Print ISSN : 2395-1990
Online ISSN : 2394-4099

Website : http://ijsrset.com

SECOND INTERNATIONAL CONFERENCE ON SMART TECHNOLOGIES, COMMUNICATION & ROBOTICS 27 & 28 JUNE 2024

ORGANIZED BY
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING, EPCET

Email : ijsrset@gmail.com, editor@ijsrset.com

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Peer Reviewed and Refereed International Journal

EAST POINT COLLEGE OF ENGINEERING & TECHNOLOGY

JnanaPrabha Campus, Virgonagar Post, Avalahalli,Bangalore-560049

ACCREDITED BY NATIONAL BOARD OF ACCREDITATION -CSE, ECE & ISE

Department of
Electronics & Communication Engineering

ICSCR-2024

Second International Conference on Smart Technologies, Communication & Robotics

27th & 28th June 2024

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Dedicated to our
Beloved
Honorable
Founder Chairman

Late Dr. S.M. Venkatpathi
Hon. Founder Chairman , EPGI
Bengaluru (1955-2017)

Smt.B.L Ramadevi Venkatpathi

Chairperson,
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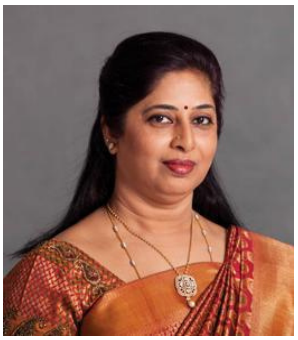


We are honored to host the Second International Conference on Smart Technologies, Communication & Robotics on June 27th-28th, 2024, at EPCET, Bangalore. This conference serves as a platform for academicians and research scholars from across the world to share their latest research ideas, results and potential applications in the field of Electronics and Communication Engineering.

I would like to extend my best wishes to the entire organizing team and committee members for their efforts in compiling the proceedings for this international conference. Additionally, I wish all participants a successful and rewarding experience at the event.

B L Ramadevi Venkatapathi

Sri. S. V Pramod Gowda

CEO,
East Point Group of Institutions, Bengaluru, Karnataka, India

We take great pride in hosting the Second International Conference on "Smart Technologies, Communication & Robotics" on June 27th-28th, 2024, at EPCET, Bengaluru. The present problem is to discover cost-effective solutions that utilize these advances, as developing countries greatly depend on rising technology for their socioeconomic development.

This conference provides a platform for research scholars, faculty and students to present and discuss their latest research ideas, fostering knowledge exchange and generating innovative solutions for future challenges.

S V Pramod Gowda

Sri. S. V Rajiv Gowda

CEO,
East Point Group of Institutions, Bengaluru, Karnataka, India

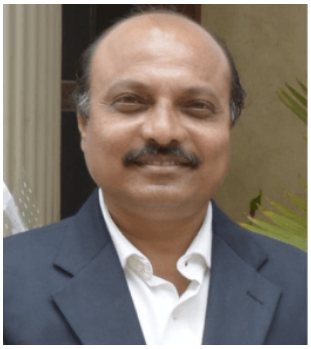
We are proud to host the Second International Conference on "Smart Technologies, Communication & Robotics" on June 27th- 28th, 2024, at EPCET, Bengaluru. Developing nations' socioeconomic progress is greatly aided by emerging technologies and the current issue is to produce affordable solutions that take use of these developments.

This conference provides a valuable platform for research scholars, faculty, and students to present and discuss their latest ideas, enriching our collective knowledge and fostering innovative solutions for future challenges.

I encourage all participants to share new inventions and innovative ideas that will contribute to the advancement of global technology. Wishing everyone great success at the conference!

Dr Prakash S

Senior Vice President,
East Point Group of Institutions, Bengaluru, Karnataka, India



I am pleased to learn that the Department of Electronics and Communication Engineering is organizing the Second International Conference on "Smart Technologies, Communication & Robotics" on June 27th-28th, 2024, at EPCET, Bangalore. This conference offers an open forum for scientists, researchers and engineers to exchange information on innovations and advancements in Electronics and Communication Engineering.

I believe this event will greatly enrich our knowledge and inspire new ideas among researchers. I commend the organizing committee for their dedication and hard work in bringing this conference to fruition, and I hope the discussions will be beneficial for all students and faculty.

Dr Prakash S

Dr. Silvia Liberata Ullo

Keynote Speaker
Researcher,Engineering Department,
University of Sannio Benevento (Italy)

The second International Conference on "Smart Technologies, Communication & Robotics" June 27th-28th, 2024 organized by the Department of Electronics and Communication Engineering at East Point College of Engineering and Technology. This is a pleasure to remark. These kinds of conferences give professors, industry professionals and young researchers a forum to showcase their research and development projects and receive comments and recommendations on how to make their work better.

Nowadays, there have been rapid advancements in research and technological development in fields like robotics, the internet of things, artificial intelligence, machine learning, etc. In light of the aforementioned issues, this conference will offer a valuable platform for exchanging views on the newest technology and applications.

I wholeheartly congratulate the organizer and office bearer of this conference for their excellent team work.

Regards

Dr. Silvia Liberata Ullo

Dr. Mohammed Misbahuddin

Keynote Speaker
Associate Director,
C-DAC, Bengaluru

It gives me great pleasure to be a part of the second International Conference on "Smart Technologies, Communication & Robotics" June 27th -28th, 2024, hosted by the Department of Electronics and Communication Engineering at East Point College of Engineering and Technology. These kinds of conferences give aspiring scientists, academicians and business experts a forum to showcase their research and development projects and receive criticism and recommendations for raising the caliber of their output.

Topics like robotics, the internet of things, artificial intelligence, machine learning, etc. have seen rapid advancements in recent years, both in terms of study and technological development. This conference will give attendees the chance to share ideas on the newest applications and technologies related to the aforementioned subjects, which will be highly beneficial.

Regards

Dr. Mohammed Misbahuddin

Dr Mrityunjaya V Latte

Principal ,
East Point College of Engineering & Technology,
Bengaluru, Karnataka, India

I am delighted to hear that the Department of Electronics and Communication Engineering is organizing the second International Conference on "Smart Technologies, Communication & Robotics" on June 27th-28th, 2024, at EPCET, Bangalore. This conference will serve as an open forum for scientists, researchers and engineers to share information on innovations and advancements in the field of Electronics and Communication Engineering.

I believe this event will significantly enrich our knowledge and inspire new ideas among researchers. I commend the organizing committee for their hard work and dedication, and I hope the discussions will be beneficial for all students and faculty. Wishing this conference great success!

Dr Mrityunjaya V Latte

Dr Yogesh G S

Vice Principal & HOD ECE,
East Point College of Engineering & Technology,
Bengaluru, Karnataka, India

I am pleased to share that our Department of Electronics and Communication Engineering is hosting the second International Conference on "Smart Technologies, Communication & Robotics" on June 27th-28th, 2024, at EPCET, Bangalore.

Scientists, researchers and engineers will have an open forum to discuss discoveries and achievements in Electronics and Communication Engineering at this conference. I believe this event will greatly enrich our knowledge and inspire new ideas among researchers.

I appreciate the hard work and dedication of the organizing committee in bringing this conference to life, and I hope the discussions will be valuable for all students and faculty. Wishing the conference great success!

DR YOGESH G S

INSTITUTE VISION

The East Point College of Engineering and Technology aspires to be a globally acclaimed institution, recognized for excellence in engineering education, applied research, and nurturing students for holistic development.

INSTITUTE MISSION

- To create Engineering graduates through quality education and to nurture innovation, creativity and excellence in teaching, learning and research.
- To serve the technical, scientific, economic and societal developmental needs of our communities.
- To induce integrity, teamwork, critical thinking, personality development, and ethics in students and to lay the foundation for lifelong learning.

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The Department aspires to be a center of excellence in Electronics and Communication Engineering to develop competent and ethical professionals through holistic development.

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ISBN NO 978-81-965079-9-2

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Modified Split Ring Resonator and CLS Metamaterial Structure of Different Geometrical Shapes-A Comparative Analysis

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Abstract— In this paper a comparative study of conventional split ring resonator (SRR) of different geometrical shapes is presented. The resonance frequencies of the conventional circular, square and hexagonal SRRs are computed using the simplified theoretical models and compared with the simulated results. A new structure of left-handed metamaterial (LHM) is then formed by combining modified split ring resonator(MSRR) and a capacitance loaded strip (CLS). Simulation and analysis was done using Computer Simulation Technology (CST) software for all the three geometrical shapes. The effect of shift in the resonant frequency and the range of negative value of permeability (-μr) and the negative permittivity (-εr) were observed. The value of permeability and the permittivity was extracted from the reflection and transmission coefficient data using a Nicolson-Ross-Wier (NRW) approach. Studies proved that the LHM structure can be designed in the desired frequency range of interest.

Keywords—SRR(Split Ring Resonator), MSRR(Modified split ring resonator), CLS(Capacitively loaded strip) , LHM(Left Handed materials), negative permittivity; negative permeability.

I. INTRODUCTION

Metamaterials, also known as left-handed metamaterial (LHM) where the permeability and permittivity were simultaneously negative. LHM is an interesting material to be investigated where this artificial material has several unique properties especially the backward wave and negative refraction. The backward wave propagation has been verified by [1], and the negative refraction has been proven by [2, 3]. The history of LHM was started from Veselago [4] when he made a theoretical speculation of this artificial material that exhibit negative permittivity and negative permeability. Since the introduction of LHM, numerous researchers were interested in investigating this artificial material and the discovery of left-handed metamaterials (LHMs) allows antennas [5]-[7] to be designed with novel electromagnetic properties such as negative permittivity and permeability.

II. METHODOLOGY

In this paper the analysis is done by first computing the resonant frequencies of the conventional circular, square and hexagonal SRRs by using a simplified model [8]. Then the simulation for all the three shapes is done using CST. The results are verified and compared. Next the LHM structure is formed by combining modified SRRs with a capacitively loaded strip. The transmission characteristics, negative permittivity and negative permeability of the simulated LHM structures were presented and analyzed. Finally analysis is done by changing the number of splits in the LHM structures.

III. CONVENTIONAL SRR

A. THEORY AND DESIGN

Fig. 1 shows a schematic view of a Circular-SRR(C-SRR) , Square-SRR(S-SRR) and Hexagonal-SRR(H-SRR) having strip width *c* and spacing *d* between the rings, g_1 and g_2 are gaps within the inner ring and outer ring, respectively. Under the exposure of external magnetic field the induced electromotive force around the SRR causes a currents which passes from one ring to the other through the inter ring spacing, *d* and the structure behaves as an oscillatory L-C circuit.

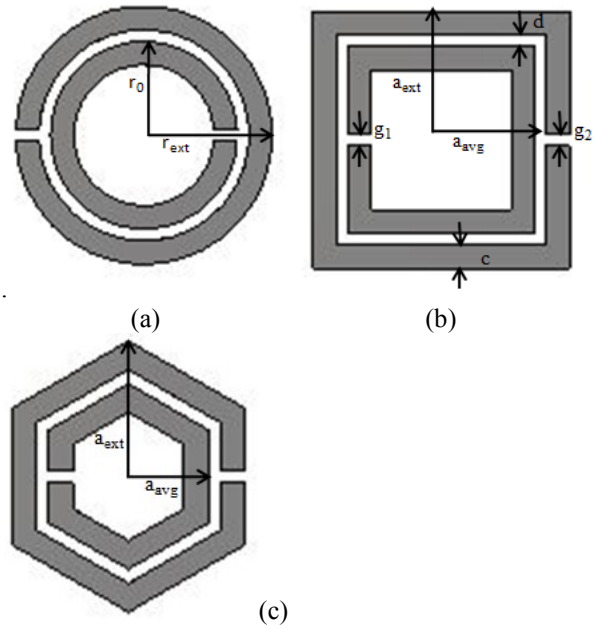


Figure 1. Schematic view of split ring resonators (a)Circular (b) square (c). Hexagonal

The resonance frequency of the SRR is given by

$$\omega_o = \sqrt{\frac{1}{L_T C_{eq}}} \qquad (1)$$

The expression of the resonant frequency of different SRR is given as

For C - SRR :

$$f_{0C} = \frac{1}{2\pi\sqrt{LC_{eq}}} = \frac{1}{2\pi\sqrt{L_T\left[\frac{(\pi r_0 - g)C_{pul}}{2} + \frac{\varepsilon_0 ct}{2g}\right]}} \quad (2)$$

For S - SRR :

$$f_{0S} = \frac{1}{2\pi\sqrt{L_T C_{eq}}} = \frac{1}{2\pi\sqrt{L_T\left[\left(2a_{avg} - \frac{g}{2}\right)C_{pul} + \frac{\varepsilon_0 ch}{2g}\right]}} \quad (3)$$

For H - SRR :

$$f_{0H} = \frac{1}{2\pi\sqrt{L_T C_{eq}}} = \frac{1}{2\pi\sqrt{L_T\left[\frac{(3a_{avg} - g_1)C_{pul}}{2} + \frac{\varepsilon_0 ch}{2g_1}\right]}} \quad (4)$$

where L_T is the total inductance of the SRR and *Ceq* is the equivalent capacitance of the structure . *Cpul*, is the per unit length capacitance, between the rings and r_0 (C-SRR) and a_{avg} (S-SRR and H-SRR) are the distance of the two constituent rings of the SRRs from the centre.. *Cpul* is calculated as [9]

$$C_{pul} = \sqrt{\varepsilon_e}/c_0 Z_0 \quad (5)$$

where $c_o = 3\times10^8$ m/s is the velocity of light in free space. ε_e is the effective permittivity of the medium and Z_0 is the impedance of the medium. The total inductance of the structures, L_T, is using equation (6) where, *l* and *d* are the wire length and width, respectively. The constant θ varies with wire geometry and is given as [10]

$$L_T = 0.00508l(2.303\log_{10}\frac{4l}{d} - \theta) \quad (6)$$

The constant θ varies with wire geometry and is given as shown below.[10]

θ = 2.451 for C-SRR (7)
θ = 2.853 for S-SRR (8)
θ = 2.636 for H-SRR (9)

B. RESULTS AND DISCUSSION

The SRRs are printed on dielectric substrate having εr = 2.33 and thickness, *h* =1.575mm. The values of the design parameters are taken as c = 0.4mm, d = 0.2 mm , g1 = g2 = 0.2mm, and $r_{ext} = a_{ext}$ = 2.2mm.

SIMULATION OF THE LHM UNIT CELL

The simulation of the circular SRR is executed using Computer Simulation Technology (CST) software. Perfect magnetic conductor (PMC) boundary condition is set on the left and right faces of the box, and perfect electric conductor (PEC) boundary condition is set on the top and bottom of the box. The incident wave propagates in z-axis direction, while the E-field of the incident wave is polarized along yaxis, and the H-field of the incident wave is polarized along x-axis. The resonance frequency in GHz for SRR of different geometries is computed using equations (2)-(4). The computed values calculated are compared with the simulated values and are presented in Table I. The S21 and S11 curves for all the three shapes are shown in figure 3.

Table 1. Frequency

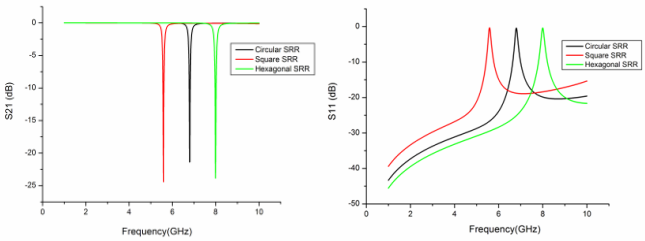
S.No	SRR	Calculated	Simulated
1.	Circular f_{oC}	7.24	6.805
2.	Square f_{0S}	5.85	5.59
3.	Hexagonal f_{0H}	7.89	8.005

The S-parameters that were obtained from the simulation were exported to Matlab software. Nicholson, Ross and Weir (NRW) approach are used to determine the permittivity and permeability of the SRRs. The basic equations [13] used to determine the εr and μr are shown below.

$$\varepsilon_r \approx \frac{2}{jk_0 d}\frac{1-\nu_1}{1+\nu_1} \quad (10)$$

$$\mu_r \approx \frac{2}{jk_0 d}\frac{1-\nu_2}{1+\nu_2} \quad (11)$$

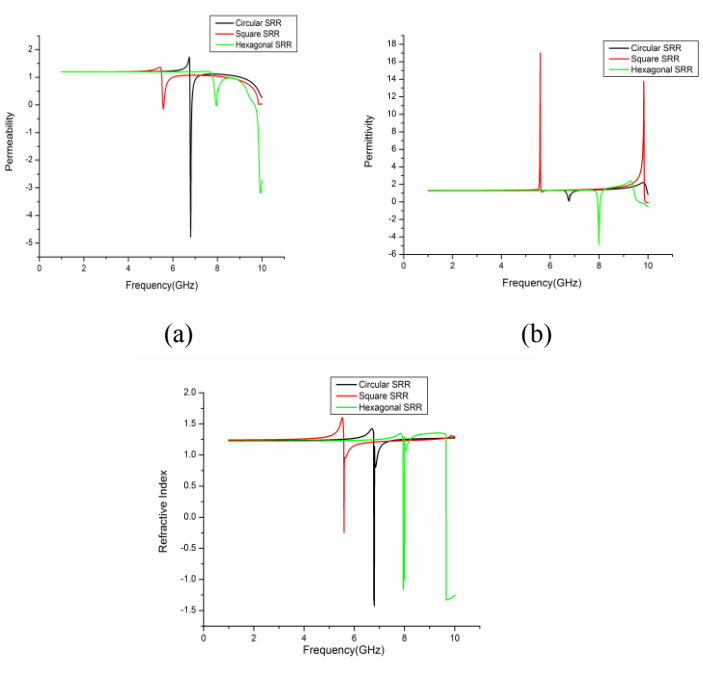
where:
$v_1 = S21 + S11$,
$v_2 = S21 - S11$,
$k_0 = \omega/c$,
ω=Radian frequency,
d=Slab thickness,
c=Speed of light.



(a) (b)

Figure 3. Transmission and reflection characteristics of SRR
a) S21 b) S11

The permeability and permittivity curves and the refractive index curves are shown in figure 4



(a) (b)

(c)

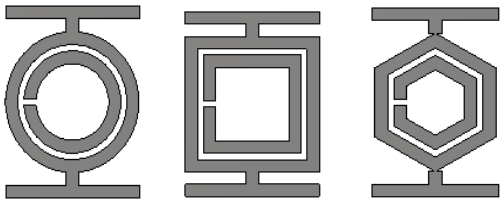
Figure 4. a) Permeability b) Permittivity c) Refractive Index

The tabulated comparison for similar dimensional parameters shows that the H-SRR resonates at a high frequency when compared to C-SRR and S-SRR. From figure 4 we can see that the C-SRR, S-SRR and H-SRR have negative permeability characteristics at exactly the resonant frequency. And the permittivity is positive at the resonant frequency This verifies that the conventional SRRs are MNG metamaterials ie.(μ negative materials)

III. LHM UNIT CELL

A. THEORY AND DESIGN

The conventional SRRs exhibit only negative permeability characteristics. In order to provide simultaneous negative permeability and permittivity, the Conventional SRR has to be modified. The initial unit cell is based on a split-ring resonator structure. The SRR is a magnetically resonant structure that leads to a perpendicular magnetic field whose application generates negative permeability. The SRR consists of two loops: a smaller loop within a bigger one, with slots incorporated onto each loop at opposite ends [11]. Gaps (or splits) added to the ring, introduce capacitance, which allows for the control of the resonant characteristic of the structure. The first unit cell in the LHM is actually the modified SRR. The modification is the closing of the loop on the outer ring, which reduces the series capacitance of the SRR. Furthermore, closing the outer ring enhances the coupling between the outer and inner ring, which enables a wide backward-wave passband [12]. Capacitance-loaded strips (CLS) were added to the modified SRR unit cell.. CLS which act as electric dipoles are I-shaped striplines that mimic long metallic wires [13]. The combined structure (modified SRR and CLS) allows for simultaneous electric and magnetic resonance because the SRR resonates through a perpendicular magnetic field and the CLS (which is in essence an electric dipole) resonates through a parallel electric field. The unit cell of the modified SRR with the additional CLS structure is shown in Figure 5. The SRR/CLS unit cell retains the dimensions of the SRR only structure described in Figure 1, except for the dimensions due to the addition of the CLS. The length and width of the CLS structure is 4.4mm and 0.4mm respectively. The structure that connects the CLS strip with the SRR has a dimension of 0.4mm X 0.4mm.



(a) (b) (c)

Figure 5. LHM structure

B. RESULTS AND DISCUSSION

The simulation of the LHM unit cell for all the three shapes shown in figure 5 is carried out using the same setup that was used for the conventional SRR. The S11 and S21 curves were obtained and is shown in figure 6. The permeability and permittivity were determined by extracting the S parameters and by using the Nicholson, Ross and Weir (NRW) approach. The permeabiltiy and permittivity curves are shown in figure7

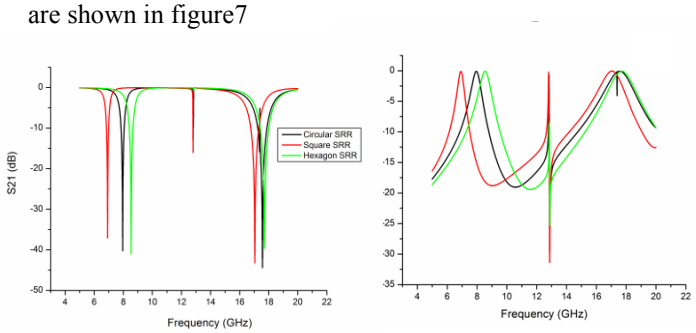


Figure 6.

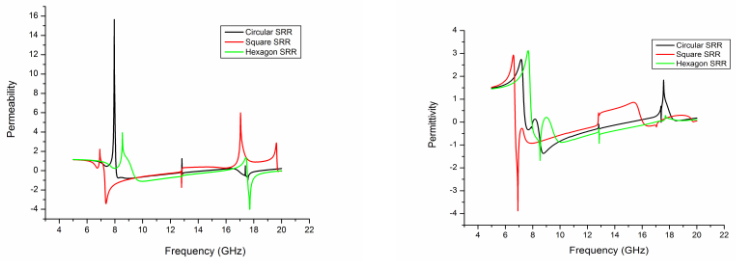


Figure 7

From the above results it is found that all the three LHM structures have two resonant frequencies and the higher

resonant frequency has a wide band when compared with the conventional SRR. From the permittivity and permeability curves it is observed that all the three structures exhibit negative index characteristics.

INCREASING THE NUMBER OF SPLITS.

Further simulations were conducted on the LHM structures that were modified by increasing the number of splits to 4 and 6 as shown in the figures 8 and 10 below. The corresponding S21 curves are shown in figures 9 and 11 below.

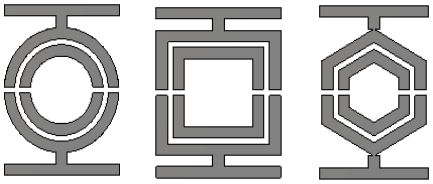


Figure 8: LHMs with four splits

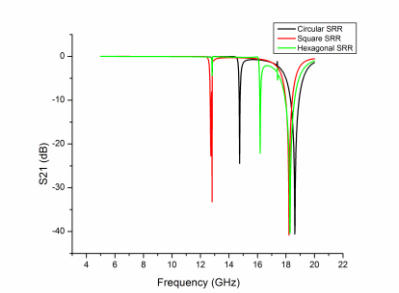


Figure 9: S21 of LHMs with 4splits

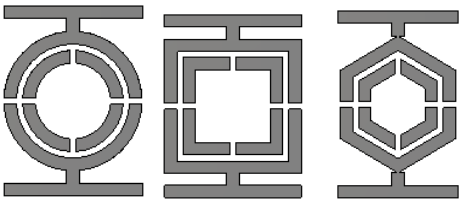


Figure 10: LHMs with 6 splits

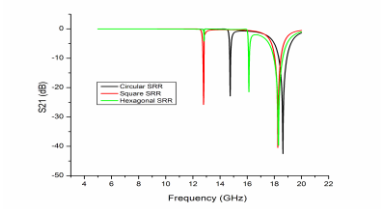


Figure 11. S21 of LHMs with 6 splits

The resonating frequencies and the corresponding return loss of the above structures are provided in table 2. All the three LHMs structures resonates at three frequencies with the higher resonating frequency have a wide bandwidth.

Table 2. Frequency and Return Loss

LHM shapes	LHMs-4 split		LHMs-6 split	
	f (GHz)	Return Loss	f (GHz)	Return Loss
C-LHM	14.758	-24.428	14.75	-22.858
	18.635	-38.431	18.635	-42.485
S-LHM	12.74	-14.619	12.785	-25.753
	18.23	-32.533	18.26	-40.393
H-LHM	16.205	-14.212	16.145	-13.821
	18.302	-33.647	18.29	-39.120

IV. CONCLUSION

This study provides a comparative analysis of SRRs and LHMs of different geometrical shapes. The comparison of their resonance frequency, which determines the region of negative permeability, suggests that for similar physical dimension the H-SRR resonates at higher frequency. Also the LHMs exhibit negative refractive index and provide better performance in terms of resonance and bandwidth. These structures are widely used by incorporating them with an antenna to improve the characteristics of the antenna and/or to obtain a UWB performance.

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MACHINE LEARNING APPROACH FOR SMS HAM/ SPAM FILTERATION

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***Abstract*—SMS is a communication protocol designed for exchange of short, written messages used for various business purposes, despite of various other method of communication. As the volume of SMS growing day by day, automated management of SMS is important in the today's context. Out of total SMS, nearly a fair percentage are identified as spam. The spam actually consumes a lot of time of the users and the memory of the device. The spammers use SMS to share messages which can also contain links to malware, phishing, or scam websites that can infect the device or steal the data. So, it necessitates to have a proper mechanism to get devoid of spam messages. This paper mainly focuses on the machine learning algorithms approach for spam classification. SVC (Support Vector classifier) in SVM approach was applied to analyze and perform data preprocessing.**

Keywords— SMS, Spam classification, Spam detection, Spam Filter, Supervised Learning, Machine Learning Algorithms, Spam Detection, Machine Learning Algorithms.

I. INTRODUCTION

SMS is a communication protocol designed for exchange of short, written messages upto 160 characters to mobile devices including cellular and smartphones. SMS messages are transmitted over the cellular networks. Almost 2/3rd of the world's population sends and receives SMS data predicts and 91% of business owners and marketing managers say they see higher conversion rates with integrated marketing campaigns that include SMS. SMS is very popular in the commercial industries for it is an instant method to send data. Out of total SMS, nearly a fair percentage is identified as spam messages. Spam messages are the unwanted messages that contains various information including mobile numbers, malicious links, ID numbers, phishing, or scam websites that can infect the device or steal the data etc. An effective spam detection should consider the following factors into account are

1. Privacy of user
2. Personalization of user
3. Accuracy
4. Self-learning capability
5. Real time filtering support

Machine learning is the area of computational science which focuses on analyzing and interpreting patterns and structures in data to enable learning, reasoning, and decision making outside of human interaction. Machine learning allows the user to feed a computer algorithm an immense amount of data and have the computer analyze and make data-driven recommendations and decisions based on only the input data.

There are many spam detection techniques used in machine learning. Few methods are

Logistic Regression: It is for the binary classification problems. This method chooses parameters that maximises the likelihood of observing the sample values.

Random Forest method: It works on the basis that each branch of a tree makes a unique prediction that are different from the other tress. This difference gives a better generalization for the given problem.

Naive Bayes method: It is a simplest classification method. In this method every single word is considered not only mutually independent but also single.

Support vector machine (SVM): SVM gives a more optimal solution and best classifies the learning data.

The unsupervised machine learning algorithms are more preferably used as it can understand and resolve complex environmental issues. Some of their applications are grouping of specific datasets, reducing the dimensionality, virus detection, customer preference detection etc.

II. PROBLEM STATEMENT

The spam messages are those which normally increases the message stream. Presently the user themselves segregate the ham and the spam messages by themselves manually. It is a tedious job if a particular message has to be found. The emergence of machine learning algorithm made this segregation a simple one. As a follow up of, the proposed work focuses on choosing a particular data set which contains SMS messages labelled as Ham and Spam. The ham is replaced as 0 and spam as 1. Here spam is considered as positive class for which tf and tf-id vectorization using count vectorizer and tfidf vectorizer using scikit-learn is performed. tf means the number of times a word appears in a given sentence. tf-idf means Term Frequency - Inverse Document Frequency.

Every supervised model needs a proper dataset to be modelled. The dataset is chosen from impartus and they are split as testing and training set. In this 5- fold cross validation with SVC classifiers is used.

The dataset used in training and testing the current hybrid system was collected from impartus. The data contains instances of SMS messages in English. The collected data is featured and labelled as ham and spam along with the content of the text message. Then the data was converted to CSV (Comma Separated Value) form from text form for easier feature extraction. This process is done by cleaning the data

by removing punctuation marks and stop words as they appear very often and cannot help in concluding the final classification. Furthermore, the general data is analysed by implementing various feature extractions techniques. Term frequency inverse document is a feature extraction technique in which is used to evaluate importance of a word to a document [7]. Then the data is separated as training and test sets. Then a classifier is applied based on its accuracy and precision.

In the program flow the required modules are imported first. Then a data frame is generated from the spam database. It is further labelled in such a way that spam is 1 and ham is 0. The method by which an algorithm could be tested is by these following performance metrics Recall, Precision and Accuracy. These metrics are based on the confusion matrix parameters

Precision =True positive/ (True positive + False positive)

Accuracy = (True positive + True negative)/ Total

Recall = True positive/ (True positive + False negative)

The steps in designing an algorithm are as follows

- Collecting and preparing the dataset
- Data preprocessing
- Building the classifier
- Building a classified model
- Train model with the labelled training dataset
- Testing train model with the trained dataset
- Analysing results using machine learning tools

III METHODOLOGY

The process gets initiated by assigning token for each word so that, it can be treated separately. All are converted to single case, either upper or lower case for easy comparison. The data has to undergo preprocessing, filling the null data, removing punctuations. Then, it is to be noted that which words are common among ham and spam messages. The spam word cloud is given below

Fig. 1. Spam word cloud

Fig. 2. Ham word cloud

Now convert spam as 1 and ham as 0. Then the tf is calculated using count vectorization. This is a statistic that is based on the frequency of a word in the corpus but it also provides a numerical representation of how important a word is for statistical analysis. tf-idf is better than Count Vectorizers because it not only focuses on the frequency of words present in the corpus but also provides the importance of the words. The dataset is first read.Then spam is taken as 1 and Ham as 0.

	label	msg
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
5	spam	FreeMsg Hey there darling it's been 3 week's n...
6	ham	Even my brother is not like to speak with me. ...
7	ham	As per your request 'Melle Melle (Oru Minnamin...
8	spam	WINNER!! As a valued network customer you have...
9	spam	Had your mobile 11 months or more? U R entitle...

Fig. 3. Dataset

	label	msg
0	0	Go until jurong point, crazy.. Available only ...
1	0	Ok lar... Joking wif u oni...
2	1	Free entry in 2 a wkly comp to win FA Cup fina...
3	0	U dun say so early hor... U c already then say...
4	0	Nah I don't think he goes to usf, he lives aro...
5	1	FreeMsg Hey there darling it's been 3 week's n...
6	0	Even my brother is not like to speak with me. ...
7	0	As per your request 'Melle Melle (Oru Minnamin...
8	1	WINNER!! As a valued network customer you have...
9	1	Had your mobile 11 months or more? U R entitle...

Fig. 4. Dataset with spam is taken as 1 and ham as 0

In these type of word problems a techniques called word embedding technique is used. As a part of it the tf, tfidf and count vectorizer methods are used. This converts word into numeric format. The count vectoriser converts words

into matrix of words. This is called Document Text Matrix (DTM). This further converts into sparse matrix. Here tf-idf means term frequency-inverse document frequency, and tf is just the frequency of the term in document term matrix and

$$IDF = \log [(1 + D) / (1 + df (d, t))] + 1$$

where D is number of documents and df (d,t) is number of documents a term t has appeared in the DTM.

Then a function is created to calculate the tf and tf-idf values based on SVM parameters.The kernel values are linear, RBF (Radial Basis Kernel function) and sigmoid. The tf and tfidf vectorizer uses 3 classifiers Linear, RBF, Sigmoid.

Each classifiers uses 3 values each C=0.1, C=1 and C=10. Further the Macroaverage precision gives the value for true positive case of the confusion matrix. The Macroaverage recall gives the value for true negative case and the Macroaverage F1 is the weighted average of both precision and recall. Similarly, these classifiers are used with tf-idf and the Macroaverage precesion, recall and Macroaverage F1 is recorded.

	Vectorizer	Classifier	Macroaverage Precision	Macroaverage Recall	Macroaverage F1
0	tf,	C=0.1,linear	98.76981611216722	93.8659317731335	96.12788008074682
1	tf,	C=1,linear	98.76161085724793	94.25870106988444	96.35234394985591
2	tf,	C=10,linear	98.77160768726868	94.3253677365511	96.39502375635375
3	tf,	C=0.1,rbf	43.29684971540362	50.0	46.40762015762016
4	tf,	C=1,rbf	43.29684971540362	50.0	46.40762015762016
5	tf,	C=10,rbf	96.58787123428837	77.23169547124759	83.52063112014486
6	tf,	C=0.1,sigmoid	43.29684971540362	50.0	46.40762015762016
7	tf,	C=1,sigmoid	43.29684971540362	50.0	46.40762015762016
8	tf,	C=10,sigmoid	93.63387328881406	52.88008948545862	52.021104884266514

Fig. 5. Output for tf vectoriser for types of classifiers.

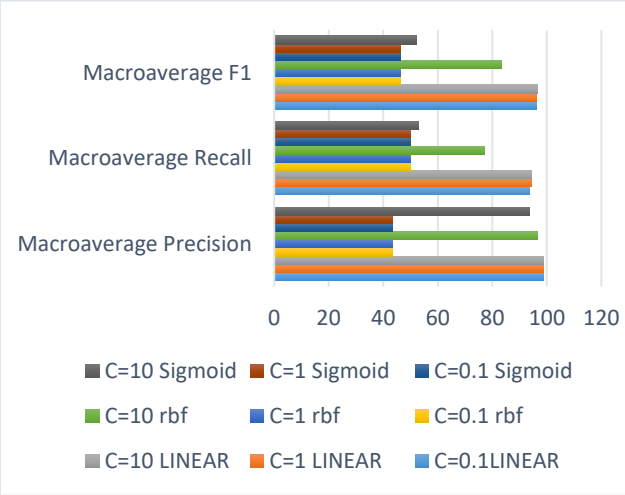

Fig. 6. Graphical representaion for tf vectoriser for different types of classifiers

	Vectorizer	Classifier	Macroaverage Precision	Macroaverage Recall	Macroaverage F1
0	tf-idf,	C=0.1,linear	96.4781088618292	76.42766862560998	82.78171043053581
1	tf-idf,	C=1,linear	98.5393885800984	93.70106292960557	95.93173499183429
2	tf-idf,	C=10,linear	98.39837995778801	94.20599274379572	96.16453015612143
3	tf-idf,	C=0.1,rbf	43.29684971540362	50.0	46.40762015762016
4	tf-idf,	C=1,rbf	43.29684971540362	50.0	46.40762015762016
5	tf-idf,	C=10,rbf	43.29684971540362	50.0	46.40762015762016
6	tf-idf,	C=0.1,sigmoid	43.29684971540362	50.0	46.40762015762016
7	tf-idf,	C=1,sigmoid	43.29684971540362	50.0	46.40762015762016
8	tf-idf,	C=10,sigmoid	43.29684971540362	50.0	46.40762015762016

Fig. 7. Output for tfidf vectoriser for 3 types of classifiers

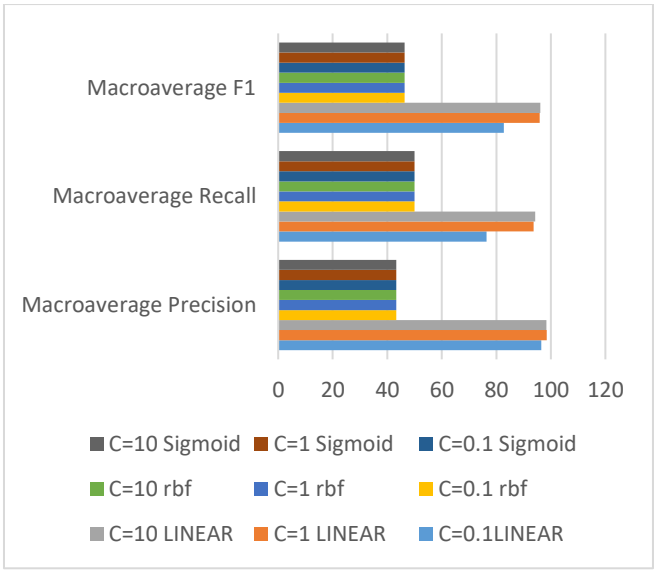

Fig. 8. Graphical representaion for tfidf vectoriser for different types of classifiers

IV CONCLUSION

A method is proposed to effectively segregate Ham and Spam messages was initiated from the data obtained the following observations could be made.

From the output using TF vectoriser, it is observed that for the classifier value C=10, Linear,the macroaverage precision, macroaverage recall and the weighted macroaverage F1 is fairly high and delivers maximum efficient percentage of output.

Similarly, From the output using tfidf vectoriser, it is observed that for the classifier value C=10, Linear, the macroaverage precision ,macroaverage recall and the weighted macroaverage F1 is fairly high and delivers maximum efficient percentage of output.

This defined model suits for other set of datasets as well. Further the work can be extended by using various deep learning and machine learning algorithms.

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Analysis of microstrip antenna arrays for wireless applications

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***Abstract*— In this paper, single rectangular and triangular microstrip antenna are designed at an operating frequency of 2.4GHz. To achieve high gain for wireless applications, 2 x 1 and 4 x 1 rectangular and triangular microstrip antenna arrays are designed and the performance of rectangular and triangular microstrip antenna arrays are measured in terms of gain, return loss, band width and directivity. The antenna is simulated using CST microwave studio.**

***Index Terms*—rectangular micro strip antenna, triangular micro strip antenna, micro strip antenna arrays, CST Microwave studio.**

I. INTRODUCTION

Wireless communication is the transfer of data from one point to other one point or multi points without using any electrical conductors. [1].. In recent years there are lots of changes happening in communication system, now it become more reliable in terms of price, weight technology etc. All the integrated components of communication system also become advanced. Micro strip antennas are mostly preferred for wireless application [1]. Microstrip antennas are having advantages such as low profile, low cost, low weight. Because of these advantages, microstrip antennas are preferred for both wireless and satellite communication specially for low frequency and high frequency applications.

The micro strip antennas are also known as patch antennas [2]. It uses different patch shapes like square, rectangular, triangular, circular, etc. The micro strip patch is normally bounded on the substrate and will be placed on a conducting ground plane [3]. In this paper both single rectangular and triangular patch antenna are designed using CST Microwave studio. In order to achieve high gain,2x1 and 4x1 rectangular and triangular microstrip antenna arrays are designed and the performance of both the antenna arrays are compared. There are different types of feeding techniques for microstrip patch antenna such as microstrip line feed inset feed, coaxial feed, inset feed etc. [3].In this work, the inset feed is used for the design of rectangular and triangular microstrip antenna.

Microstrip antenna arrays are formed by connecting the element of microstrip antenna to each other. Compared to the single element microstrip antenna, arrays normally provide more gain [5].

II. DESIGN OF SINGLE RECTANGULAR AND TRIANGULAR PATCH ANTENNA

A Introduction

Designing of microstrip antenna include the selection of substrate There are lots of substrate available for these application in which most commonly used substrate are FR4 and RT Duroid 5870.But considering the availability and low cost here FR4 is used. FR4 have high dielectric constant of 4.3-4.9.].

A. Design parameter of rectangular patch antenna

Width and length of patch can be calculated using these equations

$$W = [c ((\varepsilon r+1)/2)-1/2] / 2fo \quad \text{……..……..(1)}$$

The length of the patch:

$$L = [c / (2fo (\varepsilon e)-1/2)] -2\Delta L \text{…….. (2)}$$

Where,

$$\varepsilon e = (\varepsilon r+1) / 2 + ((\varepsilon r-1) / 2) [(1+12h)/W]-1/2 \quad \text{.....(3)}$$

and ,

$\Delta L = 0.412h\ [(\varepsilon+0.300)(W/h+0.264)]\ /[(\varepsilon-0.258)(W/h+0.800)]$

……..(4)

Here W and L are the width and length of rectangular patch.

B.Design parameter of triangular patch antenna

$$f_{1,0} = \frac{2c}{3a\sqrt{\epsilon_r}}$$

Where a is the side length of triangular patch and c is the speed of light.[4].

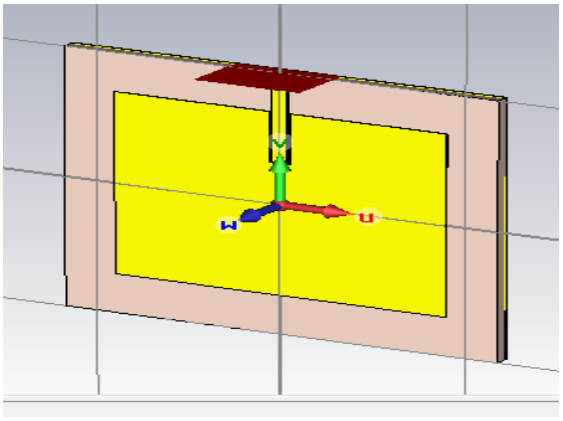

Fig.1Single rectangular patch antenna

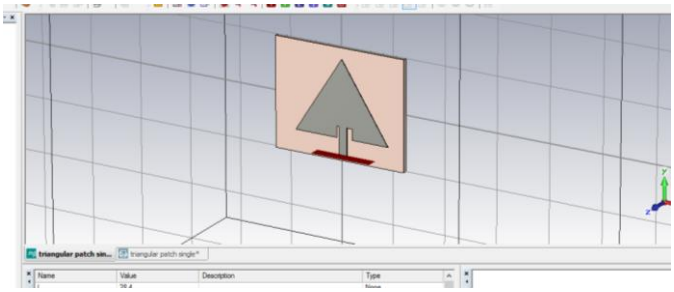

Fig 2. Single triangular patch antenna

III. MICROSTRIP ANTENNA ARRAYS

The arrays are formed by connecting antenna element each other using corperative feed technique . It will give better gain and directivity as compared to the single element. The performance depends upon the spatial distribution as well as the phase and magnitude of the each element.[5]

A. 2*1 ARRAYS

Knowing the physical dimensions L, W and Zin, the feed line network parameters can be selected by setting 50 Ω feed line Z1 = 50 Ω, which splits into two 100 Ω ones, Z2 = 100 Ω.

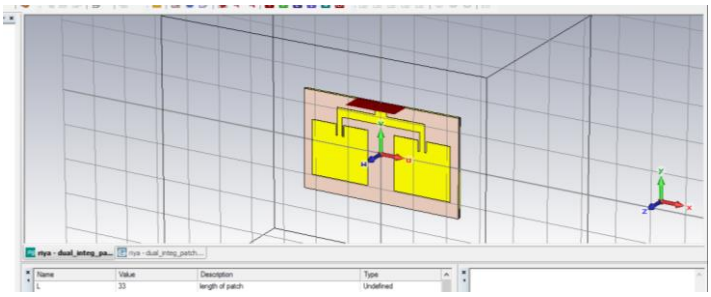

Fig 3. 2*1 rectangular patch array

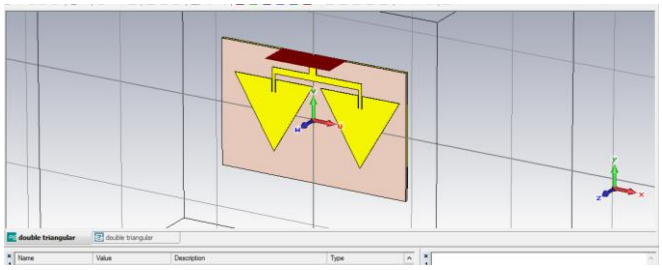

Fig.4. 2*1 triangular patch array

*B.4*1 ARRAYS*

Setting 50 Ω feed line Z1 = 50 Ω, which splits into two 100Ω ones, Z2 = 100 Ω. Then solve for impedance of quarter-wave transformer, Zc. This yields Zc = 70 Ω. After that, we found the width of the microstrip line at Zc = 70 Ω .

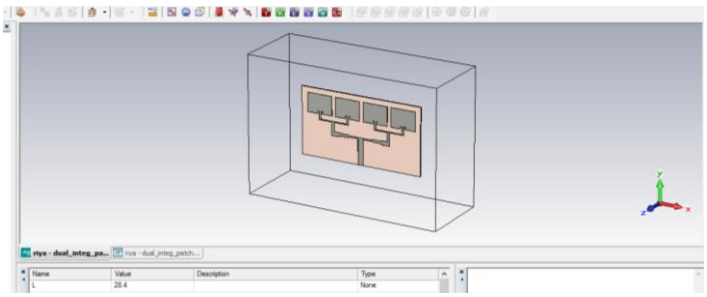

Fig.5 4*1 rectangular patch array

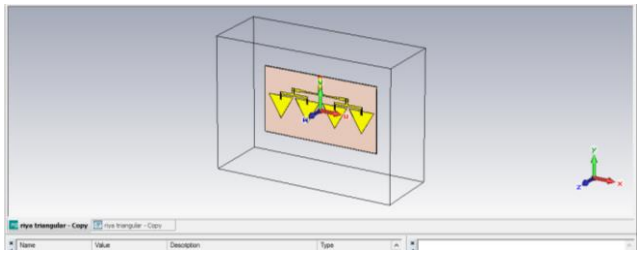

Fig.6. 4*1 triangular patch array

IV.SIMULATION RESULTS

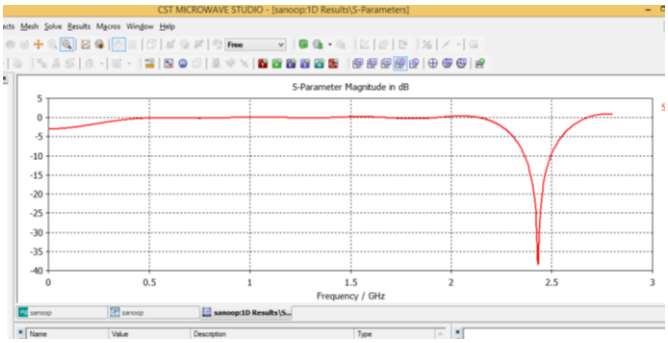

Fig 1.1 Return loss curve of single rectangular patch antenna

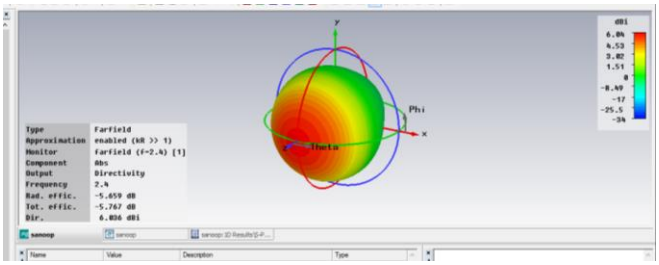

Fig 1.2 Radiation pattern of single rectangular patch antenna

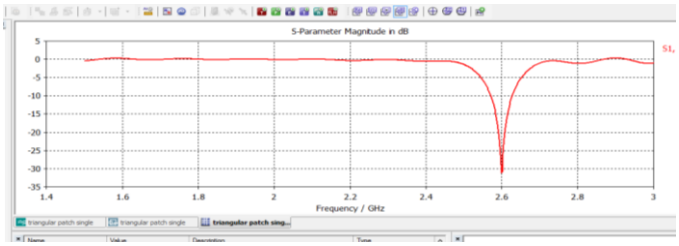

Fig 2.1 Return loss curve of single triangular patch antenna

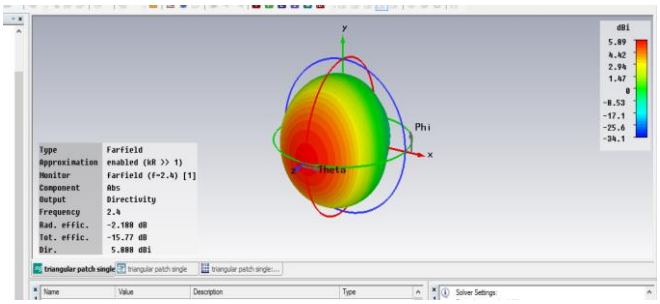

Fig 2.2 Radiation pattern of single triangular patch antenna

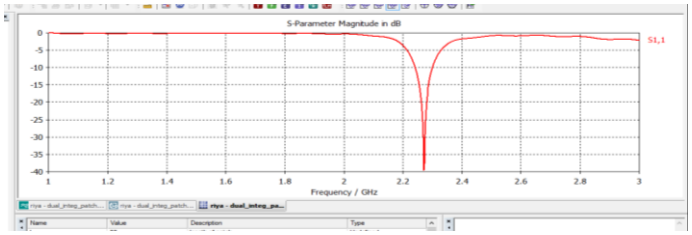

Fig 3.1.Return loss curve of 2*1 rectangular patch antenna

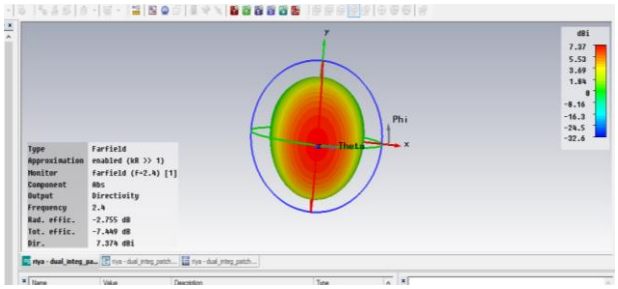

Fig.3.2 Radiation pattern of 2*1 rectangular patch antenna

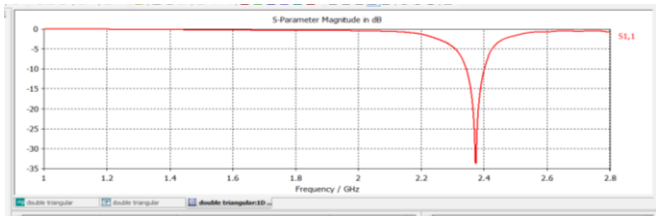

Fig 4.1.return loss curve of 2*1 triangular patch array

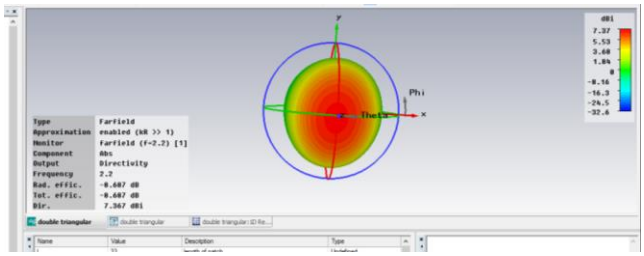

Fig.4.2 Radiation pattern of 2*1 triangular patch array

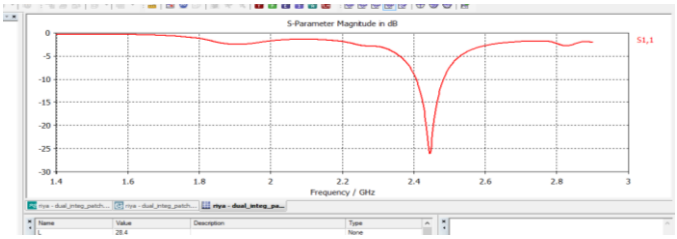

Fig 5.1. Return loss curve of 4*1 rectangular array

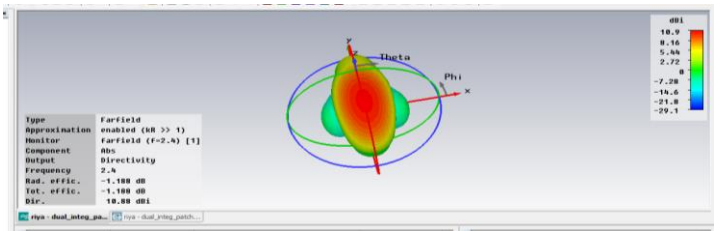

Fig 5.2.Radiation pattern of 4*1 rectangular array

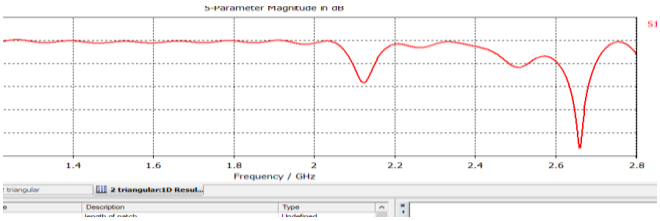

Fig.6.1 return loss curve of 4*1 triangular array

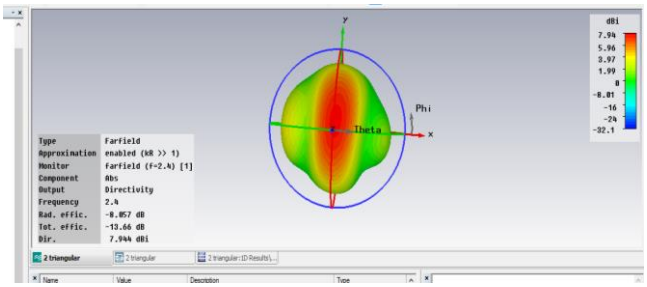

Fig 6.2 Radiation pattern o4*1 triangular array

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TABLE1.PARAMETERS OF RECTANGULAR PATCH ANTENNA

TYPE	S11	GAIN(dB)	DIRECTIVITY(dB)
SINGLE	-39	6.04	6.03
2*1	-39	7.51	7.4
4*1	-26	10.9	10.88

TABLE 2.PARAMETES OF TRIANGULAR PATCH ANTENNA

TYPE	S11	GAIN(dB)	DIRECTIVITY(dB)
SINGLE	-34	5.3	5.3
2*1	-34	7.37	7.4
4*1	-21	7.9	7.9

From the simulation result it can be seen that compared to the single element rectangular and triangular microstrip antenna,2x1 and 4x1 arrays gives much improved performance in terms of directivity and gain as shown in table1 and table 2.

V.SIMULATED RESULTS AND DISCUSSION

RETURN LOSS

The return loss obtained from single rectangular patch antenna is -39 dB, for 2*1 rectangular patch antenna array is -39dB and 4*1 rectangular array is -26dB.

The return loss obtained from single triangular patch antenna is -34dB, for 2*1 triangular patch antenna array is -34dB and for 4*1 triangular array is -21dB.

GAIN

The gain obtained from single rectangular patch antenna is 6.04 dB, for 2*1 rectangular patch antenna array is 7.51dB and 4*1 rectangular array is 10.9dB.

The gain obtained from single triangular patch antenna is 5.3dB, for 2*1 triangular patch antenna array is 7.37dB and for 4*1 triangular array is 7.9dB

DIRECTIVITY

The directivity obtained from single rectangular patch antenna is 6.03dB, for 2*1 rectangular patch antenna array is 7.4dB and 4*1 rectangular array is 10.88dB.

The directivity obtained from single triangular patch antenna is 5.3dB, for 2*1 triangular patch antenna array is 7.4dB and for 4*1 triangular array is 7.9dB.

VI CONCLUSION

In this paper, single rectangular and triangular patch antennas and 2x1 and 4x1 rectangular and triangular patch antennas arrays are designed. The performance of the rectangular and triangular arrays are compared and the rectangular microstrip arrays provide a high gain compared to the triangular

microstrip arrays which makes it suitable for wireless applications.

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Early Detection of Onion Spoilage Utilizing IoT and AI During Storage and Transportation

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***Abstract*—This paper introduces an innovative approach to reducing crop wastage by converting traditional onion warehouses into smart warehouses using IoT and AI technologies. We propose an IoT-based monitoring solution that continuously analyses and communicates the health status of onion stock in real time. Additionally, our methodology aims to support farmers by providing them with essential information about their onion stocks, enabling informed decision-making. Traditionally, farmers rely on sensory cues such as onion odor to detect decomposition. However, we propose a technological intervention utilizing image processing and AI-driven sensory mechanisms to enhance the onion detection process. Specifically, cameras are employed to identify sprouted onions, while AI algorithms analyze sensory data to detect rotten onions. Our prototype achieves an impressive 87% efficiency in identifying sprouted onions using camera-based systems. Furthermore, the response of the gas sensing system in detecting rotten onions under prescribed chamber dimensions yields encouraging results. Through the integration of IoT and AI, our methodology offers a promising solution to minimize crop wastage and promote sustainable agricultural practices.**

***Index Terms*—Internet of things (IoT), Smart warehouses, AI (Artificial Intelligence), Informed decision-making, Image Processing, Crop wastage reduction, Sprouted onion detection, Rotten onion detection, Gas sensing system.**

I. INTRODUCTION

Agriculture serves as the backbone of numerous economies, with a significant portion of the population engaged directly or indirectly in this sector. Recent years have seen the emergence of new cropping patterns aimed at transforming farming communities' economic landscape. Among crucial horticultural crops, onions are of immense commercial importance, especially in India, the world's second-largest onion-producing nation. The grading of agricultural produce, particularly onions, has become indispensable for both national and international trade, aligning with global standards and meeting specific consumer demands.

Manual sorting of onions by growers and traders results in subjective grading, leading to increased selling costs, inconsistencies, and reduced productivity. Additionally, the fragmentation of agricultural land into micro-holdings exacerbates labor shortages, impacting onion cultivation economics. Hence, there's a need for cost-effective engineering mechanisms to streamline agricultural processes.

The Internet of Things (IoT) revolutionizes computing by connecting everyday physical objects to the Internet, facilitating real-time insights and communication. In agriculture, IoT plays a vital role in monitoring and controlling operations, particularly in addressing challenges in onion storage. Smart farming, driven by IoT sensors, enables farmers to access critical field information, focusing on monitoring temperature and humidity levels. A proposed grid system for onion storage aims to mitigate degradation risks due to temperature and humidity fluctuations, promptly notifying farmers of storage issues to enhance yield quality and avert economic losses.

India, a significant onion producer, faces challenges in monitoring bulb quality and disease prevention during bulk storage. Enhanced management tools are needed for continuous quality monitoring, particularly to monitor temperature and relative humidity to ensure optimal storage conditions. This study investigates the microclimate surrounding onions in storage and examines its correlation with quality indicators, hypothesizing that diseased onions exhibit elevated respiratory heat and water vapor emissions, resulting in higher average temperatures and RH levels in storage.

II. LITERATURE REVIEW

Syed Musthak Ahmed et al. research describes the benefits of implementing the IoT-based monitoring system in onion warehouses to control losses and improve efficiency in onion storage practices [1]. The monitoring system alerts owners when onions are at risk of rotting, allowing them to take necessary actions to prevent spoilage.

Zahid khan et al. research describes the IoT-based smart farming monitoring system (SFMS) to reduce bolting in onion crops. The SFMS uses sensors to monitor environmental factors in both open and greenhouse environments [2]. The research focused especially on bolting and did not address other potential challenges in onion farming is a drawback though.

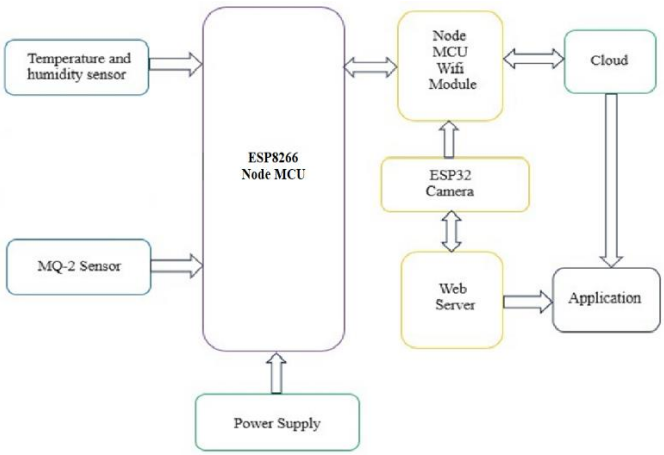


Fig. 1. Block diagram

Vinay S. Sidawadkar et al. presented IoT based system to preserve onions by monitoring and controlling temperature and humidity levels using sensors [3]. The system incorporates a thermoelectric cooling module and stores data on Google Cloud, where users can remotely monitor the onion storage conditions and receive notifications about the system status. The system includes complex setup and maintenance, and high implementation costs which could lead to some drawbacks.

A. Farha et al. discussed the cultivation of onion as a winter crop and their significance as a spice and vegetable, and the challenges faced in meeting the increasing demand for onions in Bangladesh, which ranks first in terms of production and consumption among spice crops [4]. The article highlights the need for structured and regulated onion production to reduce dependency on imports and meet the rising demand for onion.

Labanska et al. investigated the use of an electronic nose for detecting Fusarium Basal a Rot infection in onions and shallots. The study demonstrates the potential of electronic nose technology in the early detection and monitoring of fungal infections in post-harvest crops [5]. The research underscores the evolving nature of electronic nose technology, offering sensors and pattern recognition methods, making it a promising tool for rapid and non-destructive monitoring of crop health.

III. METHODOLOGY

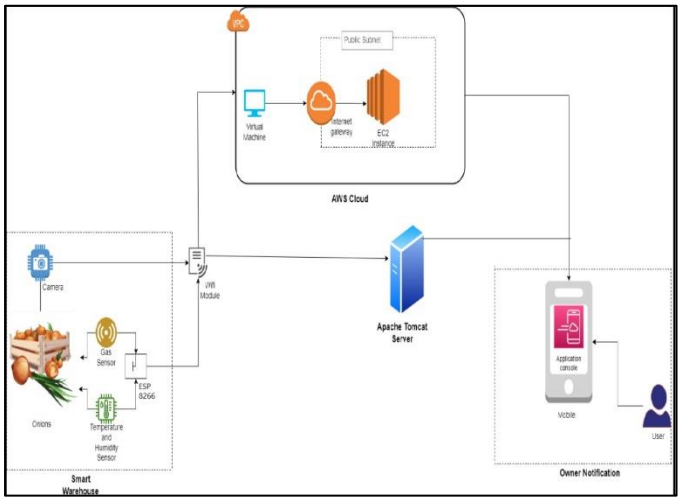
A. Hardware Design

In the Early Detection of Onion Spoilage Utilizing IoT and AI During Storage and Transportation, the system collects data from various sensors such as DHT11 Temperature and Humidity Sensor, and MQ2 gas Sensor to monitor the environmental conditions of the onion storage facility. The collected data is processed to get relevant information regarding temperature, humidity, and gas levels in the storage environment.

The system utilizes image processing algorithms, such as Convolutional Neural Networks (CNN), to analyze images captured by the ESP32 Cam. This process helps in identifying sprouted onions by detecting visually, like sprout growth. A detection algorithm is implemented to classify onions based on their condition (healthy, sprouted, rotten) using the data from sensors and image processing results.

If the system detects any issues such as low-quality onions or variations in storage conditions, it generates alert notifications. These alerts can be sent to predefined mobile numbers through a mobile application integrated with the system.

B. System Workflow



The Early Detection of Onion Spoilage Utilizing IoT and AI during storage and transportation is a step taken to control the spoilage of onions, seamlessly integrating hardware components and powerful machine learning algorithms. The sensors of this system, which include DTH11, and MQ-2, continually collect real-time data necessary for monitoring the health of onions. The ESP8266 uses this data to power a decision-making mechanism that carefully examines sensor inputs. Its main objective is to reduce the loss in spoilage and early detection of sprouting and rotting of onions.

With the use of sensor inputs and image visualization ESP8266 processes its data and sends it to the server which compares the data with given threshold values and alerts

farmers to segregate the onions from spoilage, sprouting, or rotting of onions.

Farmers can remotely able to monitor the onions ensuring the quality of onions during storage and transportation. This helps in the reduction of post-production losses.

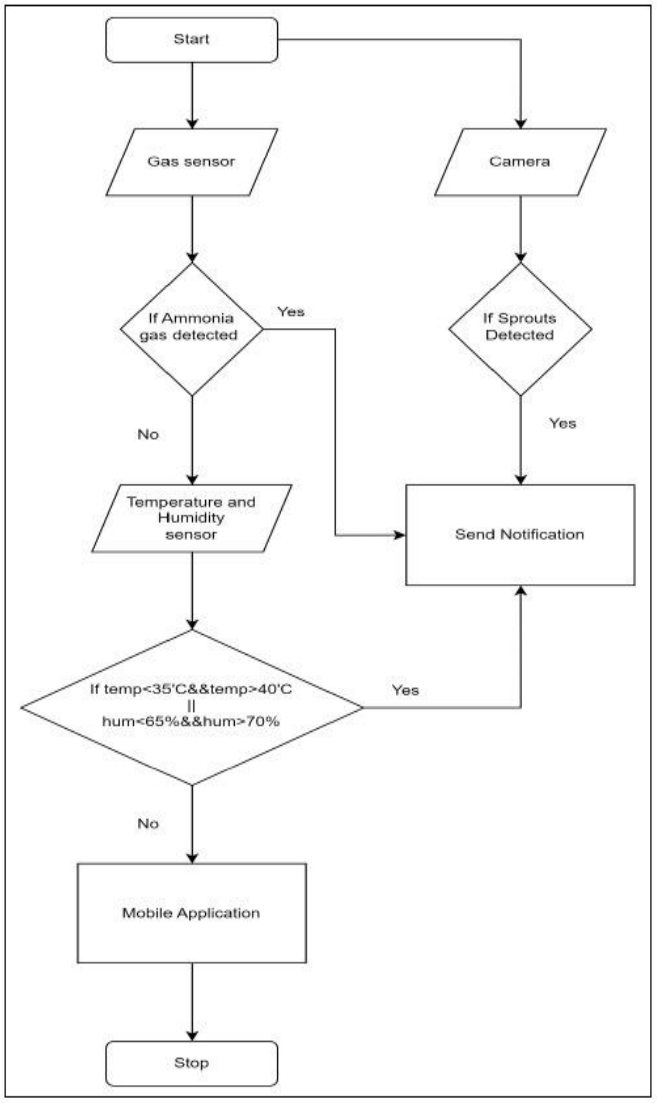


Fig. 2. Flowchart

C. Software Design

The system utilizes a communication module, such as the NodeMCU ESP8266 Wi-Fi module, to establish connectivity and transmit data between the sensors, image processing unit, and alert generation system.

A user interface is designed to provide farmers with real-time information about the health status of onion stocks. This interface may display sensor readings, image analysis results, and alert notifications in a user-friendly format.

The system uses AWS Cloud, to store and analyze data collected from the sensors.

The software design ensures continuous monitoring of onion storage conditions, enabling measures to be taken in case of any spoilage or degradation issues. This real-time monitoring helps in reducing wastage and improving overall efficiency.

Fig. 2. Hardware design

IV. RESULT

Fig 2 shows the hardware design of the system which consists of a set of sensors, a microcontroller, and a ESP32 camera. Fig 3 shows sensor readings obtained. Fig 4 shows Application developed in Android studio. Fig 5 shows the alert system in mobile application where green text indicates normal and red indicates abnormal readings and Fig 6 shows the real-time data storage for further reference.

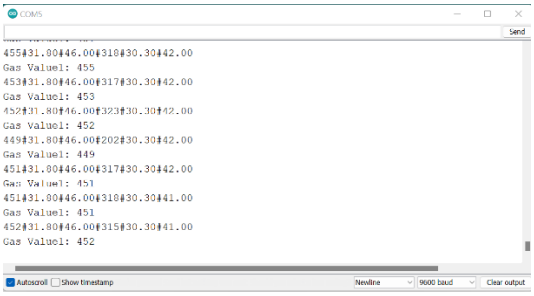


Fig. 3. Sensor output

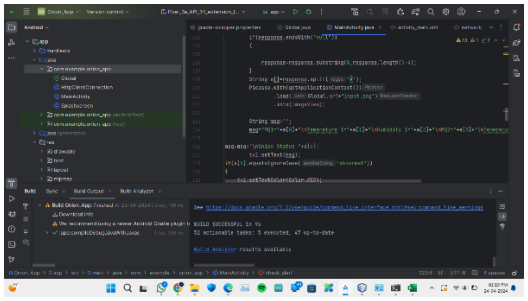


Fig. 4. Android Studio – Application development

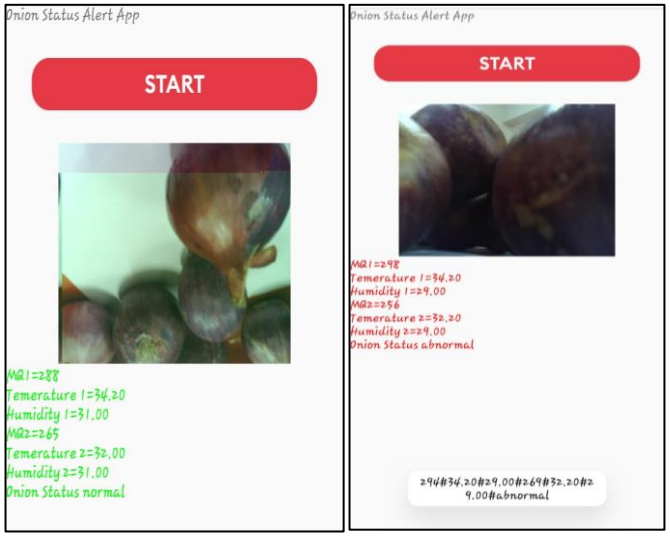


Fig 5. Mobile Alert System (green – normal, red – abnormal)

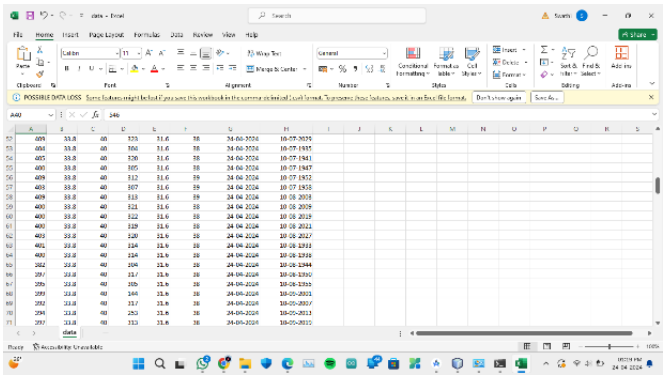


Fig 6. Storage of real-time data

V. CONCLUSION

In this paper, Early Detection of Onion Spoilage during Storage and Transportation demonstrates the use of AI and IoT technology for monitoring Onions. The system integrates sensors, machine learning algorithms, and hardware components which has given positive results in monitoring the Onions.

Our methodology, utilizes gas sensors for detecting gases, a DHT11 sensor for measuring temperature and humidity, along with a camera for visual monitoring. The system can collect real-time data and transmit it to AWS Cloud for further analysis to improve efficiency in decision-making processes for post-production work.

The data collected from sensors has been processed by the ESP32 microcontroller and is sent to the server using a Wi-Fi module. Further, the server examines and provides the alert notification to the user's application console (mobile) through messages and picture format.

Our messaging platform allows farmers real-time insights at any time through alerts, which reduces hazards for farmers during the storage and transportation of Onions. In the future, implementing predictive analytic algorithms can help further potential spoilage events based on real-time sensor readings.

Conclusively, our AI and IoT-driven monitoring system for Onions degrades the spoilage during storage and transportation.

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Design of Frequency Reconfigurable Antenna with Split Ring Resonator and Diode Control for Omnidirectional Applications

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Abstract— This paper presents a novel antenna design featuring frequency reconfiguration through the use of a diode. The antenna incorporates curved slots on the patch and a central circular-shaped split ring resonator, achieving dual-band operation. When the diode is ON, the antenna operates at 5.5 GHz and 7.1 GHz, and when the diode is OFF, it operates at 6.7 GHz and 7.6 GHz. The VSWR remains below 2 in both states, indicating efficient impedance matching. Additionally, the antenna maintains an omnidirectional radiation pattern regardless of the diode state, ensuring uniform signal distribution. The design employs a low-cost FR4 epoxy substrate and microstrip line feeding, balancing affordability and performance. This reconfigurable antenna is suitable for applications requiring flexible frequency tuning and reliable signal coverage.

Keywords— Reconfigurable Antenna, Frequency Tuning, Split Ring Resonator, Microstrip Line Feeding, Omnidirectional Radiation Pattern.

I. INTRODUCTION

Patch antennas (PAs) are a type of directional antenna featuring a thin metal patch situated above a ground plane. These antennas are connected to a transmission line through a feed point. The operational frequency of a patch antenna is determined by its dimensions and shape.

In recent years, patch antennas (PAs) have gained popularity due to their compact size, low profile, and easy integration with other electronic components, making them favorable over traditional antennas [1,2]. Their small size, high gain, and durability are particularly appreciated in mobile device manufacturing and wireless communication systems, where they see widespread use. Research continues to focus on designing smaller and more efficient PAs to support high-speed data transmission, aiming to incorporate them into micro-electromechanical systems (MEMS) for integration into compact devices [3-8]. Advances in material technology and manufacturing techniques have recently enabled the creation of even smaller and higher-performing patch antennas [9-13]. The ongoing challenge of further miniaturizing PAs is an active area of research, with new techniques being developed to achieve this goal [14-17].

In wireless communication systems, two prevalent types of antennas are ultra-wideband (UWB) and multi-band antennas [18-21]. Both are capable of operating across a wide frequency range but have distinct characteristics and uses. Multi-band antennas are composed of several resonating elements, each calibrated to a specific frequency band, enabling them to function across multiple narrow bands. These antennas are ideal for applications that require communication across various frequencies, such as cellular networks and Wi-Fi systems [22-25]. Conversely, UWB antennas utilize a single resonant element to cover a broad spectrum, operating over a wide frequency range without needing multiple resonators.

Reconfigurable planar antennas have gained popularity for their versatility in switching between different modes of operation, frequencies, and radiation patterns, effectively combining the features of both multi-band and UWB antennas. These antennas are widely utilized in modern wireless communication systems, such as ultra-wideband (UWB) and wireless local area network (WLAN) applications [26-28], that require a broad range of frequencies. Recent literature has documented several approaches to achieving UWB characteristics, including tree-like fractal slots [29], compact folded network antennas, reconfigurable antennas with diodes on an FR4 substrate [30-33], fractal arrays, and MIMO (multiple-input multiple-output) antennas. The incorporation of reconfigurable components, like PIN diodes, enables these antennas to switch between different frequency bands, adapting to various communication needs. Designing such antennas is complex, necessitating electromagnetic simulations and optimization techniques to meet performance requirements.

II. PROPOSED DESIGN

The antenna depicted in Fig. 1 features curved slots on its patch, with a circular-shaped split ring resonator positioned at the centre to introduce an additional frequency band. The

dimensions of the curved slot are meticulously designed to achieve the desired resonance within a compact form factor. Similarly, the size of the split ring resonator is precisely adjusted to attain a second resonance. This antenna employs microstrip line feeding and is constructed using an economical FR4 epoxy substrate, ensuring cost-effectiveness while maintaining performance. PIN diode is used to obtain frequency reconfiguration. The dimension of the patch antenna are shown in Table. 1

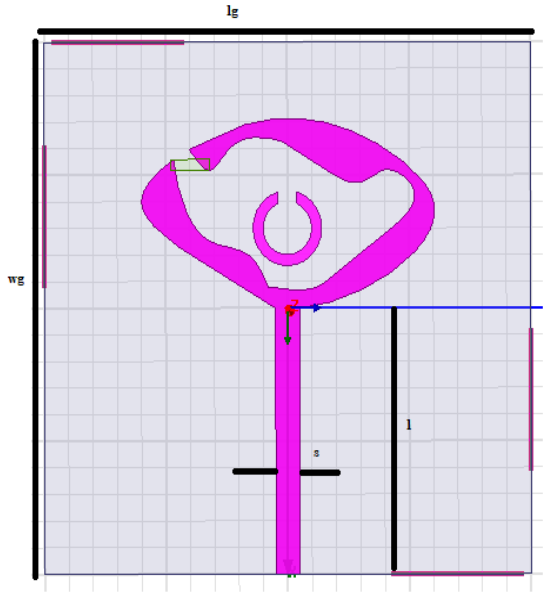

Fig. 1. Proposed Antenna Design

Table 1. Antenna Geometry

Parameters	Specifications
Lg	10mm
Wg	10mm
g	0.5mm
l	5mm

III. Parametric Study

Various configurations of the curved slot were explored to analyze their resonance behavior, as depicted in Figure 2. Through experimentation, we identified the optimal shape of the curve that facilitates achieving the desired design resonances.

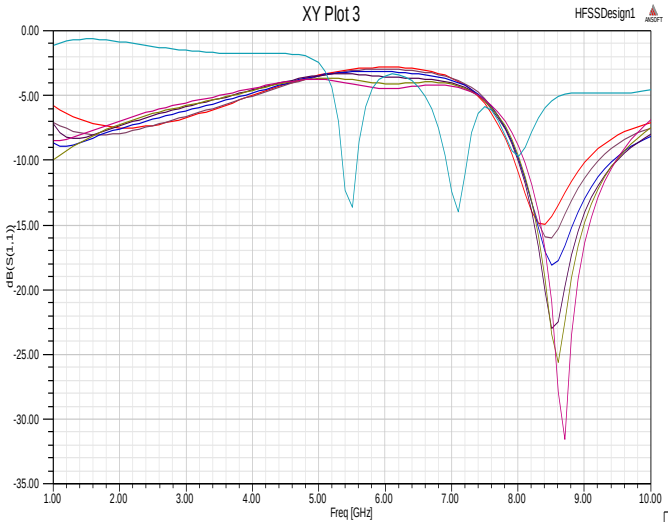

Fig. 2. Parametric Study of the proposed Antenna

IV. Results and Discussions

Figures 3 and 4 illustrate the return loss of the proposed antenna design with the diode in the ON and OFF states, respectively. When the diode is ON, the antenna operates at two distinct frequency bands: 5.5 GHz and 7.1 GHz. Conversely, when the diode is OFF, the antenna operates at different frequencies, specifically 6.7 GHz and 7.6 GHz. This ability to switch between frequency bands is achieved by toggling the diode, demonstrating the antenna's frequency reconfiguration capability.

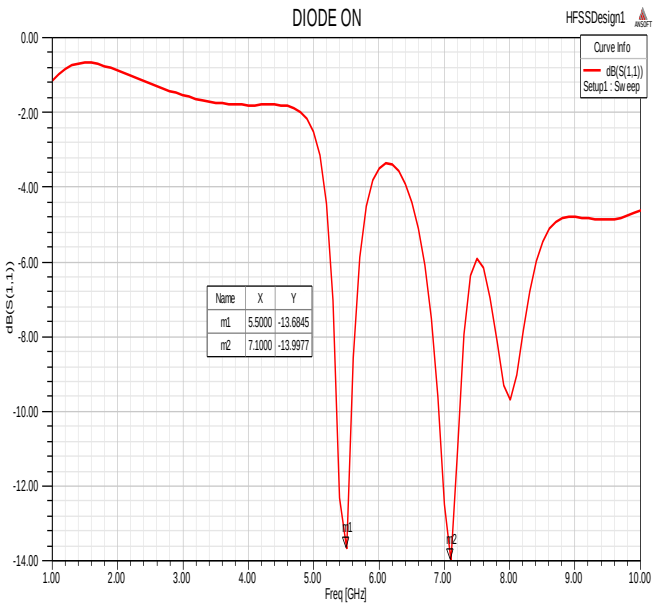

Fig. 3 Return Loss of the Proposed Antenna when Diode is ON

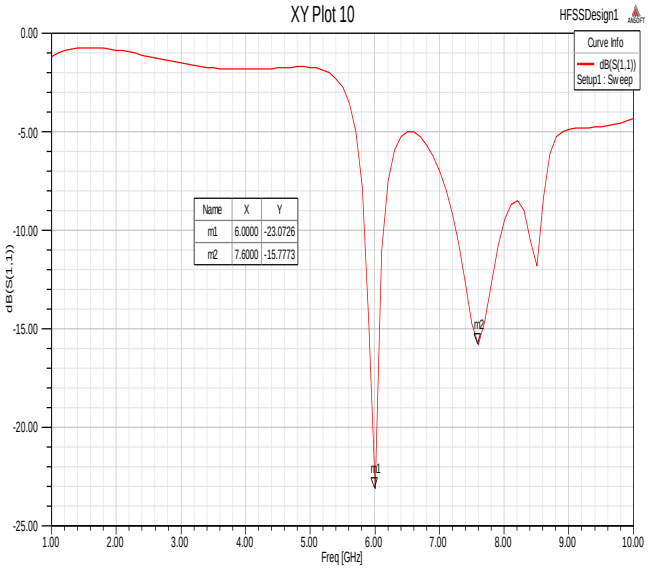

Fig. 4. Return Loss of the Proposed Antenna when Diode is OFF

Figures 5 and 6 present the Voltage Standing Wave Ratio (VSWR) pattern of the proposed antenna with the diode in the ON and OFF states, respectively. The plots indicate that in both scenarios, the VSWR remains below 2, signifying efficient impedance matching and minimal signal reflection. Figures 7 and 8 display the radiation patterns of the antenna for both diode states. Regardless of whether the diode is ON

or OFF, the radiation pattern remains omnidirectional, ensuring uniform signal distribution in all directions.

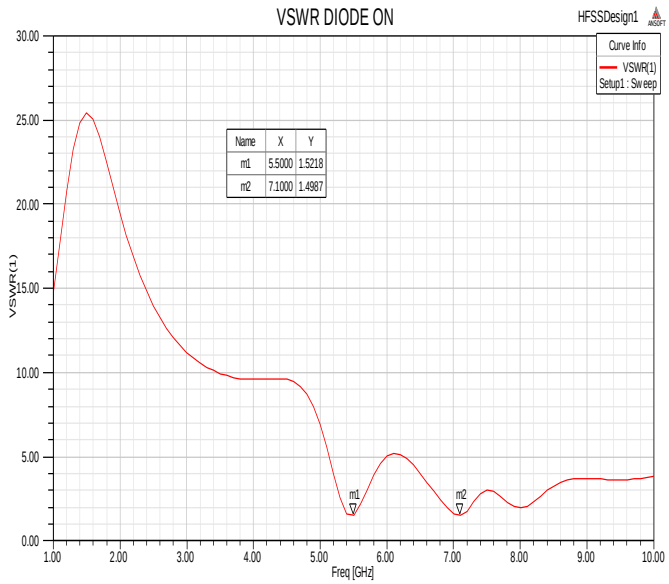

Fig. 5. VSWR plot of antenna when diode is ON

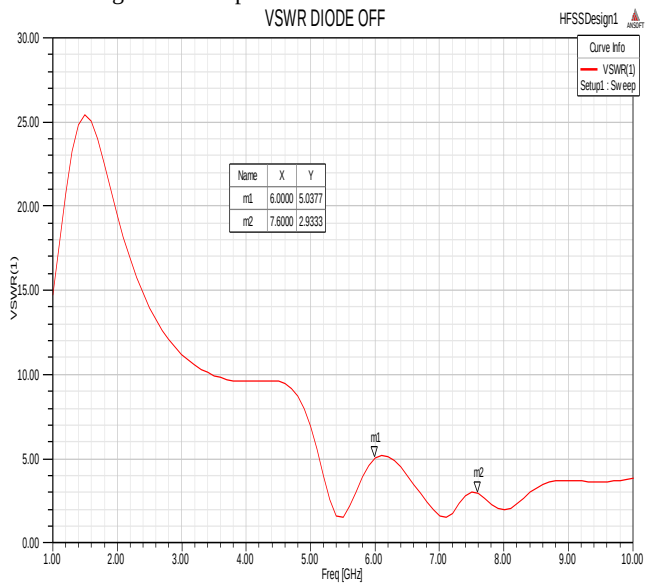

Fig. 6. VSWR plot of antenna when diode is OFF

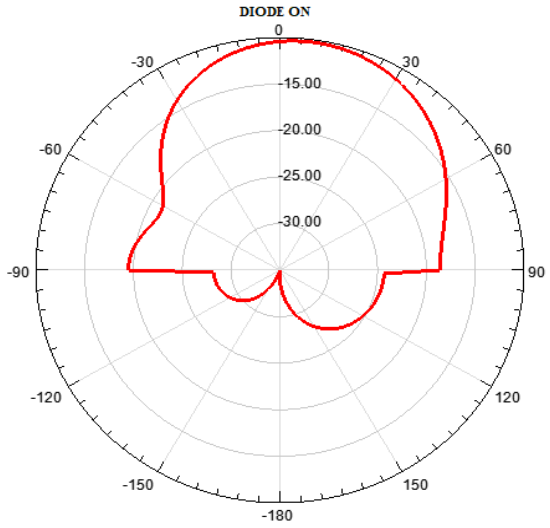

Fig. 7 Radiation pattern of the proposed antenna when diode is ON

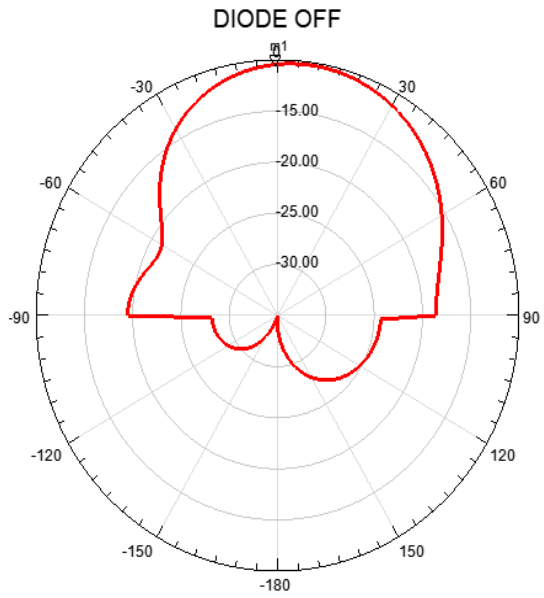

Fig. 8 Radiation pattern of the proposed antenna when diode is ON

V. Conclusion

The proposed antenna design demonstrates effective frequency reconfiguration through the toggling of a diode, as evidenced by the distinct operational bands of 5.5 GHz and 7.1 GHz when the diode is ON, and 6.7 GHz and 7.6 GHz when the diode is OFF. The antenna maintains a VSWR below 2 in both diode states, indicating optimal impedance matching and minimal signal loss. Additionally, the antenna's omnidirectional radiation pattern, consistent in both states, ensures comprehensive signal coverage. Constructed with a low-cost FR4 epoxy substrate and featuring microstrip line feeding, this antenna design combines cost-effectiveness with high performance, making it a viable solution for applications requiring dynamic frequency tuning and robust signal propagation.

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Gastric Cancer Detection: Using Deep Ensemble Learning Model

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Abstract—***Gastric cancer, a leading global killer, often goes undetected until late stages, hindering efficient treatment and survival. Despite the gold standard of histopathological analysis, its manual nature poses challenges. The rising interest in computer-aided diagnosis, particularly deep learning models, aims to fill this gap. However, individual models suffer from limited feature extraction and classification accuracy.***

This project addresses this limitation by proposing ensemble models, combining multiple deep learning models to improve feature extraction and classification. Tested on a publicly available gastric cancer dataset, these models achieved state-of-the-art detection accuracy, reaching up to 94.20%. This breakthrough suggests ensemble models can effectively analyze smaller image sizes, holding immense potential for assisting pathologists and facilitating early diagnosis, ultimately improving patient survival rates.

Beyond diagnosis, advances in molecular research are uncovering promising biomarkers for gastric cancer. These discoveries hold significant clinical potential, paving the way for personalized treatment approaches like targeted therapies and immunotherapies. The combined advancements in computer-aided diagnosis and biomarker research offer a glimmer of hope for revolutionizing the management of this deadly disease and improving patient outcomes.

Keywords—histopathology; gastric cancer; deep learning; convolutional neural network; ensemble model.

I. INTRODUCTION

Gastric cancer ranks among the top cancers worldwide in both prevalence and mortality rates [1]. It is a complex and varied disease characterized by different histopathological features [2], manifesting in multiple subtypes each with unique histological patterns that complicate its diagnosis. The gold standard for detecting gastric cancer involves histopathological examination of biopsied or surgically removed tissue specimens under a microscope [3]. Traditionally, pathologists manually inspect these specimens, beginning with low magnification to identify any suspicious areas and then switching to higher magnification for a detailed examination of these areas. This involves laborious scanning of large, gigapixel whole slide images (WSIs) to locate tiny abnormal regions of interest, a process repeated multiple times to ensure accurate diagnosis.

However, manual examination by pathologists is not only time-consuming and physically demanding but also subject to individual variability, which can lead to discrepancies in diagnosis. The accuracy of histopathological analysis heavily relies on the pathologist's experience and expertise, increasing the risk of human error, such as misdetection or misdiagnosis. Additionally, there is a global shortage of pathologists, which often results in significant delays in processing patient samples, thereby potentially delaying cancer detection.

Gastric cancer, predominantly occurring as adenocarcinomas, typically does not show symptoms in its early stages, or it might present with vague symptoms like gastric discomfort, often mistaken for less serious conditions like ulcers or gastritis [4]. This further delays diagnosis. Early detection is crucial for survival; patients diagnosed early have a survival rate over 90%, whereas those diagnosed at advanced stages have survival rates below 30% [6,7,8].

To address the inefficiencies of manual diagnostic workflows, the field has turned towards computer-aided diagnosis (CAD) systems. These systems, supported by advancements in digital pathology that improve slide scanning and reduce data storage costs, are becoming increasingly prevalent [9]. CAD not only speeds up the cancer diagnostic process but also reduces variability between pathologists' diagnoses [10].

For detecting gastric cancer in histopathological images, several CAD methods have been implemented using classification and segmentation approaches. Initially, machine learning techniques were used, employing manually extracted features like color, texture, and shape, with common classifiers including support vector machines (SVM), random forest, and Adaboost [11-16]. More recently, deep learning has revolutionized the field by automating feature extraction, with deep convolutional neural networks (CNNs) showing promising results in classifying and segmenting histopathological images, even achieving accuracies comparable to human pathologists in some cases [9,17-28].

Despite their advantages, deep learning models require extensive datasets for training, which is a significant challenge in histopathology due to the exhaustive manual labeling required. Strategies like data augmentation are often used to expand limited datasets [11,29]. Another approach to mitigate the issue of small datasets is transfer learning, where either networks are trained from scratch [30,31] or pre-trained networks are fine-tuned [5,30].

However, each pre-trained network has its strengths and limitations based on its architecture, leading to different feature extractions and interpretations, which might omit critical features for accurate prediction. To address this, this study proposes using ensemble models that combine the strengths of multiple pre-trained networks. This approach enhances feature extraction, improving the accuracy of gastric cancer detection by leveraging the collective capabilities of various models. Especially in histopathology, where high-resolution WSIs are typically downscaled into smaller, more manageable patches, ensemble models can compensate for the loss of information due to reduced resolution.

The performance of these proposed deep ensemble learning models was evaluated using the newly available public dataset, the Gastric Histopathology Sub-size Image Database (GasHisSDB) [32]. The findings indicate that these models not only outperform existing methods but also handle lower-resolution images effectively. This suggests potential reductions in the need for high-specification digital scanners and computational resources, ultimately enhancing early cancer detection and improving patient survival rates.

II. LITERATURE REVIEW

A substantial body of research [1]–[9] has been dedicated to the automatic prediction of gastric cancer through the application of machine learning and deep learning techniques.

V. V. Khryashchev, O. A. Stepanova and colleagues [1] employed a methodology for automatic detection of gastric mucosa changes using NBI-ME endoscopic images. Steps include image preprocessing, expert annotation of lesions, training a convolutional neural network (CNN), and evaluating algorithm performance with the mean average precision metric. The deep learning approach recorded the highest accuracy, reaching 94.2%, utilizing a network architecture that included three fully connected layers with 128, 64, and 32 neurons respectively, each followed by dropout layers to reduce overfitting.

Wengang Qiu, and his team [2] The methodology introduced included collecting endoscopic images for a robust training set, enhancing experimental effectiveness through data expansion techniques. The expanded dataset was utilized to train a Convolutional Neural Network (CNN), generating the DLU-Net algorithm model tailored for the identification and classification of endoscopic images achieving a 92.7% accuracy rate in detecting gastric cancer.

Sin-Ae Lee, and colleagues [3] This study introduces a computer-aided diagnosis (CADx) system for distinguishing gastric cancer using the Xception deep-learning model. The methodology involves Google's AutoAugment for image augmentation and SLIC superpixel with FRFCM for image segmentationThe performance of the CADx system is evaluated using biopsy-supported ground truth, and the results show an improved performance in identifying cancerous lesions.achieved a notable precision rate of 98.3% for the prediction of gastric cancer.

In a similar vein , Jung-Woo Chae and Hyun-Chong Cho. [4] Adopted a CADx system for early gastric cancer detection via gastroscopy, utilizing the Vision Transformer and enhancing performance with Multi-Filter AutoAugment. Results showcase effective classification of abnormalities and lesions.

Yanyu Hu, [5] Introduced RDFS algorithm for gastric cancer classification, combining gene expression and copy number variation data. It compares favorably with existing methods, validates results through survival analysis, and identifies potential biomarkers and disease mechanisms. The study aims to enhance prediction accuracy and provide insights into gastric cancer.

Yixin Li and his team [6] presents the HCRF-AM model, incorporating an attention mechanism (AM) and an image classification (IC) module for gastric histopathology image classification. The AM module employs an HCRF model to enhance interpretability, while the IC module utilizes a CNN for classification. Evaluation on a public dataset demonstrates its efficacy in weakly supervised learning, laying the groundwork for intelligent medical imaging systems., resulting in a 98.33% accuracy rate.

Yuxiu Huang and his team [7] used methodology involving developing a deep learning framework with two main components: a lymph node detection network and a lymph node benign and malignant classification network. The detection network counts the number of lymph nodes in digital pathological images, reducing the time spent on annotations. The classification network is trained on small image tiles and uses image enhancement methods to improve accuracy.

Atsushi Teramoto. [8] proposed a cascade-based deep learning model for automatic detection and classification of gastric cancer. It combines convolutional neural networks (CNNs) for image classification and U-Nets for segmentation, specifically targeting tumor location identification and detailed multiclass segmentation. The evaluation includes detection characteristics, activation maps, and metrics such as Dice and Jaccard coefficients, providing a comprehensive assessment of the model's performance ,achieving a high accuracy rate of 97.60%.

Lastly, Keping Xie and Jidong Peng [9] developed a deep CNN model incorporating specifically AlexNet and GoogLeNet, for automatic classification of gastric cancer pathological images having accuracy of 96.70%

III. METHODS

A. Methodology Overview

The paper introduced CNN-based models for patch binary classification in gastric cancer detection. The workflow involved three stages: data preprocessing, fine-tuning pre-trained networks, and evaluating the proposed models using various metrics and visualizations like confusion matrix.

B. Dataset Pre-Processing

To optimize model performance during training, the dataset underwent preprocessing to enhance its distribution. Initial examination revealed numerous empty patches within the dataset, which could adversely affect model performance. Thus, the preprocessing phase involved eliminating these empty patches and applying Gaussian Blur and Canny Edge Detection and then augmenting the dataset to increase its size and diversity, providing a more robust foundation for model training.

a. Empty Patch removal Process

We filtered out empty patches from the dataset, considering them non-informative. Empty patches were identified as those with over 10% of pixels having RGB intensity values exceeding 230 across all channels. Approximately 4.91% of patches were removed from the 80-pixel sub-database, 4.01% from the 120-pixel sub-database, and 2.86% from the 160-pixel sub-database. This resulted in reduced sample counts: 146,615 to 139,415 in the 80-pixel sub-database, 65,261 to 62,645 in the 120-pixel sub-database, and 33,284 to 32,333 in the 160-pixel sub-database. After removing empty patches, the remaining patches underwent data augmentation.

b. Gaussian Blur

Gaussian blur is a preprocessing technique commonly used in the context of histopathological image analysis for gastric cancer detection. It involves applying a Gaussian filter to the image, which smoothens the image by reducing high-frequency noise and details while preserving important structures and features. This blur helps in reducing noise and enhancing the overall quality of the image, making it easier for subsequent analysis steps, such as feature extraction or classification, to focus on relevant information. In gastric cancer detection, Gaussian blur improves the clarity of tissue structures and anomalies, thereby aiding in more accurate diagnosis and detection of cancerous regions.

c. Canny Edge Detection

Canny edge detection is a preprocessing technique used in histopathological image analysis for gastric cancer detection. It works by identifying edges in the image, highlighting regions where there are significant changes in intensity. This technique is beneficial in detecting boundaries between different tissues and structures within the histopathological images, including potential cancerous regions. By extracting these edges, Canny edge detection helps in accentuating important features and structures, enabling better visualization and analysis of the tissue morphology. In the context of gastric cancer detection, Canny edge detection can assist in identifying irregularities or abnormalities in tissue structures, potentially aiding in the early diagnosis and localization of cancerous lesions.

C. Data Augmentation

To enrich the dataset, affine transformations were applied to the training images, including rotations at 90-degree intervals and horizontal or vertical flipping. This augmentation technique effectively doubled the size of the original training set. Post-augmentation, the number of samples increased significantly: from 55,766 to 111,532 samples in the 80-pixel sub-database, from 25,058 to 50,116 samples in the 120-pixel sub-database, and from 12,933 to 25,866 samples in the 160-pixel sub-database.

D. Pre-Trained Networks

We evaluated several commonly used pre-trained networks, including DenseNet121, DenseNet169,and EfficientNetB0.

a. DenseNet Family

DenseNet, introduced by Huang et al. in 2017, is a type of feedforward convolutional neural network (CNN). Unlike traditional CNN architectures, DenseNet connects the feature maps from all preceding layers to all subsequent layers within each dense block. This design aims to address issues like the vanishing gradient problem, enhance feature reuse, and reduce the number of parameters in the model. In DenseNet, feature maps from different layers within a dense block are combined through concatenation, enabling effective information flow throughout the network. Additionally, downsampling is achieved using convolution and pooling operations to facilitate feature concatenation while maintaining spatial information.

b. EfficientNet Family

EfficientNet, introduced by Tan and Le in 2019, offers a novel approach to model optimization under resource limitations. Unlike conventional methods that scale up models for improved accuracy, EfficientNet focuses on balancing network depth, width, and resolution to enhance performance. The key idea is to maintain efficiency while achieving higher accuracy. This is achieved through a compound scaling method, which uniformly scales up the baseline model, EfficientNetB0, across all dimensions to meet resource constraints. As a result, a family of models ranging from EfficientNetB0 to EfficientNetB7 is generated, each offering improved performance without sacrificing efficiency.

E. Ensemble Model Architecture

Three ensemble techniques—majority voting, unweighted averaging, and weighted averaging—were employed to construct ensemble models, with their performance subsequently compared. The process involved selecting the best-performing base models based on their validation set accuracies for each sub-database. The number of base models chosen ranged from three to five.

In the majority voting approach, prediction classes from the base models were aggregated through a voting process, with the class receiving the highest number of votes deemed the ensemble prediction class. Unweighted averaging, on the other hand, involved averaging the prediction class probabilities from base models for all classes. The class with the highest average probability became the ensemble prediction class.

Weighted averaging, unlike unweighted averaging, assigned specific weights to each base model under each class. These weights were optimized using feedforward neural networks, rather than manually tuning them as hyperparameters. The ensemble prediction probabilities for all classes were then averaged using these optimized weights to determine the final ensemble prediction class.

IV. EXPERIMENTS

A. Experiment Setting

The GasHisSDB dataset underwent a stratified splitting process into train, validation, and test sets, maintaining a ratio of 7:2:1 after removing empty patches. This ensured a balanced distribution between the two image classes across all datasets.

To adapt pre-trained networks or base models, originally trained on ImageNet's 1000 classes, for our binary classification task, the output softmax layers were replaced with 2 nodes corresponding to the binary classes. Training parameters included 30 epochs, a batch size of 20, stochastic

gradient descent (SGD) optimizer, categorical cross-entropy loss, and a default learning rate of 0.01. All network layers, including pre-trained layers, were trainable, and the weights of the models at the epoch with the highest validation accuracy were selected.

For the weighted averaging ensemble strategy, feedforward neural networks were employed. These networks processed probabilities from multiple base models for each class, using input and output layers without hidden layers and a sigmoid activation function. The ensemble probabilities from these networks were aggregated, and the class with the higher ensemble probability was chosen as the ensemble prediction class. Model initialization involved setting the weights to zero, with training parameters including 5 epochs, Adam optimizer, batch size of 20, and a default learning rate of 0.01.

Database	Augmented Training Set	Validation Set	Testing Set
80-pixels	66,361	18,960	9,480
120-pixels	61,392	17,540	8,770
160-pixels	31,686	9,053	4,526

Table 1: Distribution of Dataset

B. Evaluation Metrics

The performance of the models was assessed using various metrics including accuracy, precision, recall, specificity, F1-score, area under the curve (AUC), and categorical cross-entropy loss. Abnormal or cancerous patches were labeled as positive samples, while normal or healthy patches were labeled as negative samples. True positive (TP), true negative (TN), false positive (FP), and false negative (FN) cases were identified based on these labels.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$Precision = \frac{TP}{TP + FP} \quad (2)$$

$$Recall = \frac{TP}{TP + FN} \quad (3)$$

$$Specificity = \frac{TN}{TN + FP} \quad (4)$$

$$F1 - score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (5)$$

Fig 1: Evaluation Metrics

C. Prediction Visualization

In this study, understanding model behaviors was aided by visualizing feature maps using the Gradient-weighted Class Activation Mapping (Grad-CAM) technique. Grad-CAM produces a coarse localization map by analyzing gradients flowing into the final convolutional layers of the model. This technique highlights important regions in the images that are used by each base model to make classifications.

The entire processing framework of the proposed ensemble learning models is summarized in Figure 2.

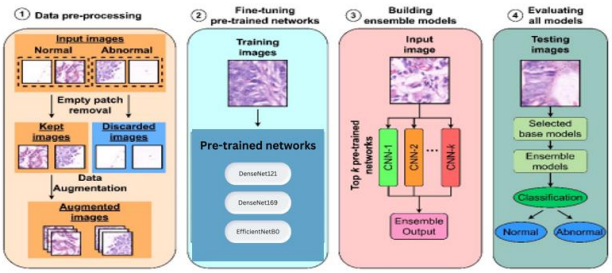

Fig 2: The architecture of the proposed ensemble model

V. RESULTS AND DISCUSSIONS

The validation set performance of different fine-tuned models on 120-pixel images from the GasHisSDB dataset is depicted in Table 2. Among the models evaluated, DenseNet121 exhibited the highest accuracy of 99.10%, followed closely by DenseNet169 with 98.23%, and EfficientNetB0 with 98.07%. These results underscore the effectiveness of deep learning architectures like DenseNet and EfficientNet in accurately classifying gastric histopathological images.

Models	Accuracy
DensetNet121	98.10%
DensetNet169	97.23%
EfficientNetB0	96.87%

Table 2: Accuracy of different fine-tuned models

Notably, these findings highlight the robustness and potential of these models for gastric cancer detection tasks, particularly when fine-tuned on histopathological datasets. Leveraging the strengths of these models through ensemble techniques further enhances overall performance. The combined accuracy of 93.21% achieved by ensembling all three models underscores the utility of ensemble learning in improving classification accuracy and robustness.

These results demonstrate promising progress in leveraging deep learning techniques for accurate and reliable gastric cancer detection, offering potential benefits for early diagnosis and treatment planning. Moreover, the availability of the GasHisSDB dataset, as a publicly accessible resource, facilitates further research and development in this critical area of medical imaging analysis.

VI. CONCLUSION

In this study, we developed deep ensemble learning models utilizing transfer learning from pre-trained networks such as DenseNet121, DenseNet169, and EfficientNetB0 for gastric cancer detection. Our findings demonstrate that ensemble learning based on the top three base models achieved state-of-the-art detection accuracy, ranging from 96.87% to 98.10%. Importantly, our experiments revealed that ensemble models can effectively extract essential features from smaller patch sizes while still achieving promising performance.

These results suggest the potential for reducing the specifications of digital scanners, data storage, and computational resources required for histopathology tasks. This advancement could significantly expedite gastric cancer detection, ultimately leading to improved patient outcomes and higher survival rates.

Looking ahead, our future work aims to leverage real datasets and further enhance the system's accuracy. Additionally, we plan to extend our efforts to classify different types of gastric cancer, thus advancing our understanding and capabilities in medical image analysis. Through continued research and innovation, we aspire to contribute to the ongoing fight against gastric cancer and improve patient care outcomes..

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Image Captioning using ResNet101 and LSTM

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***Abstract*—Image captioning, the task of automatically generating textual descriptions for images, has emerged as a significant research area with wide-ranging applications in fields such as computer vision, artificial intelligence, and human-computer interaction. This paper presents a novel approach to image captioning, leveraging the ResNet101 convolutional neural network (CNN) architecture and Long Short-Term Memory (LSTM) networks. ResNet101 is employed to effectively extract high-level features from input images, enabling the model to capture intricate visual patterns and semantics with remarkable accuracy. LSTM networks, known for their ability to model sequential data and capture long-range dependencies, are utilized to generate coherent and contextually relevant captions based on the extracted image features. In our proposed framework, the ResNet101 network acts as the feature extractor, transforming input images into compact yet informative representations, which are then passed to the LSTM network for sequential word prediction, conditioned on both the image features and previously generated words.**

Keywords—Resnet, LSTM, computer vision

I. INTRODUCTION

The primary objective of Image Captioning is to enhance user experience by generating automatic descriptions, which can be utilized for various purposes such as image identification, assisting individuals with disabilities, social media platforms, and fulfilling other NLP (Natural Language Processing) requirements. Image captioning offers a narrative explanation for a collection of images, creating captions based on the information detected within an image. This process integrates Computer Vision with NLP skills to aid in scenario comprehension. Image Captioning involves a sequence of steps transitioning images from pixels to phrases, wherein a language model is essential for NLP presentation, necessitating the processing of both textual remarks and visual information.

With the exponential growth of internet data, including images from news, articles, blogs, advertising, diagrams, NFTs, and more, the demand for automated technology in image captioning has risen. Deep Learning (DL) approaches, such as CNN, Recurrent Neural Networks (RNN), and encoder-decoder models, have gained popularity due to their capability to manage image complexity and diversity effectively, providing human-like captions. These DL architectures leverage convolutional layers, recurrent layers, and attention mechanisms to capture image features and context, enabling end-to-end modeling of visual and textual information.

Feature extraction and language modeling are key components of DL, involving the transformation of raw data into reduced feature sets to capture underlying patterns. DL utilizes feature extraction in both Computer Vision and NLP to extract significant characteristics from images and texts, respectively. In image captioning, feature vectors acquired from trained networks using models based on LSTM are employed to predict caption sequences.

Despite various techniques available for caption generation, existing methods often perform well on large datasets but struggle with small to medium-sized datasets. To address this, a novel image captioning model called Next-LSTM is proposed, aiming to achieve consistent performance across datasets of different sizes and improve accuracy and BLEU score. Next-LSTM combines CNN for feature generation and a novel approach utilizing ResNet for feature extraction and LSTM for caption generation.

In summary, ResNet is a DL framework for picture classification, characterized by its modular architecture and multi-branch structure, which has demonstrated remarkable performance in image classification benchmarks. The main contributions of the proposed Next-LSTM model include its

effectiveness in image captioning, evaluation based on accuracy and BLEU score, and comparison with state-of-the-art models. The paper is organized into sections covering literature review, proposed methodology, experimental results, conclusions, and future work.

II. Related Works

Image captioning, a burgeoning field in Computer Vision, faces challenges in effectively extracting image features and ensuring generalizability across diverse datasets. This paper introduces Next-LSTM, utilizing ResNet101 for feature extraction and LSTM for caption generation, showcasing superior performance on the Flickr-8k dataset compared to existing approaches [1]. P.Mahalakshmi et al. focused on novel DL-based information retrieval and text summarization model, utilizing BiLSTM for retrieval and DBN for summarization and image captioning. Evaluation on Gigaword and DUC corpora shows superior performance, with DBN outperforming existing methods in precision, recall, F-score, and BLEU scores, with future work focusing on hyperparameter tuning for further enhancement [2]. Roberto Castro et al. undertook cross-entropy with Adam optimizer optimal. ResNeXt-101 excels in response quality, while MobileNetV3 offers compactness. Transformer-based DeiT-LSTM surpasses benchmarks, suggesting further exploration [3].

Tongwei Lu focused on Full-Memory Transformer method enhances image captioning by addressing token attention issues with a Full-LN symmetric structure for stable training and MAN for improved language decoding, yielding a substantial performance boost on MS COCO from 38.4 to 39.3 BLEU-4[4]. Munya A. Arasi et al. compared AIC-SSAIDL combines deep learning with Sparrow Search Algorithm for automated image captioning, achieving superior performance with maximum CIDEr scores of 46.12, 61.89, and 137.45 on Flickr8k, Flickr30k, and MSCOCO datasets, respectively [5]. Qi Wang et al. proposed LCM-Captioner introduces TextLighT for efficient multimodal feature learning and VTCAM for semantic alignment, achieving high performance and low resource consumption in text-based image captioning. Extensive experiments validate its effectiveness on the TextCaps dataset, with available code for further exploration [6]. Shuang Liu et al. reviewed on deep learning methods for image captioning, including CNN-RNN, CNN-CNN, and Reinforcement-based frameworks, highlighting key approaches, evaluation metrics, and challenges in generating descriptive captions from visual content [7].

NanXiang et al. introduces SCFM, a semantic enhanced cross-modal fusion model, improving unsupervised image captioning by addressing image-text mismatches and modality gaps through innovative components like TSE-Net, contrast learning, and EVSD [8]. Kyeong Pil Kang et al. incorporated novel image topic modeling approach utilizing image captioning and a scoring model to filter noisy data, enabling efficient analysis of large-scale image datasets for tasks like data visualization and image retrieval [9]. Rana Othman Alnashwan et al. focused on LSAHCNN-ICS, a novel image captioning system utilizing ShuffleNet as an encoder and HCNN as a decoder, optimized with Lighting Search Algorithm (LSA) for improve performance, achieving maximum CIDEr scores of 43.60, 59.54, and 135.14 on Flickr8k, Flickr30k, and MSCOCO datasets, respectively. [10]. Al-Malla et al. introduced an attention-based Encoder Decoder deep structure which utilizes CNN based convolution features extraction model named Xception [11].

Together, these studies showcase a diverse array of methodologies in image captioning, spanning from deep learning models and SVM optimization to feature extraction and holistic analysis, highlighting the evolving strategies for generating accurate and efficient captions for images, enhancing various applications across domains.

III. Methodology

The methodology described encompasses a comprehensive approach to image captioning, leveraging established deep learning techniques and custom data handling processes. It integrates a pre-trained Convolutional Neural Network (CNN), specifically ResNet101, for feature extraction from images, along with a Recurrent Neural Network (RNN) comprising LSTM layers for sequential data processing and caption generation. Data preprocessing pipelines are implemented to standardize images and clean and tokenize captions. A custom data generator optimizes training efficiency by handling large datasets in batches. Model training is conducted using the Adam optimizer and categorical cross-entropy loss function, with callbacks for model optimization and monitoring. Post-training, the model is employed to generate captions for test images, employing beam search or greedy search decoding strategies, and evaluating predictions alongside images for qualitative assessment. This methodology underscores a holistic approach to image captioning, ensuring scalability, efficiency, and performance in generating meaningful descriptions for visual content.

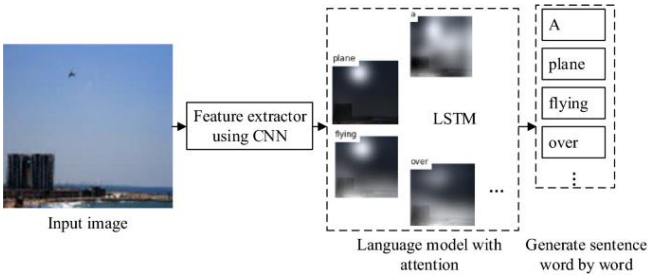
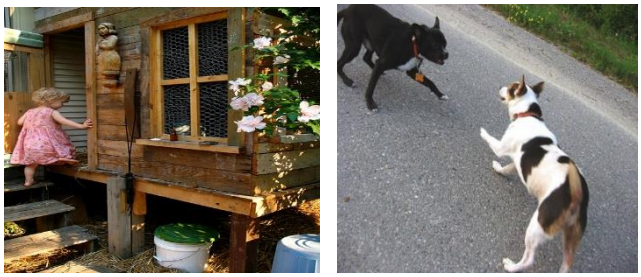


Fig 1: Block diagram of Image Captioning

A. Collection of Data

The Flicker 8k dataset [12], with its 8,000 meticulously curated images and corresponding sets of descriptive captions, is not only a cornerstone in computer vision but also a catalyst for innovation in the intersection of image analysis and natural language understanding. Its rich diversity of scenes and annotations provides fertile ground for exploring the nuances of visual and textual semantics, driving advancements in areas such as image captioning, visual storytelling, and multimodal AI systems. This dataset continues to inspire researchers and practitioners alike, fueling the quest for deeper understanding and more expressive communication between machines and humans.



(i) A child in a pink dress is climbing up a set of stairs in an entry way.
(ii) A black dog and a spotted dog are fighting

Fig 2 sample image from flicker 8k dataset

B. Image Pre-processing

Image preprocessing is a vital step in preparing images for analysis and model training. It involves several essential tasks to ensure that images are compatible with the model and conducive to accurate feature extraction. Firstly, images are loaded from file paths using TensorFlow's image processing module. They are converted to RGB format and resized to a standard size specified by a target size parameter. This standardization ensures uniformity in image dimensions across the dataset, which is crucial for consistent model performance.

Following image loading and resizing, images are converted into numerical arrays. This conversion transforms images into a format suitable for processing by machine learning models. Next, pixel values of the image arrays are normalized to a range between 0 and 1. Normalization helps stabilize and speed up the training process by ensuring that input values fall within a similar range.

Overall, image preprocessing ensures that images are appropriately formatted, standardized, and ready for feature extraction by the model. These preprocessing steps are essential for optimizing model performance and achieving accurate results in image captioning tasks.

C. Feature Extraction

ResNet101 is an advanced convolutional neural network (CNN) architecture that has significantly contributed to the field of computer vision. Developed by Microsoft Research, it is a part of the ResNet (Residual Network) family, which introduced the concept of residual learning to address the challenges associated with training very deep neural networks.

The core innovation of ResNet architectures, including ResNet101, lies in the residual blocks. In traditional deep CNNs, as the network depth increases, the accuracy often saturates and then degrades rapidly. This phenomenon, known as the degradation problem, occurs due to the difficulty of training deep networks and the vanishing gradient problem. ResNet101 tackles this issue by introducing residual connections or skip connections, which allow the network to learn residual functions with respect to the layer inputs, rather than directly fitting underlying mappings. This way, the network can focus on learning the residual (difference) between the input and output of a particular layer, making it easier to optimize and train very deep networks effectively.

ResNet101 feature extraction can significantly enhance its capabilities in capturing rich visual representations. By leveraging ResNet101's depth and advanced architecture, the model can extract more nuanced and informative features from images. This can lead to more robust and contextually relevant captions generated by the captioning model. Upon importing ResNet101 from TensorFlow, the code initializes the model with pre-trained weights obtained from the ImageNet dataset. Subsequently, the ResNet101 model is configured to exclude the fully connected layers and accept images with the specified input shape. This ensures that the model focuses solely on extracting features from the images without performing any classification.

During feature extraction, each image in the dataset is passed through ResNet101, and the output of the last convolutional layer is captured. These extracted features, which encapsulate high-level visual information, are then stored in a dictionary, associating each image filename with its corresponding feature vector. By integrating ResNet101 into the feature extraction pipeline, the code benefits from its ability to capture intricate visual patterns and semantic information. This enhances the descriptive power of the image captions generated by the subsequent captioning model, resulting in more accurate and contextually meaningful descriptions of the visual content.

In addition to image classification, ResNet101 has demonstrated exceptional performance in tasks like object detection and semantic segmentation. Its depth, combined with the effectiveness of residual connections, enables it to capture detailed spatial information and contextual relationships within images, leading to precise and robust predictions.

D. Long short-term memory (LSTM)

Long Short-Term Memory (LSTM) layers as part of a recurrent neural network (RNN) for processing sequential data, specifically for generating captions associated with images. These LSTM layers are crucial for capturing temporal dependencies in the sequential data, allowing the model to produce coherent and contextually relevant captions that describe the content of the images. Within the model architecture, LSTM layers work in conjunction with convolutional neural network (CNN) layers, such as ResNet101, which extract features from the images. This combination enables the model to leverage both visual information from the images and contextual information from the captions during the caption generation process.

E. Text Preprocessing

Text preprocessing in the code involves several key steps. Firstly, all captions are converted to lowercase to ensure uniformity. Non-alphabetic characters, such as punctuation, are removed to clean the text. Tokenization splits the captions into individual words for analysis. Special start and end tokens are added to denote the beginning and end of each caption sequence. These preprocessing steps standardize the textual data, making it suitable for training the model. By preparing the captions in this manner, the model can effectively learn the structure and context of the captions, facilitating accurate generation of descriptive captions for the associated images.

IV. Results and Discussion

A. Evaluation Metrics

In image captioning tasks, BLEU (Bilingual Evaluation Understudy) emerges as a prominent evaluation metric, comparing generated captions against reference captions. Scores range from 0.0 to 1.0, with higher scores signifying greater similarity between captions. BLEU employs N-grams to measure overlap between generated and original captions, allowing for nuanced assessment of caption quality. Implementation of BLEU scoring typically involves leveraging specialized libraries to calculate scores accurately .For meteor, evaluation metrics could include accuracy in predicting meteor shower timing and location, precision in identifying meteorite impact sites, and recall in detecting specific meteorological phenomena. In the case of rouge, evaluation metrics might involve color matching accuracy for makeup products, user satisfaction with color pigmentation and longevity, and precision in simulating different skin tones. These metrics would assess the performance and effectiveness of models or systems within their respective domains, ensuring accuracy, reliability, and user satisfaction in predicting meteorological events or simulating cosmetic outcomes.

B. Results and Comparison

In this proposal, we provide a unique ResNet and LSTM based method for automated picture captioning. The suggested model was constructed via merge model architecture. We used ResNet, a convolutional neural network, to compress an image's graphical elements into a compact representation. Following this, an LSTM language model was used to construct the descriptive phrase. We used a smaller dataset (Flickr8k) due to limited processing power in order to successfully complete what was outlined in the project proposal. Our model is capable of seeing an image and producing semantically accurate output in user-selected languages, based on the available terms in its dictionary, which is constructed based on the different words in existing captions contained in the training dataset. The purpose of the built model is to increase the chance of a phrase being produced based on a given image. We evaluated the model using Flickr8K's training photos and the results were positive. Table 2 presents performance metrics (METEOR, BLUE, ROUGE-1, ROUGE-2, ROUGE-L) for three ResNet models (ResNet50, ResNet101, ResNet152) in language-related tasks like machine translation and text summarization. ResNet101 generally outperforms ResNet50 and ResNet152 across most metrics, indicating its effectiveness in translation quality and summarization accuracy. It achieves the highest METEOR and BLUE scores, suggesting better translation output compared to the other models. ResNet152 excels particularly in ROUGE-2 and ROUGE-L, demonstrating strong performance in capturing bigram overlap and common subsequences in text summarization. The findings highlight the importance of model selection based on specific evaluation criteria. ResNet101 emerges as a favorable choice for tasks requiring high translation quality, while ResNet152 may be preferable for applications emphasizing precise summarization. These insights aid in optimizing model selection for language-related applications based on desired performance characteristics.

Table I: comparison of selected models with the proposed ResNet50, ResNet101, ResNet152 model

Model	METEOR	BLUE	ROUGE-1	ROUGE-2	ROUGE-L
Resnet50	0.2814	0.07227	0.2376	0.05945	0.2257
Resnet101	**0.2842**	**0.0736**	**0.2430**	**0.0600**	**0.2286**
ResNet152	0.2163	0.0339	0.2937	0.2759	0.2937

V. Conclusion and Future Work

In conclusion, the Next-LSTM model, which integrates CNN and ResNet101 architectures, demonstrates superior performance compared to InceptionV3, Xception, and ResNet50 in image captioning tasks. However, despite these advancements, image captioning models still encounter challenges such as contextual understanding, managing complexity, and mitigating biases. Addressing these

limitations is essential for guiding future research efforts in image captioning. Future work should focus on enhancing contextual understanding capabilities, developing more robust models to handle increasing complexity in visual data, and implementing measures to mitigate biases and ensure fairness in caption generation. By addressing these challenges, researchers can pave the way for more accurate, reliable, and inclusive image captioning systems.

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A Critical Review on Plant Diseseas Detection using Machine Learning and Deep Learning Techniques

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***Abstract*— In this paper authors reviewed the introduction to the various agriculture problems in the present scenario. In these authors also shows the methods of image processing techniques for the plant diseases. Authors focus on the methods of plant diseases detection using the machine learning and deep learning techniques. Finally authors compared the differences between machine learning and deep learning methods and their advantages and disadvantages.**

Keywords— Agriculture, Plant diseases detection, Artificial Intelligence, Machine Learning, Deep Learning Techniques

I. INTRODUCTION

In the recent years there is a huge advancement in the field of IoT, Artificial Intelligence, and Drone Technology which leads to the support the development in various broad areas. These three technologies are integrated together to afford the development in the field of agriculture mainly in the detection of the diseases which gives the accuracy data to the respective farmers. In the era of modern civilization there is always less interest is showing in agriculture due to the problems faced by the farmers daily. These leads to all the young generation people are change to the urbanization and shift to the modern cities and moving to the other employment. The main problem in the agriculture is the diseases protection which is caused mainly due to the change in the climatic conditions [1]. The real situation of present days are plant diseases are more occurred and also it can be transfer from any place to other place this may cause huge lost in the crops[2]. In the Table.1 Shows the different types of plant diseases based on segmentation techniques which are used for the machine learning and deep learning techniques.

In the current scenario there is possible to use the different types of deep learning techniques which is used to detect the plant diseases. Deep learning is used in many applications like pharmacy, bioinformatics, control systems, computer vision etc., which produce the state –of- art results. The main advantages of the deep learning techniques are it can use the raw data directly, and it produces the good results [3-4].

II. PLANT DISEASE DETECTION USING MACHINE LEARNING TECHNIQUES

Machine learning techniques are frequently used in the application of Agriculture sector like analyzing the soil fertility for the cultivating the crops and other research purposes [5]. In [6] authors explains the identifying the plant diseases using the machine learning techniques. This method is not fully identified the factors cause the diseases. In the Figure.1 shows the block diagram of the Plant diseases detection in the sequential steps.

Table.1. Plant Diseases Segmentation Techniques

Methods of Plant Diseases Segmentation methods	Advantages	Disadvantages
Threshold Method	• Proper Knowledge about image is not required. • Computation Time is very fast. • This method is easy to implement for real life problems.	• Threshold has to take correctly. • Results are bad in worst case scenario's • Clustering should be in same size.
Clustering Method	• It will work for all homogenous regions. • Speed is high • It will work for higher contrast image for all different regions.	• It will not work properly for worst case situations.
Edge detection Method	• This method also will work for higher contrast images.	• Edge detection method gives the bad results for edge images.
Regional Method	• This method as an advantage to choose between interactive and automated images. • This method also gives the more accuracy performance.	• This method as more computation time. • It will give the noisy results in fault segmentation

In [7] authors are proposed the different classification techniques which are used for the plant leaf diseases detection. Here authors are used the K-nearest neighbor machine learning algorithm to detect the diseases. The main drawback of this method is if the data is not separated then it very difficult to determine the suitable parameters.

In [8] shows the explanation about the steps involved to develop the algorithm to detect the diseases. Here authors are used the segmentation method. In the first step is involves the slow transformation is created to convert RGB into HSI. In the second step involves to the setting up as threshold value of the unwanted green pixels are removed. In the third step involves

the extraction of segments. Finally fourth step will do the segmentation process.

In [9] approaches the classification based on the machine learning algorithm. In this algorithm the authors used only feature set extraction method. And also authors used the neural network methods for automation of diseases detection.

In [10] authors proposed classifier algorithm for detection of diseases. In this used 500 plant leaves as a data base, This method gives the robustness. In [11] authors implemented the ANN classifier with image processing techniques. Here authors used the advanced filters for the feature extraction. The proposed method here gives the detection rate up to 91%.

In [12] proposed the K-Means algorithm for the specific diseases detection. Authors proposed the algorithm only for detection of malus domestica diseases. This method used in the different agriculture sectors.

In [13] shows the histogram method algorithm used to identification of plant diseases. The edge detection method and color feature is used for the detection of plant diseases. The edge detection method will be used the edge of the green images to analyze the different types and histogram method will segregate the types.

In [14] used the triangular threshold method for the detection. The advantage of this method is works fast and gives the accurate. This method also finds the how much effect the diseases in the leaf and its area calculation. This is done by the threshold segmentation method.

In [15] used the image processing techniques for the leaf diseases detection. The proposed method is done by the comparing the different types of images effects like HSI, CIE LAB and ycber. The Ostu method is used for the calculation of the threshold. This threshold which is used for the detection of disease. The model CIELAB color is used to remove the noise. The advantages and disadvantages of the Image processing Techniques for the plant diseases is reviewed in [16].

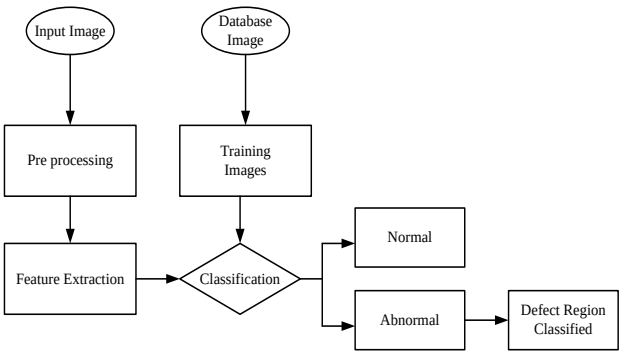

Fig.1. Sequential Steps for Crop Detection using Machine Learning Techniques

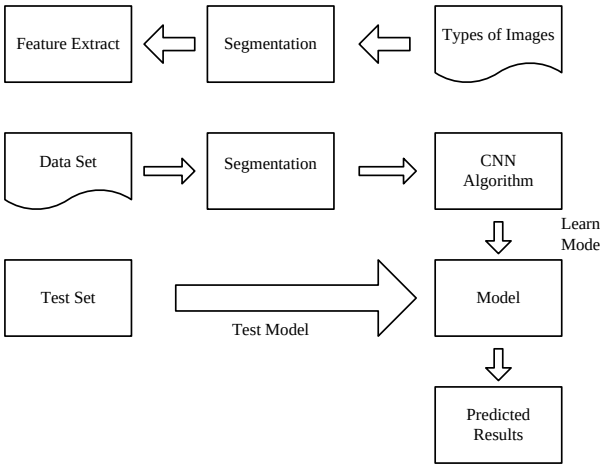

Fig.2. System architecture for plant leaf disease detection

III. ARTIFICIAL INTELLIGENCE AND DEEP LEARNING BASED PLANT DISEASE

In [17] experiences the optimal subset function method for the analysis of the plant features at stage by stage. The vector machine deep learning is also used for the classification of the plants. Finally it concluded that total accuracy rate is in between 89.6 %. In [18] idea on the implementation of fuzzy sets for the calculation of the degree for the images. In this approach the fluidity can occur the brightness is calculated. So in this authors detected the diseases of the plants.

In [19] introduced the deep learning technique called neural network algorithm for the forecast the yield in the certain place. In [20] authors evaluated the analysis of the production, water usage, and net crop rate and also various parameters to the better improvement of the crop. In [21] also authors analysis the certain parameters as a professional knowledge like tracking surveillance, detection, prevention of pesticides, various selection of fertilizers depends on the situation etc, for the crops like rice, coca, coffee using deep learning techniques.

In [22] introduced the automatic device which is using by the deep learning techniques to analysis the pictures of rice crops and gives the necessary instructions and advice to the farmers time to time. In [23] implemented various machine learning and deep learning techniques to analyze the soil fertility and gives the data to the farmers depending on the analysis farmers can take the decision like what type of crops to the cultivated.

In [24] KNN algorithm is implemented in the china for the analysis of climatic data. Here KNN used the ETO data to analyze the climatic conditions. In [25] authors used neural network technique for the analysis of the data. But here to get improve the neural network than usual the most advanced activation functions like DharnaSig, Dharna Sigm and and also SHBsig. This leads to the improvement of the efficiency and accuracy of the networks [26]. In [27] presents the deep learning method is to analyze the data in the field of computer vision which is used for various applications especially in the agriculture.

IV. Convolution Neural Network (CNN)

The Convolution Neural Network method has advantage of the images analyses with in the given own perceptive. This process leads to the main use of the CNN and over comes the disadvantages of normal neural network. The general structure of the CNN is also having the group of channels to initiate the classification of the images.

In [28] authors proposed the novel deep learning model using the inception layer and residual connection. The method is based on the convolution neural network method. The method has a depth wise separable convolution which reduces the number of parameters. This method is tested for the different types of plant data sets. The advantage of this method is to takes the less time for the training of the data sets. Finally the accuracy of this method is around 99.39%.

In [29] implemented the 14-layered Deep Convolution Neural Network (14-DCNN) to detect the diseases in the various plants. In this data argumentation method is used to balance the individual class sizes of the plant data sets. The accuracy of this method is 99.7968 % which is better than the other exiting methods.

The deep convolution neural network model has been implemented for the detection of plant diseases. This method is based on Faster- R CNN with addition of the Res Net-50 (Faster R-CNN+ResNet-50). The proposed method involves the real time photos. The learning rate of this method is around 0.1 and accuracy is achieved 93.5 % [30]. In [31] authors designed the hybrid model CNN network for the identification of the plant. This hybrid model as applied to detect the bacterial spot in the plants. In this proposed method as the accuracy of the training data is 99.35% and testing accuracy is 98.38%. This method has significantly decreases the time of training model and also this model takes less time of the detection of diseases in plants.

V. Comparative review on machine and deep learning techniques

In the Image processing the feature extraction tool is used to extract the information from the images. The information will be like colour, texture and shape of the images etc. This information will be useful for the detection of the diseases in plants. The algorithm is works in such way that set of features is to be provided to the classifier. Then the classifier will identify the healthy and non-healthy, which leads to detect the diseases. These same processes are applied to the machine learning, deep learning and convolutional neural network methods. The convolutional neural network is applied to solve with using the image data. Deep learning Techniques and CNN will gives the better accuracy and performance when compared to the machine learning algorithms. But the machine learning algorithm can be used for the wide variety of applications.

VI. Conclusion

In this study authors reviewed the various methods of machine learning, deep learning techniques for the plant diseases. Here authors discussed the various algorithm methods which is applied in the deep learning and machine learning techniques. Authors also discussed methods of methods of automation for plant diseases using advanced techniques. Finally authors reviewed the performance of the various methods involves in the machine learning, deep learning and CNN methods.

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Customer Churn Prediction and Segmentation using Machine Learning

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Abstract— **When consumers go to a rival and cease utilizing a company's goods or services, this is known as customer churn. It is a problem for businesses because it can reduce sales, damage a brand's reputation, and impede long-term expansion. Numerous things, such unsatisfactory products, bad customer service, price problems, or low engagement, can result in a loss of clients. The project aims to lower customer attrition by using machine learning algorithms to create a prediction model that identifies customers who are likely to leave. The project's activities including collecting and combining customer data from various sources to ensure proper formatting, determining probable churn drivers via exploratory data analysis, developing. A machine learning predictive model algorithms, and designing an interface that telecom business users can use to interact with the churn prediction results. Customer data with variables including purchase history, engagement metrics, and support interactions make up the project's input. The prediction model is trained using these data. A forecasting system that can precisely identify clients who are most likely to depart is the project's output, giving businesses insight into the reasons why they could go and empowering them to take preventative measures to keep their customers. Additionally, customer segmentation is done to gain insights about different customer segments. These insights serve as the base for generating retention strategies for companies.**

Keywords— customer churn, prediction model, machine learning, random forest

I. INTRODUCTION

In the modern world, telecom businesses are producing enormous volumes of data at a very quick speed. Numerous telecom service providers are in competition with one another to gain market share. Consumers can choose from a variety of options, including more affordable and superior services. Maximizing profits and surviving in a cutthroat market are telecom companies' ultimate goals. When a sizable percentage of clients express dissatisfaction with the services provided by any telecom business, this is recognized as customer churn. Customers begin to migrate their services to other service providers as a result.

The churn analysis's objective is to determine the proportion of customers who will quit using a certain good or service. Additionally, these opportunities will be extracted using data mining-based work known as the rate of client attrition analysis. Owing to the fierce rivalry of today, numerous companies are providing nearly identical products at comparable prices, both regarding services and quality. By giving each client a probability, the churn analysis makes it feasible to accurately anticipate which consumers will discontinue utilizing services or products. Depending on the degree of loss (in monetary terms) and client groups, this analysis can be carried out. These assessments can be applied to improve customer communication, which will increase the loyalty of customers and persuade them. The churn rate, also known as customer attrition, is applicable while creating marketing campaigns. that are useful for the target audience. Profitability can be raised dramatically in this fashion, or potential harm from losing clients may be decreased at a similar rate.

The model's solution employs a predictive algorithm to pinpoint customers that are likely to defect. To ascertain the variables that can be utilized to forecast churning, the system does exploratory data analysis. After pre-processing, it is trained using the customer data that is currently accessible. Random forests and decision trees, are utilized when building the prediction model. To obtain even better and more effective outcomes, principal component analysis and k-means are utilized to segment the customer into different clusters. Consequently, businesses can use the system to identify at-risk clients and take appropriate action.

II. LITERATURE REVIEW

This section provides an overview of relevant prior work in customer churn analysis.

Abhishek Gaur, et al. [1] published in 2018 as an IEEE conference paper, it highlights data mining's crucial role in telecom churn analysis. They emphasize cost-sensitive classification's importance, proposing a partition cost-sensitive CART model. Among the tested methods, gradient boosting yields the maximum precision at 84.57% AUC.

Irfan Ullah, et al. [2] explores methodologies for telecom churn prediction, focusing on machine learning on large-scale data platforms. They stress feature engineering's importance and big data platforms' function in gleaning analysis of social network characteristics from enormous

datasets. Their methodology for predicting churn, evaluated using fresh data, proves effective and is successfully deployed, integrating analysis of social networks and machine learning to bolster telecom customer retention strategies.

Nurul Izzati Mohammed, et al. [3] delves into forecasting customer churn in telecom, talking about ensemble methods, logistic regression, SVM, and decision trees. Their methodology involves data preprocessing, algorithm implementation, and classifier evaluation to optimize prediction. The study aims to refine churn analysis, prioritize client retention and develop effective prediction models, utilizing a variety of techniques for machine learning enhanced understanding of churn factors.

Nurul Izzati Mohammed, et al. [4] examines methods of machine learning for telecom churn prediction, finding K-means unsuitable for their dataset. They advocate decision trees, achieving 94.98% accuracy and 80.80% F1 score in their tests. Their recommendation carries significance for telecom firms aiming to increase income and client retention.

Anna Sniegula, et al. [5] concentrates on a random forest utilizing a model for churn prediction call detail records. They employ feature selection techniques and compare Random Forest's performance with other algorithms, demonstrating its superiority. Additionally, they conduct customer profiling and identify churning factors, offering valuable insights for telecom firms aiming to enhance retention strategies.

Xin Hu, et al. [6] suggests a model for hybrid churn prediction mixing neural networks (BP) and decision trees (C5.0) algorithms. Weighted by model confidence, their approach achieves high churn prediction accuracy. Empirical validation using supermarket data reinforces the efficacy of the strategy in anticipating consumer attrition.

Pushkar Bhuse, et al. [7] compares Random Forest, SVMs, XGBoost, and deep neural networks, and investigates the application of machine learning and deep learning to the prediction of telecom churn. They use Random Forest pre-grid search to improve models with grid search, attaining 90.96% accuracy. The study underscores the efficacy of these techniques, especially highlighting Random Forest's promise for telecom sector applications.

Praveen Lalwani, et al. [8] presents a thorough analysis of the studies conducted on predicting customer attrition via machine learning. Their methodology involves EDA, various models like logistic regression and ensemble techniques like Adaboost and XGBoost. With feature selection using GSA, their proposed model achieves an AUC score of 84%, underscoring the significance of preprocessing and model evaluation for accurate churn prediction.

Soumi De, et al. [9] introduces SS-IL, a stack structure for prediction of churn based on sampling. Utilizing a dataset from a hotel commerce platform, it employs decision trees in group learning and logistic regression as base learners and Random Forest as a meta learner. Through various sampling strategies, SS-IL enhances precision and F1-score, demonstrating improved performance in churn analysis for imbalanced datasets.

B. Prabadevi, et al. [10] explores churn prediction methodologies, emphasizing deep neural networks (DNN) and convolutional neural networks (CNN) for diverse industries. Their proposed approaches enhance prediction accuracy, with CNN achieving precision rates up to 89%. The findings underscore the efficacy of sophisticated machine learning to support customer retention and reduce costs for organizations.

III. Proposed Method

Keeping existing customers in telecom industry is frequently just as important as gaining new ones, churn is a serious problem. It is critical for telecom businesses to comprehend and anticipate customer turnover to ensure profitability and sustainability in a market marked by intense competition and changing consumer preferences. This section gives briefs about the steps adopted in analyzing, predicting customer churn, and segmenting the customers using machine learning. Fig. 1. Depicts the architecture of the adopted method including the steps: Data Cleaning which is followed by Exploratory Data Analysis which includes univariate and bivariate analysis, Model building, and Customer Segmentation.

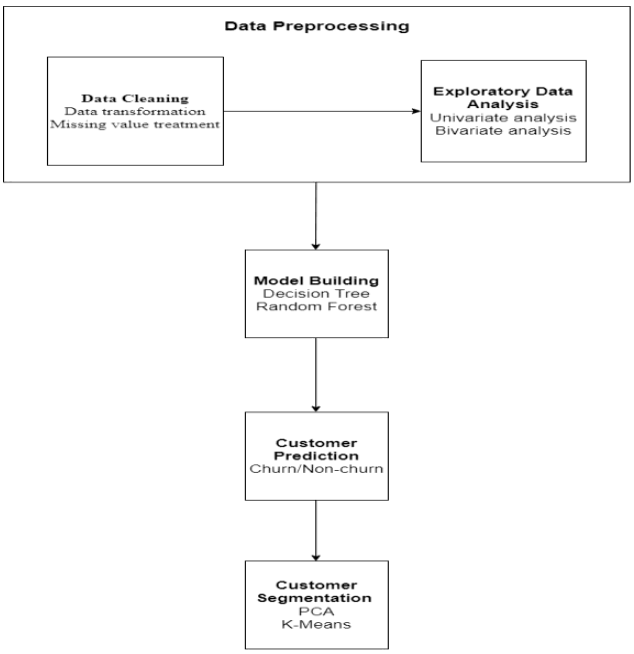

Fig. 1. Proposed Method Architecture

The dataset of a telecommunication company is used for the predictive random forest model. It is specific to telecom industry and consists of 7043 customer records and 21 attributes such as 'customerID', 'gender', 'SeniorCitizen', 'Partner' and 'Dependents'.

A. Data cleaning

Data cleaning elevates the quality of data. Following steps are performed in data cleaning.

1. Creation of a copy of base data for manipulation and processing.
2. Conversion of categorical data into a simpler numerical data type.
3. We observe that there are 11 missing values in the TotalCharges column.
4. Missing Value Treatment is performed. Given that these entries make up a relatively small percentage of 0.15% of the entire dataset, it is safe to ignore them from further processing.

B. Exploratory Data Analysis

A strategy for evaluating datasets to highlight their key features is called exploratory data analysis (EDA), and it frequently makes use of visual aids. Understanding the underlying structure and patterns in the data, finding correlations between variables, and identifying outliers and anomalies are the main objectives of exploratory data analysis (EDA). The following observations are generated using EDA:

- Count of target variables per category reveals that the dataset of telecom is imbalanced. The ratio of churners to non-churners is revealed to be 26.536987:73.463013.

- Univariate Analysis is done which focuses solely on examining one variable at a time, without considering the relationships or interactions with other variables. The relationship between monthly charge and total charge and churn by monthly charge and total Charge reveals that the churn is high when monthly charges are high and higher churn at lower total charges. Thus univariate analysis helps us in understanding the relationship between the attributes. Insights generated include:
    1. High churn seen in Month-to-month contracts, No online security, No Tech support, First year of subscription, and Fibre Optics Internet.
    2. Low churn is seen in Long-term contracts, Subscriptions without internet service and, customers engaged for 5+ years.
    3. Factors like Gender and Availability of PhoneService have almost no impact on Churn

- Bivariate Analysis is done whose primary aim is to understand how changes in one variable are related to changes in another variable. Important insights generated from EDA are:
    1. Electronic check medium has the highest churners
    2. Customers with Contract Type - Monthly likely to stop using the service and churn because of no contract terms, as they are free-to-go customers.
    3. No Online security, no Tech Support category are high churners.
    4. Non-senior Citizens are high churners.

Fig. 2. Depicts the heatmap representing the influence of the attributes on churn.

Fig. 2. Heatmap representing the impact of the attributes on churn

C. Model Building

The dataset of telecom is then split into two parts: the feature variables (X), containing independent features except for target feature, and target variable (Y), representing the variable to be predicted (in this case, 'Churn'). Further, the data is divided into a training set used to train the classifier and a testing set used to test the classifier using the train_test_split function from the scikit-learn library.

- Decision Tree Model Building:
  The decision tree algorithm divides the training data into segments to minimize impurity or maximize information gain recursively. This process is done to train the model. Based on the testing data, predictions are created. Every data point is traversed to reach a leaf node, and the majority class in that node is assigned as the predicted class.

- Random Forest Model Building:
  The random forest algorithm is implemented by defining a Random Forest class. The training dataset is used to build the random forest model. One hundred decision trees are trained using replacement (random selections of the dataset) and their predictions are combined to get the final prediction. The random forest ensemble separately predicts the class based on the testing data by examining

each decision tree and using a majority vote mechanism to arrive at a final prediction.

- Handling Class Imbalance with SMOTE-ENN:
  To deal with the issue of class imbalance in the dataset and improve the accuracy, the Synthetic Minority Over-sampling Technique followed by Edited Nearest Neighbors (SMOTE-ENN) resampling technique is employed. SMOTE is used generate synthetic customer details for the minority non-churners class by interpolating between existing minority class samples, while ENN removes noisy and borderline data from both the classes using k-nearest neighbors. The resampled data is then split into training and testing datasets, and the decision tree and random forest modeling process is repeated using this balanced dataset.

D. Customer Segmentation

K-means clustering, an unsupervised machine learning approach, is utilized for client segmentation. It divides the clientele of telecommunications companies into discrete groups according to their traits and behaviors. In order to effectively visualize the data, the code preprocesses it by scaling it using StandardScaler and reducing its dimension using Principal Component Analysis (PCA).

The elbow method is a visual method used to figure out the number of clusters (k) the k-means clustering algorithm should have. Decision Trees algorithm and random forests, which don't require grouping data points, aren't immediately affected by it. The ideal number of clusters is determined using the Elbow Method which is revealed to be 4. Fig. 3. depicts the elbow method graph.

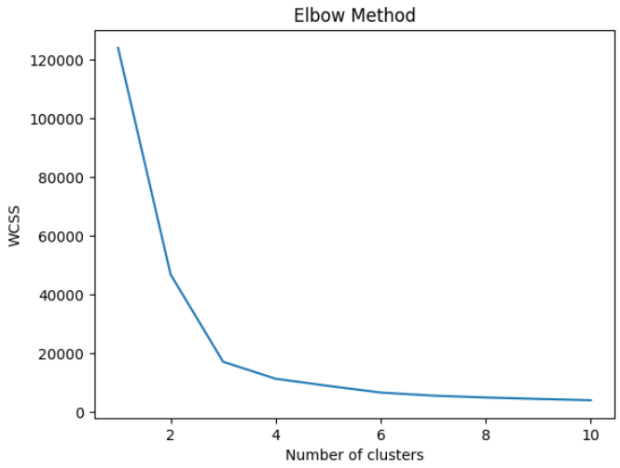

Fig. 3. Elbow method revels the optimal number of cluster to be 4

A key algorithm for clustering data is k-means. The objective is to divide an unlabelled data set into a certain number of groups, or clusters so that the data points in each cluster have comparable properties. k-means clustering is applied to partition the data into four clusters. Each cluster's average values are computed to extract insights into the typical behavior of customers within that segment. Fig. 4. depicts the four clusters by considering the top two principal components.

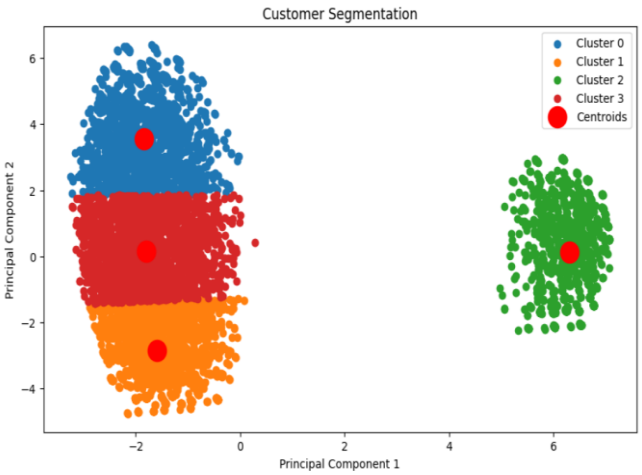

Fig. 4. Visualization of the k customer segments wherein the red dots represent the centroids.

IV. RESULTS

With an astounding 94% accuracy rate, Random Forest is a reliable algorithm for predicting client attrition. The decision tree's performance is shown in Fig. 5 across many criteria. Following the application of SMOTEEN, the decision tree's accuracy is 93%. Similarly, Fig. 6. displays the performance of random forest across different metrics The ensemble nature and ability to handle large datasets make Random Forest a reliable choice for such tasks. Customer segmentation plays a vital role by identifying distinct customer groups, allowing tailored marketing strategies, improved customer retention, and better overall business insights.

	precision	recall	f1-score	support
0	0.97	0.88	0.93	540
1	0.91	0.98	0.94	634
accuracy			0.93	1174
macro avg	0.94	0.93	0.93	1174
weighted avg	0.94	0.93	0.93	1174

Fig.5. Performance of decision tree measured across different parameters.

	precision	recall	f1-score	support
0	0.96	0.90	0.93	523
1	0.92	0.96	0.94	628
accuracy			0.94	1151
macro avg	0.94	0.93	0.93	1151
weighted avg	0.94	0.94	0.94	1151

Fig.6. Performance of random forest measured across different parameters.ss

V. Conclusion

In conclusion, this project highlights the effectiveness of machine learning in predicting churn and segmenting customers in the telecom industry. By employing a decision tree algorithm and random forests, we've developed accurate models to identify at-risk customers and inform retention strategies. Random forest, particularly, excels in handling complex datasets and mitigating overfitting, making it a valuable tool for determining churn rate. These insights provide telecom companies with actionable strategies to improve customer retention and drive long-term business success in a competitive market.

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Soccer Video Captioning using LSTM

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Abstract—***With the growth of soccer video content on various platforms, there is an increasing demand for automated video captioning systems that can accurately describe the content in real-time. Traditional video captioning techniques often struggle with capturing the dynamic and fast-paced nature of soccer games, making it a challenging domain for automated captioning. Deep learning, particularly Long Short-Term Memory (LSTM) networks, has shown promise in handling sequential data, making it a suitable candidate for this task.***

The primary objective of this project is to develop an LSTM-based deep learning model capable of generating descriptive captions for soccer videos. The model aims to understand the temporal dynamics of soccer gameplay to understand when the game is fast-paced or slow and describe it accordingly, player movements such as a run or a goalkeeper's save and significant events like goals or red cards, translating them into coherent and informative captions, which can be utilized by fans who feel the need to understand the game better. With our dense captioning model, fans of different range groups can sit together and enjoy the game.

Overall, this project contributes to ongoing research efforts to develop accurate and efficient models for soccer video captions. The LSTM-based model demonstrated remarkable proficiency in generating accurate and contextually relevant captions for a diverse range of soccer video clips. The model's ability to capture the sequences and events within soccer games surpassed traditional methods, highlighting the efficacy of deep learning approaches in video captioning tasks. The information obtained from this project have vast application scope in sports broadcasting, sports analysis, and sports-related videos.

I. INTRODUCTION

In an era marked by the convergence of technology and entertainment, sports occupy a prominent place, transcending borders and languages to unite fans worldwide. However, while the excitement of sports is universal, the ability to fully engage with and understand the intricacies of sporting events can be limited by various factors. Language barriers, hearing impairments, and the need for accessibility present challenges that hinder the complete enjoyment of sports content.

This project aims to use the power of advanced technologies, particularly deep learning and machine learning, to bridge the gap between sports content and diverse audiences. Our goal is to develop a cutting-edge system capable of automatically generating real-time, accurate, and contextually relevant captions for soccer videos, catering to the needs of a wide-ranging audience.

The fusion of sports and technology has given rise to a new era in sports entertainment. Live broadcasts, streaming platforms, and social media have transformed the way we consume sports content, opening up various opportunities for engagement. However, these opportunities come with the challenge of making this content accessible and enjoyable for everyone, regardless of language proficiency or hearing abilities.

This model can also be used for game analysis and strategy planning, player's performance analysis along with providing immersed experience to the viewers including the hearing impaired making it a good application for the entertainment industry. This model can be used for the detailed understanding of the game for those who do not have time or the possibility to watch the game. This model, called Dense Soccer Video Captioning (DVC), represents a significant research challenge due to the memory footprint of video data and the complexity of natural language and most of the research papers we have referred to focuses on generic descriptions of events and activities in open-world scenes. But inclusion of emotions and sentiment is necessary to engage fans with an expressive sport like soccer. Using the introduction of the new work of Single-anchored Dense Video Captioning (SDVC), consisting in generating fine-grained captions describing the soccer game. Here, we have a two-stage approach including an action spotting module and a captioning module. More specifically, the spotting module produces temporal proposals for the captions. Then, the videos are trimmed around the proposals and passed to the captioning module to generate captions.

The project is not just about providing subtitles for sports videos. It's about creating an immersive experience that transcends linguistic and accessibility boundaries. Whether you're a passionate fan following your favorite team's international games, someone with a hearing impairment who deserves equal access to sports content, or a viewer who simply prefers captions for clarity, this project is dedicated to enhancing your soccer watching experience.

This project is formed by the idea that technology can enhance the accessibility, inclusivity, and enjoyment of soccer for all. By the end of this project, our vision is to deliver a state-of-the-art sports video captioning system that not only generates accurate captions but also enriches the sports-watching

experience, allowing fans to connect with their favorite games in entirely new ways.

II. LITRETURE REVIEW

In the domain of dense video captioning, several innovative approaches have emerged to enhance the descriptive quality and temporal coherence of generated captions. An-An Liu et al.[1] proposed a Fine-Grained Spatial-Temporal Attention Model (FSTA), emphasizing attention mechanisms to spotlight semantic regions of interest in videos. Although effective, the model's heavy reliance on templates can limit the diversity of generated descriptions, affecting their syntactic variation[2]. In contrast, Jonghwan Mun et al.[3] introduced a Streamlined Dense Video Captioning framework, incorporating event sequence detection and reinforcement learning to improve caption coherence and quality. Despite its success on the ActivityNet Captions dataset, scalability remains a concern, potentially hindering real-world applicability [1].

Mengshi Qi et al. proposed a hierarchical recurrent neural network with attention for sports video captioning, emphasizing motion representation and group relationship modeling. However, the model's tendency to produce coarse descriptions overlooks finer motion details, impacting the appropriateness of generated captions [2].On the other hand, E G Özer et al. explored a sequence-to-sequence model for video captioning, leveraging pre-trained CNN architectures like VGG-16 and VGG-19. While achieving promising results on the MSVD dataset, the limited evaluation on a single dataset raises concerns about the model's generalizability across diverse video content [4].

Valter Estevama et al. introduced a method using unsupervised semantic information for dense video captioning, employing a temporal event proposal module and a transformer-based caption generator. However, dependency on mini-batch k-means may restrict the method's scalability and performance compared to deep clustering methods [5].Conversely, Teng Wang et al. proposed an end-to-end dense video captioning approach with parallel decoding, combining pre-trained video features with transformer-based captioning. Despite its effectiveness, segmenting videos into event pieces raises concerns about capturing subtle temporal relationships [6].

Recent advancements, like the work by A.Yang et al. on Vid2Seq, leverage large-scale pretraining of visual language models for dense video captioning. By reformulating sentence boundaries as pseudo event boundaries, the model demonstrates promising results in generating event-centric captions. However, this strategy may introduce inaccuracies in capturing true temporal dynamics and semantic nuances, impacting caption precision and coherence [9]. These diverse approaches contribute to the evolving landscape of dense video captioning, each offering unique insights and addressing specific challenges in the field.

III. PROBLEM DEFINITION AND SYSTEM OVERVIEW

A. Problem Definition

“To design and develop a real-time soccer video captioning system that can automatically generate accurate and contextually relevant captions for recorded soccer events”.

The model takes as input the SoccerNet-Caption dataset, which consists of untrimmed broadcast game videos along with their timestamps. Through its processing, the model generates a new dataset enriched with text-based commentaries precisely synchronized with specific timestamps extracted from soccer game videos. This output dataset provides viewers with a detailed and chronological description of the match's unfolding events, capturing the essence of the game as it progresses.

The proposed solution centers on the development of a Single-Anchored Dense Video Captioning (SDVC) model specifically tailored for soccer videos. This model aims to generate rich and detailed captions for soccer footage by densely annotating the video content with textual commentary. It operates through a two-stage process, comprised of a spotting model and a captioning model, which are seamlessly integrated to create a cohesive framework. In the spotting stage, the model identifies key moments or events in the video, while the captioning stage generates descriptive text corresponding to these identified moments. By combining these stages, the SDVC model facilitates the creation of comprehensive and engaging textual narratives that accompany soccer videos, enhancing the viewer's understanding and enjoyment of the game.

B. Single-anchored Dense Video Captioning

Task..Select a video, identify all moments when commentary should be localized around of this time and then generate sentence for each scene using a coherent natural language. In our case, temporal boundaries may be used. As we generate commentaries for soccer games, it is especially hard because sentences should describe a smooth combination of activities rather than several well-separated activities of a person or a group of people. A formal metric should consider not only the temporal offset of the label but also content quality. Unlike action spotting , we cannot determine which moment to choose downsampling event occurrences from a fully defined domain, rather than from a pool of unlabeled moments.
There must be some tolerance around the ground-truth action spot. The commentary quality assessment is not trivial as the expressions are semantically more closed than standard open vocabulary. Thus, deliberate variation in words choice has to be carefully assessed when describing the game. Regarding the literature, a few of metrics have been presented for DVC methods evaluation. The SODA metric is the assessment of the video narrative. It finds the temporally optimal matching between generated and reference captions. Another approach, proposed by Hammoudeh , focuses on the precision and recall of generated words. It shares some expressions, defined beforehand, and matches with the ground truth. This work is valuable in terms of semantic correctness of captions, but highly depends on the chosen words dictionary.
Second, EMScore is a Video- to-Text consistency metric that leverages an Embedding Matching-based score informed by similarities in the embedding space. The EMScore metric relies on the VLP model performance used, in this case a vision-language pre-trained model, which has not yet been trained on sports videos. We use the action spotting mAP@δ to measure how well the video spotting algorithm worked on the generated sentences footage. For the SDVC data, we start by searching for the Video Decomposition Counting metric based on the one proposed in the ActivityNet-captions dataset and come up with: heat map the space-time volume for the video of the duration on the caption time window.

We then assess the quality of our generated captions using well-known evaluation metrics such as METEOR, BLEU, ROUGE, and CIDEr. These metrics help us measure how similar the language in our generated captions is to any ground-truth captions within a certain tolerance window (denoted by δ). We calculate these metrics for each generated caption compared to all relevant ground-truth captions within the specified time window, and then average the results across the entire video and dataset. We refer to these modified metrics as METEOR@δ, BLEU@δ, ROUGE@δ, and CIDEr@δ.

Additionally, we introduce a second metric by adapting the SODA metric. This adaptation involves considering a time window around both the ground-truth and generated captions, allowing for a more nuanced evaluation of temporal alignment between the generated and reference captions.

C. System Overview

Inspired by the literature on dense video captioning, we suggest a two-stage approach functioning as an initial baseline model for our SDVC assignment. Ultimately, the model, including a spotting model and a captioning model, is cascaded. Both sub-models are separately trained and equally composed of a trapped feature encoder, E, connected to an aggregator module, A. Eventually, either a spotting head, S, or a captioning head, C, is resonantly added .

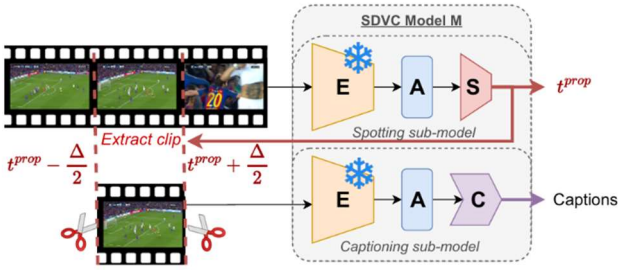

Fig 1. the Pipeline of our Single-anchored Dense Video Captioning baseline model.

The feature encoder accelerates a condensed per-frame feature reflection of the video time frame, and the presented clip rendition is centered or temporally pooled by the aggregator. Finally, the spotlight clip image is added to the labeler or the captioning head to generate either a remark or a riposte.For a video, in inference, the spotting model will generate the temporal proposals, which we denote as

$$\{t_0^{prop}, ..., t_N^{prop}\} = \mathbf{S}(\mathbf{A}(\mathbf{E}(\text{video})))$$

N is the total number of proposals. Then, the original video is trim around each proposal t prop n into a clip and passed to the captioning model to generate the caption as defined in Equation :

$$caption_n = \mathbf{C}(\mathbf{A}(\mathbf{E}(\text{video}[t_n^{prop} - \frac{\Delta}{2}, t_n^{prop} + \frac{\Delta}{2}])))$$

Here Δ is the window size of the captioning model. The architecture of our baseline model is shown in Figure .Feature encoder E: we use the feature encoders provided in SoccerNet-v2 which is ResNet-152 , I3D , C3D , Baidu .

For each video clip, the features are extracted at 1 or 2 fps from the original soccer broadcast videos in the form of a heat map. To train visual representations, we reduce the dimensionality of our features to 512 for each image using PCA for the first three encoders, and a linear layer for the Baidu features .

Aggregator A : Frame representations are aggregated into a single compact one. We adopt the four-pooling layers used by Giancola et al. . However, our version consists of a NetVLAD, NetRVLAD and the temporal-aware versions NetVLAD++ and NetRVLAD++. Spotting head S : To detect the audio event's presence in each clip, we employ a d-put sigmoid activated dense layer over feature dimensionality factors – this produces a segment tensor with '2' as the classification output. During training, binary cross-entropy loss is applied, and during inference, we use Non-Maximum Suppression to reduce redundant spots.

The captioning head consists of fully connected layers, ReLU activation, dropout, and a vanilla LSTM module. The LSTM outputs word confidence scores, and during training, we use cross-entropy loss. We also employ teacher forcing to stabilize learning. As soccer vocabulary is specific, we don't use pre-trained word embeddings but learn the language during training. During inference, we select words greedily based on confidence scores.

IV. EXPERIMENTS

A. Experiment Settings

The experimental settings in this paper involves organizing textual annotations into individual JSON files for each game, containing metadata such as starting lineups, player tactics, and contextual labels for annotated comments. The model architecture included LSTM layers for sequence modeling, with ablation studies conducted on the number of stacked LSTM layers and the teacher-forcing ratio. Experiments on the impact of video encoding, window size on the captioning model, and the use of a video encoder for the spotting task were performed using the SoccerNet-Caption dataset. This dataset, comprising 500 untrimmed broadcast games from the top five European leagues and the Champions League between 2014 and 2018 which provides a substantial corpus for analysis. Extensive metadata, covering player details, referee names, team information, player events, and tactical data, greatly enhances the dataset's usefulness for captioning model training and evaluation.

B. Evaluation Metrics

The experiment involves training baseline models on the SoccerNet-Caption dataset to establish how well these models perform in generating captions for soccer broadcasts. These baseline models serve as a reference point for comparing the performance of more advanced models later in the experiment.

To assess the quality of the generated captions, they are compared against ground truth commentaries using three widely-used metrics: BLEU, METEOR, and CIDEr. BLEU measures the overlap between the generated and reference captions in terms of n-gram precision. METEOR evaluates the semantic similarity between the generated and reference captions using various linguistic features. CIDEr assesses the consensus between the generated and reference captions based on cosine similarity.

Encoder	Decoder	Spotting (mAP@60)	Captioning (B@4)	Captioning (METEOR)	Captioning (ROUGE-L)	Captioning (CIDEr)
Baidu	NetVLAD	40.75	5.72	36.23	35.1	15.7
Baidu	NetVLAD++	41.8	5.42	32.2	34.17	17
Baidu	NetRVLAD	38.7	5.52	35.23	33.2	15.4
Baidu	NetRVLAD++	41.2	5.7	35.5	33.3	16

Table 1:Evaluation metric

V. RESULTS AND DISCUSSIONS

In our study on Single-anchored Dense Video Captioning (SDVC), we examined the performance of both the spotting model and captioning module separately before evaluating the complete pipeline.

For commentary spotting, we found that using the Baidu feature encoder with NetVLAD or NetVLAD++ pooling produced the best results, indicating the benefits of fine-tuning on soccer data. On the other hand, captioning achieved optimal performance with the same encoder and pooling combination, requiring a larger window size of 45 seconds for contextual information.

Further experiments showed that employing 4 LSTM layers and a balanced teacher forcing ratio led to the best captioning performance.

Finally, we evaluate the overall performance of our SDVC pipeline by combining the spotting and captioning models. Table 3 presents the results using the METEOR@δ, BLEU@δ, ROUGE@δ, CIDEr@δ, and SODA c metrics, which take into account both the temporal localization and caption quality.

Metric	Score
METEOR@30	27.94
BLEU@30	21.07
ROUGE@30	22.06
CIDEr@30	27.02
SODA c	7.72

Table 2: Soccer Dense Video Captioning performance on the SoccerNet-Caption dataset.

These results demonstrate the challenging nature of the SDVC task and highlight the need for further improvements, particularly in terms of temporal localization and capturing the rich semantics of soccer commentaries.

VI. CONCLUSION

This paper introduces Single-anchored Dense Video Captioning (SDVC), a novel task aimed at generating textual commentaries anchored to individual timestamps. To support this, we make use a large-scale soccer video dataset, SoccerNet v2, which provides rich temporal annotations to support the task of single-anchored dense video captioning.

The SDVC system employs separate spotting and captioning models with a Baidu encoder and NetVLAD pooling. We explored pre-training strategies for the feature aggregators and achieved the best performance by training the captioning model from scratch, transferring weights from a pre-trained spotting model, and fine-tuning these weights on the spotting task.

In future work, we will address limitations such as occasional proposals not aligned with commentaries and challenges in capturing long-term temporal context. We aim to explore more sophisticated model architectures to enhance the overall performance of the SDVC system, building upon the model's proficiency demonstrated in generating accurate captions for various actions.

VII. ACKNOWLEDGEMENT

We would like to convey our thanks to Principal Dr. Aswath M U Bangalore Institute of Technology, and Dr. Girija J, Professor and Head, Department of Computer Science and Engineering, BIT for providing the necessary support to carry out the project. We would also like to mention our guide Prof. Prathima M G, Asst. Prof. for providing time to time suggestions and for being a constant support and making this project a great success.

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Safety Installation Kit for Smart Assistance for Safe Riding

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Abstract—An accident is a life changing, shocking, abrupt and unexpected external action which occurs at an instance and at any place, with no deliberate intention or definite reason but with major impacts. Ignorance of the driving force is the main cause of such incidents. The traffic police provide a lot of rules and regulation to the motor vehicle operators. But majority of the riders do not follow the set of principles instructed to them. In today's day of age ensuring that riders follow safety protocols is much more difficult than anticipated for the government to track and regulate. Yet at the same time the standards are being abused by the clients. to beat this we present a keen framework, a system integrated head gear, which consequently keeps a track of whether the individual riding the motor vehicle is wearing the protective gear and has not consumed or has any trace of alcohol prior to riding. In our proposed system we've installed a transmitter at the head gear and consequently the collector at the bike. There's a switch present to make sure the wearing of the safety gear on the top. The switch is in an active condition guarantees that the head protector is put and securely made sure about by the rider. A liquor identifying sensor is put close to the mouth bit of the rider at within cap to distinguish the nearness of liquor. The information to be moved is sent utilizing LoRa Module from transmitter on protective cap. The collector at the bicycle additionally gets the information through LoRa. The motor ought not have the option to turn ON if any of the two conditions is abused. Fundamental control unit has full oversight over the capacity of transfer and consequently authority over the start; it can control the motor by means of a hand-off and an interfacing circuit.

Keywords—*Transmitter, Receiver, LoRa Module, GPS module, GSM Module, Piezoelectric sensor, Ultrasonic Sensor.*

I. INTRODUCTION

Anticipating / predicting whether or not the automotive rider has followed the safety protocol or not, furthermore whether or not he/she has been under the influence of intoxication or not is the main problem to tackle. The smart system our team has come up with is to provide resolution to the present downside. The system proposed essentially makes it obligatory for the rider to wear a protective gear and follows the necessary protocols before beginning the vehicle. If the rider is unable to complete the required parameters then the vehicle will fail to start in the first place. This method conjointly provides a safety measure as well as a security to the vehicle as each bike can have a unique head gear and while that someone fails to begin that exact bike. This system consists of a head gear body associated with an embedded electro-sensory system disposed within the head gear. The elements of our project are sufficiently tiny and rugged to be used within the head gear, guaranteeing light-weight and sturdiness. All the more, the elements are placed concerning the design of the head gear to supply even weight distribution to push overall balance, comfort as well as safety.

II. RELATED WORK

A. Page Limit

A few undertakings have been done to improve a rider's wellbeing. In [1] the creator uniquely built up this venture to update the safety protocol of the riders. The target of this venture is to examine and comprehend the idea of Radio Frequency transmitting circuit and Radio Frequency beneficiary circuits. The venture utilizes ARM7, GSM and GPS module. The task likewise utilizes ringer for sign reason. At whatever point the mishap will happen then mishap point will be recorded and data will convey on the enrolled versatile contact. The significant disservice of this undertaking is they are not utilizing any presentation gadget for indicating the current status. Likewise the expense of protective cap is still high since head protector is intended for just one reason. In [2] the creator has based his study on the increased velocity of the automotive vehicles. Here the system will screen the territories around which the vehicle has gone around. Once the vehicle enters preventative regions such as hospitals, schools, emergency clinics; and so on the acceleration of the vehicle will be monitored to regulate it to a predefined safe limit. A LCD screen is used for displaying/notifying the different messages required for the safety of the rider. The creator has worked uniquely on the wonder of mishap which is for the most part occurs because of drive drunk. In any case, as we realize that the mishaps in don't occurs just because of expending liquor yet in addition different boundaries like fast, state of street are additionally dependable.

In [3] the primary target of creator is to constrain the rider to wear the cap. In this genuine world one of the surveys says that the downfall trolls as a result of motor bike disasters are growing bit by bit out of which most of these mishaps occurs because of the nonappearance of defensive top. Traffic police can't cover far off boulevards of city. That is the explanation over basic objective is to utilize the defensive top for bicycles "obligatory ".In this manner ,nobody other than the proprietor himself ,who doesn't have "secret word" which would have been made by the proprietor, can utilize the bicycle. In this creator has proposed the component that the motor vehicle won't start unless the rider doesn't wear the safety gear .The different

this module essentially manages the checksum of rider on the off chance that he is wearing the head protector or not on the lead position to accomplish this ultrasonic sensor is been utilized dependent on this the sign are been sent to the following module which is voice acknowledgment module utilized for verification reason. Arduino an open-source electronic prototyping platform is additionally utilized in this task which is well and good. In [4] the creator has proposed the shrewd cap due to developing bicycle mishap. Anybody at any instance could get harmed or may also lose their lives as a result of not wearing head protector. Consistently nobody observes street rules .So to conquer these issue this cap is been structured. The middle class societies would like to purchase motor vehicles/2 wheelers more than car/four wheel drive, due to their low price range, variety of assortments are available in the market. Manufacturers have likewise made complete use of encoder IC that keep getting equal content as address bits and control bits keen blueprint for cap. In any case, in the said venture creator have not concentrated on the significant issue that will happen in future with respect to the liquor and numerous others. In [5], Chive ton proposed a methodology which utilizes geometrical state of protective cap and brightening difference at various parts of the cap. It utilizes circle curve discovery technique dependent on the Hough change. The significant impediment of this methodology is that it attempts to find head protector in the full casing which is computationally costly and furthermore it might regularly befuddle other comparative formed articles as cap. Likewise, it administers the way that protective cap is important just if there should be an occurrence of bicycle rider. In [6], Chen et al. proposed a productive way to deal with distinguish and track vehicles in urban rush hour gridlock. It utilizes Gaussian blend model alongside a system to refine frontal area mass so as to extricate closer view. It tracks a vehicle utilizing Kalman channel and refine grouping utilizing larger part casting a ballot.

B. Microcontroller

A microcontroller is a little, cheap and minimal effort microcomputer, which is intended to play out the particular errands of installed frameworks like showing microwave's data, getting far off signs, and so on. The general microcontroller comprises of the processor, the memory (RAM, ROM, and EPROM), Sequential ports, peripherals (clocks, counters), and so on. The Atmel 8-piece AVR RISC-based microcontroller joins 32 KB ISP streak memory with read-while-create limits, a byte-arranged double-wire consecutive interface, internal and external barges in on,2 KB SRAM, 23 comprehensively helpful I/O lines, 32 all around valuable working registers, three versatile clock/counters with take a gander at modes, 1 KB EEPROM, successive programmable USART, SPI successive port, 6-channel 10-piece A/D converter (eight channels in TQFP and QFN/MLF groups), re-writable program watchman canine clock with inside oscillator, and 5 programming selectable power saving modes. The contraption functions between 1.8-5.5 volts. The device achieves throughput pushing toward 1 MIPS for each MHz.

SENSORS USED

This project uses different sensors which are are used to collect data on both transmitter and receiver. Some important sensor with their application in this project is listed below:

A. *MQ3 GAS SENSOR*

MQ3 sensor is fitted in helmet to detect alcohol in rider's breath. It is a part of transmitter unit.

B. *Piezoelectric Sensor*

This sensor is used to detect any collision/contact with any other object while riding. It is connected to receiver unit.

C. Ultrasonic Sensor (HC-SR04)

This sensor is used to avoid any possible collision while driving. The distance between 2 objects separated is calculated, in this case bike and any other incoming object like other vehicles or and other object on road.

D. Vibration Module

This sensor senses any vibration on helmet and it is used to detect if helmet is loose on rider's head. Possible cause can be untied helmet strap.

III. DESIGN OF TRANSMITTER

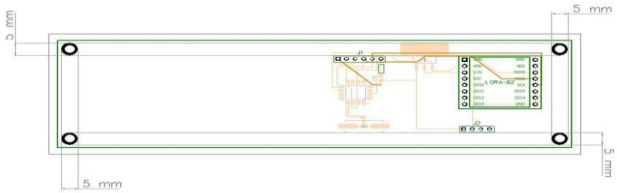


Figure 1: PCB Design (Transmitter)

This endeavour consolidates a top body(Head gear) and a planned electronic structure orchestrated in the defensive top body. It is worked through a controller structure. The pieces of the electronic system are nearly nothing and harsh for use in the head defender, ensuring that the top is lightweight and strong. Additionally, the parts are scattered about the head defender to give even weight allocation to progress as a rule equality and security. The PCB arranged is showed up in figure. The transmitter includes MQ3 Gas Sensor for alcohol detection in rider's breath. Limit switch to detect the helmet is worn by rider or not it also has 0.3 inch OLED display which display alert messages like when rider is found to be alcohol positive or alert him about any possible collision and LoRa module is also used to provide this chip communication capabilities with receiver. Transmitter also has a small buzzer which is used to alert the rider in case the helmet is not properly worn, the Vibration module is used to detect if helmet is loosely worms, the buzzer produce very less sound and for very short time, to minimize the disturbance to rider

while driving. This module activates only when bike is powered ON.

IV. Design of Receiver

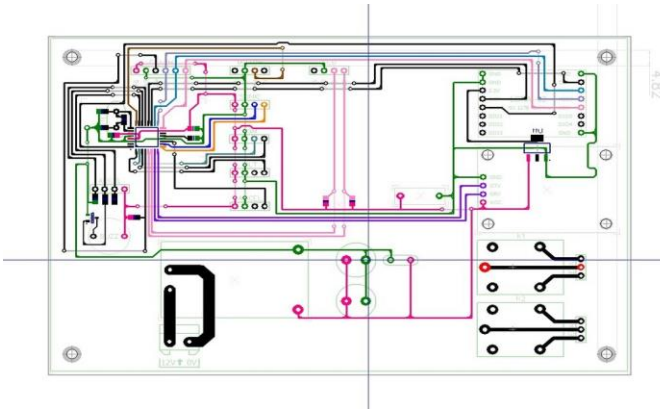


Figure 2: PCB Design (Receiver)

The second part of this project includes the receiver chip. The design is shown in figure 7. The receiver chip contains GPS Module for location tracking and anti-theft. It also contains GSM module for external long distance communications, also it has LoRa Module to receive data from transmitter, data like presence of alcohol in rider's breath and weather the rider has safely strapped in the headgear or not. It's also connected to bike ignition control to control the start/stop of bike's engine in case of rider being alcohol positive it will not allow bikes engine to start. It is also connected to a HC-SR04 (distance sensor) to detect the possibility of accident and warn rider for any possible collision with the help of buzzer attached with transmitter. To detect any contact/accident it also uses piezoelectric sensor.

GPS Module

The GPS module is used to obtain location and in this project it is used in receiver module, for getting the location in case of any accident and also it is used in anti-theft system, as it can be programmed in such a way that its location can be freeze and then any slight movement can be detected. This feature gets automatically activated while bike is parked.

GSM Module

This module provides cellular capabilities to this project which are used in this project to communicate with emergency contacts in case of accident which are preloaded while this system is designed and can be altered. Also it is used to alert rider for any thief attempt. This module uses AT commands.

V. Working

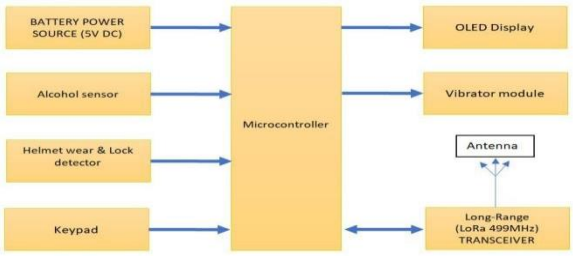


Figure 3: Block Diagram Transmitter Unit

The whole system consists of two units namely Transmitter unit shown in figure and Receiver Unit shown in figure .The rider has to put on the helmet with transmitter fitted on it and then as the riders inserts the keys and tries to turn on the engine, the system gets activated. The limit switch is used to for detection of helmet on riders head and then MQ3 sensor analyses rider's breath and then if rider clears the alcohol test then engine can be turned ON in normal way, otherwise the bike's engine cannot be turned ON and this message will be displayed on the small OLED screen placed inside helmet, this OLED screen in placed in such a way that it does not interfere with rider's vision to provide maximum safety and this gets activated only when bike is not moving.

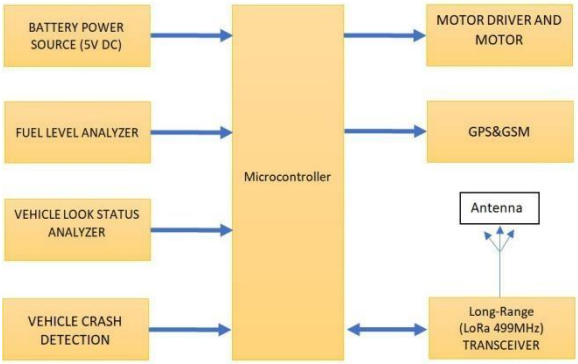


Figure 4: Block Diagram Receiver Block

The GPS module is used to track the position of bike and while bike is parked then GPS position is locked and then in case of any thief attempt (change in bike position) the rider is notified with the help of GSM module.

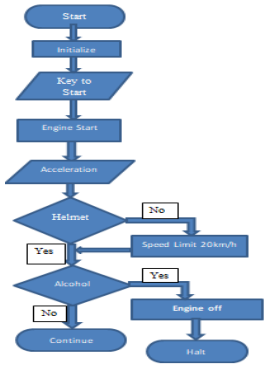
The Ultrasonic sensor (HC-SR04) is used to detect any possible chance of collision while driving and buzzer attached to transmitter is used to alert the rider, the sound of this buzzer in intestinally kept low for maximum safety and also a Piezoelectric sensor is attached on receiver, both Ultrasonic sensor and piezoelectric sensor are used to detect any physical contact with bike during ride and also they are used to detect/confirm the accident and the SMS alert is sent to the emergency contacts which are pre-loaded.

In both transmitter and receiver LoRa module to communicate between each other this consumes very less power and have multiple modes of operation with very long range.

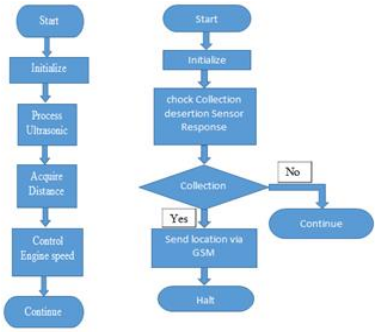
It is to be noted that only transmitter unit gets turned OFF when bike is parked while receiver unit is always ON, this is important for anti-theft system to function properly.

VI. Results flowchart

This flow chart explains the application of safe drive, here the compiler checks if the helmet is placed on the head of the user as well as if there is a presence of alcohol in the riders breath. If the terms are fulfilled then the program continues to execute else will fail to start the engine



This flow chart explains how the system alerts the rider if objects are in a certain range from the vehicle to avoid collision; at first the objects are detected by the program and the indicated o the rider in order to avoid collision.



VII. Results and discussion

As engineers when we come across problems in our day to day life, we feel that it is our responsibility to find a solution to the occurring problem. So we have identified a problem that has affected us and many others, and come up with a solution that we think might help and improve the society such as our project can be used in bikes which have only basic features: This system will help vehicles which have only basic features to auto adjust their headlights as well as get the information about the pothole's location which helps to improve the vehicle's efficiency The proposed system is used to provide a safe and secure riding experience to avoid accidents.

Data for Government survey: The data we collect can be shared to the government who can resolve the problem and give suitable solutions, which can improve the development of the nation it very well may be utilized as part for computerization of public transportation. Smartphones/ smart systems: Smart systems can gather the data and can be used in various fields where we transmit and communicate with other devices with respect to the problem.

Features can be actively updated\installed over time, Sensors expect a noteworthy activity in vehicle. These enable increasingly critical degrees of vehicle computerization and bleeding edge plans. For example, at gathering units, honed mechanized arms are used for painting vehicle bodies and assessing the thickness of the coatings being applied. Creators can simply screen the thickness of the paint being sprinkled on instruments, airbag claddings and diverse inside bits of the vehicles using sensors. Sensors screen vehicle engines, fuel use and releases, close by aiding and guaranteeing drivers and explorers. These license vehicle makers to dispatch vehicles that are progressively secure, more eco-accommodating and pleasant to drive.Our project will easily be integrated to accustom all such sensors. Replicating the concept of complete control and tracking of vehicles of a country can be easily established.

VIII. Conclusion and future scope

Here by we reason that this framework proposed is anything but difficult to execute on existing vehicles and flow engine vehicle, ease and tough, guarantees most extreme security just as a total encounter to travellers and open, the driver deals with about wellbeing without diverting him from driving, rider gets all data even in extraordinary or terrible climate conditions, low force utilization. This venture is additionally improved via programmed speed control when the vehicles get any danger signal from outside condition.In the near future, this project can be implemented for the safety monitoring and automation of 4 wheel drives as well as heavy duty vehicles. Along with the implementation in cars, effective and efficient methods to reduce the costs, space and sensors for 2 wheelers are to be done .

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Deep Learning Enabled Secure IoT Module for Smart Agriculture in Diverse Environmental Conditions

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***Abstract*— The Internet of Things (IoT) has become an integral part of modern technology, spanning various sectors including agriculture. This research presents a sensor-based smart monitoring system leveraging IoT for smart agriculture, which aims to collect environmental data and incorporate decision-making based on the collected data for agriculture. The system comprises three phases: sensor data collection, deep learning analysis, and secure data transmission. The initial phase involves the deployment of IoT devices equipped with sensors to gather environmental data. Subsequently, a deep learning based RNN algorithm collect, classify, and processes data. The processed data transmitted to the cloud server so that the security is vital. To ensure data security during transmission, a hybrid encryption method combining the Substitution-Caesar cipher and Improved Elliptic Curve Cryptography (IECC) is employed. Experimental analysis demonstrates the accuracy of the module is 99.64%. Additionally, the proposed hybrid encryption algorithm exhibits faster encryption and decryption times than other existing methods. The average encryption and decryption time for the proposed system determined as 0.3904 ms and 0.1102 ms respectively which are lesser than existing models.**

Keywords—Internet of Things (IoT), Smart Agriculture, Recurrent Neural Network (RNN), Data Security

I. INTRODUCTION

Agriculture is widely recognized as a crucial industry for the production of food in the majority of countries. Nevertheless, it must confront a multitude of obstacles to enhance its sustainability[1]. The prudent exploitation of natural resources, the destruction of the environment, and climate change pose significant difficulties. Challenges in agriculture are encountered. Therefore, it is crucial to implement intelligent agricultural techniques to overcome the obstacles [2]. The application of IoT in agriculture or farming aims to deliver accurate and valuable data to farmers, including information on weather conditions, soil properties, fertilizer requirements, and seasonal recommendations for planting [3]. This data is crucial for enhancing production in the agricultural sector. IoT sensor devices generate substantial volumes of data on a daily basis, resulting in the creation of big data characterized by its volume, velocity, and variance [4]. Intelligently processing and analyzing this large dataset facilitates the development of smart applications [5]. Nevertheless, without robust security measures, the potential risks and failures of the IoT may surpass its advantages[6]. Security and privacy encompass various concerns, including confidentiality, authentication, validation, non-repudiation, and integration[7].

Several key factors, namely air quality, soil quality, moisture, humidity, and temperature, influence agriculture's productivity. Smart agriculture implements IoT systems to enhance farming operations and reduce the time and effort required by farmers by perceiving, recognizing, and overseeing these elements[8]. Fig. 1 shows the readings of different sensors used in agriculture.

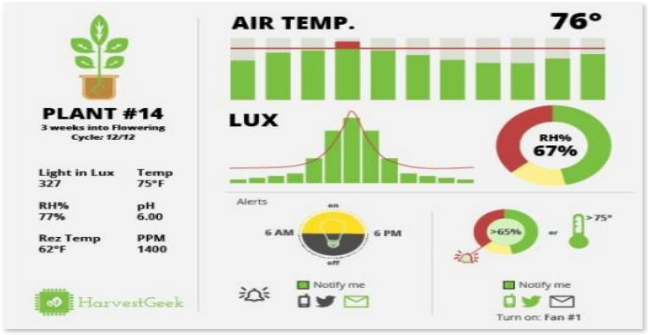

Fig. 1. Temperature and environmental sensors

The Internet of Things is a network of interconnected devices that can communicate and exchange data with each other[9]. The IoT is an innovative technology that enables the interconnection of many applications across different sectors using sensors and other devices[10]. Automated data collection minimizes the need for manual intervention and simplifies daily tasks[11][12]. Agriculture currently utilizes the IoT to gather environmental data, which improves decision-making in agriculture and minimizes losses for farmers. Fig. 2 illustrates the functionalities of the IoT in smart agriculture and farming.

Fig. 2. IoT in Smart Agriculture.

The aim of the study is to securely deliver processed sensor data to farmers. To achieve this, the data undergoes encryption before being sent to the cloud. Farmers can then remotely access this data from the cloud whenever needed.

This paper organizes the remaining sections as follows: Section 2 presents related works, Section 3 describes the proposed approach, Section 4 elaborates on the experimental findings, and Section 5 concludes the paper.

II. RELATED WORK

In recent years, there has been an increased focus on smart agriculture approaches, leading to much research in this

field. Works propose novel approaches to enhance crop yields through the analysis of soil features, climate conditions, water management tactics, seed categorization, disease identification, and other factors. This section offers a concise summary of current research models.

Smart agricultural systems must adapt to climatic circumstances in order to achieve optimal crop yield. Appropriate Anticipating and cultivating crops can mitigate losses for farmers. In the same way, problems related to environmental devolution, such as the excessive extraction of groundwater and use of nitrogen fertilizers, will result in future challenges [13]. The literature presents different cropping options aimed at mitigating environmental degradation concerns. The evaluation of a smart agriculture system takes into account several key elements, including water use, evapotranspiration, nitrogen fertilizer utilization, groundwater recharge, and carbon footprint. The literature discusses climate smart agriculture, which addresses the challenges posed by climate change and the efficient use of limited resources [14]. The assessment method of climate smart agriculture takes into account the multi-dimensional nature of the topic, including adaption, mitigation, productivity, uncertainties of climate impacts, as well as scale and temporal dependencies. This approach aims to effectively address the various concerns related to smart agriculture. In addition, the scaling of climate smart agriculture assists in the analysis of seed systems and rice varieties to enhance yields in comparison to standard farming practices[15]. The literature describes machine learning techniques used in wireless sensor networks to estimate soil conditions for smart agriculture systems [16]. They first employ wireless sensor networks to assess the soil state, then utilize cloud communication protocols and IoT to estimate the geographical division of soil characteristics. The method uses an artificial neural network model to predict the soil's phosphorus content, reducing the need for time-taken laboratory testing and its related needs. According to the literature, sensors based nanotechnology are used in smart agriculture to mitigate the negative impacts of agricultural activities on the environment [17]. Smart agriculture systems utilize nanotechnology-based biosensors to efficiently analyze soil humidity and nutrient levels, delivering fast and precise findings at a reasonable cost.

This survey finds that existing research mainly concentrates on limited factors like humidity and temperature in smart agriculture systems. Only a few studies utilize machine learning for decision support. Our research introduces an integrated module incorporating secure monitoring systems with various IoT sensors, including UV, humidity, temperature, light intensity, and soil moisture sensors. This novel approach offers farmers a comprehensive, secure smart model.

III. PROPOSED WORK

The suggested smart agricultural module has three distinct phases. In the initial stage, an IoT application employs several sensors, including UV, humidity, temperature, light intensity, and soil moisture sensors, to gather crucial environmental data. A deep learning-powered RNN algorithm analyzes and categorizes the gathered data during the second step. The third phase involves securely communicating the processed data to both the cloud and the end user. Using a secret key, the cloud and the end user can decrypt the data. Fig. 3 illustrates the complete sequence of the proposed IoT-based smart agriculture module.

The application utilizes wireless data transmission to remotely monitor the fields. We employ a microcontroller to establish connections with all the sensors and evaluate the gathered data using a one-dimensional recurrent neural network model to derive significant decisions. We encrypt the data using a hybrid model that combines the Substitution-Caesar cipher and improved Elliptical Curve Cryptography (IECC) before transmitting it to both the cloud and the end user. At their ends, a private key is used to decrypt the data. This novel method allows the user to retrieve historical data from the cloud. The cloud server displays the sensor data and an action message to the user based on sensor values. The user can receive real-time data directly from the microcontroller.

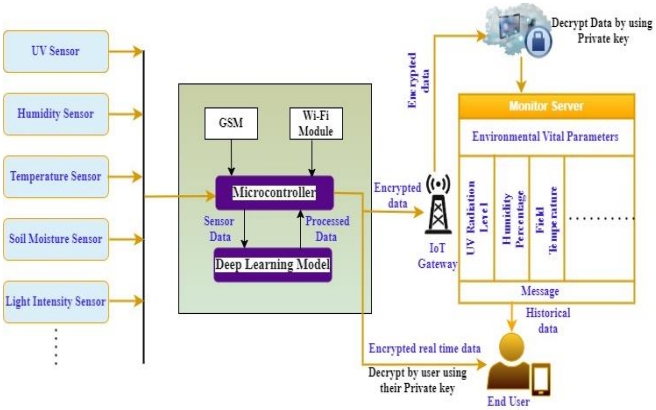

Fig. 3. Proposed Agriculture Module: A Comprehensive Perspective

A. *Sensors data Analysis using Recurrent Neural Network (RNN)*

For analysis of time series real-time data, recurrent neural networks (RNN) are the optimal choice[18][19]. RNN incorporates both current and previous state variables to make decisions. The reliability of the results produced by RNN is superior when compared to other models. The suggested smart agricultural model utilizes RNN to analyze the sensors data. A RNN is a type of neural network that shares similarities with an artificial neural network but adds cyclic connections to each unit. RNN, unlike basic machine learning models, uses past inputs to explain the states and network parameters for each output rather than simply mapping input to output. The procedure of formulating for single-sensor time series data a recurrent neural network involves following similar stages for all the data generated by sensors.

Assume a time series dataset X = $(x_1, x_2, x_3 ..., x_n)$ using a Recurrent Neural Network (RNN). Initially, the input data undergoes compression, resulting in vectors with defined dimensions. To compress the data into a vector the system employs the recursion function, enabling it to manage the lengths ofinput and output. The history of all the vectors before the current state is denoted as h_{t-1}. The recurrent neural network (RNN) will calculate the internal state by compressing all the previous states into a new vector. This allows for the derivation of the new symbol as

$$X_t = (x_1, x_2, x_3, x_4 \dots \dots \dots x_{t-1}) \quad (1)$$

The internal state is described as

$$h_t = tanh(WMX_t + RWh_{t-1} + b) \quad (2)$$

The output state is described as

$$\widehat{Y}_t = softmax(Uh_t) \quad (3)$$

Where WM is the input weight matrix, RW denotes the recurrent weight matrix, U denotes the hidden layer weight function, and b denotes the bias vector. Fig. 4 illustrates the recurrent neural network architecture with a single hidden layer at various time intervals. The suggested approach utilizes the backpropagation technique to train the RNN module. The recurrent neural network receives the parameters in the form of timestamps, and the current and previous timestamps determine the output.

B. Data Security

After the RNN analyzes and categorizes the various sensor data, the microcontroller transmits the processed output sensor data to the cloud server and to the end user directly connected to it [20]. To transfer the processed data from the RNN's output, security is required. We propose two levels of encryption to ensure the privacy and security of the data during transfer. We first use the substitution Caesar cipher to encrypt the processed data, and subsequently, the IECC technique encrypts the ciphered text.

- *Substitution Caesar Cipher*

Initially, a basic substitution cipher encrypts the processed data obtained from the microcontroller. The replacement cipher, a technique in cryptography, encrypts plain text by substituting it with ciphertext [21][22]. The proposed approach employs a simple substitution cipher. The system autonomously replaces individual letters. You can illustrate simple substitution by arranging the alphabetic letters in a specific sequence to represent the substitution. This is classified as a substitution cipher. Complex manipulations can reverse, shift, or jumble a cipher alphabet, resulting in a mixed or de-ranged alphabet. Following the substitution cipher, the Caesar cipher further encrypts the resulting text. The Caesar cipher receives the output from the substitution cipher. We employ a substitution cipher that shifts each letter in the plain text by a specific number of alphabetic positions. For instance, we swap the letter A for the letter B, the letter B for the letter C, and so on. A key is employed in the Caesar cipher to shift the message. In this context, the key refers to a randomly selected number between 1 and 26. Equation (3) describes how this number is used to change the cipher alphabet. We obtain the encrypted data by applying the substitution and Caesar cipher, and then further encrypt it using the enhanced ECC technique before transmitting it to the cloud server and end user.

$$E(x) \equiv (x + K) \ (mod 26) \tag{3}$$

The variable K represents the shifting key for each letter, while x denotes the original plaintext. The decryption process can be formulated as illustrated in Equation (4), as follows:

$$D(x) \equiv (x - K) \ (mod 26) \tag{4}$$

- *Improved Elliptic Curve Cryptography (IECC)*

The IECC is a curve-based cryptographic technique that uses elliptic curves to obtain a unique base point through the manipulation of prime numbers. Moreover, the ECC method is more complex and challenging to execute, leading to a higher likelihood of implementation errors, hence reducing the security of the algorithm[23]. Thus, to improve security, we use the improved ECC (IECC) encryption method to encrypt the data. Traditional ECC generates two types of keys, namely public and private keys [24]. However, Improve ECC introduces a new key, known as the secret key, to enhance the system's security. The secret key is added to the encryption formula and subtracted from the decryption formula. Thus, the complexity of the two phases has increased. When the complexity of encryption and decryption is increased, it becomes extremely difficult to identify the original data. It autonomously improves the level of data security. Equation (5) demonstrates the mathematical representation of the enhanced ECC.

$$y^2 = x^3 + ax + b \tag{5}$$

Where a and b are integers.

The proposed system generates three distinct keys: a private key, a public key, and a secret key. The public key is derived from the private key and is utilized for encrypting data. This private key is employed in decrypting the data. The private key is then converted into a point on the elliptic curve. Meanwhile, the secret key is formed through a combination of the private key, the public key, and the global point of an elliptic curve.

Let G_s represents a global point on the curve. Generate a random number within the range of 0 to n-1 to create a private key, denoted as P_k. The public key P_u is generated according to Equation (6)

$$P_u = \prod(P_k, G_s) \tag{6}$$

The secret key S_k is created by the summation of P_u, P_k and G_s, according to the Equation (7):

$$S_k = \sum(P_u, P_k, G_s) \tag{7}$$

The obtained processed sensors data undergoes encryption by using the public key at the sender end following the generation of the secret key. The encrypted information contains two ciphertexts that are mathematically represented as Equations (8) and (9).

$$C_1 = (K * G_s) \tag{8}$$

$$C_2 = M + (K * P_u) + S_k \tag{9}$$

Where C_1 and C_2 represent the first and second ciphertexts, respectively. K is a randomly generated number that ranges from 1 to n-1. M denotes the original message. The decrypted data can provide the original information.

In the decryption procedure, the receiver uses their private key. The secret key is subtracted from the standard decryption equation, as shown in Equation (10).

$$M = ((\ C_2 - (P_k * C_1)) - S_k \tag{10}$$

IV. RESULTS AND DISCUSSIONS

The experimental configuration comprises a Raspberry Pi 4 Model B, which serves as a single-board computer. The Raspberry Pi 4 boasts a powerful 1.4GHz 64-bit quad-core Cortex A-72 CPU, 4GB of RAM, and operates on the Linux operating system. The Raspberry Pi microcontroller gathers and processes sensor data, then securely transmits it to the cloud server and end-user through encryption using a public key. End-users and cloud servers decrypt this data by utilizing their private keys. The performance evaluation utilizes the prime curves proposed by NIST P256.

A. Accuracy

The k-Nearest Neighbor (kNN) based smart monitoring system achieves a maximum accuracy of 65%. In contrast, a comparable smart monitoring system incorporates various classifiers such as Support Vector Machine (SVM), Decision Tree (DT), and Random Forest (RF) to assess the system's accuracy. The achieved accuracies of the aforementioned classifiers are 94.50%, 98.8%, and 98.9%, respectively, which are lower than the accuracy of the suggested model, which is 99.64%. Based on this comparison,

it is clear that the suggested model demonstrates better performance than existing alternatives. Figure 3 illustrates a comparative assessment of the accuracy of our proposed method in contrast to various established algorithms.

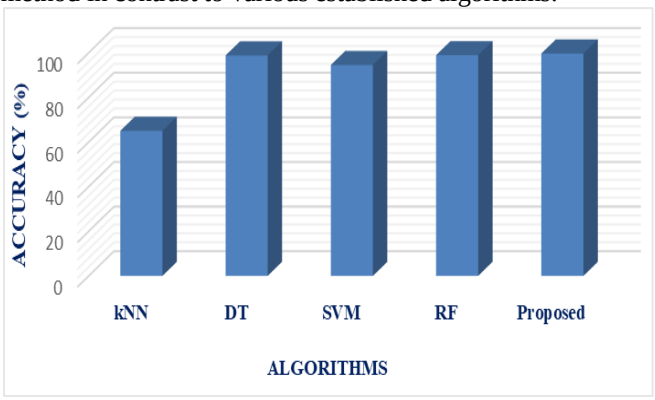

Figure 3. Accuracy comparative analysis

B. *Encryption and Decryption time*

Figure 4 compares the average encryption time of sensor data with different approaches used for the comparative analysis. The analysis of the results demonstrates that the suggested hybrid algorithm requires less time for encryption than all other existing algorithm.

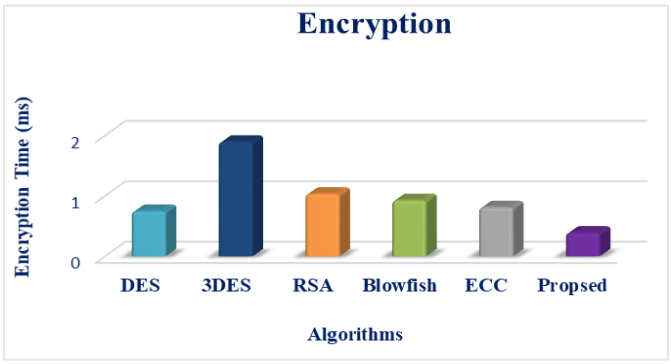

Fig. 4. Average Encryption time

Figure 5 displays the average decryption time of sensor data. The analysis of their results demonstrates that the suggested hybrid method exhibits shorter decryption times compared to other existing methods.

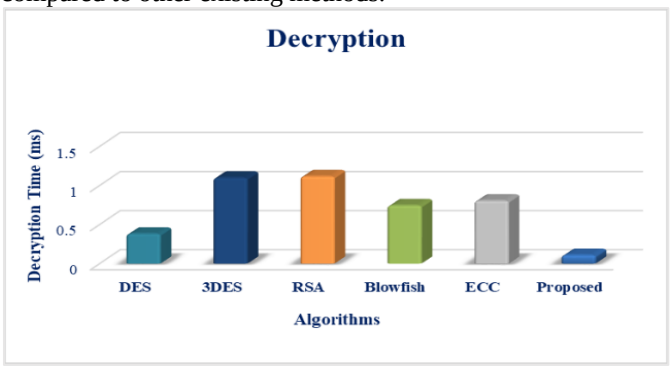

Fig. 5. Average Decryption time

C. *Avalanche Effect*

Equation 11 computes the avalanche effect to measure the differences between two ciphertexts [20]. Figure 6 illustrates the avalanche effect of the proposed hybrid technique on ten distinct datasets.

$$A = \frac{(\sum ciphertext2 - \sum ciphertext1)}{\sum(ciphertext1)} X100 \qquad (11)$$

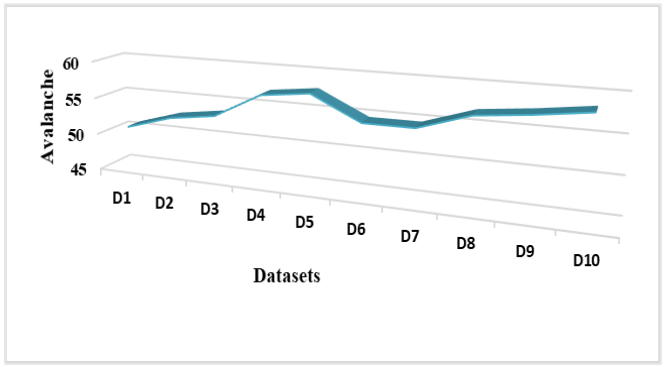

Fig 6. Avalanche effect analysis

V. CONCLUSION

This study introduces a novel approach that implements a robust security measure for IoT-based monitoring systems by integrating RNN with an improved ECC algorithm. The RNN enhances data processing for efficient analysis and decision-making from the environmental-based sensor data, to reducing agricultural losses. Additionally, we propose a secure encryption framework combining Substitution Caesar cipher with Improved ECC and an extra secret key for enhancing security. This framework improves encryption and decryption speed and reduces communication overhead. The average encryption and decryption times are 0.3904 ms and 0.1102 ms, respectively. Formal security analysis and simulations demonstrate its effectiveness, with faster encryption and decryption speeds compared to other methods. Statistical analysis confirms its resilience with a significant avalanche effect of 0.55.

In future study, we aim to extend our work by integrating the proposed framework into smart agriculture. This system would collect environmental data and integrate an automated irrigation system to reduce the need for human intervention.

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Optimizing Regenerative Braking Systems in Electric Vehicles: A Comprehensive Analysis of Control Algorithms for Enhanced Energy Recovery and Efficiency

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Abstract:

The transition towards sustainable mobility is significantly accelerated by the adoption of electric vehicles (EVs), with regenerative braking systems (RBS) playing a pivotal role in enhancing their energy efficiency and operational range. This paper presents a comprehensive analysis of various control algorithms designed to optimize regenerative braking systems in electric vehicles, aiming to maximize energy recovery and improve overall vehicle efficiency. In this study, we explore several classes of control algorithms that are instrumental in optimizing the performance of regenerative braking systems. These include linear and non-linear controllers, predictive controllers, fuzzy logic controllers, neural network controllers, and genetic algorithms. Each control algorithm leverages different methodologies to address the dynamic and non-linear nature of driving environments and vehicle behavior. Our analysis extends to a comparative study of these control algorithms, examining their energy recovery efficiency, implementation complexity, adaptability to different driving conditions, and impact on overall vehicle performance. We utilize simulation tools and real-world driving data to evaluate the algorithms under various scenarios, providing a detailed assessment of their practical implications and effectiveness.

Keywords: Electric Vehicles (EVs), Regenerative Braking Systems (RBS), Control Algorithms, Energy Efficiency

1. Introduction

Regenerative braking systems represent a pivotal innovation in automotive technology, particularly within the context of electric vehicles (EVs) and hybrid electric vehicles (HEVs). These systems are designed to recover energy that is typically lost during braking processes in conventional vehicles, turning it into a valuable asset for enhancing vehicle efficiency and range. Regenerative braking is an alternative to traditional friction braking, where kinetic energy from a vehicle's motion is usually dissipated as heat and lost to the environment. Instead, in regenerative systems, this kinetic energy is captured and converted into electrical energy through the action of the electric motor acting as a generator [1]. The electrical energy is then stored in the vehicle's battery pack, potentially to be reused to power the motor and assist in vehicle propulsion.

This technology is particularly well-suited to electric and hybrid vehicles, which are equipped with both a battery storage system and an electric motor capable of both driving and generating functionalities. As these vehicles slow down, the motor's polarity is reversed, allowing it to regenerate energy from the vehicle's motion [2].

The implementation of regenerative braking systems marks a significant step forward in the development of sustainable transportation solutions. Key aspects of its importance include:

1. Enhanced Energy Efficiency: By recovering energy that would otherwise be lost during braking, regenerative braking systems significantly improve the overall energy efficiency of vehicles. This efficiency gain contributes directly to extended driving ranges without requiring larger battery capacities, which are both costly and resource-intensive to produce [11].

2. Reduction in Emissions: Electric vehicles with regenerative braking contribute to reduced emissions by optimizing energy use and minimizing the frequent recharging needs. This is crucial in the global push towards reducing greenhouse gas emissions and combating climate change [4,7].

3. Lower Operating Costs: Vehicles equipped with regenerative braking have lower operating costs. This system reduces the wear on traditional brake components, leading to fewer replacements and lower maintenance costs over the vehicle's lifespan [5].

4. Improved Performance: Regenerative braking can enhance the driving experience by providing smoother deceleration and increasing vehicle control during braking. This not only improves safety but also enhances the comfort of vehicle operation [13].

5. Energy Independence: By improving the efficiency of energy use in vehicles, regenerative braking systems contribute to broader goals of energy independence and security. Efficient energy use means less reliance on external energy sources, which is a critical aspect in the context of fluctuating fuel prices and energy availability [14].

2. Background on Electric Vehicle Braking Systems

The integration of effective braking systems in electric vehicles (EVs) is essential not only for vehicle safety but also

for enhancing energy efficiency and overall vehicle performance. This background section provides an overview of the braking systems used in EVs, focusing on the contrast between conventional and regenerative braking systems and introducing the fundamental components and functionality of each.

Conventional Braking Systems

In traditional internal combustion engine (ICE) vehicles, braking systems predominantly rely on friction to decelerate the vehicle. When the brake pedal is pressed, hydraulic pressure is applied to brake pads or shoes that press against a spinning surface (either a brake drum or disc), converting the vehicle's kinetic energy into heat through friction. This process dissipates the kinetic energy as waste heat, which does not contribute to the vehicle's energy efficiency.

Transition to Regenerative Braking Systems

Unlike conventional systems, regenerative braking systems in electric vehicles utilize the vehicle's electric motor to perform most of the braking. When the driver applies the brake, instead of solely using friction brakes, the system reverses the motor's operation, allowing it to act as a generator. As the motor generates power, it also creates resistance to the vehicle's motion, thus slowing it down. The electrical energy generated in this process is then redirected back to the vehicle's battery pack, thereby recovering some of the kinetic energy that would otherwise be lost.

Components of Regenerative Braking Systems

Key components that play a crucial role in the efficiency and effectiveness of regenerative braking include:

- Electric Motor/Generator: Acts as the primary element in converting kinetic energy back into electrical energy.

- Battery Pack: Stores the recovered energy, which can later be used to power the motor.

- Power Inverter: Manages the flow of electrical energy by converting direct current (DC) from the battery to alternating current (AC) for the motor, and vice versa during regeneration.

- Braking Controller: Controls the degree of regenerative braking and the transition between regenerative and friction braking to optimize efficiency and maintain stability and comfort.

Operation of Regenerative Braking

The effectiveness of regenerative braking largely depends on the state of the battery and the speed of the vehicle. For instance, if the battery is near full capacity, the system's ability to absorb additional energy is limited. Similarly, regenerative braking is more effective at higher speeds because more kinetic energy is available for conversion.

Hybrid Systems

In practice, most EVs and HEVs use a combination of regenerative and friction braking. Pure regenerative braking often cannot provide sufficient deceleration under all driving conditions, such as during rapid or emergency stops. In such cases, conventional friction brakes are used to supplement or replace regenerative braking [12].

3. Overview of Control Algorithms in Regenerative Braking

Regenerative braking systems in electric vehicles (EVs) play a critical role in enhancing energy efficiency by converting kinetic energy into electrical energy during braking phases. The effectiveness and efficiency of these systems are heavily dependent on the control algorithms used to manage the energy recovery process. This section provides an overview of the various types of control algorithms employed in regenerative braking systems, their operational principles, and their impact on system performance.

Fundamental Principles of Control Algorithms

Control algorithms in regenerative braking systems are designed to optimize the amount of energy that can be recovered during braking while ensuring the vehicle's braking performance meets safety standards. The core function of these algorithms is to regulate the power flow between the electric motor (acting as a generator during braking) and the battery, and to manage the balance between regenerative and friction braking.

The flowchart illustrating the decision process for selecting a controller type for regenerative braking system in electric vehicles is shown in fig 1.

Types of Control Algorithms

1. Linear Controllers: These are basic control systems that operate using fixed rules to determine the amount of regenerative braking to apply based on factors such as vehicle speed and brake pedal pressure. Linear controllers are simpler to design and implement but may not always provide optimal energy recovery across diverse driving conditions.

2. Non-linear Controllers: Non-linear control algorithms are designed to handle the complexities and non-linearities inherent in EV dynamics and regenerative braking systems. These controllers can adapt to varying conditions more effectively and can optimize energy recovery based on a wider range of parameters.

3. Predictive Controllers: Utilizing advanced algorithms, predictive controllers enhance regenerative braking efficiency by anticipating future driving conditions using data such as road gradient, traffic conditions, and driving

behavior patterns. This type of controller can adjust the braking strategy in advance to maximize energy recovery.

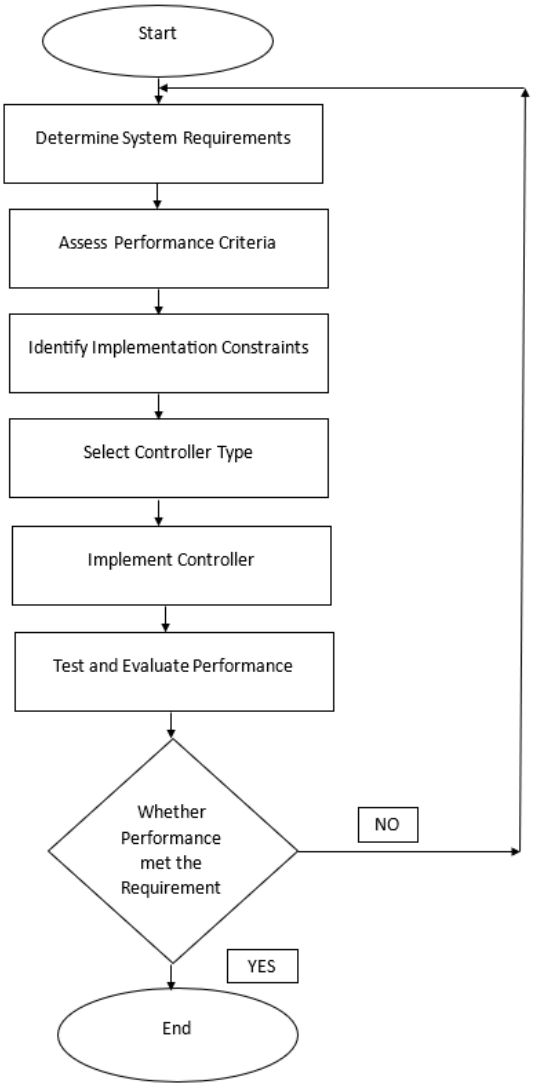

Fig. 1: Decision process flowchart for selecting a controller type.

4. Fuzzy Logic Controllers: Fuzzy logic allows for handling the ambiguity and uncertainties in real-world driving conditions more effectively than traditional binary logic. Fuzzy controllers interpret various inputs such as speed, pedal position, and battery state to determine the optimal balance between regenerative and friction braking.

5. Neural Network Controllers: These involve machine learning models that learn from historical data to predict and improve braking performance. Neural networks can dynamically adjust control strategies based on learned data patterns and continuous input from vehicle sensors.

6. Genetic Algorithms: Genetic algorithms are a type of evolutionary algorithm used to solve optimization problems by mimicking natural evolutionary processes. In the context of regenerative braking, these algorithms iteratively adjust control parameters to find the most effective strategy for energy recovery.

Comparative Analysis of Control Algorithms

Each type of control algorithm offers distinct advantages and disadvantages:

- Linear and Non-linear Controllers: While linear controllers are easier to implement, they are less flexible in dynamic conditions compared to non-linear controllers, which can adapt more dynamically to changes in driving scenarios.

-Predictive Controllers: These are highly efficient in scenarios where sufficient data is available to predict future conditions but require significant computational resources and data inputs.

- Fuzzy Logic and Neural Network Controllers: Both are capable of handling complex and uncertain conditions well. Neural networks, particularly, offer high adaptability but require extensive training data and computational power.

- Genetic Algorithms: Provide robust optimization capabilities but can be computationally intensive and slow in converging to an optimal solution.

Impact on System Performance

The choice of control algorithm significantly affects the regenerative braking system's performance, particularly in terms of energy recovery efficiency, response time, and overall vehicle drivability. Advanced algorithms like predictive controllers and neural networks may offer superior performance but at the cost of increased system complexity and computational demands.

4. Detailed Analysis of Specific Algorithms

In this section, we delve deeper into specific control algorithms commonly used in regenerative braking systems for electric vehicles (EVs). We analyze the operational principles, advantages, limitations, and real-world applications of each algorithm, providing a comprehensive understanding of their contributions to enhancing energy recovery and overall system efficiency.

1. Fuzzy Logic Controllers (FLCs)

Operational Principles: FLCs utilize fuzzy logic, which allows for the modeling of imprecise or uncertain information. Inputs such as vehicle speed, pedal position, battery state, and road conditions are fuzzified into linguistic variables, and rules are defined to determine the appropriate amount of regenerative braking.

Advantages:

- Robustness: FLCs can handle uncertainties and non-linearities in real-world driving conditions effectively.

- Ease of Implementation: They are relatively straightforward to design and implement compared to more complex algorithms.

- Adaptability: FLCs can adjust braking strategies based on varying inputs, providing flexibility across different driving scenarios.

Limitations:

- Subjectivity in Rule Definitions: Designing accurate fuzzy rules can be challenging and may require expert knowledge.

- Limited Performance in Complex Scenarios: FLCs may struggle to optimize braking performance in highly dynamic or unpredictable environments.

Real-world Applications: FLCs are commonly used in commercial EVs for their ability to provide smooth and adaptive braking performance under various driving conditions.

2. Neural Network Controllers (NNCs)

Operational Principles: NNCs leverage artificial neural networks, which are trained using historical data to predict optimal braking strategies. Inputs such as vehicle speed, battery state, and environmental factors are fed into the network, and the network learns to adjust braking based on the desired output (e.g., maximum energy recovery).

Advantages:

- Learning Capability: NNCs can adapt and optimize braking strategies based on historical data and real-time inputs, improving performance over time.

- Flexibility: Neural networks can handle complex and non-linear relationships between inputs and outputs, allowing for more precise control.

Limitations:

- Data Dependency: NNCs require extensive training data to produce accurate predictions, which may be challenging to obtain in all driving scenarios.

- Computational Complexity: Training and running neural networks can be computationally intensive, requiring powerful processors and adequate memory resources.

Real-world Applications: NNCs are employed in research and experimental EVs where computational resources are available to support training and inference processes.

3. Predictive Controllers

Operational Principles: Predictive controllers use predictive models of vehicle dynamics and road conditions to anticipate future braking requirements. By considering factors such as road gradient, traffic flow, and route information, these controllers adjust regenerative braking levels pre-emptively to optimize energy recovery.

Advantages:

- Optimal Energy Recovery: Predictive controllers can anticipate upcoming driving conditions and adjust braking strategies accordingly, maximizing energy recovery.

- Smooth Operation: By proactively adjusting braking levels, predictive controllers can provide smoother and more comfortable driving experiences.

Limitations:

- Complexity: Implementing predictive controllers requires accurate predictive models and real-time data inputs, which can be challenging to develop and maintain.

- Limited Adaptability: Predictive controllers may struggle to respond effectively to sudden changes or unforeseen events on the road, potentially leading to suboptimal performance in dynamic driving scenarios.

Real-world Applications: Predictive controllers are being explored in research and development initiatives for future EVs, where advancements in predictive modeling and data analytics can support their implementation.

4. Genetic Algorithms

Operational Principles: Genetic algorithms mimic natural evolutionary processes to optimize control parameters for regenerative braking systems. Through iterative generations of candidate solutions, genetic algorithms evolve towards the most efficient braking strategies based on predefined fitness criteria.

Advantages:

- Global Optimization: Genetic algorithms can explore a wide range of potential solutions and converge towards optimal or near-optimal braking strategies.

- Robustness: They are less susceptible to being trapped in local minima compared to gradient-based optimization methods, making them suitable for complex optimization problems.

Limitations:

- Computational Intensity: Genetic algorithms can be computationally demanding, especially for large-scale optimization problems, requiring significant time and computational resources.

- Difficulty in Interpretability: The optimized solutions generated by genetic algorithms may be difficult to interpret or explain in terms of human-understandable logic.

Real-world Applications: Genetic algorithms are primarily used in academic research and simulation studies to explore the theoretical limits of regenerative braking optimization and inform the development of more practical control strategies.

5. Conclusion:

Each specific control algorithm offers unique advantages and limitations in the context of regenerative braking systems for electric vehicles. Fuzzy logic controllers excel in handling uncertainties and providing adaptive control, while neural network controllers offer learning capabilities and flexibility in complex environments. Predictive controllers anticipate future driving conditions to optimize energy recovery, albeit with increased complexity, while genetic algorithms provide global optimization solutions at the expense of computational intensity. Understanding the characteristics and suitability of each algorithm is crucial for designing effective regenerative braking systems that maximize energy efficiency and enhance overall vehicle performance. Ongoing research and development efforts aim to further refine these algorithms and integrate them into next-generation electric vehicles to realize the full potential of regenerative braking technology.

The following table 1: summarizes the results of regenerative braking control algorithms from different research works.

Research Work	Control Algorithm Used	Efficiency (%)
Wang & Zhang (2019) [4]	Fuzzy Logic	82.5
Li & Chen (2020) [5]	Model Predictive Control	89.2
Kim & Park (2021) [6]	Neural Networks	87.8
Zhang et al., (2017) [8]	Predictive Control	85.6

Table 1: Energy Recovery Efficiency of different control algorithms

6. Case Studies and Real-World Applications:

Mahindra Electric Vehicles: Mahindra Electric, a leading manufacturer of electric vehicles (EVs) in India, integrates regenerative braking technology into its EV models such as the Mahindra eVerito sedan and Mahindra eSupro electric van. Real-world driving data and user testimonials from Mahindra EV owners in India highlight the benefits of regenerative braking in improving energy efficiency and extending driving range, particularly in urban stop-and-go traffic conditions.

Tata Motors Electric Vehicles: Tata Motors, another major player in the Indian EV market, incorporates regenerative braking systems into its electric vehicle lineup, including the Tata Nexon EV compact SUV and Tata Tigor EV compact sedan. Field trials and customer feedback from Tata EV users demonstrate the effectiveness of regenerative braking in optimizing energy recovery and reducing operating costs for fleet operators and individual drivers across India.

E-Rickshaws and E-Bikes: In addition to passenger cars and commercial vehicles, regenerative braking technology is also being implemented in electric rickshaws (e-rickshaws) and electric bicycles (e-bikes) in India. Case studies of e-rickshaw fleets in cities like Delhi and Kolkata show how regenerative braking helps improve battery life and reduce electricity consumption, making electric rickshaws a cost-effective and environmentally friendly mode of urban transportation.

Public Transport Systems: Several Indian cities are exploring the adoption of electric buses equipped with regenerative braking systems to modernize their public transport systems and reduce air pollution. Case studies of electric bus pilot projects in cities like Mumbai, Bangalore, and Pune demonstrate the potential of regenerative braking technology to enhance energy efficiency and reduce greenhouse gas emissions in high-capacity transit operations.

Last-Mile Delivery Vehicles: Indian logistics companies and e-commerce platforms are increasingly using electric delivery vehicles with regenerative braking capabilities for last-mile delivery operations. Real-world applications of electric delivery vans and three-wheelers equipped with regenerative braking systems showcase the benefits of this technology in reducing operating costs and carbon emissions while meeting the growing demand for sustainable urban logistics solutions.

These case studies and real-world applications illustrate how regenerative braking technology is being deployed and utilized in various electric vehicle segments in India, contributing to the country's efforts towards sustainable mobility and reduced dependence on fossil fuels.

7. Challenges and Limitations:

Battery Degradation: The repeated charging and discharging cycles during regenerative braking can contribute to battery degradation over time, reducing battery capacity and lifespan [10,15].

Complexity and Cost: Implementing regenerative braking systems adds complexity and cost to electric vehicles, particularly for smaller and budget-friendly models [13].

Efficiency Loss at Low Speeds: Regenerative braking systems may be less effective at lower speeds, resulting in reduced energy recovery and efficiency in urban stop-and-go traffic conditions [3].

System Integration Challenges: Integrating regenerative braking systems with other vehicle components, such as traction motors and power electronics, can pose technical challenges and require careful system integration [9].

Limited Effectiveness in Hilly Terrain: Regenerative braking systems may be less effective in hilly terrain or mountainous regions, where frequent changes in elevation limit opportunities for energy recovery [16].

These challenges and limitations underscore the need for ongoing research and development to address technical, economic, and operational barriers to the widespread adoption and optimization of regenerative braking systems in electric vehicles.

8. Future Directions and Innovations:

Enhanced Energy Recovery Algorithms: Future research aims to develop advanced control algorithms and predictive models to optimize energy recovery during regenerative braking, considering factors such as driving conditions, battery state-of-charge, and vehicle dynamics [10].

Integration with Vehicle-to-Grid (V2G) Systems: Regenerative braking systems can be integrated with Vehicle-to-Grid (V2G) technology to enable bidirectional power flow, allowing electric vehicles to store and discharge energy from the grid, thereby supporting grid stability and renewable energy integration [17].

Materials and Component Innovations: Advances in materials science and engineering may lead to the development of more efficient regenerative braking components, such as high-performance regenerative braking systems [18].

Machine Learning and Artificial Intelligence: Machine learning and artificial intelligence techniques can be applied to optimize regenerative braking control strategies, leveraging real-time data and predictive analytics to enhance energy recovery and efficiency [19].

Dynamic Energy Management Systems: Future electric vehicles may incorporate dynamic energy management systems that intelligently allocate energy between propulsion, braking, and ancillary systems to maximize overall vehicle efficiency and performance [20].

These future directions and innovations hold the potential to further improve the efficiency, reliability, and effectiveness of regenerative braking systems in electric vehicles, contributing to the continued advancement of sustainable transportation technologies.

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Smart Home Technology using FPGA

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Abstract- Focusing on FPGA-based home automation with the Basys 3 board, this project integrates sensors for temperature monitoring, door status detection, and remote-controlled operation of an LCD projector. Verilog programming facilitates real-time temperature monitoring, activating fans as necessary. Reed sensors detect door openings, automatically triggering light activation for enhanced convenience and security. Through FPGA control, users can remotely operate the LCD projector, enhancing home entertainment system flexibility and accessibility.

Keywords: Home Automation, FPGA Board, Verilog, Security

I.INTRODUCTION

The modern era witnesses the convergence of advanced technologies, ushering in an era of smart living. Homes equipped with intelligent systems redefine comfort, convenience, and energy efficiency. Among these, Field-Programmable Gate Arrays (FPGAs) offer versatility and adaptability, providing a robust platform for sophisticated automation solutions.

In this paper, we present an FPGA-based home automation system developed using the Basys 3 board, aimed at addressing the diverse needs of contemporary households through innovative sensor integration and intelligent control mechanisms. A fundamental aspect of our FPGA-based home automation system is real-time temperature monitoring. By integrating temperature sensors with the Basys 3 board, our system offers homeowners insights into ambient temperature levels. This enables optimization of indoor comfort and implementation of efficient climate control strategies, contributing to energy savings by ensuring judicious use of heating and cooling systems.

In addition to temperature monitoring, our system integrates intelligent lighting control mechanisms triggered by door activity. Through reed sensors and FPGA logic, the system detects door openings and adjusts lighting accordingly. This proactive lighting automation enhances convenience and energy efficiency, tailoring illumination to household occupancy patterns while minimizing unnecessary energy consumption.

Our FPGA-based solution extends its capabilities to include advanced functionalities such as remote-controlled LCD projection. Utilizing the processing power of the Basys 3 board and wireless communication protocols, users can remotely activate and control an LCD projector, transforming any space into a versatile multimedia environment. This feature adds entertainment value and demonstrates the flexibility and scalability of FPGA-based home automation solutions.

Central to implementing our FPGA-based home automation system is the use of Verilog programming language. Leveraging the flexibility and scalability of Verilog, we developed a robust codebase orchestrating system components with precision and efficiency. This programming paradigm empowers us to harness FPGA technology's full potential, customizing system functionality to suit specific user requirements for seamless integration and optimal performance.

II. SYSTEM LEVEL MODELLING

The system model utilizes the Basys 3 FPGA board as the central processing unit to manage sensor inputs and control outputs. Sensors, including temperature sensors for climate monitoring and reed sensors for detecting door status, interface directly with the FPGA.

For temperature monitoring, the FPGA continuously reads sensor data and processes it using predefined thresholds to trigger fan activation when temperatures exceed specified limits. Similarly, reed sensors provide input to the FPGA, allowing the system to respond to door openings by controlling connected lighting fixtures.

Additionally, the FPGA manages the interface with an LCD projector for remote-controlled multimedia display. By interpreting wireless commands received from a remote or mobile application, the FPGA activates the LCD projector and coordinates the selection and playback of multimedia content.

The entire system operates through the FPGA's

programmed logic, which handles sensor data interpretation, decision-making based on predefined rules, and actuation of connected devices. This approach ensures efficient and responsive home automation tailored to user preferences and environmental conditions.

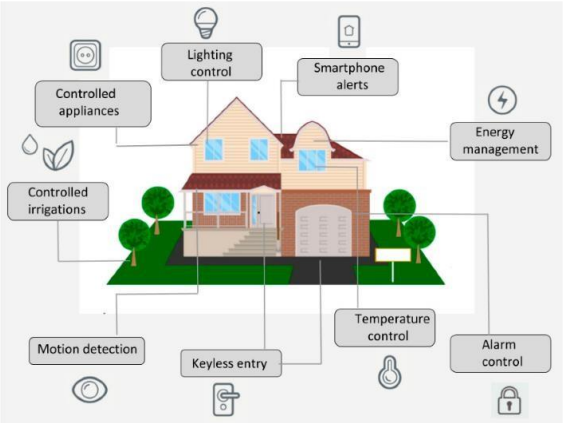

Fig 1: Model

All sensors used in the system, including the IR sensor and the reed sensor, are directly integrated into the FPGA board. The FPGA board serves as the physical support for the development platform, offering seamless integration with standard FPGA synthesis and implementation tools. Specifically, the system utilizes the latest Artix-7 Field Programmable Gate Array (FPGA) from Xilinx, mounted on the Basys 3 board. This FPGA board features 1,800 Kbits of fast block RAM, an on-chip analog-to-digital converter, 16 user switches, 16 user LEDs, and a 4-digit 7-segment display. The signal from the IR sensor is processed through the Pmod JB input port.

III. LITERATURE SURVEY

In this literature survey we embark on an exploration of the burgeoning field of FPGA-based home automation systems, aiming to elucidate the current state-of-the-art and identify key trends and challenges. First paper we reviewed "FPGA—based assistive framework for smart home automation" Md Sharif Ahmed, Ratri Mukherjee. Prosenjit Ghosh, SK Nayemuzzaman Department of Electrical Engineering 2022 IEEE l5th Dallas Circuit and System Conference (DCAS)| 978-1-6654-9885-2/22/$31.00 Ö 2022 IEEE| DOI: 10.1109/DCAS53974 .2022.9845625, this study presents a reconfigurable framework for automated home security and monitoring, leveraging FPGA technology and integrating sensors for fire safety and anti-theft measures.

"FPGA-based embedded architecture for IoT home automation application" Chee-Pun. Ooi, Wooi-Haw. Tan, Soon-Nyean. Cheong, Yee-Lien. Lee, V. M. Baskaran, Yeong-Liang. Low Faculty of Engineering, Multimedia University, Malaysia Indonesian Journal of Electrical Engineering and Computer Science ρ 646 Vol. 14, No. 2, May 2019, pp. 646~652 ISSN: 2502-4752, DOI: 10.11591/ijeecs. v14.i2. pp646-652, This project presents an IoT FPGA-based home hub for automating home operations, leveraging FPGA technology and an IoT platform. Through Verilog HDL programming and WIFI extension, it enables sensor integration and user-configurable control rules for diverse home environments.

"Home Automation through FPGA Controller" Madhuri R Mukkawar Student, Dept.of E&TC NBN Sinhghad School Of Engineering Pune, India International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 3, March – 2014, this paper delves into the integration of network-enabled digital technologies for advancing home automation, presenting a design implemented in VHDL on FPGA. Leveraging GSM communication and SMS-based interaction, the system aims to enhance living standards through wireless technology.

"IOT BASED HOME AUTOMATION USING FPGA" 2022 IJCRT | Volume 10, Issue 4 April 2022 | ISSN: 2320-2882, IoT has transformed home automation, allowing smartphone control of appliances and long-distance data exchange via Wi-Fi, benefiting users with enhanced accessibility and precision.

"IoT based home automation using FPGA" International Journal of Advanced Research, Ideas and Innovations in Technology ISSN: 2454-132X Impact Factor: 6.078 (Volume 7, Issue 5 - V7I5-1243), IoT technology is reshaping lifestyles, enabling seamless control of home appliances via smartphone apps and Wi-Fi connectivity, facilitated by FPGA for secure and flexible device integration.

IV. METHODOLOGY

The methodology for implementing the FPGA-based home automation system involves several key steps. First, the hardware components, including the Basys 3 FPGA board, temperature sensors, reed sensors, and LCD projector, are assembled and connected according to the system design.

Next, the FPGA programming environment, such as Vivado, is utilized to develop the hardware description language (HDL) code, specifically Verilog, for interfacing with the sensors and controlling the output devices. This code defines the behavior of the FPGA in response to sensor inputs and external commands.

Once the Verilog code is developed, it is synthesized, implemented, and verified using simulation tools to ensure correct functionality and performance. This step involves testing the code under various scenarios and conditions to validate its effectiveness in managing sensor data and controlling connected devices.

After verification, the FPGA design is synthesized onto the Basys 3 board, and the hardware components are integrated into the home environment. This includes installing temperature sensors in strategic locations, such as living spaces and bedrooms, and mounting reed sensors on doors to detect openings.

Finally, the system is tested and evaluated in real-world conditions to assess its reliability, responsiveness, and overall performance. Any necessary adjustments or optimizations to the FPGA code or hardware configuration are made based on the test results to ensure optimal functionality of the home automation system.

4.1 Block diagram

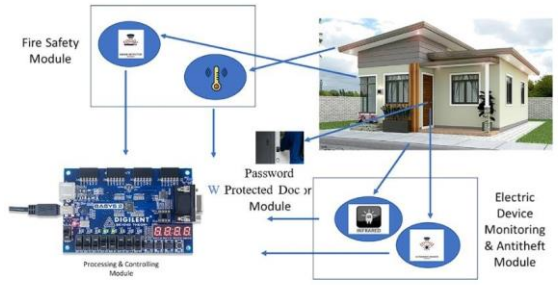

Fig 2. Block diagram of the proposed framework

In this block diagram, home automation is proposed with 2 main features such as Electronic Device monitoring & Antitheft Module, and a Password Protected Door Module. In our block diagram figure 2, a module of the virtual house has been considered. The outputs are initiated to zero. The inputs of our system include room door IR sensor, room windows IR sensor, room door ultrasonic sensor, Door lock module which are essential modules for smart home automation and assisted living. All input signals contain data such as a password to turn ON and OFF security, door, and window are in input to the IR sensor, clocks for clock input, and so on. FSM reset is going to be implied to restart the state machines and transition between each module. The output signals include door condition for opening and closing of a door, window status for opening and closing window, output on entering the wrong password. The FPGA is programmed using the hardware description language, Verilog. FPGA has multiple timing domains and there are plenty of asynchronous errors. These kinds of circumstances occur when different kinds of specific data patterns exist. It is difficult to include multiple sensors in a single FPGA platform due to the lower number of input-output ports. Also, Basys 3 FPGA board does not come with an integrated GSM, Wi-Fi module. Having so many limitations, our main challenge is to incorporate multiple sensors like IR, PIR, Ultrasonic, Temperature, and Gas sensors in a single platform which is rarely seen in the FPGA platform. This research will not only be used in home security but can also be installed in offices, schools, medical hospitals, and others.

V. RESULTS AND DISCUSSION

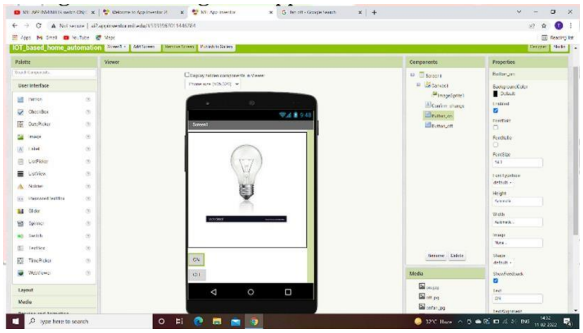

Fig 3. MIT app

The output of the FPGA-based home automation project encompasses both tangible and intangible aspects, culminating in a comprehensive enhancement of the residential living experience. Tangibly, the project delivers a fully operational home automation system adept at monitoring and regulating various facets of the domestic environment. This includes functionalities such as temperature sensing, door status detection, fan control, and remote operation of the LCD projector. Through precise sensing mechanisms and efficient control algorithms, the system demonstrates its capacity to accurately perceive environmental conditions and enact appropriate responses to ensure optimal comfort and convenience for occupants.

Beyond the realm of physical functionalities, the project yields intangible benefits that significantly augment the quality of life within the home. Through seamless integration with the MIT application, users gain unprecedented levels of convenience and accessibility in managing household devices remotely. Whether adjusting thermostat settings on-the-go or activating lighting systems upon entry, the automation system streamlines daily routines, fostering a more comfortable and efficient domestic lifestyle. Moreover, by automating repetitive tasks and optimizing resource utilization, the system contributes to improved energy efficiency and sustainability practices, aligning with contemporary trends towards eco-conscious living.

In essence, the output of the FPGA-based home automation project extends far beyond mere technological prowess, encompassing a holistic transformation of the residential living environment. By seamlessly intertwining cutting-edge sensor technologies, intelligent control mechanisms, and user-friendly interfaces, the system not only empowers users with unprecedented levels of control and convenience but also fosters a deeper sense of harmony and well-being within the home. As a testament to the transformative potential of smart automation technology, the project sets the stage for a new era of domestic living characterized by enhanced comfort, efficiency, and sustainability.

VI. CONCLUSION

In conclusion, the FPGA-based home automation project represents a significant leap forward in residential living, offering a comprehensive suite of features designed to enhance comfort, convenience, and energy efficiency. Through seamless integration of sensor technologies, intelligent control algorithms, and user-friendly interfaces, the system provides users with unprecedented levels of control and accessibility, ultimately redefining the modern domestic experience. As smart automation continues to evolve, this project serves as a testament to the transformative potential of technology in shaping the homes of tomorrow.

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Enhancing Electric Vehicle Performance: An IoT-Based Approach for Real-Time Battery Monitoring and Management-A Review

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***Abstract*—** The Battery-operated vehicles (BOVs) have become prominent today when compared to the IC engine vehicles as they are energy efficient and also are environment friendly. However, for optimum performance of the vehicle, the health and the battery's effectiveness must be routinely checked. To prevent unplanned malfunctions, the batteries to be replaced in time. In this paper, we are reviewing an IoT-based approach to monitor the battery in real time. So, In the way of monitor battery parameters including voltage, current, temperature, state of charge (SoC), and state of health (SoH), this system includes sensors.The sensor data can be transmitted to a centralized IoT platform, where advanced analytics and machine learning algorithms can be employed to assess battery health and predict remaining useful life (RUL) of the battery. When a battery reaches the last of its life cycle or shows signs of degradation, the system triggers alerts for timely replacement.

Keywords—IoT, battery-operated vehicles, battery monitoring, battery replacement, predictive maintenance, machine learning, Electric Vehicles (EV's).

I. INTRODUCTION

Electric cars (EVs) are becoming a more viable option. to the environmental and energy challenges associated with traditional fossil fuel-powered vehicles. EVs uses the different type of electrical motors like DC Motor, BLDC motors, Induction Motors etc, instead of internal combustion engines in their vehicles. which are recharged by batteries or other energy storage systems which provide a lot of advantages over the vehicles run by internal combustion engines. Primarily, as they emit zero emissions when in operation, EVs help to reduce air pollution and CO and CO2 gases.

TABLE I. ASPECTS OF EV'S

Aspects	Description
Environmental Benefits	As they produce no greenhouse gases or air pollutants from their tailpipes, the quality of the air is enhanced.
Energy Efficiency	They consume lower energy per kilometer travelled; They are therefore more energy-efficient
Performance	Electric motors give an instant torque which gives a quick acceleration thereby making the driving ranges more enhanced
Government Incentives	The Government is providing tax credits, subsidies in order to promote the use of electric automobiles.

This environmental benefit in many urban areas where vehicle emissions are a high due to this air quality index will be low. Additionally, EVs boast of a higher energy efficiency compared to internal combustion engines, as they consume less energy and also offer the benefit of low fuel costs for its consumers. Moreover, electric motors produces the instantaneous torque, resulting in smooth and responsive acceleration, enhancing the driving experience. As governments and industries worldwide prioritize sustainability, the implementation of EVs is accelerating, supported by incentives and investments in charging infrastructure Electric vehicles have the potential to significantly influence the future aspects of transportation by directing the sustainable modes of mobility, thanks to continuous breakthroughs in battery technology and rising consumer awareness.

II. BACKGROUND

A. Importance of Electrical Vehicles using IoT

With environmental issues and Since fossil fuel supplies are running low, it is more important than ever to find viable IC engine alternatives. Electric Vehicles(EV's) have become a viable option, providing environmentally friendly mobility while trying to keep costs down, dependability up, and performance high. EV's has major problem with charging time and battery range.

They usually have shorter driving ranges and slower recharge periods than conventional ICE cars. Using the Internet of Things (IoT), manufacturers are able to get around these challenges. They significantly contribute to the reduction of carbon emissions, air pollution, and the growing problem of changes in the climate by replacing the burning of fossil fuels with electricity finally, but just as importantly, operating an EV

is relatively less expensive. Fuel prices are lower and electricity instead of petrol or diesel. EVs offer potential long- require low maintenance because they have fewer moving components, which eventually makes them a more financially attractive solution.

B. Leading IoT Applications in Electric Vehicles

Connectivity in vehicles

Real-time data collection on the battery range of vehicle performance factors, including engine condition, tyre pressure, battery health, and more, is made possible by IoT technology. The vehicle's overall health and optimal operation may be monitored by processing and analyzing this continual stream of data.

Predictive maintenance

EV's may now connect directly to charging stations thanks to Internet of Things (IoT) technology. This simplifies the charging process and automates identification of the car at the station, starting the charging process, and managing the invoicing process digitally without human participation.

Energy Management

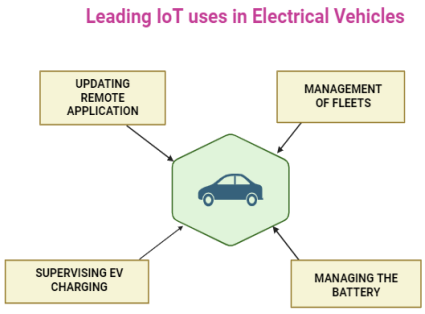
IoT systems can monitor and control energy use in several car components, such the lighting, air conditioning, and powertrain, using real-time data analytics. By making sure energy is used as efficiently as possible, this fine-tuning contributes to the vehicle's increased range.

EV charging management

Infrastructure for EV charging may be remotely managed and monitored thanks to Internet of Things technologies. This feature enhances the user experience by guaranteeing that charging stations are available and operating properly when needed. It also gives operators the ability to maximize utilization.

EV Battery Power

In EV sector the performance of battery is crucial, hence battery size, portability, reliability must be considered in the design of EV's. The charging of vehicle is divided into 3 level, level 1 low charging in 1.9 KW, Level 2 is medium charging 1.6KW, Level 3 charging is the fastest charging method with charging power levels reaching up to 100 KW. The charging stations differ for personal use, and commercial applications like malls or any other. Micro grid is an alternative solution with use of renewable energy-based approach.



Another important approach is through EVSE (Electric vehicle supply equipment), which is the basic unit of the EV charging infrastructure. The EVSE uses a control methods and a connected connection to safely charge the electric vehicles by depiction power from the nearby electrical grid.

Swapping of EV batteries also have the advantage of speed and quick charging. The center or base station will have charged batteries and the batteries can be swapped whenever and wherever required. The swapping station will have a dedicated park area for battery replacement.

III. LITERATURE REVIEW

A. Electric Vehicles batteries: Requirements and Challenges

In this paper [Jie Deng,et,al] they have analyzed various components for battery and have concluded battery Essential parameters of Electric vehicles. Factors required and considered for Implementing Batteries in Electric vehicles are :

Energy Density

Distant marker is one among the important parameter of EV selection EVs [1] and it is controlled by battery energy densities.

Cost

Cost is the important parameter for sale and purchase of EV. If the vehicle is budget friendly it is used by the consumers.

Fast Charging and Power Capability

Charging and its durability is a great concern, since battery life will define the distance covered.

Lifespan

The battery life span is other concern. It should have temperature stability to avoid any unpleasant event due to heat.

Environmental Conditions variations

Battery is consisting of chemicals, which may react with component, or changes of formation of ions, which may effect the charge and discharge of Battery in EV.

Safety

EVs are for wellbeing of both Human being and environment so it is to be designed considered all safety parameters.

Challenges

1. The first design constraint is to add multiple blocks into a system.

2. The second point is accurate calculation of each parameter of vehicle and parameters. A battery consist of various stages inside should be accurately assembled.

EVs are good perspective for green technology with low cost. The development and enhancement can be achieved by proper Government supporting policy and Battery base station installation. BSS will give an easy and helpful environment for the EV. [1]

B. Battery Exchanging terminal for charging based vehicles

The swapping techniques are divided on the basis of placement of battery in vehicle. The following techniques were emphasized for using swapping techniques [Furkan Ahmed,et.al,2020]

- Side swapping can be used in van and other vehicles where it provides comfort at side arm.
- Rear Swapping typically used for vehicles where battery position is at back.
- Bottom swapping typically used for vehicles where battery position is at bottom.
- Top swapping mostly used in top position of battery position for vehicles like bus.

Design and placement of terminal for swapping need to consider all of the above parameters. Considering all the above parameters a terminal incorporating new technology such as block chain and IoT, will give boost and accuracy to design a base station for swapping.

Battery Swapping Station strategies are increasing as the best solution to the traditional battery charging station techniques since they are giving vast employment opportunities to the involved team members Battery Swapping Station strategies are increasing as the best solution to the traditional battery charging station techniques since they are giving vast employment opportunities to the involved team members.

Merits

- Employment opportunities are increased
- Green technology

Demerits

- Difficulty in selection of place for BSS
- Vehicles based approach need to be considered, it increases complexity

C. IoT based battery management system in electric vehicles.

This paper discusses the concept of implementing IoT to monitor the performance of the battery directly [6]. Earlier Monitoring systems will do the life cycles of the battery and alerted the user using the battery indicator within the vehicle. By implementing IoT both the manufacturers and users can be informed about status of the battery

The methodology implemented a battery monitor device and interface for monitoring the battery. The proposed system is also used to locate the condition of battery life and vehicle location.

Further development or future scope is to develop a smartphone application which alerts the user if the battery damages and monitors the battery performance.

Electric vehicles rely entirely on the battery performance. A battery management system is needed to continuously monitor and manage the filling and draining of the battery management systems [5]. The battery management systems keep track of metrics of battery like battery voltage, current and the temperature when it charges and discharges. Li On batteries system are used by electric vehicles which are prone to excessive heating which can detoriate the life of the battery. To monitor the battery performance such that the user is alerted for further actions the concept of IoT is integrated.

This paper explores two varieties of Battery monitoring systems.

1. BMS used as a monitoring unit where the unit uses sensors to be linked to the equipment like humidifiers, lights and fan controls.
2. BMS used as a control unit have a control of the On/Off condition of the switches and the scheduled chores.

It also discusses the integration of IoT with the battery system using the ‘Blynk Application ‘

Future scope: The monitoring technique maybe implemented for other parts of the electric vehicle like the bearing and engine.

The Battery Management System can be improved using the below methodologies:

[A] MeshNet gateway topology and LR parameter estimation [3]

To increase fault tolerance, LR estimation is utilized to predict SOH and SOC with accuracy. To achieve accurate peak power estimation while adhering to operational restrictions, a SOP estimator has been created. An IoT platform uses MeshNet routing and efficient node selection to transport data. The experimental results demonstrate a notable improvement in performance over the current approaches

Merits

1. Enhanced Accuracy: LR parameter estimation improves the accuracy of SOC and SOH parameters

predictions, which are essential for efficient battery management.

2. Effective Peak Power Estimation: Taking operational restrictions into account, the SOP estimator guarantees accurate peak power estimation.
3. Reliable Data flow: For real-time monitoring, the MeshNet gateway topology guarantees dependable and effective data flow.
4. Improved Performance: The outcomes of the trials indicate notable enhancements in the system's functionality.

Demerits

1. Complexity: The MeshNet gateway architecture and LR parameter estimate may lead to an increase in implementation complexity.
2. Resource Consumption: Increasing processing and communication overhead may reduce the effectiveness of the system.
3. Integration of MeshNet gateway nodes and LR communication modules may present deployment difficulties.
4. Cost: By adding to the BMS's expenses, the use of sophisticated approaches may discourage adoption.

This research offers a viable method for enhancing the battery management of electric vehicles in an Internet of Things framework by utilizing MeshNet gateway architecture and LR parameter estimation. The approach exhibits notable improvements in performance while maintaining an emphasis on efficiency and accuracy. However, for real implementation, factors like complexity, resource consumption, deployment concerns, and cost must be taken into account. All things considered, it provides a strong means of improving battery management in electric cars; nonetheless, more investigation and improvement are required before practical use.

[B] Block chain IoT for Smart Electric Vehicles Battery Management

In this work a comparative research method was employed Utilizing this strategy, a specific problem or goal is addressed by contrasting two alternative strategies or implementations. This paper compares two block chain-based implementations of EV battery management systems (BMS)[4]: one that leverages a directed acyclic graph (DAG) on top of the IOTA tangle, while the other uses Ethereum as the block chain framework. These two approaches' efficacy, efficiency, decentralization, scalability, and data integrity are all to be assessed and contrasted in this research.

Merits

1. Relevance: Addresses the incorporation of block chain technology into the Electric Vehicle (EV) systems, a current and important technological challenge.
2. Interdisciplinary: Combines concepts from EV technology, battery management systems, and block chain, offering a comprehensive approach.
3. Innovation: Proposes innovative solutions to improve EV charging and battery swapping efficiency using block chain technology.
4. Comparative Analysis: Involves comparing Ethereum and IOTA implementations for EV BMS, providing valuable insights for decision-making.
5. Practical Implications: Discusses real-world applications such as enhancing the management of the batteries and expanding charging networks, with potential significant impacts.

Demerits

1. Limited Methodological Detail: The study's credibility and repeatability may be compromised by the abstract's lack of precise information about the research methodology, data collection procedure, and analytic tools used.
2. Lack of discoveries: The comparison between the Ethereum and IOTA implementations yielded no insights or discoveries, therefore readers are left in the dark about the significance of the research findings.

Through scrutinizing the application of block chain technology in Electric Vehicle (EV) Battery Management Systems (BMS), the article seems to tackle a significant and relevant problem. The comparison of the IOTA and Ethereum implementations offers value by highlighting the advantages and disadvantages of each strategy. Notable flaws include the ambiguous conclusion, lack of findings, and inadequate technique explanation. These elements could lessen the overall impact and readability of the work since readers can doubt the relevance and assessing the validity of the research if they don't know enough about the methodology and findings.

[C] Battery Management System for Electric Vehicles Using "Deep Learning-Based Sensor Fault Detection" methodology.

This methodology involves implementing various algorithms into the vehicle's Electronic Control Unit to enhance the efficiency of the electric vehicle [7].

This process involves the following steps, which is collecting the data from various sensors, preprocessing the data using Z-score, using two deep learning algorithms which is Sparse Principal Component Analysis(SPCA) to average the dataset to get values to enhance the efficiency of the battery and Marine Predator Algorithm to sort out the important data from the dataset and sends it for performance analysis.

Future Scope:

Developing a Smart Battery Management System (BMS) for Electric Vehicles (EVs) employing Deep Learning-based sensor fault detection is promising. This innovative approach offers enhanced safety, reliability, and efficiency by accurately identifying and mitigating sensor faults in real-time. Integration of deep learning algorithms enables adaptive learning and continual improvement, contributing to the evolution of EV technology towards safer and more robust

battery management systems, fostering widespread adoption and sustainability in the automotive industry.

Table 2: Comparison of Technology

Sl.No	Process or Technique applied	Parameters Considered
1	Monitoring and managing the battery based system of Electric vehicles using IoT	Sensors, GPS,GSM Ardino SIM 808,Focuses on Humidity,temperature and monitoring the sensors
2	Managing the battery system using Deep learning approaches	Based on BMS on EV with incorpated safety features
3	MeshNet gateway topology	Used AI techniques and machine learning algorithm to advance the system.
4	Battery Management using Blockchain IoT.	Providing immutable and transparent battery health records using block chain.

IV. CONCLUSION

Electric vehicle is future of the world. Replacing petrol and diesel with renewable source can result in eco-friendly and pollution free environment for generations to come. The most recent is block chain due to its numerous advantage and speed and flexibility. The comparison of technology reviewed is as shown in Table 2.

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[5] IoT-Based Battery Monitoring System for Electric Vehicle Mohd Helmy Abd Wahab*,1,5, Nur Imanina Mohamad Anuar1, Radzi Ambar1, Aslina Baharum2, Shanoor Shanta1, Mohd Suffian Sulaiman3, Shukor Sanim Mohd Fauzi3, Hafizul Fahri Hanafi4

[6] Blockchain IoT for Smart Electric Vehicles Battery Management Bogdan Cristian Florea *,ORCID and Dragos Daniel Taralunga.

ENHANCING SAFETY FOR VISUALLY IMPAIRED PERSON

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Vemana Institute of Technology

Abstract: ***When we are unable to use our own eyes to navigate through an unfamiliar situation, it can be extremely difficult. People who are visually impaired deal with this issue daily. Typically, they use a walking stick to guide them. Through basic tactile force input, they use the walking stick to detect static objects on the ground, stairs, holes, and uneven surfaces. Despite being small and lightweight, its range is constrained by its own dimensions, making it unsuitable for use with dynamic components. To help visually impaired persons walk more confidently, this study focuses on designing a Smart Walking Stick that employs the Node MCUESP32 to provide information about their surroundings. By using ultrasonic sensors to identify and notify people of impending hazards such as pits and stairs, walking accidents can be decreased. The stick is configured to automatically establish a Wi-Fi connection with the Android phone to transmit sensor data and provide audio feedback to the user.***

Keywords: Ultrasonic Sensor, Node MCU (ESP8266), Fire Sensor, Piezoelectric Sensor, ESP32 CAM, Buzzer,

I. INTRODUCTION

Visual debilitation, also known as vision impairment or visual misfortune, is a partially reduced ability to see that results in problems that cannot be resolved with conventional treatments, such as spectacles. Some also include those with reduced vision because they avoid using glasses or making eye contact with objects. The most regrettable corrected visual sharpness of 20/40 or 20/60 is typically used to describe visual weakness. The word "visual deficiency" refers to the misfortune of whole or nearly complete vision. Visual impairment may lead to problems with traditional routines, such as examining and moving around flexible preparation and equipment. Geographical differences in vision deficit are most commonly attributed to uncorrected refractive errors (43%), waterfalls (33%), and glaucoma (2%). Astigmatism, farsightedness, presbyopia, and partial blindness are examples of refractive errors. The most well- known cause of vision impairment is waterfalls. Age-related macular degeneration, diabetic retinopathy, corneal obfuscating disorders, juvenile visual deficiencies, and other conditions are among the many conditions that can result in vision problems. Visual deficiencies can also result from mental health problems brought on by stroke, early pregnancy, trauma, or other conditions. We refer to these situations as cortical visual impedance. Examining young people for visual Problems may help them acquire better vision and information in the future. Adult screening without symptoms has questionable benefits. An eye test is used for examination.

1.1 What Is Visual Impairment

Visual debilitation, also known as vision impairment or vision misfortune, is a partial loss of vision that results in problems that cannot be resolved with standard treatments like spectacles. Some also include those with reduced vision because they avoid using glasses or making eye contact with objects. Typically, visual weakness is defined as having a best corrected visual sharpness of 20/40 or 20/60, which is more disappointing than either one of the other. If you have trouble seeing completely or almost completely, you are said to have a visual deficiency. Visual impairment may lead to problems with traditional routines, such as examining and moving around flexible preparation and equipment. Errors in refractive errors are the most common causes of visual deficiencies between sides of the planet. waterfalls (33%), glaucoma (2%), and 43%. Astigmatism, farsightedness, presbyopia, and partial blindness are examples of refractive errors. The most common cause of vision impairment is waterfalls. Age-related macular degeneration, diabetic retinopathy, corneal obfuscating disorders, juvenile visual deficiencies, and other conditions are among the many conditions that can result in vision problems. Like mental impairment, visual deficiencies can also result from stroke, premature birth, trauma, and other mental health conditions. We refer to these situations as cortical visual impedance. Examining young people for visual problems may help them see better and learn more in the future. Adult screening without symptoms has questionable benefits. An eye test is used for examination.

1.2 What Qualifies Someone as "Blind"

An innate and pediatric ocular infection known as expanded pressing factor inside the eye, or intraocular pressure (IOP), is the cause of visual impairment. It is the same thing that impairs the visual field as it does the optic nerve. Patients with glaucoma should be diagnosed and treated as soon as possible since the condition is triggered by ambiguous IOP readings. Moreover, another glaucoma has four causes,
which can be tested for accurate diagnosis:

- Induced by corticosteroids.
- An incongruous element associated with initial alteration and enduring exacerbation.
- Inflammatory Ocular Hypertension Syndrome.

1.3 Common Impairment Scenarios

The challenge of walking from one area to the next independently is one of the main things preventing people with vision impairments from participating in public life and being free. To navigate independently, they must continuously adjust their orientation and location to avoid obstacles and hazards. This can be dangerous and distressing, and it can increase theattentional load, especially.

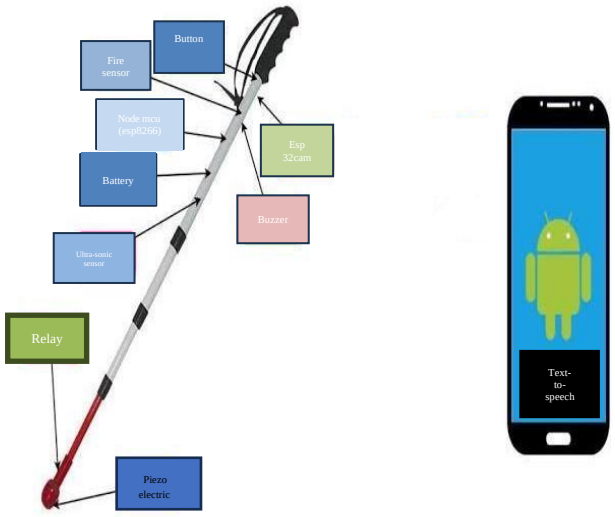

Fig.1: Smart Blind stick

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II. LITERATURE REVIEW

A. Mukesh prasad Agarwal & Atma Ram Gupta published a paper on smart stick for the blind and visually impaired,[1].

This device serves as a blind person's auxiliary senses, which is a very useful invention. Its straightforward design is entirely geared toward everyday use. It doesn't even need large machines for mass production. The aforementioned information allows us to confidently draw the following conclusions: The smart stick is an electronic guiding device that is inexpensive, straightforward, and designed to help blind and visually impaired people in a positive way. The gadget is effective and special in that it can identify the origin and distance of objects that blind people can come across. Regardless of the depth or height, it can scan to the left, right, and in front of the blind person. It is a helpful tool that may fulfil the project need the project's gadget makes use of the newest sensors available to help those who are visually impaired. The traffic detector is the project's primary innovative feature. The user can locate the traffic around him by using the stick's vibration, which is triggered by the proximity of an approaching car. Among the project's crucial elements are Dimensions: With so many capabilities, it's a moderately sized stick that is still useful and won't restrict the user's movement. Power: It runs on a rechargeable Li-ion battery that has a minimum 12-hour lifespan. Cost: All of these features are available at a low price, making it a very cost-effective device. We designed it with the low income of average Indian families in mind, so it would be reasonably priced.

B. Akshay salil Arora & Vishaka Gaikwad published paper on Blind id Stick. [2].

In this paper for Blind id stick for those who are blind or visually impaired, this article provides the concept and system design of an intelligent and user-friendly blind aid stick. The architecture and system design are straight forward and user-friendly, with an emphasis on efficiency. For the millions of blind individuals around the world, it can therefore offer an affordable gadget. Further increasing efficiency and lowering complexity is the variable duration buzzer. Increased obstacle ranges can be achieved by modifying the project, and accuracy will rise as GPS technology develops. The development of improved applications for ongoing environmental assessment will be aided by the advancement of mobile technology. Wi-Fi technology and its potential be integrated with IOT so that functions like traffic forecasting and whether can aid in the blind person's improved evaluation.

C. Sandesh chinchilla & Samir patel published paper on Artificial Intelligence and Sensors Based Assistive System for the Visually Impaired People. [3].

This paper discusses the design and development of a real-time artificial intelligence system to help blind and visually impaired individuals. The system enabled the user to freely navigate his journey by completing three key tasks: obstacle detection, collision detection, and picture recognition. Using widely used gadgets like smartphones and small-sized, high-quality hardware, our solution overcame the challenge of creating an assistive technology that was effective and reasonably priced for visually impaired individuals, particularly those from low-income homes. The user uses his smartphone to take pictures of his surroundings in order to gain some sense of them. Following the processing of these photos by the smartphone application's artificial intelligence, captions summarizing each image's contents are generated. The user is then provided with these subtitles via the smartphone reading them aloud via its speakers. The user receives audible input to adjust his route and avoid collisions with barriers once the ultrasonic sensor on the front side of the stick locates impediments that are appearing in front of him. Together with the accelerometer, the other ultrasonic sensor at the bottom of the stick finds potholes and other obstacles in the user's path, eventually informing the user via feedback to alter their course.

D. Reshma Vijay Jawale, Madhavi Vijay Kadam, Ravina Shanta ram Gaikwad & Lakshmi SudhaKondaka published paper on Ultrasonic Navigation based Blind Aid for the Visually Impaired. [4].

We have given a proposed system whose design model is controlled by an Android application. Voice instructions are used by the application developed in this article to operate. When the password is entered using voice command, the Android application is unlocked. Campus navigation and GPS navigation are the two options available once the software has been unlocked. Campus navigation is utilized in two modes: fixed route mode and hurdle detection mode. Following the selection of the campus navigation option, the Arduino Uno board's Bluetooth device is scanned. The Android phone is

linked to the scanned device. Via the Android application's Bluetooth sensor, all notifications intended for the blind are transmitted. The blind receive audio instructions via the Android application, which also translates text warnings into speech.

E. Yi-Qing Liu, Zhi-Kai Gao, Zhang-Jian Shao and Gu-Yang Liu published paper on Intelligent ultrasonic detection of walking stickd for the blind. [5].

By pushing the buttons on the walking stick and the bracelet— both of which are large, square, and easily accessible the blind man can easily operate the entire system. People who are blind can locate buttons with ease. The bracelet will alert the blind with a voice prompt after it has been initialized. Two ultrasonic detectors in the stick start to emit ultrasonic waves as the person is walking, and they use the echo to calculate how far away the obstacle is. The bracelet will vibrate to alert the user when the distance is less than three meters after the stick sends signals to it through Bluetooth. The vibration will intensify considerably when the impediment is less than one meter away, at which point the blind person can alter their gait to avoid the Stepper motor and angle sensor are added to the system in order to maintain the ultrasonic detector's forward detection direction; the angle sensor is utilized to retrieve the ultrasonicdetector's angle.

III. DESIGN METHODOLOGY

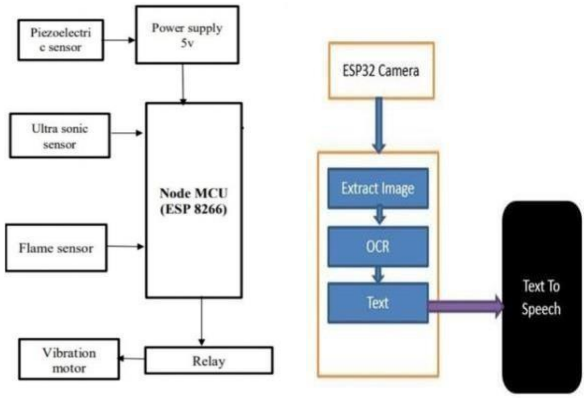

Fig. 2: Overview of enhancing safety for visually impaired person

The inventive Blind Stick was created for those who are blind or visually impaired. Here, we suggest a sophisticated blind stick that enables those with visual impairments to recognize obstacles. The ESP32 wifi camera and ultrasonic sensor are integrated into the blind stick. The image of the books, newspaper, money, bill, etc. is captured by the ESP32 camera and sent to the server for processing. Our suggested idea employs ultrasonic waves and ultrasonic sensors to identify impending obstructions. The sensor transmits this information to the microcontroller when it detects impediments. After processing this information, the microcontroller determines whether the obstruction is sufficiently close.

The circuit does nothing if the obstruction is not that close. The vibrator receives a signal from the microcontroller if the impediment is approaching.

IV. HARDWARE COMPONENTS

A. ESP8266 Node MCU Board.
B. Ultrasonic Sensor.
C. Piezo electric
D. Vibrator.
E. Flame sensor.
F. 5V Single Channel RELAY Module
G. ESP32 Camera

A. Node MCu ESP 8266

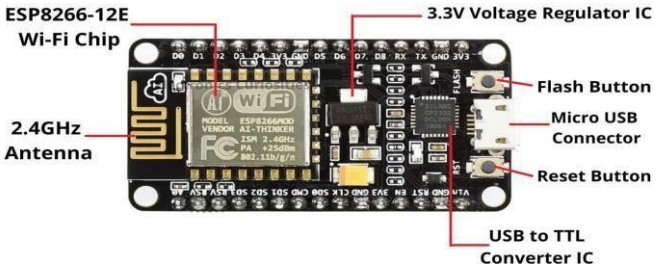

Fig. 3: Node MCU ESP 8266

The ESP8266 chip on the ESP8266 Node MCU CP2102 board, as depicted in figure 3. it is a highly integrated semiconductor created to meet the demands of an increasingly interconnected society. It provides a full and independent solution for Wi-Fi networking, enabling it to either run the application itself or transfer all Wi-Fi networking duties to another application processor. Through its GPIOs, the ESP8266 may be integrated with sensors and other application-specific devices with minimal coding required up front and minimal loading during runtime because to its robust on-board processing and storage capabilities. Because of its high level of on-chip integration, very little external circuitry is needed, and the whole system including the front-end module is made to take up the least amount of space on the PCB. For low-cost Wi-Fi projects, the ESP8266 Node MCUdevelopment board is a real plug-and-play option. Simply install the USB driver (see below) to get started; the module comes pre-flashed with Node MCU firmware. The ESP-12 Lua Node MCU Wi-Fi Dev Board is an Internet of Things board that comes in a package that is suitable for a breadboard. It includes a complete ESP8266 Wi-Fi module with all of the GPIO broken out, a full USB-serial interface, and a power supply. (“ESP8266 Module ESP-12E NodeMcu LUA WiFi Internet CP2102 New Version ...”) You can start the using of this board in a matter of minutes because it comes pre-flashed with Node MCU, a Lua-based firmware for the ESP8266 that enables simple control through the handy scripting language Lua. An all-in-one microcontroller + Wi-Fi platform, the ESP- 12 Lua Node MCU Wi-Fi Dev Board Internet of Things with ESP8266 is incredibly user-friendly for developing projects including Wi-Fi and IoT (Internet of Things) applications. The widely used ESP8266 WIFI Module chip with the ESP- 12 SMD footprint serves as the foundation for the board. The ESP8266 (ESP-12E) development board comes with all the

parts needed to write and upload code pre-installed. It features a logic level converter circuit, 3.3V regulator, and built-in USB to serial chip upload instructions.

Features:

1. 11 b/g/n Wi-Fi Direct (P2P), soft-AP
2. Integrated TCP/IP protocol stack
3. Use CH340G to replace the CP2102.
4. Arduino-like hardware IO
5. Integrated low power 32-bit CPU.

B. Ultrasonic Sensor.

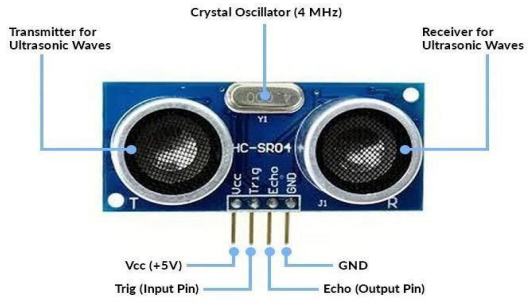

Fig. 4: Ultrasonic Sensor

Figure 4 illustrates how an ultrasonic sensor, like bats, uses the sonar to measure an object's distance. It provides exceptional non-contact range detection from 2 cm to 400 cm, or 1" to 13 feet, with high accuracy and reliable readings in an intuitive packaging. Though soft materials like cloth can be challenging to detect acoustically, the operation is unaffected by sunshine or dark materials. An ultrasonic transmitter and the receiver module are included. Sensor Ultrasonic The sensor HC-SR04 has a distance measurement capability. It releases an ultrasonic wave at 40000 Hz (40kHz) that travels through the atmosphere and returns to the module upon encountering an item or obstruction. You may compute the distance by taking the sound's speed and travel time into account. The HC-SR04's configuration pins include GND (4), TRIG (2), ECHO (3), and VCC (1). You can connect the TRIG and ECHO pins to any Digital I/O on your Arduino board, and the VCC supply voltage is +5V. To produce the ultrasound, we must place the Trigger Pin in a High State for ten seconds. That will cause an 8-cycle sound burst to be released, travel at sound speed and land at the Echo Pin. The sound wave's travel time, measured in microseconds, will be output by the Echo Pin.

C. Piezo electric.

Fig. 5: Piezo electric

In some materials, a phenomenon known as piezoelectricity occurs when mechanical stress results in the generation of an electric charge or vice versa. It was discovered in 1880 by Pierre and Jacques Curie and is used in many different technologies. Piezoelectric materials, such as quartz or some ceramics, undergo internal structural deformation in response to mechanical stress, which results in a potential difference across their surface. Piezoelectric sensors, actuators, and transducers utilize this characteristic. Sensors are used in accelerometers, pressure sensors, microphones, and other devices to detect mechanical impulses and translate them into electrical ones. Inkjet printers, ultrasonic cleaners, and nano positioners may all operate precisely because actuators translate electrical impulses into mechanical motion. Because of their efficiency and adaptability, piezoelectric materials are essential in consumer, medicinal, and industrial applications.

D. Vibrator

Fig. 6: Vibrator

Figure 6 illustrates a vibrator motor that can be utilized for small toys or any do-it-yourself project. These motors have an operational voltage range of 3V–6V, thus two AA batteries or a 5V USB power source can run them.

Features:

Maximum RPM: 10,000.
Shaft Diameter: 2 mm.
Operating Voltage Range: 3 to 6 VDC.
Weight: 15 gm per motor.

E. Flame sensor.

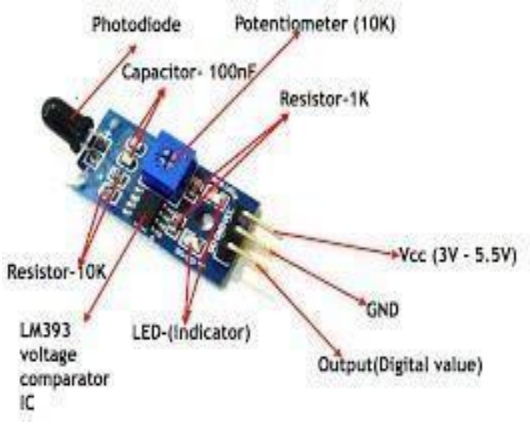

Fig. 7: Flame Sensor

Figure 7 illustrates a flame sensor that has a 700–1000 nm wavelength range for detecting infrared light. The light detected as infrared light is converted into current changes by the far infrared flame probe. The onboard variable resistor, which has a detection angle of 60 degrees, is used to modify sensitivity.

F. 5V Single Channel RELAY Module

Fig. 8: RELAY Module

This is an Arduino PIC AVR DSP ARM 5V single channel relay board module. It can be controlled by a variety of microcontrollers, including Arduino, AVR, PIC, ARM, and others. The module is triggered; the high trigger current is less than 5 mA; the output capability of 51 single-chip IO ports is partially deficient; pull or improve the circuit's drive capability. It can be utilized to operate home appliances or microcontroller development board modules.

Feature & specifications.

- Power supply indicator lamp.
- Control indicator lamp.
- Relay output status indicator.
- Operating Voltage: 5V.
- The current capacity of the relay contact at AC 250 V is 10 A, and at DC 5 V, it is also 10 A.

G. ESP32 CAMERA

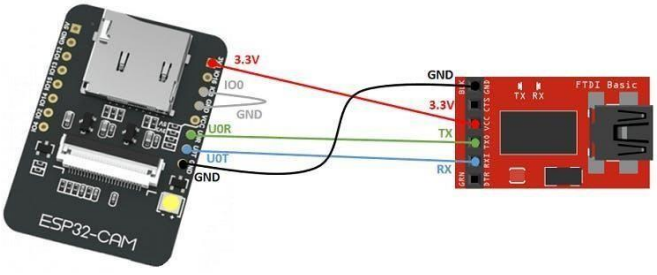

Fig. 9: ESP32 Camera

Based on the ESP32 microcontroller and an OV2640 camera module, the ESP32-CAM is a flexible and reasonably priced development board. It was created by Expressive Systems and is perfect for a range of Internet of Things, security, and image processing applications since it combines the capabilities of a camera with the power of an ESP32 chip. The ESP32-CAM is primarily equipped with the ESP32-S chip, which has dual-core processors, Bluetooth and Wi-Fi connectivity, a large number of GPIO pins, and support for multiple communication protocols. A 2-megapixel CMOS image sensor with video and image capture capabilities is integrated inside the OV2640 camera module. For projects that need embedded image processing and capture, the ESP32-CAM's tiny form factor and low power consumption make it a smart choice. The official development framework from Espresso if, called ESP-IDF, or the Arduino IDE can be used to program the ESP32-CAM may be used for a variety of activities, from straightforward ones like motion detection and remote monitoring to more intricate ones like object tracking and facial recognition. Its integrated Bluetooth and Wi-Fi technologies facilitate wireless communication, enabling data transfer and remote control. The ESP32-CAM is famous for its support of custom code or on-board algorithms for real-time image processing. This creates opportunities for on-device machine learning inference, object detection, and image filtering applications. The ESP32-CAM is a capable microcontroller, but it has drawbacks as well, like less RAM and flash memory than other microcontrollers. Its camera module could also not be appropriate for applications that need to operate in low light or with high resolution.

V. SOFTWARE COMPONENTS

A. Programming Language: C, Python, Java
B. IDE: Arduino IDE, Python IDLE, Net beans, Android Studio
C. Optical character recognition

A. C Programming

C is a high-level and versatile programming language suitable for creating firmware or portable programs. Dennis Ritchie created C for the Unix Operating System at Bell Labs in the early 1970s, initially for system software development.

B. Arduino IDE

The open-source Arduino Software (IDE) facilitates code creation and uploading to the device. This software is used to program Arduino boards. Sketches refer to programs created with the Arduino IDE. The drawings are created in a text editor and saved with a file extension. The editor supports cutting, pasting, and searching/replacing text. The message box shows error messages and provides feedback while saving and exporting. The console shows text output from the Arduino IDE, including error warnings and other information. The configured board and serial port are displayed in the bottom right corner of the window. (“GSM Based Motor Control System with Water Level Monitoring - IJRASET”) (“GSM Based Motor Control System with Water Level Monitoring - IJRASET”) The toolbar has buttons for verifying and uploading programs, creating, opening, and saving drawings, and opening the serial monitor.

- setup (): This function is called just once when a sketch starts after a power-up or reset.

It initializes variables, input and output pin modes, and other libraries required for the sketch.

- • Loop (): After calling setup (), the main program executes the loop () method continuously. It controls the board until it is turned off or reset.

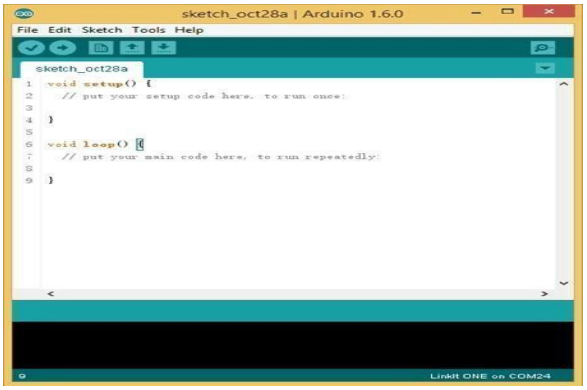

Fig. 10: Arduino IDE sketch

C. Optical character recognition

optical character recognition (OCR) converts a variety of document formats—including scanned paper documents, PDF files, and images—into editable and searchable text. To identify and extract text from pictures or scanned documents, this program uses complex algorithms and machine learning approaches.

The following functions are commonly included in OCR software:

- **Text Recognition:** Regardless of the font's style, size, or orientation, OCR software's primary job is to identify text characters found in pictures or scanned documents.
- **Image Preprocessing:** To increase recognition accuracy, OCR software frequently comes with capabilities for enhancing and preprocessing images, such as skew correction, contrast modification, and noise reduction.
- **Language Support**: A lot of OCR programs come with support for a wide range of character sets and languages, so users can process documents written in different languages using different writing systems.
- **Formats for Output:** OCR software can produce text that has been recognized in a number of formats, including plain text, searchable PDFs, editable Word and Excel files, and structured data formats like XML and JSON.
- **Batch Processing:** To save time and effort when digitizing huge volumes of content, some OCR software enables users to process many documents or photos at once.
- **Accuracy and Confidence Levels:** To help users evaluate the dependability of the OCR findings, advanced OCR software may include accuracy metrics and confidence levels for the identified text.

VI. APPLICATIONS

Makes it easier for blind persons to walk to the necessary location. aids in the identification of obstacles to protect the user. The sensor's attachment aids in warning the user of any obstacles or holds up ahead.

VII. IMPLEMENTATION AND RESULT

The experiments were conducted in order to assess the effectiveness of the suggested approach. The findings presented in this study mark the start of our attempts to develop a portable travel assist that enables people with vision impairments to navigate their daily surroundings. The sensor circuits provide information about the surroundings, as was previously explained.

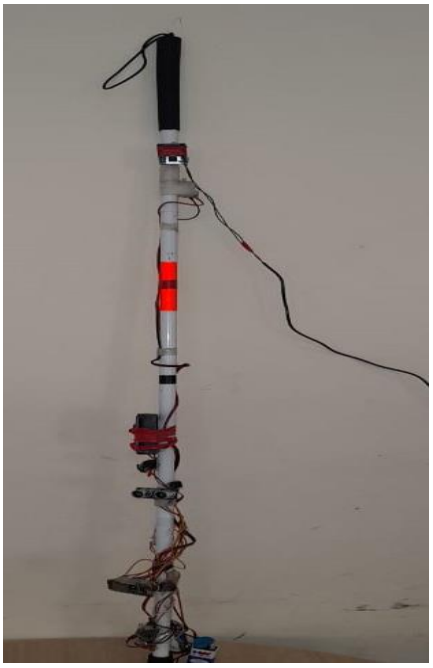

Fig. 11 Working Model

Our suggested technology employs ultrasonic waves and ultrasonic sensors to identify nearby obstructions. The sensor notifies the Node Mcu when it detects obstructions. After processing this information, the Node Mcu determines if the obstruction is sufficiently close. The circuit accomplishes nothing if the obstruction is not that near. The vibrator receives a signal from Node Mcu if the obstruction is nearby. After the impediment is identified, it vibrates. Additionally, it vibrates in order to detect the manholes. As a result, this technique enables vision impaired individuals to sense obstacles. Our project's detection range is adjustable up to 500 cm, with a default value of 20 cm. The blind stick will vibrate if the obstruction is within this range. OCR technology is being utilized to create a gadget that makes text from books, newspapers, or cash audible to blind individuals. An Android application for text-to-speech conversion has been developed. Another special characteristic of the gadget is its ability to detect fires. The ESP32 camera records the digital text, which is subsequently translated into voice and played on the mobile device when the blind stick detects heat higher than usual. This alert sound alerts the user to the fire that is ahead of them. After the designed mobile software is downloaded to an Android phone, it will do all the tasks required for the blind stick.

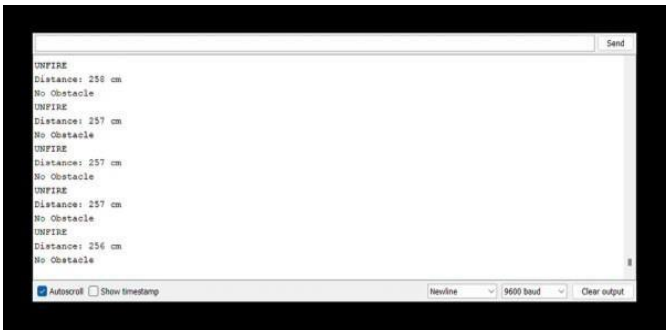

Fig1 12: Screenshot of output

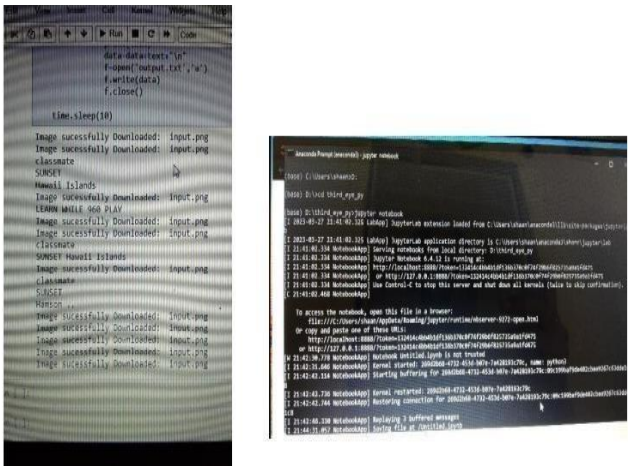

Fig 13: Output of ESP32 Camera

VIII. CONCLUSION AND FUTURE SCOPE

At this point, it's important to note that the study's goal designing and implementing a smart walking stick for the blind has been completely accomplished. The Smart Stick serves as a foundational platform for the next wave of assistive technology, which will enable the blind to securely traverse both interior and outdoor environments. It is both economical and efficient. It produces decent results when it comes to identifying impediments in the user's path up to three meters away. This system provides a strong, affordable, portable, low-power, and dependable navigation solution with a noticeable quick reaction time. Despite having sensors and other components hardwired in, the system is lightweight. Wireless communication between the system's components may be used to enhance the system's functionality in other ways, such as extending the ultrasonic sensor's range and putting in place a technology that measures the speed of impending obstacles. We prioritized the needs of blind individuals in all poor nations when creating such an empowering solution.

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Long-Distance Medical Device Communication

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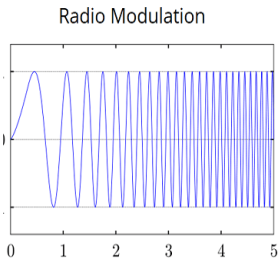
Abstract **- Late market studies show that the market for far off checking gadgets of various clinical boundaries will develop dramatically. Worldwide, multiple million people will be checked distantly according to the point of view of various wellbeing boundaries by 2023. Of specific significance is the method of distant transmission of the data gained from the clinical sensors. As of now, there are a few strategies like Bluetooth, WI-FI, or other remote correspondence interfaces. As of late, the correspondence dependent on LoRa (Long Range) innovation has had a dangerous improvement that permits the transmission of data over significant distances with low energy utilization. The execution of the IoT (Internet of Things) applications utilizing LoRa gadgets dependent on open Long-Range Wide-Area Network (Lora WAN) convention for significant distances with low energy utilization can likewise be utilized in the clinical field. Along these lines, in this paper, we proposed and fostered a significant distance correspondence engineering for clinical gadgets dependent on the LoRaWAN convention that permits information interchanges over a distance of in excess of 10 km.**

Index Terms **- Long-Range Wide-Area Network (Lora WAN), the IoT (Internet of Things), Clinical boundaries.**

INTRODUCTION

LoRa is a short form for Long Range. It is a wireless Radio frequency technology developed by the company Semtech. This LoRa technology can be used to send bi-directional information over long distances while consuming little power. This property can be used by remote sensors that should transmit data while only using a small battery. Lora typically has a range of 15-20km (more on this later) and can run for years on a single charge. Realize that LoRa, Lora WAN, and LPWAN are all unique terminologies.



LoRa employs unlicensed frequencies that are widely available around the world. The following are the most commonly used frequencies:
Europe's frequency is 868 MHz, 915 MHz is the North American frequency, Asia's 433 MHz band.

LoRa Topologies:

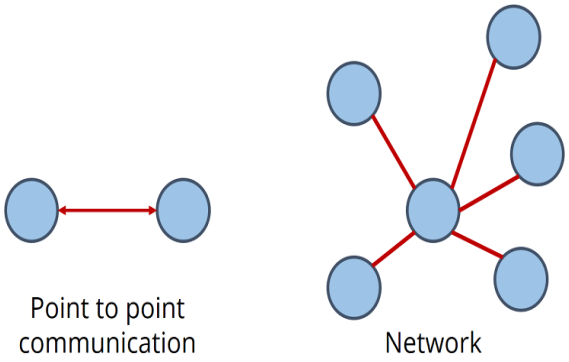


Fig 1 LoRa Topologies

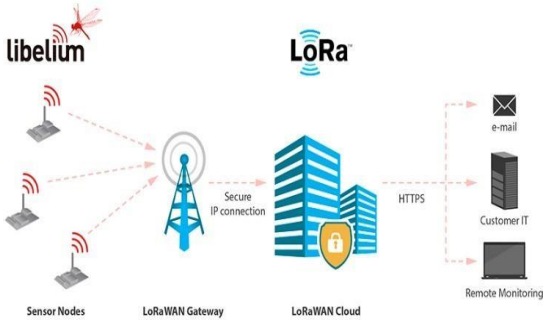
- Communication from one point to another
- Create a LoRa network instead (using Lora WAN for example)

Communication from one point to another:
Two LoRa-enabled devices communicate with each other via RF signals in point-to-point communication. This is basic for transferring data between two ESP32 boards equipped with LoRa transceiver chips that are relatively far apart or in environments at which Wi-Fi coverage is absent.

Lora WAN:

The Lora WAN protocol is a Low Power Wide Area Network (LPWAN) specification derived from the LoRa Alliance's normalized LoRa technology.

A LoRa Node is typically powered by a battery and is comprised of a Radio Module and a Microprocessor. The microprocessor reads data from the sensor and sends it into the air via the radio module, where it is picked up by a LoRa Gateway. The LoRa Gateway also has a Radio Module and a Microprocessor, but they are typically powered by AC mains because they require more power.



LoRa is classified as an LPWAN, which stands for Low Power Wide Area Network. Not only can LoRa operate on LPWAN, but other technologies including such Narrow Band IoT (NB-IOT), Sigfox, and others are also capable of doing so. When LoRa technology was introduced, it needs a specific set of protocols to be followed by all manufacturers, so the LoRa alliance was formed, which then introduced the Lora WAN. Lora WAN is a modified form of LPWAN that specifies the protocol for using LoRa in a physical layer to send and receive data between nodes, gateways, and the internet.

Many people compare LoRa to Wi-Fi or Bluetooth, but neither compares to Lora. Bluetooth is used to send data between two Bluetooth devices, whereas Wi-Fi is used to send data between an Access Point (Router) and a Station (Mobile).However, LoRa technology was not designed to transmit data between two LoRa modules.

EXPERIMENTAL ANALYSIS

Transmitter LoRa

Lora SX1278 and esp8266 communication with DHT sensor.

Transmitting module consist of LoRa that provide spread spectrum communication and high interference that minimize the current consumption Using a low-cost crystal, SX1278 can achieve a sensitivity of more than -148dBm.The combination of high sensitivity and an integrated +20dBm power amplifier results in an industry-leading link budget, making it ideal for any application requiring range or robustness.

Lora SX1278 also outperforms conventional modulation techniques in terms of blocking and selectivity, resolving the traditional design. The DHT11 is a basic digital temperature and humidity sensor that is extremely inexpensive. It measures the surrounding air with a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin. This is a blue OLED display module with a 0.96-inch diagonal. Using SPI/IIC protocols, the display module can communicate with any microcontroller. It has a resolution of 128x64 pixels. The package contains a display board, a display, and a 4 pin male header that has been pre-soldered to the board.

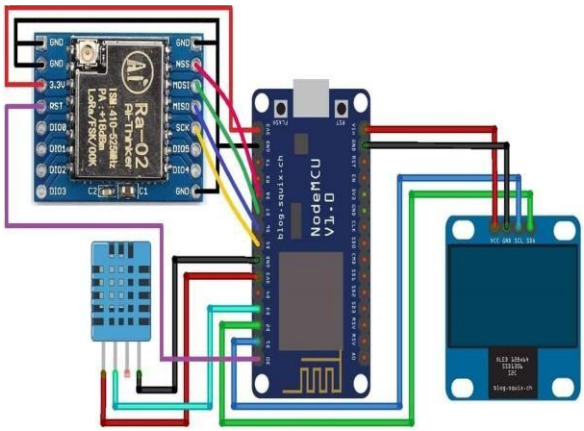


Fig 2 LoRa Transmitter

Recevier lora

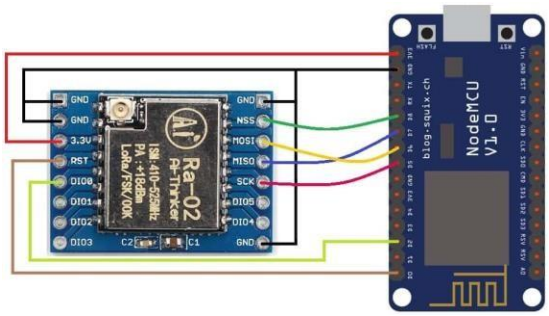


Fig 3 LoRa Receiver

The SX1278 transceiver module will be used to send and receive LoRa messages with the ESP32.All LoRa modules are transceivers, meaning they can send and receive data. You will require two of them.

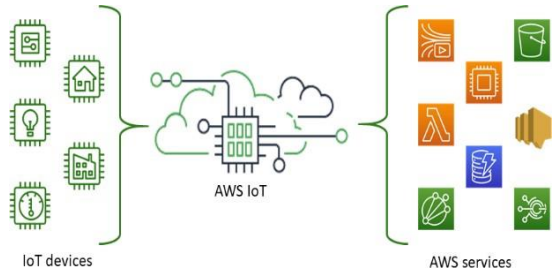
AWSIoT Core

Nowadays, the Internet of Things (IoT) is integrated into almost every device. There are countless hardware and software IoT platforms on the market for establishing IoT-based applications. In my previous article, I described how to connect a DHT22 to a NodeMCU and send the temperature and humidity to a Thing speak webserver. Similarly, we can connect sensors to hardware development kits such as ESP32, ESP8266, Raspberry Pi, Particleboards (Aargon, Boron, Xenon), and send data to clouds such as Thing speak, Ubidots, AWS IoT Core, and Microsoft Azure. Amazon is not only development of e, but it is also focusing on IoT and providing a cloud-based platform called AWS IoT. AWS IOT is an abbreviation for Amazon Web Service Internet of Things. This service enables us to securely connect our devices to the internet for processing, operating, and exchanging data. Aside from AWS IoT, Amazon Web Services offers a plethora of other services such as virtual machine deployment, web hosting, and so on.

AWS IoT Core supports connections with IoT devices, wireless gateways, services, and apps. Devices connect to the AWS IoT Core so they can send data to and receive data from AWS IoT services and other devices. Apps and other services also connect to AWS IoT Core to control and manage the IoT devices and process the data from your IoT solution. This section describes how to choose the best way to connect and communicate with AWS IoT Core for each aspect of your IoT solution. Figure4.

Fig 4 AWS IoT

There are cloud services provided by Amazon Web Services for IoT that connect your IoT devices and AWS cloud services. If you're interested in integrating your IoT devices into AWS IoT-based solutions, check out AWS IoT's device software. Using AWS IoT, your devices can be connected to the cloud services that AWS offers.



When publishing and subscribing to messages, the AWS IoT Core message broker supports devices and clients that use MQTT or MQTT over WSS protocols. Support for HTTPS-enabled devices and clients is included.

Multiple communication scenarios are supported by IoT applications, including those between devices, between devices and the cloud and between devices and users. A majority of MQTT communication models stem from three MQTT patterns: point-to-point, broadcast, and fan-in.

IoT Rules

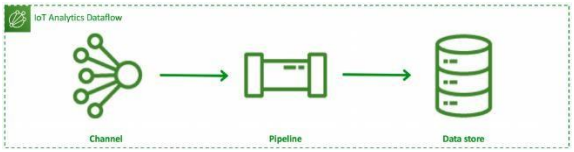
When AWS IoT gets messages from your devices, it follows IoT regulations, according to AWS.A rule extracts data from messages, evaluates expressions based on message data, and executes one or more actions when the rule's conditions are fulfilled.

IoT Rule Actions

When the rule's query returns results, the Lambda function processes those results and passes them on to an AWS IoT rule action. What happens when an AWS IoT rule triggers an action? Sends a message via AWS IoT Analytics channel as the result of this rule's operation.

AWS IoT Analytics

"IoT Analytics" is a fully-managed solution, according to Amazon Web Services, that makes it easy to execute and operationalize advanced analytics on huge quantities of IoT data. Five components make up IoT Analytics - channels (or channels and pipelines), data stores (or data stores), datasets, and notebooks.



Messages are sent to the IoT Analytics channel via the IoT Rule's IoT rule. The channel publishes the data to a pipeline for processing. In the pipeline, you consume messages from the channel and process and filter them before saving them in the data store, allowing you to process and filter them. Receives and stores message data in a data storage unit (DSU).For retrieval, you need to create a SQL dataset or an object-oriented dataset (ODBC).When a query against the data store is run against the SQL dataset, a SQL query is returned. Documentation states that Amazon Athena and Amazon IoT Analytics SQL expressions are based on Presto DB.

EQUIPMENTS

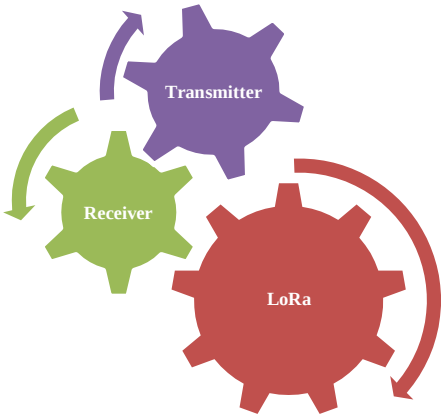
A. Hardware

- ESP8266 (SX1278)
- LoRa AI tinker ra-02 433Mhz

B. Software

- Arduino ide
- OpenSSL
- AWS IoT Core

PROPOSED METHODOLOGY



BLOCK DIAGRAM

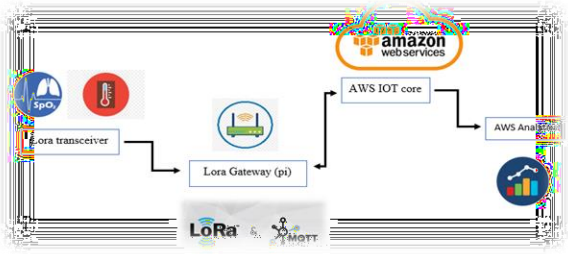
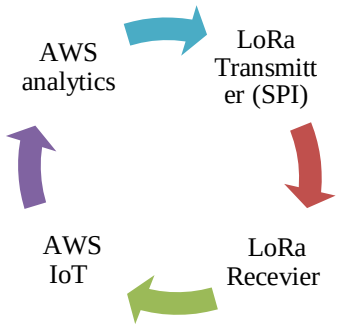


Fig5: Block diagram

Working

Considering a physiological parameter of body example temperature and humidity (DHT12 sensor).LoRa is long radio transceiver with serial peripheral interface with esp8266 as client and another LoRa transceiver as server with AWS-IoT core. With help of MQTT protocol Lora receiver publish the data to AWS IoT by subscribing the topic. Temperature sensor data will publish to AWS IoT Core. The data securely transmitted to cloud by RSA (keys) and certificate policy. Edge device is connected to AWS IoT, Rules adjusted such that data is transmitted to device (exact device).actions are made to access the services of AWS IoT. Here we are using AWS IoT Analytics to extracting the data which are more important example DTH sensor gives values of humidity with temperature ,by writing SQL command to perform data operations to send specific data to AWS IoT. Here we wrote the SQL condition to send data if the humidity is above 90. This data subscribed to topic creating a topic to this data this results gives the values. Data is transferred pipeline by sending the data through channels. This data can be extracted by downloading the data in excel format. By storing data in AWS S3 and channeling the data into AWS Quick Sight. This service gives the visualization of data with real time plots and data. This can be again send to any kind of telemetry device.



AWS-IoT core with ESP8266

1. Creating a Thing in the AWS, generating a certificate and attaching a policy to it.
2. Converting AWS credential(Certificate, Private Key, Root CA) from .pem to .der format
3. Installing ESP8266 sketch data upload tool in Arduino IDE
4. Arduino sketch and modifications according to the thing.
5. Uploading AWS certificates & code to the NodeMCU ESP8266
6. Testing/Subscription of thing on Amazon Web Services (AWS).
7. Results& Data Analytics.

Creating AWS thing with Certificate and policy

- STEP1: In the wake of making account, look for "IoT center" under AWS administration, click on it to open the control center.

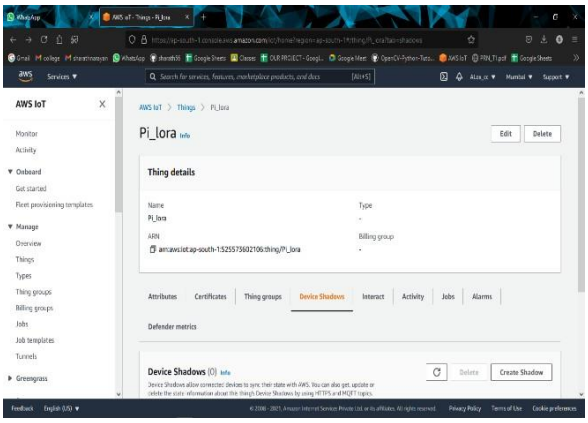


Fig6: IoT thing

- STEP2: Getting started with AWS IoT.
- STEP3: Register a Thing in our case it is LoRa with ESP826. It acts like an IoT device.
- STEP4: Create a Certificate.

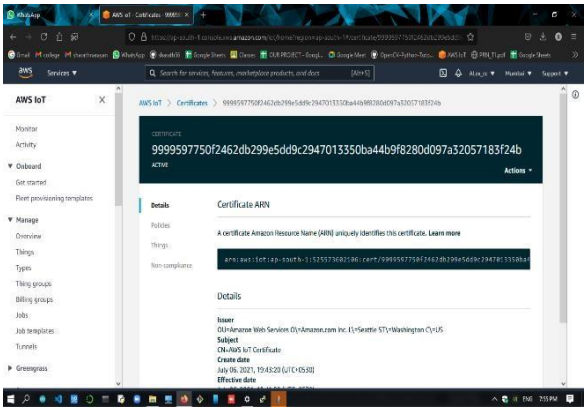


Fig6: Certificate and policy

- STEP5: The keys for the Thing which are created earlier are provided by AWS. These keys provide access to the Thing. Three key files are been downloaded by clicking on Activate button and saved in the PC.
- STEP6: By clicking on 'Attach a policy' policy for the Thing is created after the Certificate is created.
- STEP7: No policies are present at this time in the account as we created no account so far. Now we need to click on 'Register Thing'.
- STEP8: After the window gets open, we need to click on the 'secure' and 'policies' shown in the left side of the menu and by this we can create policy.

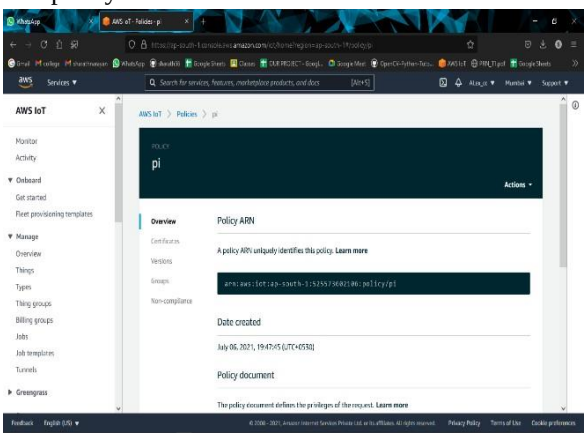


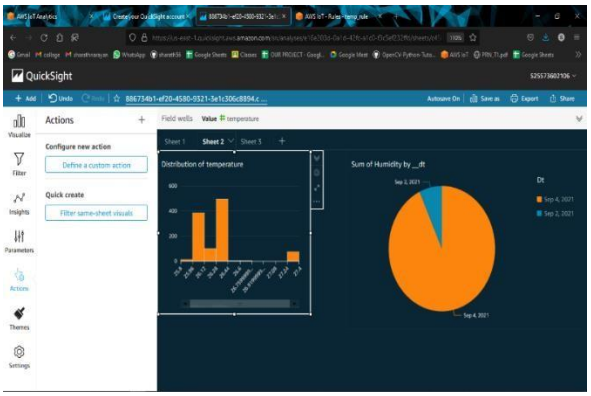
Fig7: policy attach

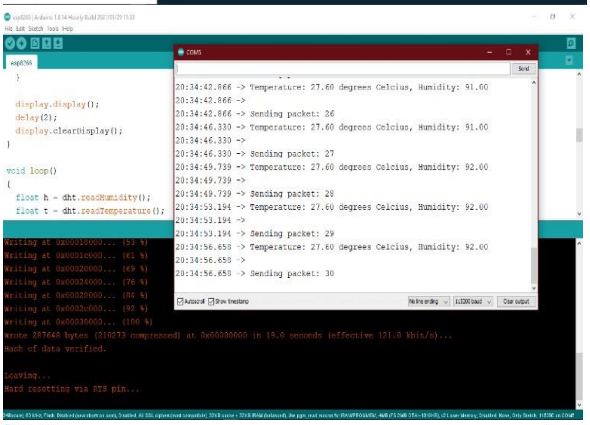
- STEP9: Now we need to click on 'Create a policy'.
- STEP10: Here we can name the policy accordingly. After checking the allow button we need to type 'IoT:*' in the 'action box' and type '*' in Resources ARN. Finally create policy by clicking on the 'create' button.
- STEP11: Click on 'secure' and then the 'certificates' after opening a window. Policy is created then it is attached by clicking on 'certificates' and 'attach policy'.
- STEP12: We have to select the created policy name and then click on 'attach' button.
- After getting a broker address of the Thing, the working of the Thing is checked by using the 'test' option present in the 'AWS IoT console'.

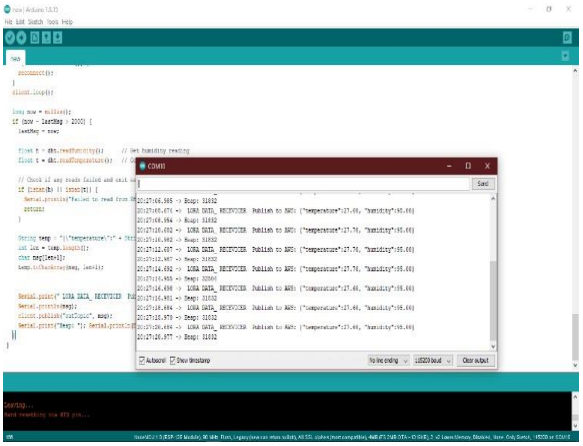
RESULTS

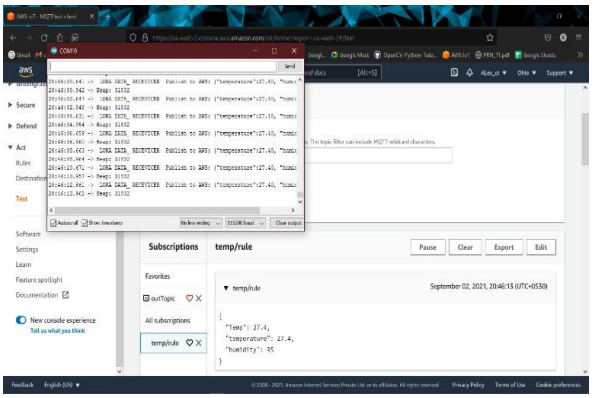
AWS IoT Quick Sight:

Data visualization of DTH11 sensor in Real-time with help of AWS S3.









CONCLUSION

In this paper, we proposed a significant distance correspondence engineering for clinical gadgets dependent on Lora WAN Protocol, which is committed to long haul wellbeing checking of clients/patients in metropolitan/country conditions without help and is coordinated into a more extensive IoT foundation. For this significant distance correspondence design for clinical gadgets dependent on Lora WAN convention. These were performed over distances that didn't experience snags, (for example, geological snags or structures); no enhancements were made as far as inclusion and energy utilization, transmission distance, and the number of hubs the Lora WAN door can acknowledge. There is a requirement for additional double-dealing and reconciliation of clinically usable gadgets in such keen frameworks. Right assessment of clinical indications, for example, ECG waves, is

Essential. These new methodologies will have a direct clinical effect since they will be utilized for the finding, observing, and treatment of the patients, utilizing the freshest and most progressed obtaining and correspondence advancements utilizing LoRa.

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Machine learning-based UAV detection using multiple sensors for Anti-drone system

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***Abstract*—In the recent past, applications of unmanned aerial vehicles (UAVs) have been increasing rapidly to solve numerous real-time problems. While UAVs are beneficial, concerns have also been arising regarding their possible misuse of sensitive airspace and public spaces. Hence, it is crucial to develop an efficient anti-drone system (ADS) to detect and neutralize an unauthorised/malicious drone activity. The crucial function of ADS is to develop an efficient algorithm that can detect the malicious drone accurately. Numerous approaches have been suggested to detect malicious drone's activity that include different types of sensors such as acoustics, optical/thermal imaging, and radio frequency (RF) based sensors. However, the accuracy of these techniques is sub-optimal due to limitations such as single node sensing and limited search space. Hence, in this work, we focused on leverage multiple RF sensors, which are strategically placed over the entire region to be protected. The machine learning algorithm, namely ensemble learning technique (ELT) is developed to improve the detection rate as well as the search range using multiple RF sensors. Synthetic signal data that emulates communication between ground station and UAV is considered to train and test the proposed model performance. The results reveal that the proposed ELT based detection can increase the search range, which is proportional to the number of sensors placed. It can detect drone signals with improved accuracy up to -9 dB SNR using five base-learners.**

***Index Terms*—Malicious drone detection, RF signatures, Ensemble learning, random forest algorithm, detection rate.**

I. Introduction

The proliferation of unmanned aerial vehicles (UAVs) also called Drones in various sectors creating numerous benefits/applications. Furthermore, UAVs play a significant role in the vision of Internet of Things (IoT) and smart cities. Where, IoT services deploy drones to collect environmental data [1]. However, over the past one decade, it has been a growing concern owing to the risks that the drones are posing on safety and security public safety as well as restricted spaces. Particularly, when misuse of drones in aviation sector impairs infrastructure and aviation safety. Several incidents have been reported on disruption of flights which include Gatwick airport and Heathrow airport incidents in 2018 and 2019, respectively [2]. These intrusions are happening because of the lack of mitigation techniques or anti-drone systems (ADS) in place. This highlights the need of robust and reliable ADS to brace for security attacks. An ADS contains three important units/function namely, detection/classification, localization/tracking, and Neutralization units which must be efficient in reducing false alarms.

The primary unit among them is a detection system that can detect the presence of unauthorized Drones. Numerous methods have been developed to detect malicious drones using acoustic, Optical/thermal Imaging, and Radio frequency (RF) sensors [3], [2]. Each method has its own pros and cons. Among these methods, RF sensor-based detectors are low cost and takes less processing time [3], [4], [5]. Traditional drone detection methods for ADS have been developed often with single sensor. However, the accuracy (detection rate) of single sensor based detection methods is suboptimal due to channel noise, multipath fading, and limited range of RF detection which is normally less than 1.6 km [6], [7]. Hence, developing a multi-sensor based algorithms are crucial for enhancing the ADS overall accuracy, extending the search space, and reducing false alarms. Ensemble learning techniques (ELT) are efficient machine learning (ML) techniques that combines the measurements of multiple sensor data to improve detection rate and is also a promising method to enhance ADS detection capabilities [7]. The fundamental concept behind ELT is that these techniques combine the predictions of multiple base learners which are trained using multiple sensor data instead of single sensor data. This leads to enhance overall detection accuracy by mitigating individual model biases and errors. In general, ELTs can be broadly classified into homogeneous and heterogeneous ensemble methods. In this work, homogeneous ensemble method namely random forest algorithm based on bootstrap aggregation is studied and applied because of its ability to reduce model variance.

The authors in [8] have developed an ensemble based IoT-driven automated Anti drone detection system using computer vision. This method can detect and alert the authorities when drones entered into restricted airspace. In [3], authors have presented a drone detection system in 2.4 GHz control channel using passive RF imaging techniques. In [9], the authors have developed unauthorised small sized drone detection using YOLO-V5 algorithm. Though the accuracy of the above three image based detection techniques is optimal, these models are computationally expensive and may not be effective under varying environmental conditions. Particularly, owing to poor visibility during dark times. In [4], the authors considered three specific Mavic drones for detection and tracking using Identification (ID) tags in Radio frequency signals. However, prior information of IDs of an unauthorized drones may not be available on-time. In addition, the authors work mainly focused on individual detection range of each drone, rather

than improving the range. In [10], authors have developed a joint time-frequency complementary model to enhance detection accuracy of sound signals using wavelet transform and one dimensional CNN is proposed. However, the recognition rate or detection accuracy of the model with respect to signal-to-noise ratio (SNR) is low. The authors in [11], designed and developed an RF signal-based drone detection system that can work in 2.4 GHz control channel. However, the detection range is less than 12 meters and the detection rate reduces to almost zero after 12 m range. Hence, in this work we focus on developing a less complex detection method that can leverage multiple RF sensor data to improve both detection rate as well as search range even under noisy environment.

The main objective of this work is to design an ELT based detection ssytem for ADS to improve detection rate and range. To achieve this, homogeneous ensemble method namely random forest algorithm with bootstrap aggregation is considered and applied. To extend the search range, the data is collected from multiple RF sensors placed strategically over the entire region to be protected. Synthetic signal data that emulates communication between ground station and UAV is generated and considered in the training and testing of the proposed ELT model performance. The ratio of training and testing data collected from sensors is 4:1. The advantage of the proposed algorithm is that it can reduce model variance and can increase detection performance using multi- base learners even under noisy channel environment.

The rest of the paper is prepared as follows: In section II, the problem statement and methodology of proposed ELT for ADS is presented. In Section III, simulation set-up and results are illustrated and discussed. Finally, our conclusions are drawn in Section IV.

II. Problem Statement and Methodology

Figure.1 shows the proposed malicious drone detection method using multiple RF sensors (M = 3) deployed strategically in the desired airspace to be protected. Each sensor listens to the radio communication bands (2.4 GHz/433 MHz) used for drone control. The range of search space can be increased with multiple RF sensors where each sensor can sense the RF signatures of drone in its vicinity. Here, the database contains two features/attributes (energy and maximum eigenvalues) which are computed from intercepted RF signals from all sensors. The total dataset is divided into training (80%) and testing (20%) to train and test the proposed model. The samples are taken from training population based on bootstrapping method. Different decision trees (base-learners) are developed from corresponding sample data taken randomly from database. The test data is used to evaluate the model. Finally, the predictions from each model is aggregated to improve the accuracy using Voting and OR fusion logic. This is due to the fact that individual weak learners may not reliably detect the drone.

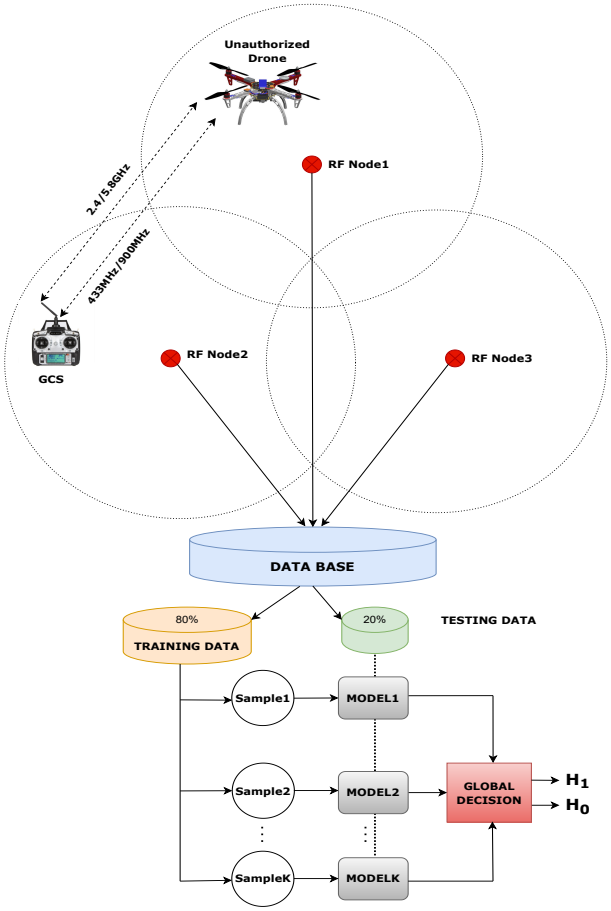

Fig. 1. Block diagram of the proposed ensemble learning technique for drone detection

A. Extracting detectable features

The drone detection using intercepted signal $r(n)$ can be expressed mathematically as [1], [12].

$$H_0 : \mathbf{r(n)} = \mathbf{w(n)},$$
$$H_1 : \mathbf{r(n)} = \mathbf{H_c d(n)} + \mathbf{w[n]},$$

where, n is the sample index, $\mathbf{H_c}$ represents channel gain. The intercepted drone control signal is $\mathbf{r}(n)$. The vectors $\mathbf{d(n)}$ and $\mathbf{w(n)}$ represents drone communication signal and white Gaussian noise in the control channel, respectively.

The feature-1 (energy (ϕ)) using intercepted signal $\mathbf{r}(n)$ of each sensor/node is calculated as,

$$\phi(n) = \sum_{n=0}^{N-1} |r[n]|^2, \tag{1}$$

And the detection threshold has to be used at root node (λ_ϕ) can be computed based on sample size and desired value of false alarm probability (P_{fa}) [1].

$$\lambda_\phi = \sigma_w^2 (Q^{-1}(P_f)\sqrt{2N} + N), \tag{2}$$

where, Q^{-1} is the Inverse Q-function.

Second attribute or maximum eigen-value (ε) is determined using sample covariance matrix ($R_x(N)$) which is computed by finding all the eigen-values of the Matrix. [13],

$$R_x(N) = \frac{1}{N}\{\sum_{n=L-1}^{L-2+N} \hat{r}(n)\hat{r}^{\dagger}(n)\}, \quad (3)$$

Maximum eigenvalue is identified using $max(.)$ function available in Matlab. The detection threshold (λ_ε) for second feature at root nodes is given in [13].

Decision split can be made based on following logical test at root/decision nodes,

$$\phi/\varepsilon \underset{H_0}{\overset{H_1}{\gtrless}} \lambda \quad (4)$$

B. Ensemble learning based on Random forest algorithm

Step 1: Based on the generated/intercepted drone signal, we have created a training data set and extracted the two attributes (energy and maximum eigenvalues for random SNR signal) as explained in above sub-section-A. The feature scaling (normalization) is performed to avoid dominance of one feature in the decision criterion. The data is generated such that it forms two clusters with binary labels (drone detected (1) and Drone not detected (0)).

Step 2: Compute the entropy (φ) of the sample data for two attributes to choose best attribute, which is computed as,

$$\varphi = -\sum_{i=0}^{1} P_i \log_2 P_i \quad (5)$$

Where, $P_i = \frac{f_i}{N}$ is the probability of samples fallen in each bin, f_i denote the number of samples falling in the i^{th} bin.

Step 3: Matlab function fitctree (ϕ, ε) is used to train base learners (decision trees) based on two features. The splitting process at root node and decision node compare their corresponding thresholds.

Step 4: Predict the class for the test set using the trained model.

Step 5: Compute the confusion matrix (given below) based on number of Monte-Carlo trails for each base learners that can estimate detection rate of each base learner (P_{dr}). Where in confusion matrix, ND represents $not - detected$ drone.

		Prediction	
		Drone	**ND**
Actual	**Drone**	True Positive	False Negative
	ND	False Positive	True Negative

Step 6: Aggregate decision of all base-learners decisions using decision fusion logics (OR and Majority/Voting rule). The cumulative drone detection rate (Q_{dr}) can be computed as,

$$Q_{dr-OR} = 1 - \prod_{k=1}^{K}(1 - P_{dr,k}), \quad (6)$$

$$Q_{dr-Majority} = \sum_{k=s_d}^{K} \begin{pmatrix} K \\ k \end{pmatrix} P_{dr,k}(1 - P_{dr,k})^{K-k}, \quad (7)$$

where $P_{dr,k}$ is the detection rate of the k^{th} decision tree or base learner. The letter K represents number of base learners, $s_d \geq K/2$ is an integer, $\begin{pmatrix} K \\ k \end{pmatrix}$ is a factorial function.

III. Simulation results

Table.1 shows the details of simulations parameters used to perform this work. We have generated Radio frequency (RF) signals that emulates real-time drone control signals in the 2.4 GHz band. Control channel noise is considered as zero mean, unit variance additive white Gaussian noise. The signals are generated with varying signal to noise ratio (SNR) ranging from -12 dB to -10 dB. Different sample size of data (N = 128, 256, and 512) is captured using rectangular windowing technique to estimate the detection features. The channel matrix (H_c) is assumed ideal (identity matrix). Matlab is used as a simulation tool to analyse the drone detection algorithm. The features/attributes are extracted from intercepted data such as energy (ϕ) and maximum eigenvalues (ε) for all possible SNR values. Created a training and data set to train and test the base learners (Decision tress). We have considered varying number of base learners (K = 3 to 5). Thresholds are predefined using desired value of false alarm probability (P_f = 0.1). Energy feature/attribute (ϕ) is calculated using eqn.(1). Another feature namely maximum eigenvalue (ε) is estimated using sample covariance matrix of the intercepted drone signal. Out of two attributes, the best attribute to place in root node is identified using entropy measure of each attribute in sample data. This process is applied to all base learners as part of model training. The binary classes are labelled as 1 (for drone detected) and 0 (for drone not detected) based on RF signal in the control channel. Drone RF dataset and multi-sensor datasets are given in [14], [7]. In this work we have generated synthetic data that emulates Signals in Drone control channels using Quadrature phase shift keying and Frequency hopping modulation techniques. The search space can be improved because of multiple sensors placed at different distance. This is due to the fact that the feature extraction is based on all the RF sensors data and the final decision is based on multiple base learners which are trained using those features. Geometrically, the search space can be increased to approximately up to two times. That means, In practice, the normal detection range of RF sensor is approximately 1.6 km (that covers an area of

approximately 8 km^2 based on area of a circle πr^2). Owing to strategically placing of three RF sensors, the detection range of the proposed method can be extended upto 2.8 km (equivalent area is 24.2 km^2).

TABLE I
SPECIFICATIONS FOR SIMULATION

Frequency Bands (ISM)	2.4 GHz, 433 MHz
Sample Size	128, 256
Control Channel Noise	AWGN
Modulation	QPSK
Features for detection	Energy, Max eigenvalue
Number of base-learners (DTs)	3, 5, 7
False alarm probability (P_{fa})	0.1
Simulation tool	Matlab
SNR range	-16 dB to 10 dB
Ensemble learning method	Random forest algorithm
Aggregation	OR, Voting logic

In general, ML algorithms are evaluated based on the key parameters such as Accuracy, Recall, Precision, and F1 score [15]. These metrics depend on the following parameters: true positive (TP), false positive (FP), true negative (TN) and false negative (FN) that can be seen in Confusion matrix given above. The TP and TN provide the number of correctly identified attempts of a present drone. Conversely, the parameters FP and FN give the measurement of the number of wrong identifications of drones. Out of all these parameters, accuracy is the most important metric for correct identification of a drone. Hence, in this work the performance of the proposed algorithm is evaluated and illustrated as Accuracy/detection probability (in statistical terminology) against SNR of the drone control signal. The successful drone detection rate/probability (if we consider only the feature-2) can be computed using the following expression, $P_{dr} = \frac{TP}{TP+FN}$. Monte-Carlo trials are performed on the algorithm to estimate the TP and FN parameters.

Fig. 2 and 3 illustrate the normalized features spread (Energy and max eigenvalue) over SNR ranging from -16 dB to 10 dB. For instance, Fig. 3 plots maximum eigenvalue against SNR for three different sample size (128, 256, and 512). From the graphs, it is evident that these two features are changing with change in SNR of the drone control signal, which can be used for detection. The entropy value of the attribute dependence on variance of the spread. Hence, the attribute that is having highest spread/variance is considered as a root node for best split. The effect of sample size on Feature-1 is significant, whereas it is insignificant on Feature-2. We have considered a sample size of 256 to evaluate the performance of the proposed ELT-based detection method.

Fig. 4 illustrates the detection rate of proposed ELT based detection using various number of base learners (K = 1, 3 and 5). The aggregation method using OR and Majority logic is also presented. From the Figure, it is clear that the individual

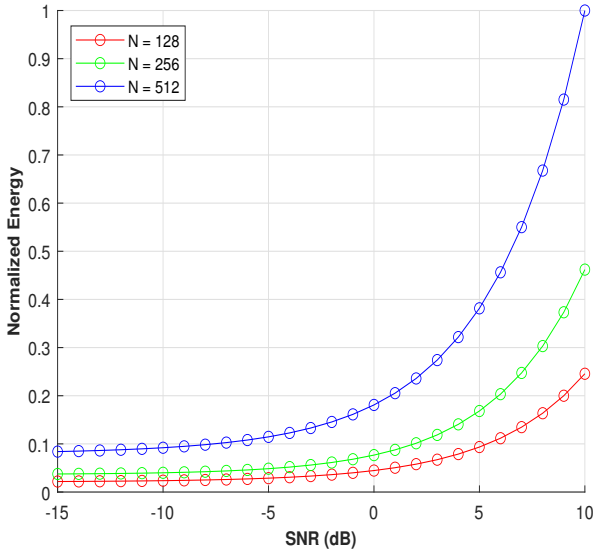

Fig. 2. Normalized energy feature against SNR(dB) (SNR = -16 dB and 10 dB, N = 128, 256, and 512)

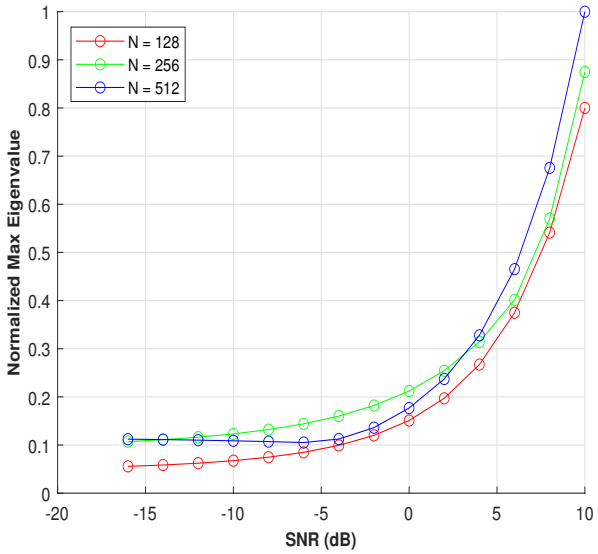

Fig. 3. Normalized maximum eigenvalue feature against SNR(dB) (SNR = -16 dB and 10 dB, N = 128, 256, and 512)

base learners (K = 1) performance is weak and its detection rate is reduces when the signals SNR is less than -3 dB. However, the drone detection rate increases with increase in number of base learners from 3 to 5. For instance, with K = 5, drone detection rate is 90 % upto -9 dB SNR using OR logic. In addition, the detection improvement of Majority based fusion is not significant even increasing no of base learners from 3 to 5. Out of two fusion, aggregation using OR logic gives highest performance due to its nature of the logic that it detects the drone if any one of the base-learner detects the drone activity. From the simulation results, it is evident

that the proposed ELT based drone detection can increase the detection accuracy and can extend the search space with multiple RF sensors with multiple base-learners.

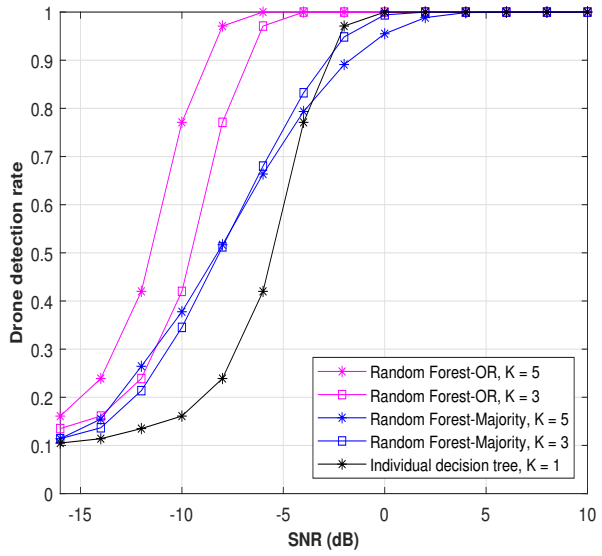

Fig. 4. Performance of proposed ELT based detection with varying signal strength and base-learners (SNR = -12 dB and 10 dB), K = 1, 3, 5

IV. Conclusions

In this work, we have developed an ensemble learning based drone detection algorithm for ADS to improve detection rate as well as the search range. To achieve this, a homogeneous ensemble method called random forest algorithm with bootstrap aggregation is considered using strategically placed multiple RF sensor data. In practice, the normal detection range of RF sensor is approximately 1.6 km (approximately 8 km^2). Owing to strategically placing of three RF sensors, the detection range of the proposed method can be extended up to 2.8 km (24.2 km^2). Synthetic signal data that emulates communication between ground station and UAV is considered to extract the detectable features and to train and test the base-learners. The attributes such as energy and maximum eigenvalues are calculated from intercepted drone control/communication signals. The entropy measure was used to select best attribute for root node data split process. The ratio of training and testing data collected from sensors is 4:1. The advantage of the proposed algorithm is that it can reduce model variance and can increase detection rate. It uses multi-sensor data aggregation based on multiple base-learners under noisy channel environment to enhance ADS detection capabilities. The decision aggregation using OR and Voting logic is used to improve drone recognition rates. The drone detection rate using OR fusion is greater than 90% even in negative region of SNR of -9 dB with a five number of base-learners. This work is limited interns of type of sensor (RF sensors only) and single target/drone detection. However, to enhance the capabilities of ADS in real-time, one has to consider real-time data of multiple targets with multiple sensors of different types.

V. Acknowledgement

The authors would like to extend their sincere thanks to the Grants Management and Resource Mobilization unit at the UNAM for their invaluable support in facilitating this research project.

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Design and Implementation of a Multipurpose Three-Axis Gimbal System Using STM32 Microcontroller for Enhanced Stability and Precision

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***Abstract*—This paper investigates the enhancement of a three-axis gimbal system, leveraging an STM32 microcontroller to achieve superior stability and control. Primarily designed for drones, UAVs, and camera systems, this gimbal operates across the yaw, pitch, and roll axes, ensuring stable payload management and vibration reduction. The system employs DC brushless motors and IMU sensors to maintain precise control and stability. Advanced control algorithms, including PID (Proportional-Integral-Derivative) controllers, are utilized to optimize the performance of the gimbal system, delivering improved operational efficiency and reliability in dynamic environments.**

I. INTRODUCTION

Self-stabilizing modules are modules that try to remain constant with respect to an external frame or constant module, e.g. the Earth, even if their outside frame of reference is moving in relation to it. An examples of this include balancing a camera on a tilting table, the table being examples of moving local reference frames. This is called inertial stabilization. The uses may differ and examples include different applications such as self-stabilizing cameras, payload stabilization in UAV's. Different examples include military applications such as stabilizing cockpits of combat boats and terrain vehicles. In this case this mechanism will be a platform. These are often referred to as Inertially Stabilized Platforms.

II. SCOPE OF GIMBAL STABILIZER

The main objective is to develop a practical physical model with self-stabilizing capabilities. Due to limitations in skills, knowledge, and time, the focus will be on meeting these requirements at a fundamental level, with any extra time dedicated to refining the model. More complex aspects of the project will make use of open source resources, such as Arduino codes and libraries. The model should be adaptable for both larger and smaller applications, but the physical prototype utilized in this project will likely have more modest dimensions. Yaw control is not a priority, and the nature of the system makes it unfeasible to compensate for linear displacement, which is also beyond the scope of this project.

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III. METHOD OF GIMBAL STABILIZER

The model being proposed should consist of three layers - one to handle the roll motion, another for the pitch motion, and a third outer layer to provide support for the first two layers. The inner layer should be the stable inertial plate itself, while the other two layers should be designed to maximize system stability, thereby enhancing control. The ultimate layer should be strong and inflexible to effectively bear the mass of the remaining ISP and withstand any external forces attempting to impact it.

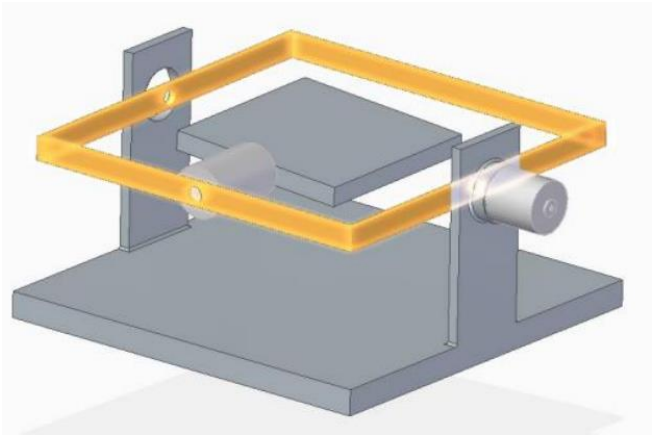

Fig 1. Concept model of a gimbal stabilizer.

IV. MECHANICS

Angular movements, such as pitch and roll, are best characterized by an angle and a distance from a point of origin, where the coordinates are zero. These coordinates are referred to as polar coordinates.

Describing any motion in polar coordinates requires only three components: angle, distance from the origin, and the position of the origin.

In this project, it is important to take into account angular position, angular velocity, and angular acceleration. The angular position of an object refers to its angle relative to a chosen axis and is typically measured in radians, but can be converted to degrees for better understanding. Angular velocity represents the rate of change of the angular position, while angular acceleration indicates how quickly the angular velocity is changing, corresponding to the first and second derivatives of the angular position.

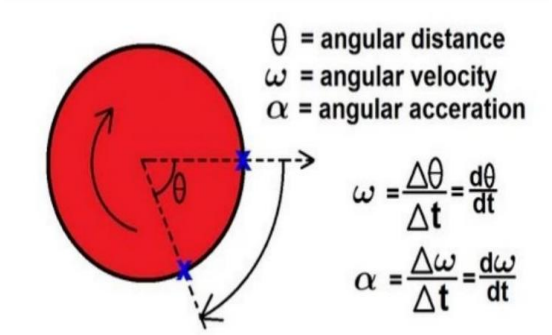

Fig 2. Conceptual visualization of the act of working.

V. CONTROL THEORY

When it comes to control, the project faces two main challenges - controlling the pitch and roll axes, and filtering out signal noise. To address the former, two separate proportional-integral-derivative (PID) controllers will be employed. Since each motor and its corresponding PID controller form an independent system with a single input and output (known as a SISO system in control theory), they can be effectively modelled as if they do not significantly affect each other; in other words, the motion of one motor does not have a major impact on the other. Ideally, noise filtering will be performed using a Kalman filter, although a low pass filter is a possible but less effective alternative.

A. PID Controller

Frequently chosen for their straightforwardness, PID controllers are currently the most extensively utilized controllers. They can handle current errors and also utilize the integral and derivative components to retain previous conditions and forecast future ones. The resulting output is a combination of the three components - P, I, and D, and is defined by the equation above.

$$u(t) = K_{\mathrm{p}}\varepsilon(t) + K_{\mathrm{i}}\int_0^t \varepsilon(\tau)d\tau + K_{\mathrm{d}}\frac{d\varepsilon(t)}{dt}$$

The proportional part of the PID controller, denoted as "P," increases in proportion to the error, which is the discrepancy between the current value and the desired value. The K value, also known as the gain, for the P part determines the strength of this relationship.

The I controller, responsible for integration, sums up all error terms it has received since it began receiving sensor input. This feature allows it to effectively accumulate smaller errors to compensate for their impact, as the proportional output alone may not be sufficient to power the motors for small error terms. The accumulation of errors also enables it to stabilize loads effectively. However, this accumulation of past errors can be problematic when dealing with large errors, as the I part continues to output even after the desired angle is reached, since the sum of all errors may not be zero at that point. Consequently, this causes the platform to overshoot the desired location.

The D component is directly related to the discrepancy between previous and present values, creating a braking effect before reaching the target angle, usually minimizing overshooting caused by the P and I components.

Simply put, increased Kp values usually result in a quicker controller but diminished stability. The integral component can effectively eliminate minor output signal errors by accumulating them gradually, but it also compromises stability. Incorporating a derivative element can enhance stability by introducing a braking effect before reaching the target position. For this project, a single PID controller will be assigned to each motor.

B. Kalman Filter

The concept of an observer in control theory involves accounting for past inputs and outputs, as well as the mathematical model of the system, in order to estimate the input. This is particularly valuable when the input signal is unreliable or inaccurate. The Kalman filter, known as an "optimal estimator," is widely regarded as the top linear estimator. Given that the system used in this project is anticipated to remain close to its original stable position, it can be approximated as linear, making the Kalman filter the preferred option for reducing signal noise.

VI. IMPLEMENTATION

After analysing the complexity of the active camera stabilizer system, it was determined that constructing a mechanical gimbal would be time-consuming, so an existing one was chosen instead. The project utilized the mechanical structure and motors from a disassembled commercial gimbal. The selection of components was based on previous similar projects and the project supervisor's recommendations. The microcontroller STM32F103 was programmed using the Keil IDE software, and several libraries including Kalman, MPU9250, and EEPROM were incorporated to simplify the programming.

The project's individual systems underwent separate testing using a breadboard and simple connections to verify their proper operation. After completing the testing, all essential components such as the motor driver circuits, Teensy microcontroller, and wiring were soldered onto a single experimental card, and the separate programs were combined into one.

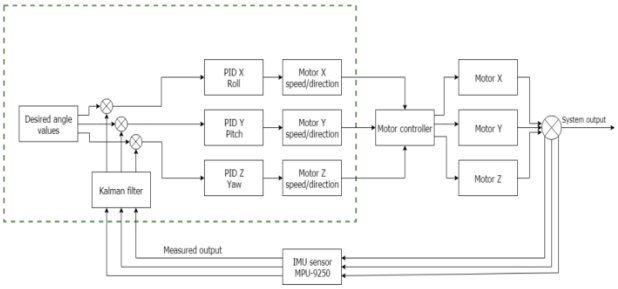

Fig 3. Feedback system (control system)

The entire feedback system is depicted in the block diagram, providing a simplified overview of the stabilization process. Inside the software, the microcontroller is symbolized by the green block, illustrating the internal workings of the process.

CONCLUSION

The design was sufficient and self-sustaining. It permitted relatively unrestricted motion while also exhibiting the required stiffness. There is potential for enhancing the design for different uses or opting for superior construction materials.

The transfer function of the system changes based on the items placed on the platform, leading to variations in the system's inertia and centre of mass. It would be ideal to have an algorithm that can effectively account for these changes.

Various types of motors can be utilized based on specific performance requirements. Motors capable of producing high torque are ideal for handling heavy loads, while motors with high angular velocity are better suited for rapid response times. However, it is uncommon to find a motor that excels in both aspects simultaneously due to the interplay between power, torque, and angular velocity.

This model has other problems, such as sensor drift, which leads to a change in the desired position of the platform over time, resulting in a tilt as time goes on. It is better to use multiple inertial sensors or an external sensor like an Encoder sensor or Hall sensor to measure the platform's angle and relate it to the zero position.

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Embeded based customised wireless message circular system using loRa technology

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***Abstract*— The proposed project involves creating a bidirectional communication system using ESP32 microcontrollers, OLED displays, and keyboards, with wireless connectivity via LoRa technology. Two identical units will be built, each with an ESP32, an OLED display, and a keypad. Users can type messages on one unit, which will then be transmitted wirelessly to the other unit through LoRa. The message will be displayed on the OLED screen of the receiving unit. This system offers a user-friendly interface, ensuring smooth interaction. It is suitable for scenarios requiring reliable, long-distance communication, such as remote monitoring or outdoor activities. The project also focuses on power efficiency for extended battery life. This innovative solution combines hardware robustness with wireless capabilities for versatile applications.**

Keywords—LoRa, OLED, ESP32

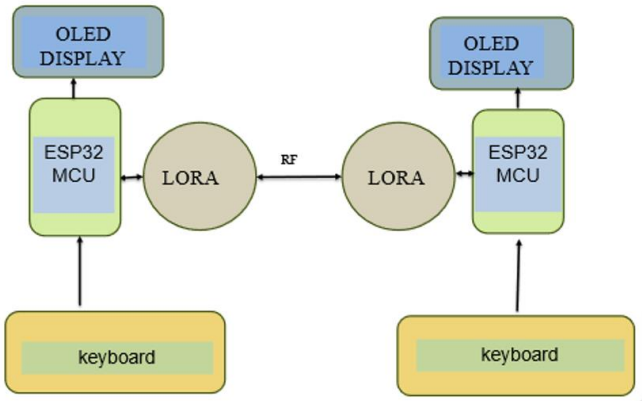
I. INTRODUCTION

The proposed project introduces a bidirectional communication system leveraging ESP32 microcontrollers, OLED displays, and keyboards, coupled with wireless connectivity through LoRa technology. This innovative system addresses the need for reliable, long-distance communication in diverse scenarios such as remote monitoring, emergency response, and outdoor activities, where conventional communication methods may falter. Comprising two identical units, each equipped with an ESP32, an OLED display, and a keypad, users can seamlessly compose messages on one unit, which are subsequently transmitted wirelessly via LoRa to the counterpart unit. The received message is promptly displayed on the OLED screen of the receiving unit. A paramount focus of the project lies in providing a user-friendly interface, ensuring smooth and intuitive interaction. This system is tailor-made for environments demanding dependable, long-range communication, such as in remote monitoring or outdoor pursuits. Moreover, significant attention has been devoted to power efficiency to prolong battery life, rendering the solution highly practical for extended usage.

II. SIGNIFICANCE OF THE PROJECT

The profound significance of this project lies in its potential to redefine communication paradigms in environments where conventional methods fall short. Remote monitoring, a vital aspect in sectors like environmental conservation, agriculture, and infrastructure maintenance, stands to benefit immensely from this innovation. In emergency response scenarios, such as natural disasters or search-and-rescue operations, where traditional infrastructure may be compromised, this communication system can serve as a lifeline, enabling swift coordination and information dissemination. Moreover, the project's focus on power efficiency represents a forward-thinking approach to sustainability and resource conservation. By maximizing the operational lifespan of the system through efficient power management strategies, the project aligns with broader efforts to minimize environmental impact. In essence, this project addresses a critical need for reliable, long-range communication, transcending the boundaries of conventional methods. Its potential applications span a spectrum of domains, offering a versatile and indispensable tool for modern communication challenges.

III. BLOCK DIAGRAM



A. *Detailed Description of ESP32 Microcontrollers*

The ESP32 microcontroller, a product of Esp resift sytems, represents a pivotal advancement in the field of embedded systems. It is built around the Xtensa LX6, a dual-core processor architecture, each core clocked at up to 240 MHz This dual-core setup facilitates concurrent execution of tasks, enabling efficient multitasking in applications. The microcontroller integrates a rich array of peripherals, including GPIO pins, UART, SPI, I2C, and ADC interfaces, which enhance its versatility for a wide range of applications. One of the notable strengths of the ESP32 lies in its wireless capabilities. It is equipped with both Wi-Fi and Bluetooth/BLE (Bluetooth Low Energy) connectivity options. This allows seamless integration with existing network infrastructure and the ability to communicate with a wide array of devices, making it an ideal choice for IoT applications.

B. *Specifications of OLED Displays:*

The OLED (Organic Light Emitting Diode) displays employed in this project offer several advantages over traditional LCD screens. They utilize organic compounds to emit light when an electric current is applied, eliminating the need for a backlight. This results in deeper blacks, higher contrast ratios, and improved viewing angles.
The chosen OLED displays are 128x64. This ensures crisp and legible display of messages, crucial for effective communication in diverse environments. Additionally, their

compact form factor and low power consumption make them well-suited for integration in portable communication devices.

C. Key Features of the Keypad:

The keypad utilized in this project is a 4x4 keypad, which means that it has 16 keys arranged in a 4x4 grid. The keys are typically labeled with numbers from 0 to 9, A to D as well as some additional symbols such as *, #, and enter. The keypad is connected to the microcontroller through a series of wires, and the microcontroller can read the input from the keypad using the GPIO pins. The keypad is a simple but versatile input device that can be used in a variety of projects. It is designed to provide a user-friendly interface for composing messages. Key features include. Furthermore, the keypad is integrated with the microcontroller through GPIO pins. This seamless integration enables efficient data input, enhancing the user experience and ensuring smooth operation of the communication system. The keypad is a 4x4 keypad with 16 keys.

IV. LoRA Module

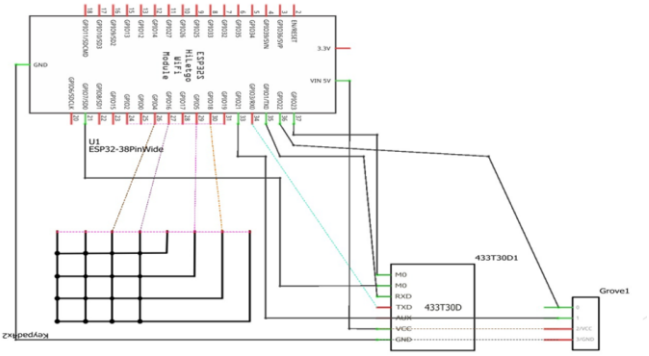
A LoRa module operating at 433 MHz is designed for long-range wireless communication in various applications. This module utilizes LoRa (Chirp Spread Spectrum) modulation, a technique known for its efficiency and resistance to interference. It operates within the 433 MHz ISM band, offering a suitable frequency range for applications that require reliable, long-distance communication. The module typically allows for adjustable output power, commonly reaching up to 100 mW (20 dBm) or higher, enabling robust signal transmission over extended distances. With selectable Spread Factors (SF) ranging from SF7 to SF12, the module provides flexibility in balancing data rate and range. These modules commonly operate at 3.3V facilitating integration with microcontrollers or other devices. With features like external antenna connectors, LoRa modules ensure flexibility in optimizing the antenna setup for optimal performance. Depending on factors like environment, antenna quality, and power settings, LoRa modules at 433 MHz can achieve communication ranges ranging from several kilometers to tens of kilometers.

A. System Architecture

The system architecture employs a modular design, which allows for seamless interaction between the components. The illustration above showcases the interconnectedness of the key elements: ESP32 microcontrollers, OLED displays, keypads, and LoRa modules. The ESP32 microcontrollers are responsible for controlling the system, while the OLED displays provide a user interface. The keypads allow users to input data, and the LoRa modules provide long-range wireless communication. This modular design allows for easy customization and expansion of the system. For example, additional sensors or actuators could be added to the system by simply connecting them to the appropriate modules.

The ESP32 microcontrollers are the brains of the system. They are responsible for controlling all the other components and processing all the data. The OLED displays provide a user interface for the system. Users can interact with the system by pressing the buttons on the keypad and viewing the information on the display. The keypads allow users to input data into the system. This data can be used to control the system or to provide feedback to the user. The LoRa modules provide long-range wireless communication for the system. This allows the system to communicate with other systems or with the internet. The modular design of the system makes it easy to customize and expand. For example, if you need to add a new sensor to the system, you can simply connect it to the appropriate module. Similarly, if you need to add a new actuator to the system, you can simply connect it to the appropriate module. This modular design makes it easy to adapt the system to your specific needs.

V. Circuit Diagram



A. Message composition in unit A

In Unit A, the user engages with the keypad to compose a message. The keypad's layout and tactile feedback enhance the user experience by making it easy to find the right keys and providing feedback that the key has been pressed. The keystrokes are processed by the microcontroller, which translates them into digital data. The ESP32, with its dual-core architecture, efficiently manages this process while ensuring responsiveness. The microcontroller then sends the digital data to the display, which displays the message as it is being composed. The user can then edit the message as needed, and when they are finished, they can send the message by pressing the send button.

B. Wireless transmission via LoRa.

Once the message is composed, the ESP32 initiates the encoding process. The data is formatted for transmission, which includes error-checking mechanisms for reliability. The LoRa module, integrated with Unit A, takes over the process. LoRa's long-range capabilities are leveraged to transmit the encoded data packet, modulating it for optimal transmission efficiency.

The LoRa module uses a technique called chirp spread spectrum (CSS) to modulate the data. CSS is a type of spread spectrum modulation that uses a chirp signal to transmit data. A chirp signal is a signal that changes its frequency over time in a linear fashion. This makes it difficult for noise and interference to corrupt the signal, as the noise will be spread out over a wider frequency range.

The LoRa module also uses a technique called forward error correction (FEC) to improve the reliability of the transmission. FEC is a technique that adds redundant data to the transmitted signal. This redundant data can then be used

to correct errors that occur during transmission. By using CSS and FEC, the LoRa module can transmit data over long distances with a high degree of reliability.

C. Message reception in Unit B.

In parallel, Unit B's LoRa module diligently receives the transmitted data packet. This reception process is characterized by LoRa's exceptional sensitivity and the ability to pick up signals even in challenging environments, such as those with a lot of interference or noise. Upon reception, the ESP32 in Unit B takes control. It meticulously processes the received data, decoding it to retrieve the original message. The ESP32 is a powerful microcontroller that is well-suited for this task. It has a built-in LoRa module, which makes it easy to connect to the LoRa network. The ESP32 also has a powerful processor that can quickly decode the received data.

D. Displaying the Received Message

With the message decoded, the ESP32 in Unit B orchestrates the presentation. It instructs the OLED display to render the message in a legible format. The OLED display, characterized by its high contrast and wide viewing angles, faithfully reproduces the message. This visual representation ensures that the recipient can easily read and comprehend the incoming communication. The bidirectional data flow allows for two-way communication between Unit A and Unit B. This means that either unit can send or receive messages, which creates a more dynamic and versatile platform for real-time communication. This versatility makes the system ideal for a variety of scenarios, such as remote monitoring and emergency response, where reliable long-distance communication is essential. In remote monitoring, the system can be used to send and receive data from sensors or cameras that are in remote areas. This allows for real-time monitoring of these areas, which can be used to detect problems or hazards early on. In emergency response, the system can be used to communicate with first responders who are in remote areas. This allows for quick and efficient communication, which can be essential in saving lives. The system's bidirectional data flow is a key feature that makes it ideal for these and other scenarios.

VI. Wireless communication with LoRa

A. Overview of LoRa Technology

LoRa is a long-range, low-power wireless communication technology that was developed to address the challenges of communication in environments with limited infrastructure or over extended distances. It has gained prominence in various IoT and remote monitoring applications. LoRa works by using spread spectrum modulation, which allows it to transmit data over long distances with low power consumption. This makes it ideal for applications where battery life is a concern, such as in remote sensors or asset tracking devices. LoRa is also relatively inexpensive to implement, which has made it a popular choice for a variety of IoT applications.

B. Advantages of LoRa Technology

Exceptional Range: LoRa technology boasts an impressive communication range, reaching several kilometers even in urban environments. In rural settings, it can achieve transmission distances of tens of kilometers. This extended range is a significant advantage over traditional wireless technologies.

Low Power Consumption: LoRa devices are designed to operate on minimal power, making them suitable for battery-powered applications. This low power consumption ensures prolonged battery life, a critical factor for devices deployed in remote or inaccessible locations.

High Penetration and Reliability: LoRa signals have a high penetration capability, allowing them to pass through obstacles and reach receivers in challenging environments. This feature is invaluable in scenarios where reliable communication is essential, even in areas with physical obstructions.

Scalability: LoRa technology supports a scalable network architecture. A single LoRa gateway can handle communication with many end-devices, making it well-suited for applications with a multitude of sensors or devices spread over a wide area.

VII. Applications

A. Remote Environmental Monitoring:

Scenario: In a conservation project, researchers need to monitor wildlife in a remote, inaccessible forest area.

Application: The bidirectional communication system allows field researchers to transmit data on animal behavior and environmental conditions to a central database, enabling real-time analysis and informed conservation efforts.

B. Emergency Response in Disaster Management:

Scenario: In the aftermath of a natural disaster like an earthquake, conventional communication infrastructure is severely compromised.

Application: The bidirectional communication system provides a reliable means for first responders to coordinate efforts, communicate critical information, and request additional resources, ensuring swift and efficient disaster relief operations.

C. Precision Agriculture and Farming:

Scenario: A precision agriculture system requires constant monitoring of soil moisture levels and weather conditions across vast agricultural fields.

Application: Each field unit equipped with the bidirectional communication system can transmit data to a central control hub, allowing farmers to make informed irrigation and planting decisions in real-time.

D. Mountaineering and Outdoor Expeditions:

Scenario: A group of mountaineers embarks on an expedition in a remote mountain range with limited cellular coverage.

Application: Each member carries a unit, allowing for continuous communication with the base camp and fellow climbers. This ensures safety, coordination, and provides an emergency lifeline if needed.

E. Wildlife Tracking and Conservation:

Scenario: Conservationists track the migration patterns of endangered species in a large, remote wilderness area.
Application: Units affixed to wildlife collars transmit location data to a central monitoring station, enabling conservationists to gather critical data on habitat use and movement patterns for conservation planning.

F. Maritime Search and Rescue Operations:

Scenario: Coast guard or search and rescue teams need to coordinate efforts to locate and rescue distressed vessels in a vast maritime area.
Application: Units on board vessels and at coastal stations facilitate effective communication, enabling quick response times and efficient coordination of rescue operations.

G. Rural Healthcare and Telemedicine:

Scenario: Healthcare providers need to offer telemedicine services in remote rural areas with limited connectivity.
Application: Units deployed in remote clinics allow for real-time communication with medical experts located in urban centers, enabling timely diagnoses and treatment plans.

H. Wilderness Exploration and Expeditions:

Scenario: Scientific explorers embark on an expedition in a remote, uncharted territory.

VIII. Conclusion

In this project, we have successfully developed a bidirectional communication system that uses ESP32 microcontrollers, OLED displays, and keyboards, and utilizes LoRa technology for wireless connectivity. This innovative system provides a seamless means of communication between two units, addressing scenarios where reliable, long-distance communication is imperative.
The system is designed to be easy to use and install, and can be used in a variety of applications, including industrial automation, asset tracking, and remote monitoring. It is also highly secure, thanks to the use of LoRa technology, which is resistant to interference and eavesdropping.
The integration of ESP32 microcontrollers with OLED displays and keyboards has yielded a user-friendly interface, ensuring smooth interaction. The emphasis on power efficiency has paved the way for extended battery life, a crucial factor in scenarios where continuous operation is paramount. This system's hardware robustness, coupled with its wireless capabilities, opens a plethora of possibilities across various domains. The project's significance spans a wide array of applications. From remote monitoring to emergency response and outdoor activities, this bidirectional communication system fills a critical niche. In remote environmental monitoring, it enables researchers to gather crucial data from inaccessible regions. In emergency response, it ensures efficient coordination and communication in disaster-stricken areas. In precision agriculture, it empowers farmers with real-time data for optimal resource utilization.

Furthermore, this system is invaluable in wilderness exploration, maritime search and rescue operations, and wildlife tracking for its capability to provide reliable communication in remote and challenging environments. It also finds application in rural healthcare and telemedicine, bringing advanced medical services to underserved areas. In summary, this project presents a versatile and robust solution for long-range communication needs. By seamlessly integrating hardware components and leveraging LoRa technology, we have created a system with far-reaching implications across a spectrum of domains. Its successful implementation showcases the potential of technology to address real-world challenges and underscores the importance of reliable communication in today's interconnected world.

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Machine Intelligence for Crime Analysis

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Abstract-Machine Intelligence for Crime Analysis presents a cutting-edge approach to crime detection and prevention by leveraging the power of machine learning algorithms. By utilizing vast data sets comprising of historical crime data, geographical information and socio economic factors, machine learning models are trained to identify patterns and trends indicative of criminal activity. The application of predictive analytics facilitates proactive decision making enabling law enforcement agencies to allocate resources effectively and anticipate emerging threats. The integration of machine intelligence into crime analysis represents a transformative approach towards proactive law enforcement strategies in modern society.

Keywords: crime analysis, Crime prediction, Machine learning, Ethical Considerations.

I.INTRODUCTION

This paper serves as a comprehensive exploration of the intersection between machine learning and crime analysis, focusing on the application of various techniques to predict and analyze criminal behavior. We delve into the diverse sources of crime data, ranging from reported incidents and arrests to calls for service and citizen reports, each presenting unique challenges and opportunities for analysis. Moreover, we discuss the critical preprocessing steps required to cleanse and prepare raw crime data for modeling, including data cleaning, normalization, and handling missing values. Public safety and security are fundamental aspects of any thriving society, and effective crime analysis and prediction play pivotal roles in maintaining these pillars. Traditional approaches to crime analysis have long relied on historical data and the expertise of law enforcement professional. However, these methods often suffer from limitations in accuracy, scalability, and adaptability to evolving crime patterns. With the exponential growth of data availability and advancements in machine learning techniques, therehas been a paradigm shift in the way crime analysis and prediction are approached. The emergence of machine learning has revolutionized various domains, and its exception. Machine learning techniques offer the promise of uncovering hidden patterns, identifying trends, and making accurate predictions based on large volumes of heterogeneous data. By leveraging algorithms that can learn from data, crime analysts and law enforcement agencies can gain deeper insights into crime dynamics and enhance their ability to prevent and respond to criminal activities effectively.In addition to discussing technical aspects, this paper also addresses the ethical considerations and challenges associated with deploying machine learning models for crime analysis. We emphasize the importance of fairness, transparency, and accountability in the development and deployment of predictive policing systems, striving to mitigate potential biases and uphold the principles of justice and equity. Furthermore, we provide an in-depth review of various machine learning algorithms employed in crime prediction tasks, ranging from traditional supervised learning methods to more advanced techniques like deep learning and ensemble methods. By comparing the performance and suitability of these algorithms for different types ofcrime prediction tasks, we aim to guide practitioners in selecting the most appropriate models for their specific needs.

II.DESIGN AND DEVELOPMENT

Data Collection and preprocessing:

Gather diverse sources of crime data including reports of accidents, arrests, call for service and citizen reports, from relevant law enforcement agencies and other authoritative sources. Perform data cleaning to remove inconsistencies, errors, and outliers, ensuring the quality and reliability of the dataset. Normalize the data and handle missing values using appropriate techniques such as imputation or deletion. Conduct exploratory data analysis (EDA) to gain insights into the characteristics and distributions of the crime data.

Feature Engineering:

Extract relevant features from the preprocessed crime data, including spatial and temporal attributes, as well as contextual factors such as weather conditions, demographic information, and urban infrastructure. Develop innovative feature engineering techniques tailored to crime data such as creating hotspot maps, calculating crime density metrics, and encoding temporal patterns.

Model Selection and Training:

Evaluate a variety of machine learning algorithms for crime prediction tasks, including supervised unsupervised, and hybrid methods. Split the preprocessed data into training, validation and testing sets to assess the performance of the models.

To experiment with different algorithm configurations, hyper parameters, and feature combinations to optimize model performance.

Model Evaluation:

Assess the performance of the trained models using appropriate evaluation metrics such as accuracy,

precision, recall, F1-score, and area under the ROC curve. Conduct cross-validation to ensure the generalizability of the models across different datasets and scenarios. Analyze the strengths and weaknesses of each model, identifying areas for improvement and refinement.

Ethical Considerations:

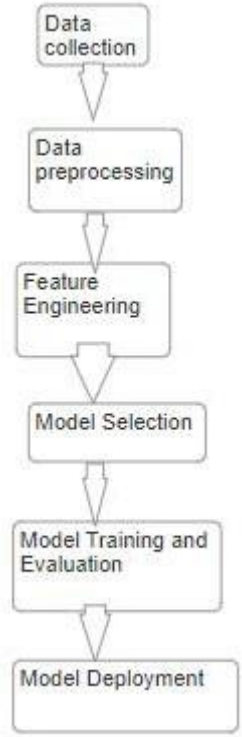
Address ethical concerns related to algorithmic bias privacy infringement, and potential misuse of predictive policing systems. Incorporate fairness-aware techniques to mitigate biases and promote equity in the deployment of machine learning models for crime analysis. Implement transparency and accountability measures to ensure the responsible use of predictive analytics in law enforcement practices.

Model Deployment and Integration:

Deploy the trained models into production environments, integrating them into existing crime analysis workflows and decision support systems.Provide user-friendly interfaces and visualization tools to facilitate the interpretation and utilization of model predictions by law enforcement personnel and other stakeholders.

Continuously monitor and evaluate the performance of the deployed models, incorporating feedback and making iterative improvements as needed

IV.FLOW MODEL:



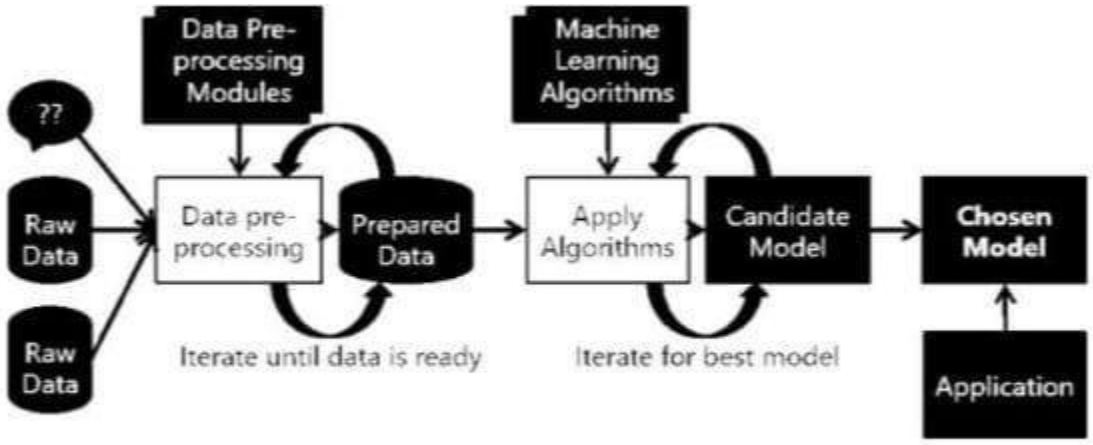


Fig 4.2 System Architecture

III. LITERATURE SURVEY:

1. "Predictive Policing: The Role of Crime Forecasting in Law Enforcement" by Mohler et al. (2015) This paper explores the concept of predictive policing, emphasizing the importance of crime forecasting in law enforcement. It discusses various machine learning algorithms used for crime prediction, such as random forests and neural networks, highlighting their effectiveness in identifying crime patterns and hotspots.
2. "Crime Prediction using Data Mining Techniques: A Comprehensive Review" by Malathi and Geetha (2016) This review paper provides a comprehensive overview of data mining techniques applied to crime prediction. It discusses the use of algorithms like decision trees, support vector machines, and clustering methods in analyzing crime data. The paper also examines the challenges and limitations associated with crime prediction models.
3. "A Survey of Crime Prediction using Data Mining Techniques" by Alwakeel et al. (2018) This survey paper presents an overview of recent advancements in crime prediction using data mining techniques. It discusses the integration of geographical information systems (GIS) with machine learning algorithms for spatial analysis of crime data. The paper also examines the ethical implications and privacy concerns associated with predictive policing technologies.

4. "Crime Prediction using Machine Learning Techniques: A Survey" by Bhatt et al. (2020) This survey paper reviews the application of machine learning techniques in crime prediction. It discusses the use of supervised, unsupervised, and hybrid learning approaches for analyzing crime data. The paper also explores the role of feature selection and dimensionality reduction techniques in improving the accuracy of predictive models.
5. "Deep Learning Techniques for Crime Prediction: A Comprehensive Survey" by Tripathi et al. (2021) This comprehensive survey focuses on the application of deep learning techniques for crime prediction. It discusses the use of convolutional neural networks (CNNs), recurrent neural networks (RNNs), and hybrid architectures for analyzing spatiotemporal crime data. The paper also examines the challenges and future directions in deep learning-based crime pre

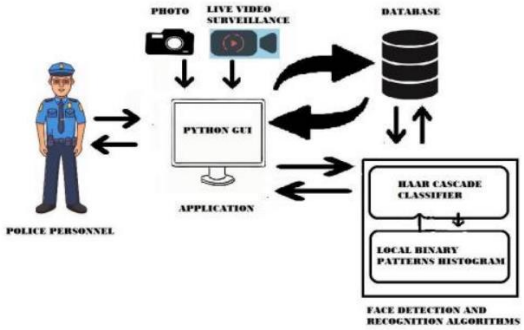
IV. METHODOLOGY:

System development method is a process through which a product will get completed or a product gets rid from any problem. Software development process is described as a number of phases, procedures and steps that gives the complete software. It follows series of steps which is used for product progress. The development method followed in this project is waterfall model.

Model phases Requirement Analysis: This phase is concerned about collection of requirement of the system. This process involves generating document and requirement review. System Design: Keeping the requirements in mind the system specifications are translated in to a software representation. In this phase the designer emphasizes on: -algorithm, data structure, software architecture etc.

Coding: In this phase programmer starts his coding in order to give a full sketch of product. In other words, system specifications are only converted in to machine readable compute code. Implementation: The implementation phase involves the actual coding or programming of the software. The output of this phase is typically the library, executables, user manuals and additional software documentation Testing: In this phase all programs (models) are integrated and tested to ensure that the complete system meets the software requirements. The testing is concerned with verification and validation. Maintenance: The maintenance phase is the longest phase in which the software is updated to fulfill the changing customer need, adapt to accommodate change in the external environment, correct errors and oversights previously undetected in the testing phase, enhance the efficiency of the software.

System architecture:



The system architecture for crime analysis and prediction using machine learning is a comprehensive framework designed to process, analyze, and predict criminal activities based on historical data and relevant factors. At its core, the architecture consists of several interconnected layers, each serving a distinct purpose in the overall workflow. The process begins with the Data Collection Layer, where data from diverse sources such as crime reports, demographics, socioeconomic indicators, and environmental data are gathered. This layer ensures the availability of a rich and comprehensive dataset for analysis. Subsequently, the Data Preprocessing Layer takes charge, where collected data undergoes cleaning, transformation, and normalization to ensure consistency and reliability. Missing values are handled, outliers are removed, and categorical

variables are encoded to prepare the data for further analysis.

V. RESULTS:

Table 1.

Req_Id	Tkt_Id	Req_Description	Actual_o/p	Expected_o/p	Tkt_status
1.	101	During registration of criminal, 5 criminal photos must be uploaded with faces in it.	Registration successfull	Registration successful	PASS
	102	If NO faces found in images.	NO faces found error message	NO faces found error message	PASS
	103	If less than 5 images are selected	Alert message Please select 5 images	Alert message Please select 5 images	PASS
	104	If above 5 HD images are selected then.	Memory Limit exceeded	Memory Limit exceeded	PASS

Fig : Test Case of Criminal Registration

Req_Id	Tkt_Id	Req_Description	Actual_o/p	Expected_o/p	Tkt_status
2.	201	Upload image from pictures and if criminal is found.	Criminal details will be displayed	Criminal details will be displayed	PASS
	202	Upload image from pictures and if criminal is not found.	No criminal recognized message	No criminal recognized message	PASS

Table 2: Test case for detecting criminals

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7. LBPH Based Improved Face Recognition at Low Resolution Aftab Ahmed, Jiandong Guo, Fayaz Ali, Farha Deeba and Awais Ahmed 2018 International Conference of Artificial Intelligence and Big Data, China

8. Criminal Identification System Using Face Detection and Recognition Piyush Kakkar and Vibhor Sharma International Journal of Advance Research in Computer and Communication Technology Vol 7 issue 3 march 2018

9. Criminal Face Recognition System. Alireza Chevelwalla, Ajay Gurav, Sachin Desai and Prof. Sumitra Sadhukhan International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 4 Issue 03, March-2015.

IOT SYRINGE INFUSION PUMP

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Abstract— Aiming at the current medical equipment market demand for information transmission and monitoring system of drug Syringe pump with low energy consumption and high stability, a wireless remote information transmission system with low cost and high reliability based on IOT (Internet of things) communication was proposed. In this IoT-based syringe pump monitoring system, a web interface is created using HTML for controlling the syringe pump remotely. The interface allows users to adjust parameters such as flow rate and volume easily. This web page is hosted on the ESP8266 microcontroller, which acts as the central processing unit for the system. Power is supplied to the ESP8266 microcontroller through a regulator, ensuring stable operation. The microcontroller interfaces with a driver board, which in turn controls the gear motor responsible for driving the syringe pump. The movement of the syringe pump is precisely controlled using a pinion rack mechanism, ensuring accurate dispensing of fluids as per the user's settings. Furthermore, the microcontroller is connected to an LCD display, providing real time feedback on the status of the syringe pump and the parameters being adjusted. This feedback enhances user confidence and enables them to monitor the process closely. By integrating these components seamlessly, the syringe pump controller not only regulates the flow rate and volume of the dispensed fluid with precision but also provides a user-friendly interface for remote control and monitoring. This enhances patient safety and improves the overall efficiency of medical fluid administration. Additionally, the system aims to verify the compatibility of different syringe sizes with the desired drug flow rates, ensuring flexibility and adaptability in clinical settings.

INTRODUCTION

In modern healthcare, the integration of technology has revolutionized patient care, aiming for precision, efficiency, and most importantly, safety. One such innovation is the IoT-based syringe pump monitoring system, designed to address the critical need for accurate and automated drug administration in medical settings. This project introduces a novel approach to syringe pump control and monitoring, leveraging the Internet of Things (IoT) technology to create a seamless and reliable system. With an emphasis on low energy consumption, high stability, and ease of use, this system aims to enhance patient safety by ensuring precise delivery of medicinal fluids at designated doses and times. At the heart of this system lies the NodeMCU microcontroller, serving as the core component for controlling the syringe pump's movements. Through a meticulously designed interface, users can remotely adjust parameters such as flow rate and volume via a web-based application hosted on the ESP8266 microcontroller. The integration of various hardware components, including power supply, regulator, LCD display, and driver board, ensures smooth operation and real-time monitoring of the syringe pump's activities. The gear motor, combined with a pinion rack mechanism, enables precise control over the pump's movements, guaranteeing accurate dispensing of fluids. Furthermore, the syringe pump controller is designed to verify the compatibility of different syringe sizes with the desired drug flow rates, providing flexibility and adaptability in clinical settings. This ensures that healthcare professionals can tailor the system to meet the specific needs of each patient, optimizing treatment outcomes while minimizing the risk of errors.

LITERATURE SURVEY

[1] W. S. Kim, W. S. Lee, and Y. J. Kim, “A Review of the Applicationsof the Internet of Things (IoT) for Agricultural Automation,” J.Biosyst. Eng., vol. 45, no. 4, pp. 385–400, 2020, Technological advances can encourage new innovations byapplying the concept of IoT (Internet of Things), a concept thataims to broaden the benefits of

continuous internetconnectivity such as data sharing, remote control, andincluding objects in the real world. For example, food,electronics, any equipment, including living things, areconnected to local and global networks through embeddedsensors and are always active. Several studies related to IoTapplications include, in the agricultural sector Smarthome ,smart fish farm. [2] A. P. J. P. J. Santoso, S. Luthfiyah, T. B. Indrato, and M. Omoogun,"Vital Sign Monitor Device Equipped with a Telegram NotificationsBased on Internet of Thing Platform," Indones. J. Electron.Electromed. Eng. Med. informatics, vol. 3, no. 3, pp. 108–113, 2021, The IoT concept is also widely applied to medicalequipment, such as research conducted by a researcher fromthe Department of Electromedical Engineering PoltekkesMinistry of Health, Surabaya Agatha Putri Juniarandcolleagues . Their research offers IoT applications forVital signs monitoring patients who need treatmentintensively, and their vital condition can be monitoredremotely. IoT is also applied to the Patient Monitoring System . Heart disease monitoring , Remote HealthMonitoring Systema, and similar studies were carried outby Shivam Gupta et al. [3] L. E. Putri, Muhammad Ridha Mak'ruf, and Abd. Kholiq, "SyringePump With Nearly Empty Based Microcontroller Atmega328," J.Electron. Electromed. Eng. Med. Informatics, vol. 1, no. 2, pp. 25–30,2020, A syringe pump is a medical device that is used to provideliquid medicine or nutrition into the patient's body in a certainamount and time regularly and automatically .Syringe pumps are designed to push liquids [4] K. S. Tee, M. S. Saripan, H. Y. Yap, and C. F. Soon, "Developmentof a Mechatronic Syringe Pump to Control Fluid Flow in aMicrofluidic Device Based on Polyimide Film,"IOP Conf. Ser. Mater.Sci. Eng., vol. 226, no. 1, 2022, generallydriven by a stepper motor or direct current motor, which is controlled by a microcontroller. Syringe pumpsare applied in various fields such as the healthcare andpharmaceuticalindustries . [5] Mahmut UN, "Control System Design of Syringe Infusion Pump andMATLAB Simulations," Int. J. Sci. Res., vol. 7, no. 7, p. 6, 2022, But unfortunately, the currentsyringe pump still has several weaknesses, including theabsence of notification if the liquid inside is about to run outor experience blockage. These problems will only be known ifobserveddirectly at the location. [6] Aa. Silva and G. by Muhammadu Sathik Raja, "Advanced ControlSystemFor Syringe & Infusion Pump Using IoT," Int. J. Innov. Res.Adv. Eng., vol. 6, no. 03, pp. 2349–2163, 2020, In this paper, we offer a syringe pump design that isequipped with a NodeMCU8266 WiFi module to providenotifications via a smartphone so that nurses or doctors canknow the alarm even though they are outside the patientmonitoring room. [7] Costa."Calibration Batista, Elsa, Nelson Almeida, Eduarda and use of syringe Filipe, and Anselmo pumps." In 16th InternationalCongress of Metrology, p. 02007. EDP Sciences, 2023 So this is expected can improve patientsafety. The syringe pump is equipped with a Near EmptyAlarm to provide information that the drug or nutrient liquidwill be running out soon . Alarms have a vital role inproviding information to nurses or doctors. The mechanical system of the syringe pump consists ofseveral components that have synergistic functions. Thestepper motor rotates at speed according to the settingvalue. Gear serves to convert the rotation of the motorinto linear motion on the Feed screw . Then the motor'srotational speed is monitored by the sensor disk .Theforward thrust can be determined with the ratio of the syringesize detected by the potentiometer . This is where thevolume that comes out can be seen. And finally, this tool isalso equipped with a Nearly empty sensor to determinethe remaining drug in the syringe and also a volume countersensor

EXISTING METHOD

The existing manual system for syringe pump operation relies heavily on human intervention, requiring healthcare professionals to manually adjust the flow rate and monitor the infusion process. ● This manual approach is prone to errors and inconsistencies due to factors such as human error, distraction, and fatigue. Monitoring the syringe pump's operation in real-time is challenging, as it often requires constant physical presence near the patient's bedside. ● The manual system lacks the capability for remote monitoring and control, limiting the flexibility and efficiency of healthcare delivery. Moreover, the manual operation of syringe pumps may result in suboptimal patient outcomes and compromise patient safety.

PROPOSED SYSTEM

The proposed system aims to develop a wireless remote information transmission system for drug syringe pumps, catering to the demand for low energy consumption and high stability in medical equipment. ● Utilizing IoT modules, the system establishes a Mesh network to extend the transmission distance of individual devices, enhancing reliability. ● Leveraging the practicality

and user-friendly nature of IoT technology, the system facilitates easy monitoring and control of syringe pumps. ● With the NodeMCU microcontroller as the core component, the system ensures precise control of syringe pump movements, interfacing seamlessly with various hardware components. ● The integration of gear motors and pinion rack mechanism enables accurate dispensing of fluids, contributing to patient safety. Additionally, the syringe pump controller regulates the flow rate and volume of dispensed fluid, enhancing precision and efficacy. ● Through these advancements, the proposed system aims to optimize drug delivery processes and improve patient outcomes in medical settings.

SYSTEM FUNCTION

ARCHITECTURE DESIGN

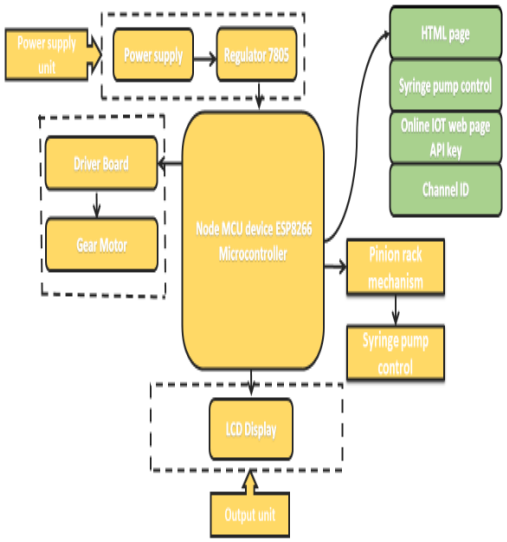

Fig no:1 PROPOSED FOR ARCHITECTURE DESIGN

CIRCUIT DIAGRAM

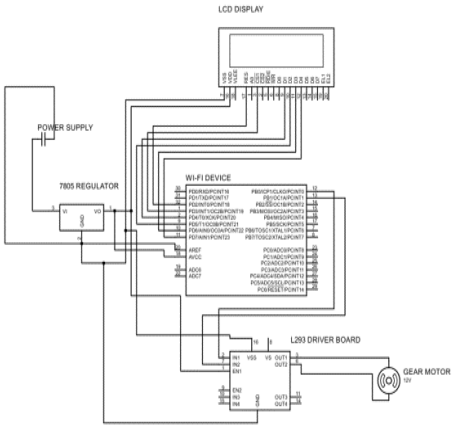

Fig no:2

INTERNAL BLOCK DIAGRAM OF 7805 VOLTAGE REGULATOR

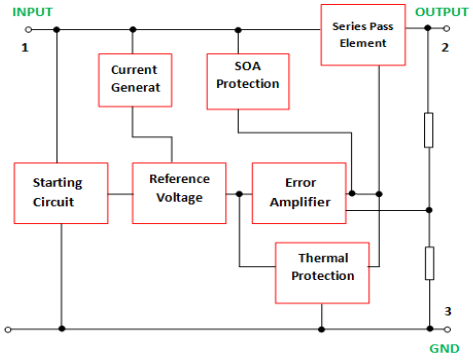

Fig no:3

VOLTAGE REGULATOR 7805 AND THE OTHER COMPONENTS

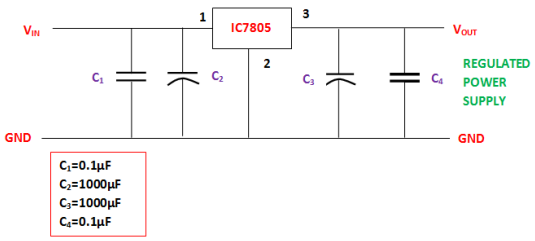

Fig no:4

PIN FUNCTIONS

Function	PIN N.O	Name	Logic State	Description
Ground	1	Vss	-	0V
Power supply	2	Vdd	-	+5V
Contrast	3	Vee	-	0 - Vdd
Control of operating	4	RS	0 1	D0 – D7 are interpreted as commands D0 – D7 are interpreted as data
	5	R/W	0 1	Write data (from controller to LCD) Read data (from LCD to controller)
	6	E	0 1 From 1 to 0	Access to LCD disabled Normal operating Data/commands are transferred to LCD
Data / commands	7	D0	0/1	Bit 0 LSB
	8	D1	0/1	Bit 1
	9	D2	0/1	Bit 2
	10	D3	0/1	Bit 3
	11	D4	0/1	Bit 4
	12	D5	0/1	Bit 5
	13	D6	0/1	Bit 6
	14	D7	0/1	Bit 7 MSB

Fig no:5

TYPES OF POWER SUPPLY

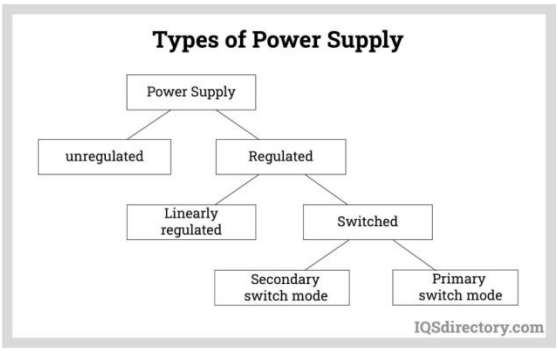

Fig no:6

SOFTWARE SPECIFICATION

- Embedded C
- Arduino IDLE
- IOT think speak web page

6.3 EMBEDDED C LANGUAGE

Embedded C use most of the syntax and semantics of standard C, e.g., main() function, variable definition, datatype declaration, conditional statements (if, switch. case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros, etc. In addition, there are some specifics to embedded C which are mentioned below:

1. Low Level Codes

Embedded programming requires access to underlying hardware, i.e., timers, memory, ports, etc. In addition, it is often needed to handle interrupts, manage job queues, etc. As C offers pointers and bit manipulation features, they are extensively used for direct hardware access.

2. In-line Assembly Code

For a particular embedded device, there may be instructions for which no equivalent C code is available. In such cases, inline assembly code, i.e., assembly code embedded within C programs is used; the syntax depends upon the compiler.

Assembly code is written in C program itself. Above code assigns ‘a’ to ‘b’. Writing inline assembly code is much easier than writing full-fledged assembly code.

3. Features like Heap, recursion

Embedded devices have no or limited heap area (where dynamic memory allocation takes place). Hence, embedded programs do not use standard C functions like *malloc*. Structures like linked lists/trees are implemented using static allocation only.

Similarly, *recursion* is not supported by most embedded devices because of its inefficiency in terms of space and time.

Such other costly features of standard C which consume space and execution time are either not available or not recommended

4. I/O Registers

Microcontrollers typically have I/Os, ADCs, serial interfaces and other peripherals in-built into the chips. These are accessed as IO Registers, i.e., to perform any operation on these peripherals, bits in these registers are read/written.

Special function registers (SFRs) are accessed as shown below:

SFR portb= 0x8B;

It is used to declare portB at location 0x8B.

Some embedded processors have separate IO space for such registers. Since there are no such concepts in C, compilers provide special mechanisms to access them

unsigned char portB @portB 0x8B;

In this example, '@portB<address>' declares portB at location 0x8B by the variable portB.

Such extensions are not a part of standard C, syntax and semantics differ in various embedded C compilers.

5. Memory Pointers

Some CPU architectures allow us to access IO registers as memory addresses. This allows treating them just like any other memory pointers.

6. Bit Access

Embedded controllers frequently need bit operations as individual bits of IO registers corresponds to the output pin of an I/O port. Standard C has quite powerful tools to do bitwise operations. However, care must be taken while using them in structures because C standard doesn't define the bitfield allocation order and C compilers may allocate bit fields either from left to right or from right to left.

7. Use of Variable data type

In C, datatypes can be simply declared, and compiler takes care of the storage allocation as well as that of code generation. But, datatypes usage should be carefully done to generate optimized code. For most 8-bit C compilers, 'char' is 8-bits, 'short' and 'int' are 16-bits, long is '32-bits'.

Some embedded processors favor use of unsigned type. Use of 'long' and floating variable should be avoided unless it is very necessary. Using long data types increase code size and execution time. Use of floating point variables is not advised due to intrinsic imprecise nature of floating point operations, alongside speed and code penalty.

8. Use of Const and Volatile

Volatile is quite useful for embedded programming. It means that the value can change without the program touching it. Consequently, the compiler cannot make any assumptions about its value. The optimizer must reload the variable every time it is used instead of holding a copy in a register.

Const is useful where something is not going to change, for e.g., function declarations, etc.

ARDUINO WINDOW

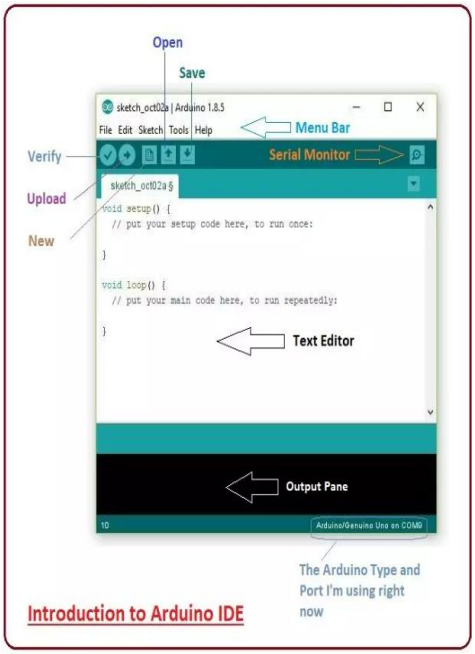

Fig no:7

RESULTS

An IoT-based syringe pump monitoring system was developed, enabling remote control and monitoring via a web interface hosted on an ESP8266 microcontroller. Precise fluid dispensing is ensured through a pinion rack mechanism controlled by a gear motor. Real-time feedback on syringe pump status is provided through an LCD

display, enhancing user confidence and patient safety. The system offers flexibility by verifying compatibility with various syringe sizes and drug flow rates, optimizing clinical adaptability.

CONCLUSION

In conclusion, the IoT-based syringe pump monitoring system represents a significant advancement in medical technology, offering a comprehensive solution to the challenges associated with drug administration in healthcare settings. By integrating IoT technology with precision control mechanisms, this system ensures enhanced patient safety, optimized fluid delivery, and streamlined monitoring processes. Through the use of a user-friendly web interface hosted on the ESP8266 microcontroller, healthcare professionals can remotely adjust parameters and monitor the syringe pump's activities in real-time. This enables quick response to changing patient needs and facilitates more personalized treatment approaches. Moreover, the system's ability to verify the compatibility of different syringe sizes with desired drug flow rates enhances flexibility and adaptability in clinical settings, ensuring optimal medication delivery. Overall, this project underscores the potential of IoT technology to revolutionize healthcare delivery, offering tangible benefits in terms of efficiency, accuracy, and patient outcomes. As technology continues to evolve, the IoT-based syringe pump monitoring system stands as a testament to the power of innovation in improving the quality and safety of patient care.

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[2] A. P. J. P. J. Santoso, S. Luthfiyah, T. B. Indrato, and M. Omoogun,“Vital Sign Monitor Device Equipped with a Telegram NotificationsBased on Internet of Thing Platform,” Indones. J. Electron.Electromed. Eng. Med. informatics, vol. 3, no. 3, pp. 108–113, 2021,

[3] L. E. Putri, Muhammad Ridha Mak’ruf, and Abd. Kholiq, “SyringePump With Nearly Empty Based Microcontroller Atmega328,” J.Electron. Electromed. Eng. Med. Informatics, vol. 1, no. 2, pp. 25–30,2020,

[4] K. S. Tee, M. S. Saripan, H. Y. Yap, and C. F. Soon, “Developmentof a Mechatronic Syringe Pump to Control Fluid Flow in aMicrofluidic Device Based on Polyimide Film,”IOP Conf. Ser. Mater.Sci. Eng., vol.226, no.1, 2022,

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Impact of Load Capacitance on CMOS Inverter Propagation Delay

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***Abstract*—Load capacitance plays a crucial role in determining the speed, power consumption, noise immunity and fan-out capability of a CMOS inverter. This paper gives an overview of effects of increasing load capacitance on CMOS inverter. Using Analog Design Environment (ADE) the load capacitance of a CMOS inverter is varied and its effects on circuit performance during simulation in Cadence Virtuoso was observed. Load capacitance is varied in 45nm technology. And by setting the input signal to a pulse with rise time, fall time and pulse width, the input voltage and output voltage of designed inverter is plotted. The results for considered load is compared. The design and performance using DC Analysis and Transient Analysis for the CMOS was carried out.**

***Keywords*— CMOS inverter, load capacitance, ADE, width of inverter, dc analysis, transient analysis**

I. INTRODUCTION

The CMOS (Complementary Metal-Oxide-Semiconductor) inverter is integral to modern digital electronics due to its efficiency, reliability, and versatility. It serves as the foundation for building a wide array of digital logic circuits and systems, and its design principles are central to understanding more complex electronic systems. Load capacitance plays a critical role in determining the performance of a CMOS inverter. Understanding and managing load capacitance is essential for designing efficient and fast digital circuits. By considering the impact of load capacitance, designers can optimize the inverter and overall circuit performance, balancing speed, power consumption, and signal integrity.

The effect of load capacitance on CMOS inverter is that it causes a transient current demand on the inverter output, which causes a number of secondary effects. Increasing the output load capacitance in a CMOS inverter can have several effects on the circuit's performance. The output load capacitance refers to the total capacitance that is connected to the output node of the inverter, including any external capacitive loads.

One of the primary effects of increasing the output load capacitance is an increase in propagation delay. The propagation delay is the time it takes for the output of the inverter to transition from one logic state to another in response to a change in the input. The higher the output load capacitance, the longer it takes for the output voltage to reach its final value due to increased charging and discharging times. As the output load capacitance increases, the switching speed of the CMOS inverter decreases. This is because the increased capacitance requires more charge to be transferred during each transition, leading to slower rise and fall times of the output signal.

When the output load capacitance is increased, the CMOS inverter needs to deliver more charge to drive the output node, leading to increased power consumption. This is because the charging and discharging of the additional capacitance require more energy. Higher output load capacitance can make the CMOS inverter more sensitive to noise and other sources of interference. The larger capacitance can act as a sink for noise, affecting the stability and reliability of the circuit.

II. PROBLEM STATEMENT

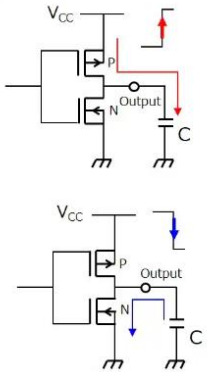
Increasing the output load capacitance in a CMOS inverter can have several effects on the circuit's performance. The output load capacitance refers to the total capacitance that is connected to the output node of the inverter, including any external capacitive loads.

If in CMOS circuit you increase the load capacitance assuming you kept other parameters constant. As you increase the load capacitance output current will take more time to charge the capacitor, this will increase the delay transition in logic.

If it is necessary to connect a capacitor directly to the output of a CMOS IC in order to increase its delay time or filter out noise, we have to check the effect of increasing the capacitor value.

III METHODOLOGY

Increasing the load capacitance in CMOS circuits will lead to an increase in the propagation delay. This is because the load capacitance is one of the factors that determines the RC time constant, which governs the charging and discharging of the capacitive loads in the circuit.



The propagation delay in a CMOS circuit is primarily influenced by the time it takes for the output to transition from one logic state to the other.

This transition time is directly proportional to the RC time constant, where R represents the effective resistance of the CMOS driver, and C represents the total capacitive load.

When the load capacitance is increased, the total capacitance C in the RC time constant also increases. This results in a larger RC time constant, which in turn leads to a longer charging and discharging time for the capacitive loads. Consequently, the propagation delay of the CMOS circuit will increase.

The relationship between the propagation delay (t_pd) and the load capacitance (C_L) can be approximated as:

$$t\_pd \propto R \times C_L$$

where R is the effective resistance of the CMOS driver. This means that as the load capacitance increases, the propagation delay will also increase, assuming the driver resistance remains relatively constant. The exact magnitude of the delay increase will depend on the specific circuit design and the relative values of the resistance and capacitance.

Using Analog Design Environment (ADE) the load capacitance of a CMOS inverter is varied and its effects on circuit performance during simulation in Cadence Virtuoso was observed. Load capacitance is varied in 45nm technology. The load capacitance C_L for different values 1pF, 10pF and 100pF was considered and analog simulation was carried out and transient response for each value of C_L was observed. It was noted that with increase in C_L with a higher output load capacitance, the output voltage of the CMOS inverter may experience more significant voltage droop during switching transitions. This can lead to issues such as signal integrity problems

C_L	*Voltage droop*
1pF	*0.4967V*
10pF	*0.4935V*
100pF	*0.4914V*

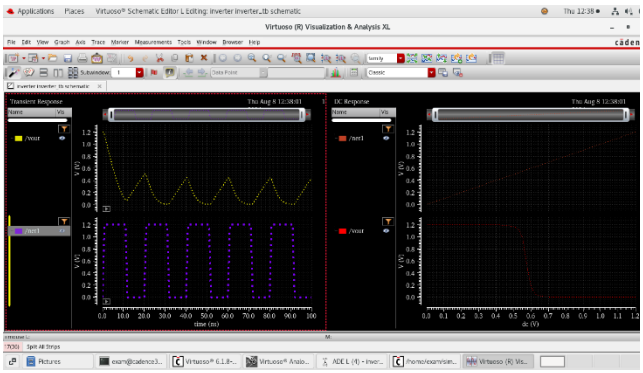


Figure 1: Transient response with C_L =1pF

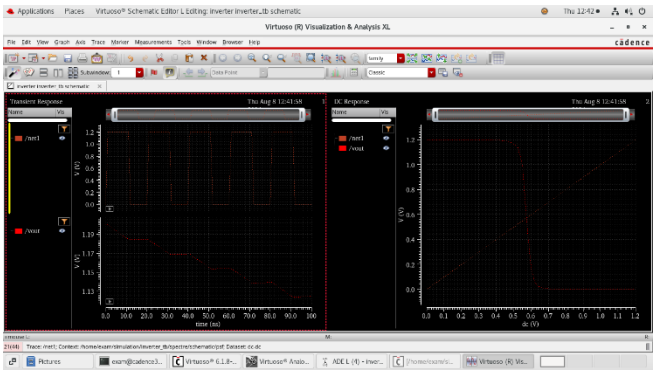


Figure 1: Transient response with C_L =10pF

Figure 3: Transient response with C_L =100pF

IV CONCLUSION

The increased C_L It slows the rising and falling edges and increases the power supply current when switching. It was noted that with increase in C_L with a higher output load capacitance, the output voltage of the CMOS inverter may experience more significant voltage droop during switching transitions

To conclude, increasing the output load capacitance in a CMOS inverter has several notable effects, including slower switching speeds, increased propagation delays, higher power consumption, reduced noise margins, potential instability and voltage droop. Designers must carefully balance these trade-offs when selecting the appropriate output load capacitance for their specific application.

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Pet Pal Feeder

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Abstract - The new design of the pet feeder represents a significant leap forward in convenience and functionality. By integrating an interactive remote controller, users are given unprecedented control over their pet's feeding schedule. Gone are the days of manual adjustments and repetitive settings. The remote controller allows for effortless customization of crucial parameters, such as the timing of feeds, the duration between consecutive meals, and even the precise quantity of food served during each feeding session. One notable feature of this design is the inclusion of a call for the pet at feeding time. This ensures that the pet is alerted and drawn to the feeder, minimizing the chances of missed meals. Additionally, refill alerts provide timely reminders to owners to replenish the food supply, preventing any interruptions in feeding routines. The inclusion of a dual power supply with a battery charger adds a layer of reliability to the feeder's operation.

Index Terms – Pet Pal feeder, ESP8266, Relay, Servo Motor, Blynk IOT Platform.

1. INTRODUCTION

1.1 Problem definition

Pet owners struggle to ensure consistent and timely feeding for their pets when they are away from home. Existing solutions are inconvenient and unreliable, leading to concerns about pets' nutrition and well-being. There is a need for an automated pet feeder that allows owners to control feeding remotely, customize schedules, and monitor their pets' diet to ensure they receive proper nourishment, even in the owners' absence.

1.2 Related Work

Existing systems for addressing the challenge of consistent and timely feeding for pets in the absence of their owners include: Traditional Manual Feeding: Pet owners rely on manual feeding by themselves or by assigning the task to a family member, friend, or neighbour. However, this method is prone to human error and may result in irregular feeding schedules or inconsistent portion sizes. Timed Automatic Feeders: These feeders allow owners to pre-set feeding times and dispense predetermined amounts of food. They operate on a timer or a simple programming interface, ensuring that pets receive meals at scheduled intervals. However, they lack the flexibility of remote control and real-time monitoring.

This feature prevents overeating or any unauthorized access to the stored food, ensuring that the pet's diet remains controlled and balanced. Furthermore, the sensor-based system in the feeder enables it to serve previously dispensed food if any remains. This minimizes wastage and promotes efficiency in feeding routines. The feeder's design also includes a priority feeder option, giving owners the flexibility to schedule multiple feed times or allowing the pet to select a single meal within the specified time gap. This empowers owners to cater to their pet's individual feeding preferences. The other parking system is Shuttle Parking System which use the elevators and shuttles for the retrieval of parked vehicles. Here Vehicles are moved between the shuttle and a specified parking place using conveyor belts and a pallet exchanger.

2. PROPOSED SYSTEM

Our proposed system addresses pet owners' challenges in ensuring consistent and timely feeding while away from home. Current solutions are often inconvenient and unreliable, raising concerns about pets' nutrition and well-being. We aim to develop an automated pet feeder that allows remote control, customizable feeding schedules, and real-time monitoring of pets' diets. This system will ensure pets receive proper nourishment and attention, even in the owners' absence, by leveraging smart technology for a more reliable and convenient feeding experience.

2.1. FEATURES OF PROPOSED SYSTEM

The proposed automated pet feeder system offers several advanced features designed to ensure pets receive consistent and timely nourishment. It includes remote control capabilities, allowing owners to adjust feeding times and portions via a smartphone app. Customizable feeding schedules enable precise meal planning tailored to each pet's needs. The system also features real-time monitoring, providing updates on feeding times and quantities to ensure pets are properly nourished. Additionally, refill alerts remind owners to replenish the food supply, while a safety lock prevents pets from accessing food outside scheduled times. Backup power ensures continuous operation during outages, and a call function alerts pets when it's time to eat, enhancing their routine and well-being.

Smart Automatic Feeders: These feeders are connected to a mobile app or a web interface, allowing pet owners to control feeding schedules, portion sizes, and monitor their pets' feeding habits remotely. They offer features such as customizable feeding schedules, portion control, and real-time notifications. Some smart feeders even have built-in cameras to enable visual monitoring of pets during mealtimes.

3. METHODOLOGY

Pet Pal Feeder System Implementation

1. Identify Requirements: Begin by understanding the requirements of the pet feeder system. Determine the desired features, such as remote control, scheduling, portion control, monitoring capabilities, and any specific needs for your pet. Consider factors like pet size, food type, feeding frequency, and any special considerations.

2. Define System Architecture: Design the architecture of the pet feeder system. Identify the key components, including microcontrollers, sensors, motors and power supply. Determine how these components will interact and communicate with each other to achieve the desired functionality.

3. Develop software: Develop the software that will run the microcontroller. This includes writing code to control the sensors, actuators, and communication modules. Implement the logic for feeding schedules, portion control, sensor readings, and communication protocols. Ensure that the firmware is efficient, robust, and user-friendly.

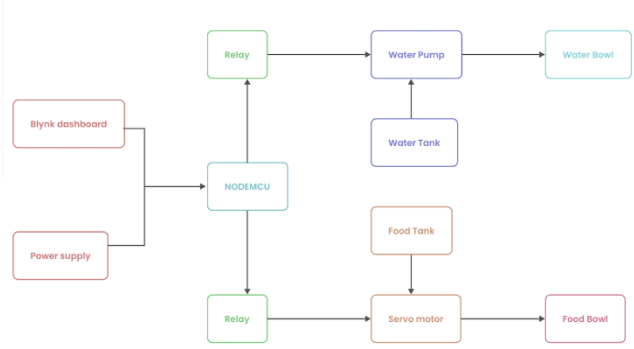
4. Build the Hardware: Assemble the selected hardware components according to the system architecture. Connect sensors, motors, and communication modules to the microcontroller based on the design specifications. Pay attention to proper wiring, connections, and physical integration of the components. Use appropriate tools, equipment, and techniques for hardware assembly.

5. Implement User Interface: Develop a user interface for the pet feeder system. This will be done in Blynk for both mobile and desktop.

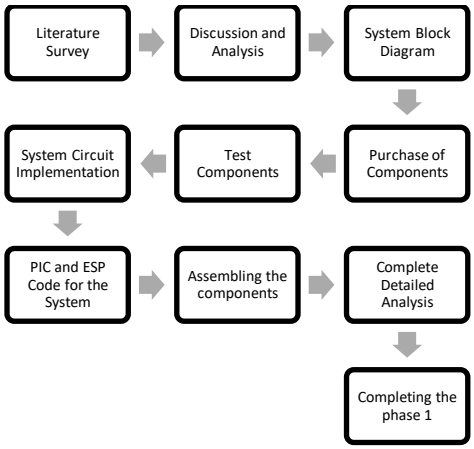
6. Test and Debug: Conduct thorough testing of the pet feeder system to ensure its proper functioning. Test different scenarios, including scheduled feedings, manual feedings, portion control, and communication reliability. Address any issues or bugs identified during testing and perform necessary debugging and optimizations.

4. WORKING

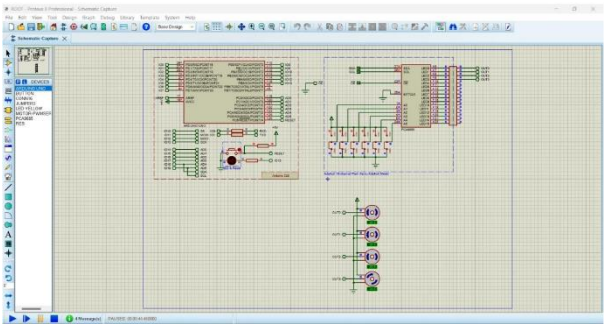
4.1 System block diagram:



4.2 End-to-end communication diagram



4.3 Circuit simulation



4.3 Hardware and software tools used:

1. ESP8266 WIFI Controller
2. Servo Motor
3. Power supply
4. Relay
5. Bread board
6. Water pump

5. CONCLUSION

There is an increasing focus on human interaction with physical devices and objects. Much research has attempted to provide a natural and intuitive approach to requesting services. The current trend of combining pet control with his IOT technology offers exciting future developments. The proposed system is also related to smart home he technologies such as smart pet doors and pet feeders. This result not only represents a significant improvement in pet monitoring systems related to IOT technology, but also satisfies the demands of pet owners. The underlying vision behind IoT could be new ways of operating, new ways of connecting devices, and even a completely clean slate approach. The next step is to fully integrate other pet grooming devices into the system, including litter boxes, pet cameras, etc. It can meet the diverse needs of owners. Also, all health, surveillance and entertainment issues are insured by your pet. In addition to cloud terminology, the next question is how can a large number of network devices around the world be connected to each other. In the future, we will focus on researching IOT gateways and remote pet detection.

6. FUTURE SCOPE

The project can advance by integrating solar systems to power the IoT-based pet feeder, enhancing its self-sufficiency and environmental friendliness. Solar panels capture sunlight to ensure continuous operation, reducing reliance on the grid and minimizing costs. This promotes sustainability and reliability, functioning even during power outages or in remote areas. Additionally, transferring the system to battery backup further enhances reliability, ensuring uninterrupted feeding schedules. Scheduled feeding and health monitoring can be improved by integrating precise feeding schedules and health sensors. Alerts notify users of any anomalies in their pet's health, facilitating proactive care. This comprehensive approach ensures pets' well-being and owners' peace of mind, aligning with sustainability and reliability goals.

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Dual-Tree Complex Wavelet Transformation and Bit Plane Slicing: Approach to Image Steganography for Secure Communication

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Abstract— Image steganography plays a pivotal role in concealing sensitive information within digital images in the realm of secure communication. This manuscript presents a novel approach utilizing Dual-Tree Complex Wavelet Transformation (DTCWT) in conjunction with Bit Plane Slicing (BPS) for image steganography, aiming to enhance robustness and security. The proposed method embeds secret data into cover images using DTCWT to exploit its multi-resolution and directional analysis capabilities, followed by BPS to further enhance the imperceptibility of the embedded data. The efficacy of the proposed approach is evaluated through extensive experimentation, yielding a Peak Signal-to-Noise Ratio (PSNR) of 79.873dB and Mean Square Error (MSE) of 0.0259, indicating minimal distortion between original and stego images. Comparative analysis with existing steganographic systems demonstrates superior performance, as evidenced by lower MSE. The obtained results underscore the robustness and effectiveness of the proposed method in ensuring secure communication through covert data transmission. This paper contributes significantly to the field of image processing and steganography, offering a promising avenue for enhancing the security and confidentiality of sensitive information exchange.

Keywords: Steganography, Dual-Tree Complex Wavelet Transformation, Bit Plane Slicing (BPS), Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE).

1. INTRODUCTION:

Image steganography, a fundamental technique in the realm of secure communication, entails concealing confidential data within innocuous-looking digital images to evade detection. As digital communication continues to proliferate across various domains, the need for robust steganographic methods becomes imperative to safeguard sensitive information from unauthorized access. In this context, the amalgamation of Dual-Tree Complex Wavelet Transformation (DTCWT) and Bit Plane Slicing (BPS) emerges as a promising paradigm for enhancing the security and imperceptibility of embedded data within cover images. Leveraging the multi-resolution and directional analysis capabilities of DTCWT, coupled with the fine-grained manipulation afforded by BPS, this manuscript presents a novel approach aimed at fortifying image steganography against detection while ensuring minimal distortion to the cover image.

Moreover, this work introduces a novel aspect to the steganographic process by incorporating pixel value adjustment of the cover image prior to embedding secret data. By dynamically adjusting pixel values based on predefined criteria, the cover image is subtly modified to accommodate the embedded data, thereby further enhancing the imperceptibility and robustness of the stego image. This holistic approach not only bolsters the security of covert communication channels but also underscores the significance of meticulous preprocessing techniques in augmenting the efficacy of steganographic methods. Through comprehensive experimentation and comparative analysis with existing systems, the efficacy and superiority of the proposed methodology are validated, positioning it as a formidable contender in the realm of secure image communication [1].

2. LITERATURE REVIEW:

Gandharba Swain [2] presented image steganography adopting Quotient Value Differencing (QVD) and LSB. Barnali and Samir [3] illustrated the Natural Language Processing (NLP) supported text steganography. Liyan Zhu et al. [4] presented robust steganography for social networks. Kamaldeep Joshi et al. [5] presented the indicator in CI for the 7th bit of a pixel. Aya Jaradat et al. [6] rendered the image steganography by employing Particle Swarm Optimization (PSO). The proposed technique uses PSO and chaos scheme to embed the guard image to CI effectively. Asmaa Abdelmonem Eyssa et al. [7] presented an image steganography approach to conceal data on wireless communication systems. The target of the methodology is to conceal three-color images in one. To minimize the distortion in the channels, Orthogonal Frequency-Division Multiplexing (OFDM) is used. Sachin and Rashmi [8] proposed a survey on various steganographic techniques. Sahar A. El Rahman [9] contributed image steganography based on Discrete Cosine Transform (DCT) and Least Significant Bits (LSBs) (1-LSB & 2-LSB). The CI is converted into 3×3 blocks, the substitution is on two LSBs and QVD is utilized on the outstanding 6 bits. Srilekha Mukharji et al. [10] manifested the Mid-Position Value (MPV) supported image steganography, progressing masking of the key is examined and Arnold's conversion has been executed on the chosen CI. H J Ko et al. [11] proposed the magic cube method along with LSB. The payload information bits are mapped out to a presumed cube, achieving the PSNR of 44 db.

3. PROPOSED MODEL

In this paper, a methodology of combining Dual-Tree Complex Wavelet Transformation (DTCWT) and Bit Plane Slicing (BPS) for image steganography, enhancing security

and imperceptibility is proposed. Leveraging DTCWT's multi-resolution and directional analysis alongside BPS's fine-grained manipulation, our approach ensures covert data transmission within digital images. By dynamically adjusting pixel values of the cover image, we further fortify the steganographic process against detection. This research contributes to advancing secure communication protocols, with implications for cybersecurity and digital forensics. This approach offers a promising avenue for safeguarding sensitive information in various domains. The blocks are explained as below.

Cover Image (CI): A CI often referred to as the host image, is the original image in which a payload is hidden. The CI conceals the payload, and the goal is to make any alterations to the CI as imperceptible as possible to the human eye.

Payload Image (PI): The PI is the image or data that, we hide PI within the CI.

Stego Image (SI): The SI the result of embedding the PI into the CI. It appears similar to the CI but contains hidden data from the PI. The SI is the output of the steganographic process.

Preprocessing: Conversion from color image to grayscale and resize the input images.

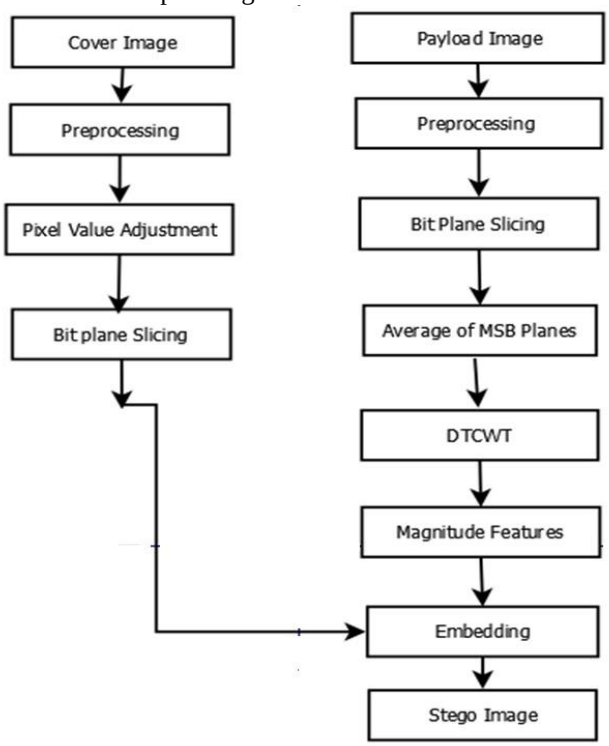

Figure 1: Proposed model of image steganography

3.1 Pixel value adjustment (PVA):

PVA is a preprocessing step in image steganography aimed at subtly modifying the intensity values of pixels in the cover image to accommodate the embedded secret data. The process involves systematically adjusting pixel values based on predefined criteria while minimizing perceptible changes to the overall appearance of the image. In this case, the adjustment rule specifies that if the intensity value of a pixel is equal to 255 (maximum value for an 8-bit image), then subtract 255 by a predetermined value, in this instance 15, to obtain the adjusted pixel value.

Begin with the cover image containing pixel intensity values ranging from 0 to 255, where 255 represents pure white. Iterate through each pixel in the image. For each pixel, check if its intensity value is equal to 255. If the intensity value of the pixel is indeed 255, proceed with the adjustment. Subtract the predetermined value (15 in this case) from the intensity value of the pixel (255) to obtain the adjusted pixel value. Update the intensity value of the pixel with the adjusted value obtained from the subtraction operation.

3.2 Bit Plane slicing (BPS)

Bit plane slicing is a technique in image steganography that conceals data within the binary representation of pixel values. It divides each pixel's binary representation into separate bit planes, allowing for subtle modifications to be made in less significant planes without perceptible changes to the image. By substituting secret data bits into selected pixel values across these planes, information can be hidden securely. Bit plane slicing is advantageous for its simplicity, resilience to common image processing operations, and enhanced security through data distribution across multiple planes. To craft a scientific paper on this topic, it's crucial to cite reputable journals, providing empirical evidence and theoretical frameworks to support discussions on principles, applications, and performance metrics. Analyzing existing approaches documented in the literature would contribute to advancing understanding and refining bit plane slicing techniques for secure communication. Figure 2 as shown below is of bit plane slicing.

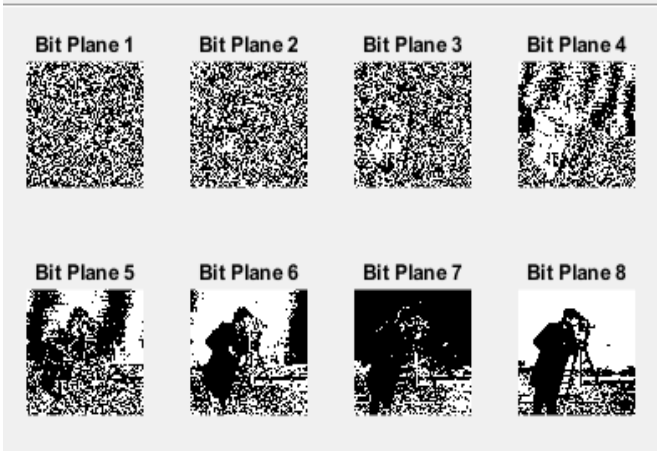

Figure 2: Bit Plane slicing importance

3.3 Dual-Tree Complex Wavelet Transform (DTCWT)

Dual-Tree Complex Wavelet Transform (DTCWT) is a powerful technique in image processing known for its ability to capture both local and directional image features effectively. Unlike traditional wavelet transforms, DTCWT employs two separate filter banks operating on real and imaginary components, enabling enhanced directional

selectivity and shift invariance. This characteristic makes it particularly suitable for tasks such as image denoising, compression, and feature extraction. The figure 3 as shown below is 2D Dual-Tree Complex Wavelet.

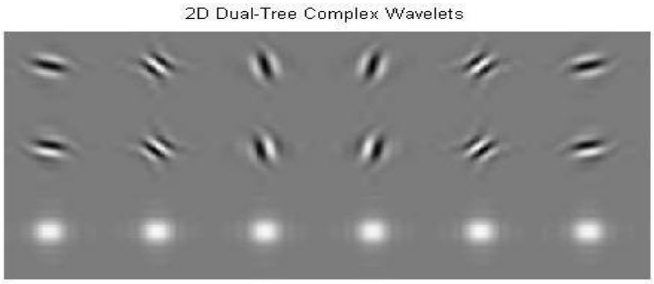

Figure 3: 2D Dual-Tree Complex Wavelet

4. RESULT ANALYSIS: The result analysis is described along with equations as below.

i) **Mean Squared Error (MSE):** The MSE values are the average squared difference between the pixel values of the stego images and their corresponding cover images. MSE is represented by Equation 1.

$$\mathrm{MSE} = \left[\frac{1}{\mathrm{R} * \mathrm{C}}\right] \sum_{\mathrm{i}=1}^{\mathrm{M}} \sum_{\mathrm{j}=1}^{\mathrm{N}} (\mathrm{SI} - \mathrm{CI})^2 \ldots\ldots\ldots\ldots [1]$$

Here, Row is represented as R, and Column as C. Multiplied $R * C$ gives the image dimension, SI an CI are stego and cover image.

ii) **Peak Signal-to-Noise Ratio (PSNR):** PSNR values are a measure of the quality of the stego images compared to their respective cover images. PSNR quantifies the level of distortion introduced during the steganographic process, with higher values indicating less distortion and better quality. PSNR is measured in decibels (dB) in Equation 2.

$$\mathrm{PSNR} = 20\log\left[\frac{(255)}{\sqrt{\mathrm{MSE}}}\right] \ldots\ldots\ldots\ldots [2]$$

Table1: Result Analysis of proposed model

CI	PI	MSE	PSNR
Cameraman	Barbara	0.0382	76.481
Elephant	Heron	0.0351	77.224
Lettuce	Common ivy	0.0333	77.681
Peppers	Pelican	0.0278	79.244
House	Boat	0.0302	78.524
Truck	Tank	0.0447	75.122
Airplane	Asiancat	0.0259	79.873

The table1 as shown above presents the results of steganographic embedding for various pairs of cover and payload images, along with corresponding PSNR and MSE values. By analyzing these metrics, one can evaluate the effectiveness of the steganographic techniques employed and assess the trade-offs between hiding capacity and image quality.

Higher PSNR values and lower MSE values generally indicate better-quality stego images with less perceptible distortion. The result as shown is MSE and PSNR. The achieved PSNR and MSE are 79.873db & 0.0259 respectively.

Table2: Result Comparison

Authors	PSNR
Ghoshal N. et al.[29]	33.20
H J Ko et al.[11]	44.0
Aya Jaradat et al.[6]	68.51
Proposed System	79.873

Table 2 is about the proposed methodology result compared with the existing. The proposed algorithm has achieved the PSNR value of 79.873db & it proves to be better comparatively. The figure 4 is simulation result which consists of cover image, payload image and stego image generated from proposed methodology.

Figure 4. Simulation Result

Figure 4 illustrates the steganography process, depicting the transformation of the cover image into the stego image through the embedding of the payload.

5. CONCLUSION AND FUTURE SCOPE:

The proposed work presents a robust approach to image steganography for secure communication, leveraging Dual-Tree Complex Wavelet Transformation (DTCWT) and Bit Plane Slicing (BPS) synergistically. By harnessing DTCWT's multi-resolution analysis and BPS's fine-grained manipulation, the method achieves a delicate balance

between concealment and security, enabling covert transmission of sensitive data within digital images. Furthermore, the inclusion of pixel value adjustment enhances obfuscation, fortifying the steganographic process against detection. Through extensive experimentation and comparative analysis, the proposed methodology demonstrates superior performance, with a PSNR of 79.873 dB indicating minimal distortion and low MSE validating robustness.

Future research may focus on integrating advanced encryption and adaptive embedding strategies to enhance security further. Additionally, optimizing pixel value adjustment algorithms and exploring alternative transform domains offer avenues for improving imperceptibility and efficiency in image steganography.

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A Modular Snake Robot That Uses Arduino

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Abstract—The "Arduino Based Snake Robot Controlled using Android" Nature is a treasure trove of inspiration for amazing inventions! This project lets you tap into that creativity by building your own snake robot, mimicking the wonders of the animal kingdom.Become a Robotics Mastermind.This is a fantastic way to learn about robotics in a fun and interactive way. We'll utilize tiny motors and an Arduino board to craft a snake robot that slithers and dodges obstacles, just like a real snake! It's bio-inspired, meaning its design is based on the way real snakes move.The Power of Customization.The size and design are entirely in your hands! This guide focuses on a medium-sized, 12-segment robot that can navigate its surroundings. These multiple segments give your robot incredible flexibility, allowing it to bend, reach, and explore tight spaces with an almost endless range of movement. Imagine the possibilities – search and rescue missions, exploring hazardous environments, and more.The Secret Weapon: Multiple Joints and App Control.The key to realistic snake-like movement lies in the robot's modular design with numerous joints. These joints provide the robot with many "degrees of freedom," essentially acting as bendy points that allow it to twist, turn, and reach incredible places.

This flexibility allows the robot to navigate complex environments.Take Control with Your Smartphone.Here's where things get awesome – this project lets you control your robot with an Android app! Imagine using your phone or tablet to guide your snake robot through tight spaces or dangerous areas. The app offers a user-friendly interface for real-time control and monitoring.The Perfect Learning Platform.This project combines beginner-friendly elements to make learning robotics a breeze. It utilizes Arduino, a popular micro controller platform, and an Android app interface, familiar to most smartphone users. The goal is to create a platform for students to easily interact with robots they build themselves! Arduino simplifies robot construction, while the Android interface provides a comfortable environment for students to take their first steps in robotics.

The project even uses Wi-Fi for wireless control, offering greater freedom during operation.Unveiling the Magic of Robotics with Your Snake Robot App.The Android app for your snake robot isn't just for control, it's a learning powerhouse! It's designed to be super user-friendly, guiding you through the core concepts of robotics.Decoding the Robot's World: Sensor Data Robots use sensors like eyes and ears, but for machines. The app will help you understand the data these sensors collect, giving you a window into the robot's environment.Bringing the Robot to Life: Actuator Activation .Imagine the muscles of a robot – those are the actuators. The app lets you control these, essentially making the robot move and interact with the world around it.The Feedback Loop: The Heart of Robotics.This is where things get really cool! It's all about using sensor data to make decisions on how the robot moves. The app will help you build these feedback systems, allowing the robot to react and adapt to its surroundings.

I. INTRODUCTION

Snakebots nature's Secret Weapon for Robotics Inspired by the Masters of Movement.Take a cue from nature's most impressive mover – the snake! These incredible creatures inspire a new generation of robots called snakebots.Imagine robots that can tackle any terrain, mimicking the snake's amazing flexibility. From squeezing through tight spaces to navigating open fields, these machines can handle it all. Some snakes can even climb and glide like they're flying.Building a Bio-Inspired Marvel.This project takes inspiration from these masters of movement. We'll build a mechanical snake powered by Arduino and servo motors. Just like a real snake, the robot will have multiple segments connected by joints. This design grants it incredible flexibility, allowing it to bend, reach, and explore its surroundings in countless ways.App Control for Real-World Missions.Here's where things get exciting! This robot can be controlled through a user-friendly Android app. Imagine using your phone or tablet to send your snakebot on missions in dangerous or hard-to-reach places! These robots have the potential to revolutionize tasks like search and rescue, firefighting, and maintenance in hazardous environments.A Revolution in Robotics.Snakebots are more than just machines; they're a glimpse into the future of robotics. By combining the power of Arduino with the user-friendliness of an Android app, we're creating a sophisticated yet easy-to-use system for controlling these innovative robots.

key to this groundbreaking innovation lies in the synergistic combination of Arduino, a highly adaptable microcontroller platform, and the user-friendly interface of an Android app. This harmonious integration of hardware and software results in a sophisticated yet accessible system for controlling these remarkable snake robots. These robots demonstrate exceptional proficiency in navigating various environments, including urban landscapes, suburban areas, and challenging terrains. The ultimate objective is to develop a system that not only performs exceptionally well in controlled settings but also seamlessly integrates into the complexities of the real world. By leveraging the power of Arduino and the intuitiveness of the Android app, this innovative solution aims to revolutionize the field of robotics, opening up new possibilities for practical applications and enhancing the capabilities of these snake-inspired robots..

Imagine the possibilities of controlling a snake robot through a user-friendly Android app! With just your phone or tablet, you could send this remarkable machine on missions to places that are dangerous or difficult to reach. These snake robots, also called slither bots, have the potential to completely transform how we tackle tasks such as search and rescue, firefighting, and maintenance in hazardous environments. By harnessing their unique abilities, we can navigate through treacherous terrains with ease and precision. This innovation has the power to revolutionize.

II. OBJECTIVE

Taking Snake Robot Control to the Next Level.Advancing Features This project has already introduced a remarkable snake robot controlled through an Android app. However, let's explore the possibilities of pushing it even further with some exciting features that can elevate this snake robot to new heights.Advanced Control and Communication:To ensure seamless control, a reliable wireless connection is essential. Bluetooth or Wi-Fi can be utilized to establish a strong and stable connection between the Arduino and your Android device.This guarantees uninterrupted control and communication.Intuitive App Interface.Imagine an app that provides effortless control over the robot's movements, speed, and more. A user-friendly interface is crucial to create a smooth and enjoyable experience for the user. With an intuitive app interface, controlling the snake robot becomes a breeze.Smarter Movements.

To enhance the precision and responsiveness of the snake robot, sophisticated algorithms can be implemented on the Arduino. These algorithms can accurately translate your commands from the app into precise motor movements, allowing the robot to respond with utmost accuracy to your control.Sensor Integration.By incorporating sensors like accelerometers and gyroscopes, the snake robot can gain a better understanding of its surroundings. This sensor integration enables the robot to adapt to different environments and exhibit more autonomous behaviors. It becomes capable of sensing obstacles, adjusting its movements accordingly, and even making intelligent decisions based on the data received from the sensors.By incorporating these advanced features, we can unlock the full potential of the snake robot, revolutionizing its control, responsiveness, and adaptability. This opens up a world of possibilities for applications such as exploration, surveillance, and tasks in hazardous or hard-to-reach areas, where the snake robot can excel and make a significant impact.behaviors.

III. METHODOLOGY

This project aims to develop a snake robot that can be controlled remotely, ensuring enhanced safety for the operator. By utilizing this robot, the operator can avoid potentially risky environments while the robot explores and gathers valuable information. The core of the operation lies in the Control Unit, which is a PC equipped with a Visual Basic 6.0 Application. This application serves as the brain of the system, providing a user-friendly interface that displays directional arrows (left, right) for controlling the robot's movements. To establish a wireless connection between the control unit and the robot, an RF Transceiver device is utilized. This device enables the chosen direction signal to be sent wirelessly, ensuring seamless communication and control between the operator and the robot. By integrating these components, this project enables safe and efficient remote control of the snake robot, facilitating exploration and data collection in challenging environment.Through this seamless communication between the Android app and the Arduino, users can effortlessly command the snake robot and witness their instructions translated into precise movements. This technology empowers users to control the snake robot with ease and precision, opening up a world of possibilities for exploration, data collection, and various applications in diverse environments.

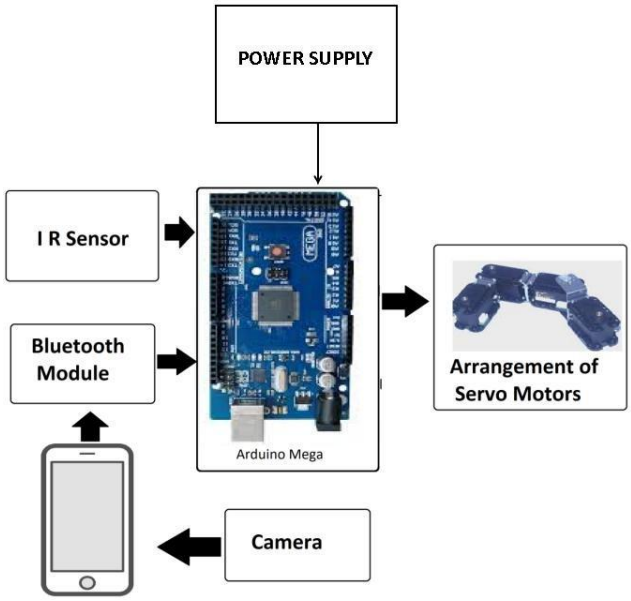

Figure 1: Block Diagram of Snake Robot Controlled by Android

Based on the interpreted command received from the Android app, the Arduino takes charge and sends precise control signals to each servo motor present in the segments of the snake robot. These servo motors are responsible for bending and slithering motions, allowing the robot to mimic the movement of a real snake. To ensure precise control over the motors, the Arduino leverages servo libraries that come in handy for accurate motor control.The process remains in a continuous loop, with the Arduino always listening for new commands from the app. This real-time responsiveness enables seamless control of the robot as the Arduino promptly executes the received commands and adjusts the movements of the snake robot accordingly.To account for potential errors or unexpected situations, the code implemented on the Arduino may incorporate error-handling routines. These routines help manage scenarios such as communication failures or the reception of unexpected signals, ensuring the system remains robust and resilient.

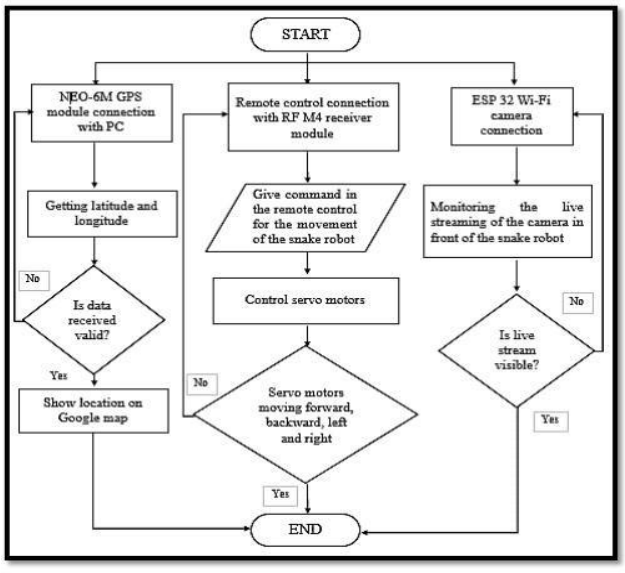

Figure 2: Flow chart of Snake Robot Controlled Using Android

IV. RESULTS

The "Arduino Based Snake Robot Controlled using Android" project has been successfully implemented. In this initial version, the focus is on functionality rather than complex features, aiming to showcase the snake robot mechanism system using limited resources.One notable feature of this robot is its ability to provide images and videos to the connected Android device through a dedicated app. A Wi-Fi camera is mounted on the robot's head, capturing images of the surrounding area. The camera is designed intelligently, activating only when the robot detects movement. This not only conserves battery life but also ensures that relevant data is captured.To facilitate secure and remote storage of the captured images, they are uploaded to the Thing Speak cloud platform. This allows users to access and store their data conveniently, without the need to be physically tethered to the robot. Users can access the stored images on their phones for analysis or any further use they may require.

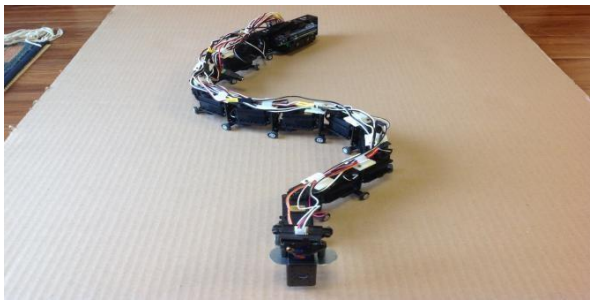

Figure 3 : Snake Robot

V. ADVANTAGES AND DISADVANTAGS

Advantages:

Search and Rescue: Disaster zones or collapsed buildings often have cramped spaces. Snake robots can navigate these areas, locate survivors, and even deliver supplies, saving valuable time in critical situations.

Inspection and Monitoring: Pipelines, machinery, and infrastructure often have hard-to-reach nooks and crannies. Snake robots can perform visual inspections, identify potential issues, and prevent costly breakdowns.

Exploration and Research: From exploring volcanic vents to studying underwater ecosystems, snake robots can venture into remote or dangerous locations, gathering valuable data for scientific research.

Imagine controlling a snake robot through a familiar Android app! This user-friendly interface makes the technology accessible even to those without extensive robotics experience.

Wireless Freedom: No more tethered operation! Control the robot remotely using Bluetooth or Wi-Fi, allowing for safer navigation in hazardous environments.

Disadvantages:

The robot's operational range is limited by Bluetooth or Wi-Fi. This can be a constraint in large or complex environments, keeping your robot tethered to a shorter leash.

Larger or more powerful robots can quickly drain batteries. Careful selection of motors and efficient control strategies are key to extended operation.

Basic Arduino code might limit the robot's movement repertoire. Fancy maneuvers like climbing walls or avoiding obstacles might require more sophisticated control systems..

Adding sensors like accelerometers or gyroscopes increases the complexity of the project. You'll need additional code to interpret the data and make the robot react accordingly.

These robots are built for navigating tight spaces, not hauling heavy loads. Their size and motor limitations might restrict the types of payloads they can carry for specificapplications.

Programming complex snake behaviors can be streamlined by designing the robot with modular segments. This allows for easier integration of additional components like sensors or even upgrading the controller for more advanced functionalities later.

Multiple servos can be power-hungry. To extend runtime, explore techniques like efficient servo control libraries or using a separate power supply for the servos. A lightweight design can also help reduce the overall power consumption.

VI. REFERENCE

[1] **A PIPELINE INSPECTION ROBOT V** Srinivas Rao, B Prakash, G Rishi, S Srikanth, P Sushan (IJCRT) – 2022. This paper describes an in- pipe inspection robot. Here, all major components of robot are designed. This robot is used for offline visual inspection of gas pipelines, water pipelines and drain pipes etc. This robot also has wide applications in chemical industries as well as in gulf countries for inspection of oil and gas pipelines.

[2] SNAKE ROBOT FOR MONITORING DAMAGE OR OBSTACLES BY ANDROID APPLICATIONS Usha, M Karthik, K Thilakan, M Thiruchselvam, K Dhakshin, P Aravindaswamy AIP Conference Proceedings 2387 (1), 2021. In this present day society snakes detectable characteristics into robots is becoming more dominant factor for creating a latest kind of locomotive and expanding the function of the robots. In this project, a 6-link snake like robot is designed

[2] **PIPE INSPECTION ROBOT** Dinesh Kumar D S, Bi Bi Kadejatul Kubra, Jennifer J, Varsha P, Varsha Rani Sah (IRJET) – 2020. This project aims to propose an autonomous robot used for in-pipeinspection which provides easy way of detecting crack and obstacles inside the pipe by using Non Destructive Testing. This project is conceived to redesign the electronic as well as mechanical control systems. Requirements for the robot were that it must be able to operate in dark, compact and wet conditions.

[4] AN FPGA BASED SNAKE ROBOT Mudasar Basha, Javeria Azain, Akshitha, K Mounika (IJARIIT) – 2018 .Two new design concepts for snake robot locomotion in unstructured environments Real-time Computing and RPal Liljback, Kristin Y Pettersen, Oyvind Stavdahl, Jan Tommy Gravdahl (PALADYN)

Human Pose Detection Estimation Using Wi-Fi

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Abstract: Paper explores using Wi-Fi signals to detect human presence and estimate their poses in an indoorenvironment, without cameras or wearable's. The research aims to characterize the impact of human pose on Wi-Fi signals and develop deep-learning models to map 1D signals to 2D pose. A dataset of Wi-Fi channel state information (CSI) from 4 volunteers are used to train a deep-learning model, achieving 60.39 % accuracy on CSI data. The system allows contactless, privacy- preserving human sensing for applications like rescue operations, military applications, and elderly monitoring, leveraging Wi-Fi infrastructure beyond communication. Field tests validate the system's performance in an indoor environment, demonstrating the potential of Wi-Fi-based vision-free human sensing.

Keywords: WiFi Sensing, Pose detection, Channel State Information, Human Activity Recognition

1. INTRODUCTION

The evolution of human detection and pose estimation has significantly benefited from recent advances in wireless communication and deep learning. The novel use of Wi-Fi signals, captured by ESP32 modules equipped with high-performance antennas, offers an innovative departure from traditional computer vision techniques. This method is particularly advantageous in challenging environments with poor visibility, as it relies on Wi-Fi's Channel State Information (CSI), which is sensitive to human presence and motion.

Deep learning technologies like DensePose and GANs have further revolutionized Wi-Fi-based sensing systems. DensePose translates CSI data into detailed 3D human poses, while GANs enhance data diversity for training, enabling the system to better generalize across various scenarios. This integration has positioned Wi-Fi-based human detection as a powerful tool for various applications, overcoming the shortcomings of vision-based systems.

This research leverages deep learning models to harness the ESP32 Wi-Fi module and advanced antennas for human detection and pose estimation. The goal is to create a versatile system that thrives in multiple environments, offering non-intrusive, high-accuracy monitoring. These developments mark a significant step forward in Wi-Fi-based sensing and have the potential to transform applications in smart homes, healthcare, and security.

Classification of Human Detection Techniques

Human detection techniques have broadly branched into vision-based and sensor-based methodologies. Vision-based methods, particularly those employing convolutional neural networks (CNNs), have substantially refined the analysis of images for human detection and pose estimation. CNNs discern human figures in images, whereas pose estimation delineates body orientation by digitizing key anatomical landmarks into skeletal models. A notable method presented in recent literature employs Part Affinity Fields (PAFs) to associate body parts with individuals during pose estimation, ensuring real-time efficiency coupled with precision.

In contrast, sensor-based detection leverages non-visual data from sources like Wi-Fi signals, which interact with human presence, to ascertain location and movements without needing visual input. These methods benefit from various sensors, including those found in wearable devices and smartphones like accelerometers, gyroscopes, and GPS, providing a rich tapestry of tools for detecting humans. Notably, a study has demonstrated a gait analysis system that utilizes data bands attached to a person's lower limbs, capturing gait metrics for individual identification with impressive accuracy. This sensor-based is further classified into (i)wearable sensors and (ii) smart phone based

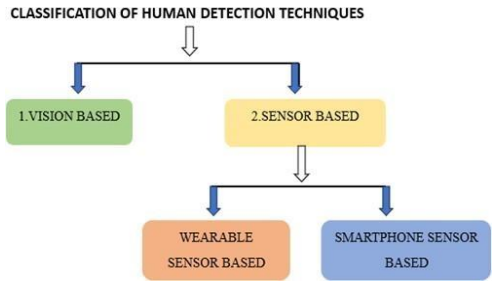

Figure 1: Classification of human detection techniques.

2. LITERATURE SURVEY

In [1], the author presents develops an innovative approach for dense human pose estimation using Wi-Fi signals. By mapping the amplitude and phase of Wi-Fi signals to UV coordinates within human body regions using deep learning architectures, they achieve performance comparable to image-based methods. In [2] introduces a sensor-based human identification system using gait analysis with an impressive accuracy of over 97%. In [3] proposes a hybrid deep learning model using CNNs and LSTMs for activity identification, showing a 98% accuracy on the MHEALTH dataset. [4] presents "Person-in-WiFi," which uses WiFi signals for body segmentation and pose estimation. [5] introduces CSI- Net, which utilizes WiFi CSI for tasks like biometricsand action recognition.

[6] presents a WiFi signal-based activity recognition using deep learning with LSTM networks. [7] discusses the temporal consistency of WiFi-based recognition systems, maintaining 94.5% accuracy over time. [8] describes a real-time human activity detection in smart homes using ESP32 microcontrollers with 70% accuracy.In [9], the author presents an efficient real-time method using Part Affinity Fields for human pose estimation. [10] demonstrates WiFi CSI-based activity recognition using deep CNNs with accuracies up to 100%. [11] discusses human pose estimation from WiFi signals, comparing performance with image-based methods.

[12] outlines the Point R-CNN network for 3D pose estimation using point clouds. [13] introduces a real-time tracking system using YOLO-v2 on drones with 96.5% accuracy. [14] provides an extensive overview of human behavior recognition using WiFi CSI. [15] introduces the eHealth CSI dataset for human activities with up to 99.9% accuracy in detection. [16] discusses a differential CSI-based HAR method achieving 95.13% accuracy.

[17] introduces Widar2.0 for passive human tracking using a single WiFi link. [18] describes WiFi-ID, a system identifying individuals through WiFi CSI with up to 93% accuracy. [19] examines a WLAN-based outdoor human detection system with a 99.86% accuracy rate.

[20] showcases a real-time human detection system using YOLO deep learning for aiding visually impaired individuals. [21] introduces an IoT and Blockchain-based security system for human detection using fingerprintdata with 98% accuracy.

[22] compares deep learning models on embedded platforms for human detection with the SSD MobileNet V2 model achieving a 0.94 PR. [23] discusses a deep learning-based system for detecting humans in outdoor NLOS scenarios using WLAN technology. [24] outlines an SDR platform for human activity recognition using USRP devices. [25] introduces WFID, a human identification system using WiFi CSI with over 91% accuracy. [26] proposes hybrid deep learning models for HAR using smartphone sensors, achieving up to 98.2% accuracy.

Comparison Table

The comparative analysis of human activity recognition (HAR) methods, as outlined in Table-1a and Table-1b, spans vision-based, sensor-based, and WiFi-based approaches. Techniques such as DensePose and Sensor-based Gait Analysis deliver high precision but require different levels of data input and participant engagement. Hybrid models and WiFi-centric strategies like Person-in-WiFi demonstrate the versatility of deep learning combined with non-intrusive sensing for HAR, providing both privacy and adaptability. Meanwhile, CSI-Net and WiFi-HAR with Deep Learning capitalize on WiFi's capability for nuanced biometrics and gesture recognition. Other methods prioritize the temporal aspect and real-time application, like the WiFi-CSI-based HAR for Smart Homes, emphasizing cost-efficiency and functionality suitable for diverse HAR applications.

Table. 1a: Comparison table of survey papers from [1] to [10].

Paper	Proposed Method	Type of HAR System	Method Used	Output Parameters (N)	Dataset Used	Advantages	Drawbacks
1	DensePose	Vision-based	Fully Conv. and Region-based	Image-to-Surface Corresponde nces	COCO Dataset	Handles occlusion, Scale-invariant	Requires large annotated data
2	Sensor-based Gait Analysis for ID	Sensor-based (Wearable)	Multi-Sensor Fusion, Geometric Calc.	Gait Data	10 Participants	Overcomes vision limitations	N/A
3	Hybrid Deep Learning for HAR	Sensor-based (Smartphone)	CNN-LSTM Architecture	12 Physical Activities	MHEALT H Dataset	98% accuracy, Spatial-temporal modeling	N/A
4	Person-in-WiFi	WiFi-based	Deep Neural Network	Body Segmentation , Pose Estimation	105 frames	Contactless, Uses standard WiFi	Accuracy improvement needed
5	CSI-Net	WiFi-based	Deep Neural Network	Biometrics, Recognition, Gesture, Fall Detection	N/A	Utilizes WiFi, Addresses privacy	Limited evaluation details
6	WiFi-based HAR using Deep Learning	WiFi-based	LSTM, SoftMax Classifier	N/A	N/A	Improved accuracy and speed	Limited experimental setup
7	Consistency of WiFi-CSI based HAR	WiFi-based	Pattern-based	N/A	Collected over days	High temporal consistency	N/A
8	Smart Home WiFi-based HAR	WiFi-based	Statistical Features, SVM Classifier	Walking, Jumping, Sitting, Falling	N/A	Edge computing, Low-cost	Accuracy around 70%
9	OpenPose	Vision-based	Convolutional Neural Network	Body, Foot, Hand, Facial Keypoints	N/A	Real-time, High accuracy, Open-source	N/A
10	WiFi-based HAR using Deep CNNs	WiFi-based	Image Construction, Data Aug., Deep CNNs	16 Activities	WiAR Dataset	High accuracies, Contactless	N/A

Table. 1b: Comparision table of survey papers from [11] to [21].

11	DensePose From WiFi	WiFi-based	Deep Neural Network	CSI, Phase, Amplitude, UV Coordinates	N/A	Addresses camera limitations, Low-cost	N/A
12	Point R-CNN	Vision-based	Point Cloud Fusion, Feature Ext., Instance Det., Pose Estimation	3D Pose Estimation	CMU, MVOR	Efficient fusion, End-to-end training	Lacks drawback discussion
13	Person Detection and Tracking on Drone	Vision-based	YOLO-v2 CNN, PID Controller	Person Detection	N/A	Real-time, High precision, Adaptable	Occasional missed detections
14	Overview of WiFi-CSI based HAR	WiFi-based	Pattern, Model, Deep Learning	Activities, Gestures, Authenticatio n	N/A	Methods discussed, Challenges identified	Interference, Robustness issues
15	eHealth CSI Dataset	WiFi-based	CSI Data Collection	Positions, Activities, Phenotype, Heartbeat	Over 100 participants	Enables CSI-based application dev.	Accuracy drop on new data
16	Differential CSI-based HAR in IoT	WiFi-based	Differential CSI, LSTM Model	Amplitude, Phase, 70 Subcarriers	Ermon Group	Eliminates sensors, Improved accuracy	N/A
17	Widar2.0	WiFi-based	Joint Param. Est., Range Refinement	AoA, ToF, Doppler	6m x 5m Area	Accuracy like multi-link methods	N/A
[18]	WiFi-ID	Device-free	CSI analysis, Feature extraction, SAC	Individual ID	20-subject corridor data	Uses existing WiFi, non-intrusive, 93% accuracy (2	Small group limit, LoS only, requires training
19	Outdoor Human Detection using WLAN	WiFi-based	CSI Preprocessing, Deep NN Classifier	Presence, Location Detection	Outdoor Setup	Feasibility of outdoor WLAN sensing	Environment affects performance
20	Real-Time Human Detection for VI	Vision-based	YOLO Deep Learning, CNN	Multiple Person Detection	Real-World Datasets	High accuracy, Real-time, Aids VI	Diminutive object detection hard
21	IoT and Blockchain-based Security	Sensor-based (Biometrics)	Improved ACO, Heap Algorithm	Fingerprint, Gender	N/A	High accuracy, Reduced errors, Secure	N/A

Within the broader spectrum of HAR, each paper contributes novel techniques and insights. DensePose From WiFi and Point R-CNN exemplify innovative vision and 3D data approaches to activity recognition and pose estimation. The use of WiFi CSI data for human identification is further illustrated in works focusing on differential CSI and WiFi Frequency Identification (WFID), which boast high accuracy and computational effectiveness.

Table. 1c : Comparision table of survey papers from [22] to [26].

22	Real-Time Human Detection on Embedded	Vision-based	PedNet, Multiped, SSD MobileNet, SSD Inception	RGB Video, Building Env.	N/A	Insights on accuracy-efficiency trade-off	N/A
23	WLAN-based Outdoor NLOS Detection	WiFi-based	PCA, Multiple CSI Stations	CSI, Outdoor Obstacles	University Campus	99.58% accuracy, Addresses NLOS	N/A
24	SDR Platform for HAR	WiFi-based	WCSI Extraction, 64-point FFT	Hand Waving, Pendulum	Lab Experiments	Scalable SDR platform	Lacks performance evaluation
25	WFID: WiFi-based ID	WiFi-based	SAF Matrix, PCA, Linear SVM	Frequency Diversity Patterns	Corridor, Lab	91.9-93.1% accuracy, Low cost	Scalability limitations
26	Hybrid Deep Learning for Smartphone HAR	Sensor-based (Smartphone)	DNN, LSTM, GRU, CNN, DeepCNN-RF	Accelerometer, Gyroscope	UCI HAR, WISDM	State-of-the-art results, Hybrid models	N/A

3. METHODOLOGY

3.1Block Diagram

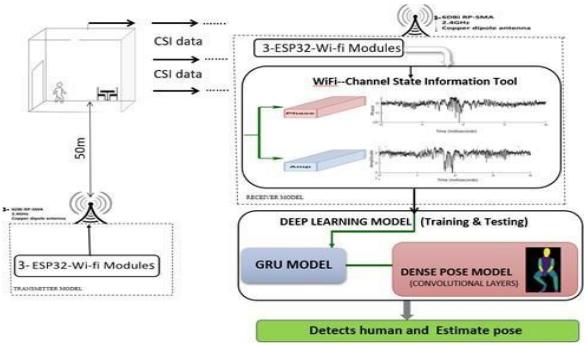

Figure 2: Block diagram of Human detection and pose estimation using Wi-Fi signals

This system, comprises a transmitter with three ESP32 modules and dual-band antennas broadcasts Wi-Fi signals, while the receiver, similarly equipped, captures the signals' Channel State Information (CSI), as illustrated in Fig.2. The CSI data, reflecting human movement through changes in signal amplitude and phase, is then analyzed using a specialized tool to visualize signal perturbations. A deep learning model, combining a Gated Recurrent Unit (GRU) for temporal patterns and a Dense Pose Model for spatial analysis, is trained on a dataset of various human poses paired with their CSI signatures. This robust model, capable of detecting human presence and estimating poses even through walls, demonstrates significant potential in applications ranging from smart home systems to healthcare monitoring, without relying on traditional visual cues.

Flow Chart

The Wi-Fi signal-based human detection and pose estimation system harnesses Channel State Information (CSI) data from ESP32 modules to identify and analyze human presence within an indoor setting, as shown in Fig.3. The process initiates with three ESP32 transmitters that emit Wi-Fi signals, while counterpart receivers capture the CSI data at a 100Hz frequency, ensuring detailed acquisition of signal interactions with the environment. This data is then processed to extract amplitude and phase variations, indicative of human movement and presence, by employing the Wi-Fi Channel State Information Tool.

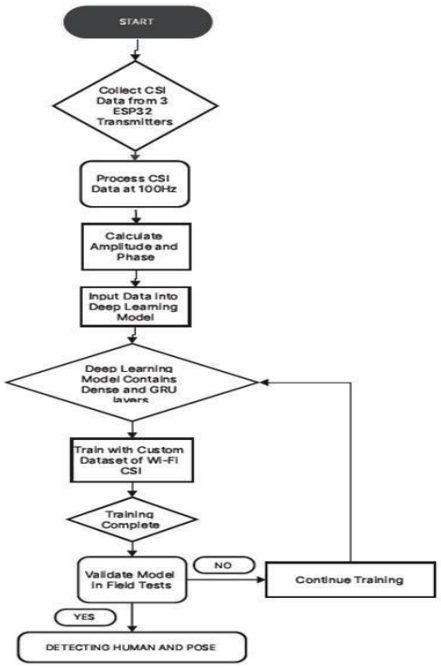

Figure. 3 : Flowchart of Human detection and pose estimation using Wi-Fi signals

Following data acquisition and processing, the core analysis is conducted through a sophisticated deep learning model composed of a Dense Pose Model for spatial feature extraction and a GRU Model for temporal data analysis. Trained on a dataset with varied human poses, the model learns to discern patterns correlating CSI data with specific poses. Post-training, field tests validate the model's efficacy in real-time human detection and pose estimation, showcasing its ability to determine various poses, even through obstructions.

Hardware Implementation

The system architecture incorporates ESP32 Wi-Fi modules, dual-core 32-bit microcontrollers with integrated Wi-Fi transceivers, functioning as both transmitters and receivers, ensuring a seamless exchange of wireless data. These modules, capable of operating on dual Wi-Fi bands, are connected to high-gain 6dBi antennas via U.FL-IPEX cables, enhancing the communication range and signal strength. The ESP32's substantial processing capabilities and a low-power co-processor facilitate efficient data modulation and power management, ensuring robust performance across diverse environmental conditions.

Software Implementation

*A . Data Collection:*The data collection was conducted using the open-source ESP-IDF, harnessing the capabilities of the ESP32 microcontroller. The methodology for acquiring CSI data was based on the protocol outlined in the ESP32-CSI-Tool, a GitHub repository curated by Steven Hernandez. This repository provides a comprehensive toolkit for transmitting and extracting CSI data from the ESP32, which we employed to capture the wireless signals' amplitude and phase changes induced by human activity.

B. Signal Processing: Upon collection, the CSI data was processed to extract the Amplitude and Phase components. The amplitude and Phase are calculated by using the 1 and 2.These metrics were derived using signal processing techniques to discern the characteristics of the human poses within the environment. The amplitude provides information about the signal strength, while the phase indicates the signal's displacement, both of which are perturbed by human movement.

$$\text{Amplitude} = \sqrt{\frac{(Rea)^2}{(Imaginar)^2}} \quad (1)$$

$$\text{Phase} = \arctan\left(\frac{Imaginar}{Real}\right) \quad (2)$$

C. Pose Estimation with GRU Networks: For the task of pose estimation, we employed Gated Recurrent Unit (GRU) models due to their efficiency in capturing temporal dependencies in sequence data. The GRU model was trained using CSI-derived features, bypassing the need for direct visual data and maintaining privacy

*D. Visual Representation through DensePose:*To correlate the abstract CSI signals with human-understandable representations, we utilized DensePose, a method that maps all human pixels of an RGB image to the 3D surface of the human body. The DensePose was implemented on recorded video footage to create a visual dataset that associates specific human poses with their respective CSI signatures.

*E. Integration and Output:*The integration of these components culminated in a system capable of predicting human poses in real time based on CSI data. Once a pose was estimated using the GRU model, a corresponding visual representation was retrieved. If the predicted pose matched a pre-defined category (e.g., "Sitting"), a image from the corresponding category in the frames directory was displayed. Conversely, for poses that lacked visual data or were undefined, a placeholder image (a black frame) was generated.

4. RESULTS AND DISCUSSION

This section of the research paper presents the evaluation of a novel approach for pose estimation using GRU networks on time-series data obtained from Channel State Information (CSI). The model's predictive capabilities were assessed in real-time conditions and through retrospective analysis of recorded data.

Model Performance Evaluation

The GRU model was trained on a dataset that encompassed CSI amplitude and phase information collected via three ESP32 sensors. It achieved a training accuracy of 60.39%, a figure that reflects the model's ability to generalize from the data it was trained on. The accompanying accuracy and loss plots elucidate the model's performance throughout the training epochs. As shown in the Fig.4.

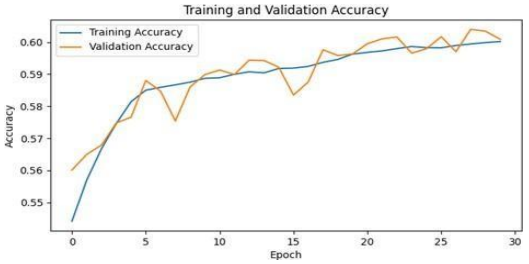

Figure. 4: Training and validation accuracy

The model demonstrated a gradual improvement in accuracy distinguishing between different poses as training progressed. The Fig.5 similarly indicated a consistent decrease in error rate, corroborating the model's increasing proficiency.

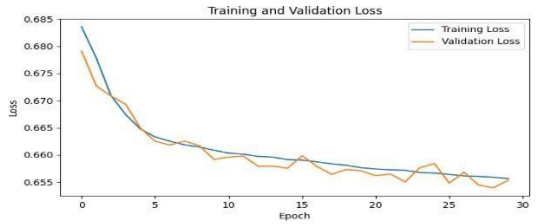

Figure. 5 : Training and validation loss

The classification report presented in the Table 2 provides a detailed breakdown of the model's predictive performance across different classes. The precision and recall metrics for each category underscore the model's strengths and limitations in distinguishing between 'Sitting' i.e pose label-0, and 'No Pose' i.e pose label-1. The f1-scores presented serve as a harmonic mean of precision and recall, offering a singular measure of accuracy that takes into account both the purity and completeness of the predictions.

Table 2: Values Of Pose Label, Precision, Recall, F1-Score.

Visualization Of Amplitude Data

A critical part of the analysis involved visualizing the amplitude readings from the first 100 data points (representing one second of time) from each of the three ESP32 sensors in Fig.6. This visualization provided insight into the variance and patterns within the amplitude signals over a short duration, critical for understanding the temporal characteristics that the GRU model was expected to capture.

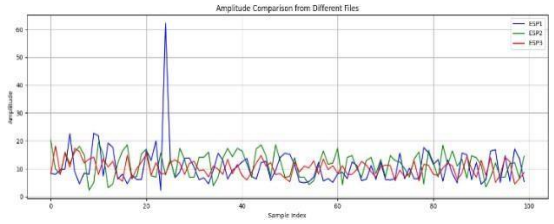

Figure. 6 : Amplitude comparison from three -ESP32 receivers for 1-sec

Real-Time Data Predictions

When deploying the trained GRU model in a real-time environment, it successfully predicted 'Sitting' and 'No Pose' categories with significant accuracy. The model's predictions were subsequently mapped to visual data that were aligned with the training sets. The seamless transition from numerical data to an interpretable visual output demonstrated the model's potential in applications where real-time monitoring and instant visual feedback are indispensable.

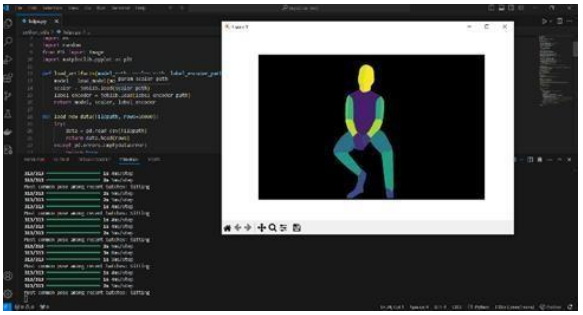

Figure. 7 : Result of detecting and estimating a sitting pose of a human

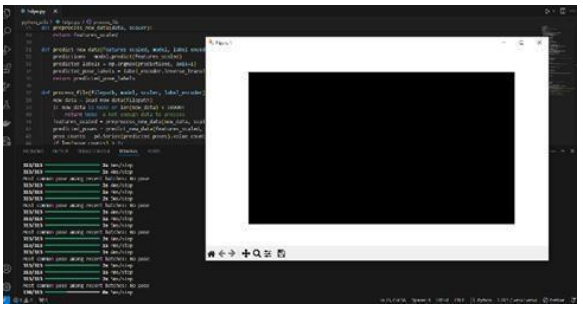

Figure 8: Result when there is no person or movement behind

Pose Label	Precision	Recall	F1-Score
0	0.61	0.58	0.59
1	0.60	0.63	0.61

the wall.

5. CONCLUSION

In Conclusion, this study showcases an economical solution leveraging Wi-Fi signals for human detection and pose estimation, utilizing ESP32 modules paired with dual-band Wi-Fi SMA antenna operating at frequencies of 2.4 GHz and 5 GHz, with a gain of 6dBi, to capture the intricate Channel State Information (CSI) at 100Hz. This approach, transcending physical obstructions, employs deep learning with DensePose and GRU networks to accurately infer human presence and activities. The synergy of these technologies presents a promising avenue for Human Activity Recognition (HAR), setting the stage for impactful advancements in both research and practical applications.

ACKNOWLEDGEMENT

we would like to express sincere gratitude to our Professor, whose guidance and insightful critiques were indispensable throughout the research process. This work was significantly bolstered by the contributions of the esteemed co-authors, whose relentless dedication and expertise helped bring this research to fruition.

We utilized the ESP32-CSI-Tool, an invaluable resource developed by Steven Hernandez, available at https://github.com/StevenMHernandez/ESP32-CSI-Tool. The tool's utility in collecting high-resolution CSI data was pivotal in the successful execution of the experiments detailed in this study.

Also Special acknowledgment is extended to Flode Labs for their "Vid2DensePose" tool, which played a crucial role in the visualization of pose estimation. The tool's ability to transform video data into detailed pose maps significantly enriched the analysis and discussion presented in this paper.

we also extend their thanks to the institution that supported this work, providing the necessaryinfrastructure and resources for conducting this research. Their support was a cornerstone that enabled the exploration of new ideas and the advancement of knowledge in the field.

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Effects of Slot Incorporation on Antenna Radiation Pattern: Analysis and Optimization

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Abstract

This paper investigates the influence of incorporating slots above the antenna structure on the radiation pattern of the antenna. The addition of slots alters the electromagnetic properties and radiation characteristics of the antenna, resulting in a tilted radiation pattern by 30 degrees. Through careful analysis, it is demonstrated that slots introduce changes in the distribution of electromagnetic fields and currents within the antenna, affecting both amplitude and phase. The observed maximum gain at a 30-degree angle suggests that the slots enhance radiation in that specific direction, leading to the tilt in the radiation pattern. This study highlights the importance of considering slot design and placement for achieving desired radiation characteristics in antenna systems. Further optimization of slot configurations could pave the way for advancements in antenna design across various applications in wireless communication and radar systems.

Keywords - Antenna radiation pattern, Slot effects, Electromagnetic properties, Slot design, Tilted radiation pattern

Introduction

With advancements in communication technology, reconfigurable antennas have garnered significant interest, particularly for their use in various wireless communication systems. These antennas can be adjusted to achieve the desired frequency band, radiation direction, or polarization. Compared to wideband antennas, tunable antennas offer several benefits, such as smaller size, consistent radiation patterns across multiple frequency bands, efficient use of the electromagnetic spectrum, and the ability to reduce co-channel interference and jamming [1-2].

Most research has focused on tuning a single property of the antenna rather than multiple properties simultaneously. For instance, microfluidic-controlled polypropylene tubes placed between the main radiators and the ground plane have been used for frequency reconfigurability. PIN diodes have been used to vary the antenna's bandwidth from narrow to wide, and varactor diodes have been employed to continuously change the resonant frequency within a narrow band, making them suitable for cognitive radio applications. A multiband reconfigurable

printed monopole antenna for WLAN/WiMAX applications using a PIN diode was reported [3-8].

Voltage-controlled varactor diodes have achieved a wide range of frequency tunability in a probe-feed patch antenna. Additionally, a hooked-shaped, stub-loaded printed antenna with reconfigurable frequency for multiple applications has been developed. Various studies have achieved frequency tunability using lumped switches, PIN and varactor diodes, and different configurations in Vivaldi antennas. Beam direction reshaping has been explored using high impedance surfaces, loops with diodes, multiple lumped switches, and irregularly placed diodes. Furthermore, a dual-polarized antenna with different frequency options using metamaterial and a dual-band antenna with independently controllable bands using varactor diodes have been presented [8-17].

The rapid advancement of communication systems requires antennas that can independently tune both frequency and pattern, which is challenging to achieve in a single design. Recent progress includes several designs with both frequency and pattern tunability. For instance, a slot antenna using PIN diodes for frequency and pattern reconfigurability has been reported. It features multiple resonant bands and pattern reconfigurability through switches on the slot and additional slits. However, this antenna doesn't cover the entire elevation or azimuth plane and is complex due to the numerous RF PIN diodes, which increase insertion losses. Another design uses multiple PIN diodes for reconfigurability but is too large for modern applications. A different approach involves matching stubs to shift resonant frequency and PIN diodes in the annular slot for directing the main lobe and null. Liquid crystal technology and slits connected via PIN diodes have also been utilized for reconfigurability, though with limited pattern tilt capabilities. A flexible antenna for 1.9 GHz and 2.4 GHz features frequency tuning and beam switching but is not suitable for modern systems due to its complexity and size. An array antenna with stub and varactor diodes achieves beam steering and frequency shifting but has limited beam shifting capability and large size. High gain antennas based on High Impedance Structures (HIS) and frequency switchable antennas with beam choices have also been developed, though these designs also face limitations in beam shifting and size [18-26].

Development Stages of the Designed Antenna-Antenna Design

The antenna shown in Fig. 1 is a 1x2 Circular Patch Array designed to operate at 2.4 GHz with a gain of 5.74 dB. This means the antenna consists of one row and two columns of circular patch elements. At 2.4 GHz, the antenna is efficient at transmitting or receiving electromagnetic waves. The gain of 5.74 dB indicates that the antenna's radiation pattern is more focused in a specific direction compared to an isotropic radiator, leading to a higher power density in that direction. This gain suggests that the antenna can achieve better signal strength or coverage in its intended radiation direction, making it suitable for applications such as wireless communication systems, radar systems, and satellite communication terminals.

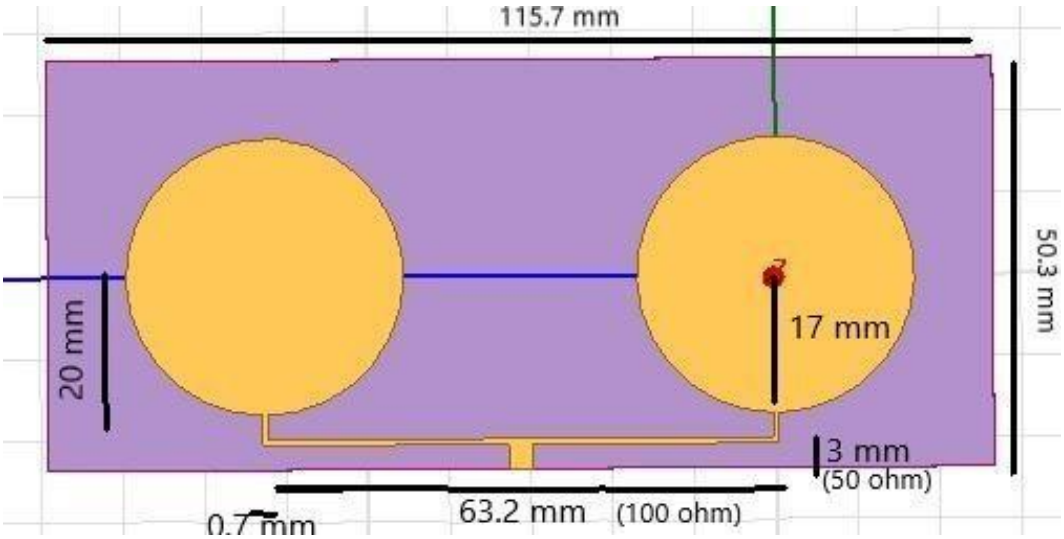

Fig. 1: Antenna Array Design

The antenna setup shown in Fig. 1 features a substrate made of FR4 epoxy material, measuring 115.7 x 50mm. This substrate hosts two circular patches, each with a radius of 17mm, which act as the radiating elements. The antennas are powered using microstrip line feed, a method where power is delivered through microstrip transmission lines. A power divider ensures equal power distribution between the two antennas. This arrangement enables efficient transmission or reception of electromagnetic waves, making it ideal for various wireless communication applications.

The proposed array structure in Fig 3 includes two semi-spherical slots etched into the surface of one antenna. These slots modify the antenna's overall resonant frequency. To counteract any frequency shift caused by the slots, their thickness is optimized; ensuring minimal deviation from the antennas intended operating frequency. Additionally, a horizontal slot is etched onto the same surface during the design phase. The length of this slot is adjusted to achieve the desired reconfiguration of the antenna's radiation pattern. By precisely controlling the dimensions and placement of these slots, the antenna's performance, including frequency response and radiation characteristics, can be tailored to meet specific requirements. This highlights the importance of meticulous design adjustments to optimize antenna performance for various applications.

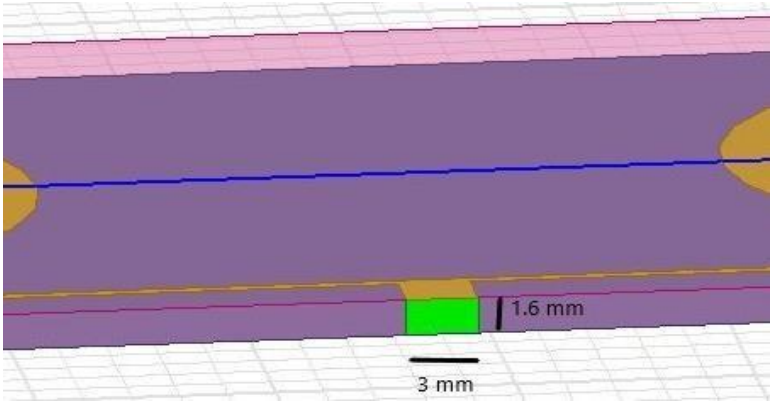

Fig. 2 Feeding Method

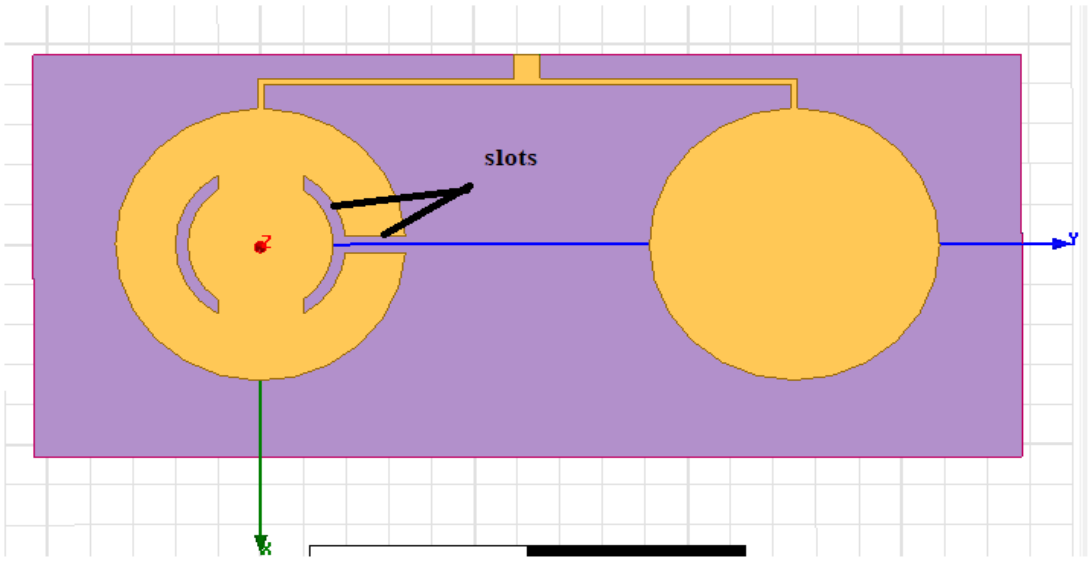

Fig.3 Proposed Patch Antenna Array

Simulation Results and Discussions

The S11 plots shown in Fig 4, which graphically represents the scattering parameter S11, shows that the antenna operates at two distinct frequencies: 2.4 GHz and 4 GHz. At these frequencies, the return loss values are -15 dB and -8 dB, respectively. Return loss measures the power reflected by the antenna due to impedance mismatch, with more negative values indicating better matching. Thus, the antenna demonstrates strong resonance at both 2.4 GHz and 4 GHz, reflecting minimal power back into the system at these frequencies. This information is vital for evaluating the antenna's performance and ensuring it meets the specifications required for applications such as wireless communication or radar systems operating within these frequency bands.

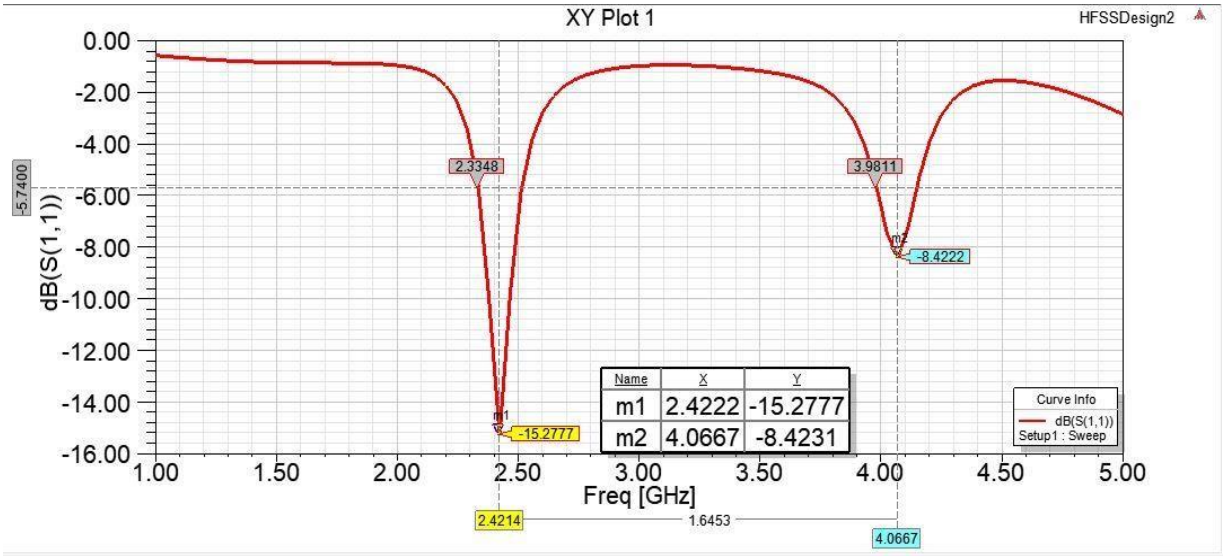

Fig. 4 Return Loss Plot of CMPA array

The return loss plot of the proposed Circular Microstrip Patch Array (CMPA) shown in Fig 5 provides valuable insights into the antenna's frequency response. The graph indicates that the antenna operates over a wide frequency range from 0.5 GHz to 5 GHz. This broadening of the operating frequency range is due to the addition of slots on one side of the antenna, which alter its electromagnetic properties. These slots introduce extra capacitance and inductance, impacting the antenna's impedance and resonance.

Specifically, the semi-spherical slots etched onto the antenna's surface cause changes in the electromagnetic field distribution, modifying the resonant frequency. By optimizing the thickness of these slots, the antenna's resonant frequency can be controlled to stay close to the desired operating frequency.

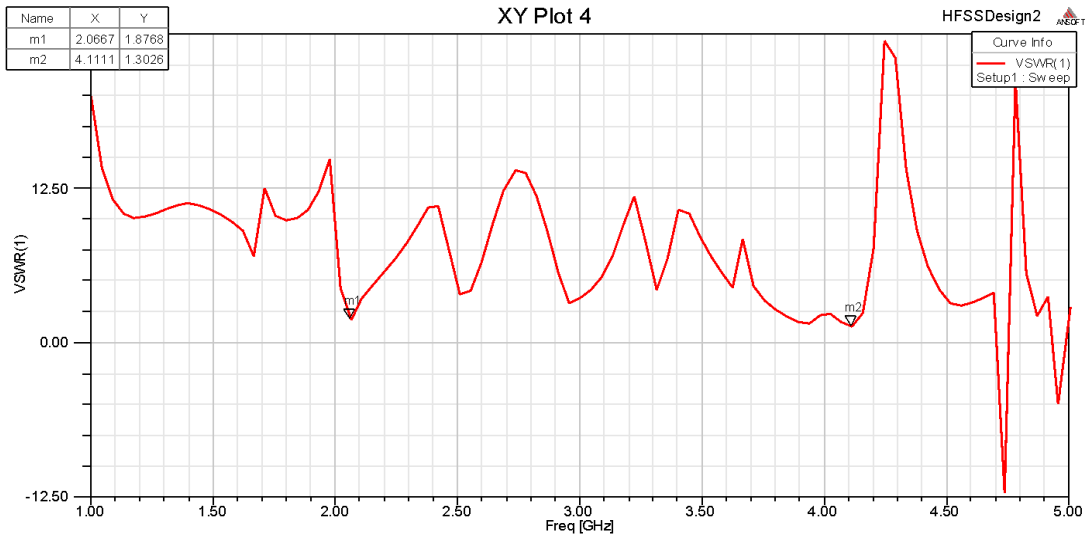

Fig. 5

Fig.5 S11 Plot of the Proposed Array

Adding slots above the antenna can tilt the radiation pattern by 30 degrees due to changes in the antenna's electromagnetic properties and radiation characteristics as shown in Fig. 6. These slots alter the distribution of electromagnetic fields and currents within the antenna, affecting both the amplitude and phase of the radiation pattern. Specifically, slots can act as additional radiating or parasitic elements, influencing the phase relationship across the antenna. This phase shift can tilt or skew the radiation pattern in a particular direction. The observed maximum gain at a 30-degree angle indicates that the slots enhance radiation in that specific direction, causing the tilt in the radiation pattern. The 3D plot is shown in Fig. 7.

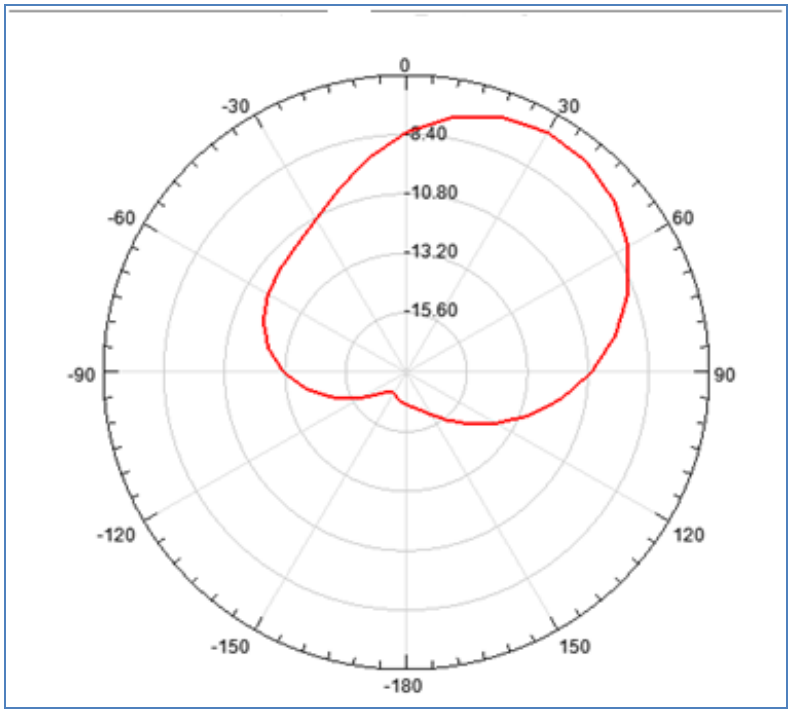

Fig. 6 Radiation Plot of the Proposed Array

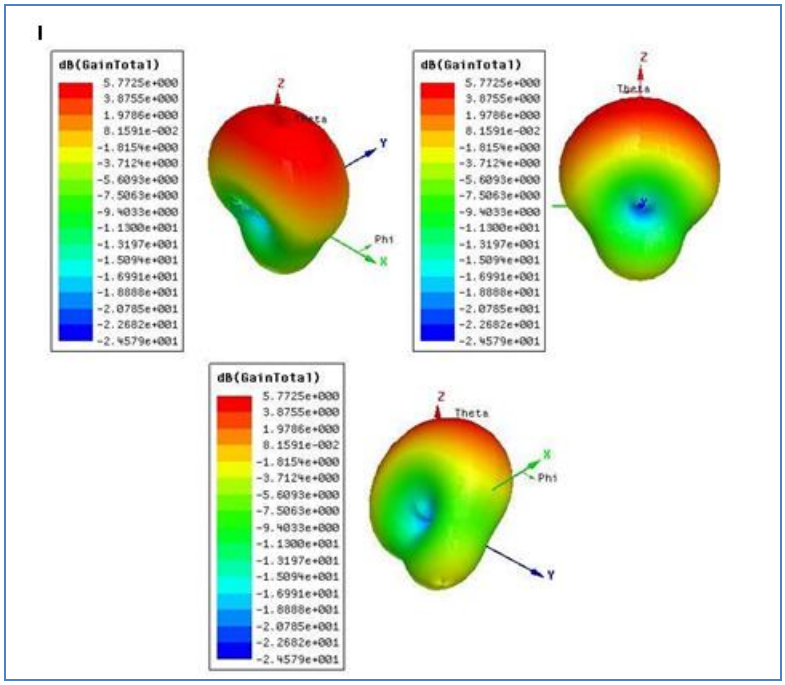

Fig. 7 3D radiation Pattern of the Proposed Antenna Array

Conclusion

The research presented in this paper has explored the effects of incorporating slots above the antenna structure on the antenna's radiation pattern. Through

careful analysis, it has been demonstrated that these slots can significantly influence the electromagnetic properties and radiation characteristics of the antenna. The observed tilting of the radiation pattern by 30 degrees highlights the impact of the slots on the antenna's performance. By introducing changes in the distribution of electromagnetic fields and currents, the slots effectively modify the phase relationship across the antenna, resulting in a directional radiation pattern. This study underscores the importance of considering slot design and placement to achieve desired radiation characteristics in antenna systems. Moving forward, further investigation into optimizing slot configurations could lead to advancements in antenna design for various applications in wireless communication, radar systems, and beyond.

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A Study on the Different Variables with Reference to Augmented Reality and Its Implications: A Literature Review

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Abstract

The existence of augmented reality is somewhere at a midpoint between the digital and physical Worlds, and it has emerged as one of the promising business opportunities for different companies. With the help of augmented reality based technologies and concepts marketers are able to superimpose digital imagery over the existing physical world and they are able to create an augmentation for any phenomenon. Augmented reality is able to specify the presence of two very important characteristics like interactivity in real time and registering in three dimensions. Due to all these factors, reflector or holographic sight would not be considered as augmented reality on the contrary it could be defined as a combination or amalgamation of digital and the physical Worlds which absolutely blends with three different dimensions. Various product or service designers have already worked with various designs, drawings and physical models to communicate their ideas with the target audience. It is observed that physical models are quite expensive to create and very time-consuming. That's why it could be an additional burden on cost structure. It can provide an excellent idea to the marketer about the final result by capturing quite complex details about the product or service design. On the contrary, digital design tools would be able to make this entire process quite simpler with the help of required modifications and reengineering of different existing models in the market. So it is quite evident that instead of a physical model, marketers are using digital models which could be cost effective for any marketer and they will be able to implement their final strategy. However it is also a fact that the digital model is lacking behind creating the real essence of the product or service and touch motivation. Now it has become quite inevitable to bridge the gap between the physical and digital Worlds with the help of augmented reality and with the help of that marketers should try to enhance their efficiency. The researcher tried to find various factors those affect augmented reality. The implication of augmented reality is also explained in the research paper. The author had done extensive literature review to find the gap between the concept and the application of augmented reality.

Keywords – Augmented reality, Digital platform, Product design, Virtual reality

Objectives:

Objectives of the paper are mentioned below: -

- To explain various variables those are affecting various

augmented reality based technologies.

- To analyze the implications and future scope of augmented reality

There are different types of technological solutions which are related to augmented reality, one of those can be mentioned as Head Mounted Display which could be considered as the most developed concept in the market. There are various forms of Head Mounted Display size namely projection, retinal, optical and video. A new form of Technology has already been used by organised retail sectors worldwide and with the help of that the overall retail sector has gone through different kinds of transformation. With the help of all such transformation the retail sector has shown enormous growth in the global market. Such transformations include different types of immersive Technologies like augmented reality and virtual reality which eventually could revolutionize the process of shopping online and offline. The research paper basically aims at analysing these immersive technologies and its impact on retail outlets from customer perspectives. To go ahead with the research work researchers try to analyse the background and evolution of augmented reality and various technological involvement with reference to retail setting in different contexts. Initially any emerging technologies used to be the part of science fiction but due to the advancement of Information Technology various computer processing started changing the essence of technological usage with the help of many real world applications (Park, Lim, Seo, Jung & Lee, 2015). Such emerging technologies can be defined as internet of things, artificial intelligence, robotics and nanotechnology and its usage at various scales as per the requirement of the industry. It is also observed that augmented reality based technologies are quite flexible and with the help of that organisations would be able to compete with the existing technologies across multiple criteria in different parts of the world.

Literature review

It is always predicted at various levels that augmented reality based technologies will eventually transform personal and professional words. The popularity has grown quite rapidly over the last few years and as the computer technology continues to advance among these technologies due to those modern technologies will become much more economical and refined for the people. Most of the usage of modern technologies can be observed in the field of entertainment

industry but we should not forget that other industries also started using lots of upgraded technologies. The corporate world has realised that these modern technologies have the capabilities to influence different marketplaces and different business processes as well (Hua & Zhang, 2011). With the help of these modern technologies they will able to increase and improve employee productivity at reduced risk level and at the same time it could be costeffective as well. If we look particularly at the retail Industry then we will also be able to observe the extensive usage of modern technologies and with the help of that modern day retailers are trying to provide real time experience to the customer. In recent times the quick changes in internet facilities we have seen that online shopping has grown almost exponentiallyeach year. Now modern day retailers also realised that retail is not only focusing on just product selling but also they are trying to provide overall experience with the help of technological inclusions.

It is also observed that many retailers are not currently prepared for the transaction or shift happened due to technological advancement so rapidly. Retailers those are still struggling to integrate the internet and current technologies into their basic business model and how to connect it with emerging technologies. Most of the retailers currently are not well prepared with emerging technologies and related strategies and with the monitoring plan. One of the reasons due to which retailers fail to integrate augmented new technologies is related to their emotional connect at a managerial level with the basic business plan that they had already formulated long back (Xin, Sharlin & Sousa, 2008). There are a lot of organised retailers that are still refusing to use modern technologies or to upgrade to the next level. Lots of forward thinking companies have already started to invest in implementing modern augmented reality based technologies into the business model and at the same time they are trying to integrate their basic business model with that. Companies realised the importance of immersive Technologies which is actually an umbrella term quite commonly used within the technology industry to describe various technologies such as augmented and virtual reality (Zhang, Ong & Nee, 2010). These technologies are basically concentrating on the real world and the virtual world. Immersive Technologies that are also often used quite interchangeably with mixed reality in the market.

Augmented reality helps any user to visualise and interact with the superimposed computer graphics over a real world environment and with the help of that the user will get the real essence of reality through a virtual platform. The system should be able to display and use various relevant information to guide the user in a real time manner so as to get the reality of the platform in the best possible way. The feature related to augmented reality is not just to showcase the information on a screen but also to contextualize and segment the overall information to make it more useful for the real time users. There are lots of new advancementswhich would eventually help to overcome various issues which are faced by the company but now they are trying to provide continuous augmented information

to the real world which would be more efficient and relevant to the changing needs of the users' context. There are several types of augmented reality which are available there in the market. The most basic form of augmented reality can be denoted as market based augmented reality. It basically involves various usage of a camera or other equipment to scan a QR code which then produces a virtual object over the space where actually the code is processed (Ishii, Ratti, Piper, Wang, Biderman & Ben-Joseph, 2004). This type of basic technology is most commonly used in children's education to enhance a more immersive experience. Superimposition based augmented reality able to create more reliable and consistent real world objects and landscapes. Such technologies are basically used to enhance the real world environment for any company.

Modern day smartphone applications have already showcased the potential of Smartphones as augmented reality enablers (Furht, 2011). Other than the media industry various Technologies related to augmented reality and virtual reality are quite extensively used up to a certain extent in various business domains like advertising, tourism, health, education etc (Azuma, 1997). For both applications like augmented reality and virtual reality headset where ones predicted as oneof the equipment to facilitate various experiences for the users. It is observed that the effects of immersive technologies are mostly visual and the significance of other sensors is also playing an important part in the overall feeling of presence in the virtual world. It is also essential to find the sense of presence in a virtual environment which is extremely vital to feelthe emotional responses with the help of the technology which is trying to differentiate from the user. Mixed reality Technologies would be able to create an emotional connection with theuser through a virtual platform. As it is already explained that among different industries organised retail is one of the trendsetting industries which is using augmented reality up to a great extent (Calife, Bernardes & Tori, 2009). Through such technological inclusion retailers would be able to provide benefits to consumers and to the intermediaries as well. Organised retailers started implementing augmented reality inside their showroom which eventually allows customers to customise their preferred brands instantly with reference to colours and various features that they may like before going out with the final purchase decision. Various applications also help to go ahead with the trial before going ahead with the final purchase. During the trial if any customer is not happy with the performance of the brand the retailer also would able to make necessary changes as per the preference of the customer. Augmented reality also helps customer to analyse their choice criteria as per their brand preferences. Through various other applications different organisations are also able to analyse the potential market space for the product and they will be able to work more effectively on place constraints (Marner et. al., 2011). It is also observed that in many cases virtual stores have the better potential then the physical stores in many instances considering various difficulties faced by customers at various levels. Virtual reality and augmented reality also generated various

storefeatures which basically allow customers to browse online stores as per their comfort whenever they are asking for or any preferences. Virtual Stores are often found to have an increased cognitive effect which will eventually drive any customer to go ahead with increased engagement. Virtual stores are quite distinctively different from physical stores on different fronts. In many cases it is also observed that the brand recall value is also on a higher side in case of virtual stores then a standard physical store (Kaufmann & Csisinko, 2011). Nevertheless retailers must understand the kind of technology which could be best suited for their business and the decision should be on the basis of the market demand and according to the situation. All these technologies are having different types of potential benefits within the retailers do men as well as there is an impact on consumer decision making and societal thought process as well.

The practitioners need to understand the effect of Technologies on users' cognitive responses and various other measurement criteria. In technology usage resolution plays an important roleand in any context standard quality resolution is required to satisfy the users' needs (van Krevelen & Poelman, 2010). The interactivity of various Technologies is extremely important to compensate for any loss during resolution while it is compared to other traditional media. Though there are lots of researches work is going on but still there is a lack of support for design process stages at the beginning and end of the design process for augmented reality. There is a relative lack of perceived value from user side and due to that it would be extremelydifficult to monitor the ground reality of augmented reality or if there is any competitive advantage that could be achieved by any company in any context. Various task definitions is quite often performed generally on the basis of various specifications given by the client considering various technical limitations which could be related to the modern technology or any process which may require less visualization to understand the flow. At the end of the design process the main documentation part is generally performed by the collating informationthat is generally collected over a period of time during the design process by the company and at that point of time augmented reality based systems may play an important role in recording of data during the process. Depending on the situation, the company may go ahead with the collecting process at the end or if it is necessary during the process otherwise the whole process of collating various data could be performed later. Many times it could be argued that the influence of various other related technologies may disturb the overall design process and there could be a serious need for remote working eventually which may bring forward the need for an improvement in this specific fields which generally not realised by today's marketers.

Conclusion

Most of the technologies which is already discussed are having different perspectives at different points of implementation and these technologies are also driven by the requirement which is been mentioned in front of the company for the customization required during the overall implementation process. There could be the presence of huge competition that may be experienced by the company in the similar systems such as a projective or video based solution which is actually not related to the development or the design process of the system. It is also

observed that there has been a considerable number of works in the development of varied technologies had already performed which could be related to the concept development preliminary layout and various other definitive layout stages across most of the Technologies dozer discussed in the research paper. However it can be said that the spatial projection requires the largest level of Investigation. What are the emerging trends of augmented reality which is at quite advanced level there is a presence of lots of Adobe solutions which would have to mature into two different products and that can be acquired and used by different design professionals as per the requirement of the solution need. Once various steps are finalized it will be absolutely possible to find out the true impact of augmented reality in the design process and at the same time will also able to understand that which kind of competitive advantage could be gained by a company through various customizations. In fact new methodologies would able to increase the efficiency of various technologies up to a great extent and with the help of that they will able to make the process of augmented reality smoother than ever there are many impediments or major drawbacks of different augmented reality based platforms are also researched and companies are trying to find different projections strategies for such cases.

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Pulmonary Health Monitoring and Analysis Device

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Abstract*—Spirometers are essential tools used to measure lung capacity and assess the response of the lungs and chest during physical therapy. However, the current available spirometers in the market are often expensive, making it difficult for physicians in underdeveloped countries like India to afford them. As a result, they face challenges in providing necessary spirometry supplies to their patients and evaluating their pulmonary well-being. To overcome this issue, there is a need for the development of a low-cost and reliable spirometer that can address both cost concerns and provide accurate measurements. In response to these challenges, a compact spirometer design utilizing a stable-state pressure sensor has been envisioned and is being developed. The aim is to create a device that is affordable, accessible, and capable of providing precise measurements for improved respiratory health assessment. Spirometry is a diagnostic method used to measure the flow and volume of air entering and leaving the alveoli in the lungs. It involves the use of a spirometer, which is a device used to perform a series of medical tests. These tests are crucial in identifying and quantifying defects and abnormalities associated with various lung conditions in the human respiratory system. Additionally, spirometry helps in monitoring the response of the lungs to medical treatment. By utilizing a spirometer, early detection of chronic obstructive pulmonary disease (COPD) becomes possible. Unlike monitoring coughing and wheezing, which may not provide an accurate assessment of the severity of asthma in a patient, spirometry tests conducted with a spirometer allow for a more precise evaluation of an asthma patient's condition and their response to treatmenThe Pulmonary Health Monitoring and Analysis Device is a sophisticated system designed to monitor and analyze pulmonary health in individuals. This device utilizes advanced sensors and algorithms to collect and analyze various respiratory parameters.The abstract outlines the key features and functionalities of the device. It highlights the ability to monitor respiratory rate, oxygen saturation levels, and lung function parameters. The device also incorporates real-time data display and alerts for abnormal respiratory patterns.Additionally, the device offers data logging capabilities, allowing for long-term tracking and analysis of respiratory health trends. It can generate graphical representations to visualize the data, enabling healthcare professionals to gain valuable insights.

Keywords – Arduino Uno, Computer-based Spirometer, Pulmonary health, Sensors, IoT.

I. INTRODUCTION

Spirometers play a crucial role in measuring lung capacity and assessing the response of the lungs and chest during physical therapy. However, the current market availability of spirometers is often accompanied by high costs, making it difficult for physicians in developing countries like India to afford this essential equipment. Consequently, a significant number of individuals suffering from chronic obstructive pulmonary disease (COPD) are unable to receive proper monitoring and treatment for their condition. To address this issue, there is a need for the development of a low-cost and reliable spirometer that can be accessible to physicians in such regions. This led to the creation of a computer-based miniaturized spirometer system, utilizing a solid-state pressure sensor. A prototype of this system has been successfully developed, incorporating a dedicated analog signal acquisition and processing channel, alongside the solid-state pressure sensor. Calibration tests have been performed to ensure the linearity of the pressure sensor for known applied pressure values. The micro-controller firmware program, utilizing the MSP430, has been designed to digitize and transmit the acquired signal to a computer for further analysis. A dedicated computer software application was developed using the .NET platform for the purpose of acquiring, displaying, and analyzing data from spirometry tests. Spirometry is a technique used to measure the flow and volume of air entering and leaving the lungs. By employing a spirometer, a series of medical tests can be conducted to identify and quantify defects and abnormalities associated with various lung conditions in the respiratory system. These tests also play a crucial role in monitoring how the lungs respond to medical treatment. Early detection of chronic obstructive pulmonary disease (COPD) becomes possible with the help of a spirometer. In contrast, monitoring coughing and wheezing may not provide an accurate assessment of the severity of asthma in a patient. However, by conducting breathing tests using a spirometer, it becomes possible to accurately monitor the response and improvement in an asthma patient's condition during the course of treatment. This accurate monitoring aids in enhancing the quality of treatment by minimizing judgment errors. One of the key advantages of this device is its ability to log respiratory data over time. By incorporating an SD card module, it allows for long-term data storage and analysis. This feature is particularly beneficial for healthcare professionals, enabling them to track trends, identify patterns, and make informed decisions regarding treatment plans.Furthermore, the device offers graphical representations of respiratory data trends, making it easier to visualize and interpret the collected information. This graphical representation aids in effective communication and understanding of pulmonary health trends, both for individuals and healthcare providers.With the potential integration with health platforms and cloud services, the device can seamlessly connect with existing healthcare systems.

There are two main types of breathing tests that can be categorized based on the specific lung characteristics they assess. These types are Gas Exchange Functions and Dynamic Lung Functions. Among the dynamic lung functions, the Forced Vital Capacity (FVC), Flow-Volume Curves, Maximum Voluntary Ventilation (MVV), and airway resistance tests are commonly performed and provide valuable information in various cases.

II. OBJECTIVE

The objective of this project is to develop a Smart spirometer that can effectively assess a patient's breathing status. The designed device aims to provide the following benefits:

i. Offer real-time information about the patient's breathing condition.

ii. Construct and test a reliable spirometry device, which is a widely used diagnostic tool for assessing pulmonary function.

iii. Measure individual exhalation and inhalation chest volumes over time, providing valuable physiological data.

iv. Recognize that spirometry relies on patient effort, which can sometimes be a challenge to ensure consistent cooperation, especially with geriatric patients, foreign-language subjects, and young children.

v. Acknowledge that conditions like asthma and Chronic Obstructive Pulmonary Disease (COPD) are chronic respiratory disorders that significantly impact a person's breathing.

vi. Highlight the importance of early diagnosis and management of bronchial asthma to prevent severe attacks.

vii. Review different design approaches and topologies involved in the implementation of spirometry.n.

III. METHODOLOGY

The design of a spirometer is utilized to measure and study the lung physiology. It involves the patient blowing air in and out through a mouthpiece with maximum effort. The spirometer design incorporates a differential pressure sensor that measures and converts the pressure changes. Monitoring coughing and gasping alone cannot provide an accurate assessment of the severity of asthma in a patient. By conducting respiratory tests using a spirometer, the response and improvement in an asthma patient's condition can be accurately observed. This contributes to enhancing the quality of treatment by minimizing judgment errors.Pulmonary function tests (PFTs), also known as breathing tests, are conducted to identify and quantify any defects or abnormalities in the functioning of the respiratory system. The signals captured during these tests are filtered and processed by a microcontroller. The output from the microcontroller is then connected to a desktop application (such as LabVIEW) for convenient access and analysis.

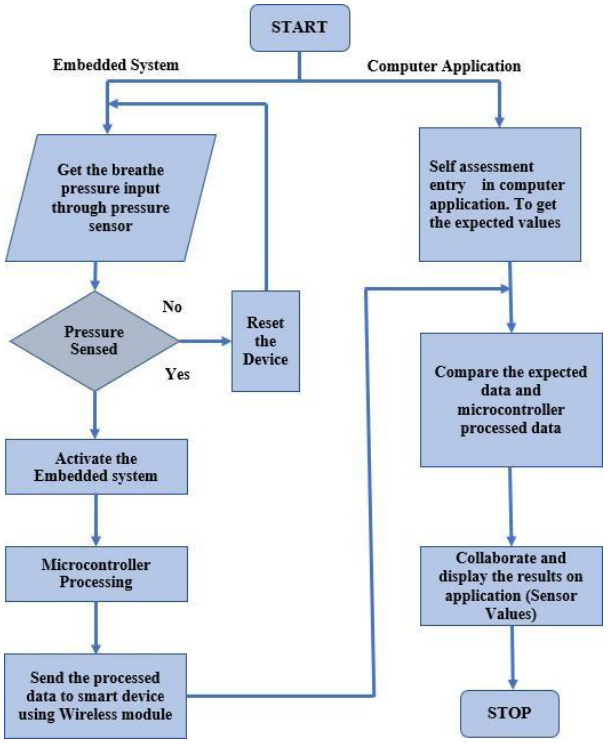

Figure 1: Flow chart of respiratory health analyzer and monitoring

The collected data can be studied, diagnosed, and interpreted by pulmonologists on the go, facilitating easier access to vital information for effective treatment planning. The components used in this system are classified into three sections: A) Design of the mouthpiece along with the placement of the pressure B) Sensor interface to the Arduino Uno microcontroller unit C) Serial transmission Measuring body temperature is crucial in assessing a patient's health. In this project, we utilize the LM35DZ temperature sensor from the LM35 family. Unlike its counterparts, LM34 and LM355, LM35DZ provides temperature readings in °C. With its low self-heating and an accuracy of 0.4°C, it proves to be reliable for temperature measurement.To enable connectivity, we incorporate a Wi-Fi chip with a TCP/IP protocol stack. This chip allows seamless integration into Wi-Fi networks. It is programmed with an AT command set, simplifying the process of connecting it to the Arduino device. The Wi-Fi chip is compact, lightweight, and cost-effective, making it highly suitable for IoT applications.

A computer application is employed to collect, visualize, and respond to real-time data obtained from the device connected to ThingSpeak via the internet. This enables efficient monitoring and analysis of the collected data. In hospitals, an Incentive Spirometer, also known as a Spirometer, is commonly used for patients with chest and lung conditions. Patients blow air into the tube attached to the spirometer, aiming for higher scores. The spirometer features three glass columns with required flow rates of 600cc, 900cc, and 1200cc respectively, aiding in the assessment of lung function The patient's airflow is measured based on the number of balls reaching the tops of the columns. If all three balls reach their respective tops, it indicates maximum airflow of 1200cc. Similarly, if two balls reach the tops, it corresponds to an airflow of 900cc, and if only one ball reaches the top, it indicates an airflow of 600cc. This method provides a visual representation of the airflow generated by the patient.

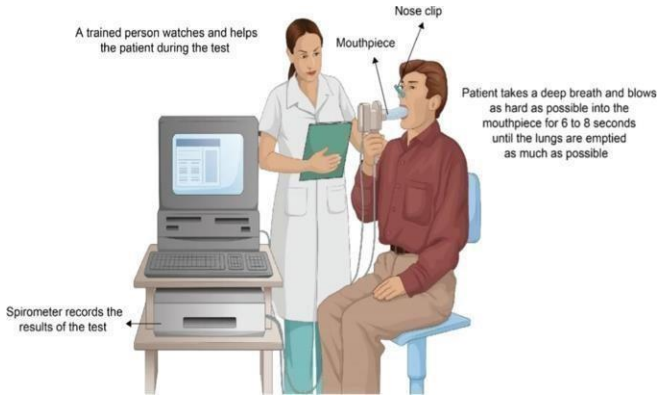

Figure 2: Performing spirometry

. spirometer used in this project can prove to be beneficial for doctors in determining if the patient is receiving appropriate treatment. Additionally, in emergency situations, the patient can take an online exam and communicate with the doctor immediately.The spirometer is linked to the internet via a web server, which enables unsupervised home spirometry technology. Furthermore, it is linked to the doctor through Ethernet, ensuring that the doctor can monitor the patient's progress remotely..

RESULTS

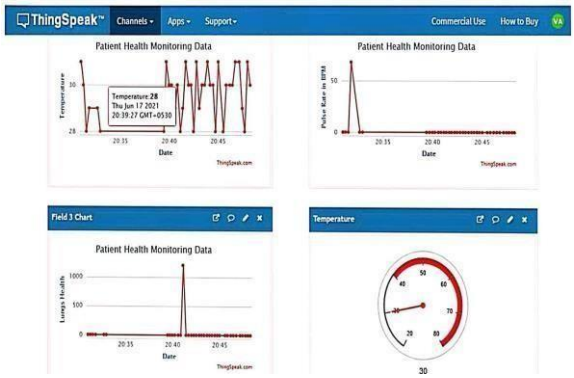

Figure 3: Outcome

The project focuses on developing a basic respiratory rate monitoring system with various features and functionalities. It aims to measure and display the respiratory rate in breaths per minute based on sensor input. The system will provide LED or display indications to indicate whether the respiratory rate is normal, high, or low.

To enhance user convenience, real-time respiratory data will be displayed on an LCD or LED screen, allowing for easy monitoring. Additionally, an alert system will be implemented to notify users of abnormal respiratory patterns that exceed a predefined threshold.

For further analysis and tracking, the system will incorporate an SD card module to log respiratory data over time. This data can later be accessed for comprehensive analysis and may also be represented graphically to visualize respiratory trends over time.

Exploring integration with health platforms or cloud services will enable long-term data storage and analysis, providing a more holistic view of respiratory health.

IV. ADVANTAGES AND DISADVANTAGES

Advantages:

Affordability: Arduino components are relatively inexpensive, making the project cost-effective compared to commercial spirometers.

Customizability: You can tailor the spirometer to specific requirements and even add features like data logging or mobile app integration.

Accessibility: The open-source nature of Arduino allows for widespread availability and easy replication of the project.

Learning Opportunity: Building a smart spirometer with Arduino provides a valuable educational experience, teaching about both electronics and respiratoryhealth.

Real-time Data: It can provide immediate feedback on lung function, aiding in monitoring and managing respiratory conditions.

Disadvantages:

accuracy and Calibration: Achieving medical-grade accuracy can be challenging, and calibration may be required for reliable measurements.

Regulatory Compliance: Commercial medical devices need to adhere to strict regulatory standards, which might not be met by a DIY project.

Safety Concerns: Ensuring safety and sterility in a DIY medical device can be difficult, potentially posing risks to users.

Limited Features: A DIY spirometer might not have the advanced features or capabilities found in professional medical devices.

Support and Maintenance: Troubleshooting and maintaining a DIY spirometer can be more challenging without professional support.

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IOT BASED FOREST FIRE PREVENTION SYSTEM WITH ANTI-SMUGGLING IDENTIFICATION

*Note: Sub-titles are not captured in Xplore and should not be used

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***Abstract*— Our study introduces an IOT-driven solution for forest fire prevention, coupled with anti-smuggling identification. By deploying IOT sensors to monitor environmental conditions and employing advanced algorithms, our system can swiftly detect signs of forest fires and identify suspicious activities. Real-time alerts enable rapid response, helping authorities to intervene promptly. This integrated approach aims to safeguard forests from both natural and human-induced threats, promoting sustainable conservation efforts.

Keywords— IoT, Forest fire prevention, Anti-smuggling, Identification, Environmental monitoring, Real-time alerts

I. INTRODUCTION

Protecting our forests from the destructive effects of wildfires has become a top priority in light of the growing environmental issues. The Real-Time Forest Fire Detection and Suppression System with Tree Cutting and Trespassing Detection is an inventive solution that was developed as a result of new avenues for tackling these difficulties created by the integration of advanced technologies. The ESP32 microcontroller, smoke sensor, water pump, relay, GPS module, DHT11 sensor, vibration sensor, flame sensor, microwave body radar motion sensor, and an OLED display are just a few of the many parts that this innovative system uses.

This integrated system forms a strong network by integrating multiple sensors and actuators to continuously monitor forest conditions, with the goal of achieving effective forest management and early wildfire detection. The central processing unit, or ESP32 microcontroller, is responsible for coordinating the data gathered from various sensors to offer real-time insights and prompt reactions to possible threats. In addition to identifying forest fires and initiating rapid suppression actions, this system has other features including monitoring for trespassing and detecting tree cutting.

Often called the "lungs of our planet," the world's forests are essential to preserving ecological balance and sustaining a variety of habitats. But because of human activity and shifting climatic patterns, wildfires are becoming a more serious danger to these priceless resources. It is therefore essential to improve forest protection and conservation activities in response to these difficulties by developing novel technology.

Using cutting-edge parts and clever data processing, the Real-Time Forest Fire Detection and Suppression System with Tree Cutting and Trespassing Detection is a ground-breaking solution. The purpose of this integrated system is to promptly detect incidences of trespassing, illegal tree cutting, and forest fires, allowing for quick response and mitigating measures. The integration of an extensive array of sensors and actuators provides a holistic approach to forest monitoring and management through this system.

II. LITERATURE SURVEY

Forests are seriously threatened by forest fires and illicit activities like smuggling, which calls for efficient monitoring and preventative actions. The integration of forest fire monitoring systems with anti-smuggling identification technologies through the use of IoT (Internet of Things) and related approaches is the subject of this review of the literature.

A. "IoT-Based Forest Fire Detection Systems: A Comprehensive Survey"

An overview of IoT-based forest fire warning systems is given in this survey article, which also covers sensor technology, data analytics approaches, and real-time monitoring strategies. Although it is mainly concerned with fire detection, it recognizes that anti-smuggling identifying elements might be added to these devices to improve overall forest protection.

B. "Combating Illegal Activities in Forests Using IoT: A Review"

This research examines the usefulness of IoT technology in preventing illicit activities in forests, primarily focusing on smuggling and illegal logging. It talks about using GPS tracking devices, sensor networks, and security cameras to find and stop illegal invasions. For complete protection, the

assessment also emphasizes how crucial it is to incorporate anti-smuggling measures into forest monitoring systems.

C. "Machine Learning Approaches for Anomaly Detection in Environmental Monitoring: A Review"

This review discusses machine learning techniques for anomaly detection in environmental monitoring systems. While not specifically focused on forests, it explores the applicability of anomaly detection algorithms for identifying unusual patterns indicative of both forest fires and illicit activities like smuggling. The review emphasizes the potential for leveraging machine learning to enhance the capabilities of integrated forest monitoring systems.

D. "Advances in Remote Sensing Technologies for Forest Monitoring: A Literature Review"

This review of the literature looks at developments in aerial drones and satellite imaging as well as remote sensing technology for monitoring forests. It covers the possibility of employing remote sensing data to identify and monitor forest fires and illicit activities, even if its main focus is on mapping land cover and assessing the health of forests. The review emphasizes how crucial it is to combine IoT systems based on the ground with remote sensing technologies to provide thorough forest monitoring.

Finally, To improve forest conservation efforts, extant literature emphasizes the significance of combining anti-smuggling identification technologies with forest fire warning systems. The development of integrated IoT-based systems that can identify, stop, and lessen risks to forests from both natural and man-made sources should be the main emphasis of future research. Promoting sustainable forest management and conservation techniques requires the use of such integrated approaches.

III. METHODOLOGY

The Real-Time Forest Fire Detection and Suppression System with Tree Cutting and Trespassing Detection is a system that combines hardware, sensors, data processing, and communication protocols in a well-organized architecture to provide a complete forest protection solution.

The ESP32 microcontroller, which was selected for the system's core due to its wireless and computational capabilities, is the central component. This central processing unit is the brain that directs and coordinates the activities of the entire system. Numerous sensors, such as the DHT11 sensor, vibration sensor, smoke sensor, flame sensor, and microwave body radar motion sensor, connect with the microcontroller. These sensors keep an eye out for trespassing activity, unapproved tree cutting, temperature changes, humidity, and evidence of fire or smoke in the forest environment. Their data is fed into the module for data processing, which does real-time analysis.

Data from the numerous sensors is received, interpreted, and analyzed by the data processing module. The decision logic module's algorithms analyze this data and choose the best course of action for various scenarios. The technology uses a relay to activate the water pump in the event of a fire or smoke detection, starting the fire suppression process right away. When someone chops down a tree without permission or trespasses, the system sends out email warnings with the exact GPS coordinates of the occurrence.

The user interface is an OLED display that gives personnel on-site visual feedback in real-time. They may see alerts, keep an eye on the system's status, and assess general operating conditions thanks to this display. The smooth interchange of information both inside the system and with external stakeholders is guaranteed by the communication module. It makes it easier to create email alerts that include incident details and coordinates, swiftly alerting the appropriate authorities to respond quickly.

The GPS module makes sure that incidents are identified accurately and provides geographic coordinates so that emergency services can locate the incidents. Email alert creation, formatting, and delivery are managed by the alert management module.

IV. BLOCK DIAGRAM

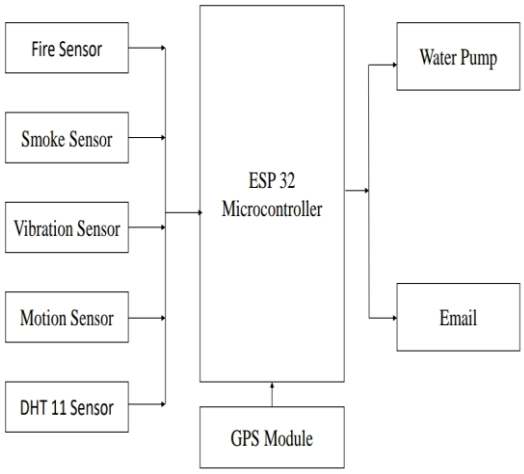

Fig 3.1 Block Diagram

V. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware Requirements:

1. ESP32 Microcontroller
2. Fire Sensor
3. Water pump
4. Vibration Sensor
5. Motion Sensor
6. GPS Module
7. DHT 11 Sensor
8. Smoke Sensor

Software Requirements:

1. Arduino IDE

VI. APPLICATIONS

Many uses exist for the Deforestation, Fire, Smoke, and Wildlife Monitoring and Anti-Smuggling System for Trees in Forest with Fire Suppression System and Deforestation, including:

1. Conservation of Forests: The system contributes to the protection and preservation of forests by keeping an eye on and stopping illicit logging, tree smuggling, and deforestation, which protects important ecosystems and biodiversity.
2. Wildlife Protection: It contributes to the conservation of wildlife by spotting and addressing risks such habitat degradation and poaching, protecting the security and welfare of threatened and endangered species.

VII. RESULT

The Real-Time Forest Fire Detection and Suppression System with Tree Cutting and Trespassing Detection represents a pivotal advancement in the realm of forest protection, management, and ecological conservation. By seamlessly integrating cutting-edge technology, sophisticated sensors, and intelligent algorithms, this system offers a comprehensive solution to address the complex challenges posed by forest fires, unauthorized activities, and the preservation of valuable natural resources.

Through a meticulously designed architecture, the system demonstrates its ability to swiftly detect incidents such as fires, smoke, unauthorized tree cutting, and trespassing activities. Its proactive approach, triggered by real-time data analysis and decision-making, ensures rapid response and efficient management of such events. The integration of sensors like the smoke sensor, flame sensor, vibration sensor, and microwave body radar motion sensor, coupled with the power of the ESP32 microcontroller, forms the backbone of its success.

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A Short-circuit Model Based on Artificial Neural Network and Artificial Bee Colony Algorithm for SiC MOSFETs

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Abstract: A short-circuit model for silicon carbide (SiC) metal-oxide semiconductor field effect transistors (MOS- FETs) using hybrid modeling method based on artificial neural network (ANN) and improved artificial bee colony (ABC) algorithm is proposed in this paper. In order to improve the search ability of the ABC, particle swarm optimization (PSO) is introduced to the scout bees' search strategy. The improved ABC is employed to find suitable initial parameters for ANN model, which can improve the accuracy of modeling results. Based on hybrid modeling method, the normal working model of SiC MOSFETs is established first. The modeling results of I−V characteristics, C−V characteristics and small signal parameters (g_m, g_d, etc.) are in good agreement with datasheet, which fully demonstrates the validity of the normal working model. Then the short-circuit model of SiC MOSFETs is further obtained based on the relationship between short-circuit current and junction temperature and normal working model. Eventually, the proposed short-circuit model is verified by device- and circuit-level tests. With its precision and simplicity, the proposed short-circuit model can be used to analyze short-circuit faults in SiC MOSFET simulation circuits and provide assistance for the design of protection circuits.

Keywords: Artificial bee colony (ABC) algorithm, artificial neural network (ANN), silicon carbide (SiC) metal-oxide semiconductor field effect transistors (MOSFETs)

1. Introduction

With the rapid development of process technologies of silicon carbide (SiC), SiC metal-oxide semiconductor field effect transistors (MOSFETs) have been commercialized in mass production and are popular in the de- sign of high-power electronics [1]. Compared with tra- ditional Si MOSFETs, SiC MOSFETs have lots of out- standing advantages, such as higher switching speed, higher switching frequency, smaller ON-state resistance, and better high temperature stability [2]. Due to the excellent characteristics of SiC MOSFETs, they are of- ten used in harsh circuit conditions.

Hence, it is nec- essary to ensure its reliability and safety to guarantee that SiC MOSFETs can operate normally under harsh conditions. One of the key reliability issues is the short- circuit capability of the SiC MOSFETs [3]. Therefore, an accurate and simple SiC MOSFET short-circuit sim- ulation model is urgently needed to predict the charac- teristics of the faults caused by the short-circuit and provide guidance for the design of protection circuits.

In the past few decades, many SiC MOSFET mod- els [4–6] have been proposed, but most of them only consider normal working scenarios. Recently, several models [7–9] describing the short-circuit characteristics of SiC MOSFETs have been reported. Physics-based models [7] can describe the internal physical characteristics of SiC MOSFETs and are usually considered to be accurate, but they are too complex to be suit- able for power electronic circuit simulation [10]. The PSpice short-circuit model of SiC MOSFETs [8, 9] is simpler than the physics-based model, but it still has many parameters. The extraction of parameters is time- consuming and may lead to inaccurate results. In addition, the PSpice model only considers the short-circuit situation when the case temperature is 25℃, but different case temperatures have an impact on the short-circuit current. Data-oriented modeling methods can be quickly applied for the newly generated device data. Ar tificial neural network (ANN) is considered as a data-oriented modeling method [11] and can achieve an accurate model in a short time, which has been employed in the modeling of semiconductor devices [12, 13]. In order to reduce the developing time and obtain an accurate model, a short-circuit model of SiC MOSFETs considering case temperatures based on ANN is proposed in this paper.

In this work, a Multi-layer perceptron (MLP) [14] based on the levenberg-marquardt (LM) algorithm [15] is adopted to establish a short-circuit model for SiC MOSFETs. Since the LM algorithm is quite sensitive to the initial values, for the sake of overcoming the sensitivity of the LM to the initial values and get better modeling results, an improved artificial bee colony (IABC) algorithm [16] combined with particle swarm optimization (PSO) [17] (IABCPSO) is proposed and introduced into the training of MLP to find the ap- propriate initial weights and biases for the LM. In this paper, we first build the SiC MOSFET model under normal working conditions, and then the short-circuit model is developed based on the normal working model and junction temperature. A SiC MOSFET of type C2M0080120D (1200V/36A) [18] is chosen as the mod- eling

object in this paper. Furthermore, the accuracy of the short-circuit model based on this hybrid modeling method is verified by both the device and circuit-level tests.

2. Normal Working ANN Model

Since the drain-source current Ids under normal operating conditions also contributes to the short-circuit current, it is first modeled based on ANN modeling method, which takes into account the temperature characteristics. The ANN model contains the drain-source current Ids, body diode Db, gate-drain capacitor Cgd, gate-source capacitor Cgs, drain-source capacitor Cds and internal gate resistor Rg, as shown in Fig. 1.

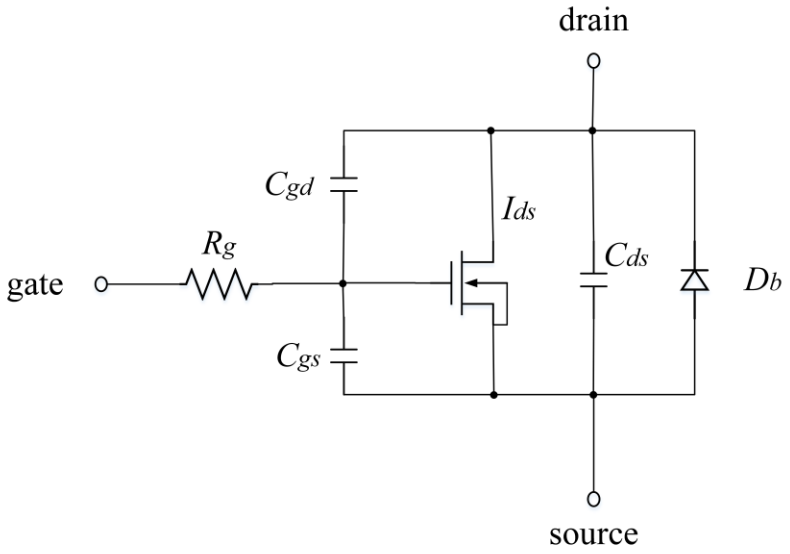

Fig. 1 The ANN model of SiC MOSFET

2.1 Improved artificial bee colony algorithm combined with particle swarm optimization

In our previous work [19], we used the MLP based on the LM algorithm for modeling SiC MOSFETs, which is also adopted as the basis of this paper. Different from [19], the ABC algorithm in this paper is improved by introducing PSO into the search strategy of the scout bees.

In PSO [17], each particle represents a possible solution, and the optimization process of the particle is related to two important factors: the individual optimal solution (pbest) and the swarm's optimal solution (gbest). And the fitness function of PSO will guide the particle swarm to find the optimal solution. In this paper, PSO is introduced into the optimization process of the scout bees of ABC. When the employed bees and onlooker bees are converted to scout bees because their corresponding nectar sources aren't updated in the limited times, they will restart the search for the best solution in the entire range set at the

beginning, which is undoubtedly a waste of current information resources, such as the current best solution of the entire bee colony (Xbest) found by the employed bees and the onlooker bees. After introducing PSO into the optimization process of the scout bees, we can effectively use the Xbest information, and the optimization of the scout bees will be carried out in accordance with the idea of PSO, thereby improving the efficiency of the whole algorithm. The optimization process of the scout bees can be described as:

$$Nij = w \cdot Nij + ri1 \cdot c1(pbest - Mij) + ri2 \cdot c2(gbest - Mij) \quad (1)$$

$$Mij = Mij + Nij \quad (2)$$

where Nij and Mij represent the velocity and position of the i th particle, respectively; w is an inertia factor describing the contribution rate of the particle's previous speed to its current speed, which helps particles to search a wider area in the previous direction. Moreover, ri1 and ri2 are random numbers in the range of [0,1]; c1 and c2 are the acceleration factors. In order to use the Xbest information, we set Mi as:

$$Mi = Xbest. \quad (3)$$

Then, the particle swarm will use Xbest as the initial position to help scout bees search for the best solution, which effectively enhances the search ability of the whole algorithm. After that, the mean square error of the I-V modeling results and the datasheet is set as the fitness function, and we compared modeling results of IABCPSO and IABC in [19] running 100 times respectively, the results of which are shown in Fig. 2. The conclusion can be drawn from Fig. 2 that, IABCPSO can get better results in a shorter time, which confirms the effectiveness of our proposed algorithm in this paper.

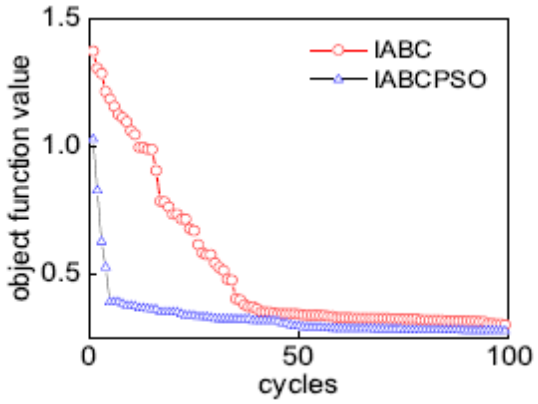

Fig. 2 Comparison results between IABCPSO and IABC

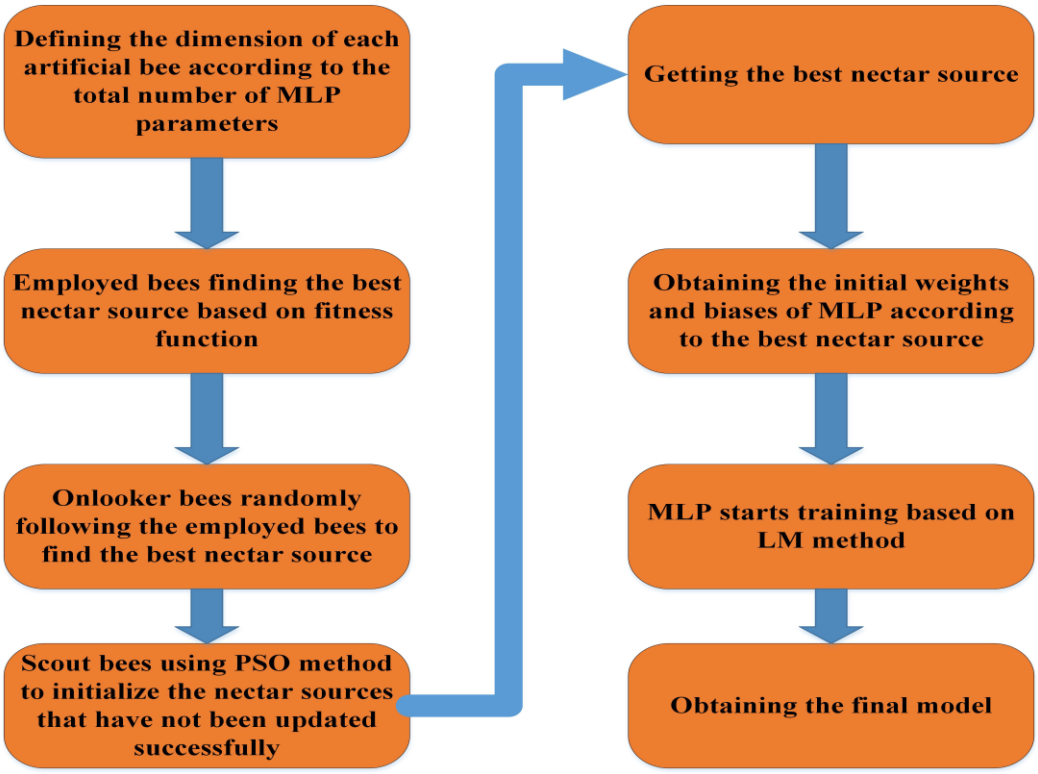

Fig. 3 The flow chart of a hybrid algorithm based on MLP and IABCPSO

2.3 Modeling of drain-source current Ids, body diode Db and internal capacitors

In this paper, the drain-source current Ids, body diode Db and internal capacitors are all modeled using our

proposed hybrid modeling method (IABCPSO-MLP). According to I-V curves provided by datasheet [18],

the drain-source current Ids can be modeled by an ANN with three inputs (drain-source voltage Vds, gate-source voltage Vgs, and operating temperature T). In order to obtain a high-precision model, we use an ANN containing two hidden layers to model Ids and each layer contains 8 neurons. The final modeling results can reach an accuracy of more than 99%.

From datasheet [18], we can find that the current of body diode Isd, like Ids, varies with Vds, Vgs, and T.

Therefore, the modeling of Isd adopts the same ANN structure as that of Ids and the accuracy of modeling

results of Isd can also reach more than 99%.

According to the datasheet [18], both Cds and Cgs vary nonlinearly with one variable, i.e., Vds or Vgs. Hence, Cds and Cgs can be modeled by

same MLP structure with one input (Vds or Vgs) and one output (Cds or Cgs). Considering the simplicity and accuracy, the 1-5-5-1 MLP structure is finally selected among many tested structures, the accuracy of which can reach 98%.

3 Short-circuit model of SiC MOSFETs

When the short-circuit faults occur, the circuit power loop impedance will become extremely small, and the short-circuit current Isc of the SiC MOSFETs will rise to a large amount. As the current of the circuit is very large, the power loss Ploss at this time will also become very large. Therefore, the junction temperature Tj begins to increase, leading to decrease of the channel carrier mobility and Isc. However, Tj is still increasing, and the leakage current caused by thermal ionization is also gradually increasing. When the leakage current rate generated by thermal ionization is higher than the decrease rate of carrier mobility, Isc starts to rise again. It can be concluded that the change of the short-circuit current of the SiC MOSFETs is mainly caused by the change of Tj. Therefore, to establish a short-circuit model, the change curve of Tj during the short-circuit process should be obtained first.

3.1 Thermal network model

In order to obtain the change curve of Tj during the short-circuit process, the thermal network of the SiC

MOSFETs is established. The thermal network model based on the case-to-junction thermal impedance formed by a resistance-capacitance (RC) network [9] is the most commonly used, which is also used in this paper. As shown in Fig. 4, Tc and Tj are the case and junction temperatures of SiC MOSFETs, respectively. Ri and Ci are the thermal resistance and thermal capacitance, respectively.

After the development of the thermal network model, the transient thermal impedance Zth can be obtained

by [9]:

$$Z_{th} = \sum_{i=1}^{n} R_i \cdot \left(1 - e^{-\frac{t}{R_i \cdot C_i}}\right). \quad (4)$$

The transient power loss Ploss is given by [9]:

$$Ploss = Vds \cdot Ids. \quad (5)$$

After getting Ploss and Zth, the junction temperature Tj of SiC MOSFETs can be obtained, which can be expressed as [9]:

$$Tj = Ploss \cdot Zth + Tc. \quad (6)$$

In this paper, the experimental data [20] is used as model reference. In [20], the DC bus voltage

(Vds) is set as 400V and the corresponding short-circuit current curves under different case temperatures are given.

In Fig. 5, the change of Tj is shown for Tc=25℃ and Vds=400V, which is obtained by Eq. (6) after substituting the transient power loss Ploss. When SiC MOSFETs work under normal conditions, the junction temperature is consistent with the case temperature, and when a short-circuit fault occurs, the junction temperature begins to rise.

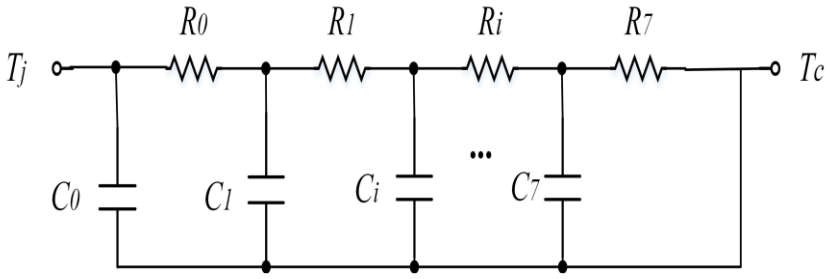

Fig. 4 Thermal network model between case and junction

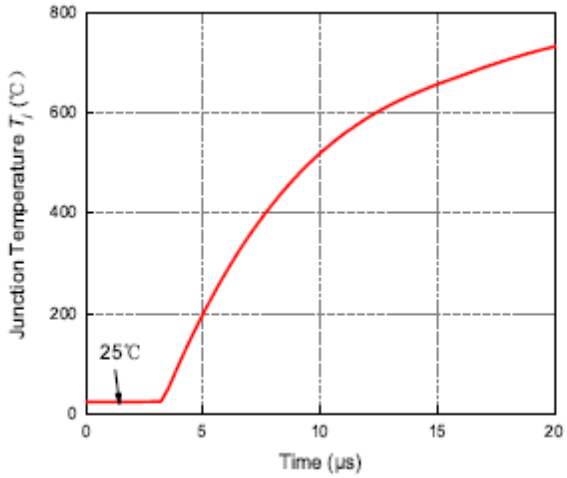

Fig. 5 The change curve of junction temperature Tj

3.2 Modeling of short-circuit current Isc

After getting the instantaneous change curve of Tj, we can acquire the relationship between Isc and Tj , as shown in Fig. 6, where the short-circuit current Isc can be fitted based on Tj . Since when the short-circuit fault occurs, the current Ids under normal working conditions also has output, Isc needs to be fitted based on Ids.

In this paper, the impact of different case temperatures on the short-circuit current is considered. Since the relationship between Isc and Tj is various under different Tc, Isc can be expressed as:

$$Isc = Ids \cdot f(Tj , Tc), \quad (7)$$

where f (Tj, Tc) is a variable that changes with Tj and Tc. In this paper, f (Tj, Tc) is fitted by a 2-5-5-1 ANN structure with hybrid modeling method, that is, ANN has two inputs (Tj and Tc), five neurons in two hidden layers and one output (f (Tj, Tc)). Hence, the final expression of Isc can be rewritten as:

$$I_{sc} = \begin{cases} I_{dsANN} & T_j = T_c \\ I_{dsANN} \cdot f(T_j, T_c)_{ANN} & T_j > T_c. \end{cases} \tag{8}$$

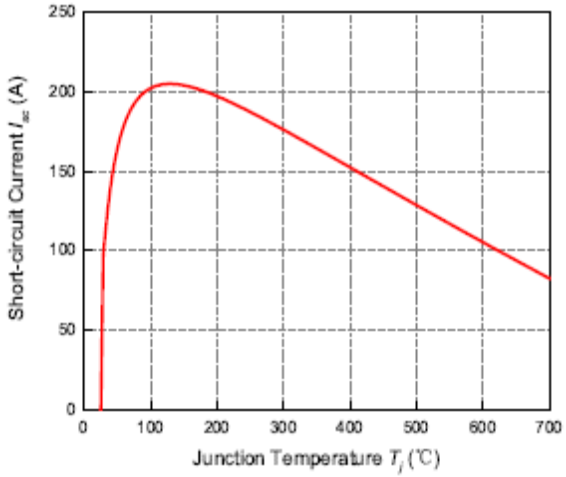

Fig. 6 The corresponding relationship between short-circuit current Isc and junction temperature Tj

4. Conclusion

A short-circuit model based on IABCPSO-MLP modeling method for SiC MOSFETs is presented in this paper. In order to overcome the sensitivity of the basic algorithm (LM) of ANN to the initial values and enhance model accuracy, a scheme that uses IABCPSO to find the initial values for ANN is proposed and verified. The model under normal working conditions is verified by comparing the simulation results of the I-V characteristics, C-V characteristics and small signal parameters (gd and gm) that are not exposed in the training process with experimental data. And the short-circuit characteristics of the proposed model are proved by comparing short-circuit current waveforms predicted by our model and experimental data under different working conditions. Hence, our proposed SiC MOSFET short-circuit model can facilitate analysis of short-circuit faults and provide guidance for circuit design.

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Speaker Verification Comparison between GMM and GMM-UBM under limited data condition

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***Abstract*—This work demonstrates the verification of speakers with the Constraint of Limited data (<15 sec). The existing techniques for speaker verification work well for sufficient data (>1 minutes). Developing techniques for verifying the speakers for limited data condition is a challenging issue. In this paper, a comparision study is made using Gaussian Mixture Model (GMM) and GMM-Universal background model (GMM-UBM) with mel-frequency cepstral coefficients (MFCC) as a feature is given. The NIST-2003 database is used to carry-out the experiments. The experiments are conducted using different amount of training and testing data. The experimental results show that GMM-UBM gives a lower equal error rate (EER) compared to GMM.**

I. INTRODUCTION

The objective of speaker recognition is to recognize the speakers using their voice [1]. Speaker recognition involves speaker verification and speaker identification [2]. Speaker verification is the process of accepting or rejecting the identity claim of a speaker. In speaker identification since there is no identity claim, the system identifies the most likely speaker of the test speech signal [3]. Speaker recognition can be classified into closed-set and open-set recognition. The task of recognizing a speaker who is known a priori to be a member of the set of N enrolled speakers is known as closed-set speaker identification. On the other hand, the speaker recognition system which is able to identify the speaker who may be from outside the set of N enrolled speakers is known as open-set Speaker identification [3] [4]. Depending on the mode of operation, the speaker recognition system can be either text-dependent or text-independent [5]. The same text is used for both training and testing in the text-dependent case while no restrictions on text are made in the text-independent case.

Speaker recognition in limited data condition aims at recognizing speaker with the constraint that both training and testing data are limited. Limited data symbolizes the case of having speech data of few seconds (less than or equal 15 seconds) [6]. Since the amount of data available is less in limited data condition, the number of feature vectors is insufficient to model and discriminate the speaker well. Therefore, it is a challenging task to improve the speaker recognition in such situations.

Speaker recognition under limited data conditions could be used in the following applications [7] [8]:

1) Controlled access and authentication like banking operations through telephone.
2) Criminal and forensic investigations.
3) Person authentication using voice as a Biometric.

All the above mentioned applications face the constraint of limited data. Therefore, it is essential to build a system which will be able to recognize speaker with the constraint of limited data.

The most widely used classifier for speaker recognition is GMM which was proposed by Reynolds in 1995 [9]. In GMM, the underlying probability density function of the feature vectors of each speaker is captured using Gaussian mixtures [10]. The complete GMM is parameterized by the mean vectors, covariance matrices and mixture weight. In GMM, Log likelihood ratio test is used for testing. The advantage of using GMM is, it's more economical and is based on a well-understood statistical model for text-independent speaker verification [9]. The disadvantage of GMM is that it requires sufficient data to model well the speaker parameters [9] [11]. To overcome this problem, GMM-UBM modelling technique is used for speaker recognition task [12].

In GMM-UBM, speech data from a large pool of speakers were used to design a speaker independent model. UBM is trained, which acts as a speaker-independent model. The speaker-dependent model is then created from the UBM by performing maximum a posterior (MAP) adaptation technique using speaker-specific training speech. As a result GMM-UBM gives better results than the GMM. The advantage of the UBM-based modelling technique is that it provides good performance even through the speaker-dependent data is minimal. The disadvantage is that a gender-balanced large speaker set is required for UBM training [11].

The paper is organised as follows: Section II describes the database used for the experiments. Feature extraction using MFCC and speaker modelling using GMM and GMM-UBM are presented in Section III. In Section IV comparison of experimental result is presented. Section V gives summary of

the present work and scope for the future work.

II. Database for the Study

The NIST-SRE-2003 database consists of speech data from 356 speakers (149 male and 207 female). The spontaneous speech of speakers was collected over cellular phone, sampled at 8 kHz and stored with 16 bits/sample resolution for use as training and testing data. The range of speech data varies from few seconds to few minutes. Since the database is not meant for limited data condition, we have taken four, five and six seconds of each speaker data to create the database for the present work. A detailed description of the database can be found in the NIST-SRE-2003 plan (NIST 2003) [13]

III. Feature Extraction and Modeling

A. Mel-frequency cepstral coefficients (MFCC)

The purpose of feature extraction is to extract the speaker-specific information in the form of feature vectors at a reduced data rate [14]. In this work, features are extracted using MFCC technique. The state-of-the-art speaker verification system uses MFCC as a feature for recognizing speakers [15]. Fig.1 shows the block diagram representation of the MFCC method. Speech signals were sampled at the rate of 8 kHz. Frame duration of 20 msec and overlapping duration of 10 msec (160 and 80 samples respectively) are considered. Upon framing, we advance to the Windowing process. Windowing (Hamming) method is carried out to minimize the spectral distortion. The mathematical expression for the Hamming window is as follows:

$$h(n) = 0.54 - 0.46\cos(2\pi n/N - 1) \quad (1)$$

Fourier transform is then applied on the windowed frame signal to obtain the magnitude frequency response. A magnitude spectrum is computed. The resulting spectrum is passed through a set of triangular band pass filters. We have considered 22 filters. These filters are equally spaced along the Mel-frequency scale. The Mel scale is a mapping between the real frequency scale (Hz) and the perceived frequency scale (Mels). The mapping from linear scale to Mel scale is given in equation 2

$$fmel = 2595\log_{10}(1 + f/700) \quad (2)$$

In order to get the cepstral coefficients, Discrete cosine transform (DCT) is applied. In this work, 13 coefficients are considered as feature vectors. Since the 0th coefficient can be regarded as a collection of average energies of each frequency bands, it is unreliable [11].

B. Gaussian mixture model (GMM)

The Gaussian mixture model (GMM) is a density estimator and is one of the most commonly used types of classifier for speaker recognition [16]. In GMM, the distribution of the feature vector is modelled clearly using a mixture of M

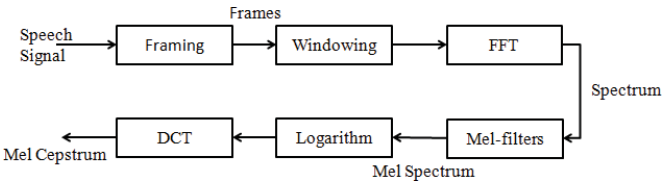

Fig. 1: Block diagram of MFCC Technique

Gaussians. Given a collection of training vectors, maximum likelihood model parameters are estimated using iterative expectation-maximization (EM) algorithm [10].The EM algorithm iteratively refines the GMM parameters to monotonically increase the likelihood of the estimated model for the observed feature vectors. The complete GMM is parameterized by the mean vectors, covariance matrices and mixture weights from all components densities. These parameters are collectively represented by the notation,

$$\lambda = \{\omega i, \mu i, \Sigma i\} \quad (3)$$

During testing the speaker recognition system uses the matching and decision logic [11]. Test features vectors are matched with the reference models, matching gives a score which represents how well the test feature vectors are close to the reference models. Decision will be taken based on a final set of matched scores, which depends on the threshold value. In GMM, Log likelihood ratio test is used for testing.

C. GMM-Universal background model (GMM-UBM)

UBM is a large GMM which represents the speaker independent distribution of features. UBM is generally built using large population of speech. UBM is the core part of GMM-UBM speaker verification system. UBM should be balanced with respect to male and female speakers. To train a UBM, the simplest approach is to merely pool all the data and use it to train the UBM via the EM algorithm. Maximum a posteriori (MAP) adaptation integrates coupled target and background speaker model components is an effective way of performing speaker recognition [17].During the testing stage, log likelihood ratio test is used for testing.

IV. Experemental Results

The present work focuses on speaker verification using two different modelling methods. A perfect speaker verification system should accept all the true claims and reject all the false claims. But in practice, some true trials may be rejected and some false trials may be accepted by speaker verification system. The speaker verification performance is measured in terms of false rejection rate (FRR) and false acceptance rate (FAR). These parameters compute to give equal error rate (EER).

In the present work, all experiments were carried out with a constant set of 356 train and 2559 test speakers from NIST2003 database and time span for each speaker sample varies around 4sec, 5sec and 6secs in order to make a relative

comparison in the performance of speaker verification using two modelling techniques. In GMM, the parameters (mean vector, covariance matrix, mixture weights) were estimated using expectation maximization (EM) algorithm. In GMM, the speakers were modelled for Gaussian mixture of 16, 32 and 64. In case of UBM, speaker specific models were created by adapting only the mean vectors using maximum a posterior (MAP) adaption algorithm. UBM is modelled for Gaussian mixtures of 16, 32 and 64. The performance of both the methods is tabulated in table 1 and 2.

TABLE I: GMM verification performance EER (%) for different amounts of Training / Testing data and Gaussian mixtures.

Train/Test data	Gaussian Mixtures		
	16	32	64
4sec	44.30	45.70	47.40
5sec	42.68	44.12	45.21
6sec	42.09	41.96	44.98

TABLE II: GMM-UBM verification performance EER (%) for different amounts of Training / Testing data and Gaussian mixtures.

Train/Test data	Gaussian Mixtures		
	16	32	64
4sec	39.52	38.66	39.06
5sec	38.34	37.85	37.75
6sec	36.72	37.12	37.17

Fig. 2 and 3 show the individual performance of GMM and GMM-UBM models, respectively. Fig. 4, 5 and 6 indicates the comparison between both the models for 16, 32 and 64 Gaussian mixtures. The Experimental results in Table 1 and 2 show that the performance of GMM is poor compared to the performance of GMM-UBM. This is because, GMM needs sufficient data to model the speaker well [9] and GMM fails as there are two many parameters that need to be estimated given the limited amount of training and test data. Since the GMM-UBM uses the background models obtained from large set of speakers data, it gives good performance even through the speaker-dependent data is small. It can be observed in Fig. 4, 5 and 6 that the GMM-UBM gives lower EER compared to GMM. An average percentage reduction in EER of 11.24%, 13.72% and 17.2% was obtained for Gaussian mixture of 16, 32 and 64, respectively.

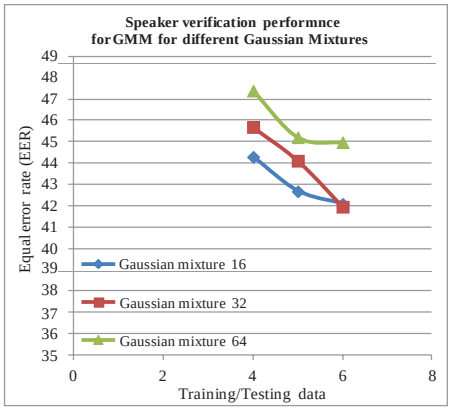

Fig. 2: Performance of speaker verification for GMM for 16,32 and 64 Gaussian mixtures

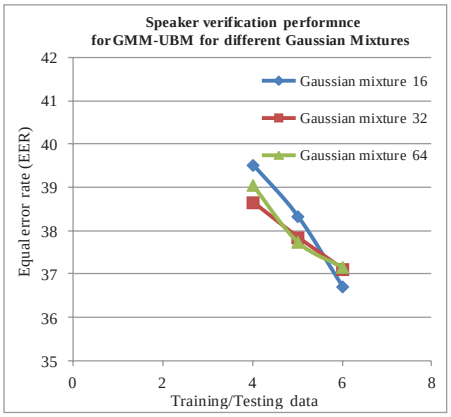

Fig. 3: Performance of speaker verification for GMM-UBM for 16,32 and 64 Gaussian mixtures

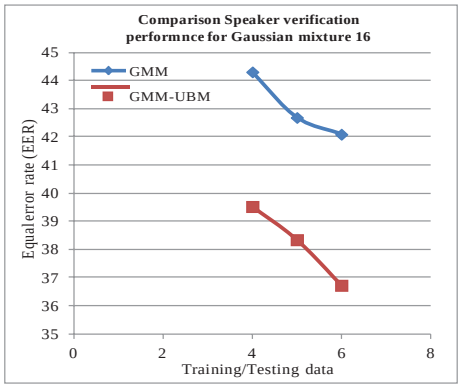

Fig. 4: Performance of speaker verification for Gaussian mixture 16

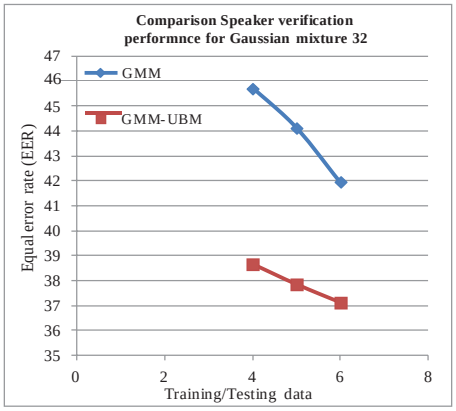

Fig. 5: Performance of speaker verification for Gaussian mixture 32

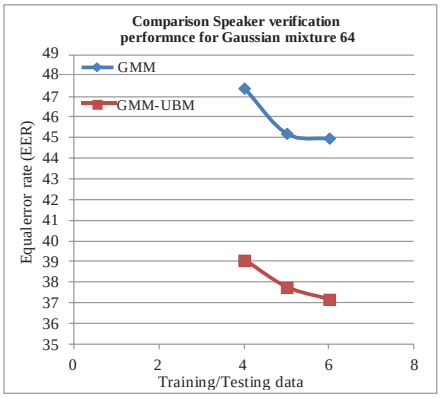

Fig. 6: Performance of speaker verification for Gaussian mixture 64

V. Conclusion

In this paper we have compared the performance of GMM and GMM-UBM modeling techniques using MFCC for speaker verification with the constraint of limited data. The results indicated that GMM-UBM gives lower EER compared to GMM in all the cases. Therefore, we suggest that the GMM-UBM can be used as modeling technique for speaker verification with the Constraint of limited data. The significance of different features need to be analyzed for speaker verification under limited data.

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Optimal method for Trajectory Tracking for Autonomous Unmanned Aerial Vehicle using Machine Learning

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ABSTRACT

Unmanned Aerial Vehicle (UAV) is used in many applications because of their high speed and flexibility. The drone flies autonomously in different altitudes and it is equipped with sensors to observe the environment and communication units to exchange data with other drones or central stations. UAV system has complex nonlinear characteristics and analyzes their dynamics benefits in controller design process. The attitude and position of UAV are controlled by up and down movement, back and forth movement and yaw angle change of the UAV. The current research on UAV focused on intelligent sensor technology and automatic control technology. UAV collects environmental information through intelligent sensors and then processes the information to attain the control signal. UAV acts on control signals during flight and perform their tasks autonomously according to the set targets. Target tracking and vehicle control are two problems in trajectory tracking with UAV. But, the limited computation capability of UAVs hardly supports computation-intensive tasks. In addition, the accuracy level was not improved and time consumption was not reduced by existing methods. Therefore, different controller methods are reviewed with UAV imaged by different researchers.

Keywords: Unmanned Aerial Vehicle, drone, attitude, position, sensor technology, trajectory tracking

1. INTRODUCTION

With fast growth of science and technology, Unmanned Aerial Vehicles (UAVs) are widely used in production and daily life because of their versatility, flexibility and low cost. The autonomous operational capability increased the efficiency and accuracy in diverse fields such as electrical inspections, agriculture, and cargo transportation. UAVs play an important role in the field of rescue and environmental monitoring. UAV capabilities are expanded to promote scientific and technological development as well as social progress. Researchers aimed on the control, planning, and UAV application in the past decade. Many trajectory algorithms are introduced for UAV slewing maneuvers with tracking through convex optimization. The research mentioned has contributed to the development of UAV techniques. With expansion of application fields, harsh environments have raised huge demands for UAV control performance in high altitude or open environments. The airflow was caused by propeller rotation in discovering narrow environments. The different controller methods used for efficient target tracking with UAV images are:

Adaptive Neural Networks Controller

- Model Predictive Controller
- Reinforcement Learning Controller
- Multi-Agent Deep Reinforcement Learning Controller
- Deep Deterministic Policy and Transfer Learning Controller
- Path planning
- Outlier Filters and Frame Buffer Control

● Sliding Mode Controller

Unmanned aerial vehicles (UAVs) are also used by commercial industries, research institutes and military sectors over last decade for different applications like aerial refueling, forest fire monitoring and payload transportation. With increasing use of UAVs, maintenance of desired performance is a key requirement to achieve the dissimilar user demands. UAVs promises to vary the landscape of logistics industry for last-mile parcel delivery. Many researchers improved the tracking accuracy and safety of
UAVs. UAVs are introduced with small size and low moment of inertia that affected by environmental disturbances and payloads. UAVs operate in heavily forested areas lose contact with GPS signals. UAV increased their interest in localization and guidance in GPS environments. The safety of UAVs is not guaranteed with accurate location. UAV move along path is preplanned and sent from ground station or generated onboard in real time depending on system constraints. An autonomous UAV needs the capability to carry out path planning without any obstacles to accomplish the assigned mission. The generated path accommodates the environmental constraints with physical as well as kinematic constraints of UAV. With limited processing power of UAVs, the computational complexity is a key need for target tracking. The main contribution of the article is given as:

- To identify the suitable controller for trajectory tracking in UAV with minimum time and overhead
- To design optimal technique to reduce the time consumption during trajectory tracking in UAV
- To compare conventional approach performance in selecting the optimal controller to track the trajectories based on the position and distance factors

The contents of this paper are structured as follows: Section 1 presents the introduction to the target tracking with UAV images and the challenges faced by the subjects. Section 2 presents the review of various controller methods for target tracking. Section 3 describes the datasets used in this study. Section 4 explains the description of different controllers for target tracking. Section 5 explains different performance metrics used for target tracking. The results obtained after various experiments are presented and discussed in Section 6. Section 7 concludes the work with future direction.

2. LITERATURE REVIEW

A novel intelligent controller employing adaptive neural network with non-linear control model using Lyapunov function was designed by Gabriel da Silva Lima., et al., (2023) [1] for frictional forces and external disturbances. The application of fused error signal in neural network reduced the computational complexity and ensured trajectory tracking in an intelligent manner. The target tracking was guaranteed with tracking error reduction. A complicated dynamic method enhanced accuracy but not pertinent in computational aspects. A data driven method was designed by Luca Castro Sousa and Helon Vicente Hultmann Ayala (2022) [2] for increasing the autonomous tracking. The non-linearity between lateral and longitudinal vehicle dynamics was captured with minimum computational cost. But, the time complexity was not minimized by data driven method.

An adaptive dynamic programming algorithm was introduced by Yiting Feng., et al., (2020) [3] depending on reinforcement learning theory. The index function and control law approximated the optimal values through training Back Propagation (BP) neural networks namely critic neural network (NN) and actor NN. However, the computational overhead was not reduced by adaptive dynamic programming algorithm. A decentralized MADRL technique was designed by Wenhong Zhou., et al., (2022)

[4] with the maximum reciprocal reward to study the cooperative tracking policies for UAV swarms. The designed method reshapes each UAV reward with regularization term. The decentralized MADRL method was dot product of reward vector of all neighbor UAVs and dependency vector between UAV as well as neighbors. But, the tracking error was not reduced by decentralized MADRL method.

A deep deterministic policy gradient (DDPG)-based control framework was introduced by Bo Li., et al., (2021) [5] for autonomous decision-making capability in UAVs. MN-DDPG with mixed noises assisted the UAV with stochastic strategies for online optimal planning. But, the memory consumption was not minimized by DDPG. An outlier filter was designed by Yang Wang., et al., (2024) [6] to enhance applicability of depth estimation networks for efficient target localization. A frame buffer method was An adaptive dynamic programming algorithm was introduced by Yiting Feng., et al., (2020) [3] depending on reinforcement learning theory. The index function and control law approximated the optimal values through training Back Propagation (BP) neural networks namely critic neural network (NN) and actor NN. However, the computational overhead was not reduced by adaptive dynamic programming algorithm. A decentralized MADRL technique was designed by Wenhong Zhou., et al., (2022) [4] with the maximum reciprocal reward to study the cooperative tracking policies for UAV swarms. The designed method reshapes each UAV reward with regularization term. The decentralized MADRL method was dot product of reward vector of all neighbor UAVs and dependency vector between UAV as well as neighbors. But, the tracking error was not reduced by decentralized MADRL method.

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Aerial Vehicle driving has become the centric point of evolution in UAV. As UAV is concerned, path tracking or trajectory was considered as the fundamental technology. Many methods have been researched over recent years for ensuring reliable trajectory tracking controller. The deep deterministic policy gradient algorithm of the double critic network was applied by Jialing Yao and Zhen Ge (2023) [13] with control commands for making wise decisions through Markov decision process. The deep deterministic policy gradient algorithm increased the accuracy level. Though accuracy level was imporved, the time complexity was not minimized. The neural networks learning was proposed by Jiangang Li., et al., (2022) [14] based on both online and offline strategy. However, the error rate was not reduced.

A robust bounded-error estimation approach was introduced by Julius Ibenthal., et al., (2020) [15] to determine and estimate at each time step guaranteed with actual state of localized true targets and decoys. An energy-efficient UAV-aided target tracking system was designed by Xiaoheng Deng., et al., (2022) [16] with video processing tasks from a UAV to edge nodes (ENs). A cost minimization issues were addressed through optimizing task execution time and energy consumption for efficient task processing. A localized solution was given by Dimitrios Zorbas., et al., (2013) [17] for drones to fly at lower altitudes to conserve energy. An adaptive multi-rotor UAV system of dynamic target tracking and path planning was introduced by Haiqing Li., et al., (2023) [18] with occlusion, and target interference in an unstructured environment. A DTE-tracker

module comprised detector, tracker, and examiner. A dynamic target capture mechanism was used to increase robustness and continuity of target tracking. Multi-object tracking and segmentation (MOTS) was introduced by Mar Ariza-Sentís., et al., (2023) [19] to determine the individual white grape bunches and berries from RGB videos obtained from a UAV with high density of leaves. Cross Stage Partial Darknet53 (CSPDarknet53) backbone network was introduced by Wenyuan Xu., et al., (2024) [20] with lightweight MobileNetV3 backbone network for minimizing parameters and computational complexity with inference speed. The issues identified from the above literature are: lesser tracking accuracy, higher computational cost, higher tracking time, higher tracking overhead, higher tracking error, higher computational complexity and so on. In order to address the above mentioned issues, the suitable controller has to be selected.

3. DATASET DESCRIPTION

In this section, the dataset description is listed for unsupervised depth dataset and drone dataset. Drone dataset is taken from https://www.kaggle.com/datasets/dasmehdixtr/drone-dataset-uav?select=dataset_xml_format.

Drone dataset is gathered by Mehdi Özel for UAV Competition. Drone (UAV) Dataset contains the photos taken by UAVs (i.e., drone-to earth view). The dataset is used to train UAV to guide and dodge other UAVs. Drone dataset comprised 1359 labeled photos. Drone dataset have both ".txt" and ".xml" files to train on Darknet (yolo), Tensorflow and PyTorch Models. The controller identification for accurate trajectory tracking results are discussed based on certain parameters such as trajectory tracking accuracy, trajectory tracking time, trajectory tracking overhead and trajectory tracking error rate with respect to a number of sample images. Dataset for research purpose has been collected from the Kaggle. The sample images collected fro the dataset is given below:

Table 1 Sample images from dataset

In unsupervised depth dataset, Pix4D is the professional software for UAV mapping and photogrammetry. The software is used to process the image data gathered by UAV to generate the orthophotos, 3D point clouds or realistic 3D models. Pix4D is specialized for UAV perspective scene reconstruction. Pix4D generated the intermediate data like camera intrinsic parameters, and scene point cloud data. In addition, the software is user-friendly and generates the high-quality point cloud results. Through inputting test image sequence into Pix4D, dense 3D point cloud scenes and transformation between 2D pixel coordinates of input images and 3D point cloud gets generated. The depth label point cloud scene gets reconstructed through Pix4D 32 commercial software. An image sequence was inputted during the scene reconstruction. The virtual 3D

point cloud space with proportional scale is constructed based on the virtual scale. The multi-view image sequence and depth labels from test set are joined to create the dataset of UAV depth estimation. The dataset has depth maps and does not build camera internal parameters in middle of depth estimation dataset, drone flight altitude and data-based depth labels. The dataset construction method is built by Pix4D software to generate many transformation intermediate data information like Pmatrix, camera internal parameters and scene point cloud data for subsequent scale recovery and experimental verification. Table 2 describes the main information of UAV depth estimation dataset.

Table 2 Main Information of UAV Depth Estimation Dataset

Content	Volume
Number of images	19,516
Number of video sequences	28
Image size	640 × 352
Annotation category	Scene depth information
Object categories	Pedestrians, Vehicles
Camera intrinsic parameters	Included
UAV flight heights	Included
Pmatrix	Included
Scene 3D point cloud modeling	Included

As network downsample input images by factor of 5, all image data sizes are converted to 640×352 for subsequent network training. During UAV image capture, the depth variation in scene is relatively small when camera is perpendicular to the ground. When the camera is close to parallel with ground, the depth range in the scene changed significantly. The camera experienced substantial changes during actual UAV flights. The multi-view UAV image sequences are added with the training dataset to learn depth distribution features from different perspectives.

4. PROPOSED METHODOLOGY

Trajectory tracking control is used in number of applications in high-tech fields like aircraft and space vehicle, mobile robot, tank system and underwater vehicle. For trajectory, the control design identifies the suitable controller to track the reference trajectory with tracking error converging to zero. Consequently, the trajectory tracking problem gets transformed into stability problem. In many applications, trajectory tracking problem are subjected to the additional needs for tracking the target within shorter time to consume less energy. Figure 1 explains the steps in proposed workflow with image pre-processing, tracking control and target tracking from input UAV images.

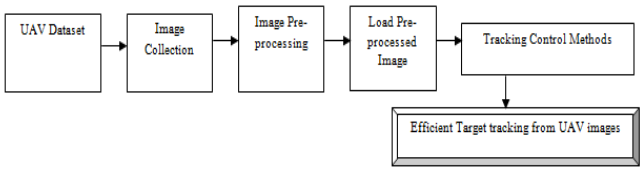


Figure 1 Proposed Methodology Workflow

Figure 1 explains the proposed method workflows in UAV images. Initially the number of UAV images is collected as an input from dataset. After that, the collected image gets preprocessed. Then, the pre-processed images are loaded for performing tracking control. Thus, an optimal control theory is used for addressing the trajectory tracking control problems. The tracking control is to design control law to allow output of dynamical system to track the reference signal. For linear feedback systems, tracking control is designed with rigorous guarantee of stability. The nonlinear tracking control is demanding one to track complex signal. The tracking control design need complete knowledge of system model and equations. The nonlinear control methods address the significant challenges to handle high-dimensional states. The controller gets adjusted in real-time to new dynamics under uncertain conditions to accommodate quick variations in system dynamics or control objectives. Nonlinear control techniques are better choice for automatic control design of UAV. Many researchers have been discussed on nonlinear controllers for UAV. The nonlinear control methods are used for UAV control

through feedback linearization, non-linear dynamic inverse technique, backstepping control and sliding mode control.

4.1 Adaptive Neural Networks Controller

A novel intelligent controller was developed for trajectory tracking of omni-directional robots depending on unstructured uncertainties. An adaptive neural network was employed with Lyapunov-based nonlinear control to handle the frictional forces. Online learning was used to allow robot to learn on its own how to compensate for uncertainties and disturbances by interacting with environment. The single input in neural network minimized computational complexity of disturbance compensation and allowed intelligent controller in embedded mobile robots. The convergence properties of control scheme were verified by Lyapunov-like stability analysis. The intelligent compensation scheme depending on adaptive neural networks minimized the tracking error for guaranteeing tracking with high superiority. The computational complexity of neural networks and fuzzy systems was related to the number of neurons in input layer for efficient rules.

4.2 Model Predictive Controller

Model Predictive Controller (MPC) was employed for path tracking control to deal with system limitations and future forecasts. MPC was directly affected by adopted model. A complex dynamic model improved accuracy in path tracking with computational terms. The data-driven tire modeling enhanced the autonomous ground vehicle path tracking control. The neural tires gathered nonlinearities in interaction between lateral and longitudinal vehicle dynamics with minimum computational cost for predictive controllers. An experimental tire data were approximated to design the data-driven tire model with radial basis function and multilayer perceptron neural networks.

The model predictive controllers were introduced to adjust the wheel torque and steering angle inputs depending on ground vehicles with neural tires. The designed methodology was used to perform efficient trajectory and velocity tracking of ground vehicles. MPC with neural tire model minimizes the computational effort.

4.3 Reinforcement Learning Controller

An adaptive dynamic programming algorithm was introduced based on reinforcement learning theory. The performance index function and control law approximated the optimal values through critic neural network (NN) and actor NN.

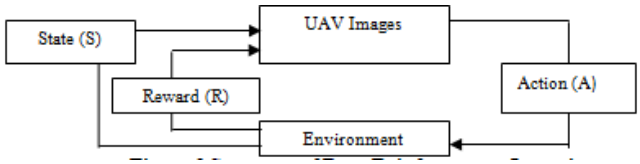


Figure 2 Structure of Deep Reinforcement Learning

Actor NN used the three-layer neural network with nonlinear structure in hidden layer. The number of input neuron depends on number of state vector in plant. The number of output neurons depending on number of reward vector components. The bipolar sigmoid function was employed as activation functions of hidden layer and output layer. Actor NN comprised the forward calculation and back error propagation. The model-free control was realized through implementing control method. The optimal deployment trajectory of tethered system was attained by parameter optimization depending on Nelder-Mead method. The optimal trajectory was carried out by reinforcement learning controller. The reinforcement learning algorithm has a good control effect on in-plane trajectory tracking of tethered system to increase the feasibility and robustness of control method.

4.4 Multi-Agent Deep Reinforcement Learning Controller

Multi-Agent Deep Reinforcement Learning (MADRL) was capable method used for learning cooperation with minimum computational complexity or global information

requirement. The decentralized MADRL method was introduced with maximum reciprocal reward to study the cooperative tracking policies for UAV swarms. Every UAV reward with regularization term was described as the dot product of reward vector with neighbor UAVs and dependency vector between UAV as well as neighbors. The dependence between UAVs was gathered through Pointwise Mutual Information (PMI) neural network without aggregation statistics. Reciprocal Reward Multi-Agent Actor-Critic (MAAC-R) algorithm was introduced to study the cooperative sharing policy for all homogeneous UAVs. MADRL method improved UAV cooperation more efficiently and stimulate cooperative tracking behaviors of UAV swarms.

4.5 Deep Deterministic Policy and Transfer Learning Controller

An online path planning approach was introduced for UAV based on deep reinforcement learning control to address the maneuvering target tracking and obstacle avoidance issues. The designed approach performed perception of environment and continuous motion output control through end-to-end learning in neural networks. A deep deterministic policy gradient (DDPG) based control framework was used to provide learning and autonomous decision-making capability. MN-DDPG was used for mixed noises to help UAV with stochastic strategies for optimal planning. The task-decomposition and pre-training for efficient transfer learning to improve the generalization capability of UAV control model based on MN-DDPG. The designed approach attained good self-adaptive adjustment of UAV flight attitude in maneuvering target tracking tasks with enhancement generalization capability and training efficiency of UAV tracking controller in uncertain environments.

4.6 Path planning for moving target tracking Control

An unmanned aerial vehicle (UAV) circles on any of the one side of tracked target. A circular path algorithm was introduced for monitoring the relative position between UAV and target considering real-time range and bearing angle. The designed algorithm computed center of new circular path when the predicted range between UAV and the target not meet monitoring needs. A transition path algorithm was introduced for planning the transition path between circular paths with turning radius limitations of UAV. The transition path algorithm created the waypoints to address the flight ability needs. A continuous curvature path was constructed to maintain the distance between UAV and target within the mission requirements.

4.7 Outlier Filters and Frame Buffer Control

An outlier filter was introduced to improve the applicability of depth estimation networks to target localization. A frame buffer method was designed to attain accurate scale recovery for handling complex scene textures in UAV images. The network was first used for drone images to obtain the road masks. The road masks represent the pixels corresponding to road in the scene. At the same time, the drone images were fed into the depth estimation network to attain the corresponding relative depth maps. From the unique UAV perspective, a network of depth estimation was used for UAV image target localization. In unique perspective and ground scene of UAV, the scale recovery was suitable for UAV.

4.8 Sliding Mode Controller

An antidisturbance sliding mode control was introduced based on reference model to realize accurate, robust and chatterless trajectory tracking under wind disturbance. The extended state observers, nonderived forms, and inadequate information usage was addressed by state compensation function observers to improve estimation accuracy for states and disturbances. The disturbance variation was computed through tracking differentiator and compensated in the controller to increase the antidisturbance sensitivity. The two-step

verification was carried out with input disturbances and actual flight under two wind field types. The multiple industrial fans were used to generate the average wind and wind shear.

1. EXPERIMENTAL SETUP AND PERFORMANCE METRICS

The experimental analysis of existing methods are carried out using four different parameters, namely trajectory tracking time, trajectory tracking error, trajectory tracking accuracy and trajectory tracking overhead. The trajectory tracking time refers to the time consumed in tracking the corresponding trajectory via controller. Trajectory tracking time 'TT_{time}' is measured by product of sample images 'SI_i' and the actual time consumed in tracking the corresponding trajectory '$Time\ (TT)$'. It is computed in terms of milliseconds (ms). Trajectory tracking error is the second metric for accurate tracking. The trajectory tracking error 'TT_{error}' is measured by ratio of the sample images that were not tracked accurately 'SI_{TIA}' to the total number of sample images 'SI_i'. It is measured in terms of percentage (%). The trajectory tracking accuracy is measured as the ratio between the accurate trajectory samples that are accurately tacked to the total number of sample images. It is measured in terms of percentage (%). The trajectory tracking overhead 'TT_{OH}' is measured using sample images 'SI_i' and the memory consumed '$Mem\ (TT)$' in performing the target tracking process. It is measured in terms of kilobytes (KB).

TT_{time}	$\sum_{i=1}^{m} SI_i * Time\ (TT)$
TT_{error}	$\sum_{i=1}^{m} \frac{SI_{TIA}}{SI_i}$
TT_{acc}	$\sum_{i=1}^{m} \frac{SI_{TA}}{SI_i}$
TT_{OH}	$\sum_{i=1}^{m} SI_i * Mem\ (TT)$

Table 3 Performance Metrics

6. RESULT AND DISCUSSION

The result depends on how accurate model is trained. The measuring performance is a key to the target tracking model. Performance evaluation metrics are used to compute the effectiveness and performance of the target tracking model on UAV dataset. The performance of existing methods is discussed with the aid of tabulation and graphical illustrations.

Techniques/ Parameters	Trajectory Tracking Accuracy (%)	Trajectory Tracking Time (ms)	Trajectory Tracking Overhead (KB)	Trajectory Tracking Error (%)
Adaptive Neural Networks Controller	89.21	8.23	5.28	10.79
Model Predictive Controller	82.45	9.12	6.51	17.55
Reinforcement Learning Controller	94.12	6.54	2.58	5.88
Multi-Agent Deep Reinforcement Learning Controller	96.28	5.15	2.03	3.72
Deep Deterministic Policy and Transfer Learning Controller	95.25	5.38	3.29	4.75
Path planning	89.92	7.36	9.25	10.08
Outlier Filters and Frame Buffer Control	90.58	6.87	8.54	9.42
Sliding Mode Controller	93.81	5.96	6.85	6.19

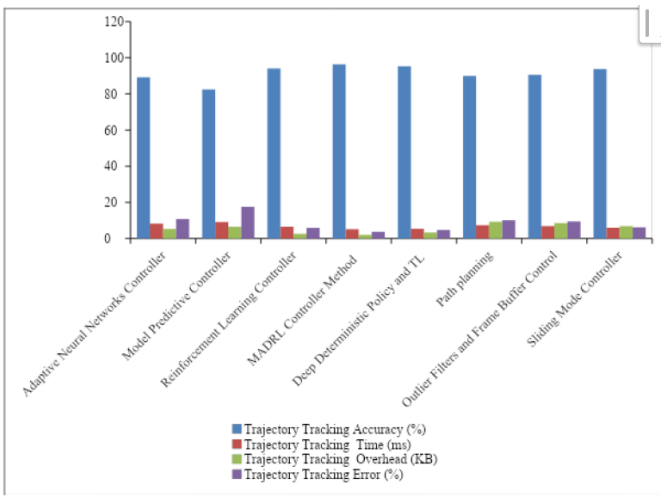
Table 4 Tabulation for Experimental Results of Drone Dataset

Techniques/ Parameters	Trajectory Tracking Accuracy	Trajectory Tracking Time	Trajectory Tracking Overhead	Trajectory Tracking Error
Adaptive Neural Networks Controller	88.99	10.89	6.11	11.01
Model Predictive Controller	80.25	11.56	8.77	19.75
Reinforcement Learning Controller	92.87	8.91	4.91	7.13
Multi-Agent Deep Reinforcement Learning Controller	93.35	9.53	3.68	6.65
Deep Deterministic Policy and Transfer Learning Controller	94.12	7.68	5.55	5.88
Path planning	87.88	9.91	11.34	12.12
Outlier Filters and Frame Buffer Control	88.23	8.26	10.50	11.77
Sliding Mode Controller	91.18	7.51	8.64	8.82

Table 5 Tabulation for Experimental Results of Unsupervised Depth Dataset

Table 4 and Table 5 explain the performance results for eight different methods with two datasets and four performance metrics. From the table, it is clear that Multi-Agent Deep Reinforcement Learning Controller method attained better results than any other existing methods for two datasets. For Drone Dataset, Deep Deterministic Policy and Transfer Learning Controller attained 96.28% trajectory tracking accuracy, 5.15ms trajectory tracking time, 2.03KB trajectory tracking overhead and 3.72% trajectory tracing error rate. For Unsupervised Depth Dataset, Deep Deterministic Policy and Transfer Learning Controller attained 9.12% accuracy, 7.68ms time consumption, 5.55KB overhead and 5.68% error rate. Figure 4 and figure 5 illustrate the performance analysis of drone dataset and unsupervised depth dataset.

Figure 4 Measurement of Accuracy, Time, Overhead and Error for Drone Dataset



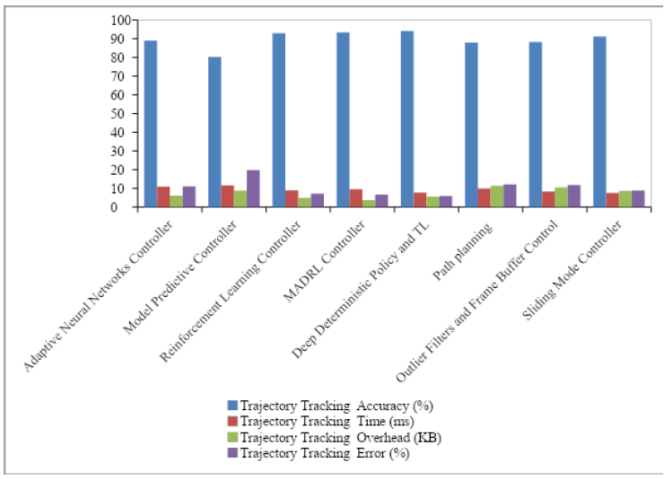


Figure 5 Measurement of Accuracy, Time, Overhead and Error for unsupervised Depth Dataset

Figure 4 and figure 5 explains the performance metric of eight different existing methods for two different datasets. From the graphical analysis, it clear that performance of Multi-Agent Deep Reinforcement Learning Controller method is higher than any other techniques for drone dataset. This is due to the application of PMI neural network and MAAC-R algorithm to study the cooperative sharing policy for homogeneous UAVs. MADRL method improved UAV cooperation more effectively and stimulated cooperative tracking behaviors of UAV swarms. For Unsupervised Depth Dataset, the performance of Deep Deterministic Policy and Transfer Learning Controller is higher than other methods. This is because of using DDPG based control framework to provide learning and autonomous decision-making capability. MN-DDPG was employed for mixed noises with stochastic strategies for optimal planning. The transfer learning improved the generalization capability of UAV control model. For drone dataset, MADRL method increased the accuracy by 6% and reduced time by 25%, overhead by 59% and error by 52% when compared to other existing methods For Unsupervised Depth Dataset, Deep Deterministic Policy and Transfer Learning Controller increased the accuracy by 6% and reduced time by 18%, overhead by 17% and

error by 40% when compared to other existing methods.

7. CONCLUSION AND FUTURE DIRECTION

In the survey, target tracking was carried out with UAV images using various machine learning and deep learning based controller techniques. Different performance metrics were used to analyze the results of controller models implemented for target tracking. When comparing the result with another recent study, controller with deep learning method attained results. In this work, after image pre-processing both MADRL method and Deep Deterministic Policy and Transfer Learning Controller attained approximately same accuracy for two datasets. Deep learning with controller model was able to achieve highest accuracy result than all the other techniques. These results strongly suggest that a DNN based controller model can be implemented in future for efficient target tracking with UAV images instead of the other conventional machine learning classifier discussed in existing studies.

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Overview of Latest Technology of Mobile Communication and Future Scope of 7.5G

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Abstract- Over the past year wireless technology makes tremendous growth. The evolution and revolution of wireless technology are reached 7.5G. Wireless technology FG (Future Generation) mobile communications will have higher data transmission rates than 6G and 7G. Wireless technology is continuously one of the hottest areas that are developing at a high speed, with advanced techniques emerging inall the fields of mobile and wireless communications. Current times are just the beginning for deploying 5G mobile communication systems. At present, we have many technologies each capable of performing functions like supporting voice traffic using voice over IP (VoIP), broadband data access in mobile environments, etc., but there is a great need of deploying such technologies that can integrate all these systems into a single unified system. 8G presents a solution to this problemas it is all about seamlessly integrating terminals, networks, and applications. In this paper, an attempt has been made to provide a study of different cellular technologies namely 4G, 5G, 6G, 7G, and FG respectively, and a detailed comparison among them. Wireless and mobile communication has a vital action in the information exchange system in the world. By that, every user needs to access the data at a huge data rate speed, bandwidth, and precise reliability network protocol. Therefore year by year develop the technology with its domain scenario. This paper to proposed the evaluation of cellular and mobile communication at the availability of different technology in International Standards. The help of the latest technology of 7.5G improves the efficiency of peak download and upload data speed.

Keywords— Future Generation, Communication, Voice over IP, Wireless Technology.

I. INTRODUCTION

The origins of cellular lie surprisingly deep in the past. As early as 1947, at essentially the same time that the first 150 MHz system was installed in St Louis, the Bell System (AT&T) proposed a “broadband urban mobile system,” and requested 40 MHz for its implementation somewhere in the region between 100 and 450 MHz. At that time, the idea that a large geographic area could be served using many small coverage areas had already been put forward at Bell Laboratories, primarily to allow low-power radios to be used. The FCC denied this request, citing the unavailability of frequencies in that range. In 1949, the FCC considered allocation of the band from 470 to 890 MHz but chose to reserve this band for the vast educational and entertainment opportunities thought to be offered by the newly proposed UHF TV band. Once again, in 1958, the Bell System requested an allocation for mobile telephones, this time in the range of 764-840 MHz, and once again the FCC declined to take action. By this time, however, the essential ingredients of the cellular system were under discussion—the use of small cells and the reuse of channels that would increase dramatically the number of simultaneous calls per channel. There are two different concepts such as wireless transmissions & mobility. One can be used mobile while using wired technologies - nomadism: moving between several offices. A few things can be fixed while using wireless technologies e.g.: a fixed host using IEEE 802.11b. The other can be physically mobile but fixed at the network layer e.g.: move within the coverage area of an 802.11 base station.

Today the whole world is aware of the revolutionary changes in the cell phone communication field. Wireless communication has brought innovation in this field. In the context of the present scenario, the 3G experienced a better internet experience. Later on, 3g has been improvised. It has been felt urgent to have a better communication network than 5g has come which can be a complete wireless communication without any hindrance or limitations. It is completely advanced in terms of wireless communication. In the 5G system, every cell phone will have a permanent home “IP address and care-of address”. Now awaiting the future will experience 6G. At present, cell phones have everything and are compact, with high memory and high speed with low power consumption. Today Bluetooth technology and other technology are just like child’s play. 6G wireless cell phone communication network shall meetworld-class standards covering the whole world under its communication just like the Global covering system has been devised by some companies. This individual system creates difficulty in space roaming. 7G mobile phone communication system is developed to integrate these into one unified communicationsystem.

Mobile communication has become a major source of information exchange throughout the world. Year by year, we see a lot of development in the world of mobile technology. All the mobile technologieswhich have been developed up to now have improved our way of living. It has always been our aim to empower the world community with top-class internet capabilities, thereby designing a future-proof groundwork for new ideas as well as opportunities to build on, to start the revolution of communication. Wireless Technology helps in transferring information over a distance without the use of

wires. The distance can be short or it can be of thousands of kilometers. A new subscriber signs up after every 2.5 seconds. With the increasing demands in the field of mobile and data communications, the sole aim is to connect users as fast as possible. Mobile communication deals with talking, texting, or sending data as well as image files through a wireless network, which is a technology in which the information is transmitted as well as received using microwaves. We have been continuously looking at the growing mobile technology which is driving mobile devices at a very fast speed. Gadgets supporting mobility have become very powerful and useful as well as very handy by being small in size. We see different uses of these devices everywhere, thereby making the lives of all of us very easy and interesting also. Throughout the world, mobile device availability is expanding rapidly with different features and technologies which are making our lives better than before. It is only through this mode of communication that we are in touch with people we need to reach, it can be either work-related or for some personal reasons. We are capable of sending important files anywhere in the world within a very short time thereby addressing business needs. Also, we can get on-spot approval for vital decisions, to enrich our lives. It is making communication possible for those who live in remote parts of the world. Loved ones living very far from each other have become close, no matter in which part of the world they live. Mobile communication has brought the world together, which is an amazing situation. We saw as early as the 1940s, the invention of mobile phones when some engineers working at AT&T came up with the development of cells for base stations of mobile phones. Mobile devices have come up with different faces, if we go into the history of mobile phones; we see that the first device was not an actual phone. They were two-way radios, allowing users such as taxi drivers to communicate. Rather than using base stations with separate cells with signals passing between cells, the very first mobile phone network was based on a powerful base station allowing communication in a much wider area.

The rest of paper is organized as follows. Some of the related works on existing technology are discussed in section 2. In section 3, comparision of various technologies is discussed. In section5, advantages and disadvantages and in section 6, applications are given .In section 7, conclusions and future work is explained.

II. OVERVIEW OF MOBILE COMMUNICATION

History was created in April 1972 with the first call made on a mobile phone. “G” refers to generation, related to next-generation wireless technologies. Mobile phones started out coming in the market with Motorola introducing the first mobile phone on 3 April 1973. The generation of these phones was known as 0G mobile phones in which different technologies were used like push to talk, mobile telephone system, improved mobile telephone system, etc. Martin Cooper, an employee of Motorola Company is considered as key player as he developed the first mobile phone. Before him, handsets were used in vehicles, but he came with the development of the first truly portable mobile phone. We have gone through a very big change in the generation of mobile communication. Each generation is making us faster, more secure as well as more reliable as compared to previous ones. It is hard to overcome this reliability factor. We see smartphones as our companions today and we are dependent on these devices in a large number of ways. Below we start with the generation 1G of the mobile world, moving towards all the latest development that has been done up to 7.5G connectivity. In this paper, the birth of different generations of mobile wireless technology with their advantages and significance are presented. In the past few years, mobile wireless communication has experienced different generations of technology mainly from 0G to 4G. A snapshot of future technologies such as 5G, 6G, and 7G has also been shown providing immense scope for innovative research and development. Wireless Technology helps in transferring information over a distance without the use of wires. The distance can be short or it can be of thousands of kilometers. A new subscriber signs up after every 2.5 seconds. With the increasing demands in the field of mobile and data communications, the sole aim is to connect users as fast as possible. In this paper, the birth of different generations of mobile wireless technology with their advantages and significance are presented. In the past few years, mobile wireless communication has experienced different generations of technology mainly from 0G to 4G. A snapshot of future technologies such as 5G, 6G, and 7G has also been shown providing immense scope for innovative research and development.

III. Various Generation of Mobile Communication

[1] **ZERO GENERATION (0G – 0.5G)** Wireless telephone started with what you might call 0G if you remember back that far. In those pre-cell days, you had a mobile operator to set up the calls and there were only a handful of channels available. 0G refers to pre-cell phone mobile telephony technology, such as radiotelephones that some had in cars before the advent of cell phones. Mobile radio telephone systems preceded were the predecessors of the first generation of cellular telephones; these systems are called 0G (zero generation) systems. These early mobile telephone systems can be distinguished from earlier closed radiotelephone systems in that they were available as a commercial service that was part of the public switched telephone network, with their telephone numbers, rather than part of a closed network such as a police radio or taxi dispatch system. These mobile telephones were usually mounted in cars or trucks, though briefcase models were also made.

[2]FIRST GENERATION (1G) The first generation of cellular systems used analog radio technology. Analog cellular systems consist of three basic elements: a mobile telephone (mobile radio), cell sites, and a mobile switching center (MSC). A mobile telephone communicates by radio signals to the cell site within a

radio coverage area. The cell site s base station (BS) converts these radio signals for transfer to the MSC via wired (landline) or wireless (microwave) communications links. The MSC routes the call to another mobile telephone in the system or the appropriate landline facility. These three elements are integrated to form a ubiquitous coverage radio system that can connect to the public switched telephone network (PSTN). It supports speeds up to 2.4kbps. Major contributors were AMPS (advanced mobile phone system) was first launched by the US, NMT, and TACS.

[1] SECOND GENERATION (2G) It is based on GSM or in other words global system for mobile communication. It was launched in Finland in the year 1991. It was the first digital cellular network, which had some obvious benefits over the analog networks they were supplanting: improved sound quality, better security, etc. [1]. 2G technologies have replaced analogy technology with digital communication by providing services such as text messages, picture messages, and MMS. All text messages are digitally encrypted in 2G technology. This digital encryption allows for the transfer of data in such a way that only the intended receiver can receive and read it. There are 3 different types (FDMA, TDMA/GSM, and CDMA) of 2G mobile technologies that are designed with different working methods, properties, and specifications.

[2] THIRD GENERATION (3G) The third generation of mobile systems provides high-speed data transmissions of 144kbps and higher. It comes with enhancements over previous wireless technologies, like high-speed transmission, advanced multimedia access, and global roaming. 3G is mostly used with mobile phones and handsets as a means to connect the phone to the Internet or other IP networks to make voice and video calls, download and upload data, and surf the net. 3G will support multimedia applications

such as full-motion video, video conferencing, and Internet access. The data are sent through the technology called Packet Switching Voice calls are interpreted through Circuit Switching. It is a highly sophisticated form of communication that has come up in the last decade.

[3] FOURTH GENERATION (4G) The Fourth Generation of mobile communication upgrades existing communication networks and is expected to provide a comprehensive and secure IP-based solution where facilities such as voice, data, and streamed multimedia will be provided to users on an "Anytime, Anywhere" basis and at much higher data rates compared to previous generations.

[4] FIFTH GENERATION (5G) In 5G, research is related to the development of the World Wide Wireless Web (WWWW), Dynamic Adhoc Wireless Networks (DAWN), and Real Wireless Communication. The most important technologies for 5G technologies are 802.11 Wireless Local Area Networks (WLAN) and 802.16 Wireless Metropolitan Area Networks (WMAN), Ad-hoc Wireless Personal Area Networks (WPAN), and Wireless Networks for Digital Communication. Some features of 5G Technology are given below:

- 5G is a completed wireless communication with almost no limitation; somehow people called it the REAL wireless world
- Additional features such as Multimedia Newspapers, also to watch TV programs with the clarityof an HD TV.
- We can send data much faster than that of the previous generations.
- 5G will bring almost perfect real-world wireless or called “WWWW: World Wide Wireless Web

Wearable devices with AI capabilities.

[5] SIXTH GENERATION (6G) Sixth Generation technologies use a combination of the latest in radio and fiber optics technology. We deliver through via line of sight which means we don’t have to rely on thecopper cable or base. The 6G mobile system for global coverage will integrate a 5G wireless mobile systemand satellite network. The telecommunication satellite is used for voice, data, internet, and video broadcasting; the earth imaging satellite network is for weather and environmental information collection; and the navigational satellite network is for the global positional system (GPS). It is assumed that 6G will proffer the speed of 1GB data transfer. 6G mobile communication networks can integrate satellite communication networks and 5G to make global coverage. The four different countries which developedthese satellite systems are; the GPS by the USA, the COMPASS system developed by China, the Galileo system developed by the EU, and the GLONASS system by Russia. Handoff and roaming will be the bigissues in 6G because these satellite systems are different networks. 6G has four different standards namely Pico cell, Microcell, Macro cell, and satellite cell. So the handoff and roaming must take place between these four networks but how it will occur is still to be to be answered.

[6] SEVENTH GENERATION (7G) These mobile networks are like the 6G for global coverage but they will also define the satellite functions for mobile communication. In the satellite system, the telecommunication satellite will be for voice and multimedia communication; the navigational satellite will be for the global positional system (GPS), and the earth image satellite for some extra information like weather updates. The 6G mobile wireless networks will support local voice coverage and other services. The 7G will be the most advanced generation in mobile communication but there will be some research on demanding issues like the use of the mobile phone during moving conditions from one country to another country because the satellite is also

moving at a constant speed and in specific orbit, the standards and protocols for cellular to the satellite system and for a satellite to satellite communication system. The dream of 7G can only be true when all standards and protocols are defined. The major factor here will be the cost of phone calls and other services. It provides seamless movement of mobile phones from one country to the other. This will be a major benefit for frequent international travelers

[7] FUTURE GENERATION [7.5G] It provides a very high speed of peak download and peak upload of data rate. Here space-time block codes are used to view the high definition of video broadcasting. Within a second we can download the five films that are 20 GB files and upload the 15 GB files or any datum. Therefore it also navigates the satellite network techniques, hence using the OFDM methodology and FEC for the speed of the communication process. It is a possible technique only when achieving a higher bandwidth and improving the satellite cell sensitivity with its signal fidelity. The benefits of 7.5 G can easily communicate with others even if they are in the center of the sea.

III. COMPARISON OF VARIOUS TECHNOLOGIES

TABLE I: COMPARISON BETWEEN 1G, 2G/2.5G, AND 3GTECHNOLOGIES

Features	**1G**	**2G/2.5G**	**3G**
Deployment	1970-1984	1980-1999	1990-2002
Bandwidth	2 Kbps	14-64 Kbps	2 Mbps
Technology	Analog Cellular	DigitalCellular	Broadband/CDMA/ IP Technology
Service	Mobile Telephony	Digital Voice, ShortMessaging	Integrated High Audio,Video
Multiplexing	FDMA	TDMA/ CDMA	CDMA
Switching	Circuit	Circuit/ Circuit for Access N/WAnd Air Interface	Packet exceptforair interface
Core Network	PSTN	PSTN	Packet Network
Handoff	Horizontal	Horizontal	Horizontal

TABLE II:COMPARISON BETWEEN 4G AND 5G TECHNOLOGIES

Features	**4G**	**5G**	**Features**
Deployment	2000-2010	2014-2015	**Deployment**
Bandwidth	20 Mbps	>1Gbps	**Bandwidth**
Technology	ified	4G+WWW	**Technology**
Service	Dynamic Information Access, VariableDevices	Dynamic Information Access, Variable Deviceswith AI capabilities	**Service**
Multiplexing	CDMA	CDMA	**Multiplexing**
Switching	All Packet	All Packet	**Switching**
Core Network	Internet	Internet	**Core Network**

TABLE III: COMPARISON BETWEEN 6G AND 7G TECHNOLOGIES

Generation	**6G**	**7G**	**3G**
Period	Soon probably 2030	Soon probably 2030	1990-2002
Frequency	95GHz-3THz	95GHz-3THz	2 Mbps
Multiplexing	CDMA	CDMA	Broadband/CDMA/ IP Technology
Switching type	All packet	All packet	Integrated High Audio, Video
Core Network	Internet	Internet	CDMA
Data rate	11Gbps	11+Gbps	Packet exceptforair interface
Handoff	Horizontal and vertical	Horizontal and vertical	Packet Network
Pros	Global coverage system	No issue of data capacity coverage andhand-off left behind, low cost of a call	Horizontal
Cons	Difficulty with space roaming. High cost of a mobile call and similar with5G advantages	Similar to 5G and 6g advantages	**Cons**

IV.ADVANTAGES AND DISADVANTAGES

A. Advantages of 7.5G

- 7.5G could have faster data transfer rates, improved network reliability, higher capacity, lower latency, and better energy efficiency than previous generations of mobile networks.
- 7.5G could revolutionize various industries and improve the overall quality of life for individuals.

7.5G could enable advanced applications and technologies, such as self-driving cars, augmented reality, virtual reality, and the Internet of Things (IOT), to operate more efficiently and effectively (11)

B. Disadvantages of 7.5G:

- High cost: Developing and implementing new technologies can be expensive, and this cost may be passed on to consumers.
- Limited coverage: New technologies may not be available in all areas, especially in rural or remote locations.
- Increased energy consumption: More advanced technologies may require more energy, leadingto higher carbon emissions and increased environmental impact.
- Security concerns: As communication networks become more advanced, they may also becomemore vulnerable to cyber-attacks and other securitythreats.

V. APPLICATIONS

- Augmented and virtual reality: With faster and more reliable connections, it will be easier to stream high-quality AR and VR content, which could revolutionize industries such as gaming,education, and healthcare.
- Internet of Things (IOT): The IOT refers to the network of interconnected devices, sensors, and other objects that can communicate with each other. With faster and more reliable connections,it will be easier to manage and control these devices remotely.
- Autonomous vehicles: Self-driving cars rely on fast and reliable communication to navigate and avoid obstacles. With advancements in mobile communication technology, we can expect to see more widespread adoption of autonomous vehicles.
- Telemedicine: With faster and more reliable connections, it will be easier for doctors and patients to communicate remotely, which could revolutionize the healthcare industry.

VI. CONCLUSION & FUTURESCOPE

In this article, we have discussed the existing (1G-4G) and future (5G-7.5G) wireless mobile communication generations. The first generation (1G) has fulfilled the basic mobile voice, while the second generation (2G) has introduced capacity and coverage. This is followed by the third generation (3G), which has the quest for data at higher speeds to open the gates for a truly “mobile broadband “experience. Moreover, the demanding requirements in terms of QoS were realized by the fourth generation (4G). The 5G mobile networks will focus on the development of the user terminal where we can watch an HD TV channel on our mobile phones without any disturbance. 5G technology offers high resolution for passionate mobile phone consumers. Satellite networks will be used from 6G mobile communication systems and onwards. A new revolution of 5G technology is about to begin because 5G technology going to give tough completion to normal computers and laptops whose marketplace value will be affected.technologies at the identical time and the terminal should be able to merge different flows from different technologies. 5G technology offers high resolution for passionate mobile phone consumers. The 5G mobile phone will be a tablet PC. Many mobile embedded technologies will develop. In addition to that the future generation of 6G, 7G, and 7.5G. The main aim of this generation is to create the fastest and most reliable mobile network which will access all the users with high speed of peak upload and download methodologies.

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Intelligent Solar Powered Meteorological conditions Adjustable Smartwear for Combatants

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Abstract*—Combatants operate in a variety of extreme environments, from hot deserts to frigid mountains. This can put a strain on their bodies, making it difficult to maintain a comfortable temperature. An intelligent solar-powered Meteorological conditions- adjustable smartwearcan help to address this problem. This uniform would use solar energy to power a system that can heat or cool the combatant's body depending on the environmental conditions. The smartwearwould use a variety of sensors to monitor the combatant's body temperature and the ambient temperature. This data would be used to control a series of thermoelectric devices that are embedded in the uniform. The thermoelectric devices can be used to heat or cool the combatant's body depending on the desired temperature. The increasing challenges posed by Meteorological conditions variability on military operations necessitate innovative solutions to enhance the adaptability of combatants in diverse environmental conditions.*

This introduces an intelligent solar-powered Meteorological conditions-adjustable smartweardesigned for military personnel, employing Arduino technology. The proposed system integrates advanced sensors and actuators into the uniform fabric, enabling real-time monitoring of environmental parameters such as temperature, humidity, and solar radiation. The Arduino microcontroller processes this data and automatically adjusts the uniform's Meteorological conditions control features to optimize the combatant's comfort and performance. Key components include a solar power harvesting system that provides sustainable energy to the uniform's electronic components, reducing reliance on traditional power sources. The smartwearincorporates a responsive Meteorological conditions control algorithm that dynamically regulates ventilation, heating, and cooling elements powered on the combatant's physiological and environmental needs. This intelligent uniform aims to enhance operational efficiency, mitigate heat related stress, and improve the overall well-being of military personnel by offering a personalized and adaptive Meteorological conditions control solution. The integration of Arduino technology not only ensures reliability and precision in environmental sensing and control but alsofacilitates future upgrades and customization for evolving mission requirements. In summary, the proposed intelligent solar-powered Meteorological conditions-adjustable smartwearrepresents a cutting- edge approach to address the challenges of Meteorological conditions variability in military contexts, offering a versatile and sustainable solution for enhancing the performance and resilience of combatants in environments.

Keywords— Solar Panel, Rechargeable Battery, Temperature sensor, Heart Rate sensor, Peltier Plate.

INTRODUCTION

In an era characterized by rapid technological advancements and an increasing focus on sustainability, innovation has become a driving force in addressing the unique challenges faced by various sectors, including defense. One such groundbreaking development is the Intelligent Solar-Powered Meteorological conditions Adjustable Smartwearfor combatants, a cutting-edge solution that seamlessly integrates advanced technologies, particularly Arduino-powered systems, to enhance the comfort, performance, and adaptability of military personnel in diverse environmental conditions. The conventional challenges associated with military uniforms, such as discomfort, inadequate Meteorological conditions adaptability, and energy consumption, have prompted a paradigm shift towards more intelligent and eco- friendly solutions. The proposed intelligent smartwearleveragessolar power as a renewable energy source, tapping into the inexhaustible potential of the sun to power a range of features designed to optimize the combatant's experience in the field. The incorporation of Arduino, an open-source electronics platform, adds a layer of programmability and customization, allowing for real-time adjustments powered on environmental parameters and individual preferences. At the heart of this innovation is theintegration of intelligent sensors that monitor and analyze ambient conditions, including temperature, humidity, and solar radiation. These sensors provide crucial data inputs to the Arduino microcontroller, which acts as the brain of the system, orchestrating a dynamic response to ensure optimal thermal comfort for the combatant. The e-uniform's Meteorological conditions-adjustable functionality goes beyond the traditional one-size-fits-all approach, offering a personalized and responsive solution that adapts to the specific needs of each wearer. The solar panels integrated into the fabric of the uniform serve a dual purpose – harnessing solar energy to power the system and acting as a smart layer that regulates temperature. This innovative use of solar technology not only reduces the reliance on conventional power sources but also contributes to a more sustainable and energy-efficient solution for military applications. The Arduino platform enables efficient energy management, ensuring that power is distributed intelligently among the various components of the e-uniform, thereby maximizing operational longevity in the field. Furthermore, the Intelligent Solar-Powered Meteorological conditions Adjustable Smartwearincorporates state-of-the-art communication modules that facilitate seamless connectivity with central command systems.

I. OBJECTIVE

The objective of the project "Intelligent Solar-Powered Meteorological conditions Adjustable Smartwearfor Combatants using Arduino" is to design and develop a cutting-edge, sustainable solution that addresses the challenges faced by military personnel in varying environmental conditions. The primary goal is to enhance the comfort, performance, and well-being of combatants by integrating intelligent technologies into their uniforms. The project aims to create a Meteorological conditions-adjustable electronic uniform that utilizes solar power through embedded photovoltaic cells. These cells will harness solar energy to power an Arduino-powered control system, enabling real-time monitoring and adjustment of the uniform's Meteorological conditions control features. The key objectives of the project include the development of a sensor array to gather data on environmental factors such as temperature, humidity, and solar radiation. The collected data will be processed by the Arduino microcontroller, which will implement intelligent algorithms to assess the combatant's thermal comfort level. The system will then automatically adjust the uniform's features, such as built-infans, heating elements, and ventilation, to maintain an optimal microMeteorological conditions within the uniform. Furthermore, the project will focus on designing a user-friendly interface for combatants to manually override the automatic adjustments if needed. This interface will be integrated into the uniform, allowing combatants to customize their comfort settings powered on personal preferences and specific mission requirements. Additionally, the project will explore energy-efficient mechanisms to ensure the sustainable operation of the electronic components, maximizing the utilization of solar power and minimizing the reliance on external energy sources.

II. METHODOLOGY

The following figure shows the block diagram for theIntelligent Solar-Powered Meteorological conditions Adjustable Smartwearfor Combatants using Arduino comprises several interconnected components that work cohesively to create a sophisticated and adaptive system. The diagram reflects the key functionalities and interactions within the electronic framework. At the core of the system is the Arduino microcontroller, which serves as the central processing unit. The Arduino is responsible forreceiving inputs from various sensors strategically placed on the uniform. These sensors include temperature and humidity sensors to measure environmental conditions, a solar radiation sensor to assess available sunlight, and potentially physiological sensors to monitor the wearer's vital signs. The information gathered by these sensors forms the basis for the intelligent decision-making process. The Arduino communicates with a control algorithm designed to assess the thermal comfort level of the combatant. This algorithm takes into account the environmental data collected by the sensors and determines whether adjustments are required to the uniform's Meteorological conditions control features. These features include built-in fans, heating elements, and ventilation systems.The solar power subsystem is a critical component, consisting of photovoltaic cells integrated into the fabric of the uniform. These cells capture solar energy and convert it into electrical power to sustain the operation of the electronic components, reducing dependence on externalpower sources.

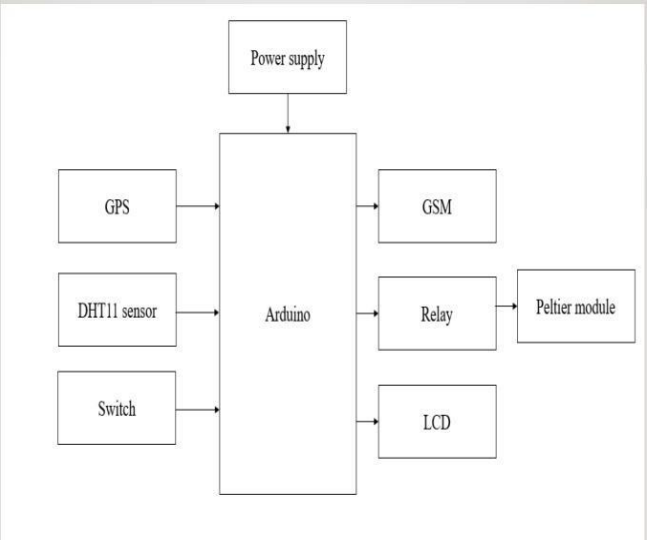

Figure 1: Block Diagram of Proposed System

The energy management module ensures efficient utilizationof the harvested solar power and may include a battery storage system to store excess energy for periods of limited sunlight. The user interface module allows combatants to interact with the system, providing manual control options. This interface could be in the form of a control panel integrated into the uniform, allowing users to override the automated adjustments powered on their personal preferences or specific mission requirements. The actuation and control elements represent the mechanisms responsible for physically adjusting the uniform powered on the decisions made by the control algorithm. These may include actuators for fans, heating elements, and other Meteorological conditions control features, as well as valves or vents for regulating airflow. In summary, the block diagram illustrates a comprehensive and integrated system that combines environmental sensing, intelligent decision-making, solar power harvesting, and user interaction to create an innovative Intelligent Solar-Powered Meteorological conditions Adjustable Smartwearfor Combatants. This design aims to enhance combatant comfort, adaptability, and operational effectiveness in diverse environmental conditions.

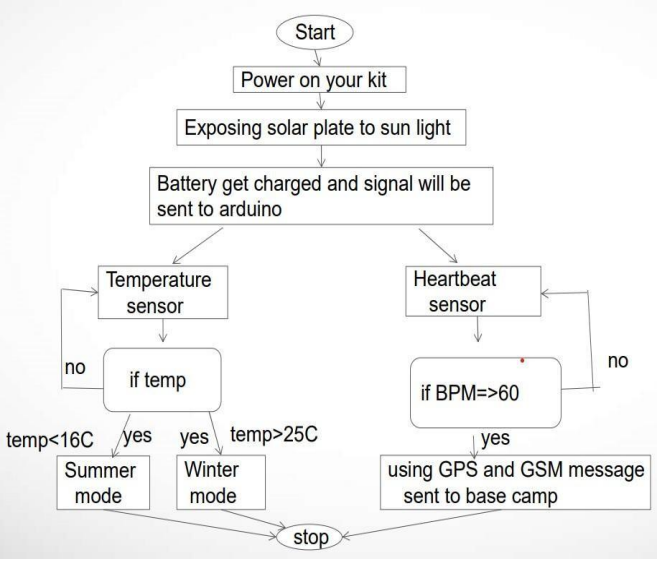

Figure 2: Proposed Methodology Flow Chart

III. RESULTS

The "Intelligent Solar-Powered Meteorological conditions Adjustable Smartwearfor Combatants using Arduino" project aims to revolutionize military apparel by integrating advanced technologies to enhance the comfort and performance of combatants in diverse environmental conditions. The expected outcome is a cutting- edge electronic uniform that utilizes Arduino microcontrollers, solar panels, and sophisticated Meteorological conditions sensors. The uniform will dynamically adjust its features, such as ventilation, heating, and cooling, powered on real-time climatic data. The integration of solar panels will enable the uniform to harness solar energy, reducing dependence on external power sources and ensuring prolonged operational capabilities. The Arduino platform will serve as the brain of the system, orchestrating the seamless interaction between sensors, actuators, and power sources. This intelligent smartwearnot only optimizes the combatants' thermal comfort but also enhances their overall operational efficiency by adapting to the ever-changing environmental conditions on the battlefield. Ultimately, the project aims to provide a scalable and modular solution that can be easily integrated into existing military gear, showcasing the potential for technological innovation to improve the well- being and performance of military personnel

Figure 3: Final result

IV. ADVANTAGES AND DISADVANTAGES

Advantages:

Meteorological conditions Adaptability: These uniforms can adjust to various Meteorological conditions conditions, providing combatants with optimal comfort regardless of whether they are operating in hot, cold, or humid environments. The ability to regulate temperature can prevent heat exhaustion, hypothermia, and other weather-related health issues.

Energy Efficiency: By harnessing solar power, these uniforms reduce the reliance on conventional power sources, thus lowering the logistical burden of supplying batteries or fuel for combatants in the field. This energy efficiency also aligns with sustainability goals, reducing the environmental impact of military operations.

Customizable Comfort: Intelligent e-uniforms can be personalized to individual preferences and physiological needs. Combatants can adjust settings such as temperature, humidity, and ventilation to suit their comfort levels, enhancing overall morale and performance during missions. Enhanced Performance: Maintaining optimal body temperature is crucial for peak physical and cognitive performance. By regulating temperature and moisturelevels, these uniforms can help combatants stay focused, alert, and effective in challenging operational environments.

Health Monitoring: Some intelligent e-uniforms may incorporate biometric sensors to monitor vital signs such as heart rate, body temperature, and hydration levels. This data can be transmitted to commanders or medical personnel in real-time, enabling early intervention in case of health emergencies.

Disadvantages:

Complexity and Reliability: Integrating advanced technology into uniforms increases their complexity, which can lead to higher chances of malfunctions or technical issues. Combatants rely heavily on their equipment, and any failure could compromise their safety or effectiveness.

Maintenance Requirements: Intelligent e-uniforms require regular maintenance and upkeep to ensure proper functioning. This adds to the logistical burden of military units, requiring specialized personnel and resources for repair and maintenance.

Cost: Developing and manufacturing intelligent e-uniforms with solar-powered Meteorological conditions adjustment technology can be expensive. The initial investment in research, development, and production may pose budgetary challenges for military organizations, especially those with limited resources.

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SECOND INTERNATIONAL CONFERENCE ON SMART TECHNOLOGIES, COMMUNICATION & ROBOTICS 27 & 28 JUNE 2024

Publisher

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