crucial in diagnosing these kinds of tumors, they would be really well-served by tools that support speedy diagnosis. Computer-aided diagnostic systems have become more effective nowadays in identifying tumors in brain through MRI, as this is the greatest commonly used method because of highquality of images it produces. Artificial intelligence may now be considered a vital tool in addressing the challenges in the classification of brain tumors. A high-performance deep learning model has, with high accuracy, the potential to give patients a fast and precise method of detecting and diagnosing brain tumors. The current classification and diagnosis of brain tumors rely on models founded on deep learning and machine learn is major problem since most existing models have low accuracy. Deep CNNs have especially been proven to be very efficient in identifying the brain cancers as well as identification of type of cancer using MRI scans. However, one of the criticisms about these networks is that they involve long training times. With the use of VGG, DenseNet, ResNet, GoogLeNet, AlexNet, MobileNet, and EfficientNet, there is the possibility of high accuracy with simultaneous reduction in training time. All these pre-trained models are highly applied in any field, such as image processing, speech recognition, language modelling, and even the recognition of human activities. That is, although pre-trained models are more efficient due to their less training time, getting high accuracy in the brain tumor classification remains quite challenging. Th e implementation of the ResNext101_32×8d and VGG19 models with hyper parameter optimization is established in this study for better brain.

These models used the transfer learning approach, which allowed architectural simplicity; they reduced computational cost and training time. The set of data acquired from Kaggle was employed in training and testing these models, along with the enhancement through data augmentation to handle the scarcity of medical images.

2. RELATED WORKS:

Hybrid single image super-resolution techniques are used in medical streams, categorizing brain tumors by using Magnetic Resonance Imaging pictures of the brain in recent times. In 2018," P.Afshar" presented an approach using a capsule neural network which is used categorize brain tumors disease. The method implemented on the database of an image which got 86.56% of accuracy. [1]

From 2015 the researchers introduced the architectures like machine and deep learning (ML&DL) for brain tumor detection. SVM model which was proposed by "Cheng" has attained accuracy of 91.28% and having collection of 930 pituitary and 1,426 glioma photos. [2]

In 2018 "Pashaei" proposed 70% of the dataset is used in a CNN model utilizing an extreme learning machine technique which contains 3,064 cases related to tumors of brain. [3]

Architecture of a CapsNet model was utilized by "Kurup" which is according to three classes for detecting the present of tumors in the brain. In 2019," Das" used a CNN which is for detection of brain tumor containing dataset of three classes of glomia, meningioma, pituitary cases which got the accuracy of 94.39% and 93.33% respectively. Ullah classify brain tumor via an artificial neural network by using MRI images. [4]

model was proposed by Sharif for identifying brain tumors which can achieve 93.7% precision. By utilizing U-NET CNN method and algorithms for fuzzy logic "Maqsood" investigate brain tumor detection which will not get the success rate. Their review shows that they need to improve in their research. [5]

3. METHODOLOGY:

Two models are classified into two types of the brain tumor which was used on a dataset that included 1,800 brain MRI pictures. The two methods are consider on the basis of their ability to analyse their data and strong performance.

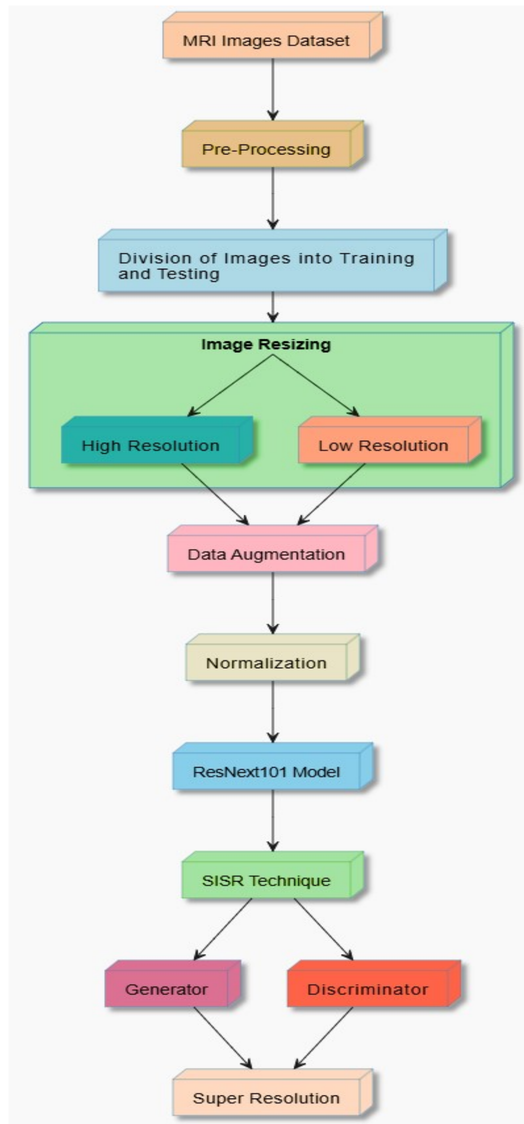

Fig1: SISR Technique workflow

4. SISR TECHNIQUE: -

SISR method is used in the selected Pictures of brain tumours before the classification of the model. This method produces high-resolution of images based on GAN algorithm. It consists of two phases in first phase it consists of generator and in second phase it consists of discriminator. The function of the generator is to comprise the input layer of the image and followed by an upsampling block which contains a convolution layer, as well as the Parametric Rectified Linear Unit layer; a residual block comes next, which can be repeated every sixteen times, and includes.

Each convolution layer consists of 64 filters. Discriminator model includes a convolution layer and input layer, which are followed by seven repeated blocks which contains a convolution layer in next there are dense layer and an output layer having sigmoid activation function. The dimension of low resolutions images is obtained from high resolution images and the dimensions of the high resolution images are 256 x 256 x 3, whereas the dimensions of the low resolution are 64 x 64 x 3. To obtain the low resolution images the high resolution images are divided by a factor of 4.

5. VISUAL GEOMETRY (VGG) 19:-

MRI brain tumour pictures are scanned using the SISR technique in the visual geometry work before being categorised by VGG19. The architecture of VGG19 model consist of 19 layers. The architecture of VGG19 model consist of 19 layers. In that 19 layers three are fully connected layers and sixteen are 2- D-conv- layers. Following each layer is 2-D MPL. These VGG19 are really accurate.

In this architecture first a 2-D convolution layer with an activation function is applied independently to every input image in order to extract spatial features. The add layers VGG19 to the recognise features at a higher level which was absent in the previous convolution layer. The binary cross-entropy loss function was used to determine the difference between the true and anticipated values for VGG19.

Loss=-[ylog(y')+(1-y)log(1-y')]

Y= accurate output label

Y'=predicted label

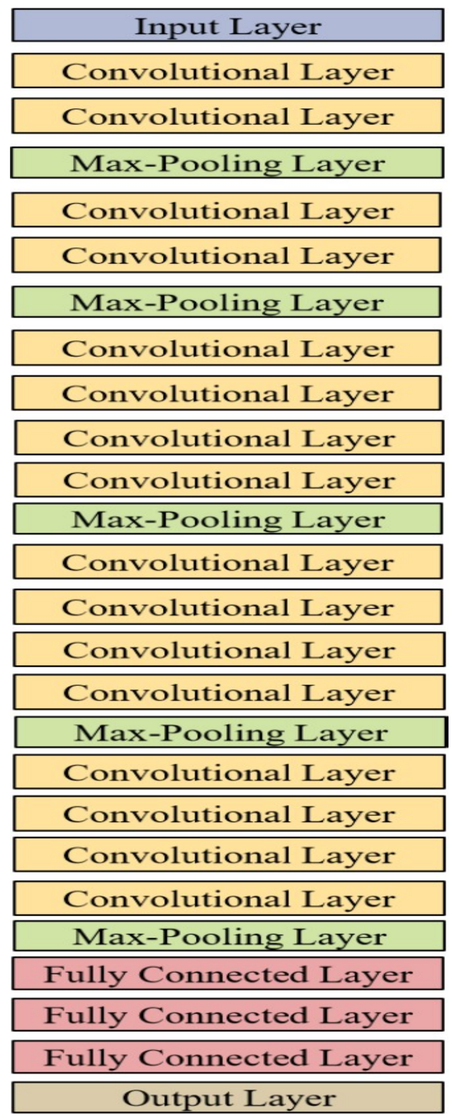

Fig 2: Architecture of VGG19 Model

6. DESCRIPTION OF DATASET:

Table 1: VGG19 Model Layers summary

Layer	Type	Kernel Size	Output Shape
I	Input	-	224 x 224 x 3
2	Conv2D	3 x 3	224 x 224 x 64
3	Conv2D	3 x 3	224 x 224 x 64
4	Max-Pooling2D	2 x 2	112 x 112 x 64
5	Conv2D	3 x 3	112 x 112 x 128
5	Conv2D	3 x 3	112 x 112 x 128
6	Conv2D	3 x 3	112x112x128
7	Max-Pooling2D	2 x 2	56 x 56 x 128
8	Conv2D	3 x 3	56 x 56 x 256
9	Conv2D	3 x 3	56 x 56 x 256
10	Conv2D	3 x 3	56 x 56 x 256
11	Conv2D	3 x 3	56 x 56 x 256
12	Max-Pooling2D	2 x 2	28 x 28 x 256
13	Conv2D	3 x 3	28 x 28 x 512
14	Conv2D	3 x 3	28 x 28 x 512
15	Conv2D	3 x 3	28 x 28 x 512
16	Conv2D	3 x 3	28 x 28 x 512
16 17	Conv2D Max-Pooling2D	3 x 3 2 x 2	14x14x512
17	Max-Pooling2D	2 x 2	14x14x512
18	Conv2D	3 x 3	14x14x1024
19	Conv2D	3 x 3	14x14x1024
20	Conv2D	3 x 3	14x14x1024
21	Conv2D	3 x 3	14x14x1024
22	Max-Pooling2D	2 x 2	7 x 7 x 1024
23	Fully Connected	-	4096
24	Fully Connected	-	4096
25	Fully Connected	-	1000
26	Output	-	2

7. METRICS EVALUATION: -

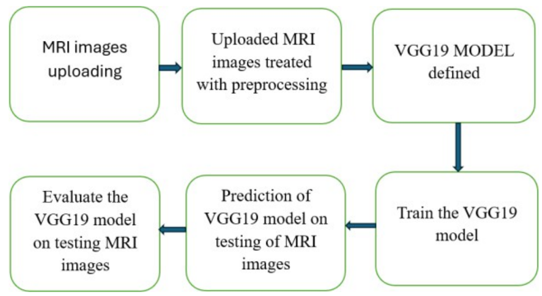

Fig 3: VGG19 Workflow

Three data augmentation techniques are used in this model that are flipping vertically, flipping horizontally, and rotating. Every 45-degree random rotation of the image with flips in both horizontal and vertical directions.

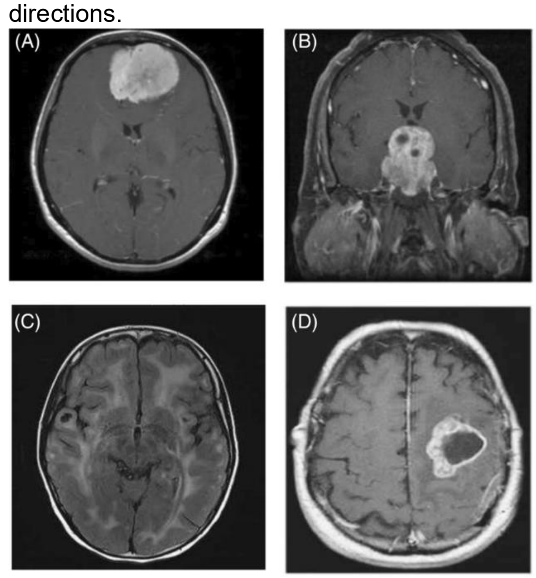

Fig 4: Four classes of sample brain tumour datasets: (A) meningioma, (B) Pituitary, (C) no tumor, (D) glioma.

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

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

TP=number of sick samples that were accurately identified.

TN=accurately recognised healthy samples.

FN=number of infected samples that were mislabelled as healthy.

FP= number of samples that were misdiagnosed as ill but were actually healthy

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

$$F1 - Measure = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$

$$AUC = \int_0^1 TPRd(FPR)$$

The evaluation of the SISR technique utilizing the GAN algorithm includes metrics such as MSE (Mean Squared Error), MS-SSIM (Multiscale Structural Similarity Index Measure), PSNR (Peak Signal-to-Noise Ratio), and SSI (Structural Similarity Index Measure). These measurements are used to gauge the quality and accuracy of the images.

8. EXPERIMENTAL RESULTS:

$$MSE = \frac{1}{n}\sum_{k=1}^{n}\left(i_r(k) - i_y(k)\right)^2$$

$$PSNR = 10log_{10}\frac{MAX_i^2}{MSE}$$

$$SSIM = \frac{\left(2\mu_{ir}\mu_{iy} + c_1\right)\left(2\,o_{iriy} + c_2\right)}{\left(\mu_{ir}^2 + \mu_{iy}^2 + c_1\right)\left(o_{ir}^2 + o_{iy}^2 + c_2\right)}$$

$$MS - SSIM = \frac{1}{nm}\sum_{p=0}^{n-1}\sum_{j=0}^{m-1} SSIM$$

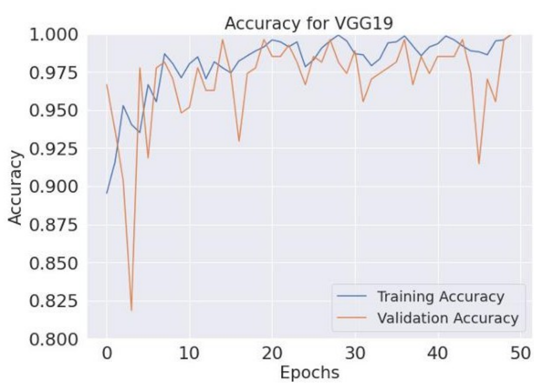

Fig 5: Accuracy curve training and validation for VGG19. [8]

Above fig illustrates the VGG19 model's training and validation accuracy results. The line in blue indicates the accuracy of training, which consistently improves as the quantity of eras increases, nearly reaching 100% following 50 epochs. The validation accuracy is represented by the brown curve, which rises from 97.56% to 99.89% after 50 epochs.

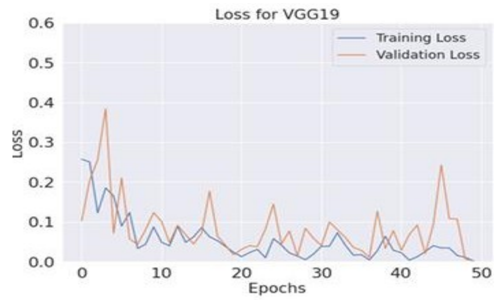

Fig 6: Validation and training of VGG19 loss curves. [8]

Above fig illustrates the instruction and loss curves for the VGG19 model's validation. A score of 0.0 indicates flawless learning devoid of mistakes. Both the training and validation losses consistently declined with a rise in the number of epochs. The lack of training reached After 50 epochs, the validation loss was 0.0030, whereas it began at 0.110 and dropped to 0.0120.

Fig 7: Error Matrix of VGG19. [8]

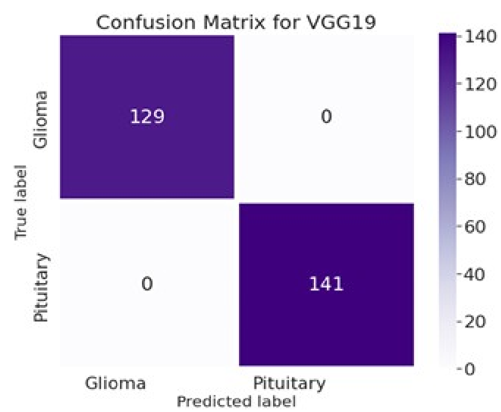

Table 2: Precision and F1-score classification of the VGG19 model.

Class	Precision	Recall	F1-score
Glioma	0.9907	0.9978	0.9992
Pituitary	0.9974	0.9900	0.9986
Accuracy	-	-	0.9989
Macro average	0.9990	0.9989	0.9989
Weighted average	0.9990	0.9989	0.9989

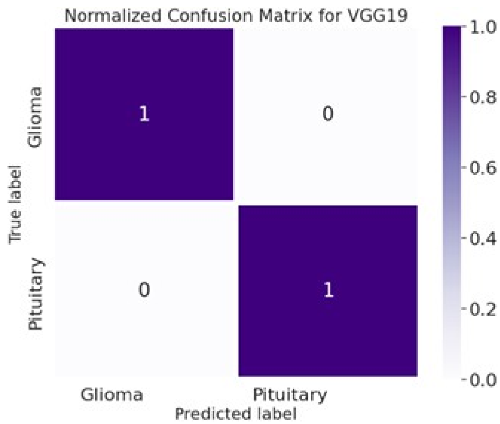

Fig 8. Normalized error matrix for VGG19. [8]

Figures 7 & 8 illustrate the VGG19 model's error and normalised error matrices,
which are employed to assess how well the model classifies pituitary tumours and gliomas using MRI test data. In Figure 7, the dark purple blocks signify classification accuracy, whilst error rates are represented by the values outside the blocks. The matrix of error indicates
129 actual positive results for glioma and 141 for pituitary tumors. The matrix of normalised errors displays a 100% accuracy of classification for both tumor types, with no classification errors.

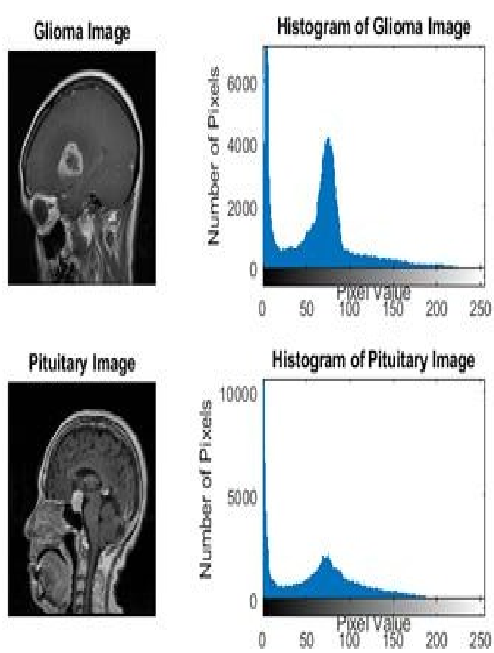

Fig 9: Glioma and Pituitary picture histogram

Table 3: Comparison between the suggested and earlier models' accuracy.

Reference	Model	Testing Accuracy (%)
[20, 2018]	CapsNet	86.56
[21, 2019]	CNN + GA	94.2
[22, 2019]	Inception-V3	55
[22, 2019]	Inception-V3	55
	ResNet-50	95
[23, 2019]	DenseNet-LSTM	92.13
[24, 2015]	SVM	91.28
[24, 2015]	SVM	91.28
[25, 2018]	CNN	84.19
[26,2020]	KNN + nLBP	95.56
[26,2020]	KNN + nLBP	95.56
[27, 2018]	CNN + ELM	93.68
[28, 2009]	SVM-KNN	85
[29, 2019]	CapsNet	92.6
[30, , 2019]	CNN	94.39
[30, , 2019]	CNN	94.39
[31,2020]	ANN	95.8
[32, 2020]	CNN	95.49
[33, 2020]	CNN	96
[34, 2021]	HMM	96.88
	Xception	93.77
[35, 2021]	Inception-V3	94.34
The Proposed	VGG19	99.89
Models	SISR + ResNext101_32x8d	100

CONCLUSION:

The study investigated using deep learning models, ResNext101_32x8d and VGG19, to categorise brain tumors (glioma and pituitary) from MRI pictures. To enhance image quality, a single image super-resolution (SISR) technique was employed. Both models achieved high accuracy in tumor classification, with ResNext101_32x8d performing slightly better. The study highlighted the significance of hyperparameter tuning in optimizing performance of the model. Future research could involve expanding the dataset and exploring other pre-trained models to further improve accuracy and robustness.

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DYNAMIC SIGN LANGUAGE DETECTION USING K-NEAREST NEIGHBORS

[1]T. Sushma, [2]T. Mahalakshmi,[3]A.Vasavya,[4]G. Jayanth, [5]K. Supreeth,[6]G. Veerababu,
[1,2,3,4,5,6]PVP Siddhartha Institute of Technology
tsushma@pvpsiddhartha.ac.in, dasari.maha@pvpsit.ac.in, 21501a0403@pvpsit.ac.in, 21501a0437@pvpsit.ac.in, 21501a0457@pvpsit.ac.in, 21501a0434@pvpsit.ac.in

ABSTRACT: In this study, we provide a dynamic sign language recognition system based on the K-Nearest Neighbors (KNN) algorithm. The system processes video frame sequences to identify dynamic hand gestures that match sign language symbols. The KNN performs well in human activity recognition tasks and explains how sequential data degrades performance and enhancements using probabilistic graphical models to boost temporal alignment and accuracy.

KEYWORDS: Sign language, Computer Vision, K-nearest neighbour, Pattern recognition, Feature extraction.

1. INTRODUCTION

Due to the restrictions placed by conventional verbal communication techniques, people with hearing impairments frequently encounter major obstacles while trying to obtain information and communicate ef fectively. These barriers can impede involvement in a variety of social, educational, and professional contexts and cause feelings of loneliness [1]. It becomes clear that sign language is a vital tool that not only makes communication easier but also gives this group the ability to fully express themselves.

Sign language is distinguished by unique body movements, facial expressions, and hand and finger gestures that collectively represent certain emotions and meanings. However, the requirement for real-time interpretation of dynamic movements is one of the main obstacles to using sign language with technology. The way each sign is produced might differ greatly depending on regional dialects personal flair, and contextual usage, making standardization difficult [2].There is great potential for using sophisticatedmachine learning (ML) methods to solve theseissues. By analyzing and interpreting time series data, these technologies can handle subtitles of gesture generation. Patterns in the intricate sequences of movements can be recognized by machine learnin g models, especially deep learning techniques like co nvolutional neuralnetworks(CNNs) and recurrent neural networks(RNNs)[3].

Large sign language gesture datasets canbe used to help machine learning applications gradually increase the precision and

effectiveness of real-time sign recognition. Furthermore, by converting gestures into spoken language and vice versa, these systems can help simplify communication between hearing people and sign language users [4]. This promotes inclusivi ty and accessibility in society, allowing for a more thorough exchange of information amongst many diverse groups.

1.1 Challenges in Sign Language Recognition

The development of automated sign language recognition systems faces several key challenges:

1. **Temporal Dynamics**: Signs often involve complex sequences of movements that vary in speed and duration
2. **Spatial Variations**: Different signers may perform the same sign with slight variations in hand position and movement
3. **Environmental Factors**: Lighting conditions, bac-kground complexity, and camera angles can affect recognition accuracy
4. **Real-time Processing Requirements**: The need for immediate response in communication applications

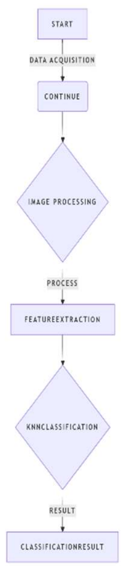
1.2 State of the Art

Recent advances in sign language recognition have seen the emergence of various approaches:

- Deep learning-based methods achieving
- 90%+ accuracy
- Hybrid systems combining multiple algorithms
- Mobile-optimized implementations
- Multi-modal approaches incorporating facial expressions

2. METHODOLOGY

The proposed system leverages computer vision to capture and process sign languagegestures, followed by KNN classification to identify the specific sign being made. Key stages include data acquisition, preprocessing, feature extraction, andclassification



2.1 Data Acquisition:

The proposed system's data collection phase is a fundamental part that uses computer vision techniques to record and process sign language motions in real time [4]. Video footage of someone doing different sign language signs can be captured primarily using a basic webcam, which offers an affordable and easily available alternative to specialized equipment. Every video

frame that is recorded is converted to grayscale, which greatly improves processing efficiency by lowering the computing load. This is crucial for real-time applications where speed is of the essence [5]. By averaging pixel values in a specific region, Gaussian blurring smoothes the image and removes small fluctuations and artifacts while maintaining the key hand gesture outlines and characteristics. To preserve clarity while preserving important geometric elements that aid in gesture recognition, this step is essential.

By removing color channels from the image data, grayscale conversion makes processing faster and improves the ability to identify edges and contours. This makes it easier to identify the ROI, or region of interest, particularly the dynamic gestures of sign language. Grayscale images increase the overall accuracy of gesture identification by highlighting intensity differences, which helps the system concentrate on hand movements even in a variety of lighting situations.The system can identify hands and motions in the presence of distracting factors thanks to this method, which also lessens the effect of background unpredictability. In the end, a standard webcam and grayscale processing work together to create the foundation for later steps in the gesture recognition pipeline.This guarantees precise and prompt identification of sign language gestures as they are made, whichis crucial for improving communication for sign language users. The efficiency of the system is improved by a number of extra factors in addition to the basic elements of data collecting for sign language recognition. The first consideration when choosing a webcam is itsresolution and frame rate; cameras with greater resolutions are better able to record more detailed images, which is especially crucial whentrying to pick up on subtle gestures and fine handmovements. The webcam should ideally runat a minimum of 30 frames per second (fps) to record the motions precisely and smoothly, avoiding motion blur that could make detection difficult. Frame rate is also very important. Additionally, the quality of data gathering can begreatly impacted by the dynamics of the signing environment; uniform lighting conditions assist minimize reflections and shadows that could obfuscate the hand gestures. In addition to the fundamental aspects of data acquisition for sign language recognition, several additional considerations enhance the effectiveness of the ssystem

Firstly, the selection of the webcam should factor in the resolution and frame rate; higher-resolution cameras can capture more detailed images, which is particularly important for discerning fine hand movements and gestures.

Additionally, real-time feedback mechanismscould be integrated to assist users in adjusting their signing posture or distance from the camerathereby improving data quality. By considering these factors during the data acquisition stage,the system can maximize the accuracy and reliability of the sign language recognition process, ultimately leading to better communication outcomes for users.

2.2 Image Processing

Image preprocessing is essential to the gesture recognition pipeline because itconverts unprocessed photos into a format that increases hand gesture clarity By averaging pixel values in a specific region, Gaussian blurring smoothes the image and removes small fluctuations and artifacts while maintaining the key hand gesture outlines and characteristics. To preserve clarity while preserving important geometric elements that aid in gesture recognition, this step is essential.

Grayscale Conversion:

It makes the images simpler by converting them from olor, which uses numerous channels, to grayscale, which uses just one channel. Finding the shapes and contoursof hand motions is made simpler by this reduction in complexity, which enables faster processing and concentrates the studyon intensity fluctuations [7]. The elements required for hand position recognition are highlighted in grayscale photos, which also remove color-based distractions.

Noise Reduction:

Unwanted noise introduced by the camera sensor, the surrounding environment, or movement during capture is frequently present in raw photos. Techniques like Gaussian blurring are used to address this. By averaging pixel values in a specific region, Gaussian blurring smoothes the image and removes small fluctuations and artifacts while maintaining the key hand gesture outlines and characteristics. To preserve clarity while preserving important geometric elements that aid in gesture recognition, this step is essential.

Image Scaling and Normalization:

Images are scaled to a fixed size to guarantee uniformity between frames, which facilitates uniform processing of the images across the recognition system. Furthermore, the brightness and contrast ofthe photographs are usually adjusted to astandard range (generally 0 to 1) by normalizing the pixel values. Toinput properties, minimize variance that can impair machine learning algorithm performance, and guarantee that features are equivalent regardless of variations in lighting or camera distance, normalization is essential.

Binary Thresholding:

This technique turns the grayscale image into a binary format in which the pixels are classified as either the background or the hand's foreground. A threshold is used, designating pixels below a specific intensity value as "0" (background) and those above as "1" (hand). With a more defined separation from the surroundings, this binary representation greatly improves the characterizati on of hand motions. More efficient feature extraction is thus made possible by this distinction, which allows algorithms to concentrate on the pertinent aspects of the hand movements for classification.

These preprocessing steps enhance input data quality, enabling more precise gesture identification by reducing ambiguity and clarifying hand movements, which are essential for accurate feature extraction and classification in sign language recognition. These methods establish a strong foundation for real-time, reliable sign language interpretation, ultimately improving the user experience.

2.3 Feature extraction:

A crucial stage in the identification of sign language is feature extraction, which focuses on identifying essential hand gesture traits that enable the differentiation of one sign from another. Important methods used in this stage include:

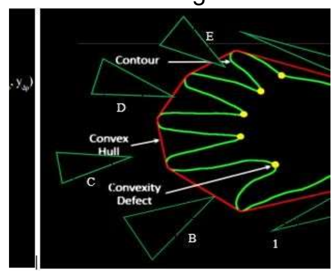


Fig1. Feature Extraction

Contour Detection: This methoddetermines the hand's outer edges, defining its shape and orientation—acrucial component in gesturerecognition.

Convex Hull and Defect Analysis: Thesystem identifies the posture of the fingers by analyzing the gaps between them using convex hull algorithms. This approach facilitates the identificationof movements that rely on particular finger configurations.

Key Point Extraction: This technique finds important hand points, like jointsand fingers, which are important forcorrectly deciphering motions. By monitoring these sites, the system can identify changes in finger positions and movements shown in Fig:2.

A feature vector representing each gesture is created from the retrieved features, and the K-Nearest Neighbors (KNN) classification algorithm uses this feature vector to determine which sign isbeing done. The unique features ofthe gesture are efficiently recorded for accurate real-time recognition thanks to this procedure.

2.4 K-Nearest Neighbor (KNN) Classification:

KNN is a non-parametric, straightforward, lazylearner-supervised machine learning technique. Based on the largest number of matching characters, it generates the result by assuming thatthe new datasets are identical to the original datasets. KNN facilitates the easy identification of a given data set's category, whichhelps address the issue where new datasets fall under the original dataset categories. Because its neighbors' majority vote determines its classification, it is also known as the Nearest Neighbors algorithm.

The Euclidean distance is

$$(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \ldots (x_n - y_n)^2}$$

Procedures for applying the KNN algorithm:
1) Pre-processing of the data

2)Align training data with the KNN classifier

3)Project the test. Result

4)Developing the Confusion Matrix

5)Show the test set result

After training and before training the data, the difference is shown in Fig 2.

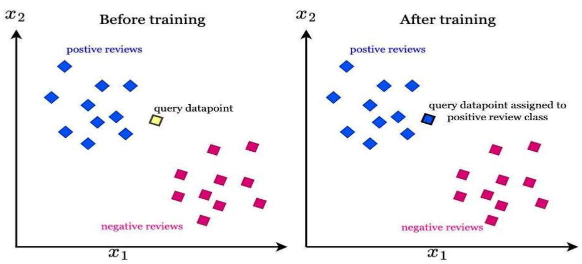


Fig2. Difference after training and before training data

2.5 Performance Optimization

Our enhanced system implements several optimization techniques:

1. **Batch Processing**: Implementing batch operations for faster computation
2. **GPU Acceleration**: Utilizing GPU resources for parallel processing
3. **Memory Management**: Efficient caching of frequently accessed features
4. **Dynamic Resolution Scaling**: Adjusting image resolution based on processing requirements

3. ALGORITHM

The pseudocode of classical KNN:
Input: X: training data,

Y: class labels of X,

K: number of nearest neighbors.

Output: Class of a test sample x.

Start

Classify (X, Y, x)

1. for each sample x do

Calculate the distance :

$$d(x, X) = \sqrt{\sum_{i=1}^{n} (x_i - X_i)^2}$$

end for

2. Classify x in the majority class:

$$C(x_i) = \mathrm{argmax}_k \sum_{x_i \in KNN} C(X_j, Y_k)$$

End

The dataset is separated into training and test sets to construct the sign language recognition model; the KNN model is trained on the training set, and its performance is assessed on the test set. The input processing starts with picture preparation using OpenCV,which involves cropping to eliminate undesired regions defined by a region of interest (ROI), turning photos to grayscale to minimize dimensionality, and shrinking images to a uniform size to satisfy KNN requirements.

Then, using a Histogram of Oriented Gradients (HOG) descriptor to generate feature vectors that represent the distribution of gradient orientations, feature extraction separates pertinent elements of hand movements. The distance between the featurevectors of the new gesture and those in the training set is measured by the Euclidean distance metric, which allows the identification of the closest examples.
It uses the k–Nearest Neighbors (KNN) method for classification. When a new gestureis represented by a feature vector x, we determine the distances between the k closest training samples and choose the closest using the Euclidean metric. Once the indices of the k lowest distances have been determined, the new gesture is given the label that these neighbors most frequently use. The most common label in the vicinity is identified throughout the classification phase, which yields the projected class for the sign under recognition.

Collections of manual gesture photos used for various gesture recognition applications make upthe training and testing datasets. The PCA methodis trained using the training dataset, and the suggested recognition system's adaptability and flexibility are assessed using the testing dataset. One of the main differences is that the testing set includes motions made by a different collection of subjects, preventing any overlap between the two datasets, whereas the training set contains photographs from a particular group of people.

Training Database:

There are 100 pictures in this database, which includes pictures of 20 people (10 women and 10 men) making five different gestures. The fist, index, and V signs are among the movements that were captured by a PC camera against a uniform background. These choices make it easier to test against results from earlier research.

The testing dataset includes fist and V sign motions from earlier research conducted in a range of lighting situations. While hundreds of photos with both uniform and complex backgrounds are included in Marcel's dataset, this research concentrates on uniform backgrounds. In order to provide a wide variety of gestures for assessment, Maqueda's study also includes 30 video sequences from six distinct people.

a) Index posture b)v sign posture c)Fist posture

Fig3. Training Dataset

Fig4.Test Data

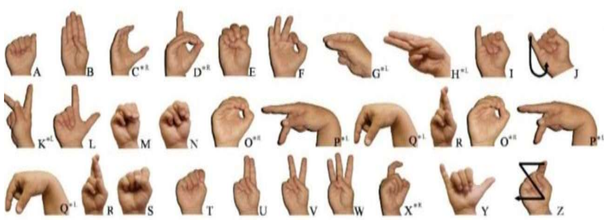


Fig5.Alphabetic sign language

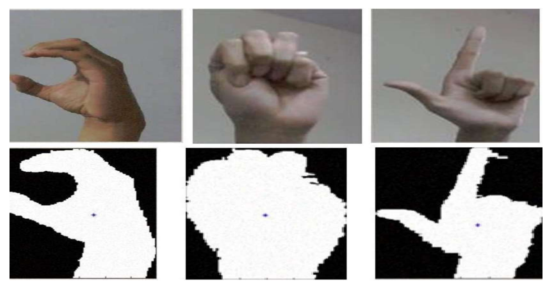
By initially generating a tagged dataset of similar hand motion photos for every letter, the K-Nearest Neighbors (KNN) algorithm can classify each of the hand signs displayed in the image. To improve clarity, the photos undergo preprocessing that includes grayscale conversion, scaling, normalization, and noise removal. Each gesture's shape and finger placements are captured by feature vectors created by feature extraction techniques such as contour detection and key point identification. KNN facilitates the effective real-time recognition of ASL letters by classifying the new gesture by comparing its properties to those in the dataset and labeling the closest matches.

4. RESULTS

Especially when it comes to human-computer interaction, gesture recognition is an intriguingand difficult field of study. Numerous techniques, including Random K-NN, Tree K-NN, and Fuzzy K-NN, can be used to recognize hand gestures. It is intriguing to investigate the K-Nearest Neighbour approach. To increase the accuracy of the classification, the Simple Multi-Attribute Rating Technique (SMART) weighting method can be applied. Starting with determining the weighting, normalization, utility value, and recommendation criteria, the approach is well-known for being extremely easy to apply.

Fig: 6 shows how well binary silhouette processing may improve gesture recognition. Hand motions are transformed into high-

Fig6. Alphabet sign detection



contrast binary forms so that the system can determine each gesture's shape and features with ease. Because of this simplified representation, the K- Nearest Neighbors (KNN) algorithm is able to precisely extract important information, like the centroid and shape of the gesture. This increases the accuracy and efficiency of real-time sign language recognition by enabling the KNN model to consistently categorize each gesture by comparing it to comparable shapes in a pre-labeled dataset.

CONCLUSION

K-Nearest Neighbors (KNN) is a promising technique that offers simplicity and the capacity to recognize local motion patterns for dynamic identification of sign language motions. It does not take into consideration the time connections between gestures, hence its performance can deteriorate with sequential data. In order to improve accuracy in real-time applications, KNN can be enhanced with temporal models such as probabilistic graphical models or dynamic time warping(DTW).Sign language translation systems, assistive communication devices, gesture-based control interfaces, and GPS-based navigation systems for the hard of hearing are examples of real-time applications. Future uses might include wearable technology, smart home systems, augmented reality (AR), and virtual reality (VR) interactions, allowing for smooth communication, improved accessibility, and easy navigation for a wide range.

Future Research Directions

1. **Integration with Deep Learning**:
   - Exploring hybrid KNN-CNN architectures
   - Implementing attention mechanisms
   - Developing end-to-end learning approaches
2. **Real-world Applications**:
   - Educational tools for sign language learning
   - Mobile applications for real-time translation
   - Integration with smart home systems
3. **System Improvements**:
   - Enhanced noise resistance
   - Multi-language support
   - Reduced latency in real-time processing

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INDEX MODULATION MULTIPLE ACCESS FOR FUTURE WIRELESS COMMUNICATION SYSTEMS

[1] Rajnish Kumar Ranjan, [2]Atanu Chowdhury, [3]Dibyendu Ghoshal
[1,2,3]National Institute of Technology Agartala, Tripura India
ranjaneced@gmail.com,atanunita@gmail.com,tukumw@gmail.com

ABSTRACT: The Index Modulation Multiple Access (IMMA) technology presents a prospective advancement for future communication systems, aiming to significantly boost spectrum efficiency, energy consumption, and overall system performance. It possesses the distinctive capability to facilitate extensive connectivity, hence becoming an innovative advancement beyond the conventional Non-Orthogonal Multiple Access (NOMA) method. This study delineates the significance of the IMMA technique, with a particular focus on its core concepts, including time domain IMMA, frequency domain IMMA, and spatial domain IMMA.

INDEX TERMS Index Modulation Multiple Access (IMMA), Non-Orthogonal Multiple Access (NOMA), Multiple Input Multiple Output (MIMO), Time-domain IMMA, Frequency-domain IMMA, Spatial-domain IMMA.

I. INTRODUCTION

Future communication networks are expected to face increased scarcity of spectral resources due to a projected rise in user numbers. Moreover, divergent quality of service (QoS) needs necessitate that networks dynamically modify their numerous access techniques and allocate resources among users. Consequently, the conventional linear correlation between the quantity of serviced customers and the requisite wireless resources, predicated on orthogonal multiple access (OMA) systems, is improbable to be sufficiently satisfied in the foreseeable future. In contrast to orthogonal multiple access (OMA) methods that utilize orthogo nal resource allocation, nonorthogonal multiple acc ess (NOMA) allocates non-orthogonal resources to various users to improve system performance [1].

NumerousNOMA systems have been investigated, generally classifying them into two categories: power-domain NOMA and code-domain NOMA.

Powerdomain NOMA utilizes power domain diversities for multiple access, while codedomain NOMA facilitate s multiplexing in the code domain through methods such as low-density spreading code-division multiple access (LDS-CDMA) and sparse code multiple access (SCMA).

Nonetheless, current NOMA systems predominan tly employ superposition coding for channel allocation, requiring complex detection methods such as successive interference cancellation (SIC) and the message passing algorithm (MPA). These complications result in elevated processing requirements, inevitable inter-user interference (IUI), and limited system performance, especially as the number of users served escalates [2].

Index modulation (IM) presents a novel approach to tackle the challenges linked to NOMA approaches. In IM, index patterns function as an extra dimension to regulate information bits for transmission. These patterns can denote numero-us factors, including the activation status of time slots, subcarriers, broadcast or receive antennas, spreading codes, and power levels. Th-is distinctive arrangement provides IM with various beneficial attributes, including elevated energy efficiency (EE), high spectral efficiency (SE), and diminished detection complexity. As a result, IM multiple access(IMMA)has developed, combining IM with NOMA to capitalize on the advantages of both methodologies. Numerous IMMA methods have been established, principally classified into five categories according to the modified signal domains: time-domain IMMA (T-IMMA), spatial-domain IMMA (S-IMMA), frequency-domain IMMA (F-IMMA), code-domain IMMA (C-IMMA), and power-domain IMMA (P-IMMA) [3].

Unlike conventional NOMA schemes, IMMA allows each user to transmit supplementary information bits, referred to as index bits, utilizing partial resources, hence improving spectrum efficiency (SE) and energy efficiency (EE). Moreover, the challenges of successive interference cancellation (SIC) and inter-user interference (IUI) can be alleviated by allocating separate resources to each user. Currently, the majority of research on IMMA focuses on performance analysis and optimization, highlighting the necessity for an in-depth investigation of its practical applications. Multiuser applications such as automotive networ

ks, reconfigurable intelligent surface (RIS)-aided networks, cooperative networks, and secure netw orks are essential in the 6G framework. The implementation of IMMA in these networks is expected to markedly enhance system performan ce.This paper commences by clarifying the essential ideas of IMMA, thereafter examining its potential effects on vehicle networks, RISassisted networks, cooperative networks, and secure networks. Finally, we examine the current obstacles and prospective directions for future research in IMMA [4].

In this study, the glimpse of the IMMA is highlighted with respect to concept of its operation. The organisation of this study as follows. Section II illustrates the basic concepts of IMMA which further describes time, spatial and frequency domain IMMA as subsection. Finally, a short concluding remark is provided in section III.

2. BASIC CONCEPTS OF IMMA

A. Time-Domain IMMA

The Time-Domain Index Modulation Multiple Access (T-IMMA) was first proposed and executed in the uplink multi-user network.

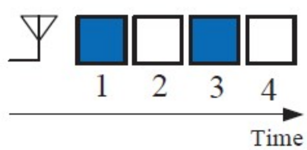

Figure 1. Time domain IMMA [1].

This method involves each user using a separate transmit antenna to transmit its signal independently, utilizing time-domain index modulation (IM) over various orthogonal time slots. Figure 1 depicts the operational mechanism of T-IMMA. In this context, index bits are employed to identify a particular time index pattern (TIP), succeeded by an additional set of bits utilized to generate M-ary phase shift keying (PSK) or quadrature amplitude modulation (QAM) constellation symbols. The constellation symbols are broadcast via the selected TIP, while the other time slots stay dormant, leading to a sparse transmission system characterized by high energy efficiency (EE). The TIP indices denote supplementary information bits (index bits) for each user, enabling the T-IMMA system to attain superior spectral efficiency (SE) compared to traditional time-division multiple access (TDMA) schemes.
Research in [5] demonstrates that T-IMMA significantly enhances the bit error rate (BER) in comparison to TDMA. To augment the SE of T-IMMA, the in-phase and quadrature components of the constellation symbols are sent individually via designated TIPs to all users [6].

B. Spatial-Domain IMMA

The Spatial Index Modulation multiple Access (S-IMMA) method consists of a base station (BS) with several antennas and several users, each possessing multiple antennae as well. In the uplink situation, S-IMMA partitions the information bits for each user into index bits and modulation bits, conforming to the principles of spatial modulation (SM) [7].

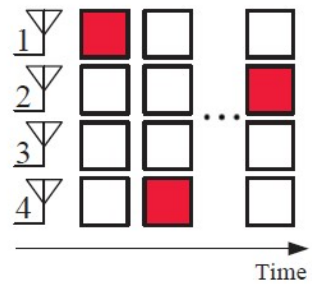

Figure 2. Spatial domain IMMA [1].

Figure 2 illustrates that only one transmit antenna is operational at any given moment, with the index of the active antenna denoting the index bits for that specific time slot. In S-IMMA, each user simultaneously transmits the SM signal vector to the base station. [8] The base station subsequently utilizes maximum-likelihood (ML) detection to extract the information bits from all users. S-IMMA has enhanced error performance relative to traditional multi-antenna multi-user uplink transmission methods [9].

C. Frequency-Domain IMMA

For F-IMMA, OFDM-IM is employed on both the user and base station sides for uplink and downlink transmission. The signal generation in OFDM-IM closely resembles that of SM. The index bits are allocated to the indices of active subcarriers rather than to active antennas, as illustrated in Figure 3.

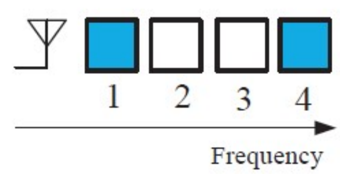

Figure 3. Frequency domain IMMA [1].

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Current research demonstrates that F-IMMA surpasses traditional NOMA and OFDMA methods [10].

CONCLUSION

This study elucidates the fundamental principle related to the index modulation multiple access technique. This paper theoretically elucidates time domain IMMA, spatial domain IMMA, and frequency domain IMMA to facilitate a comprehensive comprehension of the principles behind index modulation.

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Prasad V Potluri
Siddhartha Institute of Technology