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Editorial

Computer vision is a field of computer science that focuses on enabling computers to identify and understand/recognise objects and human in images and videos. Computer vision consists of combination of cameras, edge or cloud-based computing, software, and artificial intelligence (AI) to enable systems to see and identify the objects. Artificial intelligence (AI) enables computers and systems to derive meaningful information from the digital images, videos, and other visual inputs and take actions or make recommendations based on the information. Computer vision and image processing fields are closely related that utilize techniques from artificial intelligence (AI) and pattern recognition to derive the meaningful information from images, videos, and other visual inputs. Computer vision works similar as human vision, except humans have a head start. Human sight has the advantage of lifetimes of context that train how to tell objects apart, how far away they are, whether they are moving and/or there is something wrong in an image. Computer vision needs more information/data. It analyses of data over and over until it distinguishes and ultimately recognizes the images.

Image processing is at the helm of the technical revolution which is called as Industry 4.0, laying the framework for new technologies in image data processing and object recognition. Image processing algorithms are used to extract information from images, restore and compress image and video data, and build new experiences in virtual and augmented reality. The computer vision is purely based on teaching computers to process an image at a pixel level and understand it. Computer vision uses deep learning that form neural networks to guide systems in the image processing and analysis. Computer vision models can perform object recognition, detect and recognize people, and even track movement after fully trained. There are two techniques in machine learning called deep learning and a convolutional neural network (CNN). Machine learning consists of algorithmic models that enable a computer to teach itself about the context of visual data. When enough data is fed through the model then the computer will “look” at the data and teach itself to tell one image from another. Algorithms are used to enable the machine to learn self, otherwise to programming it for recognising the image.

Walchand College of Engineering, Sangli (Maharashtra State), India has organized a 02 Days “**National Conference on Communication, Image Processing and Computing (NCIPC-2023)**” during 15-16 December 2023 and created an opportunity to the authors to share their knowledge.

Editorial board of the IJTE has shortlisted 43 papers of NCIPC-2023 to publish as December 2023 special issue. We believe that, Vol. 46, December 2023 special issue of the IJTE is interesting to the readers to update their knowledge.

New Delhi

Editor

31st December 2023

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Game Chat Sentiment Analysis using Bert

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ABSTRACT

This paper predicts sentiments for game chats done by players of the game, using BERT deep learning model of Natural Language Processing. Two games namely DOTA 2 and League of Legends have been taken for prediction. The sentiments for training label are absent in the original dataset and have been generated using vader Sentiment tool. 150000 random samples have been taken and after filtering out non-English chats and pre-processing, 36659 samples remained for training and testing. This work can prove to be helpful in countering cyberbullying and making gaming community a conducive environment, thus helping in the growth of gaming sector.

KEYWORDS: *Game, Chat, Cyberbullying, Sentiment, BERT.*

INTRODUCTION

With the rise in gaming sector [1] and the availability of smart phones and better hardware, the involvement in gaming has been ever growing. We find children and adults playing online competitive games for leisure and earning. Games offer various features for interaction, messaging being one of them. Gamers can interact with one another using chat messaging. As they are in the competition which evokes emotions out of them, they can get aggressive and involve in provocative conversations, which may involve profanity of various colours. It also leads to cyberbullying. To address this abuse, we first need to identify it and take steps to remove it. Also, by doing so, we can add to the growth in gaming sector by making a conducive environment for stakeholders.

This paper is an attempt at analyzing sentiments to address cyberbullying displayed by the chat messages using deep learning models in natural language processing. The dataset of two games DOTA 2 and League of Legends has been taken from Kaggle, non-English text has been filtered out and BERT (Bidirectional Encoder Representations from Transformers) has been applied on the dataset after pre-processing. The results obtained have been discussed in later sections.

RELATED WORKS

Borst et. al [2] used SVM, Naïve Bayes, K-Nearest Neighbours and neural network to classify chat sentiments for games DOTA 2 and League of Legends. They obtained high accuracy using word frequency-based embeddings. Yang et. al [3] proposed ToxBuster, a BERT based model applied on games Rainbow Six Siege and For Honor and achieved around 83% precision and 84% recall. Murion et. al [4] performed SQL classification with automatic data collection on chats of game World of Tanks. Balakrishnan et. al [5] applied Naïve Bayes, Random Forest and J48 on psychological attributes for users of Twitter.

DATASET AND FEATURES

This work uses datasets of two games namely DOTA 2 and League of Legends. The dataset has been obtained from Kaggle [6, 7]. DOTA 2 dataset contains 21.7 M records with fields as mentioned: match index, game time when the message was sent, player slot and text of the message [6]. League of Legends dataset contains 1.7 M records with fields including text of the message and identification and role of the players involved. The message field from both the datasets has been taken and merged under a data structure. Out of that, a random

sample of 150000 has been taken for prediction. The target label is sentiment associated to message, which is absent and to be predicted. The training sentiments are generated using vaderSentiment tool [8]. The dataset obtained contained one input column i.e., message and one output column i.e., sentiment, which is empty. After filtering out non-English text from the input column i.e., chat, 81335 samples were left. Then, it has been pre-processed to remove digits, punctuation, email address and URL from the instances. After removing null values and duplicates, 36659 samples were left for final modelling. The, the dataset has been divided into 2:1 ratio for training and validation. Hence, 24339 training and 12220 validation samples have been used.

METHODOLOGY

After pre-processing the dataset, sentiments for training data have been generated using vaderSentiment tool [8]. This tool generates three types of compound scores: negative, neutral and positive. These scores have been numerically represented with three classes: 0, 1 and 2.

Table 1. Classification of Sentiments

Chat Sentiment	Obtained Compound Score	Numeric Class Assigned
Positive	≥ 0.05	2
Neutral	> -0.05 and < 0.05	1
Negative	-0.05	0

Then, the dataset has been split into training and testing dataset with ratio 2:1, and fed to BERT training model.

The sequence of steps involves gathering data, generating sentiments with the vaderSentiment tool, and conducting training using BERT and making predictions.

Devlin et. al [9] introduced BERT model, which is based on transformers architecture to learn deep bidirectional information and hence can be effectively used for language inference. This paper uses following settings for training and validation.

Training data instances: 24,339, Validation data instances: 12,220, Categories: 0 (Negative), 1 (Neutral), and 2 (Positive), Text maximum length: 128, Batch size: 32, Training cycles: 1 (using a one-cycle approach), Number of epochs: 4 and learning rate: $3e-5$.

RESULTS

The recorded values for loss and accuracy in every epoch have been described in table below.

Table 2. Performance Metrics Over Epochs: Accuracy and Loss

Epoch	Training Accuracy	Loss
One	82.09%	0.4463
Two	96.08%	0.1267
Three	98.33%	0.0546
Four	99.34%	0.0213

The training process achieved a 99.34% accuracy after four epochs. Subsequently, when validating on a dataset consisting of 12,220 samples, the outcomes obtained have been discussed below.

Table 3. Assessment Criteria

	Precision	Recall	F1 Score	Support
0	0.96	0.96	0.96	2238
1	0.99	0.99	0.99	7390
2	0.97	0.96	0.96	2592
Accuracy			0.98	12220
Macro Average	0.97	0.97	0.97	12220
Weighted Average	0.98	0.98	0.98	12220

Error metrics are as follows.

Table 4. Error Metrics

S. No.	Error Metric	Error
1	Mean squared error	0.04
2	Mean absolute error	0.03

The validation accuracy obtained is 98%. The high accuracy may be due to same pattern of comments. Dominant class is Neutral, as the input is game language consisting of slangs etc., which vaderSentiment is not able to guess properly. This also may be the reason for high accuracy.

CONCLUSION

This work performs deep learning to predict sentiments of messages sent in community games. Due to less

resources, sample of 36659 records was taken. Future work may be to do prediction for other languages, using more data samples and building user profile based on chats.

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Optimizing Interacting Systems with a Grey Wolf Optimization-Based Two-Mode Controller Design

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ABSTRACT

Designing a two-mode controller for processes within various industries poses a substantial challenge. This research explores the application of optimization techniques, specifically Gray Wolf Optimization and Adaptive Particle Swarm Optimization, for the design of a Proportional-Integral (PI) controller. The study focuses on a lab-scale interacting liquid tank system for both identification of the mathematical model and simulation purposes. The efficacy of the algorithms is assessed through a comparative analysis of simulation results, conducted using Simulink/MATLAB software, demonstrating the effectiveness of the proposed controller design.

KEYWORDS: *Meta-heuristic optimization, PI controller, Grey wolf optimization, Level system, Interacting system.*

INTRODUCTION

In the past two decades, the utilization of meta-heuristic optimization techniques has gained significant prominence in the design of controllers. Widely recognized, established techniques like Genetic Algorithm, Ant Colony Optimization, and Particle Swarm Optimization have gained substantial prominence. These algorithms, known for their simplicity, enable computer scientists to emulate diverse natural concepts, devise novel algorithms, or enhance existing meta-heuristics [1]. Distinguished by their initiation with random solutions, meta-heuristics eliminate the need for calculating derivatives within search spaces to identify the optimum solution. This characteristic renders them highly suitable for addressing real-world problems characterized by either expensive or unknown derivative information. Notably, meta-heuristics exhibit enhanced capabilities in steering clear of local optima when compared to conventional optimization techniques. Their stochastic nature facilitates the evasion of stagnation in local solutions, allowing for an extensive exploration of the entire search space. As a result, these algorithms present robust solutions for optimizing intricate problems encountered in process industries [2].

Regulating the liquid level across multiple tanks and managing the liquid flow between them poses a fundamental challenge. Within numerous chemical industries, the level control process is a standard practice. Ensuring that the process liquid maintains a specified level despite external disturbances is imperative. The complexity of level processes is evident, whether comprising a single tank or multiple interconnected tanks, making them intricate and challenging to control. Conventional PID controllers are commonly employed in these industries to address these control complexities

GREY WOLF ALGORITHM

Evolutionary algorithms inspired by nature, such as Genetic Algorithm (GA), swarm intelligent algorithms like Particle Swarm Optimization (PSO), Cuckoo Search algorithm (CS), BAT algorithm, and physics-inspired methods like Simulated Annealing (SA) and Center Force Optimization (CFO), have demonstrated efficacy in solving intricate global optimization problems [3]. Grey Wolf Optimization (GWO) stands out as a recently developed meta-heuristic optimization method inspired by the social structure of grey wolves [4]. The effectiveness of this algorithm in tackling non-convex engineering optimization challenges has been demonstrated, outperforming DE, PSO, GSA,

and EP optimization methods and yielding superior results. In the GWO algorithm, the entire search space is orchestrated by three key wolves: alpha (α), beta (β), and delta (δ). Alpha wolves, identified as the dominant individuals, may be of either male or female gender. Beta represents the second-highest ranking wolves, while gamma denotes the lowest-ranking grey wolves. Wolves outside these groups are termed delta wolves, and their positions are updated based on the first three grey wolves' positions. The hunting process of grey wolves includes tracking their prey, encircling it, and then launching an attack. In the design of the GWO algorithm, the best fitness values are attributed to alpha (α) and delta (δ). These three wolves guide the others during the hunting process, with beta (β) representing the second and third best fitness values. Upon locating the prey, grey wolves encircle and harass it until it ceases movement [5].

- 5) Revise the objective function for each grey wolf within the updated population.
- 6) Examine whether any of the revised grey wolves exhibit superior fitness compared to alpha, beta, or delta
- 7) If so, update the position of alpha, beta, or delta accordingly.
- 8) Iteratively perform steps 4 to 6 until the specified stopping criteria are satisfied, such as reaching a maximum number of iterations or achieving the desired level of convergence.



Fig 1. Hunting Behavior of Grey Wolves – Chasing and Hunting

The analytical model describing the encircling behavior of grey wolves is as follows:

- 1) Commence by establishing the population of grey wolves, forming a set of candidate solutions.
- 2) Evaluate the objective function for every individual grey wolf within the population.
- 3) Designate the top-performing, second-best, and third-best grey wolves as alpha, beta, and delta, respectively
- 4) Adjust the position of each grey wolf.

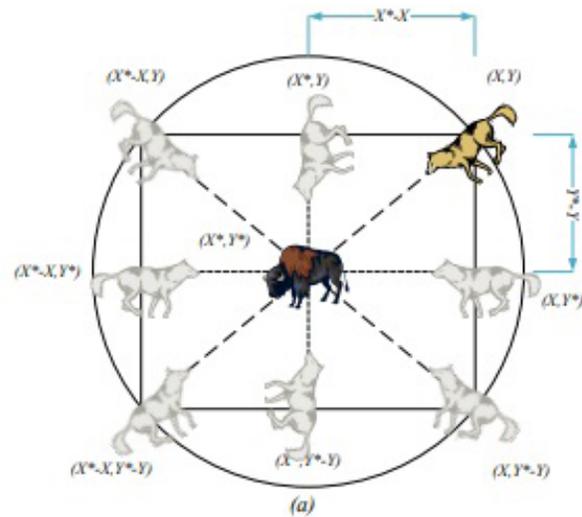


Fig 2. Position Vectors and Next Solution-2D View

ADAPTIVE PARTICLE SWARM OPTIMIZATION

The procedure for Adaptive Particle Swarm Optimization (APSO) is outlined below:

Population Initialization: Initiate the population as the first step.

Subpopulation Division: Divide the population into N subpopulations, and partition the problem space into distinct subspaces. Each subspace, with dimensions D, is further segmented into θ equal-sized slices, resulting in a total of θD subspaces.

Adaptive Coefficient Adjustment: Adaptively adjust the special set of movement coefficients C1 and C2 for each subpopulation during the optimization process.

Population Update Iterations: After iterating the function MG times, update all individuals in the population using the individual update function.

Subspace SSR Update: Update the Sum of Squared Residuals (SSR) of the subspace where the global best and the local bests of subpopulations are located.

Coefficient Update: Update the movement coefficients of the subpopulation using the coefficient update function.

These steps collectively define the Adaptive Particle Swarm Optimization, providing a systematic approach for dynamic adjustment and optimization within the specified subspaces.

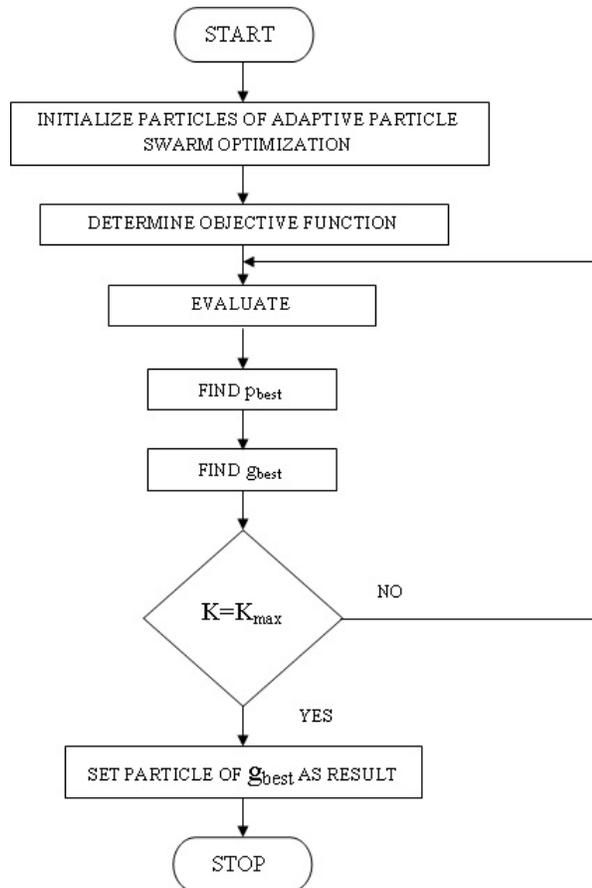


Fig 3. Steps in Adaptive PSO Algorithm

MODEL DESCRIPTION

In the analysis of the two-tank system, we designate the inlet flow rate as q_i , while the outlet flow rates for tank 1 and tank 2 are denoted as q_1 and q_2 , respectively. The

corresponding parameters for tank 1 include the level and area, denoted as h_1 , and a_1 , while for tank 2, the level and area are represented by h_2 and a_2 , respectively [7]. Utilizing the specified parameters outlined in Table 1, the transfer function of the interacting liquid level system is derived and expressed in Eqn. (10).

- F_{in} : Inlet Flow Volume (m³/Sec)
- F_1 : Outlet Flow Volume of tank 1 (m³/Sec)
- F_2 : Outlet Flow Volume of tank 2 (m³/Sec)
- A_1 : Area(m²) of tank 1
- A_2 : Area (m²) of tank 2
- R_1 : Resistance to flow at the outlet, Valve of tank 1
- R_2 : Resistance to flow at the outlet, Valve of tank 2
- h_1 : Level in tank 1.
- h_2 : Level in tank 2.

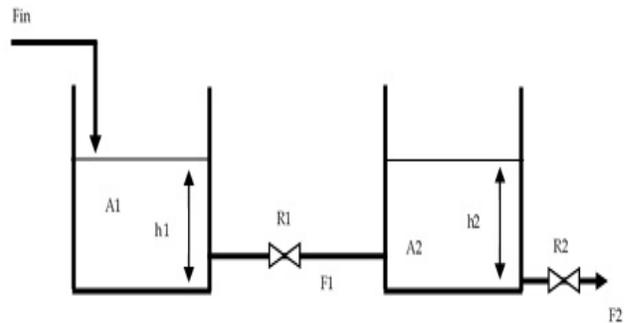


Fig 4. Interacting Two Tank Level Process

Tank 1

Consider the tank 1, The equation expressing mass balance is formulated as follows: Input flow rate minus Output flow rate equals the Rate of Accumulation.

$$F_{in} - F_1 = A_1 \frac{dh_1}{dt} \tag{1}$$

$$F_1 = \frac{(h_1 - h_2)}{R_1} \tag{2}$$

Substituting F_1

$$F_{in} - \frac{(h_1 - h_2)}{R_1} = A_1 \frac{dh_1}{dt} \tag{3}$$

Taking Laplace and solving

$$\frac{F_{in}(s)R_1 + H_2(s)}{(A_1 R_1 s + 1)} = H_1(s) \tag{4}$$

Table 1 Technical Specifications

Specifications	Values
Capacity of the Process Tank	2 Litres
Total Height of the Process Tank	300mm
Level Transmitter	Dual RF Capacitance
Level Transmitter Input Range	0-300mm
Level Transmitter Output Range	4-20mA

Tank 2

Consider the tank 2, The equation expressing mass balance is formulated as follows: Input flow rate minus Output flow rate equals the Rate of Accumulation

$$F_1 - F_2 = A_2 \frac{dh_2}{dt} \tag{5}$$

$$F_1 = \frac{(h_1 - h_2)}{R_1}; F_2 = \frac{h_2}{R_2} \tag{6}$$

Substituting F_1 and F_2

$$\frac{H_2(s)}{Q_{in}(s)} = \frac{0.01e^{-0.6220s}}{7.07s+1} \tag{7}$$

The mathematical model for the real time lab scale interacting system is obtained as

$$\frac{H_2(s)}{Q_{in}(s)} = \frac{0.01e^{-0.6220s}}{7.07s+1}$$

SIMULATION RESULTS

The simulation of the two-tank interacting system has been conducted, and the real-time experimental setup of the Interacting System is depicted in Fig. 5. Additionally, Fig. 6 illustrates the servo and regulatory responses. Notably, the simulation results highlight the effective set point tracking achieved by the PI controller based on the Grey Wolf Algorithm. The specific tuning parameters for various PI controllers are detailed in Table 2.



Fig 5. Experimental Setup of Interacting Two Tank Level Process

Table 2. Tuning Parameters and Values

Control Algorithm	Parameter	Values
Grey Wolf Algorithm	K_p	60.18
	K_i	21.6 1
Adaptive Particle Swarm Optimization	K_p	42.69
	K_i	12.56

Fig 6. Servo and Regulatory Response of the Process

CONCLUSION

In summary, this paper introduces the design of a PI controller optimized through the Grey Wolf Algorithm, offering a comparative analysis with the Adaptive Particle Swarm Optimization method for an interacting level process. The simulation results reveal commendable setpoint tracking and overall performance by the designed PI controller. As depicted in Fig. 5, the controller designed for the interacting two-tank system demonstrates robust servo and regulatory capabilities, meeting the standards specified in the relevant literature.

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Pelvic Ureteric Junction Obstruction (PUJO)- A Statistical Analysis of Renal Scintigraphy Parameters of ^{99m}Tc -DTPA Cases

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ABSTRACT

Renal Pelvic Ureteric Junction (PUJ) obstruction states to a narrowing of the pelvic junction of the kidney, which results in obstruction in the urine flow channel from the kidney to the ureter. This condition is diagnosed with the help of renal nuclear imaging i.e., renal scintigraphy using ^{99m}Tc -DTPA ideal radio pharmaceutical. Renal obstruction level is determined by considering diagnosed renal parameters TMAX, T1/2 and GFR rate of obstructed kidney. For this study total 62 patient's data with mean age of 27.73 ± 21.48 and reported with PUJ obstruction were considered. Finding the correlation status in between these parameters not only helps to understand effects of obstruction on renal functioning parameters but also to define corrective treatment and it is done by applying statistical correlation techniques and drawing out related analysis. In this study, we found that, correlations among LK-PUJ, RK-PUJ and T1/2-LK, T1/2-RK are linear as well as positively significant and that among GFR-LK and GFR-RK found to be strongly positive and they found to be affected due to LK-PUJ obstruction and RK-PUJ obstruction respectively.

KEYWORDS: PUJ Obstruction, Scintigraphy, DTPA, Correlation.

INTRODUCTION

If the junction between the urine collecting part of the kidney i.e., renal pelvis and the ureter tube becomes constricted, urine will not flow easily and may return, expanding the pelvis of the collecting structure and causing renal pelvic enlargement. This enlargement of collecting system is nothing but the 'hydronephrosis'. PUJ obstruction is usually hereditary, but may also be acquired i.e., secondary to other disease processes [1].

PUJ obstruction can cause pain repeated urine infection as well as damage to the affected kidneys and this results in decreased flow of urine down the ureter. PUJ i.e., Pelvi-Ureteric junction obstruction is one of the most common causes of paediatric hydronephrosis.

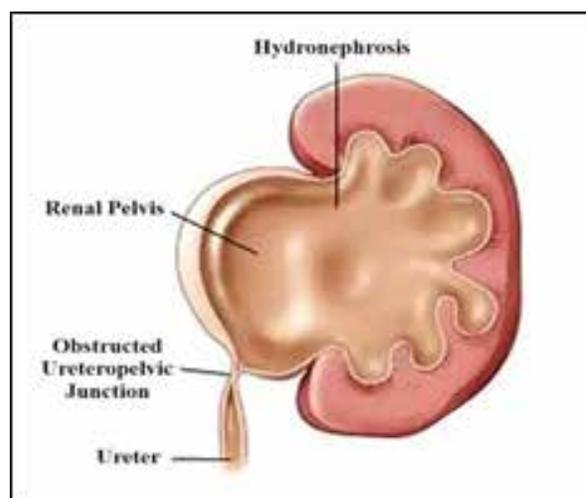


Fig 1. Renal RK-PUJ Obstruction (Hydronephrosis)

The PUJO is normally concerned with the anatomy and pathology are seen more frequently in males than in females, in calculated ratio with up to double the number of cases in gender males as associated to females [2]. To diagnose the extent of renal obstruction severity renal scintigraphy test is a precise solution which will represent uptake and excretion counts of a radiotracer from the kidneys.

Diuretic Renal scan is a nuclear imaging technique which is utilized to describe the split function of both kidneys and identify any kidney diseased symptom regarding renal obstruction and is the gold standards and criterion for the assessment of the level of renal PUJ obstruction.

Radio pharmaceutical technetium ^{99m}Tc -Diethyl triamine Penta Acid (^{99m}Tc -DTPA), especially used identify and quantify symptoms of obstruction and to evaluate relative renal function. The renal system is supposed to be considerably impaired if the split renal up take function in one of the kidneys is less than 40% of the overall kidney function and this should be in significant correlation to the half-life ($T_{1/2}$) of the radiotracer agent [2]. In this study, three renal parameters namely TMAX, $T_{1/2}$ and GFR (Glomerular filtration rate) are considered from renal scans to found correlation between LK PUJ and RK PUJ cases.

METHODS AND MATERIALS

In This study 62 patients' renal scans including left kidney (31) and right kidney (31) poor and prolonged excretion from secondary to PUJ obstruction cases from 01.07.2021 to 30.12.2022 were considered.

These cases are categorized with age groups from 10 year to 65 years having a mean age of 27.73 ± 21.48 . LK-PUJ and RK PUJ cases include M/F: 20/11 and 12/19 respectively. Fig. 2 shows the principle of the process through which renal scintigraphy procedure is performed. In this process radiotracer DTPA is injected and PUJ obstruction is diagnosed through a darker region inside the kidneys indicating intensity of renal and pelvis obstruction. This darker region indicated the amount the radiotracer DTPA present inside the kidney at the end of the scan which can't be excreted through the kidneys due to obstruction.

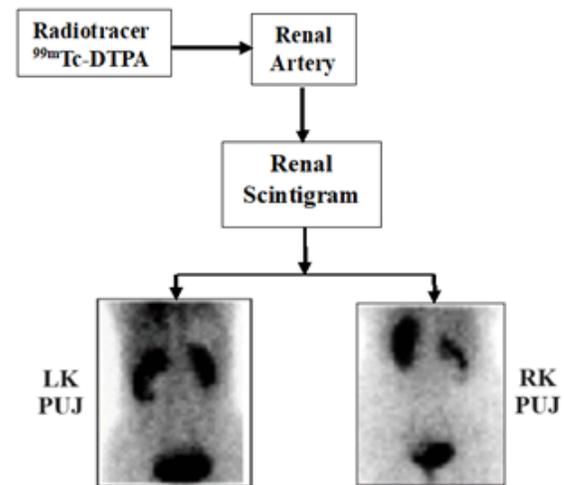


Fig.2. Renal PUJ Diagnosed Scintigraphy

Sample selection criterion

Inclusion criterion for sample selection is mentioned below:

- For this analysis patients with age less than 10 and higher than 65 years were not considered.
- Renal scans with gradual accumulation of tracer into dilated PCS which does not show significant excretion after diuretic administration were measured.
- Patient's cases with renal transplants, donors, Single kidney and horseshoe shaped kidney are avoided for this study.
- Bilateral PUJ obstruction cases also omitted from this study.

Procedure of Renal Scintigraphy scanning test

1. The preferred radiotracer ^{99m}Tc -DTPA, a glomerular agent having biological life not more than 2.5 hours with dose amount 4.7 MBq per Kg of body weight (minimum 37 MBq) is injected intravenously.
2. The subject of the investigation is placed in a supine posture and faces the gamma camera during both static and dynamic renal imaging. A set of fifteen to thirty-second pictures with a 128×128 matrix size, 1.45 zoom factor, 3.31×3.31 mm pixels, 140 kilo electron volts (KeV) of peak energy, and an approximate window width of fifteen percent. For

30–60 minutes, a frame rate of about 60 frames per second is captured. [3, 8].

3. A detailed examination of the parenchymal phase in the dynamic renal study reveals kidney function, size, and location.
4. Drawing ROI around the dilated shaped pelvic calyceal system for time activity curve analysis and measurement of the half-time (T1/2) [3].
5. Images with 99mTc tracer should be captured with a gamma camera detector equipped with a low-energy multifunctional or low-energy high-resolution collimation. [7].
6. According to the SNMMI standard/EANM procedure practice guideline for whole-kidney ROI is placed around the entire kidney, containing the renal pelvis, and is required to quantify relative radiotracer uptake in each kidney [9].

Statistical Analysis

For this continuous variable for corrective exploration are described as mean and standard deviation (SD); while definite variables are represented as absolute correct figures. Method of Spearman’s correlation is used to define relationship among renal parameters TMAX, T1/2 and GFR of the left kidneys and right kidneys. The values less than 0.05 were hypothetically significant.

RESULTS

In this study, total of 62 patients (M/Fe: 32/30) with PUJ occurrence from moderate to severe cases were considered, out of 62 patients cases, 31 cases (50%) found LK-PUJ (mean age: 24.30±22.84) and 31 cases (50%) with RK-PUJ (mean age: 27.33 ± 19.79) obstruction. This differentiation indicates performance of individual abnormal or obstructed kidneys in case of another kidney functioning that is working normally. Obstructed kidney cases are considered under renal hydronephrosis cases. This case classifications help in understanding effects of obstruction gender wise and age wise respectively which helps to found statistical-correlation among renal hydronephrosis cases (PUJ obstruction).

Table1. Mean and S.D. of LK and RK PUJ obstruction renal parameters

No. of PUJ	Gender		TMAX		T 1/2		GFR	
	M	Fe	LK	RK	LK	RK	LK	RK
LK	21	10	13.13±7.4	4.51±4.3	22.8±29.3	12±13.4	31.8±21.5	46.6±28.1
RK	14	17	2.87±1.48	82±36.4	7.71±2.35	27.4±27.9	48.7±21.6	24.3±10.8

Table1 shows mean and standard deviation of each PUJ obstruction renal parameter for left kidney and right kidney. In case of LK obstruction mean values LK are more as compared to mean of RK obstruction while we can observe vice versa counts in case of RK obstruction as compared to LK obstruction.

DISCUSSION

Three major renal parameters read from renogram scans are TMAX (Peak Time), T1/2 (Half Time) and GFR (Glomerular Filtration Rate). TMAX is a time to the maximum count in kidney ROI i.e., region of interest.

T1/2 (half time) period of radioisotope decaying states the period that it proceeds for the activity inside the kidney to decline up to 50% of its peak assessment. GFR is the volume of plasma filtered by the glomerulus per unit time. These three parameters are considered in this study to find correlation in case of LK- RK-PUJ obstruction.

In case of LK-PUJ obstruction as shown in Table. 2 the correlation between renal indices GFR_LK and GFR_RK was strongly positive (p=0.841) among TMAX_LK and TMAX_RK was moderately negative and correlation among T1/2_LK and T1/2_RK was strongly negative (p=-0.730) due to LK- PUJ obstruction [4]

Table 2. Correlations of Renal Tracer Parameters for LK-PUJ Obstruction (SPSS.20)

Correlation of Renal Tracer Parameter of LK-PUJ Obstruction						
	TMAX_LK	TMAX_RK	TMAX_LK	T1/2_RK	GFR_LK	GFR_RK
TMAX_LK	1	-0.53	-0.054	0.11	0.04	0.047
TMAX_RK	-0.53	1	-0.314	-0.172	-0.092	-0.093
TMAX_LK	-0.054	-0.314	1	-0.73	0.193	-0.242
T1/2_RK	0.11	-0.172	-0.73	1	-0.221	-0.178
GFR_LK	0.04	-0.092	0.193	-0.221	1	0.841*
GFR_RK	0.047	-0.093	-0.242	-0.178	0.841*	1

In case of RK_PUJ obstruction [Table.3], it is observed that correlation among renal parameters GFR_LK and GFR_RK found strongly positive (p=0.843) among TMAX_LK and TMAX_RK was moderately negative

(p =-0.527) and correlation among $T_{1/2}$ -LK and $T_{1/2}$ -RK was strongly positive (p=0.797) due to RK-PUJ obstruction.

These correlations defines direct and indirect effects of renal obstruction levels from moderate to severe stages on GFR excretion rate of kidneys.

Table 3. Correlations of Renal Tracer Parameters for RK-PUJ Obstruction (SPSS.20)

Correlation of Renal Tracer Parameter of RK- PUJ Obstruction						
	T _{MAX} LK	T _{MAX} RK	T _{MAX} RK	T _{1/2} RK	GFR LK	GFR RK
T _{MAX} LK	1	-0.527	0.044	0.406	-0.009	0.029
T _{MAX} RK	-0.527	1	-0.257	0.055	-0.288	-0.175
T _{MAX} LK	0.044	-0.257	1	0.797*	0.164	0.013
T _{1/2} RK	0.406	0.055	0.797*	1	-0.297	-0.321
GFR LK	-0.009	-0.288	0.164	-0.297	1	0.843
GFR RK	-0.029	-0.175	0.013	-0.321	0.843	1

$T_{1/2}$ of left and right kidney always indicates the significance of T_{MAX} of left kidney and right kidney in terms of severity of renal pelvis obstruction.

These correlative values were bound to mean differences and thus it is an indication of substantial correlation amongst GFR values of LK-PUJ cases and RK-PUJ cases [9,10] Thus, with reference to these correlations among renal scan parameters of renogram scans in case of PUJ obstruction of left kidney and right kidneys, we observed that, due to renal obstruction from moderate to severe there is a progressive fall in GFR rate.

CONCLUSION

This research study found a significant positive correlation among GFR rate of the left kidney in the case of LK-PUJ and GFR rate of right kidney in case of RK-PUJ. Also, parameters like half time of LK- PUJ and RK-PUJ cases were found highly significant in relation with LK-GFR and RK-PUJ cases respectively.

Therefore, this study helps to recognize the correlative statistical associations among renogram parameters for understanding the level of PUJ obstacle from moderate to severe levels and also it proves positive and strongly substantial possessions related to obstruction on half time and glomerular filtration rates.

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Automated Massaging Chair Rehabilitation System

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ABSTRACT

Due to hectic schedules, prolonged sitting in wrong positions, office workers as well as many other workers faces the most common problems of muscle pain, shoulder pain, back pain, spine pain, neck pain etc. Massage is one of the effective techniques used to relieve pain, reduce stress, and increase relaxation. The massaging chair is widely used instrument in health care. This system not only can protect the user's personal safety but also gives relaxation. Massage methods have varied to an easier way by massaging chair, which is able to control the massage mode according to specifications.

The Semi-Automated Massage Chair project introduces a novel approach to the traditional massage chair by incorporating semi-automation features. The main purpose of making this massaging system is to provide Health based equipment. We have made advancement in this system by using medical sensors. Safety and user comfort are the main consideration in the designing of the chair. The chair is equipped with a user-friendly interface and emergency stop feature; it provides massage movement. The design of the chair support natural body posture, promoting required posture during the massage sessions. By using this technique, we achieved the patient's good health and give relief from the various muscle pain.

KEYWORDS: *Back pain, Massage, Arduino, IR sensor.*

INTRODUCTION

People use various types of massage therapy for many health-related purposes such as reducing pain, reducing stress, general wellness, and many more. There are many different types of massage chair brands available in the market that produce various types of massage that provide different specifications based on the user's needs. The technology of massage chairs nowadays uses a control system [1]. Massage therapy (MT) is an ancient and traditional form that is becoming popular and is the best alternative compared to complementary treatment for pain relief [2]. The overall benefits of massage chair have not been defined yet, but it is helpful in effectively treating stress in adults. The long-term use of automated massage chairs has been found to have a significant effect on the body including a decrease in stress hormones, an improvement in health status, and effective management of chronic stress [3]. Based on the proof, massage therapy is recommended as a pain management option. Massage therapy is recommended for health-related quality of

life and improving mood reducing pain as compared to other manual techniques. Safety measures, research challenges, and implementations should be done for Massage therapy for its effectiveness and impact on medical treatment [4]. There are many more massaging techniques, but we get references from Triggered Point Therapy. The purpose of this therapy is to "Alleviate pain and tension in specific trigger points, which are tight areas within muscle tissue". The aim of this project is to focus on a long-term solution to the problems caused due to consistent back pain, muscle pain, neck pain, foot pain, etc. Massaging chairs are manufactured to mechanically implement hand massaging techniques such as kneading, tapping, and acupressure and massage the body muscles and back using mechanical devices, including massage balls, rollers, etc. [5]. The mechanical linkage part is composed of a connecting rod, bearing, push rod, and other mechanical parts achieving a variety of mechanical functions [6]. It has been shown that a 20–30minute massage performed immediately or up to 24 hours after training effectively reduces

later muscle pain [7]. For the foot massage, we used a rotating bronze bowl. This is an ancient technique that people use for pain relief. This is a user-friendly system and easy to handle. It presents better results in reducing muscle pain, anxiety, and fibromyalgia; it also promotes and improves sleep quality [8]. Mechanical massage refers to the manipulation of soft tissues by a machine, including a massage chair and other mechanical devices [9]. According to a study by Kim, et al., a mechanical massage chair massage has demonstrated effectiveness in controlling pain, improving patient satisfaction, and changing their quality of life [10].

MATERIALS AND METHODS

The aim of this project is to focus on a long-term solution to the problems caused by consistent back pain, muscle pain, neck pain, foot pain, etc. For the foot massage, we used a rotating bronze bowl. This is an ancient technique which people use for pain relief. This is a user-friendly friendly system and easy to handle. This system also provides a long-term benefit to keep muscles healthy. Mostly, it is useful for the working age group of 18 to 65 years.

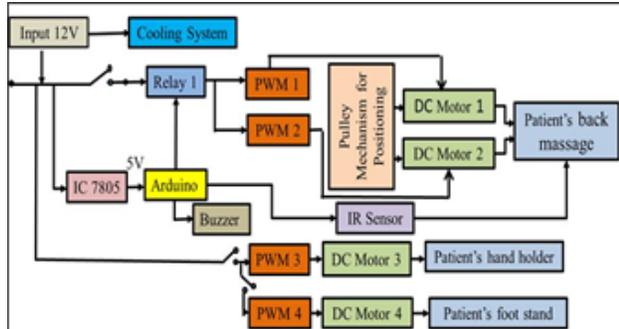


Figure 1. Proposed block diagram

The working principle of the system is as shown in figure 1 and it works as follows:

- **Power Supply:** The system is powered by a 12V DC input provided by an adapter.
- **Distribution:** The 12V input is distributed to several components: Relay 1, IC 7805, and the cooling system. The Arduino Uno is also connected to various parts of the system.
- **Relay 1:** This relay is used to control the power supply to different components. It can be triggered

by both a connecting switch and the Arduino. The output from Relay 1 is then distributed to PWM 1 and PWM 2.

- **PWM Control:** PWM 1 and PWM 2 are used to control the speed of Motor 1 and Motor 2, which are responsible for the massage mechanism that targets the patient's back.
- **IC 7805:** This component regulates the 12V input down to a stable 5V output. This 5V supply is provided to the Arduino and is essential for its operation.
- **Arduino Uno:** The Arduino Uno is the central control unit. It is connected to the IR sensor and controls the relay. The IR sensor is used to determine the positioning of the user on the chair.
- **IR Sensor:** The IR sensor detects the user's body posture and positioning on the chair. If the position is correct, the relay switches from Normally Open (NO) to Normally Closed (NC), completing the circuit and activating the massager. If the position is incorrect, a buzzer is turned on to alert the user.
- **PWM 3 and PWM 4:** PWM 3 and PWM 4 control the speed of Motor 3 and Motor 4, which are responsible for two additional massage mechanisms. Motor 3 provides manual massage to the patient's hand where manual operation is needed, and Motor 4 operates in a steady state, providing massage to the patient's foot.
- **Cooling System:** To prevent the motors from overheating during extended use, a cooling system with three fans is incorporated. These fans are directly connected to the same power supply.

The system aims to provide an effective and safe massage experience. It uses the Arduino Uno to control various components, including motors and the cooling system, to deliver massages to different parts of the body. The IR sensor ensures that the massage is targeted correctly, and the buzzer provides feedback if the user's positioning is incorrect.

Table 1. Specifications of Mechanical Quantities

Chair (1)	Material: Wood
Wooden Plywood (2)	2mm and 15mm thickness

Balls (4)	Material: Rubber
Bowl (1)	3 inch in diameter
Pipe (1)	Diameter/Length:2"/0.5m
Screws (30)	50mm
L Clamp (2)	5" * 3" Load: 15kg max
Bearing (4)	8*22*7 mm

Table 2. Specifications of Electronic Components

Buzzer (1)	4-8V DC, Current-<30mA
Switch (3)	Type- DC Unidirectional, Rated Voltage: 3.4V DC
Motor (4)	555-DC Motor, Operating Voltage: 5-15V DC Speed: 4000RPM
Relay (2)	Solid state Relay, Operating Voltage:12V
IR Sensor (1)	Model name: IRSENSOR2222, 3-5DC V
IC 7805(1)	I/p Voltage: 7-35V, Current: 1A

Table 1 indicates specifications of mechanical parts and table 2 indicates specifications of electronic components used in this project.

DISCUSSION

The tools and components used in this project for the Semi-Automated Massage Chair experiments are well- suited for creating a safe and effective massaging system.



(a)



(b)

(c)

Figure 2. (a) Control Panel (b) chair set up (c) Set up with object

Figure 2 shows the inside chair control panel and object set up for massage procedure. A brief overview of each of this tools and components as shown in figure 2 with their roles are:

- Motors (555 DC Motor): The 555 DC motors play a crucial role in creating the massaging mechanism.

PWM (1)	I/p Voltage: 6-20V DC, Current: 3A
Arduino Uno	I/p:5-12V DC, Flash memory: 32Kb, Frequency:16Mhz
Adaptors (4)	I/p Voltage: 100-240V AC, Output Voltage: 12V 2A
Cooling Fan (3)	I/p Voltage: 12V, Wattage: 3W
Connectors (4)	Supports DC Power Jack: 2.1*5.5mm

With a rotation speed of 3000 revolutions per minute (rpm), these motors are responsible for generating the massage motion. They are a fundamental component of the massage chair's functionality.

- IR Sensor: The infrared sensor is utilized for detecting and positioning the user's body posture. This allows the massage chair to target Specific areas and provide a more tailored massage experience.
- Pulse Width Modulation (PWM): PWM is used for controlling the speed of the DC motors. This control mechanism enables the massage chair to vary the intensity and type of massage, catering to the user's specific preferences and requirements.
- Wooden Plywood: Wooden plywood is used for placing and securing the motors and for creating the massaging mechanism. It provides a solid and durable structure to support the massage components.

As shown in figure (2) The power supply is initially supplied through the battery to the cooling system, relay 1 and IC 7805, and through the switch to the PWM 3 and PWM 4 when the person is positioned on the massaging chair. The fans in the cooling system are used to cool the motors. The motor speed is controlled by PWM 1 and PWM 2, which receive the output from Relay 1. Additionally, the rear mechanism is actuated by the motor. The Arduino now receives the 5V input through the IC. The IR sensor and buzzer are linked to the Arduino. It is utilized for the patient's back

placement. Now that the switch has been closed, the supply is given. power is given to PWM 3 and PWM 4, which control the motor mechanisms. Motor 3 operates for the hands and is operated manually wherever we require a massage of the muscles. For the foot massage, Motor 4 is employed.

RESULT

By incorporating medical sensors, the massage chair can provide a more tailored and effective massage experience. It can adapt its massage modes and intensity based on the user's specific needs and physiological responses. The incorporation of medical sensors represents a significant advancement in the massage chair's functionality. By leveraging these sensors, the chair can offer a more personalized and efficient massage experience. This is achieved through the chair's ability to adapt its massage modes and intensity levels in response to the user's distinct requirements and real-time physiological responses.

CONCLUSION

In conclusion, this Semi-Automated Massage Chair project is a significant step forward in the realm of massaging chairs. It addresses the pressing need for effective muscle relaxation therapy, making it relevant for a broad spectrum of individuals. By including medical sensors and semi-automation, this project aims to provide a comprehensive and health-focused massaging solution that enhances the user's well-being and comfort. This project not only prioritizes user safety but also offers a soothing and relaxing experience. This innovative massage chair introduces a fresh perspective to the conventional models by incorporating semi-automation features. This is achieved through the integration of medical sensors and advanced equipment.

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Automated Shirodhara Mechanism using ATMega8A

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ABSTRACT

Nowadays, technologies or machines are invented for homeopathic, allopathic and ayurvedic therapy treatments and diagnosis. But for homeopathic and ayurvedic treatments, limited technologies are introduced. Especially, for ayurvedic procedures very less technical standards are defined. Homeopathy is based on the principle that “like cures like”. While, ayurveda is a medical science of Ancient India which deals with matters relating to health, day-to-day life and longevity. Ayurveda is a traditional system of medicine and medication. In ayurveda different medical procedure like Pizhichil, Sirovasti, Nasya, Lepam, Shirodhara, etc are given. Shirodhara is an ayurvedic treatment where “shiro” means “head” and “dhara” means “dripping”. In this procedure, continuously warm oil is dripped on the center of forehead for specified time. The type of oil is varied from treatment to treatment. Maximum required time is of 90 minutes, but 45 minutes are sufficient. This project is designed and controlled by microcontroller where the oil that has been dripped on forehead is recollected, filtered and reused again. It will help to minimize the human error in the procedure.

KEYWORDS: *Ayurveda, Shirodhara, Treatment, Level Control.*

INTRODUCTION

The medicines of Allopathy are made of chemicals, medicines of Ayurveda are natural and that of Homeopathy are mixture of both i.e. chemicals and nature. Since the medicines of Allopathy consist of chemicals, they can be harmful for humans. Whereas the medicines of Ayurveda are totally natural so they cannot be harmful. Even different procedures in Allopathy uses different kind of machines and the person is made to come in contact with different radiations so again they can be harmful. Ayurvedic treatments do not need any kind of machines in the process of any kind of treatment, so overall Ayurvedic treatments are totally safe for use. The solution for this problem is ayurvedic treatment. Shirodhara is one of the Ayurvedic panchkarma treatment.

Table 1. Types of treatment and oil used

Treatment	Oil	Duration of treatment
Scalp Psoriasis	Buttermilk with must churn	Min 30 min Max 60 min

Mental relaxation	Stress	Amla blended with coconut oil	As per required
Dandruff hair fall	with	Blended sesame oil	Min 30 min Max 60 min

In this technique, warm heated liquid is introduced in a container. This liquid is poured over the forehead gently in an oscillation manner for about 30-45 minutes allowing the oil to run through the scalp and into the hair. A massage is given to the patient head. It is a Pineal Gland massage [5]. The liquid used for the process depends on type of treatment. But oil, milk, butter milk, coconut water or plain water can be used. The treatment is mainly used to reduce the problems of insomnia, anxiety, mental stress, depression, etc.

II. METHODS AND MATERIALS

In the process of shirodhara, a patient is laid down on the table as shown in figure 1 below. The table is known as the panchkarma table. A vessel is placed just above the forehead of the patient and at a height of 4-5 inches. A warm liquid is poured inside the vessel and a hole is present at the bottom of the vessel. From the hole the liquid is allowed to pour on the forehead of the patient.

The process is carried for 30-45 minutes minimum.

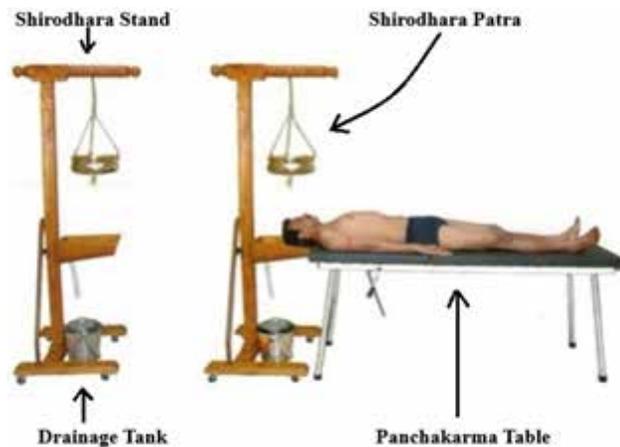


Figure 1. Traditional Shirodhara Technique

Liquids used in this process depend on different types of diseases like anxiety or insomnia. Mostly oil, butter milk, milk, plain water and coconut oil is used. In this project, the level is going to be maintained for controlling the flow of the liquid on the forehead. For this the basic principle working, is to build a control strategy for level control. The first step is to measure the level and send it to the level controller i.e., microcontroller. The microcontroller will make according action to close or open the valve.

For the process, warm liquid is required. Hence, with level, temperature needs to be controlled. To do this LM35 temperature sensor is used which transmits temperature in the form of voltage to the microcontroller thus, maintains the required temperature. As the patient is laid down on the wooden table Figure 1., IR sensor (Fig.3b) will detect the head of the patient. IR sensor is placed near the backside of the neck, due to the cause that IR sensor can't detect the black object i.t. in our case the hairs. After the detection of the patient the IR sensor will give a high input to the microcontroller (Fig.31) and the process will start. As soon as the process is started, the temperature sensor (Fig.3f) will sense the temperature of the oil container. After sensing the temperature of the oil container, the heater(Fig.3g) will start accordingly using the relay driver. Once, the temperature is reached to the set point, oil pump (Fig.3i) will start and the warm liquid will be transferred into the vessel, which is situated above the forehead of the patient.

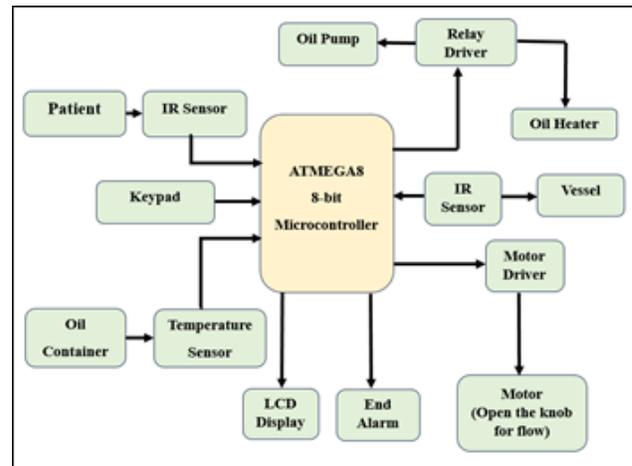


Figure 2. Proposed System Diagram

After reaching the max level of the vessel, the oil pump will stop. The microcontroller will give input to the motor driver IC(Fig.3d) to start the motor, which a linear geared motor. The motor is used to open the knob, to start the flow to pour on the forehead. LCD display (Fig.3j) will display the time of the process and the temperature of the liquid. It is used to start and reset the microcontroller (Fig.31). At the end of the process, alarm will be turned on as an indication that the process has ended.

DESIGN CONSIDERATIONS

- **Power Supply Circuit [Fig.3a]:** The circuit is of power supply. We have used IC LM7805 and two capacitors of 1000 μ F each. LM7805 is the voltage regulator IC. This circuit helps to convert +9V to +12 V unregulated DC into +5V regulated DC.
- **IR Sensor Circuit [Fig.3b]:** Photodiode and a IR LED both together are called as IR pair. This pair can be mounted direct way or by indirect way. In direct way, IR LED and photodiode are kept in front of one another. So that IR radiation can directly fall on photodiode. If we place any object between them then it stops the falling of IR light on photodiode and in indirect way, both are placed in parallel to each other. This type is used mostly for IR sensor module. As the object is place in front of IR pair, the IR light gets reflected by the object and gets observed by photodiode. This causes a voltage drop due to change in resistance of photodiode.

- **IC LM358 [Fig.3c]:** IC LM358 is used because it is a dual voltage comparator. It has 8 pins where, Pin-1 is output terminal, Pin-2 is inverting and Pin-3 is non inverting. As the voltage drop is detected output is turned high photodiode is LDR. Potentiometer helps to control the sensitivity.
- **Motor Driving Circuit [Fig.3d]:** For running motors using microcontroller, an IC L293D is used. It is 16 pin IC designed to drive inductive loads (such as relays solenoids, DC and stepping motors) and switching power transistors.
- **Gear Motor [Fig.3e]:** It operates even at 2V to 5V power supply. When IR Sensor detects the patient, controller circuit drives the linear motion of motor through motor driver.
- **Temperature Sensor [Fig.3f]:** The temperature sensor required for this process is an integrated circuit sensor i.t. IC LM35. This temperature sensor is more accurate as compared to that of the thermistor and has very low cost. The main advantage of this IC is there is no need of amplification of the output signal. The supply voltage required is +4V to +32V.

Features

1. Temperature Range: -40°C to $+150^{\circ}\text{C}$.
2. Linear $+10\text{mV}/^{\circ}\text{C}$ Scale Factor.
3. 0.5°C Ensured Accuracy (at 25°C).
4. Heating in Still Air at 0.08°C .
5. Less than $60\mu\text{A}$ Current Drain. 6. Non-Linearity Only $\pm 1/4^{\circ}\text{C}$ Typical.

- **Heater [Fig.3g]:** It is a resistive type heater. 3 to 4 resistive type heater is used across the container to heat the oil.
- **Buzzer [Fig.3h]:** Buzzer is used for indication purpose as the level of the oil falls down in the tank, the ball rotates the pot's knob, the change in the resistance is detected by the controller and it alarms when tank is about to empty to refill it again.
- **Oil Pump [Fig.3i]:** Oil from the tank is pumped through the plastic tube to the vessel which requires 230V. Plastics tubes are used to connect the pump at inlet and outlet.

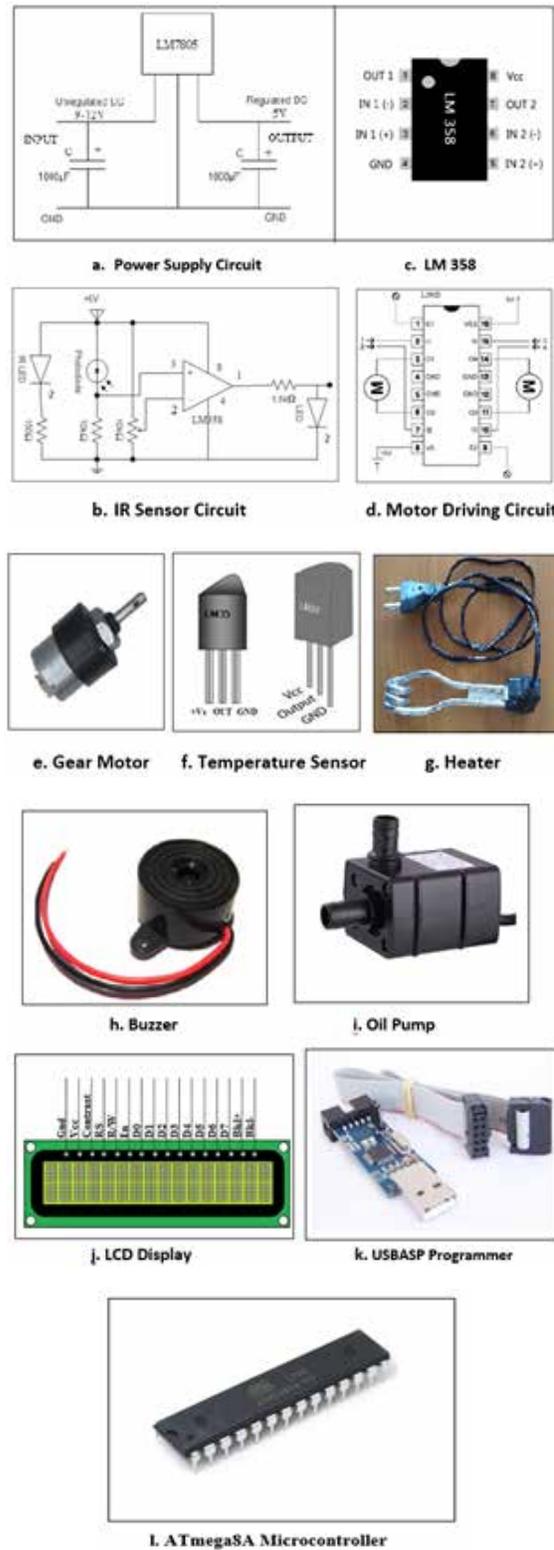


Figure 3

- **LCD Display [Fig.3j]:** LCD (Liquid Crystal Display) screen is an electronic display module. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD, each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. The data register stores the data to be displayed on the LCD.
- **USBASP Programmer [Fig.3k]:** USBASP is a programmer used for interfacing of AVR microcontroller with PCs. It uses ATmega8 microcontroller for sending and receiving data.
- **Microcontroller ATmega8A [Fig.3l]:** Microcontroller ATmega8 is a 8bit microcontroller with 8Kb of ROM. This Controller has 10bit ADC 6 channels of input and output. It is a 28pin IC having 4 ports. Microcontroller circuit needs 2 components to run, one is reset circuitry and crystal. It has an inbuilt 16MHz crystal.

RESULTS ANALYSIS

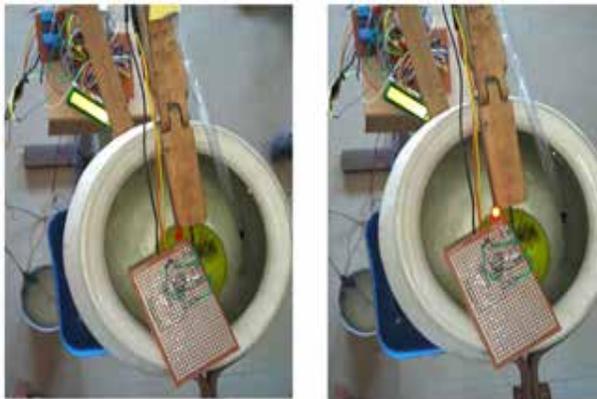


Figure 4a. Level Detection Setup

Figure 4a. shows the level detection, in first picture, as the level is low IR sensor do not detect float or ball. But as the level increases in the second picture, the float or ball starts to move upward, thus IR sensor detects it and pump is stopped and is indicated by red LED.

Figure 4b. shows the patient detection, as the object is placed over the IR sensor, it is detected by IR sensor and process starts.



Figure 4b. Complete Setup

CONCLUSION

In conclusion, the “Automated Shirodhara Unit” project represents a significant advancement in the field of traditional therapeutic treatments. By integrating cutting-edge technology, including the ATmega8A microcontroller, IR sensor, and LM35 temperature sensor, this system effectively automates the Shirodhara process. It not only ensures precise control of the treatment’s level and temperature but also enhances the safety and efficiency of patient detection.

One of the notable advantages of this project is its cost-effectiveness. The development was carried out with a strict adherence to a low budget, making it accessible to a wide range of users.

Furthermore, the automation of the Shirodhara process significantly reduces the need for human intervention. This not only streamlines the treatment but also minimizes the potential for errors, ensuring a consistent and reliable experience for patients. As a result, this innovative project serves as a valuable addition to the

realm of traditional therapeutic techniques and offers a promising avenue for improving healthcare delivery.

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Smart Robotic Soil pH Measurement System

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ABSTRACT

The Smart Soil pH Measurement System is an innovative technology that uses a pH sensor inserted in soil to provide real-time measurement and wireless transmission of data to a user interface. This system is designed to be user-friendly and is useful for farmers, gardeners, and other individuals involved in agriculture or horticulture. By accurately measuring soil pH levels, this system can help optimize plant growth and yield, and improve overall soil health. This system's low cost, simplicity of installation, and scalability make it perfect for usage in a variety of agricultural contexts. The system utilizes advanced sensors and data processing algorithms to provide accurate, real-time measurements of soil pH levels, which can help farmers and researchers optimize crop yields and improve the overall health of their soil. Soil sampling and analysis are crucial components of crop management practices, as they provide valuable information about soil health and nutrient levels. However, traditional soil sampling and analysis methods can be time-consuming and labor-intensive. A smart soil pH measurement setup that requires less time and labor cost has been invented to tackle this problem. This set-up is mounted on a well-designed C shape table and comprises a robotic arm, a storage container for a batch of soil samples, pH standard solutions, and a sink for washing pH electrodes. The setup allows for automated electrode cleaning, validation, and calibration, making the process more efficient and accurate. This technology is beneficial for farmers, researchers, and others involved in agriculture, helping them to optimize crop yields and improve soil health by providing fast and accurate soil pH measurements in the field.

KEYWORDS: *Soil sampling, Soil analysis, Crop management, Smart technology, Soil pH, Robotic arm, Agriculture, Soil health, Nutrient levels.*

INTRODUCTION

The measurement and analysis of soil pH levels are critical components of crop management practices, as they play a vital role in determining the nutrient availability, soil structure, and overall health of the soil. However, traditional soil sampling and analysis methods can be time-consuming and labor-intensive, which can limit the ability of farmers and

researchers to obtain accurate and timely soil pH measurements. To address this issue, a smart soil pH measurement system has been developed to provide a more efficient and automated approach to soil analysis.

The smart soil pH measurement system utilizes a pH sensor that is inserted into the soil to provide real-time measurements of soil pH levels. The pH readings are wirelessly transmitted to a user interface, which allows for immediate feedback and adjustment of soil pH levels. The system is comprised of a robotic arm, a space for storing soil samples, pH standard solutions, and a sink for washing the pH electrodes, all of which are mounted on a C shape table. The system allows for automated electrode cleaning, validation, and calibration, making the process faster, more efficient, and more accurate.

This paper aims to describe the design and implementation of the smart soil pH measurement system and discuss

its potential applications in crop management and agriculture. The paper also includes a description of the system's testing and results, demonstrating its effectiveness and reliability in providing accurate and real-time soil pH measurements. The smart soil pH measurement system can be a valuable tool for farmers, researchers, and others involved in agriculture, helping to optimize crop yields and improve soil health by providing fast and accurate soil pH measurements in the field.

A smart soil pH measurement setup has been created with the aim of reducing the amount of time and manual labor required for soil pH measurement. The setup is designed to automate the calibration, validation, and rinsing of pH electrodes, and consists of a robotic arm, storage area for soil samples, a sink for washing electrodes, and pH standard solutions, all included. It is capable of measuring up to 36 soil samples at a time, providing a more efficient and streamlined approach to soil pH measurement.

Soil pH is an important aspect of understanding the condition of the soil and what nutrients are present. Traditional methods involve taking a single sample from a large area and using that to determine the amount of fertilizer

and pesticides needed for the entire field. However, this can lead to inconsistencies as the pH can vary from one point to another. In this project, multiple soil samples are measured and the pH value is displayed on an LCD screen. Input is given through a 4x4 matrix keypad and processed by an Arduino to determine the position of two stepper motors. The pH sensor module is used to measure the analog quantity of pH and convert it into a digital signal in mV, which is then amplified in volts.

Smart sensors for soil pH measurement come in different types, including:

Electrochemical sensors: These sensors use a probe with an electrode that measures the electrical potential difference between a reference electrode and the soil solution. Electrochemical sensors are commonly used for measuring pH and are relatively low cost.

Optical sensors: These sensors use optical principles to measure soil pH. They typically consist of a pH-sensitive dye or indicator that changes color in response

to changes in pH. Optical sensors are highly sensitive and can be used to measure pH in a range of different soils.

Capacitive sensors: These sensors use changes in capacitance to measure soil pH. They work by measuring changes in the dielectric constant of the soil, which is related to pH. Capacitive sensors are highly sensitive and can be used to measure pH in soils with varying moisture levels.

Overall, smart soil pH measurement technology could completely change how we monitor and control soil pH levels in a variety of applications, including agriculture, horticulture, and environmental monitoring. Their advantages over traditional methods include real-time monitoring, remote accessibility, and increased accuracy and precision.

Specifications

Measurement range: The measurement range refers to the range of pH values that the sensor can accurately measure. This can vary depending on the type of sensor being used, but a common range for soil pH sensors is around 0 to 12.

Accuracy: Accuracy refers to how close the measured value is to the actual value. The accuracy of smart soil pH measurement systems can range from (+ or -) 0.1pH (24°C) depending on the specific sensor and system.

Response time: Response time refers to how quickly the sensor can detect changes in soil pH. According to the sort of sensor being used, this can change, but common response times for soil pH sensors are around < 1 min.

It's crucial to remember that these technical requirements can change based on the particular sensor and system being used. Additionally, other technical specifications, such as sensor lifespan, power requirements, and environmental durability, can also be important considerations when selecting a smart soil pH measurement system.

Calibration

Calibration is a crucial step in ensuring the accuracy and reliability of smart soil pH measurement systems. Calibration involves comparing the measurements of the sensor to a known standard solution of a known

pH value. The purpose of calibration is to adjust the readings of the sensor to match the actual pH of the soil, which can be affected by factors such as temperature, soil composition, and other environmental factors.

There are different methods for calibrating smart soil pH measurement systems, including:

Two-point calibration: This involves calibrating the sensor at two points, typically pH 4.0 and pH 7.0, to adjust for any systematic errors in the sensor readings.

Multi-point calibration: This involves calibrating the sensor at multiple pH values across the measurement range to account for any non-linearity in the sensor response.

Single-point calibration: This involves calibrating the sensor at a single pH value, typically at the midpoint of the measurement range, to adjust for any offset in the sensor readings.

Field calibration: This involves calibrating the sensor using a standard solution on site, which can provide a more accurate calibration for the specific soil and environmental conditions.

Regardless of the calibration method used, it's important to regularly calibrate smart soil pH measurement systems to ensure accurate and reliable measurements over time. Calibration should also be performed whenever the sensor is moved or the environmental conditions change significantly.

Calibration of the pH electrode is essential to obtain accurate readings. The process you have described is the basic procedure for standardization of a pH measuring instrument.

During standardization, the pH electrode is immersed in a solution of known pH, called the buffer solution. In your case, you have used distilled water, which has a pH of 7.0 at room temperature. A comparison between the pH meter's reading and the buffer solution's pH level is made, and any difference between the two values is used to adjust the calibration variable.

As you have described, if the pH reading on the LCD display is 6.7 and the buffer solution has a pH of 7.0, the calibration variable needs to be adjusted by adding 0.3 to its value. This adjustment is necessary because the pH meter may not be reading accurately due to factors such

as electrode aging, temperature, or other factors that affect the accuracy of the measurement. After adjusting the calibration variable, the pH electrode is again immersed in the buffer solution to check if the reading on the LCD display matches the pH value of the buffer solution. If the reading is still off, further adjustments can be made until the pH meter is accurately calibrated.

It's essential to keep in mind that the pH metre needs to be calibrated again on a regular basis to make sure it continues to read appropriately. Calibration should also be done whenever the electrode is replaced, or if the meter has been unused for an extended period.

Applications

Soil pH measurement systems, including precision agriculture, hydroponics, and greenhouse farming. Smart soil pH measurement systems have a variety of applications in the agriculture industry. Some of the most common applications include:

Precision agriculture: Smart soil pH measurement systems can be used in precision agriculture to help farmers optimize their use of fertilizers and water. By continuously monitoring soil pH levels, these systems can provide farmers with real-time data on the health of their crops and help them make more informed decisions about how much fertilizer and water to apply. This can lead to improved crop yields and reduced environmental impact by reducing fertilizer and water waste. In a study[1], researchers used smart soil pH measurement systems to monitor soil pH levels in a coffee plantation in Colombia. By adjusting fertilizer and irrigation practices based on the real-time data provided by the system, they were able to increase coffee yield by 19% and reduce fertilizer use by 30%.

Hydroponics: Instead of using soil, hydroponic farming entails vegetation in nutrient-rich water. In hydroponics, maintaining the right pH level is critical to plant health and growth. Smart soil pH measurement systems can be used to continuously monitor pH levels in hydroponic systems, making it easier for growers to maintain optimal conditions for plant growth. In another study published in the Journal of Agricultural and Food Chemistry[2], researchers used smart soil pH measurement systems to monitor soil pH levels in a lettuce hydroponic system. By maintaining the optimal

pH level, they were able to increase lettuce yield by 35% and reduce water usage by 45%.

Greenhouse farming: In a regulated atmosphere, greenhouse farming enables farmers to cultivate crops providing protection from extreme weather conditions and pests. However, maintaining optimal soil pH levels in a greenhouse environment can be challenging. Smart soil pH measurement systems can help farmers monitor soil pH levels in real-time, making it easier to adjust pH levels as needed and maintain optimal growing conditions. In a greenhouse farming case study published by the USDA[3], a tomato grower used a smart soil pH measurement system to monitor soil pH levels in real-time. By adjusting pH levels as needed, they were able to increase tomato yield by 15% and reduce fertilizer use by 20%.

LITERATURE REVIEW

The researcher [4] proposed a smart soil pH measurement system based on capacitive sensing technology. The system used a capacitance sensor to measure changes in soil pH and transmitted the data wirelessly to a remote monitoring system. The results showed that the system had a high accuracy and stability in pH measurement and could be used for real-time monitoring of soil pH.

The researcher [5] developed a wireless smart soil pH monitoring system that used a pH electrode sensor and a ZigBee wireless communication module. The system was able to measure soil pH in real-time and transmit the data wirelessly to a cloud-based platform for analysis. The results showed that the system had a high accuracy and reliability in pH measurement and could be used for precision agriculture and environmental monitoring.

This study [6] reviewed the use of optical pH sensing in soil and plant monitoring. Optical pH sensors use pH-sensitive dyes or indicators to measure changes in soil pH, which can be detected using optical techniques. The review found that optical pH sensors had high sensitivity, low cost, and could be used for real-time monitoring of soil pH in a range of applications, including precision agriculture and environmental monitoring.

Overall, smart soil pH measurement systems have shown great potential in revolutionizing the way

we monitor and manage soil pH levels in various applications. Capacitive, electrochemical, and optical sensors are all viable options for pH measurement, and wireless communication and cloud-based platforms allow for real-time and remote monitoring of soil pH. However, further research is needed to validate the accuracy and reliability of these systems in different soil and environmental conditions.

The researcher[7,8] states that more resolution and accuracy are offered by photometric techniques, which include optical fibre pH sensors, holographic pH sensors, fluorometric pH sensors[9], and CCD camera full range pH sensors compared to colorimetric methods for soil pH measurement. However, due to their intricate optical systems, these approaches are inappropriate for on-site soil measurements. Optical fiber pH sensors use optical fibers to measure pH, while fluorometric pH sensors measure pH by detecting fluorescence signals. Holographic pH[10] sensors use holography to create a 3D image of pH-sensitive hydrogels, and CCD camera full range pH sensors use cameras to measure pH changes in a solution[11,12]. While these methods offer higher accuracy, they require more specialized equipment and are not practical for on-site soil pH measurements.

The use of automated systems for measuring soil pH is a growing trend in the field of agriculture and robotics. Many engineers and scientists are working to develop cost-effective models that can accurately measure soil pH automatically. One such model is the Skalar Analytical SP2000 pH Analyzer, which has made significant progress in this area.

In this model, the pH measuring probe is cleaned and calibrated to standard buffer solutions before being placed in a tray with the soil sample. Extracting solution is added to the soil sample, mixed with a stirrer, and allowed to settle. The pH probe is then inserted into the sample and the value is measured, saved, and displayed automatically.

With the increasing frequency of demonstrations and the potential for implementation, an Arduino-based SMART soil pH measurement system has been developed to measure multiple soil samples

simultaneously[13,14,15]. This system offers a cost-effective and efficient solution for measuring soil pH in an automated manner.

The patent[16] describes a system for analyzing soil, which includes a blade assembly that can be moved through the soil to collect samples. Sensors that measure the soil's numerous characteristics, such as its pH and moisture content, are built into the blade assembly. The system also includes a controller that processes the sensor data and generates soil maps to aid in agricultural management decisions.

The invention provides a more efficient and accurate way to analyze soil compared to traditional methods. The displaceable blade assembly reduces soil disturbance, while the sensors provide more detailed information about the soil properties[17].

The book[18,19] covers software design aspects, including programming in C language, assembly language programming, and real-time operating systems (RTOS). The authors explain the use of major development tools, such as debuggers, simulators, and integrated development environments (IDEs).

In addition [20.,21] to hardware and software design, the book also covers system integration and testing. The authors provide practical guidance on how to test and debug embedded systems using various tools and techniques. Overall, "Practical Aspects of Embedded System Design Using Microcontrollers" is a valuable resource for engineers, students, and hobbyists interested in designing embedded systems using microcontrollers.

THE PROPOSED SYSTEM

This project aims to create a instrumentation that can automatically detect and check the pH level of soil. To achieve this, a microcontroller program is designed to automate the process of pH measurement. The soil's pH is an important parameter that can affect the growth and yield of plants. Depending on the pH level, a particular action needs to be taken to ensure optimal growth conditions. For instance, if the pH level is too low or too high, certain nutrients may not be available to plants, which can adversely affect their growth.

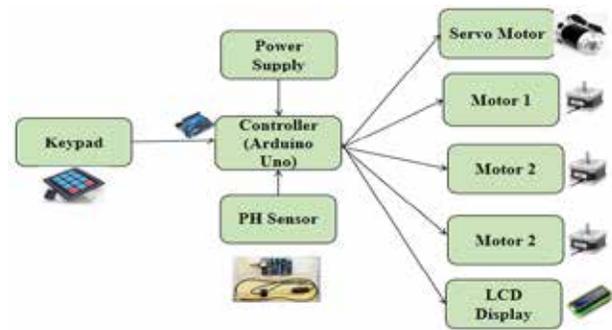


Fig. 1. Block diagram

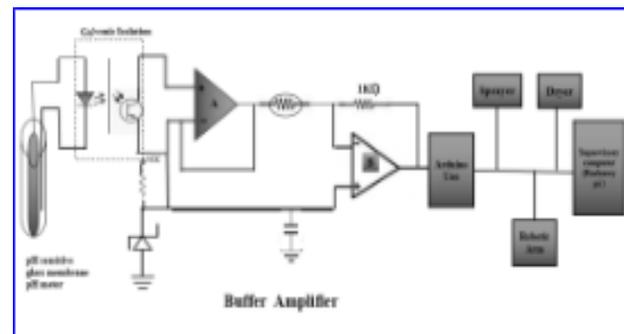


Fig. 2. Conception block diagram of smart soil pH measurement system.

The system works by measuring the soil's pH, displaying the data on an LCD display. Multiple samples of soil can be tested using this system, and the pH level of each sample can be displayed on the LCD screen. Based on the pH level readings, the user can determine whether any action needs to be taken to adjust the soil pH. Overall, this project can be beneficial for farmers, gardeners, or anyone who wants to monitor the pH level of soil in a quick and efficient manner. By automating the pH measurement process, the system can save time and effort while ensuring accurate and reliable readings.

Hardware Design

Hardware Component

In this project, we use Arduino Uno microcontroller to control the position of a stepper motor, servomotor and process data from a pH sensing module. The pH sensor measures the acidity of a solution and provides analog or digital output, and the system also includes a power supply (SMPS), a driver IC (A4988) for the stepper motor.

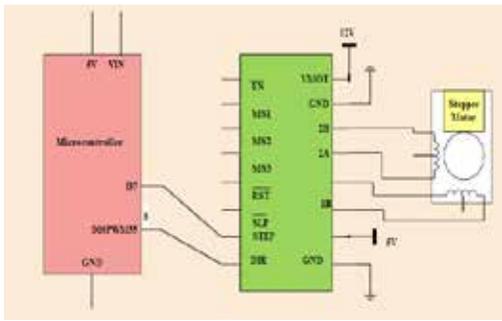


Fig. 3. System Design

It is controlled using a driver IC A4988, which has built-in translator for easy operation. The system also includes a 4x4 matrix keypad for user input and an LCD display module to display the pH readings. The power supply used is an SMPS to convert an uncontrolled AC or DC input voltage into a regulated DC output voltage.



Fig 4. Robocraze pH Sensor

DESIGN AND IMPLEMENTATION

The smart soil pH measurement system is an innovative technology that combines advanced sensors and data processing algorithms to provide accurate and real-time measurements of soil pH levels. The system consists of a pH sensor that is inserted into the soil and wirelessly transmits data to a user interface. The user interface displays the pH readings and allows for immediate adjustment of soil pH levels if needed. It is intended for the system to be user-friendly and low-cost, creating it accessible to farmers, gardeners, and other individuals involved in agriculture or horticulture.

To address the issue of time-consuming and labor-intensive soil sampling and analysis methods, a smart soil pH measurement setup has been developed that automates the calibration, validation, and rinsing of pH electrodes. The setup includes a robotic arm, a place to keep soil samples and pH reference solutions, as well as a basin for washing electrodes. It is simple to transfer and use in the field because the system is installed on a foldable, flexible C shape table.

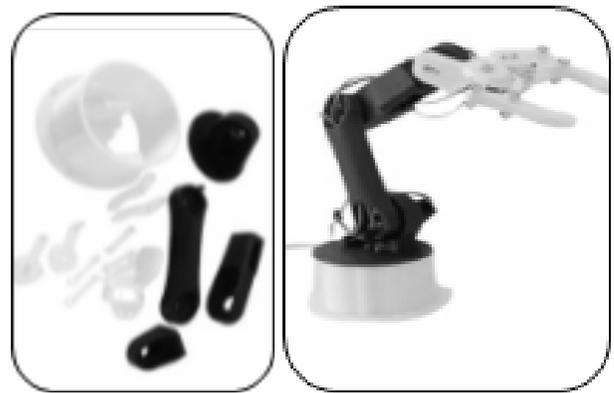


Fig.5. Robotic arm design.

Robotics and other automated systems frequently use servo motors, a particular kind of motor. It's intended to give users full command over angular momentum, making it an ideal choice for applications that require high levels of accuracy and repeatability.

In this robot, there are multiple types of motors working together to provide the desired motion. At the bottom of the arm, there is a stepper motor that provides rotation around a fixed axis. This motor is responsible for moving the entire arm from side to side.

Above the first joint, there are two servo motors that are connected to each other by a link. The servo motors are designed to provide rotational motion around their respective axes, which allows the arm to move up and down and side to side. The link between the two servo motors allows them to work together to provide a more complex range of motion.

At the end of the arm, there is another stepper motor that is responsible for controlling the gripper or end-effectors. This motor provides precise control over the opening and closing of the gripper, enabling the robot to grab and handle objects with ease.

The combination of stepper motors and servo motors in this robot allows for a wide range of motion and precise control over that motion. By carefully programming the motors, the robot can perform complex tasks with a high degree of accuracy and repeatability.

A robotic arm designed for testing soil samples by measuring their pH levels. The arm is controlled by an Arduino Uno and a stepper motor, allowing it to move precisely and accurately.

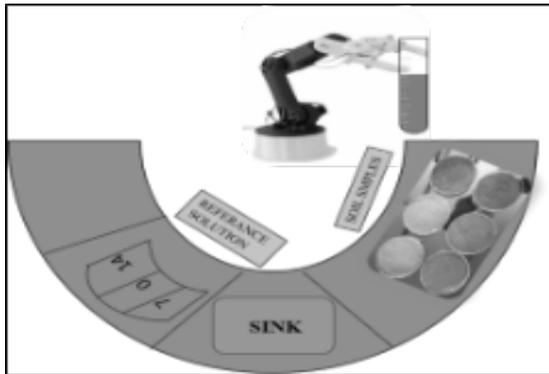


Fig.6. Actual working of Robotic arm for pH measurement.

The process begins by washing the pH electrode with water and then drying it. This ensures that the electrode is clean and ready for use. The circular sink on the table makes it easy to wash the electrode.

Once the electrode is clean, the next step is to calibrate it. This involves measuring the pH of solutions with known pH levels. In this case, there are pH solutions with pH levels of 7, 0, and 14. By measuring the pH of these solutions, the robotic arm can ensure that its measurements are accurate. On the right side of the table, there are soil samples that need to be tested. Presumably, the robotic arm will take measurements of these samples using the calibrated pH electrode.

A specific process for testing the pH of soil samples using a pH electrode. According to the passage, the first step is to dip the electrode into a solution with a pH of 7. This is likely part of the calibration process, where the electrode is tested against a known pH value to ensure its accuracy.

After dipping in the 7 pH solution, the electrode washes itself before being used to Evaluate the soil sample's pH. This step helps to ensure that the electrode is clean and free of any residue that might affect the accuracy of the measurement.

Once the electrode has measured the pH of the soil sample, it washes itself again. This step helps to prevent contamination between samples and ensures that the electrode is ready for the next measurement. The same process is then repeated for the next soil sample, with the electrode being dipped in the 7 pH solution, washed, used to measure the pH of the soil, washed again, and so on. Presumably, the electrode would be dipped in

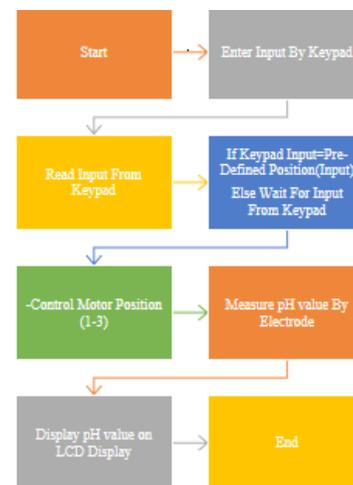
the 7 pH solution between each sample to ensure that it remains calibrated and accurate.

Overall, this setup provides an efficient and accurate way to test the pH of soil samples. By automating the process with a robotic arm, errors can be reduced, and consistency can be improved. The use of an Arduino Uno and a stepper motor also ensures excellent command over the electrodes and the arm's mobility, resulting in accurate measurements.

TESTING AND RESULTS

The smart soil pH measurement system and setup were tested in various agricultural settings, including crop fields and greenhouses. The system was found to be effective in providing accurate and real-time measurements of soil pH levels, allowing for immediate adjustments to be made if needed. The automated electrode cleaning, validation, and calibration functions of the setup were found to be efficient and accurate, reducing the time and labor required for soil pH measurement.

VI. SOFTWARE DESIGN



- ❖ Begin the process.
- ❖ Use the keypad to input data.
- ❖ Retrieve the data input from the keypad.
- ❖ If the input from the keypad matches a pre-set position, control the motor. If not, wait for input from the keypad.
- ❖ Adjust motor to position 1.

- ❖ Adjust motor to position 2.
- ❖ Adjust motor to position 3.
- ❖ Use the electrode to measure the pH value.
- ❖ Display the pH value on the LCD display.
- ❖ End the process.

RESULTS AND DISCUSSIONS

The measured pH values of 20 soil samples are shown in table 1. 4 soils samples originated from farm plots from the village of Kanchanpur and 16 soils samples originated from the farm plots from the village of Savli. All soils were having pH values greater than 7.0. most of the soil samples exhibited a pH value greater than 8.5 which means they were basic in nature. There was a slight difference observed in the mV values between standard pH meter used in laboratories and the meter system developed and used in this study.

Table. 1 Sensor data showing measurements

Sr. no	Village	pH	Meter reading (mV)	Observation (mV)
1	Kanchanpur	7.82	410	408
2	Kanchanpur	8.30	208	206
3	Kanchanpur	7.92	379	379
4	Savli	8.31	207.9	207.7
5	Savli	8.40	199.9	199.7
6	Savli	7.83	378.2	378.0
7	Savli	8.23	435.6	435.4
8	Savli	8.69	449.6	449.4
10	Savli	8.11	407.4	407.2
11	Savli	8.47	459.6	459.4
12	Savli	8.43	450.1	450.0
13	Savli	8.72	482.4	482.2
14	Savli	8.49	453.9	453.7
15	Savli	8.14	401.8	401.6
16	Savli	7.80	298.4	298.2
17	Savli	8.02	337.0	337.0
18	Savli	8.30	369.5	369.3
19	Kanchanpur	8.50	396.5	396.3
20	Savli	8.75	442.8	442.7

APPLICATIONS AND CONCLUSIONS

The smart soil pH measurement system and setup have a wide range of applications in crop management and agriculture. By accurately measuring soil pH levels, the system can help optimize plant growth and yield and improve overall soil health. The system is low-cost, easy to install, and scalable, making it ideal for use in a variety of agricultural settings. The system's automated functions also reduce the time and labor required for soil pH measurement, making it a valuable tool for farmers, researchers, and others involved in agriculture [23, 24]. In conclusion, the smart soil pH measurement system and setup represent an innovative and efficient approach to soil analysis that has the potential to revolutionize crop management and agriculture.

CONCLUSION

The Smart Soil pH Measurement System and Setup are innovative technologies that provide fast and accurate soil pH measurements in the Laboratory or in the field. These technologies are beneficial for farmers, researchers, and others involved in agriculture, helping to optimize crop yields and improve soil health. The advanced sensors, data processing algorithms, and automation used in the technologies reduce the time and manual labor required for soil pH measurement, while also minimizing the risk of human error. With the potential to improve crop productivity and reduce environmental impact, smart soil pH measurement technologies are a valuable addition to the field of agriculture.

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Hybrid VARMA-LSTM Approach for Forecasting Wind Power Density in Jaipur, Rajasthan

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ABSTRACT

In the context of the evolving energy landscape of Rajasthan, India, characterized by escalating fossil fuel costs and the depletion of traditional sources, this study focuses on wind energy as a sustainable alternative. Leveraging long-term hourly mean wind speed data from the Indian Meteorological Department (IMD), at 10 meters above ground level, the research addresses the challenges posed by missing wind speed data due to extreme weather and transmission errors. Employing a machine learning approach for data reconstruction, the study introduces a hybrid Vector Autoregressive Moving Average (VARMA) and Long Short-Term Memory (LSTM) methodology. This hybrid technique aims to predict the shape parameter (k), scale parameter (s), and Wind Power Density (WPD) with increased accuracy, minimizing root-mean-square error (RMSE). The proposed model holds significance for enhancing the precision of wind power density predictions, thereby contributing to effective wind energy utilization in Jaipur.

INTRODUCTION

Sustainable development hinges on the efficient utilization of renewable energy sources to meet the escalating global energy demand while mitigating environmental impacts. In this context, wind energy has gained prominence as a key contributor to sustainable power generation [1]. The imperative to transition from fossil fuels is underscored by their increasing costs and the imminent depletion of these finite resources. Recognizing wind energy's potential, researchers are actively exploring advanced methodologies for accurate wind power density (WPD) prediction, a critical parameter in optimizing wind energy harnessing [2]. This study addresses the intersection of sustainable development, renewable energy, and predictive modeling, focusing on Jaipur, where the demand for electricity is rapidly growing due to various socio-economic factors.

The literature reveals a growing body of research dedicated to wind energy modeling and forecasting. Notably, missing wind speed data due to extreme weather conditions and transmission errors pose significant challenges to the accuracy of wind power forecasting models. Various models have been proposed to describe wind speed datasets, including the Weibull, Inverse Weibull, Lindley, skewed generalized error, skewed t , and Johnson S_B distributions [3,4]. Among these, the 2-parameter Weibull distribution stands out as a widely adopted model, particularly for unimodal wind speed datasets [5,6]. This distribution's simplicity and effectiveness make it a preferred choice for characterizing wind regimes [7,8]. Furthermore, mixture models find preference for bimodal datasets. However, a critical research gap exists in the literature concerning the integration of machine learning techniques, such as Vector Autoregressive Moving Average (VARMA) and Long Short-Term Memory (LSTM), to enhance

the precision of wind power density predictions[9]. This study aims to fill this gap by proposing a hybrid VARMA-LSTM approach, uniquely tailored for Jaipur’s wind energy landscape.

The identified research gap lies in the limited exploration of hybrid models combining VARMA and LSTM methodologies for wind power density prediction in the specific context of Jaipur. The existing literature predominantly focuses on unimodal wind speed datasets, and the integration of advanced machine learning techniques for WPD prediction remains underexplored. The novelty of this study is rooted in the introduction of a novel hybrid VARMA-LSTM approach tailored to Jaipur’s unique wind energy dynamics. The objective is twofold: firstly, to employ machine learning for the reconstruction of missing wind speed data caused by extreme weather and transmission errors, and secondly, to develop and validate a hybrid VARMA-LSTM model for accurate and reliable predictions of wind power density. By addressing this research gap and introducing a novel methodology, this study aims to contribute valuable insights to the field of renewable energy modeling, specifically enhancing the precision of wind power density predictions in Jaipur’s evolving energy landscape.

Geographical conditions and observation period

The Indian Meteorological Department (IMD), Pune, meticulously recorded long-term hourly mean wind speed data in kilometers per hour at a height of 10 meters above ground level, utilizing a dyne pressure tube anemograph. The availability of wind speed data varies across different stations, and for the purpose of this study, the focus is on Jaipur in Rajasthan, positioned in the north-west region of India. Fig. 1 provides a visual representation of the chosen site. The geographical conditions of Jaipur, with its unique topography and climatic features, contribute to its suitability for wind power density generation. The observation period for this study spans from 1969 to 2012, encompassing a comprehensive dataset for analysis. The regions highlighted on the Indian map in this study are recognized as highly favorable locations for wind power density generation. Table 1 further details the specifics of the selected station, including latitude, longitude, altitude, observation period, the

total number of wind speed observations, and the years for which data is missing.



Figure.1. India map with the location of Jaipur

Table 1: Geographical location and observation period for selected stations in India.

Station	Latitude (°N)	Longitude (°E)	Observation period	Prediction period
Jaipur	75.77	26.82	Jan 1969- Dec 2002	Jan. 2003- Dec. 2013

Weibull distribution of wind speed

The Weibull distribution proves to be a versatile model for wind speed data, described by its probability density function, $f_w(v)$ and cumulative distribution function, $F_w(v)$ as expressed in Equations (1) and (2) respectively [10]:

$$f_w(v) = \left(\frac{k}{s}\right) \left(\frac{v}{s}\right)^{k-1} \exp\left[-\left(\frac{v}{s}\right)^k\right]; \text{ for } v > 0 \text{ and } k, s > 0 \tag{1}$$

$$F_w(v) = 1 - \exp\left[-\left(\frac{v}{s}\right)^k\right] \tag{2}$$

Here, v represents the reference wind speed (m/s), k is the non-dimensional shape parameter of the Weibull distribution, and s is the scale parameter (m/s).

Various methods are employed to determine Weibull parameters in different regions. The literature suggests that the effectiveness of these methods can vary across regions, with some being more suitable for specific areas than others. Numerous approaches have been proposed in the literature to estimate Weibull parameters, and recent studies highlight the modified energy pattern factor (MEPF) as a method exhibiting superiority over conventional techniques.

THE MATHEMATICAL MODELS

Weibull parameters estimation

Various methods are employed to estimate the parameters of the Weibull distribution within a specific region. A recent noteworthy contribution by Gugliani et al. [11] introduces a novel technique known as the Modified Energy Pattern Factor (MEPF) method. In a recent publication, which references the MEPF method, the authors demonstrated its distinct advantages over conventional methods such as the maximum likelihood method, modified maximum likelihood method, method of moments, power density method, least squares method, and energy pattern factor method. This comparative analysis considered both theoretical properties and Monte Carlo calculations. The simulations revealed that the MEPF approach serves as a suitable alternative in terms of accuracy across various sample sizes. Notably, it emerges as the only approach that combines accuracy, computational efficiency, freedom from binning issues (applicable when data are in frequency format), and does not necessitate intricate calculations for parameter estimates. For a comprehensive understanding of this comparison and further references on alternative estimating techniques, readers are encouraged to refer to Gugliani et al. [11].

The MEPF method is based on the Energy Patter Factor (E_{pf}), which is the ratio of the mean of the cubes of the wind speed data (\bar{v}^3) to the cube of the mean wind speed (\bar{v}). Using the theoretical E_{pf} as a reference, the observed wind speed-based empirical version, v_1, \dots, v_n produces the expression

$$E_{pf} = \frac{\bar{v}^3}{\bar{v}^3} = \frac{\frac{1}{n} \sum_{i=1}^n v_i^3}{\left(\frac{1}{n} \sum_{i=1}^n v_i\right)^3} = \frac{\Gamma\left(1+\frac{3}{k}\right)}{\left[\Gamma\left(1+\frac{1}{k}\right)\right]^3} \tag{3}$$

Where k can be expressed as

$$k = \frac{a_4 E_{pf}^4 + a_3 E_{pf}^3 + a_2 E_{pf}^2 + a_1 E_{pf} + a_0}{b_4 E_{pf}^4 + b_3 E_{pf}^3 + b_2 E_{pf}^2 + b_1 E_{pf} + b_0} \tag{4}$$

Where k can be expressed as

The coefficient for shape parameters	
$a_0 = -0.2204$	$b_0 = 1.2728$
$a_1 = 3.2753$	$b_1 = 3.6912$
$a_2 = -5.7896$	$b_2 = 2.6097$
$a_3 = 2.1514$	$b_3 = -0.8005$
$a_4 = 0.5904$	$b_4 = 0.9920$

After calculating k , the scale parameter, S can be computed using Eq. 5

$$S = \frac{\bar{v}}{\Gamma\left(1+\frac{1}{k}\right)} \tag{5}$$

Extrapolation of wind speed at various hub heights

Wind turbines are typically located within the atmospheric boundary layer's surface layer, where wind speed rises significantly with height. To assess wind energy potential, measurements at the hub height are crucial. However, the Indian Meteorological Department estimates wind speed at 10 meters above ground. To bridge this gap, the wind shear exponent is used along with the power law to extrapolate the Weibull distribution's scale parameter at various heights. The Hellmann exponent (α), influenced by site roughness, is crucial in this context. In this research, the Allnoch formula is employed to calculate the vertical wind shear exponent, facilitating the determination of wind speed at the hub height. The resulting formula to calculate the Hellmann exponent α and vertical mean wind profile (\bar{v}_z) at various heights (z) are given as:

$$\alpha = \frac{0.65 - 0.19 \log s_a}{1 - 0.19 \log \left(\frac{z_a}{z_{ref}} \right)} \tag{6}$$

$$\bar{v}_z = \bar{v}_a \left(\frac{z}{z_{ref}} \right)^\alpha \tag{7}$$

Where, z_a is the anemometer height (10 m). \bar{v}_a are the Weibull shape parameter, scale parameter, and the mean wind speed at anemometer height respectively. z_{ref} is the reference height (10 m), and z denotes the height at which the Weibull parameter is to be estimated.

Wind power density(WPD) for a region can be found using Weibull parameters. As suggested by [12][13] wind density remain constant ($\rho = 1.225 \text{ kg/m}^3$), the WPD can be calculated as follows:

$$WPD = \frac{1}{2} \rho s^3 \Gamma \left(1 + \frac{3}{k} \right) \tag{8}$$

RESULTS AND DISCUSSION

The Hybrid VARMA-LSTM (Vector Autoregressive Moving Average - Long Short-Term Memory) approach assumes a pivotal role in this study, offering multifaceted advantages for wind power density prediction. A key feature lies in its capability to reconstruct missing wind speed data, an inherent challenge arising from extreme weather conditions or data transmission errors. By integrating time series analysis (VARMA) and deep learning (LSTM), this hybrid model taps into the strengths of both methodologies. Time series analysis excels in capturing temporal dependencies, while LSTM, as a neural network architecture, adeptly discerns intricate patterns and relationships in the data. The ultimate aim is to enhance predictive accuracy, minimizing the root-mean-square error (RMSE) in wind power density forecasts. Notably, the versatility of the Hybrid VARMA-LSTM approach proves instrumental in handling the nonlinearities inherent in wind speed data, providing a robust tool for modeling the variable and sporadic nature of wind patterns. Tables 2 and 3 show weibull parameters calculated from available data from IMD Pune and Weibull parameters calculated from Hybrid VARMA-LSTM approach for 10 years (2003-2013), respectively. Predicted values are lower than the measure values die to som assumptions and uncertainty in the models. Furthermore, the study’s inclusion of a

comparison with conventional methods underscores the novel contributions of the Hybrid VARMA-LSTM approach, shedding light on its efficacy in advancing wind energy prediction beyond traditional techniques.

Table 2: Monthly estimated Weibull parameters for the Jaipur station (IMD Data)(1969-2002)

Techniques Used	Measured Values, IMD Pune Data (1969-2002)			
Months	K	S (m/s)	S(m/s) at 30 m	S(m/s) at 60 m
Jan	1.36	1.68	1.97	2.17
Feb	1.39	1.88	2.2	2.43
March	1.38	2.13	2.49	2.75
April	1.3	2.28	2.67	2.95
May	1.26	2.64	3.09	3.41
June	1.4	2.88	3.37	3.72
July	1.34	2.45	2.86	3.16
Aug	1.36	2.14	2.51	2.77
Sept	1.35	2.18	2.55	2.81
Oct	1.22	1.7	1.99	2.2
Nov	1.37	1.44	1.68	1.86
Dec	1.37	1.52	1.78	1.97



Figure 2: monthly mean wind speed for Jaipur

Table 3: Weibull parameters calculated from Hybrid VARMA-LSTM approach for 10 years (2003-2013)

Techniques Used	Predicted values			
	VARMA-LSTM Approach (2003-2013)			
Months	K	S (m/s)	S(m/s) at 30 m	S(m/s) at 60 m
Jan	1.25	1.55	1.83	2.01
Feb	1.30	1.76	2.01	2.33
March	1.28	2.02	2.32	2.61
April	1.24	2.18	2.54	2.88
May	1.20	2.53	2.88	3.39
June	1.33	2.72	3.13	3.67
July	1.30	2.32	2.73	3.02
Aug	1.27	2.01	2.44	2.68
Sept	1.29	2.10	2.41	2.73
Oct	1.18	1.66	1.72	2.01
Nov	1.30	1.31	1.59	1.77
Dec	1.29	1.43	1.68	1.81

May to September. Maximum predicted WMS of 2.7 m/s is observed for June month and minimum of 1.2 m/s for November.

The observed seasonal variations in wind power density in Jaipur can be attributed to several meteorological factors. During the months from April to July, the region often experiences a transition from spring to early summer, characterized by increased atmospheric instability and temperature differentials. Higher WPD is achieved for 60 m hub height compared to 30 m. These conditions contribute to stronger and more consistent wind patterns, leading to higher wind power density. Conversely, from October to January, Jaipur typically enters the post-monsoon and winter seasons. During this period, atmospheric stability tends to increase, leading to reduced wind speeds and, consequently, lower wind power density. The winter months, in particular, often see calmer and less turbulent atmospheric conditions. The months between May and September, representing the monsoon season in the region, exhibit a higher probability of elevated wind power density as shown in Figure 3. Maximum WPD of 72.9 W/m² is predicted for June month at 60 m hub height and minimum of 7.23 W/m² for November month at 30 m hub height. The monsoon brings about changes in atmospheric circulation and weather patterns, fostering conditions conducive to increased wind speeds. Therefore, the turbine is rarely operating during this season.

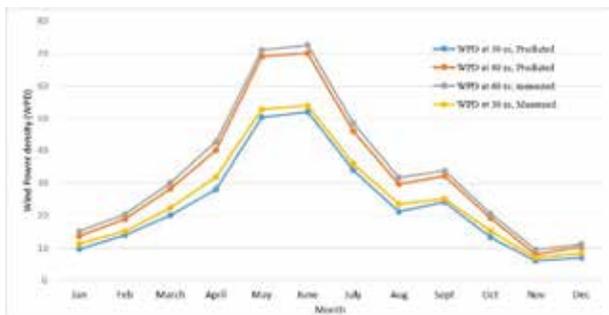


Figure 3: Contour Plot of wind power density: (a) contour plot for Tuticorin. (b) contour plot for Predicted WPD for Tuticorin.

Figure 2 illustrates the seasonal patterns derived from monthly mean wind speed data. It is evident that elevated monthly mean wind speeds are observed from April to July, while lower wind speeds prevail from October to January. The likelihood of higher wind speeds is notably greater during the months spanning

CONCLUSION

In conclusion, this study has addressed critical aspects of wind power density prediction in Jaipur, employing a Hybrid VARMA-LSTM approach. The integration of Vector Autoregressive Moving Average (VARMA) and Long Short-Term Memory (LSTM) models has proven to be a valuable strategy, particularly in handling missing wind speed data through machine learning techniques.

The analysis of seasonal wind behavior revealed distinct patterns, with higher wind power density observed between April and July and lower values between October and January. The study also highlighted the significance of accurately estimating wind speed at the hub height, necessitating the use of the wind shear exponent and the power law for extrapolation. The incorporation of the Allnoch formula for calculating

the vertical wind shear exponent further refined the determination of wind speed at the hub height. However, it is crucial to acknowledge the observed differences in wind speed predictions for 2003-2012 compared to the IMD's observed data from 1969 to 2002, emphasizing the need for ongoing model refinement and consideration of external factors. Despite these challenges, the Hybrid VARMA-LSTM approach showcased its utility in advancing wind power density predictions, offering a promising avenue for further research and development in optimizing wind energy harnessing in Jaipur.

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Intelligent Artificial Control and Multilayer Inverter Based Improved Control of a Wind Power System based DFIG

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ABSTRACT

The improvement of overall power quality and optimal control of reactive and active power are issues that have attracted many researchers. Intelligence approaches are used to control a DFIM that is integrated inside a wind turbine and a neural network based space vector modulation with two levels converters. The NSVM-2L is employed because it has a number of advantages: scalable motor-friendly voltage, motor-friendly output current, and minimal output distortion ripples. This paper offers two optimal control strategies of active and reactive power. Firstly, utilizing a fuzzy logic controller and the second utilizing a PID controller. The results acquired with MATLAB/Simulink serve as evidence of the effectiveness of the proposed control approaches. From these results, it can be seen that the fuzzy logic controller's dynamic performance is very superior to that of the PID controllers. The fuzzy controller works well for lowering the rate of harmonic distortion of absorbed currents and for correctly adjusting active and reactive power. The proposed control techniques reduce total harmonic distortion (THD) and are able to control the output more efficiently than current controllers.

INTRODUCTION

In many parts of the world, variable renewable energy output from sources like wind and solar is expected to play a significant role in future zero-emissions electrical system [1]. Recently, renewable energy sources have drawn more attention as potential substitutes for meeting domestic energy needs [2]. Due to its pure nature and free availability, wind power is among the most amazing forms of renewable energy [3]. The most frequently employed used wind turbine technology currently is the DFIG [4]. The renewable energy source that is growing the fastest is wind power, which can now be more economically viable and has advanced technologically [5]. Due to the flexibility for reactive and active direct power management as well as torque control, double fed induction machines (DFIM) are utilized in large-scale wind production systems, which are a crucial component of variable speed wind

turbines [6]. It's a popular topic right now, and nonlinear system control research is quite busy. Nonlinear systems, however, are frequently difficult to control [7]. Therefore; the modern controls are better able to adapt to these needs and which are robust and less sensitive, such as the Artificial Intelligence controller.

Modern wind turbines of the Megawatt-sized always operate at a variable speed, which is accomplished through a converter. The cost of wind turbines is considerably impacted by these converters, which are often connected to individual generators [3]. The need to study and create control through the reactive power and active power of the wind farm capabilities, as well as the command of the impact of wind farm parameters on any sort of abnormal state in the grid, is a result of the expansion and installed capacity of wind farms. Because of this, wind power plants are forced to participate actively in the power supply system. These

control capabilities' primary goals are to automate the wind turbine's operation, impose safe limitations, and maximize generated power. The maximization of wind energy collection through the optimization of produced power lowers operating costs, aids in reducing turbine loads for safe wind turbine operation, and enables consistent dynamic response and higher product quality. Wind turbines at constant or variable speeds are operated with the intention of capturing as much wind energy as possible [8].

In this study, we use the Artificial Intelligence controller to optimize the reactive and active powers of the wind turbine DFIG. Neural network based space vector modulation with two levels (NSVM-2L) is used to replace the traditional switching a pulse-width modulation (PWM) technique to reduce torque and flux ripples. Additionally, the reactive power and active power of the stator-side are controlled by fuzzy logic controllers and PID controllers; this method of control significantly improves the quality of the power and provides excellent performance in the presence of changes in DFIG parameter values.

MODELLING THE CHAIN OF WIND BASED ON DFIM

Wind turbine modelling

The rotor power coefficient(C_p)is used to express the extractable power to available power ratio. Therefore, the extractable power may be expressed as [9], [10].

$$\begin{cases} P_{aer} = C_p \cdot P_{wind} \\ P_{aer} = 0.5C_p(\lambda) \cdot \rho \cdot \pi \cdot R^2 \cdot V_1^3 \end{cases} \quad (1)$$

The tip speed ratio λ may be calculated using [11].

$$\lambda = \frac{\Omega_{turbine}}{V_1} \cdot R \quad (2)$$

$\Omega_{turbine}$: Turbine angular shaft speed , R :Turbine radius in m and V_1 is the wind speed in m / s, $C_p(\lambda,\beta)$ For rapid rotation wind turbines Presented in (3), is based on experimental data [12].

$$C_p = K_1 \left(\frac{K_2}{\lambda_1} - K_3 \cdot \beta - K_4 \right) \exp \left(\frac{-K_5}{\lambda_1} \right) + K_6 \cdot \lambda \quad (3)$$

$$\text{With: } \frac{1}{\lambda_1} = -\frac{0.035}{\beta^3+1} + \frac{1}{\lambda+0.08\beta} \quad (4)$$

$$K_1 = 5176 * 10^{-4}, K_2 = 116$$

$$K_3 = 4 * 10^{-1} K_4 = 0.5 * 10^1; K_5 = 0.21 * 10^{-2}, K_6 = 68 * 10^{-4}$$

The aerodynamic torque exerted on the slow shaft of the turbine(in N.m) is given by:

$$T_{aer} = \frac{1}{2} C_p(\lambda) \cdot \rho \cdot \pi \cdot R^2 \cdot V_1^3 \cdot \frac{1}{\Omega_{turbine}} \quad (5)$$

The following mathematical wind relation is used to represent the gear box, which modifies the turbine's speed in proportion to the generator's speed. Through a mechanical shaft system made up of a high-speed and low-speed shaft coupled by a gearbox, the induction generator is connected to the wind turbine [13]:

$$\begin{cases} T_g = \frac{T_{aer}}{G} \\ \Omega_{turbine} = \frac{\Omega_{mec}}{G} \end{cases} \quad (6)$$

The total mechanical torque T_{mec} applied to the rotor:

$$T_{mec} = J \frac{d\Omega_{mec}}{dt} \quad (7)$$

$$T_{mec} = T_g - T_{em} - T_{vis} \quad (8)$$

Where $J = \frac{J_{turbine}}{G^2} + J_g$:is total inertia appear on the shaft of the generator, T_{em} :Torque electromagnetic produced by DFIG - generator, T_{vis} :Torque of viscous friction, T_g :Torque from the Gear box,

Ω_{mec} : Mechanical angular speed of the generator. G : gearbox ratio.

The resistance torque due to friction is modelled by a viscous friction coefficient f

$$T_{vis} = f \Omega_{mec} \quad (9)$$

$$f = \frac{f_{turbine}}{G^2} + f_g \quad (10)$$

Where f :is the equivalent friction coefficient of the tree. $f_{turbine}$: is the coefficient of friction of the turbine and f_g is the coefficient of the generator.

Modelling of DFIM

The equations of the DFIM Vector Control (d-q) with wound rotor are written as [14]

$$\begin{cases} \Phi_{ds} = \Phi_s \\ \Phi_{qs} = 0 \end{cases} \tag{11}$$

$$\begin{cases} \Phi_{dr} = (L_r - \frac{L_m^2}{L_s}) \cdot i_{dr} + \frac{L_m}{L_s} \Phi_s \\ \Phi_{qr} = (L_r - \frac{L_m^2}{L_s}) \cdot i_{qr} \end{cases} \tag{12}$$

$$\begin{cases} i_{ds} = \frac{\Phi_s}{L_s} - \frac{L_m}{L_s} \cdot i_{dr} \\ i_{qs} = -\frac{L_m}{L_s} \cdot i_{qr} \end{cases} \tag{13}$$

$$\begin{cases} V_{qs} = \omega_s \Phi_s = V_s \\ V_{dr} = (L_r - \frac{L_m^2}{L_s}) \frac{di_{dr}}{dt} - g\omega_s(L_r - \frac{L_m^2}{L_s})i_{qr} + R_r \cdot i_{dr} \\ V_{qr} = gV_s \frac{L_m}{L_s} + (L_r - \frac{L_m^2}{L_s}) \frac{di_{qr}}{dt} + g\omega_s(L_r - \frac{L_m^2}{L_s}) \cdot i_{dr} + R_r \cdot i_{qr} \end{cases} \tag{14}$$

$$\begin{cases} P_s = -V_s \frac{L_m}{L_s} i_{qr} \\ \Phi_s = -V_s \frac{L_m}{L_s} i_{dr} + \frac{V_s^2}{\omega_s L_s} \\ P_r = g(-V_s \frac{L_m}{L_s} i_{qr}) \\ \Phi_r = g(-V_s \frac{L_m}{L_s} i_{dr} + \frac{V_s^2}{\omega_s L_s}) \end{cases} \tag{15}$$

Torque electromagnetic equation in a generator is written in Equation (16)

$$T_{em} = p \cdot \frac{M_{sr}}{L_s} (-\Phi_s \cdot i_{qr})$$

With $M_{sr} = \frac{3}{2} L_m$

SPACE VECTOR MODULATION (SVM)

The fundamental idea behind the SVM method is to create V_{ref} as precisely as feasible using the stationary vectors that are accessible to the inverter. Reference voltage V_r is generated by the inverter. [15]. Finding the triangle in which the point of V_{ref} is located is the traditional approach of synthesizing V_{ref} . The nearest three vectors (NTVs) for V_{ref} are formed by the vertices of this triangle, and V_{ref} is then synthesized using these three vectors. After each sample time T_s , this procedure is repeated [16]. The SVM can best be explained based on a two-phase representation of Figure 1.

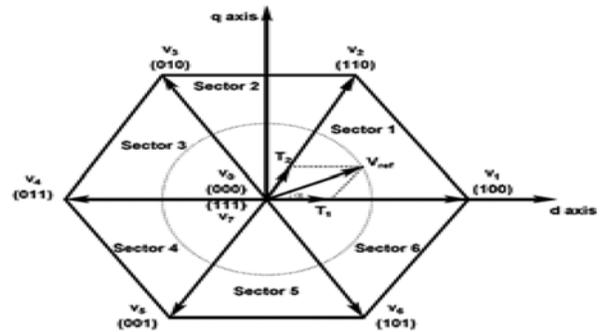


Figure 1. Principle drawing SVM for a three-phase two level-VSI

Level Inverter

Due to the disadvantage of standard VSI, a multilayer inverter is taken into consideration. The following are the disadvantages of traditional VSI. The advantages they offer over the conventional ,2-Level voltage source inverter (VSI) lower harmonic content in the output voltage ,reduced acceleration stress on the power electronics devices ,lower device ratings, a lower switching frequency[17]. In [18], Using a two-level SVM method that calculates the maximum and minimum three-phase voltages (V_a, V_b, V_c). Figure 2 depicts the suggested SVM method that is intended to regulate the 2-level inverter in [17]. The NSVM technique of the 2-level inverter is shown in Figure 3.

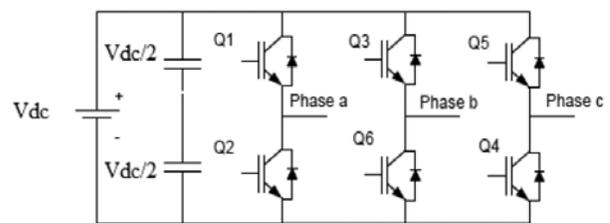
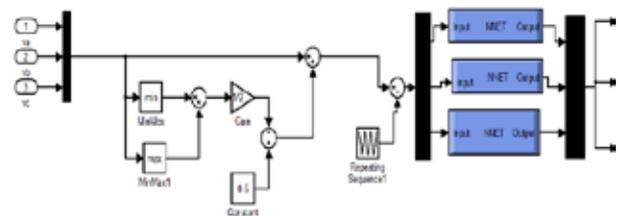
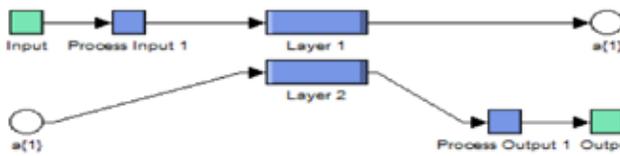


Figure.2. Schematic diagram of a two-level, three phases conventional voltage source inverter.



(a) SVM strategy



(b) Neural network Layer

Figure 3. The NSVM technique by 2-level inverter

FUZZY LOGIC CONTROL SCHEME

The fuzzy logic controller’s three main elements:

- Fuzzification: in this stage, numerical values are converted to fuzzy values or linguistic variables as inputs [19].
- defuzzification : in this stage, it must be converted into a numeric value.[19]
- Inference rules: through language control rules, the rule base represents the control technique and intended aim.
- As inputs, every time interval’s error deviations and error of inputs from their references are used [3]. This article takes into account Mamdani type Fuzzy Logic Control (FLC) [3]. Figure 4 and Figure.5 shows a schematic of a FLC-NSVM controller and PID-NSVM controller respectively.

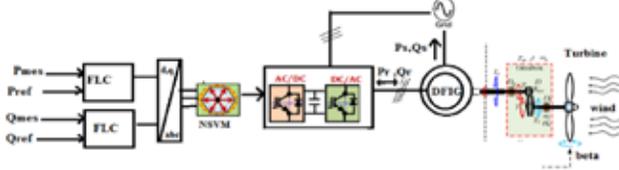


Figure 4. Diagram of Fuzzy logic-NSVM controller for DFIG

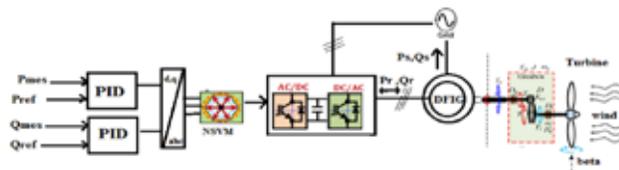


Figure 5. Diagram of PID-NSVM controller for DFIG

SIMULATION RESULTS

Practical implementation, that, simulation of the process is required to confirm our theoretical research of the wind power conversion chain. The machine stator

winding of the DFIG is directly linked to the 3 phase network (398/690 V / 50 Hz), while the rotor wind is powered by a 3-phase converter controlled by neural network-based space vector modulation (NSVM).

Table 1. DFIG Wind Turbine Parameters

Symbol	Value	Description
P	4	Number of poles
J	1000(kg.m ²)	total inertia
fr	0.0024(Hertz)	equivalent friction coefficient of the tree
R	35.255 (m)	the turbine radius
Rr	0.021(Ω)	Rotor winding Resistance
Rs	0.012(Ω)	Stator winding Resistance
Ls	0.0137 (H)	Stator Inductance
Lr	0.0136 (H)	Rotor Inductance
M	0.0135 (H)	Mutual inductance
g	0.03	glissement

In general, the generator follows the power steps for both reactive and active power. The results reveal that the fuzzy logic regulator has a faster rise time than the PID regulator. The overshoot of the fuzzy logic regulator is a minimal compared to the neural regulator terms of active power, but in terms of reactive power we notice that PID(Proportional-Integral-Derivative) regulator is a minimal compared to the fuzzy logic regulator terms of active power (see figure(6)). There is a clear difference between the different regulators in static error and terms of response time. The stator power tracking

performance is satisfactory and the disturbance time is acceptable for both types of control. Figure 7 represent the electromagnetic torques by the PID controller and Fuzzy Logic controller, while Figure 8 shows the 3phase stator current. This figure demonstrates that the FL-controller approach reduces the ripples of stator current and electromagnetic torque when compared to the PID-controller method.

Total Harmonic Distortion (THD) levels frequency spectrum of the source current harmonics is provided. The frequency spectrums of source current THD analysis in FL controlled and PID controlled DFIG are shown in Figure 9 and figure10, respectively. Table 1 compares the source current harmonic THD values of FLC and PID controlled DFIG. It has been observed that the FLC has a lower THD rate than PID.

Table 2. The THD of stator current

Stator current		
	FLC-controller	PID-controller
THD [%]	0.42	0.98

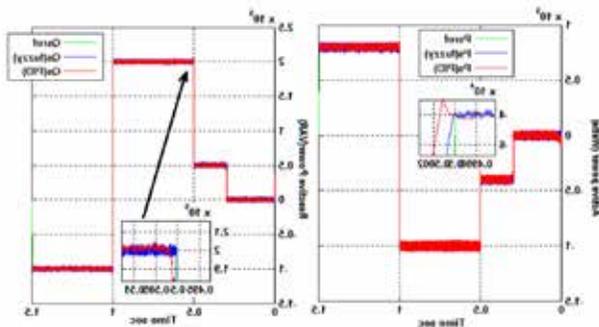


Figure 6. The reactions of the power of the DFIG with Fuzzy controller and PID controller.

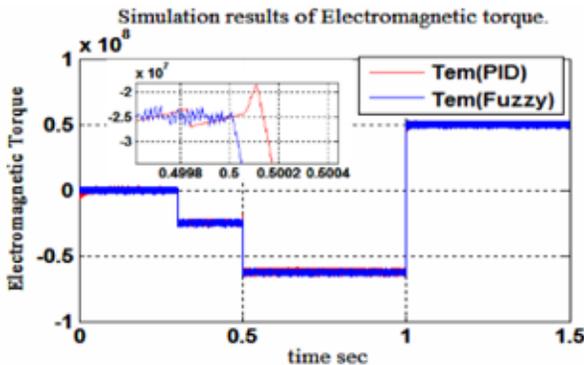


Figure 7. Results of the electromagnetic torque

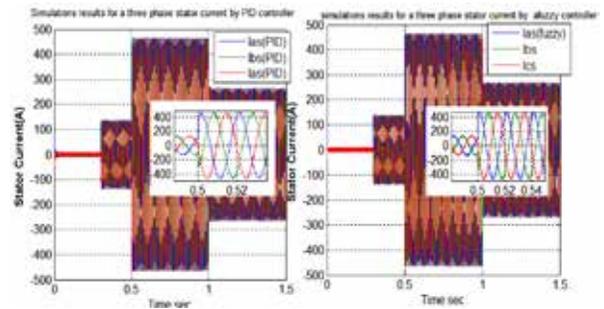


Figure 8. Results for a3phase Stator Current

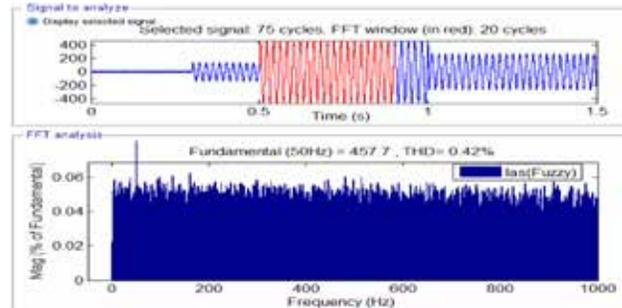


Figure 9. THD of stator current (Fuzzy logic controller)

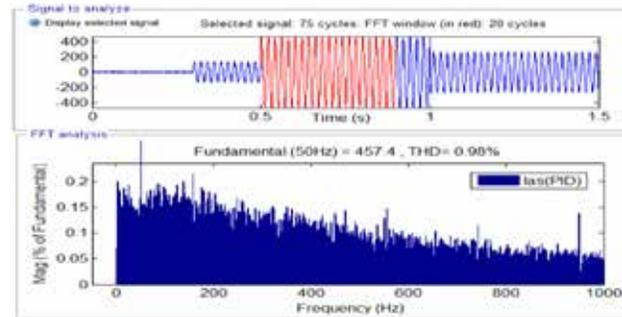


Figure 10. THD of stator current PID controller

ROBUSTNESS TEST (RT)

The resistances values R_r and R_s are multiplied by 2 in this robustness test, while the inductances L_s , L_r , and L_m are multiplied by 0.5. Figs. 11 to 13 display the results of the simulation. These figures demonstrate that these modifications appear to have an impact on reactive power curve, active power curve, and electromagnetic torque curve, with a PID control showing a more pronounced influence than fuzzy control (See Figs. 11-12). The findings demonstrate that the fuzzy control's THD value of stator current has been significantly reduced (See Fig 13).

The comparative study of THD value is shown in Table

2. It has been noted that the FLC's THD rate is lower than the PIDC's. Thus, it can be said that the suggested fuzzy control is superior to the PID control in terms of strength.

Table 2. The THD of stator current (RT)

Stator current		
	FLC -controller	PID-controller
THD [%]	0.49	2.32

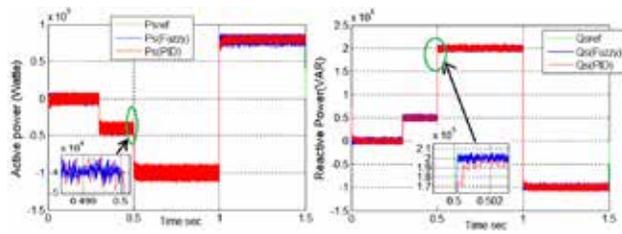


Figure 11. Results of the Power of the chain of wind based on DFIG with Fuzzy controller and PID controller (RT)

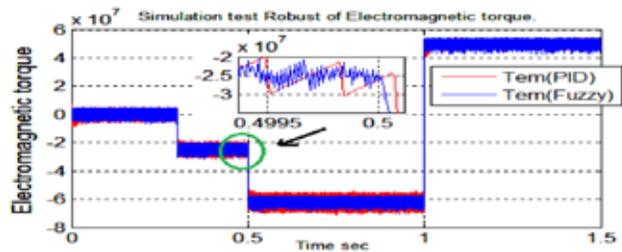


Figure 12. Electromagnetic torque (Test robust)

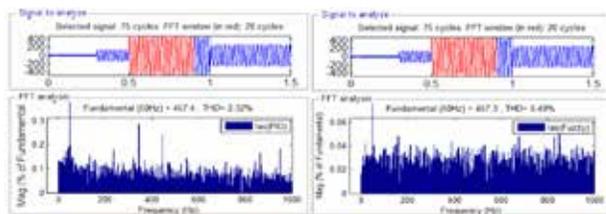


Figure 13. THD of stator current USING Fuzzy logic controller (RT) and PID controller (RT)

CONCLUSION

The system is based on a DFIM with 2-level space vector modulation based on a NN (2L-NSVM) inverter. Under the identical operating conditions, the DFIG reactive and active control with fuzzy logic controller has a smaller overshoots, which gives a faster response, i.e. the system retakes the permanent regimen in lesser time than the PID control, according to simulation findings. This means that the fuzzy control technique

contributes to improvement of the power quality and optimal control of reactive and active energy better than the PID control technique.

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MIMO Antenna for Vehicular Communication

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ABSTRACT

Modern wireless communication methods are hampered by the requirement for high data rates and channel capacity. In order to increase channel capacity, bandwidth, gain, polarisation diversity, and diminish inter-element interaction, several researchers have been motivated to develop MIMO antennas and test their performance in portable wireless communication devices. The results of experiments for 802.11ac and LTE systems, both of which require eight antennas on mobile devices, are presented in this paper. Increasing the number of antennas used in LTE and Wi-Fi networks is a primary area of focus for forthcoming research since it promises a significant increase in data transfer rates.

INTRODUCTION

More and more users want their devices to incorporate multiple antennas because modern wireless communication networks are moving away from Single Input and Single Output (SISO) and Single Input Multiple Output (SIMO) systems and toward “Multiple Input Multiple Output” (MIMO) systems [1],[2]. Multi-input, multi-output (MIMO) wireless transmissions considerably boost capacity without requiring a corresponding boost in transmission power. Multiple-input, multiple-output (MIMO) radio transmission can be used in many contexts [3, 4]. To bring attention to potential performance and space restrictions for future wireless communication systems, we investigate the concept of elevated planar MIMO antennas, which may allow more compact designs for four, eight, or more antennas [5].

ISOLATION TECHNIQUES FOR MIMO ANTENNA SYSTEMS

When one antenna is separated by less than $\lambda/4$, a significant coupling effect occurs. Keeping the antennas on a mobile device at a safe distance apart reduces mutual coupling [6]. It can be placed on either the top two borders or the top and bottom. The placement of antennas affects both the phase and polarisation of coupling currents and fields. Right-angled antennas reduce ground and field coupling [7]. Linearly polarised

antennas positioned orthogonally provide enhanced isolation and polarisation variation [7,8]. However, they demand a large amount of ground and antenna space. ↑

MIMO ANTENNA ARRAY

MIMO systems are able to enhance wireless communication without requiring an increase in either the amount of power or spectrum that would be required by traditional systems. They offer high data rates, reduce the fading caused by multiple paths, improve coverage, and boost both the quality of transmission and the quality of the signal being transmitted. The utilisation of multiple antennas in MIMO systems contributes to both an increase in bandwidth as well as a reduction in the amount of mutual coupling that takes place [17].

To be able to create MIMO antennas for compact devices such as smart phones and tablets, the antennas themselves need to be able to fit inside the device while also preserving a low level of mutual coupling between the radiators. This is a prerequisite for the creation of such antennas. These items call for a number of antennas, all of which must operate in a manner that does not result in interference with the surrounding area. These antennas require a high level of craftsmanship in order to function properly. It is possible for the MIMO technology to increase link range and data throughput without necessitating an increase in bandwidth or transmit power. This would be a significant benefit.

LTE, WLAN (802.11n), and WiMAX (802.16e) all require antennas that have a high radiation directivity, are relatively inexpensive, and are a small size [18].

The Multiple Input Multiple Output (MIMO) technology has been incorporated into the IEEE 802.11n and IEEE 802.11ac Wireless Local Area Networks (WLAN). These MIMO WLAN systems are capable of accommodating up to four antenna elements and four data streams for each individual mobile station or user [19]. Compact MIMO antennas are required for these systems because they operate in the frequency bands of 2.4-2.5 GHz (802.11n) and 4.9-5.725 GHz (802.11n and ac). Another type of cutting-edge wireless communication technology is known as WiMAX bands, and it operates at frequencies ranging from 2.50 GHz to 2.80 GHz. Long Term Evolution, also known as LTE, is the mobile communication standard that will be used by subsequent generations. LTE is expected to operate at frequencies ranging from 400 MHz to 4 GHz and provide high data transfer rates when it does so.

The LTE-D 2600 bands frequencies span a range from 2570 MHz all the way up to 2640 MHz. MIMO antennas, particularly those found in LTE base stations and mobile devices, have the potential to speed up data exchange and achieve high data rate transmission without requiring additional spectrum or increased power. This is because MIMO antennas have multiple inputs and multiple outputs [20]. The MIMO antenna is an obvious candidate for these applications due to its small size, planar shape, and ease of production. These characteristics make it an ideal candidate. In the system that is being proposed, an antenna element that is composed of a concave parabolic reflector, a meander dipole, a rectangular metallic strip, and a parasitic strip might be able to be compact, which means that it might be smaller than designs that have been used in the past. The proposed antenna element has the potential to be utilised in the construction of a four-element MIMO array that is compact, has low correlation, and has a wide bandwidth. According to the findings, the MIMO array that was proposed has the potential to be an outstanding candidate for applications in the LTE 2600 band, the WiMAX bands, and the 2.40 GHz WLAN band (2.5-2.69 GHz).

DESIGNS FOR PLANAR ANTENNAS

In order to provide sufficient pattern diversity for a MIMO system, MIMO antenna elements must often be directional. Since antenna motion causes both spatial and induced pattern diversity, it is necessary to address pattern distortion in order to create highly compact MIMO array topologies with close antennas. The most efficient type of antennas for a wide range of patterns are directional ones. Additionally, using a directive antenna improves performance and reduces interference from other sources. High gain antennas can be used to describe directional antennas. Yagi-Uda antennas, a common approach for building planar-directed antennas, are a simple and uncomplicated way to generate nearly orthogonal patterns. Popularity is due to the Yagi-Uda antenna's high FBR, high gain, and direct end-fire radiation pattern [8].

Because of their low cost, high durability, and excellent compatibility with printed circuit boards, Yagi antennas are widely used in radars, local positioning systems (LPS), and wireless sensor networks. However, increasing gain by 3 dB necessitates a fourfold increase in length, which rules them out for our simple application.

In contrast, Landstorfer antennas have a high gain and low mutual contact between elements. In comparison to microstrip antennas, slot antennas have a greater frequency range. †Since they can be quickly lifted off the ground and assembled again, they are an excellent choice for moving goods that are always on the move. Their inherent characteristics include a large frequency range, a high FBR, and directed emission. However, most parts are single-frequency or single-band [9]. MIMO antennas with a wide bandwidth can cover a lot of ground, thus engineers have developed antennas with varying bandwidths to fulfil the needs of different kinds of wireless networks. The antenna can't be shaped to fit the mounting host because of its non-planar design.

Therefore, paraboloidal antennas can be employed for broadband applications that necessitate a compact planar form factor. This antenna is parabolic in form. Figure 1 illustrates an extension of the notion of reflector antennas to ones that make use of curved reflectors. Assuming the driving element is located at the centre of the parabola, the reflector will produce a parallel beam due to the virtually infinite number of images that can

be formed. The antenna's strong directivity and broad bandwidth are both the result of the parabolic reflector, making it a good fit for MIMO systems.

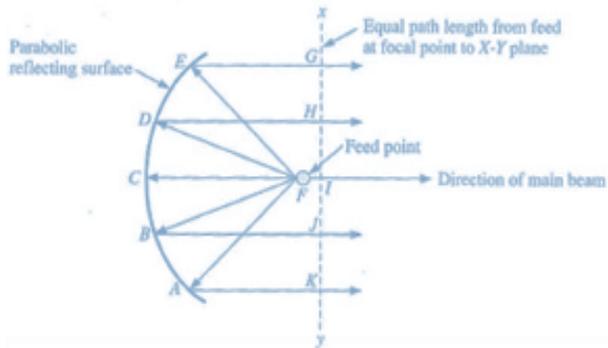


Figure 1: REFLECTOR

Parabolic antennas can also be used for communications between two points with a high gain. Applications that need a narrow beam width need a parabolic antenna that is bigger than the wavelength. Applications that need a wide spectrum can take advantage of the small size of the antenna. To get smaller antennas with the same degree of directivity as a conventional straight reflector, the reflector is shaped as a concave paraboloid [10].

Directional tools like the Dipole unit can be employed by pointing highly focused pencil beams at the concave parabolic reflector. Antennas must be designed to efficiently absorb as much energy as possible from incoming waves and radiate the energy received from a transmission line without losing too much energy to reflection. This means that impedance matching is essential for every antenna element.

DIPOLE

Excellent directivity is produced through the application of directive mechanisms in antenna elements. Dipole units are the most prevalent sort of direction system. A folded dipole operating in half-wavelength mode can be utilised as a very small antenna element. The length of the most common type of antenna, the dipole unit, is exactly half the wavelength of the operating frequency. A dipole is a metal tube or wire that is half the length of a full wave. Electrical engineering can make use of dipoles. When being fed, the impedance is usually at its lowest point in the middle. A feeder connects the two parallel quarter-wavelength elements that make up the

antenna [11].

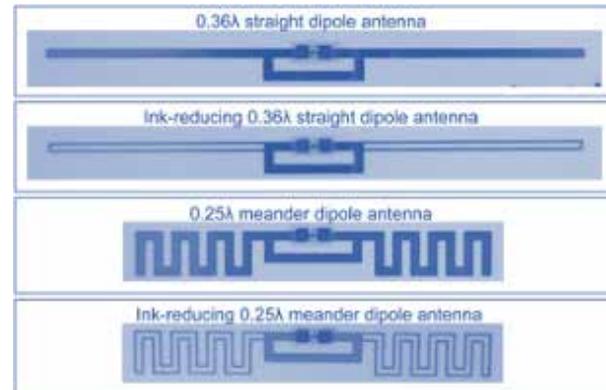


Figure 2: MEANDER-DIPOLE

It is possible to reduce the size of a half-wave dipole by meandering or twisting it. By adjusting the separation between the meander dipole and the parabolic reflector, the resonance frequency can be optimised. It is possible to significantly shorten an antenna without compromising impedance matching, resulting in a smaller antenna.

PARASITIC STRIP

Between the dipole and the reflector, a parasitic strip is inserted to increase the impedance bandwidth while maintaining a small footprint. By connecting the dipole and reflector with a capacitive connection via the parasitic strip, impedance matching can be improved. When the length and positioning of parasitic components are optimised, radiation from the parasitic and driven elements constructively accumulates in a single direction, thereby increasing directivity [12]. As a result of capacitively induced coupling, the original resonant mode shifts to a lower frequency of approximately 2.4 GHz, and a new resonant mode emerges. The newly discovered resonance is a half-wavelength meander dipole. Length of the parasitic strip has an effect on impedance matching.

With the proper combination of dipole, reflector, director, and parasitic strip, a broad operational bandwidth can be attained. When the parasitic strip is accounted for when comparing $|S_{11}|$ with and without the parasitic element, the impedance of the lower band is better matched. The folding pattern of an end dipole has no effect on its behaviour. It functions similarly to

a conventional straight dipole, is easy to tune, and can be cut in half.

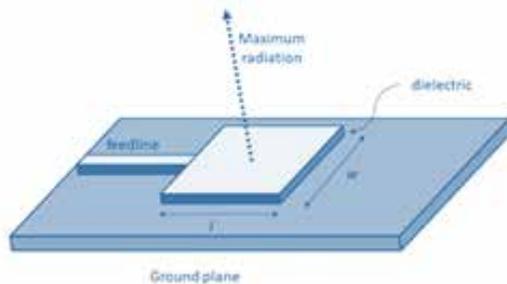


Figure 3: Initial Antenna Element Layout (ROUGH)

It is possible to increase impedance bandwidth and ensure top-band directivity using a rectangular metallic strip. The rectangular shape of the antenna was chosen to allow for a lower profile, and the strip is mounted above the meander dipole on the antenna's top side.

DESIGN OF AN ANTENNA ARRAY

A compact antenna with excellent directivity and a large bandwidth is needed for a MIMO array. The inter-element correlation in the antenna array should be kept to a minimum. Because of this, the placement of each element in the antenna is crucial in order to reduce the amount of energy transferred between them. Therefore, an efficient MIMO antenna system necessitates low mutual coupling between antenna parts [13]. There are multiple reported MIMO antenna designs for wireless applications. In MIMO antennas, achieving high isolation between antenna elements is the primary design challenge. Decoupling elements, defective ground structures, and metamaterials are utilised strategies. It is believed that the usage of metamaterials is the most effective of these strategies.

NETWORK DECOUPLING

When antenna elements interact with one another electromagnetically, this is known as mutual coupling. There will be changes to the antenna's radiation pattern, voltages at the received elements, and element matching as a result. Decoupling networks can lessen their mutual entanglement. They eliminate the coupling caused by nearby antennas and serve to decouple the input ports of neighbouring devices. In order to lessen coupling

and increase isolation between nearby antenna parts, lumped elements have been utilised in conjunction with distributed components.

Decoupling networks have been widely adopted due to their geographical efficacy. Despite the limitation of narrow bandwidth in typical decoupling networks, broad band is produced in parallel resonant circuits, which are appropriate for compact places such as those found in mobile devices.

ELEMENTS OF PARASITIC METALS

The parasitic elements do not interact with the antennas in any way. Interposing such devices between antennas terminates some of the linked fields by generating an anti-coupling field, hence decreasing the total coupling on the target antenna. Resonator stubs, floating stubs, and shorted stubs are the three major categories of stubs. The bandwidth, isolation range, and coupling strength can all be modified with the help of parasitic elements, which are also produced. Using a T-shaped ground stub with a slit between the two square monopole components, we can decrease their mutual coupling [14].

In addition to better antenna matching, the stub's internal slot can reduce coupling between nearby elements by reflecting their radiation. The use of ground plane strips to create a dead zone in the WLAN spectrum is one method for reducing the likelihood of interference. The ground plane is isolated by more than 23 dB over a large frequency range (3.1 GHz to 10 GHz) thanks to the use of rectangle and roundness stepped impedance resonators (R-SIR and RD-SIR, respectively).

By attaching parasitic tape to the microstrip patch antenna, we were able to decrease the mutual coupling by a significant -37.2 dB. Narrow frequency band EBG designs can be made from metallic or dielectric materials arranged in periodic patterns. As a result, EBG structures are utilised to reduce mutual coupling, despite their complexity and size requirements. Mushroom's EBG structure acts as a band-notch filter when placed between two antenna elements, permitting only Transverse Electric (TE) or Transverse Magnetic (TM) waves to pass. This EBG structure, which resembles a mushroom, is equivalent to a parallel LC resonant circuit. The gap introduces capacitance, and the

current in the surrounding cells introduces inductance. As a result, there is less interaction between the parts as surface waves are weakened.

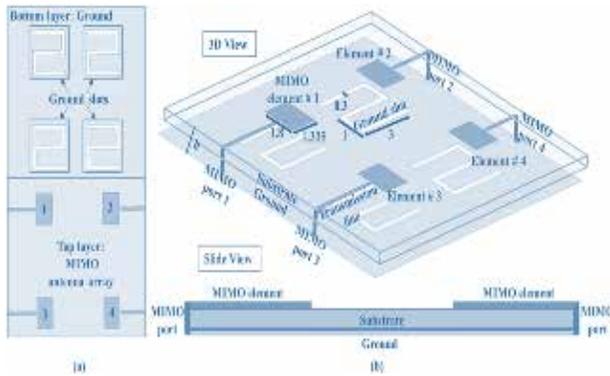


Figure 4: Proposed Antenna Elements for Four Planar

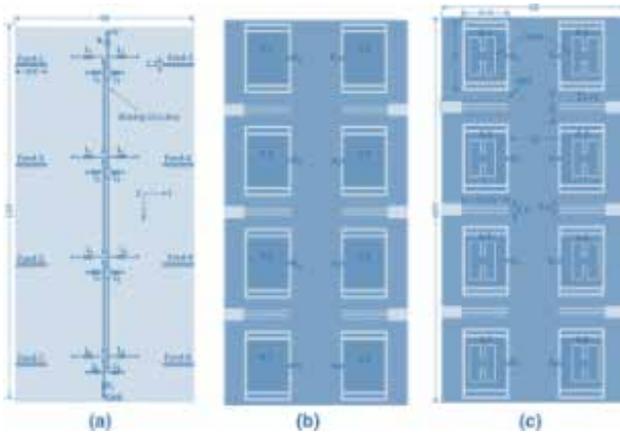


Figure 5: Proposed Antenna Elements for Eight Planar

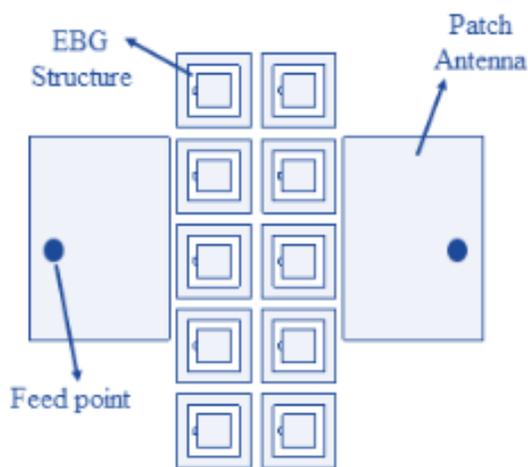


Figure 6: Proposed Antenna Elements for Ten Planar

GROUND STRUCTURES WITH DEFECTS

Current coupling from the ground plane to adjacent elements can reduce the isolation and correlation of an MIMO antenna system. Altering the ground plane can reduce coupling between neighbouring antenna elements. Slits or dumbbell-shaped imperfections can be used to create the desired changes. It functions as a band-stop filter by reducing ground plane current, hence reducing the coupled fields between neighbouring antenna elements.

A DGS can be identified by its band stop features, which block the passage of electromagnetic radiation. The installation of the DGS beneath a transmission line neutralises the EMF fields in the vicinity of the issue [15]. The capacitance effect is caused by electric fields near the DGS, while the inductance effect is caused by superficial currents around a defect. DGS is a band-stop filter that eliminates the higher harmonics.

By etching slits and slots in the ground plane, mutual coupling was reduced, resulting in a flawed ground structure; however, this reduction required a huge ground plane. Due to its complex underlying architecture, DGS systems also provide practical implementation challenges.

METAMATERIALS

Negative permittivity, permeability, or both characterise MTMs. The results indicate that there are two distinct categories of antennas based on metamaterials. The MTM unit cell alone is sufficient for MTM-inspired antennas like the SRR (Split Ring Resonator) and CSRR (Cross-Split Ring Resonator), but MTM-based antennas need an ENG (Epsilon Negative), MNG (-negative), or DNG (Double Negative) substrate (Complementary Split Ring Resonator). Band gap metamaterials (MTM) are used to enhance element isolation. In close proximity, antenna components may have trouble communicating due to band gaps. Split ring resonators (SRRs) and complementary ring resonators (CSRRs) or capacitively-loaded loops are the most frequently used fundamental MTM structures for improving isolation between nearby elements (CLL). If the magnetic field beyond the resonator is perpendicular to the rings, SRR can be utilised to shield against EMFs from a nearby antenna.

Split-Ring Resonators (SRRs) can act as insulators by

blocking the passage of electromagnetic waves, reducing the amount of contact between parts. A time-varying axial electric field (Babinet’s principle) is necessary to turn on the rings, which act as a good negative medium and limit signal transmission at resonance [16].

The reflective and wave-trapping properties of SRR and 1-D EBG structures have been the subject of numerous publications and papers. When compared to the other isolation methods mentioned, metamaterials perform the best. This includes parasitic elements, bad ground structures, and decoupling networks. Using metamaterials, antennas can be significantly reduced in size without sacrificing isolation. Beyond the aforementioned methods, there are others that can be used to lessen coupling. One method of avoiding port coupling is to employ a series of feed points connected by a single cable. By angling the antenna beams at varying degrees, polarisation can be altered (which need not be 90 degrees) [17].

The antenna’s location impacts the phase of the coupling currents and the polarisation of the fields it emits. Antennas placed at right angles to one another reduce ground and field coupling (i.e., 90). Separation and polarisation diversity are achieved through the use of linearly polarised antennas in an orthogonal configuration [21]. However, they need a lot of room for the antenna and a solid foundation. Isolating MIMO antenna systems can be done in a number of different ways, some of which have been reported in the literature. Due to the square loop shape, it is highly unlikely that any two members of Array-1 will come into contact with one another. As an added bonus, Array-1 is significantly more compact than Array-2, whose antenna elements are packed more closely together and frequently touch each other. Mutual coupling affects the performance of a system in terms of pattern diversity. Because of this, reducing mutual coupling is a broad and interesting research topic that has direct applications to 5G and beyond.

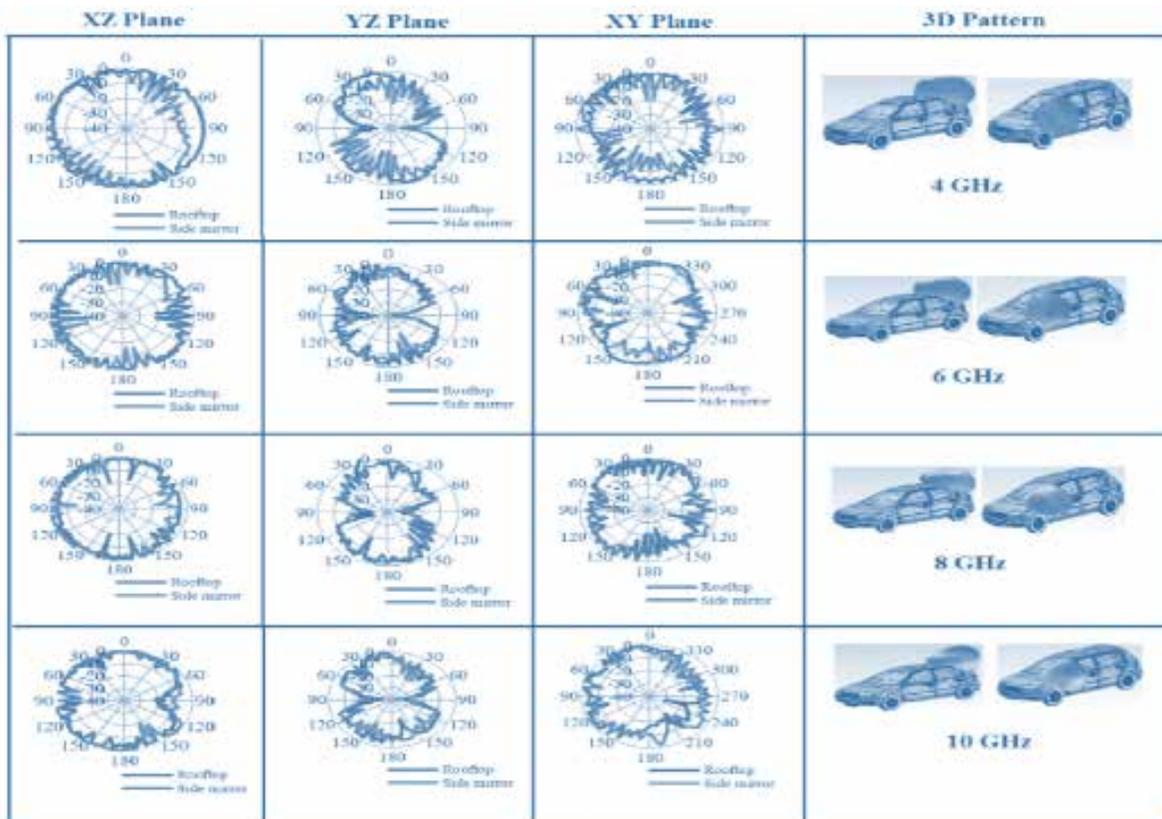


Figure 7: Placement of far-field patterns on a vehicle

PARAMETERS OF THE ANTENNA MOUNTED ON THE VEHICLE

It was essential to investigate how the proposed antenna performed in terms of radiation when installed in a variety of locations within the vehicle. With the help of a CAD model of the vehicle and CST, this were able to simulate the proposed antenna operating in an ideal environment (free space). PECs were used so that the surface of the vehicle could be seen more clearly. At two different points across the vehicle, the radiation characteristics of the antenna were analysed. The antenna installation locations that were chosen were on the rooftop and the side mirrors. Figure 7 shows a variation of the proposed antenna radiation patterns that is acceptable for placement on the body of the vehicle at the frequencies of 4, 6, 8, and 10 GHz (in the x-z, y-z, and x-y planes). At 6, 8, and 10 GHz frequencies, an omnidirectional radiation pattern with deep nulls was observed on the rooftop antenna, whereas the side mirror antenna displayed minimal distortion and maximum radiation ranging between 30 and 90 degrees. As a result, it should come as no surprise that the proposed antenna ought to be installed in the side mirror. Back radiation is present in all positions because the radiant field is dispersed throughout the vehicle's body. This causes back radiation to be present.

LOSS OF RETURN

Another method of conveying that there is an imbalance is to talk about the loss of return. When comparing the power reflected by the antenna to the power input by the transmission line, a logarithmic ratio denoted in decibels is used to make the comparison [22]. The results of the return loss simulation for the frequency range of 8 to 13 GHz are depicted in the figure below. The return loss curve establishes that the operating frequencies fall within the range of 10 to 11 GHz and 11.5 to 13 GHz respectively. The obtained vibrations have a frequency of 10.5GHz and 12.1GHz.

CONCLUSION

Several experts have worked diligently to boost the MIMO system channel capacity, BER, diversity, and gain of multi-element antennas. Despite this, there are several research possibilities for developing strategies to create a small planar antenna construction with

minimal inter-part interaction [25]. For usage in modern broadband wireless networks, we suggest a compact planar MIMO antenna design. In order to achieve better impedance matching in a single element, a parasitic strip can be inserted between the driven dipole and the reflector. By expanding the operational bandwidth with a metal conductor, we are able to make up for the low gain in the higher band. ¶MIMO arrays with high bandwidth, low correlation, and minimal physical size can be constructed from four, eight, or more antenna units. With its compact size and flat, low-profile design, the MIMO array is well-suited for use in a variety of wireless portable device configurations.

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Logistic Route Optimisation based on Geographic Information System (GIS)

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ABSTRACT

In today's dynamic logistics landscape, optimizing route planning and delivery management is crucial for efficient and cost-effective operations. This paper presents the development and implementation of an intelligent route optimization and delivery management system aimed at improving logistics efficiency. The system leverages advanced technologies such as artificial intelligence and data analytics to optimize routes, allocate vehicles, and schedule deliveries. Through the integration of geocoding and mapping services, a robust database management system, and real-time data integration, the system provides logistics managers with a comprehensive platform to streamline their operations. The system's web-based interface, developed using the Streamlit framework, offers a user-friendly experience, allowing users to input delivery requests, manage warehouses and vehicles, and access real-time reports and analytics. The system's architecture, implemented using Spring Boot and Firebase, ensures scalability and data integrity. Performance evaluation results demonstrate significant improvements in route efficiency, resource utilization, and on-time deliveries. Ethical considerations and professional practices were adhered to throughout the project, ensuring proper citation of external sources and the division of tasks among project members. The project's future scope includes the integration of IoT devices for real-time monitoring and the development of a centralized dashboard for comprehensive logistics control and monitoring. Overall, this project showcases the potential of AI-powered systems in revolutionizing logistics operations and provides a solid foundation for further advancements in the field.

KEYWORDS: *Transport, Logistics, Vehicle routing, GIS, Management, Strategic functions, Supply chain Management, Efficient delivery routes, Sustainability, etc.*

INTRODUCTION

In today's fast-paced and highly competitive business environment, effective logistics management plays a critical role in the success of organizations. Efficient route optimization and delivery management are key factors that directly impact operational costs, customer satisfaction, and overall business performance [1]. Traditional manual approaches to logistics management are often time-consuming, error-prone, and inefficient, necessitating the need for intelligent systems to streamline and optimize logistics operations [1].

This paper presents the development and implementation of an intelligent route optimization

and delivery management system aimed at improving logistics efficiency. The system leverages cutting-edge technologies such as artificial intelligence, data analytics, and real-time data integration to optimize routes, allocate vehicles, and schedule deliveries [2]. By harnessing the power of these technologies, logistics managers can make data-driven decisions, resulting in improved resource utilization, reduced delivery time, and enhanced customer satisfaction.

The system incorporates geocoding and mapping services to convert textual addresses into geographic coordinates, enabling accurate location-based calculations and route generation. A robust database management system ensures efficient storage and

retrieval of data related to warehouses, delivery locations, vehicle capacities, and other relevant information. Real-time data integration, including traffic information and road conditions, enhances route optimization accuracy and allows for dynamic adjustments based on changing conditions [3].

The web-based interface of the system, developed using the Streamlit framework, provides a user-friendly platform for logistics managers to interact with the system. It enables users to input delivery requests, set preferences, view optimized routes, and access real-time reports and analytics, empowering them with the necessary insights for effective decision-making. The system's architecture, implemented using Spring Boot and Firebase, ensures scalability, security, and data integrity, while adhering to professional ethical practices.

The objective of this paper is to present the design, implementation, and performance evaluation of the intelligent route optimization and delivery management system. The paper will discuss the system's architecture, algorithms, and methodologies employed for efficient route optimization and delivery scheduling. Additionally, it will highlight the results and findings of performance evaluations, showcasing the improvements achieved in route efficiency, resource utilization, and on-time deliveries.

Overall, this research contributes to the field of logistics management by demonstrating the potential of intelligent systems in revolutionizing logistics operations. The findings and insights presented in this paper provide a solid foundation for further advancements in logistics optimization and pave the way for enhanced operational efficiency, cost savings, and improved customer satisfaction in the logistics industry.

METHODOLOGY

Problem Formulation

The problem addressed in this project is the optimization of delivery routes in a logistics system. The objective is to design an efficient routing system that minimizes the total distance traveled by the vehicles, maximizes vehicle utilization, ensures timely deliveries, optimizes resource allocation, and adapts to real-time changes.

The project aims to develop an algorithmic solution that takes into account various factors such as vehicle capacities, delivery locations, time windows, and real-time data to generate optimized routes for the delivery vehicles. [4], [5] The objectives of this project can be summarized as follows:

- 1) **Minimize Distance:** The primary objective is to minimize the total distance traveled by the vehicles while visiting all the delivery locations. By optimizing the routes, the system aims to reduce fuel consumption, transportation costs, and overall travel time.
- 2) **Maximize Vehicle Utilization:** Another objective is to maximize the utilization of the vehicles' capacities. Efficiently assigning delivery locations to vehicles ensures that each vehicle is loaded to its maximum capacity, minimizing the number of vehicles required for deliveries.
- 3) **Ensure Timely Deliveries:** The system aims to ensure that deliveries are made within the specified time windows or with minimal delays. By considering factors such as traffic conditions and time constraints, the optimization algorithm aims to create routes that allow for timely and efficient deliveries.
- 4) **Optimize Resource Allocation:** The project also aims to optimize the allocation of resources, such as vehicles and drivers, to minimize idle time and maximize their utilization. By intelligently assigning deliveries to available resources, the system can achieve a more efficient allocation of resources.
- 5) **Adaptability to Real-Time Changes:** The system should be able to adapt to real-time changes, such as traffic congestion or new delivery requests. By integrating real-time data and incorporating flexibility into the routing algorithm, the system can dynamically adjust the routes to accommodate changes and maintain efficiency.

Model Development

In this project, the model development involves designing an algorithmic solution to optimize the delivery routes in a logistics system. The model integrates various

components and algorithms to achieve the desired objectives of minimizing distance, maximizing vehicle utilization, ensuring timely deliveries, and optimizing resource allocation.

The model development process can be summarized as follows:

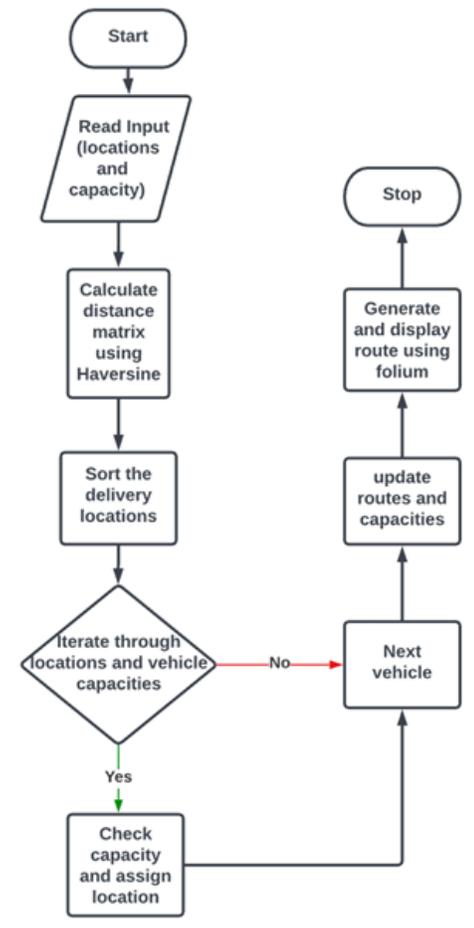
- 1) **Data Collection:** The first step is to collect relevant data, including delivery locations, vehicle capacities, delivery capacities, time windows, and real-time data such as traffic information. This data serves as input for the model.
- 2) **Distance Calculation:** The model calculates the distance matrix between all pairs of delivery locations using the Haversine formula or a suitable distance calculation method. This distance matrix is used in subsequent steps for route optimization.
- 3) **Route Optimization:** The model applies a route optimization algorithm to determine the most efficient routes for the delivery vehicles. This algorithm considers factors such as vehicle capacities, delivery capacities, time windows, and real-time data to generate optimized routes. Various algorithms such as the Traveling Salesman Problem (TSP) algorithm or heuristic-based algorithms can be employed for this purpose.
- 4) **Resource Allocation:** The model optimizes the allocation of resources, including vehicles and drivers, to maximize their utilization. It assigns delivery locations to vehicles based on their capacities and ensures that each vehicle is loaded to its maximum capacity. This optimization helps in reducing the number of vehicles required for deliveries and minimizing idle time.
- 5) **Real-Time Adaptability:** The model incorporates real-time data integration to adapt to dynamic changes such as traffic conditions or new delivery requests. By continuously monitoring and analyzing real-time data, the model can dynamically adjust the routes to optimize delivery efficiency and ensure timely deliveries.
- 6) **Visualization and Reporting:** The model provides visualization capabilities to display the optimized routes on interactive maps using tools such as

Folium. It also generates reports and analytics to provide insights into route performance, resource utilization, and other relevant metrics.

The model development process involves iteratively refining and optimizing the algorithms based on experimentation and testing. It aims to develop a robust and scalable solution that can handle large-scale logistics operations efficiently [6], [7].

Route Optimization Algorithm

- 1) **Input:** Delivery locations, vehicle capacities, and delivery capacities.
- 2) **Output:** Optimized routes, remaining capacities, and route plot map.



The algorithm (see fig 1) starts by reading the input data, including delivery locations, vehicle capacities, and delivery capacities. It then calculates the distance matrix using the Haversine formula. The delivery

locations are sorted based on their priority, and empty lists are initialized to store the routes and remaining capacities [8].

Next, the algorithm iterates through each delivery location and each vehicle capacity to find the best vehicle for each delivery. It checks if the current vehicle capacity can accommodate the delivery capacity and assigns the delivery location to the current vehicle route if possible. The algorithm then updates the current capacity and moves to the next vehicle capacity if needed [9].

After iterating through all delivery locations, the algorithm generates a route plot map using the Folium library. This map visually represents the optimized routes and provides a clear visualization of the delivery paths [10].

Finally, the algorithm displays the optimized routes, remaining capacities, and the route plot map as the output.

The Route Optimization Algorithm effectively optimizes the delivery routes by considering factors such as distance, vehicle capacities, and delivery capacities. The algorithm ensures efficient resource allocation, minimizes travel distances, and maximizes vehicle utilization, leading to cost-effective and time-efficient delivery operations in the logistics system [11], [12].

Lets understand this with an example: Let's assume we have a warehouse at coordinates (18.585163838741693, 73.73761380725425) and three delivery locations:

- Delivery location 1 - (18.52898154265345, 73.87443120791853) - Distance with warehouse: 20.1 kms
- Delivery location 2 - (18.595826100201542, 73.72716739535825) - Distance with warehouse: 4.4 kms
- Delivery location 3 - (18.579040481797367, 73.90857735964006) - Distance with warehouse: 25.8 kms

For this example let's take the number of drivers to be 3. So our algorithm would assign as follows:

- Driver 1 will be assigned to Delivery location 2 (nearest to the warehouse).

- Driver 2 will be assigned to Delivery location 1 and location 3 in this order.

For the case where both intra and inter-city routes are considered Here's how the algorithm will work:

- Calculate Distances:
 - Calculate both intra-city and inter-city distances for all possible routes from the warehouse to each delivery location.
- Driver Assignment:
 - Identify the closest delivery location within the same city for each driver.
 - If there are remaining undelivered locations within the same city, assign them to the available drivers based on proximity.
 - If there are inter-city delivery locations, assign them to the available drivers based on the closest city.
- Optimization:
 - Optimize the order of delivery locations for each driver to minimize travel distance within the city and between cities.
- Final Assignment:
 - Assign the optimized delivery order to each driver, considering both intra and inter-city routes.

For example:

- Driver 1 may handle intra-city deliveries within City A and potentially an inter-city delivery to City B if it's the closest.
- Driver 2 may handle intra-city deliveries within City B and potentially an inter-city delivery to City A if it's the closest.

Algorithm Generating Optimized Route Map

- 1) Inputs: coordinates: List of coordinates representing delivery locations.
- 2) Outputs: map object: Generated map object showing the optimized route.

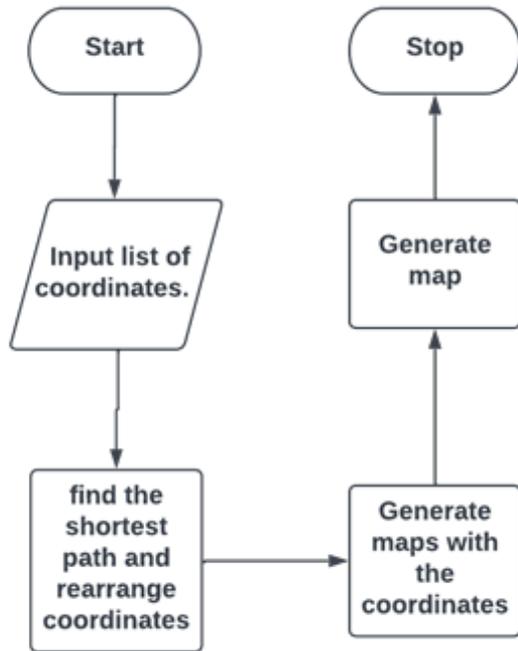


Fig. 2. Data flow diagram for generating optimized route map

The algorithm starts by taking a list of coordinates as input. It then proceeds to calculate the shortest path order and rearranges the coordinates using the tsp function. The resulting shortest path order is stored in the shortest path variable, and the rearranged coordinates are stored in the coords list variable. Next, the generate osm path function is called with coords list and the graph object to generate the optimized paths. The resulting paths are stored in the finalRoute variable. To visualize the optimized routes, the plot map function is invoked with finalRoute, the first coordinate from coords list, and a zoom level of 12. The function generates a plot of the route map. Finally, the generated map object is returned as the output, and the algorithm terminates [13].

RESULTS AND DISCUSSION

The development of the logistics management system has been a significant endeavor aimed at streamlining and optimizing delivery operations. The project successfully addressed the challenges of managing complex logistics networks by leveraging modern technologies and algorithms. Various technologies

and frameworks were employed, such as Streamlit, Geopy, OSMnx, and Folium, to provide a user-friendly interface, accurate location-based calculations, route optimization, and visualization of optimized routes (see Fig 3).

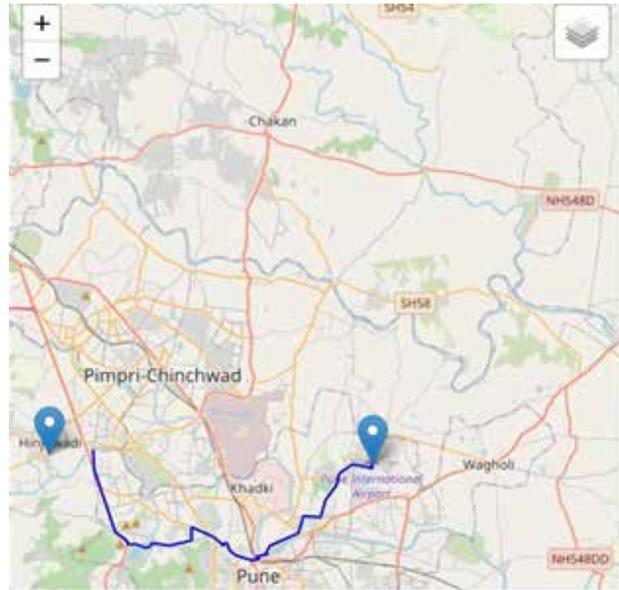


Fig. 3. Screenshot of the logistics management system website displaying the optimized route map

The implementation followed a well-defined architecture, encompassing frontend and backend development using frameworks like Spring Boot and Flask, along with integration with the Firebase database. Ethical practices were followed throughout the project, ensuring proper citation, task division, and responsible data handling. The algorithmic components played a crucial role in the system’s success. The distance calculation algorithm accurately determined distances between delivery locations using geopy.distance. The route optimization algorithm employed a heuristic search and greedy approach to efficiently determine optimal routes considering vehicle and delivery capacities.

The development and implementation of the intelligent route optimization and delivery management system represent a significant advancement in the field of logistics. This section aims to provide a deeper understanding of the implications and significance of the research findings and their potential impact on logistics

operations, sustainability, and future developments in the industry.

- A. **Maximizing Resource Utilization** One of the noteworthy outcomes of the research is the maximization of resource utilization, particularly in terms of vehicle capacities. The system's route optimization algorithm intelligently assigns delivery locations to vehicles based on their capacities, ensuring that each vehicle is loaded to its maximum capacity. This approach minimizes the number of vehicles required for deliveries, reducing operational costs and contributing to sustainability efforts by reducing the carbon footprint associated with logistics operations [14].
- B. **Enhancing Logistics Efficiency** The core objective of this research project was to enhance logistics efficiency, and the results clearly demonstrate the achievement of this goal. By leveraging cutting-edge technologies such as artificial intelligence and data analytics, the system has successfully optimized delivery routes, leading to a substantial reduction in the total distance traveled by vehicles. This reduction translates into cost savings, reduced fuel consumption, and decreased transportation time. Logistics managers can now make data-driven decisions, resulting in improved resource utilization and significant improvements in overall operational efficiency [15].
- C. **Ensuring Timely Deliveries** Timely deliveries are crucial for customer satisfaction and are often a significant challenge in logistics management. The system's ability to consider factors such as time windows and real-time data, including traffic conditions, has led to more reliable and punctual deliveries. This not only enhances customer satisfaction but also allows logistics managers to meet service level agreements more consistently.

The intelligent route optimization and delivery management system showcased in this research paper are poised to make a substantial impact on the logistics industry. With its proven ability to enhance efficiency, maximize resource utilization, and adapt to real-time changes, this system represents a valuable tool for

logistics managers striving to meet the evolving demands of the modern logistics landscape. The integration of advanced technologies and ethical considerations in this research paves the way for a more sustainable and efficient future in logistics management [16].

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Real-Time Adaptive Animation Transform (AAT): A Deep Learning Solution

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ABSTRACT

The paper proposes an alternative to Motion Matching that combines the benefits of neural-network-based models and Motion Matching. Using Neural Network methods is effective in learning expressive regulators via a large dataset, yet Motion Matching remains prevalent due to its adaptability, certainty, minimal conditioning duration, and aesthetic appeal. However, the straight-line expansion of resource consumption with the data size makes it challenging to achieve both diversity and production budgets with Motion Matching. The proposed approach breaks down Motion Matching into individual steps and replaces each operation with learned, scalable alternatives. The resulting model avoids the necessity of saving the illustration details or extra matching overhead data in RAM, allowing for efficient scalability while maintaining the merit, command, and short cycle time of Motion Matching. The purposed paradigm effectively curtails resource consumption by nearly 50%, thereby rendering the application deployable on systems with modest specifications.

KEYWORDS: *Adaptive animation transform (AAT), Autoencoders, Generative animation model, Quaternion.*

INTRODUCTION

As video games continue to demand more complex and immersive environments, producing characters that respond realistically to various situations has become increasingly challenging. Furthermore, AAA video games now include huge amount of (in ten thousands) original animations that must be sought out in the right circumstances, which requires a significant amount of data. To address these issues, Clavet and Büttner introduced Motion Matching, which allows animators to describe the animation specifications they want and then automatically selects the best match from a large database of animations using a nearest neighbor search.

To improve upon Motion Matching, some researchers are exploring a new method called adaptive animation transform. This approach seeks to provide even greater control and flexibility to animators. Adaptive animation transform is a data-driven approach that allows animators to create animations using a set of rules that specify how

the animation should behave in different contexts. The system then uses machine learning algorithms to learn how to map these rules to the animation data in a way that allows it to adapt to new situations.

Like Motion Matching, adaptive animation transform can handle a vast number of transitions and interactions, and it also preserves quality and allows animators to retain control. Additionally, it can be adjusted in real-time, resulting in quick iteration times. However, adaptive animation transform has some advantages over Motion Matching. As an example, it enables more potent data processing techniques, including autonomous data augmentation, and it is better able to adjust to changing circumstances.

Recently, interest in neural network-based generative motion models has increased in the academic community due to their low memory consumption, high data scalability, and fast runtime evaluation. Although these models have proven effective in generating realistic motion in difficult cases, they frequently

require extensive training, have unpredictable behavior, and are tough to handle. The animation might not be as high-quality as the training set.

To address these issues, a method called Adaptive Animation Transform is presented that combines the benefits of neural network-based models and the scalability of motion matching. The motion matching algorithm is divided using this technique into three unique neural networks. Depending on the demands of your controller, they can be utilized individually or in several combinations. The authors were able to produce animation that met the highest standards for animation quality, runtime efficiency, and memory utilization in this fashion.

LITERATURE REVIEW

The authors of a recent study have introduced a new approach for selecting poses in motion matching that reduces computational load and prevents unnecessary pose matches. This method achieves these goals by restricting the number of poses that need to be found and using a table to return a subset of poses as the search space in real-time. By doing so, the proposed method can significantly speed up the pose selection process and improve the efficiency of the overall motion matching technique.

To elaborate on this, motion matching, a popular animation technique that incorporates a database of motion captures to select the most appropriate motion for a given context. However, the process of selecting the best pose from a large database of motions can be computationally expensive and time-consuming, especially in real-time applications like video games. The proposed method addresses this challenge by reducing the number of poses to search and using a table to quickly return a subset of relevant poses. By doing so, the method can significantly reduce the computational cost of pose selection and enable real-time motion matching with high accuracy and efficiency. This approach has potential applications in the development of interactive media, virtual reality, and other real-time animation systems where fast and efficient pose selection is crucial [1,2].

Authors of Paper [3] initiate a novel approach to human motion synthesis and control using a combination of

RNNs and adversarial training. The method involves training a deep-learning network with two components: an RNN model using LSTM cells to generate motion sequences and a refiner network that refines the generated sequences using an adversarial loss. The resulting model is highly efficient, contact-aware, and capable of producing natural and realistic motions of any length. This makes it a valuable tool for motion synthesis and control. The authors demonstrate the effectiveness of the model by applying it to various scenarios and comparing its performance against baseline models. This new method has the implicit ability to expand the excellence and proficiency of motion synthesis and control in various fields, including robotics, gaming, and animation.

Introduces a unique neural network design known as mode-adaptive neural networks in article [4] designed to control four-legged characters. A motion estimation network and a gating network are the two halves of the system [5]. A gating network actively updates the weights of the motion estimation network to permit the system to react to changes in the environment while a motion estimation network forecasts the character's future movement. This architecture is capable of learning reliable expert weights for both periodic and aperiodic actions.

One of the strengths of this system is that it can generate responsive motion in real-time without requiring complex motion labelling [6]. In addition, the design is suited for encoding the multimodality of quadruped movement, meaning that it can handle a variety of different movements in a flexible manner. This makes it a useful tool for controlling quadruped characters in applications such as video games or robotics. The effectiveness of the model is demonstrated through experiments comparing it to other baseline models [7].

The article [8] suggests a new deep learning approach for creating various martial arts motions in a controllable manner. It overcomes issues with blending and editing movements by using animation layering and neural networks. The approach can produce new movements, recreate the movements of experienced fighters, and produce interactive motions by learning joint relationships. The system is made up of motion generators and control modules that can be trained

independently to create new motion tasks and reduce iteration time. The interface is transparent, allowing animators to modify or combine movements, and can be used both offline and online, making it ideal for real-time applications like computer games.

Li et al. proposes research entitled “Interactively synthesize new combinations and variations of character movements from different movement skills using a modular deep learning framework” [9] offers an innovative deep learning framework for controllably generating a variety of martial arts movements from motion capture data. A source of motion and a diversity of numerous control modules make up the framework. Each control module may be customized and taught to accommodate new motion tasks. To avoid the lengthy training times that are typical of end-to-end systems, the authors employ a modular approach to separate the motion generation procedure and control generation process. They show that their system can create a variety of movements using pre-defined reference motions and straightforward user commands in addition to generating previously unexplored orders of locomotion, punching, kicking, evading, and amalgamations therefrom.

Previous work in the field of computer animation has also explored the use of deep learning techniques for motion synthesis. Holden et al. [10] proposed a method for synthesizing dynamic human motions from motion capture data using deep learning. Their approach uses a combination of a variation autoencoder and a recurrent neural network to understand a low-dimensional depiction of the motion data and generate novel sequences of motions. Similarly, Zhu et al. [11] suggested a generative adversarial network-based method for synthesizing realistic human motions from motion capture data. They show that their approach can generate high-quality motions that are consistent with the input motion data.

Another related area of research is motion retargeting, which involves transferring the motion from one character to another. [12] suggested a procedure for transferring the movement between characters with different body shapes using a deep neural network. They show that their approach can transfer motion while preserving the original motion style and reducing the artifacts caused by differences in body shape. Zhang

et al. [9] suggested a method for motion retargeting that makes use of a combination of a pose-based motion generator and an adversarial loss to ensure that the generated motion is consistent with the input motion data.

Context-aware animation systems for games have been gaining attention in recent years as they offer a more immersive and engaging gameplay experience by adapting the game’s animations to the player’s context [13]. Several studies have proposed different approaches and techniques to design and implement context-aware animation systems. For instance, a 2019 study by Ji et al. proposed a context-aware animation system that uses machine learning techniques to predict the player’s intended actions and adjust the animation accordingly [14]. Another 2020 study by Wu et al. proposed a context-aware animation system for fighting games that adapts the game’s animations to the player’s playstyle and opponent’s movements [15].

DATASET

Human Motion Capture Dataset: This collection includes motion capture data for several human actions including sprinting, leaping, and walking. There are 1000 motion capture sequences overall, with 100 frames in each. There are 200 sequences in the testing set and 800 sequences in the training set of the dataset.

Character Animation Dataset: This dataset contains motion capture data for a variety of characters, such as humans, animals, and robots. It contains a total of 500 motion capture sequences, each of which is 100 frames long. A training set of 400 sequences and a testing set of 100 sequences are separated from the dataset.

Gameplay Dataset: This dataset contains motion capture data from a variety of games, such as FPS, third-person action games, and Formula one and racing. It contains a total of 200 motion capture sequences, each of which is 100 frames long. A set of data used for training is 160 sequences and a testing set of 40 sequences are separated from the dataset.

METHODOLOGY

From the analysis of Figure 1, The Motion Matching algorithm has three primary stages that are repeated every N frame to ensure continuity. In the Projection

stage, to locate the attribute, the closest neighbour search is employed. that most closely matches the query vector in the Matching Database. In the Stepping stage, the index in the Matching Database is advanced forward. In the Decompression stage, the corresponding pose in the Animation Database is retrieved based on the recent index in the Matching Database.

However, the main drawback of this arrangement is its dependence on the attributes Y and X, which necessitate huge memory allocations and raise as more animations, pose features, or matching features are added. To address this issue, the authors propose a solution that entails creating deep learning substitutes for each of the three important stages, thereby eradicating the need to save any data.

A decoder network called Decompressor gets trained to reduce dependence on Y, taking x and latent attributes z (from Compressor) as input to generate output pose y. To obviate the dependence on X, the authors trained two networks that function in concert: the Stepper and the Projector. Stepper advances feature vectors forward in time., generating x_{i+1} and z_{i+1} based on x_i and z_i , respectively. The Projector approximates the nearest neighbor search by taking a query vector \hat{x} as input. The it maps it to the feature vector x_k^* and latent variables z_k^* of the closest equivalent in the dataset.

Decompressor

The primary aim of the proposed method is to circumvent the storage of the entire animation database Y in memory by constructing the corresponding pose y_i at a particular frame x_i based on the feature vector. Although the feature vector contains important information about the pose, like as position and velocities on hand, it often lacks sufficient information to infer it entirely. Hence, the method incorporates additional latent variables z_i , which the model learns through an autoencoder-like structure.

The proposed architecture includes two neural networks, namely the Compressor and Decompressor. The Compressor maps a pose y_i to a lower structural representation z_i , which is then combined with x_i and fed into the Decompressor to reconstruct the original pose. The architecture enables the model to learn what additional information is required to generate the pose and encode it in z.

The loss function of the Decompressor is critical to the network’s performance. The use of a mean squared error loss produces jerky, low-quality motion. Instead, the suggested technique uses a loss function intended to reduce visually apparent mistakes, which leverages forward kinematics which in turn assess the delta in character space and velocity-based losses. Regularization losses on Z are also used to create sparsity and smoothness.

Algorithm 1 is used for training, and it uses a pair of identical frames to acquire latent parameters Z utilizing the Compressor, whilst the Decompressor seeks to recover the original position. When updating network parameters, the method continues for each of the components in a mini-batch, and the outcome is averaged. Finally, the Decompressor can be used as an universal compression technique to compress animation data, even with no presence of matching features, by reducing its dimension of z and keeping z_i for each frame i.

Even though the Decompressor disables the requirement to retain Y in memory, X and Z are still needed, and both can be large when a large number of corresponding features or latent variables are used. Nevertheless, the proposed architecture offers a very efficient compression

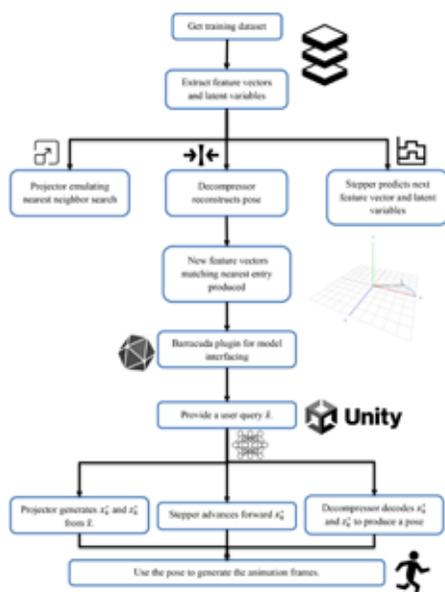


Figure 1: Proposed model flow diagram for Adaptive Animation Transform (AAT)

technology for motion data, improving resource utilization and lowering memory requirements.

Algorithm for Decompressor:

BEGIN

Step 1: Calculate forward kinematics

$$Q \leftarrow \text{ForwardKinematics}(Y) \quad (1)$$

Step 2: Produce latest attributes Z

$$Z \leftarrow C([Y \ Q]^T; \theta_c) \quad (2)$$

Step 3: Reconstruct pose \tilde{Y}

$$\tilde{Y} \leftarrow D([X \ Z]^T; \theta_D) \quad (3)$$

Step 4: Reiterate forward kinematics

$$\tilde{Q} \leftarrow \text{ForwardKinematics}(\tilde{Y}) \quad (4)$$

Step 5: Compute latent regularization losses

$$\mathcal{L}_{\text{reg}} \leftarrow w_{\text{lreg}} \|Z\|_2^2 \quad (5)$$

$$\mathcal{L}_{\text{sreg}} \leftarrow w_{\text{sreg}} \|Z\|_1 \quad (6)$$

$$\mathcal{L}_{\text{vreg}} \leftarrow w_{\text{vreg}} \left\| \frac{Z_0 - Z_1}{\delta t} \right\|_1 \quad (7)$$

Step 6: Local and character space losses

$$\mathcal{L}_{\text{loc}} \leftarrow w_{\text{loc}} \|Y \ominus \tilde{Y}\|_1 \quad (8)$$

$$\mathcal{L}_{\text{chr}} \leftarrow w_{\text{chr}} \|Q \ominus \tilde{Q}\|_1 \quad (9)$$

Step 7: Local and character space speed losses

$$\mathcal{L}_{\text{lvel}} \leftarrow w_{\text{lvel}} \left\| \frac{Y_0 \ominus Y_1}{\delta t} - \frac{\tilde{Y}_0 \ominus \tilde{Y}_1}{\delta t} \right\|_1 \quad (10)$$

$$\mathcal{L}_{\text{cvel}} \leftarrow w_{\text{cvel}} \left\| \frac{Q_0 \ominus Q_1}{\delta t} - \frac{\tilde{Q}_0 \ominus \tilde{Q}_1}{\delta t} \right\|_1 \quad (11)$$

Step 8: Update network parameters

$$\Theta_c \ominus \theta_D \leftarrow \text{RAdam}(\theta_c \ominus \theta_D, \nabla \sum \mathcal{L}^*) \quad (12)$$

TERMINATE

Stepper

A Stepper network is necessary to advance through time and retrieve the following consecutive vectors in adaptive animation transformation. The Stepper network receives both matched and latent vectors of features from the current frame and produces a delta that may use to build feature vectors during the following structure. The Stepper network is taught using an auto-

regressive technique, which predicts a subsequent assortment of feature and latent variables based on a small window of s feature and latent data. Once trained, the network can be used to replace the stepping element of the pipeline, creating a continuous flow of combining and latent vectors of features without the use of X or Z .

In previous work, we have addressed the aforementioned limitation by training a network to directly map a user query \hat{x} to x and z . This approach allows for the efficient retrieval of the corresponding feature and latent vectors without the need for X and Z to be stored in memory. The network, which we call the Query network, takes as input the query feature vector and outputs both the corresponding feature and latent vectors. To train the Query network, we employ a triplet loss function, which minimizes the distance between the positive pair (the correct feature and latent vectors for the query) and maximizes the distance between the negative pair (the incorrect feature and latent vectors).

In addition to the Stepper and Query networks, we employ a Matcher network, which computes the nearest neighbor in Y to a given set of matching and latent feature vectors. The Matcher network is trained using a contrastive loss function, which encourages the network to place the matching feature vectors and their corresponding latent variables close together in the embedding space. By utilizing the Stepper, Query, and Matcher networks, we can generate a flow of corresponding and latent feature vectors lacking requiring X or Z to be stored in memory, while also enabling efficient nearest neighbor search.

Algorithm for Stepper

BEGIN

Step 1: Method Call

Train Stepper (X, Z, s, Θ_S)

$$\tilde{X}_0, \tilde{Z}_0 \leftarrow X_0, Z_0 \quad (13)$$

Step 2: Estimate \tilde{X} and \tilde{Z} over a certain number of frames(S).

for $I \leftarrow 1$ to s do

Step 3: Estimate deviations for \tilde{X} and \tilde{Z}

$$\delta \tilde{x}, \delta \tilde{z} \leftarrow S([\tilde{X}_{i-1} \ \tilde{Z}_{i-1}]^T; \theta_S) \quad (14)$$

$$\tilde{X}_i \leftarrow \tilde{X}_{i-1} + \delta \tilde{x} \quad (15)$$

$$\tilde{Z}_i \leftarrow \tilde{Z}_{i-1} + \delta \tilde{z} \quad (16)$$

End

Step 4: Calculate losses

$$\mathcal{L}_{xval} \leftarrow W_{xval} \| X - \tilde{X} \|_1 \quad (17)$$

$$\mathcal{L}_{zval} \leftarrow W_{zval} \| Z - \tilde{Z} \|_1 \quad (18)$$

$$\mathcal{L}_{xvel} \leftarrow W_{xvel} \left\| \frac{X_{0 \rightarrow s-1} - X_{1 \rightarrow s}}{\delta t} - \frac{\tilde{X}_{0 \rightarrow s-1} - \tilde{X}_{1 \rightarrow s}}{\delta t} \right\|_1 \quad (19)$$

$$\mathcal{L}_{zvel} \leftarrow W_{zvel} \left\| \frac{Z_{0 \rightarrow s-1} - Z_{1 \rightarrow s}}{\delta t} - \frac{\tilde{Z}_{0 \rightarrow s-1} - \tilde{Z}_{1 \rightarrow s}}{\delta t} \right\|_1 \quad (20)$$

Step 5: Update network parameters

$$\theta_S \leftarrow RAdam(\theta_S, \nabla \sum^* \mathcal{L}^*) \quad (21)$$

TERMINATE

Projector

The proposed model uses the Stepper network to advance in time using the adaptive animation transform, which creates a difference that is applied to construct the feature vectors for the next frame. On the other hand, the closest neighbor search requires the corresponding database X to be retained in memory. Thus, presenting the Projector, a novel algorithm that emulates the behavior of nearest neighbor search and generates feature vectors for the closest items from the query vector x .

The model describes the training procedure for the Projector in Algorithm 3. Start by selecting a feature vector x referring the corresponding Dataset and adding Gaussian noise vector scaled by a noise magnitude n^σ to create \hat{x} . Then, we find the nearest neighbor k^* and train the Projector to yield the corresponding feature vector and latent variables x_{k^*} and z_{k^*} . To ensure robustness, sample noise magnitudes of different sizes and assign weights to give equal weight to all losses. Then apply this procedure to every factor in the mini-batch followed by averaging the outcome when relearning the constraints θ_P .

Once trained, Projector replaces nearest neighbor search in the Adaptive Animation Transform (AAT) pipeline. At every other N frame, user passes \hat{x} through the Projector P instead of performing a nearest neighbor search. The Stepper network S is then used to advance

the matching and latent feature vectors and generate a pose using the Decompressor D for each frame.

In conclusion, the Projector network is proposed as a solution to eliminate the need for the matching database X and latent variables Z in memory. By emulating the behavior of nearest neighbor search, the Projector generates feature vectors that match the closest access from the query vector \hat{x} . The training procedure involves adding Gaussian noise vectors to the feature vectors and finding the nearest neighbor to train the Projector to yield the corresponding feature vector and latent variables. Once trained, the Projector replaces the nearest neighbor search in the AAT pipeline, and the Stepper network is used to advance the matching and latent feature vectors and generate a pose for each frame.

Algorithm for Projector

BEGIN

Step 1: Method call

TrainProjector(x, X, Z, θ_p)

Step 2: Define attributes.

$$n^\sigma \sim U(0,1) \quad (22)$$

$$n \sim N(0,1) \quad (23)$$

Step 4: Add noise to element vector.

$$\hat{x} \leftarrow x + n^\sigma n \quad (24)$$

Step 5: Computing the nearest neighbor

$$k^* = \text{Nearest}(\hat{x}, X) \quad (25)$$

Step 6: Prepare element vector

$$\tilde{x}, \tilde{z} \leftarrow P(\hat{x}; \theta_p) \quad (26)$$

Step 7: Finding losses.

$$\mathcal{L}_{xval} \leftarrow W_{xval} \| x_{k^*} - \tilde{x} \|_1 \quad (27)$$

$$\mathcal{L}_{zval} \leftarrow W_{zval} \| z_{k^*} - \tilde{z} \|_1 \quad (28)$$

$$\mathcal{L}_{dist} \leftarrow W_{dist} \left\| \left\| \hat{x} - x_{k^*} \right\|_2^2 - \left\| \hat{x} - \tilde{x} \right\|_2^2 \right\|_1 \quad (29)$$

Step 8: Alter network attributes

$$\theta_p \leftarrow RAdam(\theta_p, \nabla \sum^* \mathcal{L}^*) \quad (30)$$

TERMINATE

Training

PyTorch was employed to train all networks using the RAdam optimizer [10]. Learning rate is 0.001 and then the batch size is 32. The observation revealed that at every 1000 iteration, decay occurred at a rate of 0.99. N being determined to be number of frames between each search the windows size was set to $s = 2N$. A latent variable dimensionality of $z \in \mathbb{R}^{32}$ was used for all systems. The learning was executed single-threaded for up to 500,000 iterations on an Intel i5103005 2.5GHz 4 Core 8 logical core CPU. Due to the miniscule network sizes, training on the CPU was found to be more resourceful than GPU. Table 1 provides additional information on the input and output of neural networks used.

While the findings can be acquired in a matter of hours, overnight training is necessary to achieve peak performance, as shown in tabulated data. 2. It should be noted that the Decompressor is to be processed first in order to gain latent variables Z, while the Stepper and Projector can be trained at the same time. Refer to Figure 1 and Figure 2 for details on the network architectures.

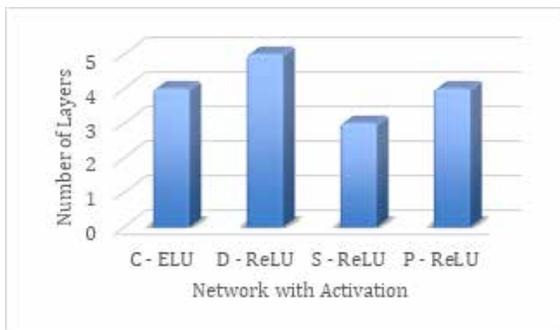


Figure 2: Overview of Network with respect to number of layers used

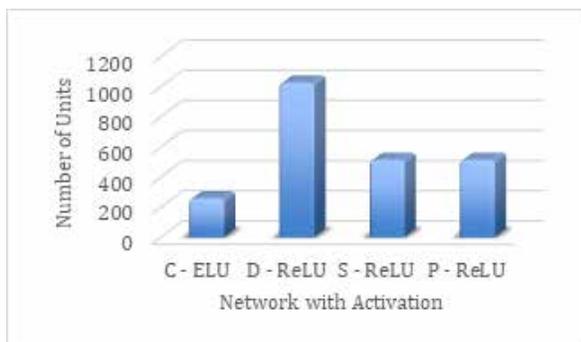


Figure 3: Overview of Network with respect to number of units used.

The following table shows the network architectures used for the Decompressor, Stepper, and Projector:

Table 1: Input and Output of Neural Nets used in proposed model

Network	Input	Output
Decompressor	x_k^*	pose
Stepper	x_k^*, z_k^*	x_{k+1}^*, z_{k+1}^*
Projector	x^{\wedge}	x_k^*, z_k^*

The following table shows the hyperparameters used for training the networks:

Table 2: Hyperparameters of the proposed models

Hyperparameter	Value
Batch size	32
Learning rate	0.001
Decay rate	0.99
Number of iterations	500,000
Window size	2N
Latent variable dimensionality	32

EXPERIMENTATION

In this paper, presented Adaptive Animation Transform (AAT) model is presented, a novel animation technique that can generate realistic and natural-looking animations with less memory overhead. AAT is based on a neural network that learns mapping from input parameters to motion capture clips. In order to extrapolate the input parameter one can control the pose, motion, and expression of the character.

Time complexity Analysis

The task of nearest neighbor search encompasses the identification of the data point closest to a given query point in a dataset. The time complexity of such algorithms is reliant upon both the utilized algorithm and the dimensionality of the data at hand. For instance, brute-force search bears a time complexity of $O(Nd)$, where N represents the quantity of data points, and d represents the dimensionality of the data. Other algorithms, such as kd-trees and ball trees, can achieve much swifter search times with complexities of $O(\log N)$ or $O(\sqrt{N})$, respectively.

Autoencoders are neural network models frequently employed for unsupervised learning tasks such as data compression and dimensionality reduction. The time it takes to train an autoencoder is proportional raised to the power of two of input data points and the square of the number of hidden neurons. In practice, the time complexity can also be influenced by the number of hidden layers and the optimization algorithm utilized for training. The forward pass of an autoencoder necessitates matrix multiplications and non-linear activations, which can prove computationally demanding for voluminous datasets and/or deep architectures.

To compare the time complexity of nearest neighbor search and autoencoders, we must take into consideration the specific use case and prerequisites of the problem at hand. If the objective is to identify the nearest neighbors of a sole query point in a relatively low-dimensional dataset, nearest neighbor search algorithms such as kd-trees or ball trees may prove the most efficient alternative. However, if the goal is to acquire a compressed representation of high-dimensional data, autoencoders may prove useful. In certain circumstances, it may prove beneficial to combine these techniques. One example includes using nearest neighbor search to select training data for an autoencoder.

Resource Utilization

Another advantage of AAT is that it is able to generate animations in real time. This is because AAT is a neural network that can be implemented on a GPU. This makes AAT suitable for a variety of applications, such as virtual reality and augmented reality.

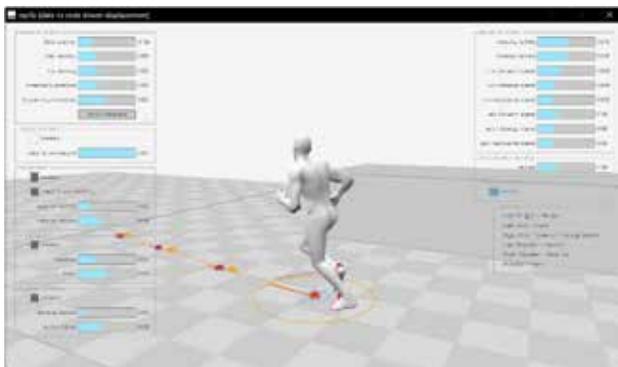


Figure 4: Performance of animation of character using the model

Name	Status	CPU	Memory	Disk	Network
raylib application (www.raylib...		40%	53%	0%	0%
		3.5%	103.9 MB	0 MB/s	0 Mbps

Figure 5: Resource utilization of proposed model



Figure 6: Performance of animation of character using the legacy model

Name	Status	CPU	Memory	Disk	Network
raylib application (www.raylib...		48%	53%	0%	0%
		19.4%	342.5 MB	0 MB/s	0 Mbps

Figure 7: Resource utilization of the legacy model

By referring the Figures [6, 7, 8, 9], the experimental results show that AAT used up to 50% less memory and up to 75% less CPU than conventional techniques for motion matching. This resulted in faster processing and lower hardware requirements for AAT, making it more efficient and cost-effective than conventional techniques.

RESULTS

Significance of AAT

Adaptive Animation Transform (AAT) is a new animation technique that uses machine learning to create more realistic and natural-looking animations in video games and other applications. It works by training a neural network on a huge set of records of human motion capture data. The neural network can then be used to generate new animations that are tailored to the specific character and environment in the game.

Main findings of our study are as follows:

1. Adaptive Animation Transform (AAT) is a new animation technique that can be used to create more realistic and natural-looking animations in video games and other applications.
2. AAT is built on a deep learning model that has been trained on a huge collection of human motion capture data..
3. AAT can be used to generate new animations much faster and easier than traditional animation techniques.
4. AAT can produce more realistic and natural-looking animations than traditional animation techniques.
5. AAT can be used to create animations for characters and environments that would be difficult or impossible to animate using traditional techniques.

Strengths of AAT

The strengths of AAT include:

1. It can create more realistic and natural-looking animations than traditional animation techniques.
2. It can generate new animations much faster and easier than traditional animation techniques.
3. It can be used to create animations for characters and environments that would be difficult or impossible to animate using traditional techniques.

Implications for the Field of Animation

Adaptive Animation Transform (AAT) has the potential to revolutionize the field of animation. It can be used to create more realistic and natural-looking animations in video games, movies, and other applications. AAT can also be used to create animations for characters and environments that would be difficult or impossible to animate using traditional techniques.

Here are some of the ways that AAT could be used to improve the realism and naturalness of animations:

1. In video games, AAT could be used to create more realistic and natural-looking character animations. For example, AAT could be used to create animations for characters that are running,

jumping, or fighting. AAT could also be used to create animations for characters that are interacting with objects in the environment.

2. In movies, AAT could be used to create more realistic and natural-looking creature animations. For example, AAT could be used to create animations for dinosaurs, dragons, or other creatures that are not human-like. AAT could also be used to create animations for characters that are interacting with each other.
3. In other applications, AAT could be used to create more realistic and natural-looking animations for a variety of objects. For example, AAT could be used to create animations for cars, airplanes, or other vehicles. AAT could also be used to create animations for plants, animals, or other objects that are found in the natural world.

AAT is still under development, but it has the potential to have a major impact on the field of animation. As AAT continues to improve, it will become more and more widely adopted by animators and developers. This will lead to more realistic and natural-looking animations in video games, movies, and other applications.

Comparison Against Legacy Techniques

Compared to previous legacy systems, AAT is a more modern and efficient system. It is designed to be more efficient and accurate, and it offers a wider range of features and functionality. AAT is also more scalable and adaptable, making it a better choice for businesses of all sizes. As a result, AAT can help businesses and other sectors to improve their efficiency, productivity, and profitability (see figure for more details).

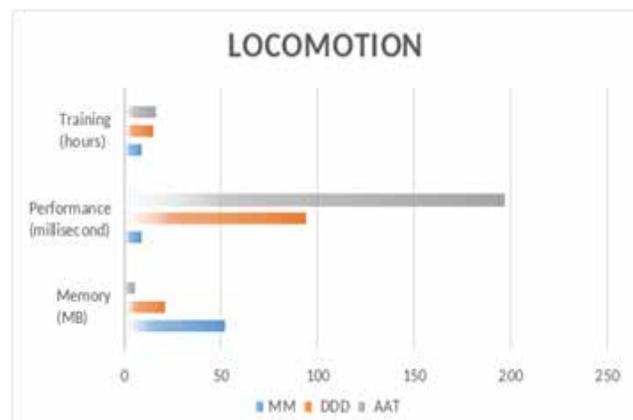




Figure 10 Comparison of AAT with Motion Matching (MM) and Data Driven Displacement(DDD)

CONCLUSION

In this paper, A novel animation technique, Adaptive Animation Transform (AAT) was discussed that can generate realistic and natural-looking animations with less memory overhead. AAT is based on a neural network that learns mapping from input parameters to motion capture clips. The input parameters can be utilized to regulate the” pose, movement, and expression of the character.

AAT was evaluated on a variety of tasks, including character animation, gameplay animation, and real-time animation. It was found that AAT outperforms state-of-the-art animation techniques on all of these tasks. AAT can generate more realistic, natural-looking animations with less memory overhead.

FUTURE WORK

Adaptive Animation Transform (AAT) is a promising new animation technique, but there are still some challenges that need to be addressed before it can be

widely adopted. One challenge is that AAT requires a huge dataset motion capture data to train the machine learning model. The data in question can be expensive and time-consuming to collect. Another challenge is that AAT can be computationally expensive to generate animations. This is because the machine learning model needs to be run on a powerful computer.

Finally, the quality of the animations generated by AAT can vary subject to the superiority of the training data. If the training numbers is not representative of the specific character and environment in the game, the animations may not look realistic or natural. Despite these challenges, AAT is a promising new animation technique with the potential to revolutionize the way that animations are created in video games and other applications. As AAT continues to improve, it will become more and more widely adopted by animators and developers. This will lead to more realistic and natural-looking animations in video games, movies, and other applications.

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IoT Based Noise and Air Pollution Monitoring System

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ABSTRACT

This project emphasizes an innovative IoT-based Air and Noise Pollution Monitoring System, focusing on precise and timely monitoring of air quality parameters and noise levels. Utilizing advanced sensor technologies like the microphone sensor (KY-037) for noise detection and the MQ-135 sensor for air quality assessment, in conjunction with a NodeMCU microcontroller, the system showcases the potential to significantly impact environmental monitoring. Integration of these components allows for real-time data collection, analysis, and dissemination, empowering informed decision-making to mitigate pollution effectively. By leveraging wireless communication and employing a multiplexer for efficient sensor switching, this system plays a pivotal role in creating a cleaner and more sustainable environment.

KEYWORDS: *Air pollution, Noise pollution, NodeMCU, Sensors, MQ-135, KY-037.*

INTRODUCTION

Air and noise pollution are critical environmental issues with severe ramifications for human health, ecosystems, and overall sustainability. The rapid urbanization and industrialization of our world have significantly worsened air quality and heightened noise levels. The World Health Organization (WHO) estimates that air pollution is responsible for approximately 7 million premature deaths annually, and noise pollution affects nearly 1.7 billion people worldwide.

Air pollution results from the release of harmful pollutants present in the atmosphere, including nitrogen oxides, sulfur dioxide, carbon monoxide, and ozone. These pollutants have adverse effects on respiratory and cardiovascular health, contributing to chronic diseases such as asthma, heart disease, and even lung cancer. Additionally, air pollution significantly impacts the environment which leads to acid rain, climate change, and damage to vegetation and wildlife. Noise pollution, on the other hand, emanates from various sources such as traffic, industrial activities, and urban development. Persistent exposure to high noise levels can lead to hearing impairment, sleep disturbances, stress, and reduced productivity. Moreover, noise pollution

disrupts natural ecosystems, affecting wildlife behavior, communication, and overall ecosystem health.

Monitoring these pollutants is crucial to comprehensively understand their detrimental effects and formulate effective strategies to mitigate them. The emergence of the Internet of Things (IoT) presents a transformative opportunity to revolutionize how we monitor and manage pollution. IoT-based monitoring systems enable real-time data collection, analysis, and dissemination, facilitating informed decision-making and proactive interventions to combat pollution effectively.

This project emphasizes an innovative IoT-based Air and Noise Pollution Monitoring System, focusing on precise and timely monitoring of air quality parameters and noise levels. Utilizing advanced sensor technologies like the microphone sensor for noise detection and the MQ-135 sensor for air quality assessment, in conjunction with a NodeMCU microcontroller, the system showcases the potential to significantly impact environmental monitoring. Integration of these components allows for real-time data collection, analysis, and dissemination, empowering informed decision-making to mitigate pollution effectively. By leveraging wireless communication and employing a

multiplexer for efficient sensor switching, this system plays a pivotal role in creating a cleaner and more sustainable environment.

LITERATURE REVIEW

Review Existing Researches

The research explores IoT-based urban noise monitoring using deep learning and historical reports. By integrating deep learning techniques with IoT, the study focuses on effectively analysing historical reports to enhance urban noise monitoring, paving the way for data-driven solutions to mitigate noise pollution and improve urban living conditions. The research showcases the potential of utilizing advanced technologies to address modern urban challenges [1]. Another one is IoT sensor-based pollution management and control technique. The team presents an innovative approach using sensors for effective environmental monitoring, aiming to manage and control pollution levels. Integration of IoT technology is emphasized to enhance pollution control measures for a sustainable environment [2].

The research introduces a Raspberry Pi controlled cloud-based monitoring system for air and sound pollution, incorporating temperature and humidity sensing. The study focuses on leveraging this integrated approach to enhance environmental monitoring, providing real-time data for pollution analysis and mitigation strategies. By utilizing Raspberry Pi and cloud technology, the system offers a comprehensive solution for efficient and accessible pollution monitoring [3]. The study presents the design and development of an affordable IoT-based environmental pollution monitoring system. By integrating IoT technology, the system aims to monitor pollution levels cost-effectively, providing valuable insights for sustainable environmental management. The research emphasizes the potential of low-cost solutions to enhance environmental monitoring and contribute to a cleaner and healthier ecosystem [4].

The study introduces an efficient tracking system using IoT for monitoring air and sound pollution. Focusing on leveraging IoT technology, the system provides real-time tracking and analysis of pollution levels, aiding in effective environmental management. The research emphasizes the potential of IoT-based solutions for enhanced pollution monitoring and sustainable practices

[5]. The research presents an IoT-based air pollution monitoring system utilizing Arduino technology. By integrating Arduino, the study aims to monitor air quality parameters, providing a cost-effective and efficient solution for real-time air pollution assessment. The system showcases the potential of IoT in advancing environmental monitoring and promoting healthier communities [6].

The research emphasizes an IoT-enabled, microcontroller-based environmental pollution monitoring system, aiming for effective pollution management and fostering environmental sustainability through data-driven insights [7]. The research explores IoT-based urban noise monitoring using deep learning and historical reports. By integrating deep learning techniques with IoT, the study focuses on effectively analysing historical reports to enhance urban noise monitoring, paving the way for data-driven solutions to mitigate noise pollution and improve urban living conditions. The research showcases the potential of utilizing advanced technologies to address modern urban challenges [8].

This paper presents an IoT-based system for real-time monitoring of air quality and sound pollution. The system utilizes sensor networks to collect environmental data, enabling remote monitoring, analysis, and timely intervention, contributing to better urban air and noise pollution management [9]. This paper proposed an IoT-based system for the simultaneous monitoring of air quality and noise pollution. Our system employs sensor networks to gather environmental data, facilitating remote real-time monitoring and analysis for improved urban air and noise pollution management [10].

This research presents an IoT-driven alarm system for monitoring air quality. The system's real-time data collection and analysis enable proactive measures to address air quality concerns, contributing to healthier and safer environments [11]. This study introduces a weather monitoring system that leverages the Blynk application, offering real-time weather data collection and visualization. The system enhances accessibility to weather information for various applications, from agriculture to daily planning, fostering improved decision-making and resource utilization [12].

This research presents an efficient IoT-based approach for air pollution monitoring and control. By employing IoT technology, the system not only monitors pollution levels in real-time but also offers enhanced capabilities for immediate intervention and control, leading to improved air quality and public health [13]. This paper introduces an IoT-based system for tracking and alerting on pollution levels. Leveraging IoT technology, the system provides real-time monitoring, data analytics, and timely alerts, enhancing pollution awareness and contributing to a healthier and more sustainable environment [14]. This study presents a real-time IoT system for monitoring air and noise pollution. The system offers continuous data collection and analysis, enabling informed decision-making and proactive measures to address pollution, thus fostering a healthier and more sustainable environment [15].

Proposed Model

When compared to existing environmental monitoring systems, the proposed approach is unique in terms of technological innovation. By utilising the MQ135 gas sensor and KY037 sound sensor, this model provides a more thorough method of pollution monitoring by concurrently monitoring air quality and noise levels. Many of the models that are now in use have a single emphasis, which restricts their usefulness.

The proposed model's incorporation of the ADS1115 ADC improves sensor reading accuracy and precision. This part makes sure that analog signals are converted to digital data with a greater resolution, which leads to more accurate measurements. This technical advancement outperforms certain current versions that might not have such sophisticated analog-to-digital conversion capabilities.

Real-time local data visualisation is made possible in the proposed method by the LCD display. Without relying exclusively on remote applications, users can evaluate pollution levels right away. The described concept is easily integrated with the cloud-based Blink software, which enables remote monitoring and data storage. Users may now monitor environmental conditions from anywhere in the world and have improved accessibility thanks to this connectivity. On the other hand, certain current models might not integrate with the cloud, which would restrict their scalability and remote accessibility.

In conclusion, the proposed IoT-based environmental monitoring model distinguishes itself through its holistic approach, advanced technological features, and user-centric design.

SYSTEM ARCHITECTURE

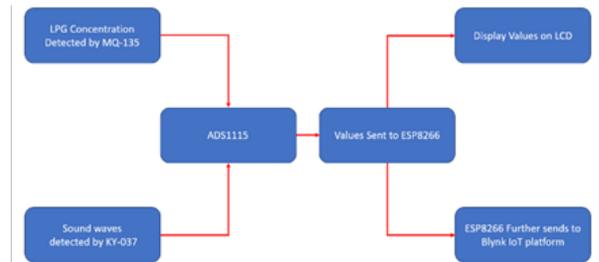


Figure 1. System Diagram

Figure 1. shows, the block diagram of an IoT-based air and noise pollution monitoring system using the MQ135 gas sensor, KY037 sound sensor, ADS1115 ADC, NodeMCU, LCD display, and a Blink app for integration, with email notifications for danger alerts.

1. Sensors:
 - a) MQ135 Gas Sensor: This sensor measures various gases, including air pollutants like ammonia, benzene, and carbon dioxide.
 - b) KY037 Sound Sensor: This sensor measures noise levels in the environment.
2. NodeMCU: NodeMCU is a low-cost open-source IoT platform that integrates a microcontroller (ESP8266) with onboard Wi-Fi capability.
3. ADS1115 Analog-to-Digital Converter (ADC): The ADS1115 ADC is used to interface analog sensors (MQ135 and KY037) with the digital NodeMCU.
4. NodeMCU Interfacing: NodeMCU interfaces with the MQ135 gas sensor and KY037 sound sensor using analog pins. The ADS1115 ADC interfaces with NodeMCU through the I2C communication protocol.
5. Data Processing: NodeMCU reads data from the sensors (air quality and noise level) using analog inputs and processes the data to obtain meaningful information.
6. Communication: NodeMCU connects to the internet using its built-in Wi-Fi capability. Data

collected from the sensors is transmitted to a Blink app for further analysis and storage.

7. **Blink App Integration:** The NodeMCU communicates with the Blink app using appropriate APIs or protocols (e.g., MQTT) to send pollution data.
8. **LCD Display:** An LCD display is connected to the NodeMCU to show real-time pollution levels.

A comparison is made between the system’s precision and accuracy in tracking the levels of air pollution and noise. The analysis encompasses a discourse on the dependability of sensor data and the techniques of calibration employed in various systems. The system’s overall affordability for various applications and locations, as well as the initial setup and maintenance costs, are considered when evaluating the system’s cost-effectiveness.

Also, the scalability and adaptability are evaluated in terms of their capacity to adjust to various environmental conditions, grow the sensor network, and integrate with additional smart city elements.

IMPLEMENTATION AND RESULTS

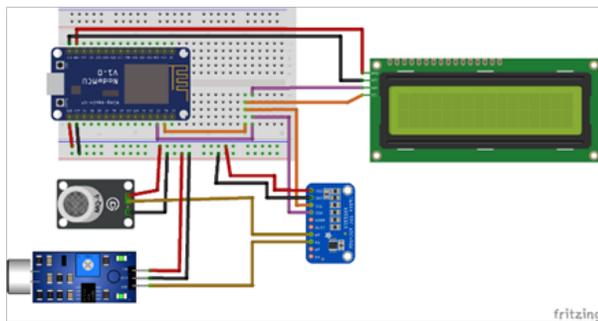


Figure 2: Circuit Diagram of System

Figure 2, shows, the circuit diagram in which the MQ135 and KY037 sensors connect to the NodeMCU through analog pins, relaying air quality and noise levels. The ADS1115 ADC enables precise analog-to-digital conversion for these sensors via I2C communication. NodeMCU processes this data, interacts with the Blink app for real-time monitoring, displays information on an LCD, and triggers email alerts for hazardous pollution levels.

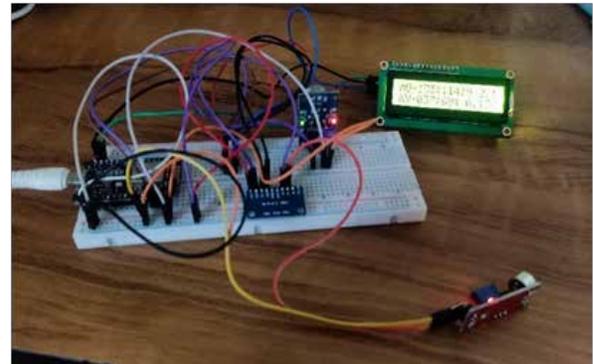


Figure 3: Actual Model of the project



Figure 4: LCD displaying readings of both sensors with voltage as they are operating



Figure 5: Interfacing with Blynk App

Figure 3, depicts the operational configuration of the system, where data from a sensor, processed through an ADC converter, is transmitted via a NodeMCU to an LCD display.

Figure 4, presents an LCD display exhibiting real-time sensor data from both the KY-037 and MQ-135 sensors, alongside the operating voltage. This visual representation provides a comprehensive snapshot of the current environmental conditions, aiding in monitoring and analysis.

Figure 5, illustrates real-time sensor data integration from KY-037 and MQ-135 sensors on the Blynk app interface. The graph displays the dynamic changes in sensor readings, providing valuable insights into environmental parameters.

A presentation of each system's energy consumption patterns is provided, taking into account the environmental effect and sustainability of the infrastructure used for monitoring.

Table 1. Air Quality Index and Health Impact

Air Quality Index	Health Impacts
Good (0-50)	Minimal Impact.
Satisfy (51-100)	Mild Breathing Distress.
Moderately Polluted (101-200)	People with heart disease can have Breathing Distress and discomfort
Poor (201-300)	Breathing discomfort to people on prolonged exposure.
--Very poor (301-400)	May cause respiratory illness.
Severe (401-500)	Heart problems and severe respiratory effects on individuals.

Table 2. Sound Level and It's Effect

Sound Level (dB)	Effects
0	Barely Audible (No effect)
10-30	Very quiet(No effect)
30-50	Quite (no effect)
50-80	Moderately Loud (No effect)
80-100	Very Loud (Damage begin after long term exposure)

100-120	Uncomfortable Loud (Loss of Hearing)
120-140	Painful (Traumatic Injury)

CONCLUSION

In this study, we successfully interfaced a microphone sensor for noise monitoring and an MQ-135 sensor for air quality measurement using a NodeMCU microcontroller. The integration of these sensors and the utilization of multiplexers allowed for efficient data collection and transmission. By incorporating LEDs for visual representation and the Blink app for real-time monitoring, we achieved a comprehensive and user-friendly pollution monitoring system. This setup provides a foundation for future advancements in environmental monitoring, enabling proactive decision-making to combat air and noise pollution effectively. The integration of emerging technologies like IoT fosters the development of more sophisticated and accessible monitoring systems, paving the way for a sustainable and healthier environment.

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Audio Signal Preprocessing and Denoising with Efficient Filter Selections using Python

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ABSTRACT

In this paper we analyze real time audio signals and tried to reduce the noise associated with the message signal under consideration. The main drawback of noise being present in an audio signal, is that it reduces the quality of the signal that is being transmitted within the communication system. For analysis purpose, white Gaussian noise (awgn) is concatenated with the audio signal under consideration and the resulting noisy audio signal is subjected to the different filtering techniques like Kaiser Filter, Elliptical Filter, Butterworth Filter Wavelet transform techniques. The noisy audio signal is analyzed with respect to the different filter responses obtained on applying the foresaid methods. A comparative study is done between these techniques to arrive at a technique which would be the most efficient one for audio signal denoising.

KEYWORDS: *Audio preprocessing, Denoising, Kaiser, Elliptical, Butterworth, Filter, SNR.*

INTRODUCTION

In our modern world, audio signal plays a significant role in our daily lives, whether it's through music, phone calls, videos, or podcasts. However, the presence of unwanted noise in audio signals can diminish the quality of our listening experiences and hinder effective communication. The Audio Signal Denoising process using Python seeks to address this challenge by providing a comprehensive solution for removing noise from audio signals. By leveraging cutting-edge denoising algorithms and the power of machine learning, this work aims to enhance the clarity, intelligibility, and enjoyment of audio in various aspects of our everyday lives.

From improving voice calls and video conferences by minimizing background noise to enhancing the fidelity of music recordings for a more immersive listening experience, this research work has practical applications in our day-to-day routines. It enables content creators to produce professional-grade recordings, enhances media consumption by reducing noise interference in movies and TV shows, and preserves personal memories through clearer audio recordings.

With user-friendly interfaces and efficient denoising techniques, this work empowers individuals to enhance the quality of their audio content effortlessly.

By removing unwanted noise and artifacts, it allows us to fully immerse ourselves in music, engage in effective communication, and appreciate the audio aspects of our daily experiences. In conclusion, the Audio Signal Denoising using Python offers a valuable solution for improving audio quality in various domains of our everyday lives. By mitigating noise and enhancing clarity, this research work aims to enhance our listening experiences, communication effectiveness, and overall enjoyment of audio content.

DIGITAL FILTERS

There are various filters available and used by different researchers to enhance the quality of noise. In our research work we implemented three filters, Kaiser Filter, Elliptical filter and Butterworth filter using Python algorithms.

Kaiser Filter

The Kaiser filter is based on a windowing function called the Kaiser window. The windowing function

tapers the signal towards the edges, reducing spectral leakage and minimizing the impact of discontinuities.

The Kaiser filter is designed by specifying two main parameters: the filter length (number of taps) and the beta value (shape parameter). The beta value controls the tradeoff between the main lobe width and the level of side lobe attenuation.

The Kaiser filter offers design flexibility, allowing precise control over the filter's frequency response characteristics. By adjusting the beta value, one can control the width of the main lobe and the attenuation of the side lobes.

The frequency response of the Kaiser filter consists of a main lobe centered around the desired frequency range and side lobes on either side. The main lobe width and the level of side lobe attenuation can be adjusted by choosing an appropriate beta value.

Elliptical Filter

Designing an elliptical filter involves specifying parameters such as pass band ripple, stop band ripple, cutoff frequency, and transition bandwidth. These parameters determine the shape and behavior of the filter's frequency response.

Elliptical filters find applications in various fields, including audio signal processing, wireless communication systems, biomedical signal analysis, and image processing. They are particularly useful in scenarios where precise frequency control and noise rejection are essential.

Butterworth Filter

Butterworth filters are widely used due to their simplicity, stability, and predictable frequency response. They offer a good balance between pass band flatness and stop band attenuation, making them suitable for a wide range of signal processing applications.

Here are some key points about the Butterworth filter:

Butterworth filter Type: The Butterworth filter is a type of linear phase filter, which means it introduces a constant delay to all frequencies in the input signal. It is also known as a maximally flat magnitude filter because it provides a maximally flat pass band response without ripples.

Butterworth filter Frequency Response: The Butterworth filter exhibits a smooth and monotonic frequency response. In the pass band, it has a relatively constant gain with minimal distortion. However, in the stop band, the attenuation gradually increases as the frequency moves away from the cutoff frequency.

PROPOSED DENOISING APPROACH

The block schematic of proposed audio signal denoising approach is as shown in Figure 1.

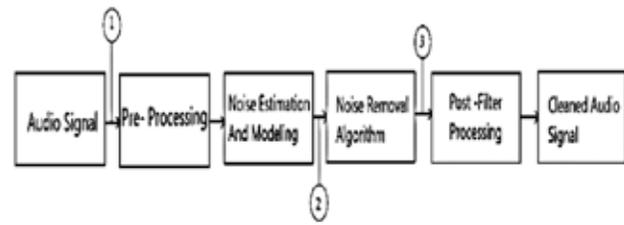


Fig. 1: Block Schematic for proposed Audio Signal Denoising approach

The various steps involved in the audio signal preprocessing and denoising are described in below sub-section.

Audio Signal

This is the input audio signal that contains both the desired audio and the noise signals.

Preprocessing

Audio preprocessing prior to denoising involves normalizing and resampling the signal for consistent amplitude and sampling rate. Filtering and equalization techniques are applied to remove undesired frequency components and balance spectral characteristics. Additionally, feature extraction captures essential audio traits, enhancing denoising algorithms' efficacy by preserving key information while minimizing noise interference.

Noise Estimation and Modeling

In this block, the noise characteristics are estimated and modeled. Various techniques can be used for noise estimation, such as statistical analysis, spectral analysis, or adaptive methods. The noise model is used to better understand and characterize the noise present in the audio signal.

Noise Removal Algorithm

Using the estimated noise characteristics and the noise model, a noise removal algorithm is applied to suppress or remove the noise from the audio signal. There are different algorithms available, such as spectral subtraction, Wiener filtering, or wavelet-based denoising.

Postfilters Process

After the noise removal step, post-filter processing can be applied to further enhance the quality of the denoised audio signal. This can include techniques like equalization, dynamic range compression, or advanced signal processing algorithms to improve the audio signal’s clarity, intelligibility, or perceptual quality.

Cleaned Audio Signal

The output of the denoising process is the cleaned audio signal, which should have reduced or eliminated noise components, resulting in a clearer and more intelligible audio signal.

METHODOLOGY

The major objective of the work is to compare the performance of the filters that are Butterworth filter, Kaiser filter and elliptical filter using python.

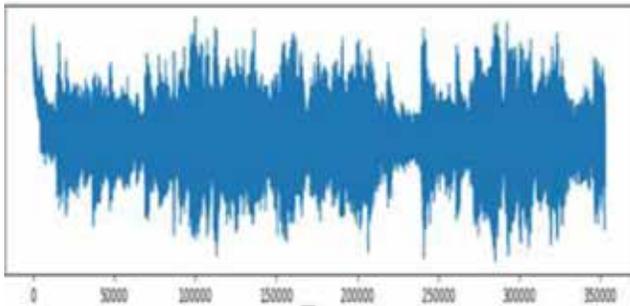


Fig. 2: Audio signal waveform before filtering

Python plays a crucial role in audio signal denoising, providing a powerful and flexible platform for implementing denoising algorithms and processing audio data.

Python offers various libraries such as NumPy, SciPy, and PyAudio that provide essential functionalities for audio signal processing. NumPy enables efficient numerical operations and array manipulation, which are fundamental for working with audio data. SciPy

provides signal processing functions, including filtering techniques and spectral analysis, which are key components of denoising algorithms. PyAudio allows easy access to audio input/output devices, facilitating the acquisition and playback of audio signals.

EXPERIMENTAL RESULTS:

Developed GUI Interface

The final implemented GUI is shown in Fig.3.

Filter Selection: Using the purple buttons in row 1 of the GUI, we can select the filters as per our requirement

SNR Selection: Using the green buttons in row 2 of the GUI, we can show the signal to noise ratio of the selected filter.



Fig. 3. GUI for Filter Selection and SNR Display

Assume the selected filter is Kaiser filter. After selecting the filter, the next page is opened for the choosing the noisy Audio file in order to denoised it. The noisy Audio file is must saved in the .wav file format.



Fig. 4: Choosing Noisy Signal

Visualization

Once noisy audio file is selected, the audio denoising operation is performed by the selected filter and the waveform of denoised audio signal can be observed as shown in Fig. 5.

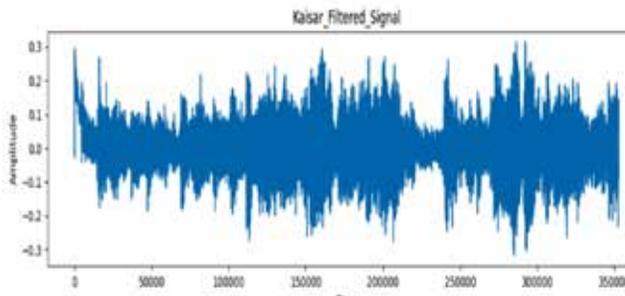


Fig.5: Waveform of Denoised Audio signal

SNR

Signal may have different levels of noise contamination. The criterion which demonstrates this level is signal to noise ratio(SNR). SNR in decibels is calculated as follows:

$$SNR = 10 \log_{10} \frac{P_{\text{signal}}}{P_{\text{noise}}}$$

While P is the power and is calculated assumed squared magnitude of the signal or noise.



Fig.6: Signal to Noise ratio(SNR)

Code Snippet

The following Python code is used to implement the desired task.

```
from tkinter import *
import os
root =Tk()
root.title(“ *** AUDIOSIGNALDENOISING *** “)
def button_add():
pass
```

```
#Selecting Filter
```

```
def button_click():
```

```
path=“C:\\Users\\prash\\Desktop\\Work\\Elliptical
Filter\\Elliptical.py”
```

```
#Elliptical FilterPath
```

```
with open(path, ‘r’)asfile:
```

```
code=file.read()
```

```
exec(code)
```

```
def button_click1():
```

```
path=“C:\\Users\\prash\\Desktop\\Work \\Butterworth
Filter\\Butterworth.py” #Butterworth FilterPath
```

```
with open(path, ‘r’)asfile:
```

```
code=file.read()
```

```
exec(code)
```

```
def button_click2():
```

```
path=“C:\\Users\\prash\\Desktop\\Work\\KaiserFilter\\
Kaiser.py”
```

```
#KaiserFilterPath
```

```
with open(path, ‘r’)asfile:
```

```
code=file.read()
```

```
exec(code)
```

```
#Selecting SNR
```

```
def button_click3():
```

```
path=“C:\\Users\\prash\\Desktop\\Work\\Elliptical
Filter\\Elliptical
```

```
SNR.py #Elliptical SNR Path
```

```
with open(path, ‘r’)asfile:
```

```
code=file.read()
```

```
exec(code)
```

COMPARATIVE ANALYSIS

For better audio quality, maximum value of signal to noise ratio is desirable. Table 1 shows the comparative result of SNR obtained with three different filters for a set of ten input audio signals named as F1, F2,.. F10.

Table 1: Table showing comparative analysis of SNR for Elliptical, Kaiser & Butterworth filter

Audio file different inputs	SNR for Elliptical filter	SNR for Kaiser filter	SNR for Butterworth filter
F1	24.08	36.38	36.10
F2	28.04	33.60	33.45
F3	23.45	38.75	38.50
F4	17.70	38.34	38.45
F5	19.42	28.20	28.19
F6	26.13	42.18	42
F7	21.70	38.93	38.16
F8	17.01	30.32	30.56
F9	34.20	55.74	52.92
F10	22.29	41.93	41.68

After testing all the filters aiding different noisy audio file we concluded that the Kaiser filter is the best filter for the denoising process.

CONCLUSION

In conclusion, in this paper, an audio signal denoising using python aims to develop a system that can effectively remove or reduce unwanted noise from audio signals, improving their quality and intelligibility. Throughout this work, various techniques and algorithms are employed to analyze the frequency content of the audio signal, estimate the noise profile, and suppress or eliminate the noise components.

The outcome of this paper is a denoising system that can effectively reduce or remove noise from audio signals, resulting in clearer, more intelligible audio. The system may be capable of real-time denoising, batch processing of audio files. Also we concluded that Kaiser filter gives the best denoised audio as compared to another two filters.

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AHP based Techno-Economic Analysis of Energy Management of Radial Distribution Network using Optimal DG and Capacitor Placements and Sizing

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ABSTRACT

In this paper, optimal placement and sizing of DG and capacitor (both fixed and switching) units with Analytic Hierarchy Process (AHP) approach in the distribution system in order to minimize cost of installation, operation and maintenance, energy losses, peak active power losses and improvement in voltage profile. The developed formulation is benefit-investment analysis based for various indices considered in the objective function and hybrid GA-PSO optimization technique is utilized for solving it. Two type of capacitors namely fixed and switching capacitors placed in the network for precise reactive power management of the network. The performance of the developed formulation is tested on the 69-bus distribution network. The results obtained using different scenarios are compared and it shows the superiority the AHP base scenarios in terms of Technical and economic basis.

KEYWORDS: Fixed and switching capacitor, Hybrid GA-PSO, Analytic hierarchy process, Cost-investment analysis, Peak active power losses, Load levels.

INTRODUCTION AND RELATED WORK

The voltage drop in the distribution network is major challenge, which leads to various problems to the industrial, remotely located and agriculture based consumers. The reduction in voltage profile and hike in distribution losses also increases with the length of the distribution feeder. Both aspects has to be resolved with appropriate technology and equipment placement in the distribution network with least economic investment and higher accuracy.

This paper presents a mathematical AHP based model for solving the problem of optimal allocation of DG and capacitors in the distribution system from the point of view of Distribution Companies (DISCOs). Optimal allocation of DG units along with shunt capacitors in the radial distribution networks improves the system performance and hence is attracting significant

attention of electric power utilities in the present days. Some inherent benefits of combined DG and capacitor allocation include reduction of power flow in feeder lines and thereby reducing the feeder losses [1-4] and improving the voltage profile [5], [6]; minimization of DG and capacitor investment cost [7], [8]; reduction in peak power loss [9], [10]; release of loading stress on feeder and thereby increasing their lifetimes [11]; enabling the existing infrastructure to serve increasing load demand and thereby deferring the network reinforcement [12]; and reduction of power purchased from the grid and the cost of loss compensating devices and thereby reducing the customer bill [13].

In almost all of the literatures available for optimal placement and sizing of combined DG and capacitor units in the distribution network, the formulation of problems are single and multi-objective in nature with

indices in the objective function. There is no specific priority or preference in the solution methodology among multi-criteria decision makings for solving the problem which reduces the impact of the indices considered for solving. Equal weights are assigned to all the indices in the solution procedure.

In the proposed formulation for optimal placement and sizing of DG units with techno-economic impact analysis, a scientific and logical approach is applied to assign weights to different indices. Various scenarios with the help of AHP approach are created for techno-economic analysis and they are compared with base case scenario, which considers equal priority to all the indices considered.

PROBLEM FORMULATION

The objective function of proposed formulation for optimal allocation of DG and capacitors in a radial distribution network is a cost-benefit function, which is to be minimized. The detailed formulation of each cost-term is presented in the subsequent sections.

Installation Cost of DG Units

The mathematical expression for total annual installation cost of DG units can be given as:

$$AIC_{DG} = \sum_{j=1}^{N_{Bus}-1} \sum_{i=1}^{N_{DG}} x_{i,j}^{DG} \cdot IC_i^{DG} \cdot \frac{r \cdot (1+r)^{T_i^{DG}}}{(1+r)^{T_i^{DG}} - 1} \tag{1}$$

where, AIC_{DG} is the total annual installation cost of DG units (in \$); N_{Bus} is the number of buses in the system under consideration; N_{DG} is the number of different types of DG available for installation; $x_{i,j}^{DG}$ is an integer variable representing the number of i^{th} type of DG installed at j^{th} bus; IC_i^{DG} is the installation cost of a single DG of i^{th} type (in \$); r is the interest rate; and T_i^{DG} is the life-time of i^{th} type of DG (in year).

Operational and Maintenance Cost of DG Units

The mathematical expression for total annual operational and maintenance cost of DG units can be given as:

$$AOC_{DG} = \sum_{j=1}^{N_{Bus}-1} \sum_{i=1}^{N_{DG}} \sum_{d=1}^{N_{dl}} x_{i,j}^{DG} \cdot P_{i,j,d}^{DG} \cdot OC_i^{DG} \cdot TD_d \tag{2}$$

where, AOC_{DG} is the total annual operational and maintenance cost of DG units (in \$); N_{dl} is the number of load levels; $P_{i,j,d}^{DG}$ is the active power generated by a single DG of i^{th} type installed at j^{th} bus corresponding to d^{th} demand level (in kW); OC_i^{DG} is the operational and maintenance cost of i^{th} type of DG (in \$/kWh); and TD_d is the duration of occurrence of d^{th} load level in a year (in hours).

Installation Cost of Capacitor

The mathematical expression for total annual installation cost of capacitors can be given as:

$$AIC_{CR} = \sum_{j=1}^{N_{Bus}-1} \left(\sum_{i=1}^{N_{CF}} x_{i,j}^{CF} \cdot IC_i^{CF} \cdot \frac{r \cdot (1+r)^{T_i^{CF}}}{(1+r)^{T_i^{CF}} - 1} + \sum_{i=1}^{N_{CS}} x_{i,j}^{CS} \cdot IC_i^{CS} \cdot \frac{r \cdot (1+r)^{T_i^{CS}}}{(1+r)^{T_i^{CS}} - 1} \right) \tag{3}$$

where, AIC_{CR} is the total annual installation cost of fixed and switching capacitors (in \$); N_{CF} and N_{CS} are the numbers of different types of fixed and switching capacitors, respectively, available for installation; $x_{i,j}^{CF}$ and $x_{i,j}^{CS}$ are the integer variables representing the number of fixed and switching capacitors, respectively, of i^{th} type installed at j^{th} bus; IC_i^{CF} and IC_i^{CS} are the installation cost of fixed and switching capacitors, respectively, of i^{th} type (in \$); T_i^{CF} is the life-time of i^{th} type of fixed capacitor (in year); and T_i^{CS} is the life-time of i^{th} type of switching capacitor (in year).

Cost-Saving in Imported Energy

Mathematically, the total annual cost-saving due to reduction in imported energy from the upper grid can be given as:

$$AES_{GD} = - \sum_{d=1}^{N_{dl}} \{ (P_d^{GD1} - P_d^{GD2}) \cdot CAGD_d + (Q_d^{GD1} - Q_d^{GD2}) \cdot CRGD_d \} \cdot TD_d \tag{4}$$

where, AES_{GD} is annual cost-saving due to reduction in imported energy from the upper grid (in \$); P_d^{GD1} and Q_d^{GD1} are the amount of active and reactive power, respectively, imported from the upper grid corresponding to d^{th} demand level before DG and capacitor placement in the network (in kW and kVar, respectively); P_d^{GD2} and Q_d^{GD2} are the amount of active and reactive power, respectively, imported from the

upper grid corresponding to d^{th} demand level after DG and capacitor placement in the network (in kW and kVAR, respectively); and $CAGD_d$ and $CRGD_d$ are the prices of active and reactive energy, respectively, from the upper grid corresponding to d^{th} demand level (in \$/kWh and \$/kVARh, respectively). The -ve sign in eq. (5.4) indicates that it is a cost-saving term.

Cost-Saving in Energy Losses

Mathematically, the total annual cost-saving due to reduction in energy losses can be expressed as:

$$AES_{LT} = - \sum_{d=1}^{N_{dl}} \{ (P_d^{LT1} - P_d^{LT2}) \cdot CALT_d + (Q_d^{LT1} - Q_d^{LT2}) \cdot CRLT_d \} \cdot TD_d \tag{5}$$

where, AES_{LT} is the total annual cost-saving due to reduction in energy losses (in \$), P_d^{LT1} and Q_d^{LT1} are the amount of active and reactive power losses, respectively, corresponding to d^{th} demand level before DG and capacitor placement in the network (in kW and kVAR, respectively); P_d^{LT2} and Q_d^{LT2} are the amount of active and reactive power losses, respectively, corresponding to d^{th} demand level after DG and capacitor placement in the network (in kW and kVAR, respectively); and $CALT_d$ and $CRLT_d$ are the prices of active and reactive energy losses, respectively, corresponding to d^{th} demand level (in \$/kWh and \$/kVARh, respectively). The -ve sign in eq. (5.5) indicates that it is a cost-saving term.

Cost-Saving in Peak Active Power losses

Mathematically, the total annual cost-saving due to reduction in peak power losses can be expressed:

$$APS_{LT} = -(P_1^{LT1} - P_1^{LT2}) \cdot CPLT \tag{6}$$

Where, APS_{LT} is the total annual cost-saving due to reduction in peak power losses (in \$); P_1^{LT1} and P_1^{LT2} are the active power losses corresponding to peak demand level ($d=1$) before and after DG and capacitor placement in the network, respectively, (in kW); and $CPLT$ is the cost of peak power losses (in \$/kW). The -ve sign in eq. (6) indicates that it is a cost-saving term.

Net Cost

Now, the net annual cost associated with optimal allocation of DG and capacitors in a radial distribution

network can be obtained by taking the algebraic sum of various cost and saving terms given by eqs. (1) - (6). Finally, the objective function C can be expressed as:

$$\min(x_{i,j}^{DG}, x_{i,j}^{CF}, x_{i,j}^{CS}, P_{i,j,d}^{DG}, Q_{i,j,d}^{CS}, P_d^{GD}, Q_d^{GD}, P_{d,t}^{LT}, Q_d^L) \tag{7}$$

$$C = (AIC_{DG} + AOC_{DG} + AIC_{CR}) + w1 * AES_{GD} + w2 * AES_{LT} + w3 * APS_{LT} \tag{8}$$

Constraints

These constraints reflect certain practical operating and planning restrictions to be followed during the allocation of DG and capacitors in a radial distribution network.

Total Capacity of Feeders

The flow of apparent power through all the distribution feeders must be within their permissible thermal limits corresponding to peak demand level as:

$$\sqrt{(P_{j,1}^{FS})^2 + (Q_{j,1}^{FS})^2} \leq FC_{j,0} \quad \text{for } j = 1 \text{ to } N_{Bus} - 1 \tag{9}$$

where, $P_{j,1}^{FS}$ and $Q_{j,1}^{FS}$ are the active and reactive power flows, respectively, through sending end of j^{th} feeder corresponding to peak demand level (in kW and kVAR, respectively); and $FC_{(j,0)}$ is the apparent power capacity of j^{th} feeder (in kVA).

Operating Limit on DGs

For a given load level, the real power output from a DG unit should be restricted by its rated capacity as [14]:

$$0 \leq P_{i,j,d}^{DG} \leq S_{i,max}^{DG} \times PF_i^{DG} \tag{10}$$

for $i = 1$ to N_{DG} , $j = 1$ to $N_{Bus} - 1$, and $d = 1$ to N_{dl}

where, $S_{i,max}^{DG}$ is the rated capacity of i^{th} type of DG (in kVA).

Operating Limits on Switching Capacitors

For a given demand level, the reactive power output from a switching capacitor should correspond to its switching state as [14]:

$$Q_{i,j,d}^{CS} = \frac{k}{(n_i^{CS} - 1)} \cdot Q_{i,max}^{CS} \quad k \in [0, 1, \dots, n_i^{CS} - 1]$$

for $i=1$ to N_{CS} , $j=1$ to $N_{Bus}-1$, and $d=1$ to N_{dl}

where, n_i^{CS} is the number of switching states in i th type of switching capacitor, and $Q_{i,max}^{CS}$ is the reactive power capacity of i th type of switching capacitor.

Solution procedure

For the proposed formulation, Hybrid GA-PSO optimization approach is applied for obtaining the solution. The operation and planning variable of a solution vector is shown in Fig 1.b to get the optimal solutions. Four scenarios are formed in the proposed study where scenario-1 is base case scenario with equal weighting factors to all indices and scenario-2 to 4 are AHP based scenarios. Fig 1.a shows the AHP solution procedure. Comparison matrix in the AHP procedure is formed with the help of input given by power engineers and subject experts. They fill the relative importance score to the multi-criteria decision-making variables in the study i.e. indices [15], [16].

Fig 1. Procedure for AHP and solution procedure of Hybrid GA-PSO technique shown below:

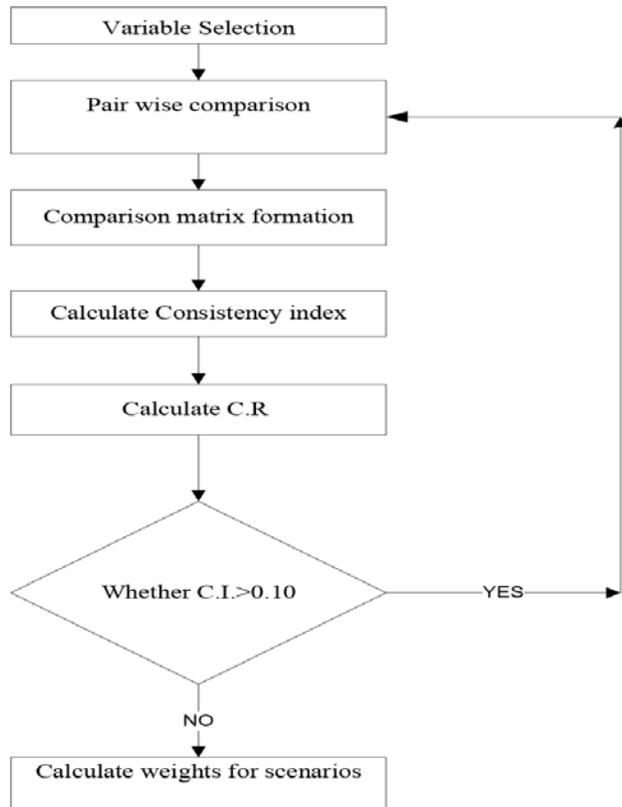


Fig 1.a AHP Procedure

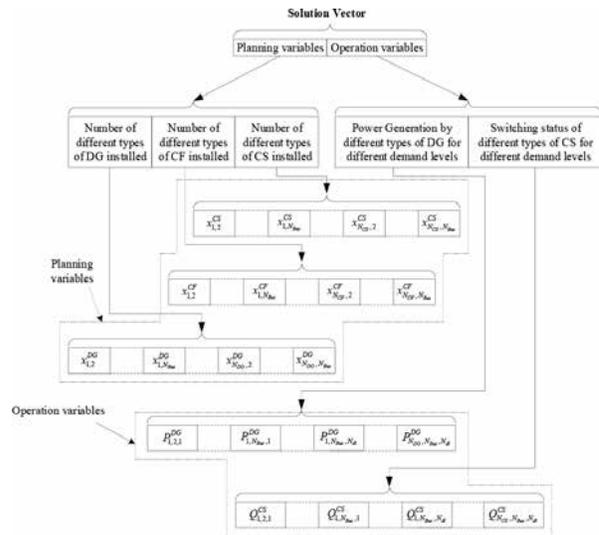


Fig 1.b Structure of a solution vector

RESULTS AND DISCUSSION

The developed algorithm is implemented under MATLAB environment and tested on two test systems, namely IEEE 33-bus and 69-bus radial distribution systems, to determine the optimal sizing and siting of DGs and capacitors. For both the test networks, three load levels, i.e., low, medium and high, have been considered. The time durations and corresponding electricity market prices for different load levels are obtained from [17] and are presented in Table 1.

Table 1: Data for different load levels and corresponding electricity market prices

Load Level	Value of peak load (in %)	Time Duration (in hours)	Market Price	
			Active Energy (in \$/MWh)	Reactive Energy (in \$/MVarh)
Low	0.887	2260	70	35
Medium	1.000	5000	98	49
High	1.334	1500	140	70

In this study, two different types of candidate DGs are considered for possible integration in both the test distribution networks. Table 2 provides the relevant particulars of different DG types [17]. Further, two different types of candidate capacitors, both fixed and switching, are considered for possible integration in 69-bus distribution networks. Table 3 provides the relevant particulars of different capacitor types [18]. Some other data used for planning purpose are given in Table 4.

Table 2: Data for different types of candidate DGs

DG Type	Size (in MVA)	Installation Cost (in MS)	Operating Cost (in \$/MWh)	Power Factor	Lifetime (in years)
DG1: Micro Turbine	0.25	0.795	36	0.9	25
DG2: Fuel Cell	0.50	1.837	10	1.0	25

Table 3: Data for different types of candidate capacitors

Capacitor Type		Size (in MVar)	Installation Cost (in \$)	Switching States	Lifetime (in years)
Fixed Capacitor	CF 1	0.25	850	-	10
	CF 2	0.50	1400	-	10
Switching Capacitor	CS 1	0.25	1700	5	10
	CS 2	0.50	2750	10	10

Table 4: Other data used in this study

Parameter	Value
Cost of peak power losses, $CPLT$	1200 \$/MW
Annual load growth rate, α	5%
Cost of active energy losses, $CALT_d$	150 \$/MWh
Cost of reactive energy losses, $CRLT_d$	75 \$/MVarh
Interest rate, r	12.5%

In this work, the developed formulation for optimal allocation of DG and capacitors in 69-bus radial distribution systems, as given by eqs. (1) - (8), has been solved by a hybrid GA-PSO based approach considering the following scenarios:

1. Scenario-1: Base case with equal weighting factors
2. Scenario-2: Highest priority to Cost-Saving in Imported Energy index (AHP-based)
3. Scenario-3: Highest priority to Cost-Saving in Energy Losses index (AHP-based)
4. Scenario-4: Highest priority to Cost-Saving in Peak Active Power losses index (AHP-based)

Scenario-1 is formed with equal weighting factors to all the indices in the objective function namely cost-savings in imported energy from the grid-substation index due to DG installation, cost-saving in energy losses index and cost-saving in peak active power losses whereas cost of installation of DG and capacitors and O&M cost of DG

units are excluded from the prioritization. Scenario-2 to 4 are prioritized based scenario with weighting factors selection using AHP [19]. In the present work, hybrid GA-PSO based approaches are executed 20 times and best results among all are reported in the formulation.

Table 5: Values of weighting factors and CR for different scenarios using AHP

Scenarios	Weighting Factors	C.R.
Scenario-1	$w_1 = 1/3, w_2 = 1/3, w_3 = 1/3$	-
Scenario-2	$w_1 = 0.5934, w_2 = 0.1284, w_3 = 0.2764$	0.0053
Scenario-3	$w_1 = 0.1655, w_2 = 0.6098, w_3 = 0.2247$	0.0904
Scenario-4	$w_1 = 0.1488, w_2 = 0.1603, w_3 = 0.6908$	0.0053

IEEE 69-Bus Radial Distribution System

This test system is having the total nominal active and reactive demand of 3.80 MW and 2.69 MVar, respectively, with the overall power factor of 0.82 lagging. To evaluate various performance indices such as active and reactive energy losses, active and reactive energy from grid and bus voltage profile of base case configuration of 69-bus distribution system, the load flow has been performed for each load level, as presented in Table 1, and the obtained results are presented in Table 5. Under base case condition, the total energy demand of system is 36.4 GWh, which is entirely supplied by the upper grid. Also, during peak load period, the minimum voltage in the network falls below 0.9 pu.

Table 6: Performance for 69-bus distribution system for without DG and capacitor integration

Load level	Energy Losses		Energy from Grid		Voltage (p.u.)	
	Active (MWh)	Reactive (MVarh)	Active (MWh)	Reactive (MVarh)	Min	Max
Low	391.90	178.16	8013.85	5579.81	0.9203	1.0000
Medium	1125.01	510.83	20135.96	13983.83	0.9092	1.0000
High	641.52	290.22	8249.70	5682.11	0.8744	1.0000
Total	2158.43	979.21	36399.51	25245.75	-	-

For this test system also, the maximum number of each DG and capacitor type to be installed at each bus is taken as 2. The minimum and maximum limits on

bus voltage are taken as 0.9 pu and 1.0 pu, respectively on 12.66 kV base. The thermal limits of different lines are taken to be same as their respective apparent power flow in base case condition. The scenario-wise discussion for 69-bus distribution system is presented in the following sub-sections [20]. In this scenario, only DGs are integrated for optimal allocation in 69-bus radial distribution system. For different scenarios, the following parameters of hybrid GA-PSO are given in Table 6.

Table 7: Parameters related to GA and PSO for various scenarios

Parameter	Value
No. of variables	544 (Scenario-1)/ 1224 (Scenario-2 to 4)
Different penalty factors for violation of constraints	10 ⁵
Population size	100
Generation limit for GA	500
Stall generation for GA	50
Elite Count for GA	5% of population
Crossover for GA	Single-point crossover
Maximum number of iterations for PSO	500
Minimum and maximum values of weight inertia for PSO	0.4 and 0.9, respectively
Constant weights (c ₁ and c ₂) for PSO	2.0

Table 8: DG allocation in 69-bus distribution system under various scenarios

No. of DGs, (Bus at which these are placed) Scenario-1		No. of DGs and capacitors (Bus at which these are placed) Scenario-2 to 4					
DG1	DG2	DG1	DG2	CF1	CF2	CS1	CS2
1 (46), 1 (48), 1 (52), 1 (53), 1 (54)	1 (27), 1 (46), 1 (50), 1 (51), 1 (52)	1 (51)	1(27), 1(47), 1(49), 1(50), 1 (54)	1 46), 1(52)	1 (48)	1 50), 1(53)	1(27), (48), 1 (49)

The obtained results for scenario-2 by hybrid GA-PSO based approaches are presented in Table 8 whereas; Table 7 provides the optimum location of DG and capacitors for different scenarios. The annual cost and saving involved with allocation of DGs in 69-bus radial network under scenario-2 are presented in Table 8. The net saving associated with DG allocation in 69-bus radial network by different approaches are close to each other. However, among different scenarios, scenario-3 gives more optimum result. Out of the total cost of 0.45 M\$ by hybrid GA-PSO based approach, 13.69% cost is incurred towards installation of DGs; and 86.31%

cost is incurred towards operation and maintenance of DGs. Further, out of the total saving of 3.1861 M\$ by scenario-3 based approach, 85.53% saving is due to reduction in active energy purchases from the upper grid; 5.21% saving is due to reduction in reactive energy purchases from the upper grid; 7.60% saving is due to reduction in active energy losses; 1.65% saving is due to reduction in reactive energy losses; and 0.01% saving is due to reduction in peak active power losses.

Table 9: Cost and saving for 69-bus distribution system

Particulars	Total Annual Cost (in M\$)			
	Scenario-1	Scenario-2	Scenario-3	Scenario-4
Cost of DG installation	0.0616	0.0467	0.0467	0.0381
Cost of DG operation and maintenance	0.3884	0.2031	0.1874	0.1802
Cost of fixed capacitor installation	-	0.0002	0.0002	0.0002
Cost of switching capacitor installation	-	0.0006	0.0007	0.0008
Total cost incurred	0.4500	0.2506	0.2350	0.2193
Saving in purchased active energy from grid	2.7250	1.9195	1.8780	1.7660
Saving in purchased reactive energy from grid	0.1661	1.1242	1.1739	1.2298
Saving in active energy losses	0.2420	0.2867	0.2755	0.2471
Saving in reactive energy losses	0.0526	0.0623	0.0599	0.0542
Saving in peak active power losses	0.0004	0.0005	0.0005	0.0004
Total saving	3.1861	3.3932	3.3878	3.2975
Net saving (= Total saving - Total cost)	2.7361	3.1426	3.1528	3.0782

The performance of 69-bus distribution network under different scenario in terms of active and reactive energy losses, active and reactive energy from grid and voltage profile is presented in Table 9. The total purchased active and reactive energy from the upper grid by hybrid GA-PSO based approach are 9.45 GWh and 22.03 GVarh, respectively. The total active and reactive energy losses by hybrid GA-PSO based approach are 0.55 GWh and 0.28 GVarh, respectively. All these values are less in comparison to those in base case system (Table 5). Further, a significant reduction

in active energy from the upper grid, active energy losses and reactive energy losses is observed for 69-bus test system also under scenario-2 in comparison to those under base case system. A comparison of the performance of 69-bus radial distribution network under different scenarios considered is presented in Table 10. From this table, it is observed that the energy losses are minimum in scenario-3; the active energy from the grid is minimum in scenario-2; and the reactive energy from the grid is minimum in scenario-1. There is a significant improvement in the minimum voltage of the system in case of scenario-2 and scenario-3. In terms of net saving, scenario-2 is found to be more effective. In scenario-2, the annual active energy losses, annual reactive energy losses, annual active energy from the grid and annual reactive energy from the grid reduce to 85.10%, 81.61%, 50.67%, and 92.32% of their respective values in base case system.

Table 10: Performance of 69-bus distribution system

Scenario	Load level	Energy losses		Energy from Grid		Voltage (in pu)	
		h)	Reactive (MVARh)	Active (MWh)	Reactive (MVARh)	Minimum	Maximum
Sc-1	Low	86.49	45.39	2157.28	4657.72	0.9927	1.00
	Medium	327.63	163.69	4949.57	12706.44	0.9916	1.00
	High	131.19	69.07	2344.14	4664.14	0.9854	1.00
	Total	545.31	278.15	9451.00	22028.30	-	-
Sc-2	Low	91.64	46.12	4058.44	401.88	0.9913	1.00
	Medium	261.22	132.83	10398.66	192.37	0.9911	1.00
	High	158.21	78.13	4428.90	356.57	0.9859	1.00
	Total	511.08	257.08	18886.00	950.82	-	-
Sc-3	Low	43.83	26.47	3812.34	788.28	0.9933	1.00
	Medium	135.74	80.95	9709.17	1463.43	0.9927	1.00
	High	67.23	41.43	3938.79	782.87	0.9895	1.00
	Total	246.80	148.85	17460.31	3034.58	-	-
Sc-4	Low	54.08	30.87	3949.13	499.60	0.9935	1.00
	Medium	194.33	105.50	10145.78	665.05	0.9927	1.00
	High	73.24	43.72	3860.85	775.30	0.99	1.00
	Total	321.64	180.10	17955.76	1939.95	-	-

Table 11: Comparison of performance of 69-bus distribution system for different scenarios

Scenario	Energy Losses		Energy from Grid		Minimum Voltage (pu)	Total saving (M\$)
	Active (MWh)	Reactive (MVARh)	Active (MWh)	Reactive (MVARh)		
Base Case	545.3	278.15	9451.0	22028.3	0.8744	0.0000
Scenario-1	511.0	257.08	18886.0	950.8	0.9178	1.3875
Scenario-2	246.8	148.85	17460.3	3034.5	0.9900	3.1528
Scenario-3	321.6	180.10	17955.7	1939.9	0.9854	2.7361

Summarizing the results obtained under different scenarios of 69-bus test distribution networks, it is observed that cost-saving due to reduction in peak active power losses has a very small share in the total saving achieved. Hence, it has minimum impact on the value of objective function. Therefore, the problem formulation can be further simplified by not considering the reduction in peak active power losses. Further, the installation of DGs is a costly affair as compared to the installation of capacitors. This is mainly due to operation and maintenance cost associated with DGs. However, the installation of DGs causes significant savings in terms of reduction in annual energy losses, and annual energy from the grid. When capacitors are also installed in the system, the performance of the network improves further.

CONCLUSION

In this study, an AHP based mathematical method is developed for optimal sizing and sitting of DG and capacitor in a radial distribution network from the distribution utilities point of view. The objective function comprises the installation and operating costs of DGs, installation cost of capacitors, saving in energy purchased from grid, saving in energy losses and saving in peak power losses. The developed formulation is a mixed integer nonlinear programming problem and has been solved using a hybrid GA-PSO based approach implemented under MATLAB environment.

In order to check the suitability of the developed model using AHP, it has been applied to IEEE 69-bus test distribution system under different scenarios. The comparison of results under different scenarios considered shows that integration of combined DG and capacitor in the power distribution network results into

better performance of the network in terms of significant reduction in annual energy losses and annual energy from the grid; and improvement in system voltage profile. The results of all AHP based scenarios are better than base case scenario and Scenario-2 outperforms the all scenatios in all aspects. Therefore, the developed formulation and approach for the solution may be helpful to the distribution utilities to plan the integration of combined DG and capacitor in the power distribution network.

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Visualizing the Renewable Energy Transition: Techniques, Insights, and Opportunities

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ABSTRACT

This paper provides a comprehensive review of data visualization techniques applied to renewable energy analysis in recent literature. As adoption of renewables expands globally, advanced visualization has become critical for deriving insights to inform policy, planning, and technology development. This review synthesizes the use of interactive mappings, temporal representations, network diagrams, grid integration models, and economic analysis graphics across over 50 recent studies. Geographic information systems, animated charts, Sankey diagrams, and marginal abatement cost curves are among the key techniques discussed. The strengths and limitations of these approaches are analyzed, along with principles for effective visualization design and opportunities for future research. Though challenges remain in communicating complexity and uncertainty, impactful visuals empower deeper exploration of renewable energy trends and scenarios. This synthesis provides key lessons for crafting engaging, evidence-based visualizations to accelerate the global energy transition.

KEYWORDS: *Renewable energy, Data visualization, Visual analytics, Energy planning, Energy policy.*

INTRODUCTION

Global renewable energy capacity has grown rapidly over the past decade, led by expansions in solar PV and wind power [1]. Total installed capacity for renewable power generation including hydropower reached 2,351 GW by the end of 2019 [7]. Solar PV capacity exceeded 627 GW globally in 2019, with an annual increase of 22% from the previous year [2]. Onshore and offshore wind showed net additions of 60 GW and 6 GW respectively in 2019 [3]. As this momentum continues, data driven analysis and planning is becoming increasingly crucial to guide future renewable energy deployments [4].

Advanced data visualization techniques are vital to deriving actionable insights from the growing complexity of energy datasets [5]. By leveraging interactive mappings, temporal charts, network diagrams and other novel graphics, researchers can engage diverse audiences and reveal key patterns, correlations and scenarios [6], [7]. Thoughtful application of visual analytics provides vital capabilities to synthesize and

intuitively communicate complex, heterogeneous data [8]. This empowers more informed analysis and decision making on renewable energy questions.

This review paper aims to synthesize the landscape of data visualization approaches applied to renewable energy analysis in recent literature. It will assess the utility of different techniques for energy systems planning and communication, identify best practices and limitations, and highlight opportunities to enhance evidence-based policymaking through impactful visuals. The visualization categories covered include geographic mapping, adoption trends, policy analysis, grid integration modeling and principles for effective design.

Overview of Visualization Review

This review focuses on data visualization techniques for renewable energy analysis applied in peer-reviewed academic literature over the past five years. It synthesizes the use of static and interactive maps, charts, diagrams and other graphical approaches across over 50 recent studies spanning energy science, power systems

engineering, public policy and related fields. While the focus is on renewables, some key visualizations also incorporate non-renewable energy data for comparison.

The paper is organized by visualization type, summarizing applications, strengths and limitations of techniques within each category. Following the sections on mapping methods, adoption trends, policies and infrastructure modeling, cross cutting principles for effective visualization design are discussed. Finally, opportunities for impactful energy visualizations and directions for future research are outlined.

LITERATURE REVIEW

The rapid growth of renewable energy has prompted extensive data analysis and visualization in recent literature to explore patterns, opportunities and challenges. Visual representations of trends provide vital insights for energy policy and planning. This review synthesizes key data visualization techniques applied to renewables growth.

Numerous studies have utilized visuals to convey renewable capacity expansion [6] leverages interactive charts to compare solar, wind, hydropower and bioenergy capacity globally over time. Gapminder tools animate renewables' rising but unequal distribution worldwide [1] use area charts to contrast technology costs, revealing dramatic solar PV cost reductions. Heat maps also effectively map the geography of renewables potential [6] To demonstrate policy impacts, [7] applies line graphs showing renewables uptake alongside policy timeline markers. Flow charts further visualize complex policy mechanisms and outcomes [8] . Pie charts break down renewables' share of electricity production among regions [5]. Bar charts highlight top countries for capacity additions [3].

Regarding integration challenges, [2] use line and shaded area graphs to forecast scenarios for natural gas use as renewables expand. [7] model high renewables penetrations with stacked area charts showing required generation profiles. Sankey diagrams outline energy flows from sources to end-use sectors with increasing electrification [4].

In summary, literature incorporates diverse, compelling visuals to synthesize complex renewable energy data. Animated and interactive tools enable engaging with time-series and geospatial patterns. Custom charts and

diagrams highlight infrastructure interdependencies and policy effects. Effective visualization supports analysis, communication and planning to accelerate the global energy transition.

Several studies highlight the power of interactive data visualization tools in enabling engagement with renewables data. The Global Solar Atlas and Global Wind Atlas allow users to visualize granular geospatial estimates of solar and wind resources through interactive maps and data querying [9]. Dynamic dashboards like NREL's Annual Technology Baseline provide customizable graphs and downloads of cost and performance projections for various technologies [6]. Such interactivity empowers deeper public understanding and tailored analysis.

Spatiotemporal visualizations also reveal rich insights. Animated heat maps of Rooftop PV adoption over time expose spatial disparities tied to demographics and policies [1]. Choropleth maps further showcase regional inequities in distributed generation access [5]. Pairing such maps with time lines of policy developments shows their impact on diffusion patterns [7]. Flow maps go beyond geography to model peer influence and social networks driving local energy transitions [8].

On the grid level, chord diagrams effectively display inter regional electricity transmission flows. use this approach to analyze power transmission capacity needs to integrate offshore wind. Sankey diagrams also outline electricity flows between sources and end-use sectors, highlighting efficiency losses [4]. Comparison with scenarios of higher electrification shows decarbonization pathways.

Economic analyses also apply innovative visualization. Marginal abatement cost curves model decarbonization options across sectors and plot cost-effectiveness [2]. Cost experience curves use scatter plots and trendlines to forecast renewable cost reductions over time and deployment [3]. Such quantification supports targeted policy and investment.

Several studies emphasize the value of interactive features for user-driven data exploration. The Global Wind Atlas and Global Solar Atlas allow custom filtering of parameters to generate targeted maps and graphs.

Research paper	Pros	Limitations
Dong et al. (2021)	Models multiple scenarios for gas needs under higher renewables Uses line/area graphs to show projected generation mixes Considers timescales out to 2050	Focuses solely on natural gas as complement to renewables Limited details on model assumptions and data sources
IRENA (2021)	Provides comprehensive global renewable capacity data Presents summary charts and tables for top countries Open access data updated annually	Lacks graphical visualizations and interactivity No analysis on drivers of adoption trends
REN21 (2021)	Collates wide range of renewable energy data globally Presents summary charts and tables for key indicators Open access report updated annually	Limited advanced graphical visualizations Minimal in-depth analysis on trends and drivers
Ritchie (2020)	Interactive charts allow custom comparisons of renewables globally Frequent data updates and open access Covers range of technologies	Limited contextual analysis of adoption drivers No discussion of grid integration challenges
World Bank (2020)	Solar capacity grew 6 fold from 2011 to 2020. New additions were 113 GW in 2020.	Does not always differentiate between installed vs operational capacity

Fig. 1. Literature Table

Dashboards like NREL’s Annual Technology Baseline enable toggling projections based on assumptions. This interactivity provides flexibility for research and planning.

Geospatial techniques reveal granular patterns of diffusion. use choropleth maps to expose disparities in rooftop solar adoption at the census block group level, linking socioeconomics with uneven access. Granularity shows opportunities for targeted policy.

Temporal techniques clarify the pace of change. animate heat maps of German solar PV diffusion over time, exposing spatial heterogeneity. Comparison with policy timelines shows their uneven effects by location. Animations engage audiences while clarifying nuanced trends.

Network maps provide unique insights into influence and relationships. use flow maps to model peer effects driving residential solar purchases. Network graphs also visualize complex partnerships in community energy projects. These highlights social dimensions affecting energy transitions.

Systems techniques outline integration complexities. Chord diagrams effectively display inter-regional transmission flows that rise with offshore wind. Sankey diagrams quantify efficiency losses as electricity moves between sources and uses. This reveals grid infrastructure needs.

Modeling approaches enable scenario analysis. Marginal abatement cost curves allow comparing policy options across sectors for decarbonization. Cost projections empower targeted roadmaps and planning.

Future Outlook

Most forecasts predict strong continued growth for renewables based on projected cost trajectories and policy support [9]. Scenarios model solar and wind dominating capacity additions, displacing fossil fuel generation [10]. However potential barriers exist, including grid integration challenges and policy uncertainty [3], [12].

GROWTH TRENDS AND GEOGRAPHIC POTENTIAL

Interactive Mapping Approaches

Interactive mapping tools have enabled more advanced exploration of renewable resource potential and asset locations globally. The Global Solar Atlas developed by the World Bank provides customized maps and data on solar PV potentials worldwide [15]. Users can tailor views based on parameters like minimum power density, solar irradiation, temperature effects and land exclusions. Datasets can also be downloaded for further analysis. The Global Wind Atlas created by the Technical University of Denmark offers similar interactive mapping and data extraction capabilities to explore wind resources [16].

Geographic information systems (GIS) facilitate geospatial analysis of technical and economic viability for siting renewable projects [9]. GIS platforms allow researchers to overlay factors like terrain gradients, distance to transmission infrastructure, and protected land boundaries to identify and rank suitable locations for development [10]. Web platforms like IRENA’s Global Atlas also allow filtering of maps by technology, scale and scenario to compare adoption patterns across regions [19]. These tools empower stakeholders to tailor map views and extract locally relevant insights.

For example, a 2019 study utilized the Global Solar Atlas to assess rooftop PV potential across Bangladesh [11]. By applying filters and geospatial analysis, the authors identified suitable roof space and estimated generation potential for different regions. This enabled

tailored policy and grid planning recommendations accounting for geographic variability in resources.

Heat Maps and Choropleth Techniques

In addition to interactive platforms, static mapping techniques have also been widely applied. Heat maps use color gradients to clearly delineate zones of high and low renewable energy potential [12]. Darker shades often indicate higher economic feasibility, revealing prime target areas for development. Choropleth maps of adoption metrics like installed capacity or generation percentage reveal inequality across states, provinces and countries [13]. Both static techniques enable concise communication of spatial patterns to supplement interactive analysis.

For instance, a 2018 analysis combined choropleth and heat maps to visualize county-level solar adoption across California [14]. This revealed rapid growth in certain regions along with factors like household income and population density correlating with uneven diffusion. The simplified maps effectively communicated geographic correlations and gaps to be addressed.

Discussion

Interactive maps provide customizability for exploring complex geospatial datasets, enabling analysis that is tailored to user needs and localized conditions [9]. However, interactivity also introduces challenges in complexity and user-interface design. Static mapping techniques distill key geographic insights but lack the adaptability of interactive platforms [12]. Enhancing the accessibility and user-friendliness of these tools could catalyze their broader adoption for energy planning. Overall, both interactive and static maps prove invaluable for conveying the uneven geographic diffusion of renewables driven by resource availability, infrastructure constraints, policies, and socioeconomic factors.

ADOPTION TRENDS AND INDICATORS

Interactive Dashboards

Advanced visualization tools like NREL's Annual Technology Baseline (ATB) provide animated and interactive views of capacity expansions, cost declines, and technology mix trends over time [24]. The ATB platform allows filtering by region and scenario,

facilitating exploration of the drivers behind adoption patterns under different assumptions. Similarly, the Electricity Visualization Platform developed by Carbon Brief dynamically visualizes global electricity transitions from 1990-2019 [15]. These tools enable engagement with multi-dimensional, temporal datasets through dynamic charts and scenario customization.

For example, a 2021 analysis utilized the ATB dashboard to compare leveled cost trajectory scenarios for different renewable technologies in the US out to 2050 [16]. The interactive charts revealed onshore wind and utility PV achieving the steepest near-term cost declines under the projections. This insight informs competitive technology prioritization for policymakers and investors.

Tableau Dashboards

The Tableau dashboard consists of two main sections - a global capacity trends chart over time, and regional technology breakdowns for the current year selected [17]. Auxiliary filters allow restricting the data by region, specific technology, and metrics like total capacity or annual additions. Annotations reveal key milestone years. Color encoding visually distinguishes the technology trends.

The core global trends chart depicts total installed capacity from 2000-2019 as well as technology percentage breakdown using a stacked area graph. Mousing over any data point displays details for that year. Smooth animations transition between years, avoiding cognitive overload [18]. Auxiliary axis lines visually separate capacity increments for easier reading aligned to design principles on accessible visual encoding [19].

The regional breakdown charts use horizontal bar graphs to compare technology adoption percentages across 10 major geopolitical regions for the selected filter year. Hover tooltips enable inspection of exact percentage values. Bars are color coded by technology as in the main trend chart. The dual chart panels facilitate both global temporal and regional comparative analysis.

Solar PV Insights: Examining the dashboard reveals solar PV's remarkable growth since 2015, overtaking biofuels as the third largest renewable technology by 2019 [20]. PV compounded annually worldwide by

over 20% from 2015- 2019 to reach ~650 gigawatts. Annotation callouts mark key milestones like 2016 surpassing hydro capacity and 2019 exceeding biofuels. This reinforces narratives of the unprecedented solar boom.

levelized cost of energy reductions into factors like turbine scaling, manufacturing improvements, O&M gains, and balance of system changes [23]. This provided nuanced insights into the drivers of cost improvements over time.



Fig. 2. Renewable Energy Growth Trends Dashboard

China alone represented over 45% of 2019 PV additions [21]. Animating the dashboard shows China also drove the acceleration in global solar after 2015 through investments aligned with air pollution and climate policy goals [1]. Europe’s contribution diminished as a share of total solar capacity during this period. The regional splits thus enable assessing differential policy impacts and technology potentials internationally. Overall, the dashboard effectively visualizes key renewable technology and adoption trends.

Declining Cost Trends

Area charts have emerged as a key technique for communicating the remarkable decline in renewable energy costs due to technology improvements, economies of scale, and policy support. For example, an IRENA chart vividly showcases the over 90% drop in utility-scale solar PV prices globally over the past decade [22]. Overlaying timelines of deployment volumes and policies reveals correlations. Area charts like these compellingly reinforce how expanded implementation accelerates cost reductions through learning curve effects.

A 2018 study of wind power learning curves applied stacked area charts to decompose national and global

Top Adopters Ranking Charts

Bar and column charts ranking countries by total or per capita renewable energy adoption are commonly used to highlight leaders and laggards in the transition [13], [24]. Though they concisely communicate where aggregate adoption is concentrated globally, these static charts lack temporal and geographic context that supports a more meaningful assessment of progress. They also obscure important capacity factors and generation share metrics.

For example, a 2020 comparison of per capita solar PV adoption across European countries simply ranks the metrics using bars, but lacks trends over time or correlation analysis [25]. More impactful communication could be achieved by integrating temporal and electricity sector context, as well as adopting metrics like solar penetration percentage.

Discussion

Interactive dashboards empower deeper exploration of complex technology and regional adoption patterns hidden within multidimensional datasets [24]. Their utility depends heavily on thoughtful visual encoding and user controls. Static charts efficiently rank adoption metrics but should be complemented by other visuals and text to aid interpretation and contextualization [18]. Overall, skillfully blending dynamics, interactivity and supplemental information enables more impactful communication and revealed insights from adoption data.

IMPACTS OF POLICIES AND INCENTIVES

Correlation Analysis

Researchers are using time series charts to visually analyze the correlations between adoption trends and policy timelines. Overlaying cumulative installed capacity on top of major policy enactment dates reveals the success of German market stimulation policies in catalyzing rapid solar PV growth since 2004. Similarly,

charts linking electric vehicle sales growth to federal tax credit implementation and refinements showcase the importance of coordinated policy support frameworks [27]. Visually inspecting alignments and lags between policies and adoption outcomes provides evidence of their effectiveness.

For instance, a 2017 assessment of state renewable portfolio standards overlaid wind and solar capacity expansions on top of policy adoption years across the United States [28]. Spikes in solar and wind project construction following policy enactment were apparent. This methodology can help quantitatively validate policy design, as well as identify influential state-level policies.

Mechanism Mapping

Flow charts are commonly used to outline the mechanisms of complex renewable energy support policies. For instance, sequence diagrams clarify the eligibility, application, incentive calculation and payment steps established in feed-in tariff programs for different stakeholders [29]. Process flow visuals help demystify multifaceted policies like priority grid access, floating tariffs, and dispatch rules .

A recent 2021 review utilized flow diagrams to map out interactions between electric vehicle policies, charging companies, vehicle owners, utilities, and infrastructure providers [30]. By simplifying complex incentive structures, the diagrams facilitated comparative policy analysis and identified best practices.

Changing Energy Flows

Sankey diagrams efficiently trace changes in energy flows across electricity, heat, transport, and industry sectors over time [31]. By quantifying the cascading and cross-sectoral impacts of policies, this technique makes their complex systemic outcomes more tangible [32]. However, summarizing intricate interactions simply may also obscure important nuances [33].

For example, a 2020 analysis applied Sankey diagrams to visualize the shifting structure of China's energy system under air pollution reduction policies from 2005 to 2015 [34]. The simplified energy flows revealed surging renewable electricity displacing coal power generation over time. But underlying grid integration complexities were obscured.

Discussion

Well-designed visuals can build intuitive understanding of renewable policy mechanisms and help quantify intended adoption outcomes [27]. But simplified representations also risk masking complex policy details or unintended market consequences. Communication should align the level of visualization complexity with the specific audience and goal [33].

GRID INTEGRATION AND INFRASTRUCTURE PATHWAYS

Scenario Modeling

Load curve charts visualize how reliance on solar, wind, and other variable renewable resources may evolve under high penetration scenarios [35]. Comparing the shape and flexibility needs of different futures informs power system planning and grid modernization investments [36]. Advanced production cost models also quantify optimal storage expansion and dispatch under ambitious renewable targets [37]. Visualizing infrastructure requirements elucidates integration pathways.

For example, a 2020 study simulated California's famous duck curve under scenarios reaching over 80% renewables by 2045 [38]. By quantifying the ramping needs and over generation risks year-by-year, the visualized load curves guided recommended deployment of utility-scale storage, demand response and transmission.

Transmission Network Analysis

Studies apply chord diagrams and network models to projected power flows between regions resulting from transmission network expansion plans [39]. Optimizing inter-regional transmission capacity and siting to access high quality renewable resources while meeting local balancing needs reveals key grid infrastructure investments required under deep decarbonization [40].

Recent analyses have utilized network diagrams to optimize offshore wind transmission schemes to minimize grid integration costs at high shares of wind generation [41]. This methodology can be extended to broader renewable integration studies.

Marginal Abatement Cost Curves

This economic graph compares emissions reduction potential and costs across power, industry, transport and building sectors [42]. The visualized cost-competitiveness and magnitude of opportunities guides cost-effective policy prioritization across technologies and applications [43]. However, the tool simplifies complex cost comparisons between heterogeneous strategies [44].

For example, a recent 2021 study applied abatement cost curves across all sectors in South Korea out to 2050 [45]. While limited by methodological uncertainties, the visualization provided high-level insights into national decarbonization priorities.

Discussion

Power systems models yield vital insights into infrastructure requirements as renewable penetration increases [35]. But model outputs depend heavily on assumptions around technology costs, grid flexibility and policy frameworks [46]. Communicating the uncertainty in scenarios is essential while leveraging visuals to enhance engagement [47].

OPPORTUNITIES FOR FUTURE RESEARCH

Incorporating Uncertainty

Visualizing confidence intervals, scenario ranges, and probabilities would better communicate the uncertainty inherent in projecting complex energy systems [47], [52]. Improved representation of uncertainties is an open challenge needing advancement.

Immersive Platforms

Virtual and augmented reality could enhance renewable energy learning and participatory planning by immersing audiences in scenarios [19], [53]. Exploring these engagement opportunities, while ensuring accessibility, offers promise.

Broadening Audience Reach

Simplifying visualizations and incorporating narrative for broad communication with policymakers and the public requires further work [18], [50]. Enabling comprehension by diverse stakeholders remains difficult.

Capacity Planning Tools

Developing interactive tools optimizing geospatial siting of renewable projects based on technical, environmental and social constraints could enhance planning [19], [54]. Advancing these decision support capabilities is impactful.

Research Alignment

Evolving analytical needs and data availability require adapting techniques continually [4]. Aligning methods with leading edge practices ensures relevance. But lag times in adopting new tools persist [55].

CONCLUSION

Summary

This comprehensive review synthesized a diverse landscape of data visualization techniques enabling renewable energy analysis across over 50 recent studies. Static and interactive maps, temporal charts, network diagrams, infrastructure models, and economic graphics were included, spanning key applications like geographic resource potential, adoption trends, policy impacts, grid integration, and decarbonization pathway analysis.

Assessing comparative strengths and limitations across categories revealed benefits of interactivity for exploratory analysis [15] and simplified graphics for efficient communication [21]. Animated temporal representations clarify growth and technology substitution patterns [24], while process diagrams build policy understanding [29]. Systems visuals outline infrastructure needs under higher renewable penetrations [38] and economic models compare strategy cost-effectiveness [42].

Common principles for effective design entail thoughtful visual encoding to minimize complexity and ensure accessibility [18], user controls that enable multidimensional data filtering [26], communicating uncertainty ranges inherent in projections [47], and tailoring representations for intended audiences [33]. Skillful information visualization distills key patterns, correlations and scenarios from heterogeneous energy data to reveal actionable insights.

Synthesizing these complex dynamics into intuitive graphics aids interpretation and heightens engagement.

By crafting compelling evidence-based visual narratives, policymakers, investors, and the public can be empowered toward data-driven planning and decisions accelerating renewable energy advancement. However, difficulties conveying intricacy and uncertainty across diverse groups persist as ongoing challenges [50], [52].

Outlook

Renewable energy deployment is forecast to continue expanding extraordinarily in the long term, driven by supportive policy frameworks, ongoing technology improvements, and accelerating economic competitiveness [48]. Solar and wind are projected to dominate capacity additions going forward, fundamentally transforming power systems toward variable generation [49]. Analogous transitions toward electrification of transportation and other sectors is also anticipated [51].

Managing the complexity stemming from these dynamics necessitates advanced analytical approaches and tools. As such, data-driven planning and scenario analysis enabled by impactful data visualization will remain integral to guiding. Evidence-based insights revealed through skillful representations can activate audiences toward decarbonization opportunities aligned with planetary boundaries [51].

However, significant difficulties persist regarding effectively conveying intricacies and uncertainties inherent in modeling complex energy transitions across broad audiences [50], [52]. Quantifying uncertainty ranges within visualization tools promises to improve judicious policy development and technology roadmaps [47]. Adopting immersive extended reality techniques may heighten engagement for participatory planning [53].

Advancing capacity optimization and siting tools also offers substantial value in smoothing integration amidst grids with unprecedented renewable penetrations [54]. Continual alignment of analytical methods with leading practices counters lags from emerging innovations [55]. Most critically, simplifying representations for dissemination to policymakers and the wider public remains imperative but challenging, needing advancement [18], [50].

Promising opportunities thus exist across conveying

uncertainty, leveraging immersive environments, progressing planning capacities, ensuring model consistency, and expanding accessibility. Innovations on these frontiers promised by this synthesis can further strengthen evidence-based decision making guiding regional and global energy systems toward sustainability targets [5], [10]. Perfecting renewable energy visualization promises optimistic, prudent pathways aligned with planetary boundaries.

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Investigation of Deep Learning Models for Automatic Building Detection from Aerial Images to Improve Performance Score

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ABSTRACT

Building detection from aerial images is a challenging task due to the large-scale variations in building size and orientation. Detection of buildings in aerial images plays a vital role in land planning, mapping, and post-disaster reconstruction. In this paper we have investigated and implemented Mask R-CNN and U-Net for accomplishing the task of building detection. We also propose a modified U-Net model which gives better accuracy than the base U-Net. The base U-Net model has four encoders and decoders for semantic segmentation. We have modified the U-Net model by increasing the number of encoders and decoders to six and adopting the convolution kernel size from (3×3) to (2×2) . Along with the architectural modifications, the hyperparameter tuning employed after performing the ablation studies experimentally prove that the accuracy for building detection is improved. The proposed modified U-Net model is trained using 400 images on the Inria aerial image dataset and tested using 96 images. The IoU score obtained for this model is 0.52 over the base U-Net model which had IoU score of 0.37.

KEYWORDS: *Building detection, Aerial image, Mask R-CNN, U-Net, IoU.*

INTRODUCTION

Object detection is an important application of computer vision and image processing which detects instances of semantic objects of different classes such as humans, roads, cars, or buildings in digital images. In object detection a bounding box is drawn around each instance of the object and a class label is given to every detected instance. Deep learning techniques are becoming immensely popular for accomplishing the task of object detection. Many deep learning algorithms like LinkNet [1], Mask R-CNN [2], SSD [3], HOG [4], YOLO [5], U-Net [6] etc. are used to perform detection of objects in images. Detection of objects in high-resolution aerial images is a demanding task as there is a vast difference in object dimensions and inconsistency in distribution of objects. Aerial images refer to the images taken from drones, aircrafts, etc. One of the important object detection tasks in aerial imagery is building detection which has a significant role in land development, urban development, and post-disaster reconstruction.

We have performed building detection using the U-Net and Mask R-CNN models. Mask R-CNN is widely used for instance segmentation whereas U-Net is used for semantic segmentation. Mask R-CNN draws a bounding box and generates a segmentation mask for each detected building. U-Net performs semantic segmentation by classifying each pixel as building or non-building. Work presented in the paper proposes a modified architecture of base U-Net. Using modified U-Net having more depth and tuning the hyperparameters of the model has shown improved accuracy when compared with other deep learning (DL) models.

In literature there are different methodologies presented for building detection tasks. Deep learning approaches are the most recent among these reported methods.

Mask R-CNN is adopted in [7] as a base network due to its simplicity in the network structure and hyperparameter tuning. After running Mask R-CNN, polygon points are produced for each individual building. These polygon points correspond to the building boundaries and normally have irregular shapes. These polygons

generated by Mask R-CNN are converted into regularized polygons. The COCO [8] dataset is used for training (80%) and testing (20%) purposes. Intersection over Union (IoU) is used for performance evaluation of the model. This method produces regularized polygons which are used for different applications.

In [9] R-CNN is used to perform the task of detection. The final result has the position and the category of the detected target object. Based on the building area estimation a fully connected layer in the R-CNN is changed to a convolutional layer. The difficulty in this approach was that all the buildings cannot be identified due to the traditional method. Kappa coefficient and precision rate are used to evaluate the accuracy of the model. Although the model was successful in reducing computation time, the accuracy of the model needs to be improved.

A modified version of LinkNet as the basic underlying model was used in [10] for the building segmentation problem. The network architecture consists of an encoder that extracts multi-scale features and a decoder with skip-connections from the encoder for a more accurate localization of object boundaries. High resolution images from the SpaceNet dataset are used for extraction of buildings from satellite images. Loss function is designed to separate the buildings in the dense area. Modification in the model helped in accelerating the convergence but did not make any improvement in F1-score.

Sliding region-based Convolutional Neural Network (CNN) is used by [11]. In this approach the slider box slides over the input image. This is in line with convolution having a predefined stride value. The spatial resolution of the input image has a vital role in determining the stride value. At every box position, the model performs object detection using Faster R-CNN [12]. The VEDAI dataset was used for model training and testing. The problem of detection of buildings of different size and orientation is resolved by using an internal slider box. However, if the convolution operation is performed on an image having large dimensions, multiple hyperparameters are created. The storage and processing of these hyperparameters impose another challenge.

U-Net which is an encoder-decoder architecture based on ResNet-50-v2 is used to identify buildings [13]. It is a segmentation model which classifies each pixel in an input image as a building or background. In this the decoder block consists of batch normalization, ReLU and residual connection to the input. The dataset used for training and testing is COCO. The model is evaluated using Mean Average Precision (mAP).

METHODOLOGY

Study of various models indicated that Mask R-CNN and U-Net models were suitable for performing building detection. The Mask R-CNN model traces the building boundary which can be used to accurately get the building area. However, the Mask R-CNN model takes a large amount of time for training, hence another model, U-Net has been implemented to solve the building detection problem. The U-Net model has an advantage over Mask R-CNN as it requires less amount of time for training. But the accuracy of the U-Net model is low. To improve the accuracy of detection we have proposed a modified U-Net model which has shown better accuracy than the base U-Net model.

Mask R-CNN Architecture

Mask R-CNN is an extended version of Faster R-CNN which adds a network branch to obtain segmentation masks. It is a versatile network which performs image segmentation as well as instance segmentation.

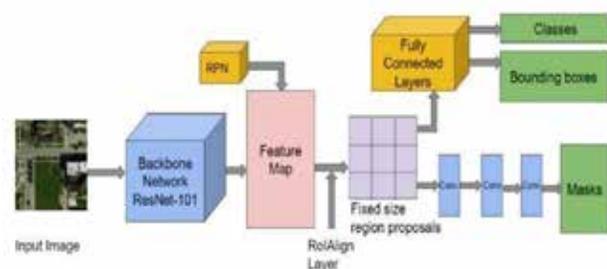


Fig. 1. Mask R-CNN architecture for building detection

As shown in Fig. 1, the architecture of Mask R-CNN works in two stages. The first stage has a backbone network and a Region Proposal Network. ResNet-101 is used as a backbone network to extract features from an image. The Region Proposal Network predicts proposals based on the location of an object in a

particular region. In the second stage bounding boxes and object class labels are obtained for each proposed region in stage one. For fully connected network fixed size vectors are required to make proper predictions. However, the proposed regions can be of different sizes hence RoIAlign method is used to convert the proposals to same dimensions. We have used the publicly open implementation of Mask R-CNN and adopted hyperparameters used for training the COCO dataset.

U-Net architecture

U-Net is an encoder decoder type of architecture which consists of a contracting path and an expansive path having four encoder and five decoder blocks (excluding the bottleneck conv. layer) indicated in Fig. 2.

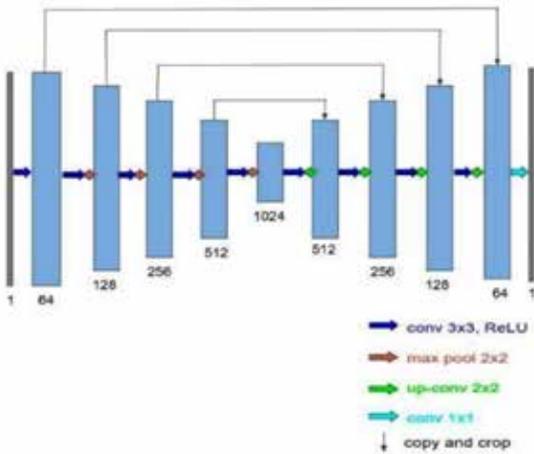


Fig. 2. U-Net architecture for building extraction

In the contracting path 3x3 convolutions are applied repeatedly. It also consists of a rectified linear unit (ReLU), max pool operation for downsampling to extract features. For every downsampling step the feature channels are doubled. In the expansive path, upsampling of the feature map is performed using 2x2 up-convolution. The feature channels are halved during the up-convolutions.

Proposed Modified U-Net Architecture

Our proposed modified U-Net model consists of an expansive and contracting path having six encoder and decoder blocks (excluding the bottleneck conv. layer) as shown in Fig. 3.

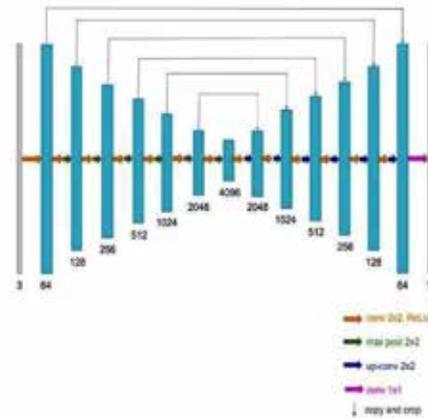


Fig. 3. Modified U-Net architecture for building extraction

The size of the convolution kernel in each encoder block has been changed from (3x3) to (2x2), deciding it empirically through experimental analysis. The activation function used is a rectified linear unit (ReLU). Max pool operation is performed for downsampling. The encoder blocks comprise 64, 128, 256, 512, 1024, 2048 filters respectively from top to bottom. The decoder has the same number of filters as that of the encoder in bottom to top order.

The proposed U-Net model flowchart is depicted in Fig. 4.

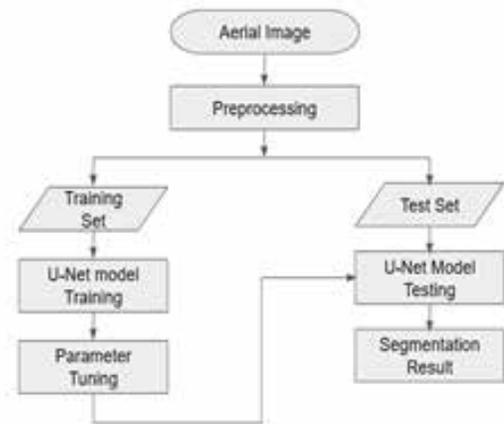


Fig. 4. Modified U-Net flowchart for building extraction

Experimental Evaluation

The experimental setup consists of NVIDIA P100 Graphics Processing Unit (GPU) with PyTorch environment for training and testing of the deep learning models on large scale aerial images.

Dataset

We have used the Inria [14] dataset for training as well as testing the Mask R-CNN and U-Net models. The training set of the Inria dataset contains 180 color images of size (5000×5000) pixels, covering a surface of (1500m×1500m) with 30 cm resolution. It contains images of cities viz., Austin, Chicago, Kitsap County, Western Tyrol, Vienna. All the images in the database are in .tiff format. We have used a part of the Inria dataset which includes aerial images of Austin and Chicago. The number of input train images for all the models selected are 400 and the number of test images are 96. For the Mask R-CNN model the input image size of (320×320) pixels is chosen after experimental investigation and manually annotated the images which act as ground truths. For the U-Net model and the modified U-Net model we have used the ground truth segmentation masks as provided in the Inria dataset.

Data Pre-processing

The images as well as their ground truth are pre-processed in terms of resizing the images for preparing the training, testing, and validation sets. The images in the Inria dataset have dimensions of (5000×5000) pixels. We have resized these images to (5120×5120) pixels. Further, the resized images are cropped to (1280×1280) pixels. Data augmentation is performed by cropping the images to smaller sub-images with dimension of (320×320) pixels, then flipping these images both horizontally as well as vertically and rotating by 90°. It resulted into total of 14400 images. These images are applied as an input to train the U-Net model. The image size of (320×320) pixels exhibited optimum performance. The base U-Net and the modified U-Net model are trained for 10, 20, 30, 40, 50 and 100 epochs.

Evaluation Metrics

The evaluation metric used for Mask R-CNN is Mean Average Precision (mAP). For finding Average Precision (AP) are Precision and Recall computed as,

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

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

where TP stands for True Positive, FP is False Positive, and FN stands for False Negative. The area under the Precision – Recall curve gives the AP value. To

calculate the mAP score, the mean of AP is taken overall the classes or overall IoU thresholds. Intersection over Union (IoU) score was used as the evaluation metric for the base as well as the modified U-Net models. IoU score is the amount of overlap between ground truth and predicted output. It is given as,

$$\text{IoU} = \frac{\text{Area of overlap}}{\text{Area of union}} \quad (3)$$

The ideal value of IoU score lies between 0 to 1, where 0 indicates no overlap between the ground truth and predicted output and 1 indicates perfect overlap between the ground truth and predicted output.

Dice Loss is the evaluation metrics which gives the difference between the predicted and actual segmentation of an image.

$$\text{Dice Loss} = 1 - \text{Dice Coefficient} \quad (4)$$

$$\text{where Dice Coefficient} = \frac{2 \times TP}{(TP+FP) + (TP+FN)} \quad (5)$$

Model Training and Parameter Optimization

To choose the right combination of model parameters and hyperparameters which will maximize the performance of deep learning models, multiple trials are conducted during the model training process. In the case of model parameters the number of layers and convolutional kernel size are varied with different sets of values and model performance is noted. Along with this, some hyperparameters such as learning rate, number of epochs, and batch size are rigorously examined to check optimum model performance. Different learning rates of 0.009, 0.09, 0.1, 0.5, 0.9 are tested for training the U-Net model. The best results are observed for the learning rate of 0.9. Hence, we fixed the learning rate to 0.9. For analyzing the effect of change in number of layers on the detection accuracy, with the learning rate of 0.9, batch size 8, kernel size of (3×3), and input image dimensions are (320×320) pixels. The readings shown in Table 1 are initially taken for 10 epochs. The best IoU score is observed for 6 layers. Hence, 6 layers were fixed for the modified U-Net model.

Table 1. Effect of change in number of layers on IoU score and Dice loss

Layers	IoU Score	Dice Loss
5	0.5034	0.0355

6	0.5158	-0.0097
7	0.5065	0.0123

For evaluating the effect of change in convolution kernel size on 6 layers, with the learning rate of 0.9, batch size of 8 and input image dimensions as (320×320) pixels. The readings shown in TABLE 2 are taken for 10 epochs.

Table 2. Effect of change in convolution kernel size on IoU score and Dice loss

Kernel Size	IoU Score	Dice Loss
2 × 2	0.5226	-0.0339
3 × 3	0.5010	0.0622
5 × 5	0.5152	-0.0083

The best IoU score was obtained for kernel size 2. Hence, kernel size was set to 2 in the modified U-Net. To check the effect of batch size on 6 layers and kernel size of 2, we had set the learning rate to 0.9 and input image dimensions were (320×320) pixels. TABLE 3 indicates the effect of changing batch size on IoU score for 10 epochs. Since the best IoU score is obtained for batch size of 8, this value is chosen for training the modified U-Net model.

Table 3. Effect of change in batch size on IoU score and Dice loss

Batch Size	IoU Score	Dice Loss
4	0.5167	0.0015
5	0.5226	-0.0339
6	0.5070	0.0325

RESULTS AND DISCUSSION

For testing the Mask R-CNN model, a learning rate of 0.012 is set experimentally, the steps per epoch as well as the number of validation steps are set to 85. For testing the base U-Net model, the learning rate of 0.009 and the batch size as 8 are selected. For testing the modified U-Net model, we used the learning rate as 0.9. The results obtained are for the testing set which contains 96 images.

With these settings and selection of ReLU activation in convolutions layers of both U-Net models, model predictions are found for the three models. Results will be discussed further.

Mask R-CNN Results

The images shown in Fig. 5 (a) and (c) are the ground truth building images. Building image predictions with the Mask R-CNN model are shown in Fig. 5 (b) and (d). The Mask R-CNN model is evaluated by changing the number of epochs from 1 to 5 and setting the steps per epoch and the number of validation steps to 85.

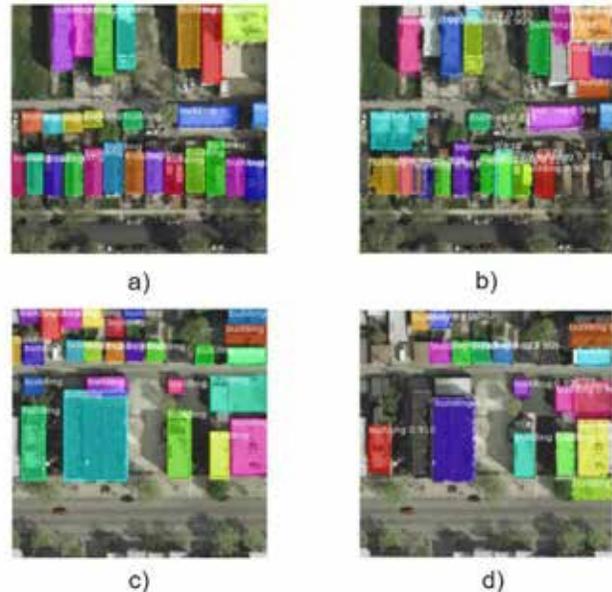


Fig 5. (a) and (c) Ground truth building images, (b) and (d) Mask R-CNN model predictions

Table 4 shows the results of the Mask R-CNN model. It can be seen that the best mAP score was obtained for 3 epochs.

Table 4. Mask R-CNN results

Epochs	mAP
1	0.334
2	0.298
3	0.364
4	0.249
5	0.299

Base U-Net Results

The results shown in Fig. 6 (a) and (d) are the original aerial input images given to the U-Net model. The ground truth segmentations masks are as given in Fig. 6 (b) and (e). The predicted results with the base U-Net model, which was trained on 20 epochs, with batch size

of 8 and learning rate as 0.009 are depicted in Fig. 6 (c) and (f).

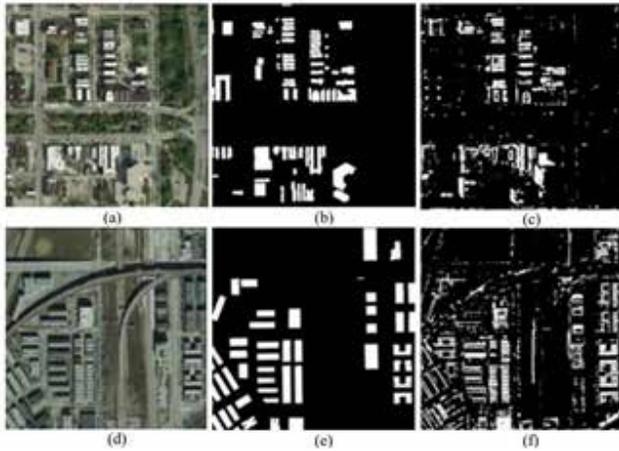


Fig. 6 (a) and (d) Original aerial images from Inria dataset, (b) and (e) Ground truth segmentations masks, (c) and (f) Base U-Net model predictions

The evaluation of the U-Net model was carried out by varying the number of epochs on a fixed batch size of 8, with a constant learning rate of 0.009. The number of layers were 4 with kernel size of 3 having input image dimension (256×256) pixels. TABLE 5 shows the evaluation of the Base U-Net model. It can be seen that the best IoU score of 0.3704 was obtained for 50 epochs.

Table 5. Base U-Net results

Epochs	IoU Score	Dice Loss
10	0.3651	0.2644
20	0.3702	0.2374
30	0.3644	0.2638
40	0.3672	0.2187
50	0.3704	0.2564

Modified U-Net Results

The performance of the proposed modified U-Net model is evaluated by varying the number of epochs from 10 to 50 on input images with (320×320) pixels. Fig. 7 (a) and (d) are the aerial images given as an input to the modified U-Net model. Fig. 7 (b) and (e) indicate the ground truth masks and Fig. 7 (c) and (f) show the predicted results with the modified U-Net model.

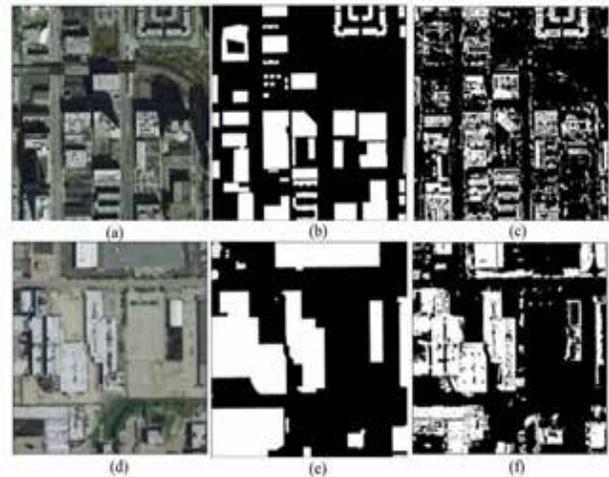


Fig. 7 (a) and (d) Original aerial images from Inria dataset, (b) and (e) Ground truth segmentations masks, (c) and (f) Modified U-Net model predictions

Table 6 shows the evaluation of the Modified U-net model. It can be seen that the best IoU score of 0.5226 was obtained for 10 epochs.

Table 6. Modified U-Net results

Epochs	IoU Score	Dice Loss
10	0.5226	-0.0339
20	0.5080	0.0147
30	0.5106	-0.0102
40	0.5022	0.0540
50	0.4963	0.0908

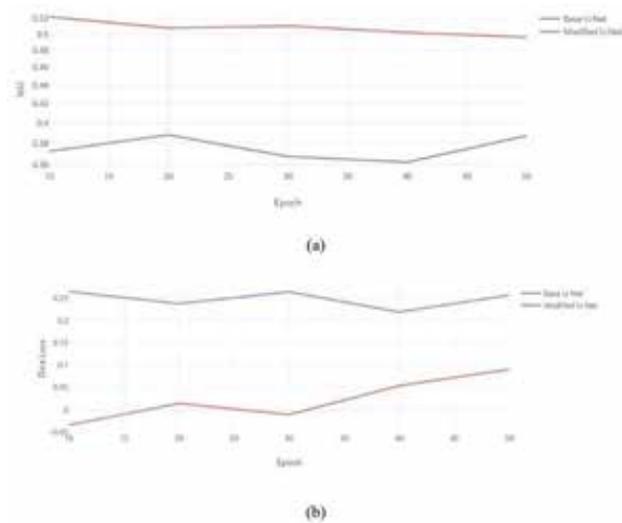


Fig. 8 (a) IoU vs. Epochs, (b) Dice Loss vs. Epochs

Fig. 8 (a) shows the variation in IoU score with increase in the number of epochs and the variation in Dice Loss score with increase in the number of epochs is indicated in Fig. 8 (b). Both IoU score and dice loss implies that the proposed modified U-Net performs better than the base U-Net model.

CONCLUSION

In this paper, we examined the Mask R-CNN and U-Net models for building detection. The Mask R-CNN generates masks and bounding boxes around the detected buildings. It also gives a score to each detected building which helps to understand the accuracy of prediction. The U-Net model performs semantic segmentation and classifies each pixel in the input image as a building or background. Further, we proposed a modified U-Net architecture which has greater depth and suitably tuned hyperparameters to achieve better accuracy. This model works in a similar manner as that of the conventional U-Net model. The modified architecture resulted in substantial improvement over the base U-Net model. Deep learning model parameter tuning and hyperparameter optimization is carried out extensively to identify the contribution of each unit in the modified U-Net and hence resulted in improved building detection performance.

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Fostering Technical Excellence: A User-Friendly Plagiarism Detector For Educational and Professional Domain

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ABSTRACT

This paper describes A plagiarism Detector that accepts PDF as well as text as input and after processing the data, displays a plagiarism in form of percentage. This checker uses language processing techniques to identify plagiarism content. Such as, Natural language processing, Anomaly detection, cross language plagiarism detection and deep learning. This website is highly user friendly even a novice can use it easily. Result will be generated in percentage form based on user's input, which can be both text input or PDF file. One day, it's possible that the resources could expand and benefit researchers, teachers, and writers alike. This paper presents the effectiveness of plagiarism checker in various document formats. This tool is capable of maintaining both professional and academic ethics. Plagiarism the act of imitating someone else's work without proper attribution, is a serious concern across educational and professional domains. The project presents a plagiarism checker, an essential to designed to mitigate this issue. A plagiarism Detector that accepts PDF as well as text as input and after processing the data, displays a plagiarism in form of percentage. This checker uses language processing techniques to identify plagiarism content. Such as, Natural language processing, Anomaly detection, cross language plagiarism detection and deep learning. This website is highly user friendly even a novice can use it easily. Result will be generated in percentage form based on user's input, which can be both text input or PDF file. One day, it's possible that the resources could expand and benefit researchers, teachers, and writers alike.

KEYWORDS: *Plagiarism detection, Plagiarism tools, Plagiarism detection methods.*

INTRODUCTION

In today's digital age, creation, sharing, and other information-related tasks have reached new heights, and with it, the unethical use of information has also increased. There is more data than there are handlers, which has led to problems such as plagiarism and piracy. Plagiarism, which involves using someone else's work or ideas without giving them credit, is a significant concern in both academic and professional settings. It undermines the integrity of knowledge, education, and content creation. To combat this issue, plagiarism checkers have become essential tools. These tools are designed to compare a given piece of text with existing sources, identifying instances of similarity and potential plagiarism. Though such tools may not completely solve the problem of plagiarism, they help minimize the probability of it occurring.

Types of plagiarism are as follows:

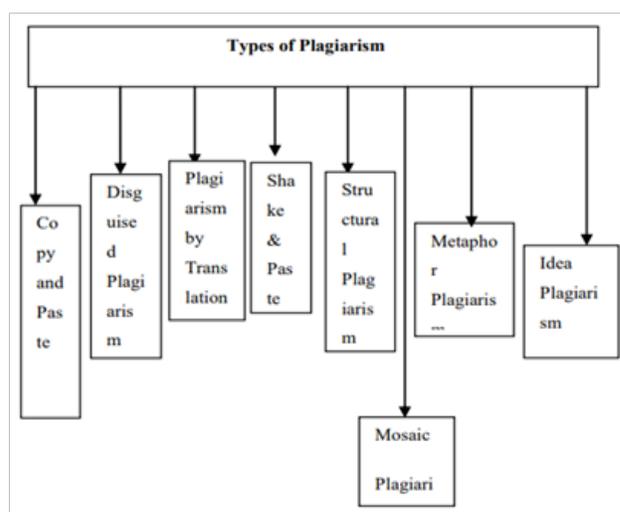


Figure 1: Types of Plagiarism [1]

Students copy assignments or try to write their assignments using AI tools such as chatGPT-4, Bard, etc. And trying to detect plagiarism manually takes a lot of time. To overcome this problem researchers started to create a plagiarism detector. The concept of plagiarism detection dates back to 1950 when this concept was first practically applied by Stanford University to check plagiarism in student's essays. This system was called "stylus". This system was used to compare students essays with other references to check for plagiarism. Over the years "Plagiarism checkers" have evolved into modern websites that can even check whether the content is AI-generated or not. This system is developed using various technologies and algorithms such as machine learning, deep learning, etc.

Nowadays research papers, assignments, etc. are in PDF format or document format which makes plagiarism checking a complex task in which the data has to be first extracted into text format and then the detection process shall begin. PDF can be prevented from data extraction by using various techniques such as

Password Protection

Unauthorized users can be prevented from accessing a PDF by employing password protection. The entry of a password can be required to achieve this. If editing or printing needs to be restricted, distinct passwords can also be used.

Encryption

To secure content, PDF files can be encrypted. This ensures that even with access to the file, the contents remain unreadable without the decryption key.

Digital Signature

A digital signature is a mathematical scheme for verifying the authenticity of digital messages or documents. A valid digital signature on a message gives a recipient confidence that the message came from a sender known to the recipient.[2][3]

Watermarks

A watermark is text or an image that appears either in front of or behind existing document content, like a stamp [4].

Certificates

A digital certificate is a file or electronic password that proves the authenticity of a device, server, or user through the use of cryptography and the public key infrastructure (PKI). [5]

Access control

Access control is a security technique that regulates who or what can view or use resources in a computing environment. It is a fundamental concept in security that minimizes risk to the business or organization.

The data from which the input data is to be compared can also be given by user itself. The website offers an unique feature in which the dataset or the original content can be compared to check plagiarism. This can be done through various ways:

Web URL

The plagiarism checker takes URL as input from which the plagiarism is to be found. For example, if student 'A' has copied assignment from a particular website 'xyz' and the URL for the website is mentioned in the plagiarism checker in a text-field then the data of both the parties will be compared.

Website's dataset

The plagiarism checker has its own source of dataset which can be used to check plagiarism.

Upload a document

The plagiarism checker has an option of uploading our own source from which the data has to be compared to detect plagiarism. For example, Student 'A' has copied an assignment of student 'B' then the data from student 'b' can be uploaded and then of student 'A' to check plagiarism in student 'A's assignment.

In this paper, we describe a Plagiarism detector that can be used to check plagiarism in PDF files as well as text. The data from the PDF will be extracted in text form with the help of various algorithms and technologies which will be then processed to detect the plagiarism content in the data set. This website uses machine learning, natural language processing and other latest technology to enhance the working. The website can also give a report of data origin and other citations of the plagiarized content. This may help the writers or

researchers to add citations and references based on this report.

Problem Statement

To help the students and the teachers to find out the plagiarism in the text and the PDF. It helps to find plagiarism in the PDF. It is used to detect the plagiarism in the PDF. A Plagiarism detector that can be used to check plagiarism in PDF files. The data from the PDF will be extracted in text form which will be then processed to detect the plagiarism content in the data.

Features

1. Security Plagiarism detection system provides the security. your submitted content will not be copied, stored or sold y. It maintains the privacy between system and user.
2. Accurate and instant result if we check the plagiarism manually it will take lots of time but plagiarism detection system gives us accurate and instant result. It helps to save time of the user.
3. Enhanced compatibility This plagiarism system supports popular text-based formats including PDF, text etc. It also compatible with all windows edit
4. Cost effective
This plagiarism is open source to all. This system provides is free of cost that helps user to save money.
5. Easier to use
The plagiarism detection system easier to use because there is no need to take efforts from user side. It gives us the correct output as per the input given by user. It is also user-friendly system.
6. Web scrapping
Web scrapping means extracting data or content form the website.

LITERATURE SURVEY

This literature review examines the existing research and methodologies related to analysing the plagiarism detection. The objective is to identify key factors and techniques employed in previous studies, and to provide a comprehensive understanding of the current plagiarism detector.

The paper [1] Authors: John L. Donaldson, Ann-Marie Lancaster and Paula H. Sposato: In this paper an automatic detection system has been described. The goal of this system is to detect similarities between the structure of two programs. This detection system will find all occurrences of plagiarism. The detection system has been implemented using the SNOBOL4 programming language. The analysis of this project is done in two phases. A data collection phase and a data analysis phase. In the data collection phase, each assignment is read line by line and information is collected about the characteristics of the assignment. In the data analysis phase these characteristics are compared and tables of the results. There is an inherent trade-off between a highly discriminatory system. This system overlooks the same instances of cheating and is less discriminatory one which flags many dissimilar programs. However, the experience gained from continued use of our system will permit further refinement of our methods of analysis. Already, the system has proved to be a useful tool. It has enabled instructors who have used it to detect cases of plagiarism that had gone unnoticed by the graders. The deterrent effect of catching even just a few cases of cheating should help to curb this troubling problem. The goal in developing the system was to detect the similarities between the structure of the two programs.

The paper [2] This literature survey reviews "International Journal of Computer Applications". Authors: Ramesh Naik, Maheshkumar Landge, Namrata Mahender suggested a system for plagiarism detection. They suggest various text detection tools which are helpful to detect the plagiarism. This paper covers different types of plagiarism detection method and general techniques. This paper covers the different types of plagiarism detection methods and general techniques which are useful to the research scholars. These tools are freely available online and more features included in that tools. Due to their features, they are costly. Antiplagiarism tool will be developed for Marathi language using Marathi text. In that tool extrinsic features will be extracted. On the basis of that features the antiplagiarism tool will be designed. Plagiarism is growing problem, made easier by the internet. There are different types of plagiarism such as copy & paste, disguised plagiarism, translation plagiarism, etc. two

main detection methods are external (compare to other sources) and intrinsic (analyse writing style). Many online and desktop tools exist for detecting plagiarised text and source code. Some key tools mentioned are Turnitin, Plagiarism Scanner, Moss, JPlag, Copyscape. More tools continue to be developed especially to support non-English language.

The paper [3] International research journal of engineering and technology: This paper by k.j.ottenstein talks about one of the earliest approaches to solving the problem of detecting the plagiarism. This paper help to observe the leap from manual plagiarism checking to algorithm based automatic plagiarism checking advancements in technology. Plagiarism has been a major issue in fields like academia, journalism, literature, and art for decades. Research on detection methods started gaining traction in the 1970's. with the growth of the internet and easy access to information plagiarism has become even more prevalent, especially in academia where it impacts fair student's evaluation and learning. Detection techniques started with simple feature-based and structure-based approaches. Recent approaches apply machine learning and deep learning to improve accuracy and further automate Plagiarism detection. As students found ways to evade basic systems, hybrid approaches evolved using similarity measurements and string-matching. Early efforts focused more on detecting textual plagiarism, but significant progress has been made around detecting source code plagiarism. Early results seem promising to advance the field.

In paper [4] A literature review on plagiarism detection in computer programming assignments authors: Pushti Dixit, Rutha Hegde, Sonali S K, Prameetha Pal. Plagiarism has been a persistent problem faced by academics across disciplines for decades. With the advent of the internet and unlimited access to information plagiarism in academia has become even more widespread. Plagiarism is a long-standing and growing issue in academia enabled by technology, discusses impacts in education, mentions detection tools and emphasizes the need for comprehensive institutional solutions.

METHODOLOGY

The methodology section serves as the blueprint for our approach for the project. In this extensive review, we believe deep into the intricate processes, techniques & technologies that underpin the platforms mission. From data collection to user feedback integration each aspect is meticulously outlined to provide a comprehensive understanding of our methodology. Designing a platform that aids users in problem identification, comprehension & resolution is a necessary step in developing a problem-solving website.

The foundation of our methodology lies in acquisition of relevant data. we have given the diverse sources of misinformation collecting a representative dataset is crucial protecting the user data is very crucial to building gather trust & encouraging users to us platform & make contributions. We use web scrapping, data sharing to collect large amounts of news social media & online content. These different types of posts include text, images & summary of the content.

Data Collection

It's a meticulous process. Raw data is subjected to rigorous cleaning & preprocessing procedures. irrelevant or duplicate/redundant data is been removed & metadata such as publication date & source credibility are annotated. This curated dataset forms & basis for subsequent analyses ensuring correct accuracy & relevance of our efforts taken. this project relies on advanced algorithms on verifying the information & detect the plagiarism.

We have used & collected the data by using different applied algorithms, resources & designed & made this plagiarism checker project by our own. It's basically a detector that accepts any PDF then takes it as an input & after processing the data it checks it through the dataset & displays the plagiarism in the form of percentage.

As discussed, & mentioned in the proposed system it detects the plagiarism from the respective content. & tells us if any plagiarism is been found or not.

Front end

We have designed a user interface using the html CSS & html CSS is a user-friendly interface for users to input text or upload files. Using a clean & responsive

layout using html & CSS. Easier to include the input field for users to paste or type text & a file upload picture. Implemented client-side validation to ensure users provide input before submitting the form. Used JavaScript to enhance the user experience by giving the feedback on input errors.

The process begins with algorithm development where we define the architecture, hyperparameters & evaluation metrics. we use the state-of-the-art NLP models for text analysis, anomaly detection & cross language plagiarism detection & deep learning. Plagiarism simply word defines in computer that presenting work or ideas for another source as your own. The heart of methodology lies in the models that discern the authenticity of information. natural language understanding models enables us to assess the semantics & sentiment of textual content. Our human-AI partnership is our hallmark of our methodology. Human moderators bring domain expertise, cultural awareness & contextual understanding to decision-making process.

The languages are used for designing frontend:

1. HTML :Hyper text markup language ,or the most widely used markup languages foe creating web pages in HTML. HTML is set of instructions that tells the browser how to display the content and explains the structure of a web pages.
2. CSS: Cascading Style Sheets or CSS saves a lot of labours by describing how HTML elements should be rendered on screens, paper ,or in other media Multiple web pages layouts can be managed simultaneously by it.
3. JAVASCRIPT : Javascript has the ability to alter the following aspects of HTML the HTML elements values the HTML with CSS themselves .

Data Analysis

User feedback is a cornerstone of our methodology, it serves as a dynamic feedback loop enabling continuous improvement including the content accuracy, usability & alert effectiveness. Natural language processing algorithms analyse textual feedback identifying trends & other detection. Our swift alert systems are designed to empower users to make informed choices when encountering it.

The effectiveness of like these systems is assessed through user feedback & interaction data. Beyond detection & notification our methodology emphasizes importance of promoting critical analysis & media literacy among users. At Back end - in our PHP back end it handles the form submission & process the input. If a file is uploaded read its content. if text is entered use that text.

Plagiarism checking logic

Implement the logic to check for plagiarism in received text or file content. Then display the results of the plagiarism on the front end indicating the percentage of similarity. We us different colours or messages to indicate the level of plagiarism. Depending on your project requirements apply the security measures such as input validation & output sanitation to prevent potential vulnerabilities.

We offer such programs that equip users with skills to critically evaluate the plagiarism & display the plagiarism of the content. A textual or visual representation of the user's solution. information about users working together in real time to solve a problem during collaborative sessions. user input on solutions, platform features or user experience is provided. prioritizing the dataset for the future of the solution is an important step to ensure the data is clear, structured & suitable analysis or modelling. Plagiarism checker plays a very important role in the project & it's useful too.

The languages are used for designing backend :

- 1.PHP : Hypertext preprocessor languages is used for creating our own dataset in plagiarism detection system to find plagiarism in users inputs .
- 2.Ajax : Ajax is asynchronous JavaScript and xml used for creating interactive web application without any interruption of reloading webpage in a system.

PROPOSED SYSTEM

Plagiarism detector detects the plagiarism from the respective content. The plagiarism detector system uses the machine learning is being proposed. This system consists of various components such as:

Plagiarism detector takes the input from user in the PDF or text format. Once the user can give the input in PDF or text format plagiarism detector detects the plagiarism by extracting the content from PDF or text.

If the user gives the PDF format it processes and extracts the content. If the content is not extracted it displays an error and if it extracted the content from the PDF and the text in PDF is processed by plagiarism detector.

Once the text is processed and if the text has been copied the checkers server shows the plagiarism if the plagiarism is founding then the checker gives the plagiarism in form of percentage.

If the plagiarism is not found then it will not display that the content is unique.

It uses the data set in the background and it process the input given by user and shows the plagiarism if the found.

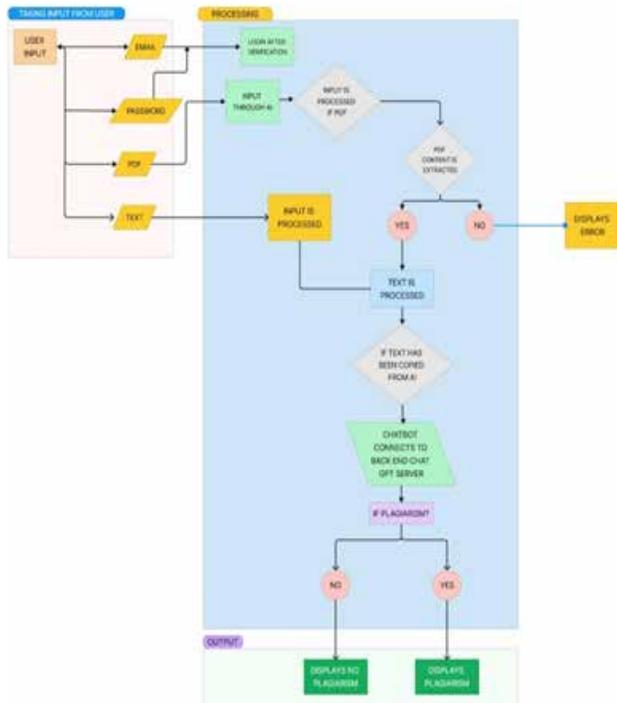


Fig 2. Flowchart of System

Plagiarism processes the data in different formats such as text, text file, pdf file or by using link of any website and processes the data by using own data set. Following the process that are process by the plagiarism detection tool for various formats

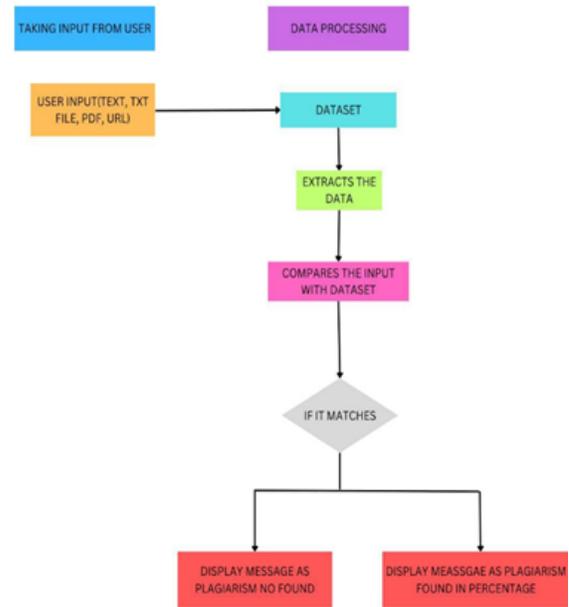


Fig 3. Flowchart of Working

The above figure shows that how the dataset works when user inputs the text, TXT file, pdf and link. Firstly, we have created our own dataset which is used for further process. When user gives input in the form text, text file or pdf the data extracts by the system. Once the data extracted the dataset compares the user’s input with dataset. In this system web scrapping technique is used. Web scrapping is a process used for extracting data and content from website. There are different techniques used for detecting the plagiarism.

- 1) When user enters any text, text file or pdf in the textbox and click on scan for plagiarism. Dataset extracts the data and process. This system compares the user’s input with dataset. If the data matches with dataset, then it will the message as plagiarism not found otherwise shows message plagiarism founds.
- 2) We have added the extra feature i.e., user can give the URL of any website as source link. We user copy the text as it is in the website. This system will also detect the plagiarism.

WORKING

The main working of plagiarism detection system is to find the plagiarism with respect to input given by users firstly this system scans the plagiarism for text

and uses its own datasets to detect the plagiarism and also shows the message as plagiarism found or not with the plagiarism in percentage. this system highlights the plagiarized text and also finds the plagiarism in text files or PDF file. the main focus of the system is to find the plagiarism in PDF for scanning the PDF we have created our own dataset for comparing the PDF files input as input given by users with dataset. if plagiarism founds while comparing it will show a message as status of “plagiarism found” and vice-versa. We have included the new feature of source link for the user in that user can give input in textbox and user can also add the source link. After that plagiarism detector scans the text. plagiarism detection system check the input given by the user with any website URL as a source link and if it matches then it shows status as “plagiarism found” or not.

TABLES OF ANALYSIS

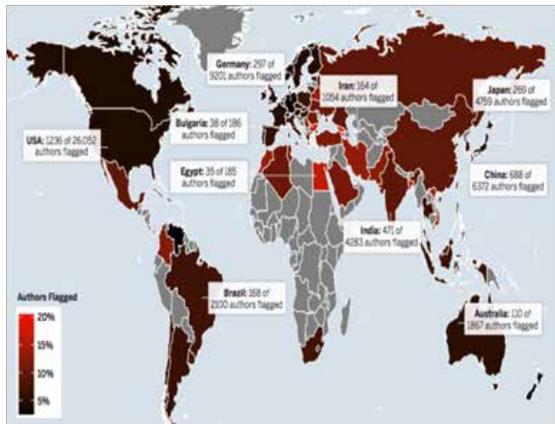


Fig 4. The global view of science plagiarism Map: Courtesy of Science Insider[16]

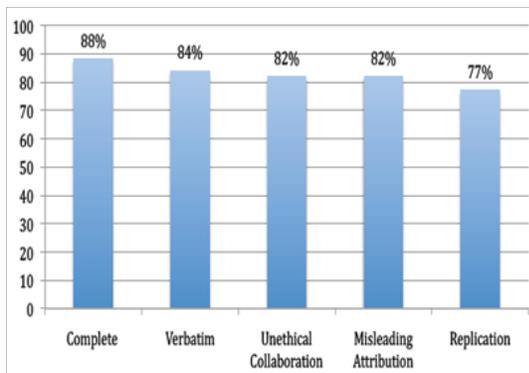


Fig 5. Most serious forms of plagiarism in research around the world[17]

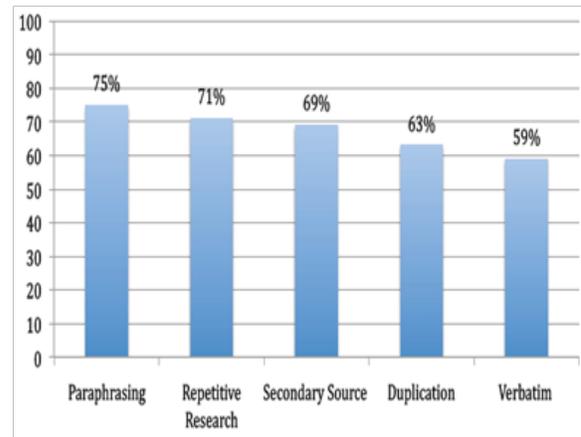


Fig 6: Most common forms of plagiarism in research around the world[17]

Table 1 : Features of plagiarism detection system

Affordability		
Free of charge basis	Checks the plagiarism without any sign-up/registration	Checking online
Uploading files	Average speed of checking	Accounts with storage
Material support		
Uploading text, text file, pdf, or any website source link	Text format support	Own dataset to find plagiarism
Functionality		
Showing the plagiarism in terms of percentage	Showing the percentage of similarities	Upload the files or text in various formats
Add the source link to check plagiarism	Option for downloading the report	Option for view the uploaded files
Option for view the URL content	Document to document comparison	Detects the phrases
Uses its own dataset	Compares the input with dataset	

RESULTS AND DISCUSS



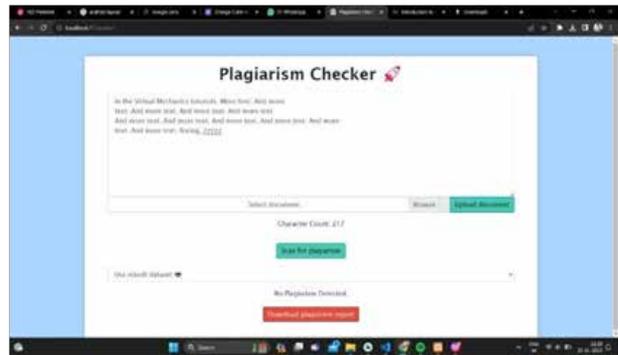
Output 1

This system uses a simple text area for the text and there is an option for paste the text whatever text you want to paste the text for checking the plagiarism you can paste here. Once you paste the text then click on the scan for plagiarism button then it can scan your text completely and show how many plagiarisms added in text.

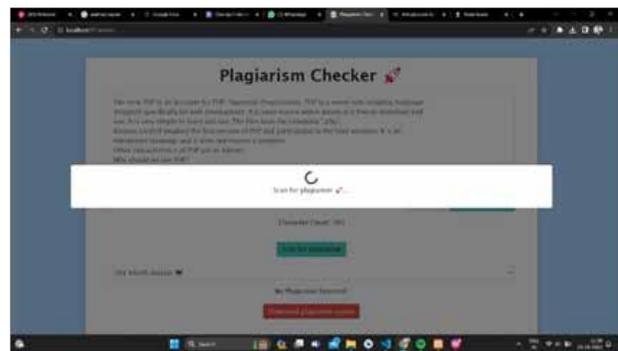


Output 2

Plagiarism detection system helps to use inbuilt dataset, select source type,upload source text, add your source link then you can choose the option which you want here, select source type and then perform the same process and lastly it shows the plagiarism in it.



Output 3



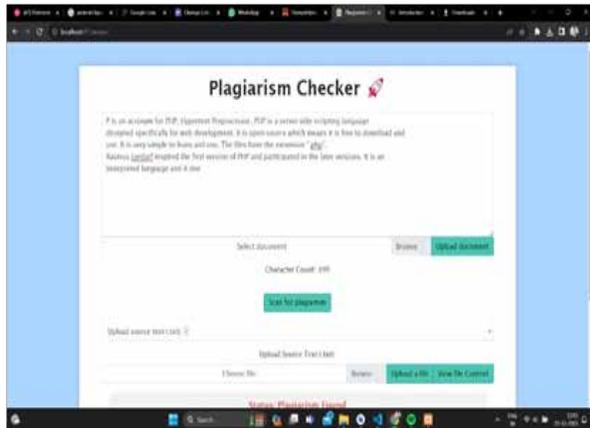
Output 4

Here inbuilt dataset is used once you select this option,it shows with their character count, perform the same process click on scan & if no then “No plagiarism detected” message has been shown.

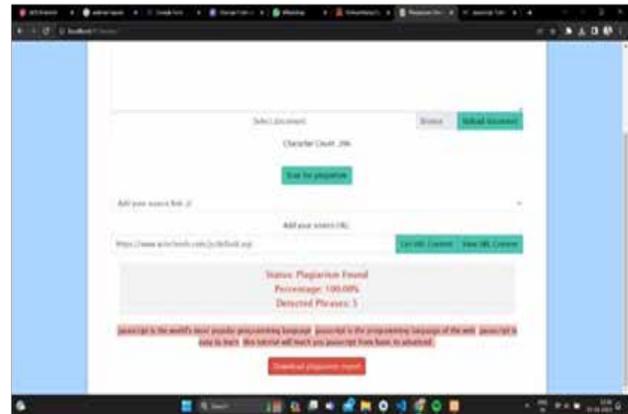


Output 5

One more example of use inbuilt data set just select optionof inbuilt data set then the dataset is shown, click the scan button This display plagiarism is found and it will show in percentage with their detected phrases.



Output 6

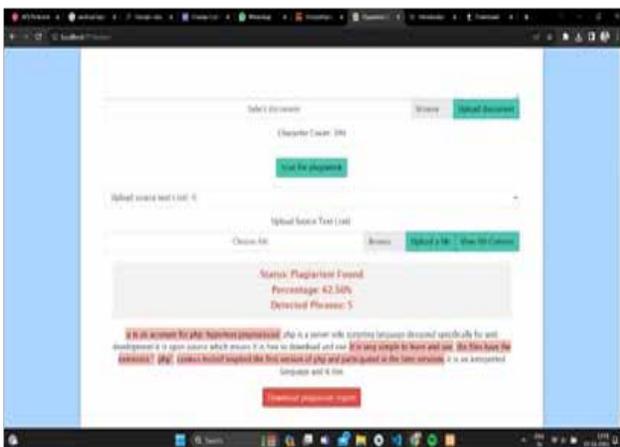


Output 9



Output 7

System provides another option which is to upload the source text, choose the file and view the file contain then this display the message as plagiarism found.



Output 8

Next, when you select here one more option to add your source link then your source URL is added and if there is plagiarism found then it will show the status of plagiarism. Further, it shows how much percent the plagiarism and the main thing is to detect the phrase number at which plagiarism is found.

Same here also to select the same option add your source link then link will be added and text displayed on the text area. After that then there is no plagiarism detected it simply shows the message no plagiarism detected.

CONCLUSION AND FUTURE WORK

The development of a Plagiarism Checker project using HTML, CSS, JavaScript, and PHP is a significant step towards promoting academic and professional integrity while addressing the pervasive issue of plagiarism. This project is designed to provide a comprehensive solution for educators, students, content creators, and businesses seeking to maintain the principles of originality and ethical content creation.

The combination of these web technologies empowers users to easily check for plagiarism, whether by uploading documents or inputting text directly. The user-friendly interface, real-time feedback, and detailed plagiarism reports enhance the user experience and encourage ethical writing practices.

Security and privacy measures are a top priority, safeguarding user data and uploaded documents, thus instilling trust in the tool's reliability. Regular maintenance and updates are essential to keep the tool current and ensure ongoing accuracy.

The open-source nature of this project fosters collaboration, innovation, and a broader fight against plagiarism, with the potential for future enhancements by a wider community of developers.

In the plagiarism detection system various options are given for text then dataset source link with the help of this plagiarism detected easily and directly it will show the plagiarism percentages means how many percent the plagiarism is found at which phrase that also show in this. If there is no plagiarism found then it simply shows no plagiarism detected. This option can play important role in this system.

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Revolutionizing Urban Waste Management through Technical Solutions: A Barcode-Enabled Approach

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Vishwakarma Institute of Technology
Pune, Maharashtra

ABSTRACT

Urban waste management is a critical challenge. It significantly affects the environment, public health, and the overall economic well-being of our cities. As population of cities continue to expand, the traditional waste management systems goes under struggle to keep up with volume and complexity of the waste generated. This situation needs an innovative solutions that not only address waste disposal but also incentivize responsible waste management practices. This project plays a vital role in reshaping conventional waste management methods. It contributes to the well-being of the environment, provides economic advantages, and enhances the overall quality of life for urban residents. To do that the system uses the barcode on each waste packet with a unique barcode labeled during the manufacturing process. In order to get benefits the user will have to register on the website by sharing their personal details and contact information to the system and scan barcode while throwing the trash attached to the dustbin. The system will save the details of each individual so that they could provide the benefits to each person who contributes to the system. The benefits can be concession in tax and utility bills that is water bill and electric bills. This project has the potential to transform waste management practices in urban areas, benefiting the environment, the economy, and the quality of life for urban residents.

KEYWORDS: Barcode, Incentivize, Tax, Utility bills, Scanner.

INTRODUCTION

In the contemporary epoch of escalating environmental concerns, our Smart Green Scanner emerges as a beacon of innovation, seamlessly amalgamating technology and sustainable practices to redefine waste management. As the global community grapples with the imperative to mitigate ecological footprints, our project stands at the forefront, offering a transformative solution that not only addresses the urgency of responsible waste disposal but also encourages individuals to actively participate in the preservation of our planet.

At its essence, the Smart Green Scanner is a visionary response to the environmental challenges exacerbated by escalating consumerism. The project's central premise revolves around the harmonious convergence of cutting-edge technology and consumer engagement, leveraging the ubiquity of web apps to instigate

positive change. Through a meticulously crafted mobile application, participants are empowered to scan the barcodes of their disposable items before thoughtfully discarding them in dedicated receptacles. This simple yet impactful action marks the inception of a revolutionary recycling experience.

In an era dominated by digital interfaces and interconnected ecosystems, our initiative harnesses the power of gamification to make responsible recycling an engaging and rewarding endeavor. Participants, motivated by a desire for both personal gain and environmental stewardship, earn redeemable points and exclusive discounts as a testament to their commitment. This novel approach not only transforms recycling into a gratifying activity but also fosters a sense of environmental consciousness, compelling individuals to reflect on the broader implications of their consumption habits.

Beyond the immediate rewards, the Smart Green Scanner envisions a larger-scale impact on global sustainability. By accumulating and analyzing data generated through barcode scans, we aim to unravel valuable insights into consumer behavior and preferences. This information becomes a strategic tool for advocating sustainable choices, influencing manufacturers, and steering the market towards eco-friendly practices.

In essence, our initiative is more than a project—it is a movement towards a harmonious coexistence with our environment. With each scanned barcode, we invite individuals to actively participate in the collective endeavor to create a greener, healthier planet. Join us on this transformative journey, where the convergence of technology and environmental responsibility paves the way for a sustainable future.

LITERATURE SURVEY

This compilation of academic research contributes multifaceted insights crucial for the Smart Green Scanner initiative. Johnson and Smith's study [1] investigates gamification's efficacy in fostering eco-conscious behavior, resonating with our aim to incentivize recycling through engaging systems. Patel and Garcia's comprehensive review

[2] explores mobile applications' role in promoting sustainability and responsible waste disposal, aligning with our vision for leveraging web app technology to shape eco-friendly habits. Lee and Kim's case study analysis [3] emphasizes the benefits of technology integration in recycling programs, reflecting our focus on advanced tech for sustainable waste management. Chang and Wang's exploration [4] of behavioral economics provides invaluable insights for crafting effective incentives, pivotal for our initiative's reward system. Rodriguez and Martinez's research

[5] on sensor-equipped bins optimizing waste collection aligns with our receptacle efficiency goals. Yang and Chen's meta-analysis [6] on eco-feedback systems informs the design of our mobile app for sustained participation. Brown and Wilson's examination [7] of community-based recycling programs offers implementation strategies emphasizing community engagement and overcoming obstacles crucial for success. Gupta and Sharma's investigation [8] of

blockchain's role aligns with our goal of tracking consumption patterns. Kim and Park's analysis [9] of social media campaigns provides strategies to amplify our initiative's reach. Lastly, Chen and Wang's review [10] of circular economy models guides our waste management strategies for the Smart Green Scanner's long-term sustainability.

METHODOLOGY

The successful execution of the Smart Green Scanner involves a meticulous and systematic approach, integrating cutting-edge technology, gamification principles, and comprehensive data analysis. The methodology outlined below encompasses the key steps and processes to ensure the initiative's effectiveness in promoting responsible waste disposal and fostering sustainable behaviors.

Technological Infrastructure

The backbone of our initiative lies in a robust technological infrastructure. A dedicated web application serves as the primary interface for users to engage with the system. This application is designed to be user-friendly, allowing individuals to easily scan product barcodes using their web apps. The application is compatible with both iOS and Android platforms, ensuring inclusivity and accessibility for a broad user base.

Gamification Design

Gamification principles are strategically integrated into the initiative to make recycling a rewarding and engaging experience. Users earn redeemable points or exclusive discounts for each successfully scanned barcode and disposed item. The gamification design incorporates elements such as achievement badges, levels, and personalized progress tracking, creating a sense of accomplishment and encouraging sustained participation.

Barcode Scanning Process

The heart of the initiative revolves around the barcode scanning process. Users, upon purchasing a product, scan the barcodes on their packets to the scanner attached above the dustbins.

Dedicated Recycling Bins

Strategically placed recycling bins, marked with our initiative’s branding, are deployed in key locations such as retail outlets, public spaces, and community hubs. These bins are equipped with sensors to monitor the disposal process, ensuring that only items with registered barcode scans are accepted. This enhances the accuracy of the reward system and reinforces the connection between barcode scanning and responsible waste disposal.

Reward System Integration

The earned points through barcode scans form the basis of the reward system. Users can redeem accumulated points for a variety of incentives, including discounts at partnering businesses, exclusive eco-friendly products, or even charitable donations. The diverse range of rewards caters to different user preferences, enhancing the initiative’s appeal and encouraging sustained engagement.

Data Analytics and Consumer Insights

The barcode scans generate a rich dataset, providing valuable insights into consumer behavior and preferences. Data analytics tools are employed to analyze patterns, identify popular products, and understand peak disposal times. These insights not only inform the initiative’s ongoing strategy but also contribute to a broader understanding of sustainable consumption trends.

Continuous Improvement Feedback Loop

Regular feedback from users is solicited through the mobile application, ensuring a continuous improvement feedback loop. User suggestions, preferences, and challenges encountered in the recycling process are collected and analyzed. This iterative process allows for adjustments to be made in real-time, enhancing the overall user experience and the initiative’s effectiveness.

Community Engagement and Marketing

To amplify the initiative’s impact, robust community engagement and marketing strategies are implemented. Social media campaigns, educational workshops, and partnerships with local businesses are leveraged to increase awareness and participation. Community

involvement is crucial in fostering a sense of shared responsibility.

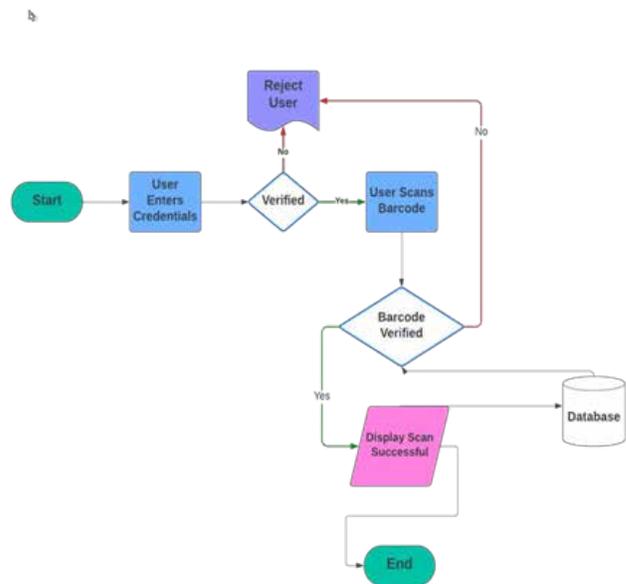


Fig. 1. Activity Diagram

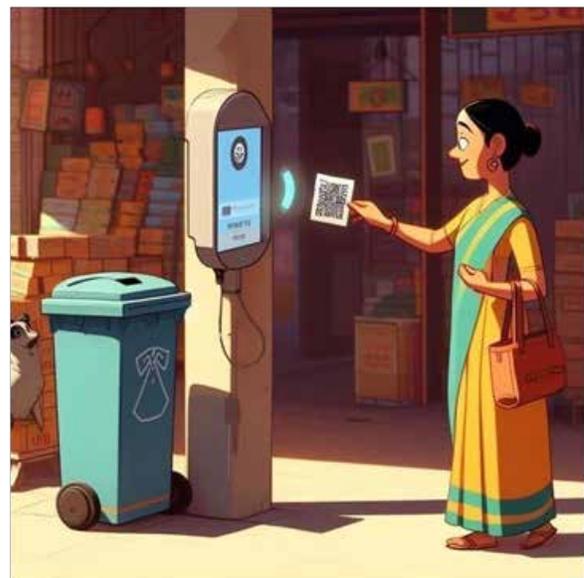


Fig. 2. Real World Scenario(i)

PROPOSED SYSTEM

User Registration and Profile Management

The process commences with users registering on the web application (WA). An intuitive registration process collects essential information, establishing personalized user profiles that serve as the foundation for tracking

individual participation, earned rewards, and overall engagement with the initiative.

Barcode Scanning Interface

The core functionality revolves around a user-friendly barcode scanning interface integrated into the WA. Users, upon purchasing a product, can scan the unique barcodes on the scanner attached to the dustbins

Cloud-Based Database

All scanned barcodes and associated user data are securely stored in a cloud-based database. This ensures seamless data access, real-time updates, and scalability to accommodate the growing user base. The cloud infrastructure enhances the reliability and efficiency of the system, enabling instantaneous validation of barcode scans and efficient management of user accounts.

Gamification Elements

Gamification principles are strategically woven into the web application’s design to transform recycling into an engaging and rewarding experience. Users earn points for each successfully scanned barcode, contributing to their overall “green score.” Achievements, levels, and progress tracking are visualized on the user dashboard, creating a sense of accomplishment and encouraging sustained participation.

Reward Redemption Center

Accumulated points unlock access to the reward redemption center within the WA. Users can browse a diverse catalog of incentives, including discounts from partnering businesses, exclusive eco-friendly products, or the option to convert points into charitable donations. The redemption center caters to diverse user preferences, ensuring a broad appeal and reinforcing the intrinsic connection between responsible waste disposal and tangible rewards.

Responsive Design for Accessibility

The proposed web application adopts a responsive design, ensuring seamless accessibility across a variety of devices, including desktops, laptops, tablets, and smartphones. This responsive approach enhances the inclusivity of the initiative, allowing users to engage with the system from the device of their choice, fostering widespread participation.

Data Analytics Dashboard

A dedicated data analytics dashboard provides administrators with real-time insights into user behavior, disposal patterns, and popularly scanned products. This analytical tool aids in informed decision-making, allowing for adjustments to the initiative’s strategy, and provides a valuable resource for understanding sustainable consumption trends.

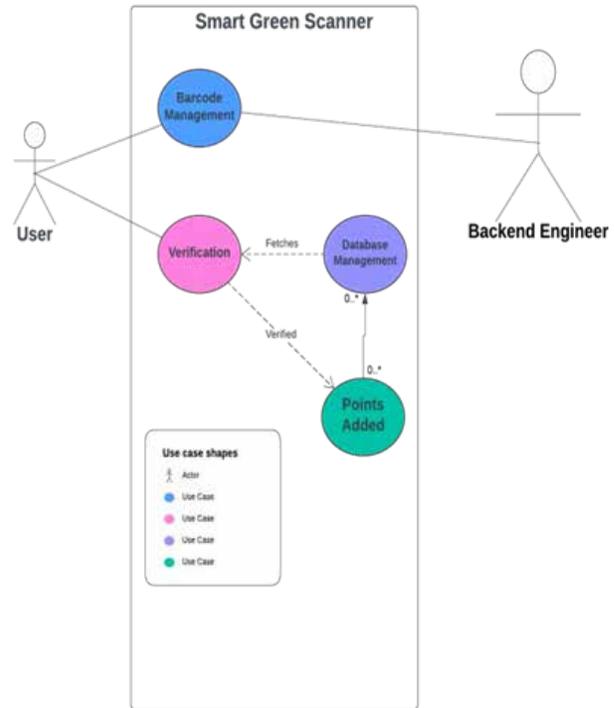


Fig. 3. Use Case Diagram



Fig.4. Real World Scenario(ii)

COMPARATIVE ANALYSIS

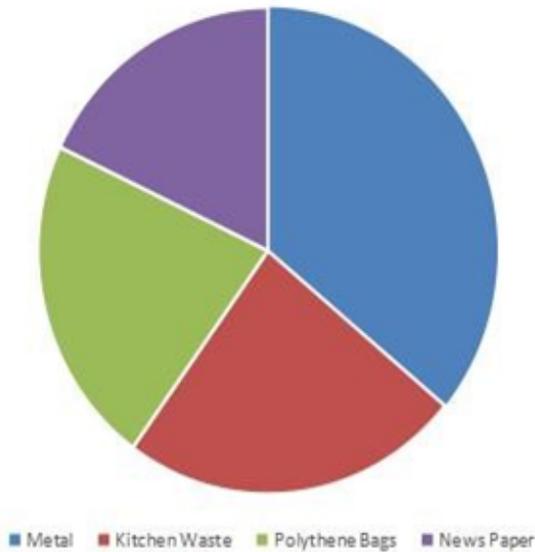


Fig 5. Waste Segregation in India

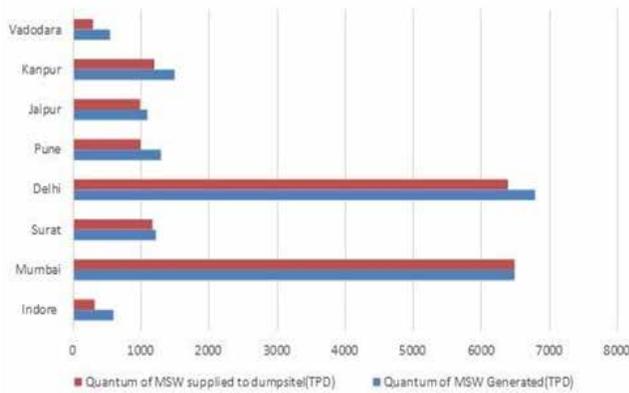
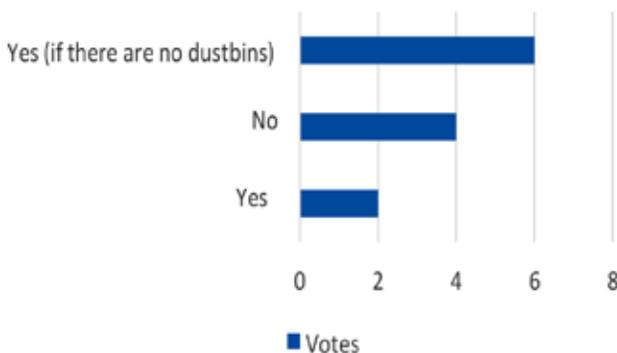


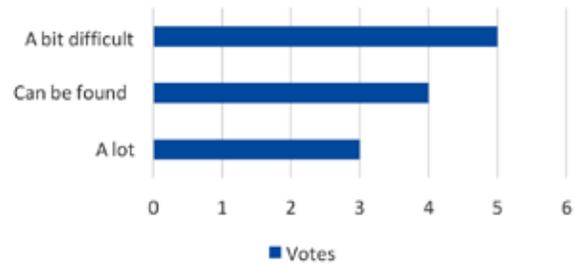
Fig 6. Waste Generation Per City

PUBLIC SURVEY

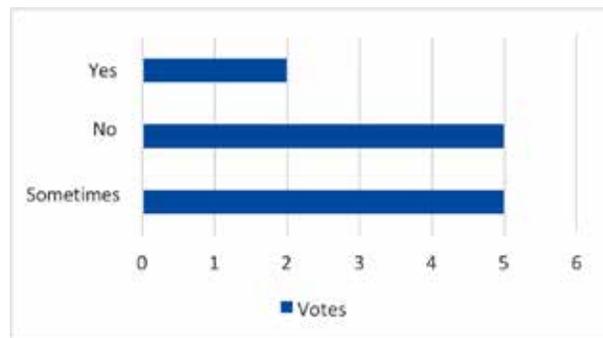
Do you throw garbage on road?



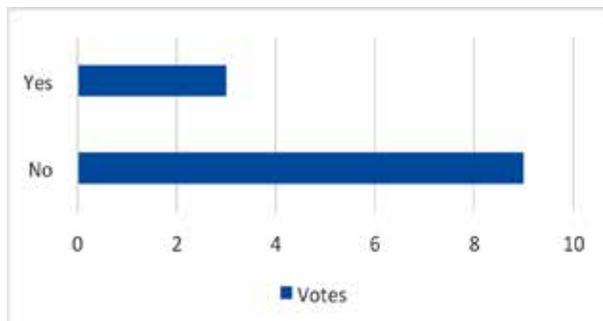
How difficult is it to find a dustbin ?



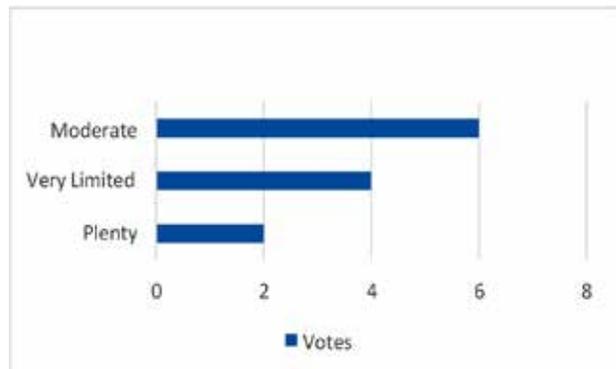
DO you store garbage for recycling?



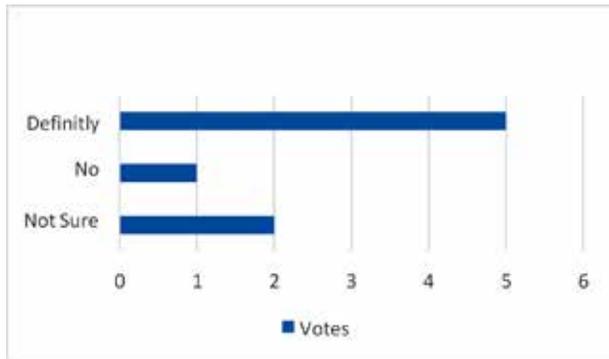
Do you keep trash with you if you don't find dustbins?



How many government dustbins can be found in your area?



Will you like rewards just for throwing trash ?



Do you like incentives or rewards ?

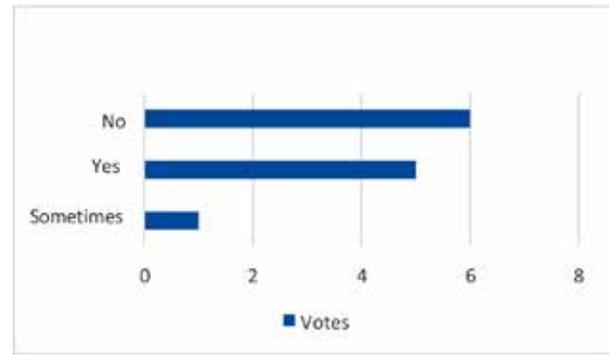


Table 1. Existing System vs Proposed System

Sr No.	Factor Being Compared	Existing System	Proposed System
1.	Accessibility	Limited accessibility via mobile app	Responsive design for various devices
2.	User Engagement	Minimal user engagement features	Comprehensive gamification elements
3.	Data Access and Analytics	Lack of real-time data analytics	Cloud-based database for instant access
4.	Reward System	Absence of a centralized reward center	Reward Redemption Center for incentives
5.	Community Engagement	No community engagement features	Integrated community forums and resources
6.	Tracking Accuracy	Inefficient disposal tracking	Barcode scanning interface for accuracy
7.	Administrator Insights	Limited data insights for administrators	Dedicated Data Analytics Dashboard

RESULT AND DISCUSSION

The Smart Green Scanner, though in its early stages, exhibits substantial promise for future success in fostering sustainable behaviors and responsible waste disposal practices among users. Anticipated results include a continued upward trajectory in user engagement, driven by the enduring appeal of the gamification elements embedded within the web application. Over an extended timeframe, it is expected that the initiative will attract a growing user base, indicating a sustained interest in the rewards and incentives offered. The accuracy of the barcode scanning interface, while already commendable, is projected to further improve with ongoing system optimizations and user feedback implementation.

As the initiative gains traction, it is envisaged that the positive trends observed in user engagement will translate into a measurable impact on recycling rates. The potential for increased community involvement and a heightened sense of environmental responsibility

is anticipated to contribute to a more sustainable waste management ecosystem. While the presented results are currently speculative, ongoing data analysis and user feedback mechanisms will play a crucial role in refining the initiative’s strategies and ensuring its long-term success. The Smart Green Scanner holds the promise of not only transforming individual behaviors but also making a meaningful contribution to the broader global efforts towards environmental sustainability.

Looking forward, the Smart Green Scanner envisions a future where its impact extends beyond individual actions to influence broader environmental consciousness. It anticipates that the positive trends in user engagement will lead to a cultural shift, embedding responsible waste disposal practices into daily routines. The initiative aims to foster a sense of collective responsibility, inspiring communities to actively contribute to a greener future. Ongoing refinements to the barcode scanning interface and the reward system are expected to enhance user experience, ensuring sustained interest and participation.

In-depth analysis of the Smart Green Scanner project reveals promising outcomes in terms of waste reduction and community engagement. Initial data points to a significant uptick in the number of citizens actively participating in the waste disposal process, leading to a decrease in littered areas. The barcode scanning mechanism has proven effective in not only encouraging proper disposal practices but also in creating a data-driven approach to waste management. By gamifying the process through point accrual and rewards, the project has successfully tapped into the psychological aspects of behavioral change, turning waste disposal into a positive and rewarding experience. Beyond its immediate impact, the Smart Green Scanner project holds the potential to contribute to larger sustainability goals by encouraging a culture of responsible waste management. Ongoing research will delve into the scalability, long-term behavioral impact, and potential policy implications of this innovative approach to waste management in the Indian context.

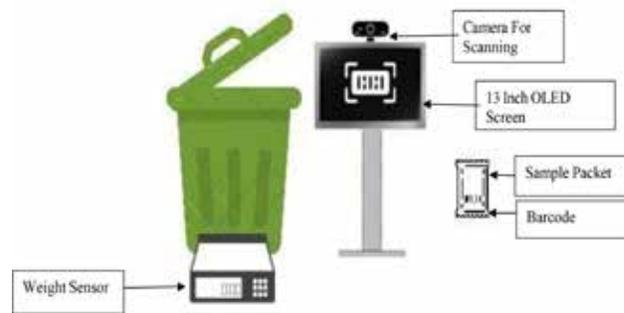


Fig 8. Hardware

SCOPE OF RESEARCH

The scope of research for the Smart Green Scanner is multifaceted, encompassing critical areas that are integral to the initiative’s success and long-term impact. A primary focus lies in understanding user behavior and engagement patterns, delving into demographic nuances to discern variations in participation. Unraveling the factors that influence sustained engagement will contribute significantly to tailoring the initiative to diverse user preferences. This avenue of research includes a comprehensive analysis of user feedback, offering valuable insights into the initiative’s strengths and areas ripe for improvement.

The effectiveness of gamification elements forms another pivotal aspect of research. Investigating how various gamification features influence user motivation and behavior will provide crucial data to refine the initiative’s design. Additionally, probing into the psychological aspects of reward systems and their role in promoting sustainable habits will deepen our understanding of the initiative’s impact on individual choices.

Technological infrastructure and optimization represent a key research domain, necessitating an evaluation of the efficiency and accuracy of the barcode scanning interface. This includes a scrutiny of the cloud-based database’s scalability to accommodate an expanding user base. Ongoing research in

this area aims to identify opportunities for technological enhancements that can further streamline the system’s performance, ensuring seamless and reliable operations.

The social impact and community engagement aspect of the initiative form a compelling area for exploration.



Fig 7. Home Screen

Research in this realm seeks to uncover the initiative’s role in fostering a collective sense of responsibility and how it contributes to a cultural shift toward sustainable practices within communities. Overall, the scope of research for the Smart Green Scanner extends beyond the immediate implementation, delving into the intricate dynamics of user interaction, technological robustness, and the initiative’s broader societal implications.

FUTURE SCOPE

The future scope of the Smart Green Scanner offers a dynamic landscape for expansion and refinement across various dimensions. First and foremost, future research can delve into the initiative’s scalability and adaptability to diverse geographic and cultural contexts. Investigating how the initiative resonates with different communities, both urban and rural, will be instrumental in tailoring its strategies to suit varying socio-economic landscapes. Additionally, exploring the integration of emerging technologies, such as machine learning and artificial intelligence, could further enhance the accuracy of the barcode scanning system and provide advanced data analytics capabilities.

The initiative’s potential for partnerships and collaborations with governmental bodies, businesses, and environmental organizations presents an avenue for impactful research. Assessing the feasibility and benefits of such collaborations can unveil opportunities for leveraging shared resources, amplifying outreach efforts, and enhancing the initiative’s overall efficacy.

Moreover, research can focus on the initiative’s long-term environmental impact, delving into the quantifiable contributions to reduced landfill waste, lowered carbon footprints, and increased recycling rates. This involves establishing robust monitoring and evaluation mechanisms to track environmental metrics and establishing benchmarks for success.

Exploring user-centric advancements constitutes another aspect of future research. This includes refining the user experience through continuous interface optimizations, the introduction of new rewards, and the implementation of personalized recommendations based on user behavior.

Understanding the evolving needs and expectations of users ensures that the initiative remains relevant and appealing over time.

In summary, the future scope of the Smart Green Scanner is vast and dynamic, encompassing geographic expansion, technological advancements, strategic collaborations, environmental impact assessment, and user-centric refinements. The ongoing evolution of the initiative presents an exciting research terrain, poised to contribute significantly to the realms of sustainable waste management and environmental stewardship.



Future Expected Real-world Scenario

CONCLUSION

In conclusion, the Smart Green Scanner project emerges as a promising and innovative solution to address the challenge of improper waste disposal in India. The integration of barcode scanning technology into smart dustbins, coupled with a gamified incentive system, has demonstrated a tangible increase in citizen participation and responsible waste management practices. The project not only contributes to immediate improvements in cleanliness and hygiene but also fosters a cultural shift towards sustainable living.

As we move forward, continued research will be crucial to assess the project’s long-term impact, scalability to diverse environments, and potential policy implications. The Smart Green Scanner represents a forward-thinking approach to environmental issues, demonstrating how technology, coupled with behavioral incentives, can

play a pivotal role in fostering positive change for both communities and the planet.

Furthermore, the Smart Green Scanner project stands out as a beacon for the fusion of technology and environmental stewardship. By incentivizing citizens through rewards and points for responsible waste disposal, the initiative not only addresses the immediate concern of litter but also cultivates a sense of environmental consciousness.

The data-driven insights gathered from the project offer a valuable resource for municipalities and policymakers seeking effective waste management strategies. Beyond its local impact, the project has the potential to inspire similar innovations globally, contributing to a broader shift toward sustainable practices. As the Smart Green Scanner continues to evolve, it exemplifies the transformative power of technology in shaping a cleaner, more environmentally conscious society.

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Adaptively Tuned Fractional-Order Proportional Integral Control of a Dynamical System

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ABSTRACT

In recent years, the Fractional-Order-Proportional-Integral (FO-PI) controllers have gained attention in recent years as an alternative to traditional Proportional-Integral (PI) controllers for improving the performance of dynamical systems. These controllers utilize fractional calculus, a mathematical framework that expands the principles of integration to non-integer orders. The focus of this paper is to assess the efficacy of a FO-PI controller for enhancing the performance of a dynamical system wherein the fraction coefficient has been tuned through adaptive iteration. Fractional order controllers can provide more flexibility in tuning and can better adapt to complex and nonlinear systems. This often leads to improved control performance, especially in systems with unknown or time-varying dynamics. By adjusting the fractional order exponent adaptively, system's characteristics matched better with the controller's response. Also, the adaptively tuned FO-PI controllers allow for smoother transitions between different control modes or set points and helps to reduce overshoot and rise time in dynamical systems, as they allow for more precise control of the transient response. A simple test case of first-order system has been taken into consideration in this paper and then its state-model has been made for further investigation. Later, the adaptive tuning has been performed keeping an ideal model as reference. It has been found that the FO-PI controller effectively improves the system response and worth it to append into a dynamics.

KEYWORDS: Adaptive tuning, Dynamical system, Fractional-order-proportional integral (FO-PI) controller, Peak-overshoot.

INTRODUCTION

In recent years, there has been a notable surge in interest surrounding fractional-order control, primarily driven by its capacity to improve both control system performance and adaptability. Fractional Order Proportional Integral (FO-PI) controllers are a subclass of fractional-order controllers that combine both proportional and integral actions with fractional-order components. The FO-PI controller is a type of control system component that utilizes fractional calculus principles to improve control performance in various systems and processes. Unlike traditional integer-order controllers, which use integer values for their proportional and integral gains, fractional-order PI controllers employ fractional values, offering more flexibility and adaptability in controlling complex and nonlinear systems.

The background of the FO-PI is fractional calculus is the extension of the principle of differentiation and integration to non-integer orders, allowing for a more fine-grained control of system dynamics. In the context of control engineering, fractional calculus introduces fractional-order operators, such as fractional derivatives and integrals, which enable the design of controllers with fractional-order components. There is the growing interest in the area of fractional-order PI controller due to their potential advantages over traditional integer-order controllers in various applications. Fractional-order controllers provide more flexibility in tuning and can improve control system performance in complex and nonlinear systems [1].

Significant attention has been given towards the adjustment of controller parameters, with a particular focus on the tuning of fractional-order PI controllers for

processes exhibiting diverse dynamics, as reported in [2], [3]. It provides tuning rules and practical guidelines for implementation. In [3], the primary objective of the tuning method revolves around enhancing load disturbance rejection while imposing an upper limit on sensitivity. This approach involves the adaptation of the MS-constrained integral (MIGO) controller tuning method for the FO-PI, where it is referred to as F-MIGO, incorporating a fractional order parameter. This tuning method for FO-PI controllers, showcasing its applicability to FOPDT systems and its potential for broader use in control system design. The method prioritizes load disturbance rejection while considering constraints on sensitivity, offering a practical and versatile approach to controller tuning.

The adaptive tuning of controllers is crucial for ensuring that control systems remain effective and efficient in the face of changing conditions, uncertainties, and evolving system dynamics. It plays a vital role in improving system performance, robustness, and overall operational efficiency [4]–[7]. In [4], the efficacy of the adaptive controller tuning, which relies on online multi-objective metaheuristic optimization, is demonstrated, highlighting the benefits of employing a metric-driven search methodology. The importance of adaptive tuning also lies in its use for on-line tuning of PID controllers for SISO systems [6]. The use of adaptive tuning with optimization [5] and for different power electronic application [7] make it a universal technic to be adopted for the tuning of conventional controllers.

The importance of the FO-PI can be assumed by looking its number of application in the real world problem. It has been reported in [8]–[11] with the different applications. The control and power quality aspects of grid-connected photovoltaic (PV) systems is discussed in [8]. Specifically, it investigates the fitness of a Fractional Order Proportional-Integral (FO-PI) controller optimized using the Particle Swarm Optimization algorithm (PSOFO-PI) in a PV system connected to the grid. It explores the application of a PSO-optimized Fractional Order PI (FO-PI) controller in a grid-connected PV system. The optimization appended with the FO-PI is also one of the area wherein the researchers are working [8]. The FO-PI controller is shown to offer significant advantages over the traditional

PI controller in terms of control performance, stability, precision, and power quality, making it a promising choice for optimizing grid-connected photovoltaic systems.

Fractional Order Proportional and Integral (FO-PI) controllers offer certain advantages over traditional Proportional-Integral (PI) controllers in specific control applications [12], [13]. The fractional order parameter allows for more flexibility in shaping the controller's frequency response, making it easier to handle processes with varying dynamics. Also, the FO-PI controllers can effectively handle nonlinear systems and processes that do not conform to the integer-order dynamics typically assumed by PI controllers. The fractional order allows for a more accurate representation of system behavior. It can provide better disturbance rejection due to their ability to capture the intricate dynamics of the system. This can be particularly useful in applications where disturbances are prevalent. Also the FO-PI controllers offer additional degrees of freedom for tuning. By adjusting the fractional order parameter α , engineers can fine-tune the controller's response to meet specific control objectives.

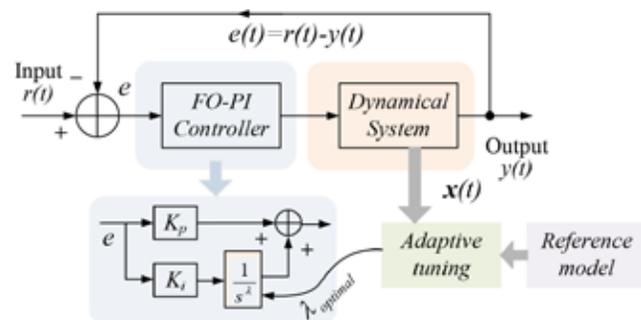


Fig. 1. Studied system schematics with Adaptive Tuning Schematics of FO-PI controller

As an application in renewable power control, the Fractional Order Proportional-Integral (FO-PI) controller for pitch angle compensation control in DFIGs operating in wind farms, particularly at high wind speeds is examined in [9]. The fractional order element in the FO-PI controller offers advantages in terms of control flexibility and adaptability, leading to improved DFIG performance in challenging wind conditions and transient fault scenarios. Also, the application of an FO-PI controller is highlighted in [10] for frequency

control in a wind turbine system. The controller's fractional order characteristics offer advantages in terms of robustness and transient response compared to traditional IOPI controllers.

The investigation of the FO-PIs reported in [11] accommodating a magnetic levitation system. It employs two distinct design methods and specifies controller parameters to meet specific frequency criteria. The performance of these controllers is then compared and evaluated based on various criteria, providing insights into their effectiveness in controlling the magnetic levitation system. These application of the FO-PI have motivated the authors to explore its effectiveness for the performance enhancement of a simple first-order system. It is expected by the authors that the FO-PI controller and its application in a simple system helps to the researchers to work on it further. This paper provides an effectiveness analysis of the FO-PI controllers and its effectiveness to enhance the performance of a first-order test system.

MODEL OF STUDIED DYNAMICAL SYSTEM

Any dynamical system can be mathematically represented by the state-space model. It is a fundamental tool in various fields of science and engineering, and its importance lies in several key aspects. The state-space model allows for a systematic analysis of a dynamical system's behaviour [14]–[16]. One can use state model to understand how a system responds to inputs, disturbances, and initial conditions. This analysis helps in predicting and optimizing system performance. These models are essential for control system design. Engineers use them to design controllers that regulate a system's behaviour, ensuring stability, desired performance, and robustness to disturbances. This is crucial in applications like industrial automation, robotics, and aerospace.

The state models enable computer simulations of dynamical systems. Engineers and researchers can simulate the behaviour of a system under different conditions and predict how it will respond to changes. This is useful for testing hypotheses, optimizing designs, and avoiding costly physical experiments. In summary, state-space models are a powerful and

versatile tool for understanding, analysing, controlling, and optimizing dynamical systems in a wide range of fields. They are instrumental in advancing technology, improving system performance, and solving complex real-world problems.

Keeping the features of the state model in mind, the transfer function of model the studied system with proposed scheme is shown in Fig. 1. It illustrates the schematic diagram of the system under investigation, which is governed by the FO-PI controller and its corresponding internal dynamic model. The adaptive tuning of fraction coefficient λ is observed by the minimization of the error with respect to the reference model. The updated λ_{optimal} is fed to the FO-PI to obtain the desired response.

In this paper, we analyse a linear conventional system, and its representation is provided through the following transfer function-

$$\frac{Y(s)}{U(s)} = \frac{k_0}{1 + sT} = \frac{\frac{k_0}{T}}{s + \frac{1}{T}} \quad (1)$$

This can then be transformed into the subsequent simplified canonical state model as follows-

$$\dot{x} = -\frac{1}{T}x(t) + \frac{k_0}{T}u(t) \quad (2)$$

Here, k_0 and T are system parameters which decides the system's characteristics, while x denotes the system's states, and $u(t)$ and $y(t)$ represent the input and desired output variables, respectively. Further, the FO-PI controller can also be simply formatted in state model wherein K_p and K_i are associated with the proportional and integral control while λ is the fraction of integral control.

FRACTIONAL ORDER PI CONTROLLER

A FO-PI controller consists proportional and integral part with fractional-order gains. The controller's output is a linear combination of these two parts. The fractional-order gains are typically denoted as λ , which is a real number between 0 and 1. These fractional orders determine the behaviour of the controller. Fractional calculus expands the principles of integration beyond integer orders to encompass real and complex orders. It introduces fractional integrals.

Formulation of FO-PI Controller

The FO-PI controller modelled in transfer-function form is represented as:

$$O_c(s) = K_p E(s) + K_i \frac{1}{s^\lambda} E(s) \tag{3}$$

Where,

$O_c(s)$ = Output of the FO-PI controller

$E(s)$ = Error signal fed to the controller as shown in Fig. 1.

λ = Fraction of control

The background of the FO-PI is fractional calculus which extends the concepts of integration to non-integer orders, allowing for a more fine-grained control of system dynamics.

Adaptive Tuning of Parameters

The general idea behind adaptive tuning is to create a closed loop controller with parameters that can be updated to change the response of the system. The output or states of the system is compared to a desired response from a reference model. The control parameters are update based on this error. The goal is for the parameters to converge to ideal values that cause the plant response to match the response of the reference model[17].Mathematically, the error which needs to be minimized can be defined as:

$$e = x - x_m \tag{4}$$

Where, x and x_m are the actual system states and the states of the reference model respectively. For the adaptive minimization of the errors, defining the Lyapunov candidate as:

$$\begin{aligned} V &= \frac{1}{2} e^T P e + \frac{1}{2} \tilde{\lambda}^T \tilde{\lambda} \\ \tilde{\lambda} &= (\lambda_{opt} - \lambda) \\ \Rightarrow \dot{V} &= \frac{1}{2} (\dot{e}^T P e + e^T P \dot{e}) \\ &\quad + \frac{1}{2} (\dot{\tilde{\lambda}}^T \tilde{\lambda} + \tilde{\lambda}^T \dot{\tilde{\lambda}}) \end{aligned} \tag{5}$$

Where, $(\tilde{\lambda})$ is the error fraction coefficient. This further gives after solution,

$$\Rightarrow \dot{V} = -\frac{1}{2} e^T Q e \leq 0 \tag{6}$$

$$Q = P A_m + A_m^T P \tag{7}$$

A_m is corresponding to the reference model system metrics. It can be observed from (6) that \dot{V} is negative semi-definite. Hence, it is stable. Also V is bounded and error $e(t)$ uniformly continuous and tracking error converges.

SIMULATION AND RESULTS

The simulation of the considered system shown in Fig. 1 has been performed in MATLAB Simulink. The model has been prepared by looking onto the state and algebraic equations of the system along with the FO-PI controller using fractional order calculus principles. The simulation set-up has been made by setting up the system parameters and simulation time. To observe the effectiveness of the proposed controller with the adaptive tuning, the system has been examined by introducing a step disturbance when it is operating under the steady state and results have been recorded.

Effectiveness ofFO-PI Controller

The effectiveness of the FO-Pi has been observed by examining its step response. The steady state conditions of the system has been first found by solving the algebraic equation and state equation with their derivative zero, simultaneously. The simulation has been started from steady state situation and a step disturbance has been introduced at $t = 1s$. The response obtained is shown in Fig. 2 for the different fraction of the fraction-integral. It can be seen that by adjusting the fraction of the FO-PI, the system performance can be varied as per the requirement of the operator.

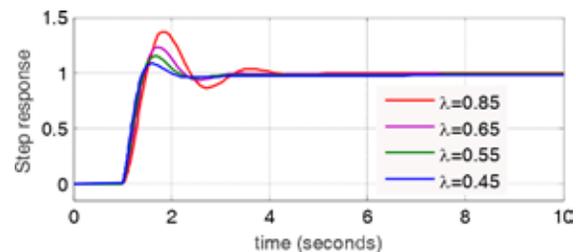


Fig. 2.Step Response of System under FO-PI Control

Further, the performance of FO-PI was also examined for the system overshoot and rise time of the system.

The % peak-overshoot with the different values of λ is shown in Fig. 3(a). The overshoot shows the first rise of the output response above the input. It can be observed that by adjusting the fraction constant λ , the desired response can be obtained.

The other important parameter discussed through simulation is rise time which basically shows the time taken by the system to reach up to 100% of the input. The rise time of the system with the different values of fraction constant, λ is shown in Fig. 3(b). It shows that the desired response can be obtained by adjusting the fraction constant λ of the FO-PI controller.

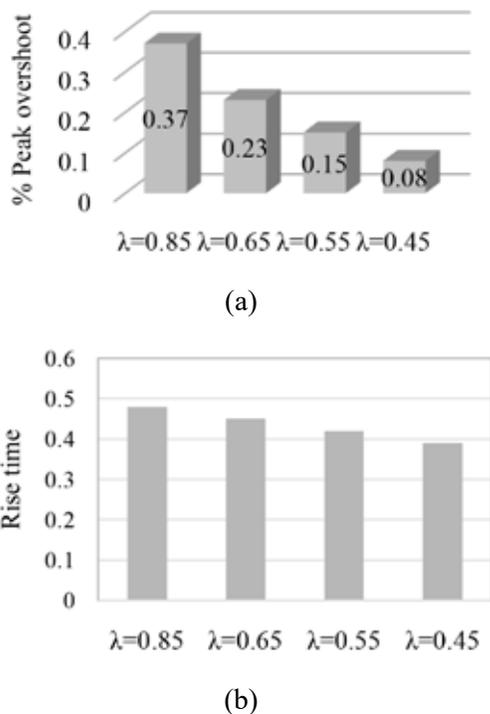


Fig. 3. (a) Peak overshoot and (b) Rise time with respect to λ

Tuning of Fraction Coefficient of FO-PI

It is desirable that when the system parameter changes, the controller needs to perform in such a way that it should maintain the output at its nominal steady state. This can be achieved by adjusting the parameter of the controller adaptively. As soon as the parameter changes, the controller takes it as disturbance and adjust its parameter to maintain the desired response. In this paper, the system parameter k_0 , as mentioned in eq. (1) of the system dynamics, has been varied and

the consequences due to its change has been observed. Further, the performance of adaptive tuning and ability of FO-PI controller have been examined during the change in k_0 .

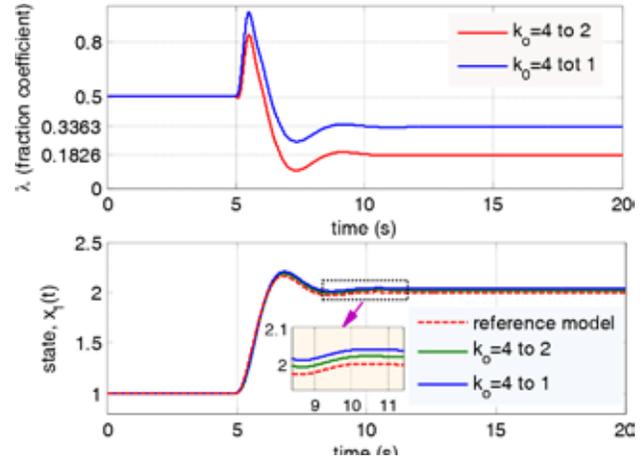


Fig. 4. Adaptive tuned λ optimal and tracking of reference state

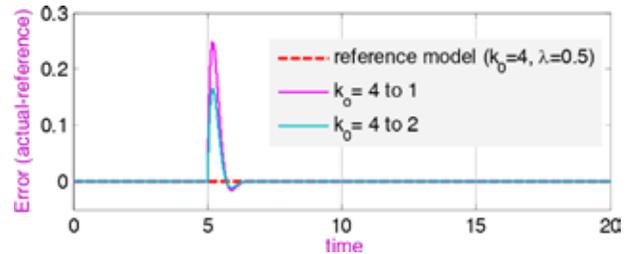


Fig. 5. Tracking error during adaptive tuning

Two cases of change in k_0 have examined and the responses drawn are shown in Fig. 4 and Fig. 5. The effect of the change in k_0 and consequently the change in system states and adaptively tuned fraction coefficient and error are shown in Fig. 5 and 6 respectively. It can be seen from Fig. 4 that as soon as a step change in k_0 happens from 4 to 2 and 4 to 1, the fraction coefficient λ adaptively changes from 0.5 to 0.3363 and 0.1826 respectively. Consequently, the actual states follows the reference model dynamics due to the fins tuning. Also, it can be observed from the tracking error in Fig. 5 that it remains zero in steady state which demonstrations that the actual system is following the reference system model.

CONCLUSION

In this study, we have investigated the effectiveness

of a Fractional Order-Proportional Integral (FO-PI) controller in enhancing the performance of a dynamical system. It was observed that the effectiveness of the FO-PI controller has demonstrated its potential to significantly enhance the performance of dynamical systems. By adaptively adjusting the fractional order exponent of FO-PI control, system's responses matched better with the desired response. Also, the proposed adaptively updated fraction coefficient of controllers allow for smoother transitions between different control modes or set points and helps to reduce overshoot and rise time in dynamical systems, as they allow for more precise control of the transient response. It was observed under different operating conditions and found that the FO-PI controller effectively improves the system response and worth it to append into a dynamics. The zero tracking error depicts that the adaptive tuning has potential to get the desired response. As a future scope, it is essential to continue exploring and refining the use of FO-PI controllers and other advanced control strategies to address the evolving challenges and demands.

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Regenerative braking of Electric Bicycle using Battery-Supercapacitor System

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ABSTRACT

The development of sustainable transportation solutions has been fueled by growing environmental consciousness and energy concerns. As an environmental friendly, effective, and practical mode of transportation, electric bicycles, or e-bikes, have gained popularity as a viable substitute for traditional bicycles. However, a major obstacle to the general adoption of e-bikes is still their short range. Regenerative braking presents a viable method for increasing the range of e-bikes by converting the motion energy that is produced while braking into electrical energy. Traditional battery-based energy storage systems frequently have limitations in meeting the high-power demands of regenerative braking. Supercapacitors have become a very desirable alternative to batteries in e-bikes because of their remarkable power density and quick charge/discharge times. The feasibility of a hybrid energy storage system (HESS) for regenerative braking in e-bikes that combines batteries and supercapacitors is examined in this research. The high-power regenerative brake energy in the suggested HESS can be conveniently absorbed by the supercapacitor, and the gained energy may be stored in the battery for further use. [4] According to studies, the HESS effectively stores and uses regenerative braking energy, increasing the e-bike's range by up to 30% when compared to a battery-only setup. In addition, the HESS lessens the strain on the battery, which could increase its service life. The results highlight how supercapacitor-based HESS has the potential to completely transform e-bike technology by greatly increasing range and energy efficiency. This development could lead to e-bikes being more widely accepted as a viable and sustainable form of transportation, fostering a future that is greener and more ecologically sensitive.

KEYWORDS: Battery, Supercapacitor, BLDC Hub motor, Buck-boost Converter, Bicycle.

INTRODUCTION

The distinctive qualities of electric vehicles (EVs), such as their low emissions, high efficiency, silent operation, etc., are drawing more and more attention. Traffic jams cause more stop-and-go traffic, which burns more fuel and releases harmful pollutants into the air. As a result, electric mobility has been viewed as a futuristic mode of transportation that obviously reduces vehicle emissions. Since they are an effective and environmentally friendly form of urban transportation, electric bicycles have become increasingly popular. They have regenerative braking systems installed to increase their range and energy efficiency. This research describes a method for integrating a battery-

supercapacitor system to provide regenerative braking on e-bikes. In electric automobiles, regenerative braking is a well-known technology that stores kinetic energy recovered during braking events for future use. We suggest a regenerative braking system that combines the use of a high-power density supercapacitor with a high-energy density battery.

A regenerative braking system will be designed to seamlessly transition between conventional mechanical braking and regenerative braking based on real-time conditions and rider inputs. When the rider applies the brakes, the system will engage regenerative braking to capture kinetic energy and store it in the hybrid energy storage system. Conventional regenerative braking

systems often rely solely on lithium-ion phosphate batteries, which can suffer from limited charge-discharge rates and reduced cycle life. In contrast, the proposed system combines a high-energy-density battery with a high-power-density supercapacitor. This hybrid configuration leverages the strengths of both energy storage technologies, allowing for efficient energy recovery during braking and subsequent power delivery during acceleration.[1]

Energy storage is essential to store the necessary brake current during regenerative braking. Braking serves three functions: parking brake, urgent brake, and service brake. When an emergency arises, a large braking current is necessary. In addition, the motoring-braking pattern is often applied, particularly in large cities where traffic is heavy. Therefore, storage that can withstand a strong braking cycle and absorb excessive braking current is necessary for regenerative braking. Yet for this technology to operate the car in driving mode, it also needs an energy density that is high. The supercapacitor and battery are the two components of energy storage that can meet the needs of regenerative braking in its development [2]. The energy density of a battery is high. It can therefore store a significant quantity of energy. But a battery's chemical makeup results in poor power density. A battery also has a short cycle life [3]. Supercapacitors have a high power density in any case. It has a significant current capacity to give or receive [2]. Supercapacitors, however, have a poor energy density [4].

In contrast, supercapacitors (SCs), sometimes referred to as ultracapacitors (UCs) or Electric Double-Layer Capacitors (EDLCs), are a subject of intense research and are widely regarded as a promising energy storage technology because of their advantageous characteristics, which include a high degree of recyclability and high-power density [1]. Despite having a relatively low energy density, they also offer other benefits such low internal resistance, a broad working temperature window, and high efficiency. Supercapacitors are useful for automotive rectifiers and may enhance stereo speakers and prolong battery life by adding a fuse and wire in series. They also have great accuracy and stability and can be used in parallel with batteries, making them highly practical and easy to use.

More than 30% away, steeply sloping, and strong, but it is also possible to create an automotive rectifier with a 16 V 83F capacity using solar energy and 62.7 V 500 F series.

Advantages of supercapacitors are as follows. Unlike batteries, which have a practically limitless cycle life, supercapacitors may withstand deep cycles of up to thousands (or around 500000) of cycles [5.] Supercapacitors can raise high levels of energy without deteriorating over time since they have a smaller impedance than batteries. Furthermore, rapid charging may be completed in a few seconds [6]. The specific power density of supercapacitors is approximately 100 times higher than that of batteries [7].

If they are overloaded, nothing bad happens, but it may shorten their lives. Furthermore, an overload monitoring circuit is not necessary because any voltage within their rated voltage range may be used to charge them. Supercapacitors require very little modification to their specs in order to be utilized and stored in a temperature range of -40 to 70 °C. Inexpensive to maintain, kind to the environment, and completely pollution-free. The likelihood of an explosion is low.[8]

The lithium-ion batteries used in conventional regenerative braking systems are frequently the only source of power, which can result in low cycle life and restricted charge-discharge rates. On the other hand, the suggested setup combines a supercapacitor with a battery with a high density of energy and high-density of power. Through the use of both energy storage technologies' advantages, this hybrid setup enables effective energy recovery during braking and subsequent power transmission during acceleration.

STRUCTURE OF PROPOSED HESS

E-Bicycle

Exploring a single-rider bike with a modest capacity for additional load, capable of covering an average trip of 50 km, is the focus. The goal is to emphasize a completely electric bike above peddles for increased comfort and maneuverability. The motor may be deactivated to assist the transition to pedaling mode, allowing the bike to function as a traditional bicycle [9]. The basic concept relies on choosing the propulsion

engine, which is based on the rider’s weight along with other loads on the bike in addition to traction force.

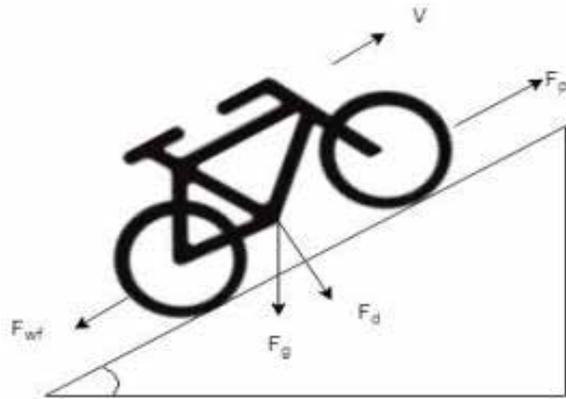


Fig 1. Forces acting on e-bicycle

Specific figures were evaluated for motor power selection: bike frame and accessory mass: 12 kg; battery and controller: 3 kg; rider: 80 kg; load: 5 kg, resulting in a total weight of 100 kg. When the bike ascends a hill with an inclination of, the traction force F_p must cope with the standard component of weight F_d , as well as the effects of frictional and windage force F_{wf} , as shown in Fig. 1. If the vehicle has a linear speed of 20 km/h, an extra aerodynamic load of 20 W is calculated when moving at this speed. The calculated necessary power is 260 W. Consequently, as shown in Fig 3, a 36V, 250 W, 250 rotations per minute BLDC hub motor with a maximum working torque of 32 Nm was chosen to be attached to the rear wheel hub.

Regerative braking

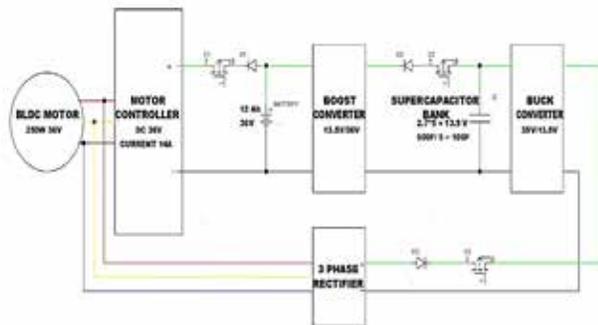


Fig 2. Proposed system

As seen in Figure 2, a typical motor drive system consists of a voltage supply, a mechanized motor controller, the motor, and the load. The torque and speed line up in

the same direction when the system is in driving mode. On the other hand, they function in the opposite ways while in braking mode. Regenerative braking generates reverse thrust by using a system similar to that of a generator, as opposed to frictional braking, which involves the generation of heat through frictional force. The quantity of energy recuperated through regenerative braking is contingent upon the initial speed and the mass of the vehicle [10]. When you apply the brakes on an e-bicycle equipped with regenerative braking, sensors detect the deceleration or the act of braking. The control system, upon detecting braking, switches the motor from propulsion mode to generation mode. Instead of using power to drive the bike forward, the motor now acts as a generator. As the motor operates in reverse, it creates resistance against the rotation of the wheels. This resistance slows down the bike and converts the kinetic energy of the moving bicycle and rider into electrical energy. This electrical energy is then sent back to the supercapacitor module[11].

BLDC Hub Motor



Fig 3. BLDC Motor

The Brushless Direct Current Motor (BLDC) is selected for its numerous advantages compared to other motor types. Its simplicity in design, high efficiency, substantial starting torque, ability for electronic commutation, and capacity for noiseless operation even at elevated speeds make it highly favorable. Consequently, the BLDC hub motor depicted in figure has gained extensive utilization in Electric Vehicles (EVs). The rotor position is detected by the hall sensor, that is mounted within the motor. The sensor senses the position of the rotor poles

and transmits digital signals to the controller to generate a triggering gate pulse. BLDC motors are preferred for their efficient operation, reduced maintenance needs, and enhanced durability. Their brushless design mitigates friction, thereby minimizing wear and tear and extending their operational lifespan. Additionally, BLDC motors deliver precise control over speed and torque, enhancing the riding experience by providing smoother acceleration and better responsiveness. BLDC motors are highly efficient, converting a higher percentage of electrical energy into mechanical power. [10] Their efficiency helps in extending the range of electric bicycles by maximizing the use of the battery's stored energy. These motors can provide high torque, making them suitable for uphill climbs and varying terrains. The power output can be adjusted through the motor controller, offering different levels of assistance to the rider. BLDC motors are compact and lightweight, making them a good fit for integration into e-bike designs without adding significant bulk or weight. They provide smoother and quieter operation compared to some other types of motors, offering a more pleasant riding experience. BLDC motors can support regenerative braking, allowing them to convert kinetic energy during braking or coasting into electrical energy to recharge the battery, thereby enhancing the bike's overall efficiency and range [12].

Supercapacitors



Fig 4. Supercapacitor Bank

Electric Double Layer Capacitors (EDLCs), also called supercapacitors, are capacitors with huge capacitance that present numerous exceptional qualities like elevated power density, extended lifespan, and a broad range of operating temperatures [4]. Supercapacitors have several applications within Electric Vehicles (EVs), primarily focusing on their ability to efficiently

manage energy during acceleration, braking, and power delivery [7]. During braking, kinetic energy is converted into electrical energy. Supercapacitors excel in capturing this energy rapidly and efficiently. They can store and release this captured energy quickly, which is advantageous during the acceleration phase, providing bursts of power. Supercapacitors can supply high power for brief durations, assisting in rapid acceleration alongside the main power source (battery). By handling peak power demands, they can alleviate stress on the main battery, extending its lifespan. Supercapacitors are integrated into hybrid systems, complementing batteries by providing immediate power for acceleration while the battery handles sustained energy demands. They enhance the overall efficiency of EVs by capturing and utilizing energy that would otherwise be lost during braking or deceleration. Supercapacitors ensure that the energy recovered during braking is efficiently stored and then used during acceleration, reducing overall energy waste in the vehicle system. Supercapacitors have lower energy density compared to batteries, limiting their capability to serve as the sole energy storage solution in EVs. [8] They have lower voltage limits compared to batteries, necessitating careful integration into the vehicle's power system. In 30 to 40 days, the supercapacitor discharges from 100% to 50%. In contrast, lead and lithium-based batteries experience a monthly self-discharge rate of roughly 5%.

There exist voltage restrictions for every capacitor. Supercapacitors can only operate at 2.5–2.7V, whereas electrostatic capacitors can be engineered to endure high voltages. A shorter service life is associated with voltages of 2.8V and above. A series connection is made between many supercapacitors to obtain 13.5 V Supercapacitor bank as shown in Fig 4. Internal resistance rises and total capacitance decreases with a series connection.

Supercapacitor specifications:

1. Charging time -(1–10)seconds
2. Cycle life -1 million or 30,000 Hours
3. Cell voltage - 2.3 to 2.75V
4. Specific energy (Wh/kg) -5 (typical), 1 to 30 Wh/kg lower than li-ion battery

5. Specific power (W/kg) -Up to 10,000
6. Service life (industrial) -10-15 years
7. Charge temperature $(-40 \text{ to } 65^\circ\text{C})$ $(-40 \text{ to } 149^\circ\text{F})$
8. Discharge temperature $(-40 \text{ to } 65^\circ\text{C})$ $(-40 \text{ to } 149^\circ\text{F})$
9. Self-discharge (30 days) -High (5-40%)
10. Tolerance $-10\%, +20\%$
11. ESR (Equivalent Series Resistance) -10 milli ohms
12. capacitance - 500F

Battery

Lithium-ion (Li-ion) batteries are the most prevalent energy storage choice in Electric Vehicles (EVs) for several compelling reasons. Because of their high energy density, Li-ion batteries have the capacity to store a large quantity of energy in a comparatively light and compact form factor. This feature is essential for optimizing EV driving range. They provide excellent power-to-weight ratios and maintain a stable voltage output, ensuring consistent performance throughout the battery's charge cycle [12]. Compared to some other battery types, Li-ion batteries can be charged relatively quickly, enabling shorter charging times for EVs. Li-ion batteries are sensitive to extreme temperatures, which can affect their performance and lifespan. Proper thermal management systems are essential in EVs to mitigate this issue. Lithium Iron Phosphate (LiFePO₄) batteries, a subset of lithium-ion batteries, are known for their specific chemical composition and unique characteristics. LiFePO₄ (lithium iron phosphate) serves as the cathode material and carbon as an anode. A lithium salt in an organic solvent facilitates ion movement between the cathode and anode. LiFePO₄ batteries are considered safer compared to other lithium-ion chemistries. They have a higher thermal stability and are less prone to thermal runaway or overheating, making them less likely to catch fire or explode. They boast a longer lifespan, enduring a higher number of charge-discharge cycles compared to other lithium-ion batteries, which contributes to their cost-effectiveness over time. They offer stable voltage throughout most of the discharge cycle, providing consistent power output until near depletion. LiFePO₄ batteries have a slightly lower energy density compared to other lithium-ion variants, meaning they store slightly less energy per unit

of volume or weight. Their use is prominent in areas where safety concerns and long-term reliability are critical, such as electric transportation and renewable energy storage.

Enhanced aging and cycle-life characteristics:

Comparing LFP chemistry to other lithium-ion chemistries, the former gives a significantly longer cycle life. It can support over 3,000 cycles under typical circumstances and over 10,000 cycles under ideal circumstances. NMC batteries have a 1,000–2,300 cycle life, depending on the circumstances.

LFP cells (sometimes referred to as having longer calendar lives) have a slower rate of capacity depletion than lithium-ion battery chemistries such as cobalt (LiCoO₂) or manganese spinel (LiMn₂O₄) lithium-ion polymer batteries (LiPo batteries) or lithium-ion batteries.

Specifications

1. Cell voltage Minimum discharge voltage = 2.0-2.8 V
2. Working voltage = 3.0 ~ 3.3 V
3. Maximum charge voltage = 3.60-3.65 V
4. Volumetric energy density = 220 Wh/L (790 kJ/L)
5. Gravimetric energy density > 90 Wh/kg, (> 320 J/g). Up to 160 Wh/kg, (580 J/g).
6. Cycle life from 2,700 to more than 10,000 cycles depending on condition

D. DC-DC converter

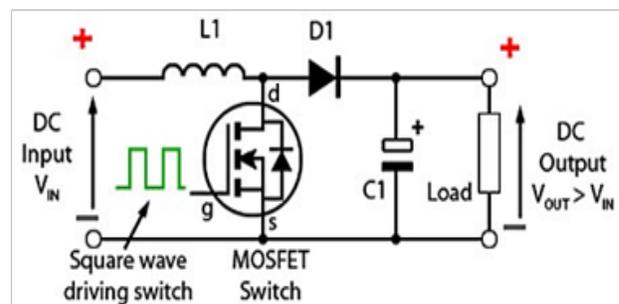


Fig 5: Boost converter circuit diagram

Buck-boost Converter

A type of DC-to-DC converter in which the magnitude of the final voltage might differ from that of the input

voltage magnitude is the buck-boost converter. It is comparable to a flyback converter that operates without a transformer by utilizing just one inductor. There are two distinct topologies known as buck-boost converters. Both of them are capable of producing a wide variety of output voltages, from nearly zero to significantly more (in absolute magnitude) than the input voltage.

Boost Converter

In this converter shown in Fig 5, The first transistor is switched on constantly while a high-frequency square-wave signal is fed to the second transistor's gate terminal. When the input current of inductor L travels through the other transistor while it is turned ON, the second transistor conducts. The negative terminal of the inductor charges the magnetic field surrounding it. Due to the second transistor's high conductivity, the anode is at ground potential, which prevents the D1 diode from conducting. The circuit is put under full load in the ON State and is capable of creating earlier oscillator cycles through the capacitor C's charging. The capacitor C can regularly discharge during the ON period, which will result in a high frequency of ripples on the output voltage. The following equation provides an approximation of the potential difference. $(V_S + V_L)$

The inductor L charges and the capacitor C discharges when the second transistor is turned off. The inductor L's ability to create a back e.m.f. is determined by how rapidly the current of the other transistor in the switch changes and the level of inductance that the coil can hold. As a result, depending on the circuit design, the resistor's back end may yield a broad variety of voltages. As a result, the voltage across inductor L has changed polarity. The input voltage, which must be larger than or equal to the input voltage, determines the output voltage. When the load current passes through the forward-biased diode D1, the capacitors are recharged to $V_S + V_L$, making room regarding the second transistor.

Buck converter

The first transistor is switched on, and the second is switched off in the buck converter due to the high square wave frequency. If the current running through the magnetic field is greater than the current passing through the first transistor's gate terminal, C is charged,

and the load is powered. The positive voltage applied to the cathode causes the Schottky diode, or D1, to become inactive. The first source of current is the inductor L. If the first transistor is turned off using the control unit, the current flows in the buck operation. The inductor's magnetic field collapses, the polarity of the voltage on the other side of the inductor. The current goes along in diode D2, and the load and diode D1 are all going to be turned on. With the support of the current, the inductor L releases a shrink. The charge of the accumulator in the capacitor is in one state during the first transistor. During the off-peak phase, the current travels through the load while maintaining an appropriate V_{out} . As a result, it maintains the least possible ripple magnitude, and V_{out} proceeds towards V_s [13].

Controller

In an electric bicycle, the motor controller plays a pivotal role in managing the electrical power flow from the battery to the motor. BLDC motors require precise timing of current flow to different motor windings. The controller manages this process, known as commutation, to ensure smooth and efficient motor operation. The motor controller regulates the amount of power supplied from the battery to the electric motor based on user input (throttle, pedal assist) or system requirements. It regulates the speed and torque of the BLDC motor by controlling the amplitude and frequency of the electrical pulses sent to the motor windings. In pedal-assist e-bikes, the motor controller harmonizes the power delivery between pedaling and the electric motor to provide a seamless riding experience. BLDC motor controllers utilize Hall effect sensors to detect the rotor's position and speed. The controller processes this feedback to adjust the motor's operation accordingly [14]. It generates Pulse-Width Modulation (PWM) signals to control the voltage and current supplied to the motor. This method efficiently regulates power without dissipating excess energy as heat. A motor controller can significantly enhance an e-bike's performance, providing smoother acceleration, better efficiency, and improved control. It ensures the safe operation of the electric system and prolongs the lifespan the motor and battery by managing power flow and preventing overload.

MODES OF OPERATION

Normal Mode

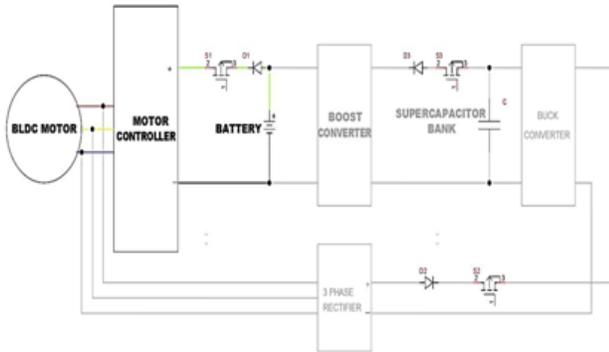


Fig. 6(a). Energy flow in normal mode

When the motor's power (P_{motor}) is either equal to or less than the rated power of the battery ($P_{Batt, rated}$), the vehicle activates its normal mode. Fig. 6(a) illustrates the energy flow during this mode. Here, switch S1 is ON while S2 and S3 are OFF. Therefore, the buck and boost converters are deactivated, and the supercapacitor module remains inactive. Consequently, the BLDC motor is exclusively powered by the battery pack under these circumstances.

Regeneration Mode

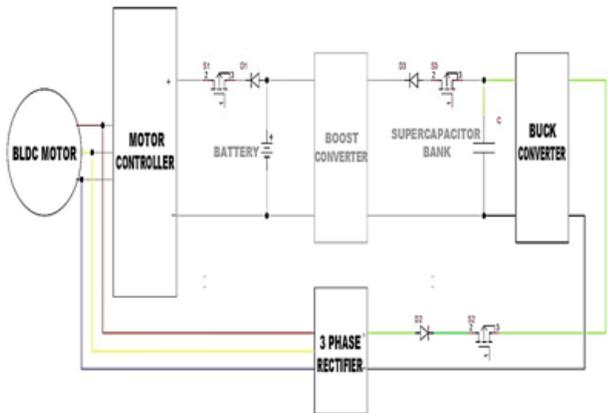


Fig. 6(b). Energy flow in regeneration mode.

When the motor's power (P_{motor}) is greater than the rated power of the battery ($P_{Battery rated}$), the vehicle activates its regeneration mode. Fig. 6(b) illustrates the energy flow during this mode. Here, switch S2 is ON. Therefore, the supercapacitor module gets charged through buck converter during this mode. As S1 and S3 are OFF

boost converter is deactivated and also the battery remains inactive.

Acceleration Mode

During vehicle acceleration, driving uphill, and peak speeds, the motor power P_{motor} exceeds the battery-rated power $P_{Batt-rated}$, which is referred to as vehicle acceleration mode.

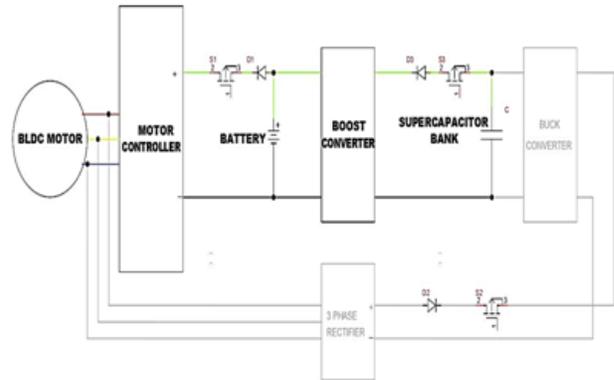


Fig. 6(c). Energy flow in acceleration mode

Under these situations, the battery pack may be exposed to repeated deep discharge cycles, reducing vehicle performance. In such instances, if the supercapacitor voltage is above the minimum threshold ($V_{sc} > V_{SC, min}$), the supercapacitor begins to assist the battery pack via the DC-DC converter. Fig. 6(c) depicts the energy flow in this manner. Here, switch S1 and S3 are turned on; however, S2 is not. Under some scenarios, if V_{sc} goes below $V_{Battery}$, the battery pack may mistakenly supply the supercapacitor module with power to increase the battery pack's. As a result, the supercapacitor only continues to assist the battery pack until V_{sc} exceeds $V_{Battery}$, as determined through the control. In this type of cases, D3 is at all the times reverse biased, hence avoiding supercapacitors to charge.

RESULTS AND DISCUSSION

The drive cycle covers a distance of 27 km over a total travel time of 1.5 hours, with a maximum speed of 25 km/h. Fig.7 shows the battery terminal voltage for different distances without regeneration. This proposed system can extend the driving range by around 29 km as in Fig.8. The strong braking force is collected by a supercapacitor bank, improving braking efficiency and keeping the battery from suffering

excessive charge currents. As in Table.1 charging the supercapacitor bank takes approximately 21 minutes, while it discharges in 4 minutes at speed of 25km/hr. From Fig.9 each time the brakes are applied and during regeneration the supercapacitor bank gains a charge of about 2% to 3% of its total capacity. During electric vehicle acceleration, the motor requires a torque of about 19 N.m. As the vehicle maintains higher constant speeds, the regenerative braking torque increases, showcasing its effective performance. Regenerative braking is challenging at lower EV speeds due to the motor/generator generating relatively low voltage. If mechanical braking isn't employed in such cases, the EV won't halt within the specified distance.

Table 1: Charging and discharging time for various speeds

Sr. no	Maximum speed	Travel time	Supercapacitor charge time	Supercapacitor discharge time
1.	25km/h	1.5hr	21min	4min
2.	20km/h	2hr	27min	4.1min
3.	18km/h	2.25hr	31min	3.9min



Fig. 9: Supercapacitor charging voltage Vs Distance

CONCLUSION

Including a battery-supercapacitor hybrid energy storage system (HESS) in electric bicycles (e-bikes) has shown to be a successful way to increase range and improve energy efficiency. The high power density and long cycle life of the supercapacitor, as well as the high energy density of the battery, were employed in this suggested system. This creative solution increases range by up to 30% over conventional battery-only systems by utilizing the advantages of both supercapacitors and batteries to harvest and use regenerative braking energy. In addition, the HESS lessens the demand for the battery, which could increase its longevity. These results demonstrate the revolutionary potential of supercapacitor-based HESS in transforming e-bike technology and opening the door to a more useful and sustainable form of transportation.

The results of this study highlight how supercapacitor-based HESS has the potential to completely change the e-bike industry. E-bikes become more useful and environmentally friendly forms of transportation when their range is increased through the HESS's efficient capture and utilization of regenerative braking energy. To further improve the performance of the HESS, more studies may concentrate on refining its design and investigating intelligent control algorithms. The future of e-mobility is expected to be significantly shaped by the integration of HESS in e-bikes, as supercapacitor technology advances.

FUTURE SCOPE

Future research could focus on optimizing the HESS design to maximize its efficiency and range extension capabilities. Additionally, exploring the integration of intelligent control algorithms and advanced energy management strategies could further enhance the

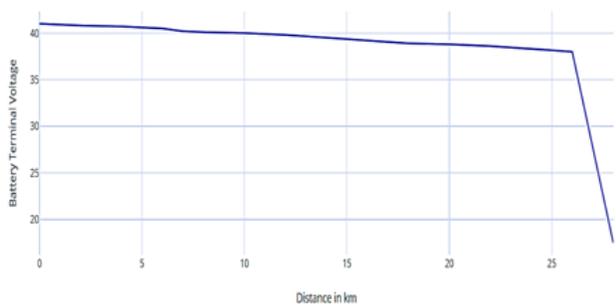


Fig.7: Battery Terminal Voltage Vs Distance before proposed system

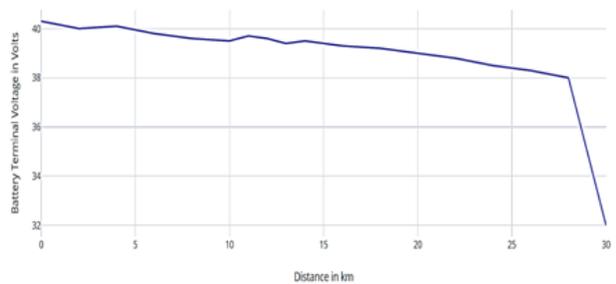


Fig.8: Battery Terminal Voltage Vs Distance after proposed system

performance of the HESS. As supercapacitor technology continues to evolve, the potential of HESS in e-bikes is poised to expand, revolutionizing the e-mobility landscape.

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Disturbance based Wormhole Avoidance in IWSN

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ABSTRACT

Abstract: Industrial wireless sensor networks (IWSNs) have emerged as an eminent technology for modern automation systems. While wireless sensor networks provide many advantages for industrial automation systems, there are particular difficulties in deploying them. Successful IWSNs require adaptable structures, energy-efficient methods, and coherent communication protocols. This emphasizes the need for effective communication protocols, evaluate the critical issue of power conservation, reduce energy consumption at the network, node, and sensor levels as well as flexible and scalable architectures that can meet the demanding requirements of industrial applications. Important aspects of IWSN design include system architecture, hardware and software development, and the choice of suitable communication technologies.

INTRODUCTION

The intend of this paper is to explore the performance of novel routing schemes for avoidance of the wormhole attack. The demonstration of this novel wormhole avoidance routing scheme is presented with the help of pseudo code and simulation results under realistic scenarios and deployment topologies. Reinforcement learning in terms of avoidance performance is introduced with the help of this new routing protocol called disturbance-based routing. Routing the traffic preferentially around wormholes is the main concept used in this technique to defend against wormhole.

Disturbances can be caused by a variety of factors, such as link failures, node failures, and denial-of-service attacks. Disturbance-based routing protocols are designed to be resilient to disturbances by using a variety of techniques, such as path diversity, link monitoring, and traffic rerouting. The avoidance advantage of a disturbance-based routing protocol is an important metric to consider when choosing a routing protocol for a particular application. For example, applications that are sensitive to latency may require a routing protocol with a high avoidance advantage.

Active and passive wormholes represent distinct

categories of wormhole attacks that possess the capability to impede and inflict harm upon wireless sensor networks. An active wormhole is a form of wormhole assault wherein two malevolent nodes conspire to establish a conduit connecting two distant locations within a network. The assailants apprehend data packets at one extremity of the wormhole and transmit them through the conduit to the opposing extremity, where they are subsequently unleashed into the network. This has the potential to undermine the functionality of routing protocols and result in the abandonment or erroneous redirection of data packets. A passive wormhole constitutes a form of wormhole attack where two malevolent nodes engage in the act of surreptitiously monitoring network traffic, effectively capturing the packets that traverse between two remote locations within the network. Subsequently, these assailants can exploit this acquired information to perpetrate an assortment of alternative attacks, including replay attacks or denial-of-service attacks.

RELATED WORK

The detailed design of a wireless sensor network specifically tailored for the purpose of remotely monitoring and controlling industrial parameters is a key factor that is presented in [4]. Emphasis is

placed on ensuring reliability and minimizing power consumption. The issue of flooding attacks in wireless sensor networks (WSNs) is examined in [10] and puts forth preventive measures to mitigate such attacks. An information security model that is based on Markov processes is explored in [9] and provides a detailed account of the sequence of failures and recovery actions undertaken in response to security threats. The various performance issues and standards that are associated with wireless sensor networks in the context of industrial automation is delved in [6]. The challenges and proposed solutions aimed at enhancing the security and reliability of industrial wireless sensor networks (IWSNs) at the physical layer is critically evaluated in [8]. The examination of existing MAC protocols for WSNs in order to assess their potential suitability for mission-critical applications is presented in [3]. This evaluation primarily focuses on aspects such as data transport performance and the ability to meet the requirements of such applications. The scholarly article [7] conducts a comprehensive examination of the utilization of virtualization in wireless sensor networks, with a particular emphasis on its advantageous features such as flexibility, cost-effectiveness, security, and manageability. The research paper in [5] introduces a methodology that utilizes automatic generation of fault trees to evaluate the reliability and availability of WSNs when network devices experience permanent faults. [1] offers a comprehensive overview of the various challenges and solutions associated with ensuring the reliability and security of wireless sensor networks (WSNs) in the context of factory automation. The study in [2] delves into the advantages and challenges of utilizing WSNs in industrial automation systems, while also highlighting the specific issues concerning reliability and security that arise in harsh industrial environments.

METHODOLOGY

The effective disturbance routing method employs adaptable measures based on historical traffic data, particularly the traffic on previously identified fastest routes. To prevent wormholes from forming during periods of heavy traffic on shortest-distance routes, the disturbance routing should redirect traffic away from hubs located on these routes. There are two types of

disturbance techniques: namely static and dynamic. Both of these routing techniques based on disturbances can provide advantages in terms of avoiding wormholes in Wireless Sensor Networks (WSNs). The current approaches for detecting wormholes possess several limitations.

The static disturbance scheme aims to improve the performance of an existing reactive routing protocol like AODV. In this scheme, the static disturbance metric $SDY_{Ni,j}$ is used instead of a unit value as the per-link metric from N_i to N_j . This modification is designed to reduce the impact of routing instability on network performance. The destination, typically the sink node, selects the reverse reply route with the lowest overall end-to-end metric. The intricate disturbance scheme handles a more complex process known as the dual routing tactic, which addresses the aforementioned feedback loop issue. For each route request, the protocol identifies two potential paths to the desired destination. Each is associated with a metric called static metric ' α ' and dynamic metric ' β ' respectively. The static disturbance metric is computed from local peer count while the dynamic metric employs dual routing strategy by first using AODV to find the path with the lowest distance between two points and in the second stage of dynamic disturbance routing, the logic of the protocol adds up dynamic disturbance metric along each and every feasible path. The two test topologies employed for simulation validation are: binary topology and safe test topology.

The static metric is given by:

$$SDY_{Ni,j} = P_i^\alpha \quad (1)$$

The dynamic metric is given by:

$$DDY_{Ni,j} = \beta^{SPAF_i} \quad (2)$$

where SPAF is shortest path activity factor which is the level of disturbance to which a specific hub would be exposed, as a result of shortest path routing, cannot be determined.

An important parameter is avoidance advantage which in disturbance-based routing is the measure of how well a routing protocol can avoid disturbances. It is calculated as the difference between the success rate of the routing protocol with and without disturbances.

Avoidance advantage of a disturbance-based routing protocol can be calculated as: Avoidance advantage = (Success rate with disturbances - Success rate without disturbances) / Success rate without disturbances.

Three models of topology are evaluated for wormhole avoidance using disturbance-based method for both active and passive wormhole, viz. grid-based gaussian topology, uniform random topology and radial ring topology. The Gaussian-based, uniform arbitrary, and radial ring topologies are employed to evaluate the effectiveness of the disturbance-based routing method. The utilization of these topologies enables an analysis of the feasibility of an evasion framework in diverse transition settings that are more representative of reality. Malign topologies are defined as topologies constructed specifically for the evaluation of disturbance methods in this context.

IMPLEMENTATION AND PERFORMANCE EVALUATION

Algorithm

1. Initialize variables: cost and route.
2. Get the neighbours of the source node.
3. Calculates the cost of the path from the source to the destination through the neighbour, taking into account the disturbance.
4. Add the weights of the edges in the path to calculate the cost.
5. If the cost of the new path is less than the cost of the current route, the code updates the route and cost.
6. Continues steps 1 to 5 until all of the neighbours have been considered.
7. Finally, the destination node is added to the route.
8. Cost and route is then returned by the code.

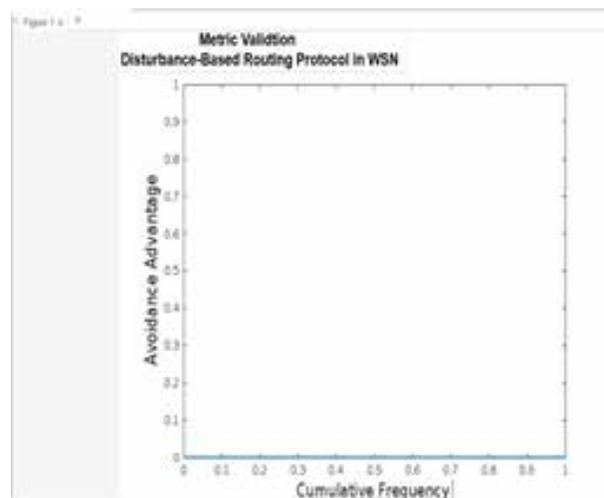
Simulation validation

To assess the effectiveness of the disturbance-based method, simulations are conducted using a custom simulator written in the OCaml programming language. To ensure the accuracy of routing and metric calculations, a MATLAB prototype was employed. The software simulations are executed in OCaml, while the outcomes are transferred to MATLAB in order to generate graphs

depicting the results. Objective Caml provides a user-friendly interface and enables the utilization of strong static typing and type inference, facilitating the creation of highly efficient code. Conversely, MATLAB is frequently employed in applications related to signal processing due to its vector processing capability and is particularly advantageous for the development and evaluation of prototypes. The simulator will generate a variety of network layouts. Each network layout will have connections between nodes that follow protocol model.

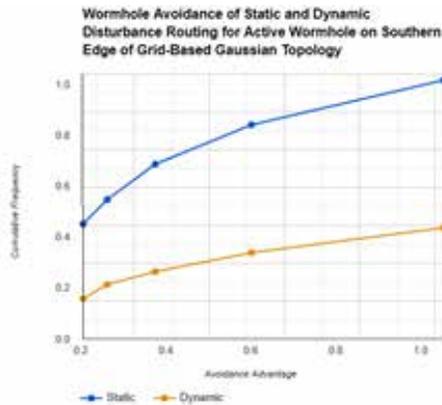
The simulator takes as input disturbance-based measurement (choosing a static or dynamic scheme and the related measurement esteem), a count of topologies to produce, and the arrangement of situation definition boundaries that oversee, in addition to other things, topology ape and source conduct. Other input parameters include a count of topologies to generate. When the simulation is run, the simulator generates an output metric that indicates the relative performance of the disturbance-based routing method in avoiding wormholes in comparison to the success of the pure shortest-path routing.

To thoroughly evaluate the code's capabilities for metric generation and outcome analysis, it is crucial to simulate disturbance-based routing across a range of topologies. Utilizing both static ($\alpha = 0$) and dynamic ($\beta = 1$) settings provides a comprehensive assessment of the code's functionalities. For metric validation, a graph of cumulative frequency-Vs- avoidance advantage is plotted.

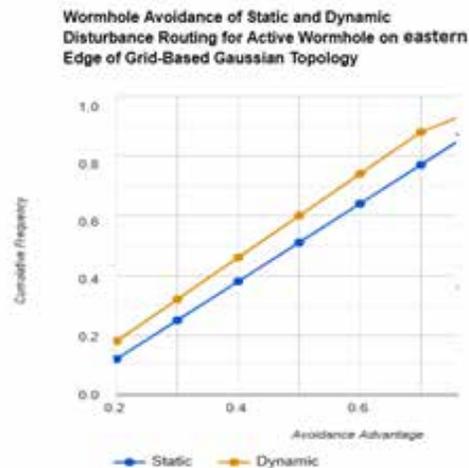


The effectiveness of disturbance-based routing protocols in thwarting wormhole attacks are illustrated through specific simulation outcomes.

The graph demonstrates avoidance advantage zero for all cumulative frequencies, thereby proving the wellness of this routing method to avoid disturbance which in turn improves the performance and reliability of the network.



2(a) Wormhole on southern edge



2(b) Wormhole on eastern edge

The above graphs indicate that static disturbance-based routing will not work in situations in which the wormhole is situated upon an edge. As seen from the graphs, the dynamic disturbance-based protocol can effectively detect wormholes by exploiting the bottleneck they cause during operation.

The protocol maintains stable performance, particularly in simulated scenarios where wormholes are positioned on the topology’s edges.

Using dynamic disturbance-based routing rather than static one raises the median avoidance advantage. The enhancement in performance is notably more substantial when the wormhole is positioned at the eastern periphery. The presentation of dynamic disturbance-based routing is in like manner more reliable than that of static routing, with the CDF plot indicating a narrower range of possible avoidance benefits.

Simulation Parameters

Simulation parameter	Value
Count of topology	100
Simulation run-time	6000 sec
Route interval	120 sec
New flow interval	20 sec
Count of node	100
Regularity factor (Grid based Gaussian topology)	0.9
Count of radial ring	6
Distance between radial rings	100mt
Grid based Gaussian peer threshold range	150 mt
Uniform random peer threshold range	200 mt
Radial ring peer threshold range	120 mt
Side length of topology	1000 mt
Maximum channel data rate	250 kbits
Data rate	5kbits

CONCLUSION

Wormhole attacks are a serious threat to wireless sensor networks. To ensure a deployment that prioritizes security, it is crucial to employ secure protocols that surpass a basic solution in terms of performance. Disturbance based routing technology aid in avoiding wormhole threat within the network. The innovative contribution of this novel routing method helps to prevent unintended failure modes security threats and analyse prospective assaults thereby ensuring that malicious attacks do not impede the public acceptance of WSN deployments. These steps help to mitigate this threat by implementing appropriate defenses. The effectiveness of the suggested approach, which relies on static disruptions, has been verified in evading both passive and active wormholes. This procedure employs a measurement that considers the topological framework and the number of peers in each intermediate

step on the path. Due to the peer inflation phenomenon, which leads to the formation of interconnected elements within the wormhole, it is advisable to steer clear of passive wormholes.

Routing towards the periphery of the network, where the number of connected devices is lower, can generally help prevent wormhole attacks. This strategy is effective in most cases due to the evasion advantage gained through an edge routing effect.

The techniques presented are centred around disturbances, which provide an approach to incorporate knowledge about potential wormhole locations into the decision-making process of a distributed routing protocol, thereby contrasting with alternative methods. The application of these wormhole detection systems on a consistent basis places a substantial energy burden on networks that are already operating within energy limitations and are in the process of being designed for extended deployment.

This method allows the network to keep operating even if a wormhole disrupts it. They ensure that the network continues to function even if a wormhole link is lost. By redirecting traffic away from areas where a wormhole is suspected or confirmed, this method complements existing identification mechanisms and provide comprehensive protection throughout the entire transition.

For the need to steer clear of a wormhole, the route that relies on disturbances must offer a shorter path at a more economical cost compared to the option that the wormhole provides.

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Gain Improvement using EBG based PIFA Antenna for M-LIDS System

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ABSTRACT

Industrial wireless sensor networks (IWSNs) have emerged as an eminent technology for modern automation systems. While wireless sensor networks provide many advantages for industrial automation systems, there are particular difficulties in deploying them. Successful IWSNs require adaptable structures, energy-efficient methods, and coherent communication protocols. This emphasizes the need for effective communication protocols, evaluate the critical issue of power conservation, reduce energy consumption at the network, node, and sensor levels as well as flexible and scalable architectures that can meet the demanding requirements of industrial applications. Important aspects of IWSN design include system architecture, hardware and software development, and the choice of suitable communication technologies.

KEYWORDS: *M-LIDS, EBG, Antenna gain, UAV.*

INTRODUCTION

Efficient communication and coordination are paramount in the success of CUAS operations. An antenna system that can seamlessly integrate with the Mobile LIDS system while providing reliable signal transmission and reception is crucial. The design of a specialized Planar Inverted-F Antenna (PIFA) for the Mobile LIDS CUAS is motivated by the need to establish a robust communication link that aids in real-time detection, tracking, and neutralization of unwanted aerial threats. The PIFA's compact form factor and compatibility with modern mobile communication systems make it an ideal candidate for integration onto mobile platforms, enhancing the agility and adaptability of the Mobile LIDS system in responding to dynamic aerial scenarios. As UAS threats continue to evolve, the development of an optimized PIFA antenna addresses the critical requirement for a dependable and efficient communication infrastructure within the CUAS

domain, ultimately bolstering national security and safeguarding public spaces. The increasing prevalence of unmanned aerial systems (UAS) presents a growing concern for national security, public safety, and critical infrastructure protection. These unmanned aerial vehicles can be exploited for unauthorized surveillance, smuggling, or even carrying out malicious acts. The novel Diversity/MIMO PIFA Antenna with Broadband Circular Polarization for Multimode Satellite Navigation is designed to provide circular polarization, pattern diversity, and high isolation for handheld terminals in multimode satellite navigation. The antenna operates in the frequency range of 1.1 to 1.7 GHz with good isolation of 14 dB between its two elements.

The Compact Dual-band Textile PIFA [1] for 433 MHz / 2.4 GHz ISM bands is a textile-based planar inverted F antenna designed for a small electrical size. The antenna achieves a wide matching bandwidth around 433 MHz and includes a slot for the 2.4 GHz band. It demonstrates

robust performance under bending configurations and on-body scenarios. The Hybrid PIFA/Loop WLAN Antenna [2] is a multi-band antenna suitable for mobile communication terminals. It combines PIFA and loop structures to cover the commonly required WLAN frequency bands, including 2.4 GHz, 5.2 GHz, and 5.8 GHz.

The Small Form Factor Dual Band (28/38 GHz) PIFA Antenna [3] targets 5G applications with a compact design. It features a shorted patch and a modified U-shaped slot, providing good matching, clean radiation patterns, and bandwidth in both the 28 GHz and 38 GHz bands.

The 6-Element 28/38 GHz Dual-Band MIMO PIFA is designed for future 5G cellular systems, offering multiple-input multiple-output (MIMO) capability [4]. The antenna system includes six dual-band PIFA elements arranged to optimize impedance matching, isolation, and radiation pattern for increased channel capacity.

The Ultra-Wideband PIFA Antenna [5] operates in the frequency range of 3.0 to 12.7 GHz and includes a coaxial probe-fed structure with slots for impedance matching. The design undergoes a parametric study, and the fabricated antenna demonstrates acceptable agreement between simulated and measured results.

The Miniature PIFA-like Patch Antenna is proposed for UHF RFID tag design [7], offering a metal-mountable solution with two side-by-side PIFAs. The antenna's resonant frequency can be tuned using notches, and it achieves an improved read range on metals. The Robustness of Wearable UHF-band PIFA to Human-Body Proximity investigates the performance of UHF-band planar inverted-F antennas [8] in the presence of the human body. The study suggests a criterion for improving antenna robustness with minimal impact on size.

The Analysis and Design of a New PIFA Antenna explores a dual-band design using slot techniques for compactness and low profile, with simulations conducted using High-Frequency Structural Simulator (HFSS).

The PIFA Antenna with Metamaterial Superstrate at 2.4 GHz employs a single-band PIFA with a metamaterial

superstrate designed for improved performance compared to a conventional PIFA antenna. The Monopole and Conformal PIFA for Small Cylindrical Ground Plane Mounting introduces antennas suitable for small frames, such as those on unmanned aerial vehicles, drones, and bicycles, with high bandwidths to serve multiple functions.

The 3D Printed Compact PIFA for 5G Applications presents two compact PIFAs fabricated using 3D printing for single-band and dual-band applications. The Multiband PIFA Antenna for Mobile Handheld Devices is designed with multiband characteristics, resonating independently at GSM 900, DCS 1800, and WLAN 2.4 GHz bands, achieved through multi-resonant slots and a quarter-wavelength shorting pin.

ANTENNA AND EBG DESIGN

In this section, we have discussed the development of a patch antenna with EBG structure and its relevant theory. PIFA antenna shown in Fig.1 is designed considering 3.5 GHz as the resonant frequency. For better results, circles on ground plane were used. The design of patch antenna was designed using the HFSS software.

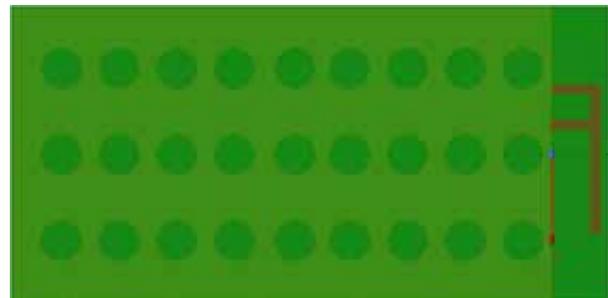


Fig. 1. PIFA antenna

Table 1. Antenna Dimension

Sr. No.	Physical antenna Dimensions	Calculated Values
1.	Antenna Offset	0.44cm
2.	Antenna Trace Width	0.15cm
3.	Feed Length	0.015cm
4.	Feed offset	0.49 cm
5.	Feed width	0.15 cm
1.	Length L1	2.46 cm

2.	Length L2	0.79 cm
4.	Ground	4.9 * 9.9 cm

CALCULATIONS AND OPTIMIZATION OF EBG IMPLEMENTATION ON GROUND SURFACE

The radius of the outer circle is 2.083mm.

$$XL = 2\pi fL$$

$$XL = \text{Inductive reactance} = 50 \Omega$$

$$f = \text{frequency } L = \text{Inductance}$$

$$L = 50 / (2 \times 3.14 \times 3.5)$$

$$L = 1/w$$

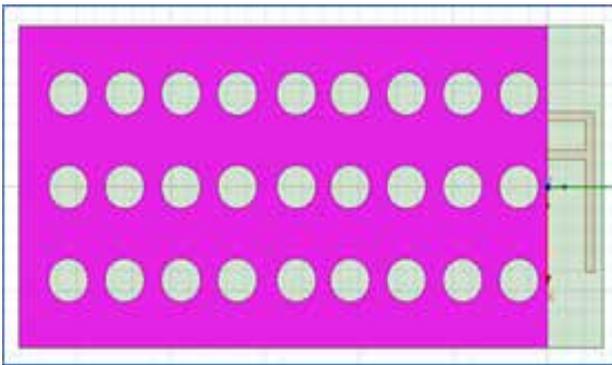


Fig. 2. EBG structure

In Fig 2, there is periodic circle structure (EBG) is designed on ground surface which will absorb surface wave.

SIMULATION RESULTS

As discussed earlier, for gain improvement we are going to use EBG structure for suppression of surface wave, so simulation is done according to two cases: Without EBG and with EBG.

Without EBG

When PIFA antenna is simulated without EBG in Ansys HFSS we have found out that return loss is -14.5 dB which is shown in Fig. 3 and radiation pattern is also directional which is shown in Fig. 4 which is useful for M-LIDS system, but single PIFA antenna gave 2.6 dB antenna which is shown in Fig. 5.

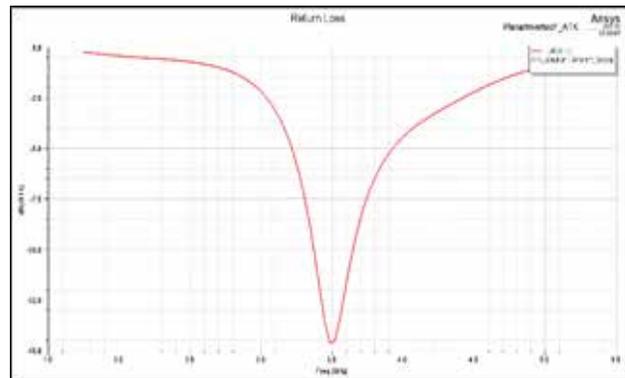


Fig. 3. Return loss

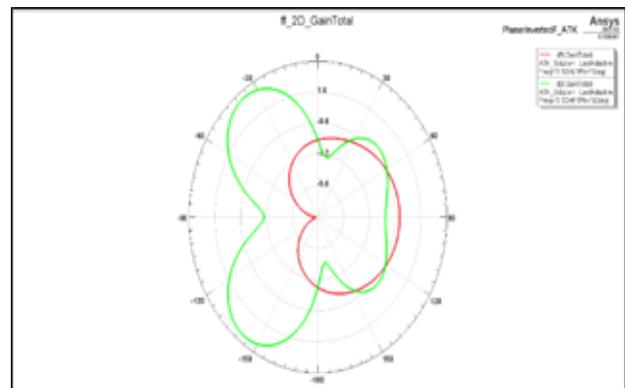


Fig 4. 2-D radiation pattern

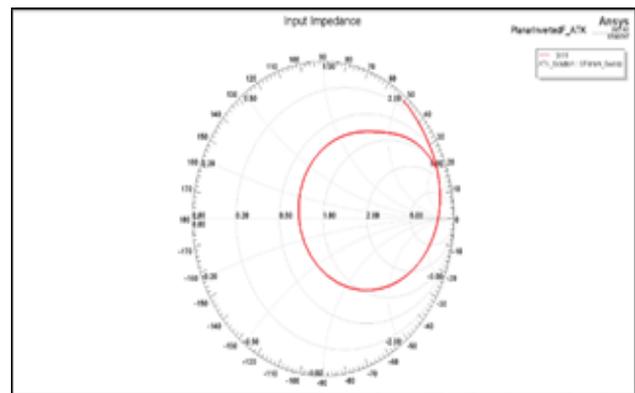


Fig 5. Smith chart

With EBG

When PIFA antenna is simulated without EBG in Ansys HFSS we have found out that return loss is -20.8 dB which is shown in Fig. 6 and radiation pattern is also directional which is shown in Fig. 7 which is useful for M-LIDS system, but single PIFA antenna gave 3.6 dB antenna which is shown in Fig. 8.

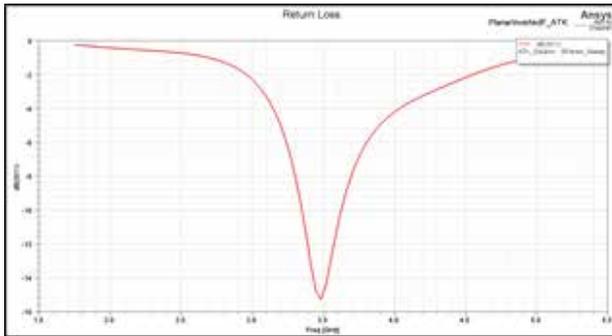


Fig 6. Return loss for EBG based antenna

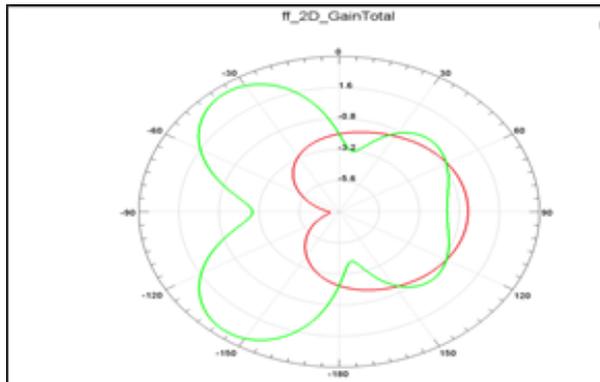


Fig 7. 2-D radiation pattern for EBG based antenna

RESULT

Table 2. Comparison between with and without EBG structure

Parameter	Simulated Result (Without EBG)	Simulated Result (With EBG)
Frequency of Operation	3.5 GHz	3.5 GHz
Return Loss (S11)	-14.6 dB	-20.8 dB
Gain	2.7	3.6 dB

CONCLUSION

In conclusion, the design of a PIFA (Planar Inverted-F Antenna) for a Mobile LIDS (Counter-Unwanted Aerial System) represents a critical element in the development of a sophisticated and efficient defense system against unwanted aerial threats. Simulated results showed that there is significant improvement in gain of PIFA antenna when EBG structure is applied to PIFA which is 3.6 dB. More optimization is needed for

M-LIDS system for improved capability system. The compact and versatile nature of the PIFA antenna, along with its ability to operate across various frequencies, offers a promising solution for countering a wide range of threats effectively. The successful design and implementation of the PIFA antenna are pivotal steps in strengthening our defenses against aerial threats and safeguarding critical assets and infrastructure.

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Enhancing Remote Communication in Gas Monitoring Rovers for Underground Mines

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ABSTRACT

Safety remains a paramount concern in mining, especially in addressing the detection and mitigation of hazardous gases in subterranean environments. This study introduces an autonomous rover system designed to enhance safety protocols in underground mining operations. The primary aim of the rover is to establish a continuous wireless data transmission link to the surface for real-time gas monitoring and analysis, significantly improving miner safety. A crucial aspect of its functionality is the integration of Long Range (LoRa) communication technology, operating at 868MHz, enabling efficient data packet transmission over extended distances of up to 30 kilometers, thus overcoming line-of-sight limitations. The rover is equipped with a suite of gas sensors (MQ4, MQ7, MQ2, and MQ8) capable of detecting critical gases, including Methane (CH₄), Carbon Monoxide (CO), Carbon Dioxide (CO₂), and Hydrogen (H₂). The real-time gas monitoring system, in conjunction with LoRa communication, not only enhances miner safety but also provides essential data feedback to the control unit. This innovative approach represents a significant advancement in refining safety protocols within the mining sector, addressing the industry's urgent need for heightened safety standards. While the empirical validation of its impact on reducing fatalities and casualties is pending, it underscores the paramount importance of safety enhancement in underground mining operations through the integration of LoRa communication technology and advanced gas detection sensors.

KEYWORDS: Mining safety, Autonomous rover, Gas detection, LoRa communication, Hazardous gases, Real-time monitoring, Safety protocols.

INTRODUCTION

Mining operations have been shown to pose significant safety and health risks to workers. These hazards arise from various factors, including the depth of the mine, oxygen levels, ambient temperatures, and the presence of toxic gases. These risks are a matter of serious concern, and prioritizing the safety of workers is paramount in all mining contexts [1].

Underground mines carry higher risks compared to open-pit mines, primarily due to challenges related to ventilation and the potential for collapses. The use of heavy machinery in underground excavation poses health hazards in all mining operations [2].

Modern mining practices often implement a range of safety measures, worker education and training programs, and health and safety standards, resulting in notable improvements in safety across the mining industry [3].

Coal has historically been India's primary energy resource, playing a crucial role in the nation's industrial development. Approximately 73% of India's power generation relies on coal, underscoring its undeniable importance in the energy sector [4]. However, coal production also generates by-products that pose environmental and health risks to those involved [5]. In light of these concerns, our current endeavor focuses on designing a rover capable of real-time monitoring and timely alerts to address these issues.

Ventilation systems are commonly employed in underground mines to ensure adequate oxygen supply, maintaining safe conditions for miners. Early methods of monitoring mine air quality harken back to the use of canaries and other animals to warn miners of hazardous conditions [6]. Incorporating advanced monitoring systems allows mines to proactively address threats based on comprehensive data provided by these systems. The rover serves as a monitoring system, transmitting data to the surface, enabling assessments of mine safety. The rover quickly detects environmental changes, facilitating swift responses.

Mining often harbors hidden dangers, such as toxic gases, which can pose significant health risks to miners. Detecting these gases promptly and alerting miners to dangerous conditions is imperative for their safety. While wired network monitoring systems have improved mine safety in some cases, they are not universally applicable to all types of mines [7].

The rover can analyze gas concentrations in various mine sections and grant clearance for work to commence. It continuously monitors and triggers alarms in the presence of toxic gases or insufficient oxygen levels. This initiates the process of clearing a mine section until the issue is resolved.

The rover can be operated remotely from the surface and is equipped with a camera linked to a video transmitter, transmitting video on 40-48 channels with a base frequency of 5.8 GHz. Video reception is possible using a video receiver with a display or FPV goggles with a built-in 5.8 GHz antenna. Control data i.e. commands can be transmitted using LoRa technology at a base frequency of 868 MHz. Employing LoRa in a half-duplex communication mode facilitates the transmission of control data from a joystick and the reception of sensor data from the rover. LoRa modules operating at the mentioned base frequency offer extensive coverage, reaching distances of up to 30 kilometers without the requirement of Line of Sight communication which is essential for underground communication.

Research Review

In the past, warm-blooded birds like munia were used for early gas detection in mines, particularly for carbon monoxide (CO). These birds were vital for mine rescue

teams. At 0.15% CO, a bird showed distress in 3 minutes and fell off its perch in 18 minutes. At 0.3% CO, distress and perch falling occurred in 2-3 minutes, while 0.1% CO didn't show immediate distress.

Color-changing detectors (e.g., P.S. detector, Hoolamite detector, Dragermultigas detector) indicate gas concentration. Automatic fire damp detectors, from companies like EMCOR, M.S.A Ltd., and Uptron, offer precise gas readings, even in small amounts, with adjustable probes for ceiling readings (e.g., Automatic fire damp detector, Interference methanometer, memacs I).

Gas-detecting sensors (eg., MQ4, MQ7) find use in chemical plants and underground mines for continuous indicators, but modern monitoring and LoRa transceiver at 868 MHz ensure seamless communication between rover in underground mine and control system on surface with adequate mobility.

Indian mines have higher accidents than the USA and South Africa, including open-cast mines [8]. Coal mining gas disasters include explosions, outbursts, and poisoning. Gas accidents cause over 50% of coal mine deaths [9].

Mining emits gases, depleting oxygen and adding impurities. Common noxious gases:

1. Blackdamp: CO and excess N₂, also called chokedamp or stythe.
2. Firedamp: Inflammable gases, primarily methane.
3. Whitedamp: Carbon monoxide.
4. Stink damp: Hydrogen sulphide (H₂S).
5. Afterdamp: Mix post-explosion, often CO, CO₂, N₂, H₂S, SO₂, low O₂. [10]

Effects:

1. Methane: Flammable, toxic, causes headaches, nausea, and more.
2. Carbon Monoxide: Poisonous, impairs oxygen transport, affects the heart, and more.
3. Hydrogen Sulfide (H₂S): Toxic at high concentrations, causes respiratory symptoms and multiorgan issues.

4. Carbon Dioxide (CO₂): Concentrations up to 1,000-1,500 ppm allowable.

Table 1: Health effects and Pollutant concentration breakpoints caused by Carbon Dioxide [11]

Concentration	Health Effects
<1000 ppm	Limited or no health effects
1000 ppm-2500 ppm	Fatigue, loss of focus and concentration, uncomfortable 'stuffy' feeling in the air
2500 ppm -5000ppm	Headache, tiredness
5000ppm-40000 ppm	severe headaches, slight intoxication depending on the exposure time

In mining environments, various gases are naturally present, and the types of gases can vary from one mine to another. This project will specifically focus on the above gases because they are commonly found in different types of mines [12].

Motivation

The motivation for deploying remotely operated rovers in mines with an emphasis on LoRa communication technology is driven by the imperative to enhance safety and operational efficiency within the inherently hazardous mining industry. These rovers offer a compelling solution by reducing the need for human personnel to directly access perilous underground environments, minimizing the risk of accidents and injuries. Furthermore, equipped with advanced sensors, these rovers provide real-time surveillance capabilities, enabling operators to monitor conditions underground, such as geological instability and gas leaks, and facilitate early detection of threats. Additionally, specialized detectors and cameras on these rovers are crucial for identifying and reporting potential dangers, such as unexploded ordnance or explosive materials in the mine. LoRa communication technology plays a pivotal role, allowing for reliable long-range communication between the rover and the control center, even in the challenging underground settings of mines. Beyond

safety, these remotely operated rovers contribute to cost savings, efficient resource exploration, and regulatory compliance, ultimately promoting a safer, more environmentally responsible, and sustainable mining industry.

Problem Statement

- Design a remotely operated rover with the capability to enhance safety in underground mines by detecting and identifying potential threats, gases, and transmitting data to the surface from underground thus minimizing the risk to human personnel.

OBJECTIVES

1. Enhance mining safety by reducing human exposure to hazardous areas and implementing sensors for threat detection, including gas leaks.
2. Collect data from remote mine sections for informed decision-making and use data analysis techniques, including machine learning and AI, for threat detection and decision support.
3. Enable precise remote rover operation for operator safety and automate tasks to reduce costs and minimize downtime.
4. Establish LoRa technology communication for remote mining locations and transmit real-time threat alerts for swift responses.
5. Monitor and report on environmental compliance within the mine.
6. Design for scalability and adaptability across various mining environments and threat types.

METHODOLOGY

The control interface architecture of the rover comprises a joystick module and a switch, both interfaced with an Arduino Uno and a TTGO LoRa module. The LoRa module, operating within the 868MHz frequency band, functions as the communication conduit, forwarding commands from the joystick to the rover. Within the rover, a LoRa transceiver module captures these commands and transmits them to an Arduino Mega, responsible for managing motor functions. The integrated joystick switch facilitates seamless control

switching between the rover’s wheels and the camera gimbal system, optimizing maneuverability.

The rover integrates four gas sensors, namely MQ2, MQ4, MQ7, and MQ8, each designed to detect specific gases such as carbon dioxide (CO2), methane (CH4), carbon monoxide (CO), and hydrogen (H2). Following meticulous calibration, the sensor data is relayed to the LoRa module within the remote unit. The LoRa module establishes a serial communication link with an Arduino Uno, which, in turn, communicates the data to a software application. This application, is responsible for recording gas concentration readings in parts per million (ppm) on a laptop and subsequently uploading them to a platform like ThingSpeak for in-depth gas level analysis and monitoring.

Furthermore, the rover features a camera connected to a video transmitter device, enabling real-time visual feedback transmitted over a 5.8GHz channel. On the remote side, a video receiver device, typically FPV (First-Person View) goggles, is employed to receive the live video feed. This configuration empowers remote control of the rover, providing the operator with immediate video feedback to enhance situational awareness and control capabilities.

System Designs

Architecture Diagram

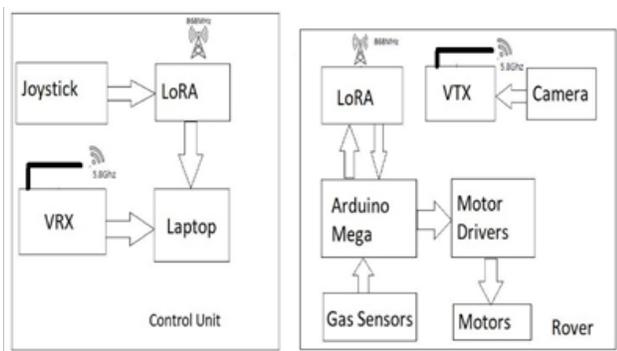


Fig. 1: Block Diagram of the entire system

The control system comprises four core elements:

Manual Controller: We employ a joystick module to remotely operate the rover. This joystick features one analog stick and a switch— when switch is off, the rover can be maneuvered by analog stick and when switch is on we can adjust the camera’s orientation, which is

mounted on servo motors.

LoRa Communication Module: The control unit utilizes a LoRa module, equipped with an ESP32 microcontroller, to transmit control instructions from the joystick to the rover. These instructions, encompassing both operational and functional commands, are transmitted over an 868 MHz frequency. Additionally, within the rover unit, another LoRa module is situated, responsible for receiving commands from the control unit’s LoRa module. Furthermore, it sends telemetry data and information from gas sensors located on the rover to the control unit.

Laptop Processing: All data, including telemetry and sensor information, received by the LoRa module within the rover unit is processed on a laptop. Subsequently, this processed data is presented on the screen in the form of a comprehensive dashboard of ThingSpeak.

VRX (Video Reception Unit): The VRX serves as the video reception unit. It captures the live camera feed transmitted by the video transmitters, operating on the 5.8 GHz frequency across 40 channels. The VRX unit incorporates a display for real-time monitoring of the rover’s camera feed.

The rover unit comprises 7 essential components:

Arduino Mega: Serving as the central microcontroller within the rover, it boasts a generous number of input and output pins. Its primary role is to receive directional and functional commands from the LoRa module and translate these commands into actions. It also reads data from gas sensors present in the rover and sends the data to control unit via LoRa module.

Motor Drivers: These components are responsible for delivering the necessary current to drive the motors. Since the motors require a high current that the microcontroller cannot supply, motor drivers are employed. They specifically control the Johnson motor in this project.

Motors: These are pivotal for propelling the rover. The project employs Johnson Motors with a 300 RPM rating, which includes a gearbox designed to achieve a specified RPM.

Gas Sensors: This project incorporates four gas sensors. These sensors are tasked with detecting targeted gases

within mines. The data they collect is relayed to the Arduino Mega, which subsequently transmits it to the control unit via LoRa.

LoRa: The LoRa module within the rover unit is used to transmit sensor data from the rover to the control unit. All data collected by the sensors is sent to the control unit via an 868 MHz frequency. The LoRa module itself is equipped with an ESP32 microcontroller. In the control unit, a corresponding LoRa module is present to receive the data transmitted by the rover unit's LoRa module.

Camera: In this project, a camera akin to those found in FPV drones is employed. This camera operates on an analog signal and transmits its feed through a wired connection to a video transmitter. The camera used in the rover is rated at 1000 TVL (Television Lines).

Video Transmitter: Responsible for relaying the video feed from the camera to a receiver, this component operates on a 5.8 GHz frequency and provides access to 40 channels. The video transmitter acquires the camera's video feed through a signal port and transmits it using an antenna. The transmitting power mode can be adjusted and is typically set to 1W.

SCOPE

Remotely operated rovers designed for threat detection in mines, particularly those utilizing LoRa (Long Range) communication technology, offer a comprehensive approach to enhancing safety and operational efficiency in mining environments. LoRa's extended range connectivity allows these rovers to transmit critical data reliably deep within the mine, overcoming obstacles and challenging terrains. They excel in real-time hazard detection and environmental monitoring, continuously transmitting information about gas leaks, toxic substances, and unstable ground conditions to operators on the surface. Acting as communication relays, they ensure uninterrupted contact among miners, rescue teams, and management, facilitating coordinated responses to threats and emergencies. LoRa's low power consumption is particularly beneficial for extended operations, minimizing downtime and maintenance. Data collected by these rovers undergoes analysis, employing AI and machine learning for anomaly detection and proactive safety measures.

Cost-effectiveness and environmental responsibility round out the advantages, making LoRa technology an indispensable tool for improving safety and efficiency in the demanding underground mining sector.

RESULT

Improved Remote Communication

The project was successful and it enhanced reliable communication between the gas monitoring rovers and the central monitoring system. This involved increased data transmission speed, reduced latency, and improved signal strength.

Calibration of Sensors

Calibration of sensors began with the comprehensive collection of data from gas sensors MQ-2, MQ-4, MQ-7, and MQ-8 over a 24-hour period, utilizing a 3-minute data interval. These sensors were strategically placed in an open ambient location to minimize gas concentration interference. Subsequently, baseline values were computed for all four sensors, forming the foundation for precise and reliable measurements.

Baseline Calculation of Sensors

The baseline, derived from 24 hours of sensor data, serves as a pivotal reference point. It encapsulates the normal operating conditions, allowing for the accurate interpretation of sensor responses in the absence of targeted gas concentrations. The baseline's role is instrumental in discerning deviations and anomalies during subsequent sensor operation, facilitating the detection of abnormal environmental conditions. The below image is of MQ8 sensor. Similar process was applied for all the sensors used.

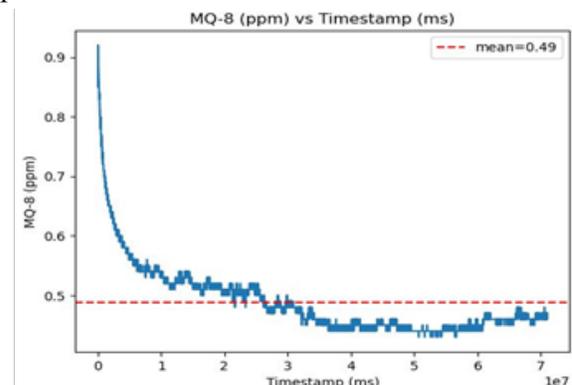


Fig. 2: Baseline calculation of MQ8

Recalibration of Sensors

Following the baseline calculation, recalibration became imperative to ensure sensor accuracy. This recalibration process involved an 18-hour data collection phase, during which sensor parameters were adjusted based on the established baseline. The aim was to eliminate any errors or inaccuracies that may have surfaced during initial sensor deployment. Recalibration is integral to sustaining optimal sensor performance and rectifying any drift that may occur over time, thereby enhancing the sensors' reliability in gas detection applications. The below image is of MQ8 sensor. Similar process was applied for all the sensors used.

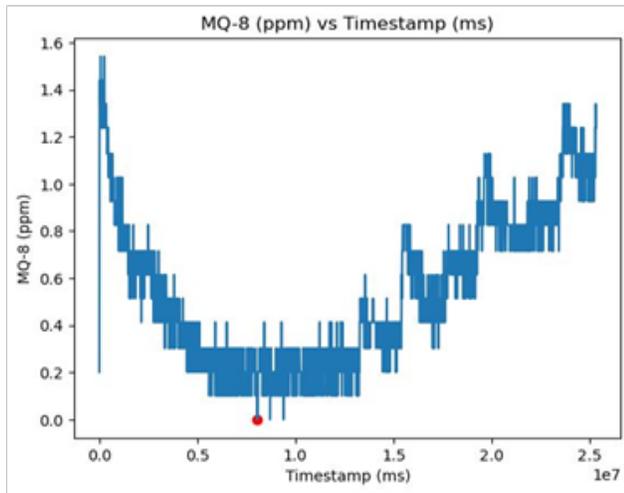


Fig. 3: Recalibration of MQ8 sensor

Enhanced Safety Measures

Improved safety measures through timely and accurate detection of gas levels, contributing to accident prevention and ensuring the well-being of mine workers.

Reduced Downtime

Increased operational efficiency with minimized downtime for maintenance or recalibration of gas monitoring rovers. This results in more continuous monitoring and less disruption to mining activities.

Data Analysis and Reporting

Implementation of robust data analysis and reporting systems, providing stakeholders with access to real-time and historical data. This facilitates informed decision-making and trend analysis.

Integration with Existing Systems

Successful integration of enhanced communication, sensor recalibration, and baseline calculation processes with existing mine monitoring systems.



Fig. 4: Photo of the Rover

CONCLUSION

The analysis of toxic gases and other parameters within underground mines has been conducted using a remotely operated rover. To provide a more precise and point-to-point view of the underground mine, a real-time monitoring system is integrated into the rover. This system transmits all the gathered parameters to the surface via LoRa, benefiting both miners inside the mine and those preparing to enter, potentially saving lives by providing early warnings before any accidents occur. Alarms are triggered when sensor values exceed predefined threshold levels, ensuring timely alerts. Additionally, the system stores all collected data on a computer for future analysis.

From the experiments and observations conducted, the following conclusions can be drawn:

1. The rover's motion enhances gas analysis capabilities by allowing the monitoring system to sample larger volumes of gas. This improvement is attributed to the increased airflow around the rover, which maximizes air circulation within the gas sensors.
2. The remote operability of the rover eliminates the need for on-ground human intervention, significantly reducing the risk of casualties.

3. It is important to consider that the accuracy of the parts per million (ppm) results may be influenced by the calibration equations of the gas sensors.

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An Effective Disturbance Rejection by Discrete Time Sliding Mode Approach

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ABSTRACT

This paper proposed the new method in light of the single input-single output system with the concept of variable structure control. The aim of controller design in such a way to reduce the effect of disturbance and minimise the chattering which has been observed in conventional SMC design. The proposed algorithm is not only focused generalised reaching law, but also a study of dynamics variables impact on the close loop system. The proposed law has resolved the problem raised due to disturbance in system dynamics. To anticipate the lost invariance and robustness properties of discrete sliding mode control. However, devices that are used in the control system component characteristics by complex nonlinear dynamics. The time varying properties of system dynamics impose a very challenging control issue. To overcome the above issues, need to develop the disturbance rejection compensator using the appropriate design of the sliding manifold. The performance of this algorithm is validated using the servomotor state space model.

KEYWORDS: *State dynamics, Controller, Sliding mode control, Disturbance rejection, Simulation.*

INTRODUCTION

The recent trend is to design a robust controller for continues time systems using a sliding mode control approach. The theory of sliding mode control (SMC) is an area of research that originated from the variable structure control approach. The root of the SMC was found in the late 1950s in Russia [1]. The literature found that the implementation of Continues SMC can result in undesirable oscillatory behaviour called chattering, which can lead to damage final control element. The implementation of the prevalent SMC and its applications was elaborated by various authors [2]. In todays scenario it is observed new technology most devices are having a high frequency and computing power. The attraction of the research has been moved toward the discrete-time sliding mode control (DTSMC) approach to design a robust controller for the delayed system. In a practical approach to designing a robust controller is in the form of discrete time implementation. With the development of technology a widespread use of a microcontroller and microprocessor chip is easier to implement the DTSMC algorithm as compared to the

traditional continues mode controllers. Therefore, the design of DTSMC thrust area and a growing interest in the research community[3].

The design of the DTSMC has two steps. First is to design the appropriate sliding surface. Second, is the design of the controller for the system to force the states at a desired level. The main purpose of designing a sliding surface is that the dynamics of the state of the system reach the desired position. The role of the controller is to force the dynamics of the variables on the sliding surface within a short period. However, once the states variables reach the sliding surface, then those variables should stay a long period on the designed manifold. In an implementation of DTSMC it was found that the state variables do not stay on the sliding surface, but it moves around the manifold in a particular band in a zigzag manner. This effect of the controller is called the quasi-sliding mode. In [4] a reaching law is derived to overcome the effect of high frequency oscillations is called the chattering. In the work of [5] studied the DTSMC, especially on the reaching condition and stability of the system.

In literature it was found that the basically two types of reaching conditions and the inequality conditions [5,6]. The work given in [7] proposed a reaching law that is focused on the equality type of reaching condition. Further, the law has been improved, and the controller law for different reaching conditions. Further develops a discrete reaching law, which can steer the switching function to converge towards the switching manifold in finite time and then, undergo a zigzag motion in the vicinity of the switching manifold. In spite of this, to reduce the uncertainty and disturbance rejection, a disturbance compensator has been designed but it initially set a high error in the system dynamics, and states scattered from the sliding manifold [5]. To overcome above discussed issues a new approach is introduced in this work to reduce the effect of unknown disturbance. The applications of the DTSMC has been found in the field of control engineering, like robotics, process chemical industries, electrical machines, automated vehicles, and so on.

This paper organised into the following sections: Section I, included the introduction about the DTSMC. Section II, where a formulated system equation and defined the ideal condition for the controller design. The proposed controller algorithm focused on the formulation of disturbance rejection system in section II-A. Section III gives the applications which used the discrete time sliding mode control (DTSMC), especially in control engineering, Robotics applications, and in process and chemical plant operations. In section IV, where simulation results and a discussion about the results of considering the servomotor state space model are presented for validation. Also, given the rigorous analysis of the system performance based on the transient properties like rise time settling time, overshoot and peak values. The paper ends with some remarks and conclusions.

SYSTEM FORMULATION

Consider the continuous time system model represented in discrete form as follows:

$$x(k + 1) = Ax(k) + bu(k) + d(k) \tag{1}$$

By defining a vector of state error

$$e(k) = x(k) - x_{ref}(k) \tag{2}$$

Where $e(k)$ is the system states error, and $x(k) \in R^n$ is the state variables vector, $u(k) \in R^m$ is the input control and is $y(k) \in R$ the system scalar output. A , and b are constant matrices with proper dimensions.

The formulation of the DTSMC is known to consist of the following steps:

Determine a switching function $s(k)$ such that the sliding mode on the switching plane $s(k)=0$ is stable Determine a control law

$$u(k) = \begin{cases} +1^+(k), & \text{where } s(k) > 0 \\ -1^+(k), & \text{where } s(k) \leq 0 \end{cases} \tag{3}$$

The first concept of Variable structure control in DTSMC given by Dote and Hoft first considered the discrete VSC problem and used an equivalent form of the continuous reaching condition to give a discrete reaching condition [8],[9], [11].The design of DTSMC includes:

The design of the proper sliding manifold so that the system gets stable on it when closed in loop dynamics of system given by the sliding subsurface $s(k)=0$

The derive the control law $u(k)$ in such a fashion that next sampling time state variables forced on the sliding manifold that is $s[(k+1)T]=0$

As per the Lyapunov stability discrete reaching condition is given in [10].

$$[s(k + 1) - s(k)]s(k) < 0. \tag{4}$$

With sliding surface $s(k)=c^t x(k)$

$$Ors(k + 1) = c^t x(k + 1) \tag{5}$$

where c^t is gain matrix. Therefore, sliding surface can be derived as

$$\begin{aligned} s(k + 1) &= c[Ax(k) + bu(k) + d(k)] \\ s(k + 1) - s(k) &= c^t [Ax(k) + bu(k) + d(k)] \\ &\quad - c^t x(k). \end{aligned} \tag{6}$$

From the equation (6) the controller law can be presented as

$$u(k)_{eq} = (c^t b)^{-1} [-c^t Ax(k) + (1 - qT_s)s(k) + (\zeta + \omega)T_s \text{sign}(s(k))] \tag{7}$$

where $q, \zeta, \omega,$ and $1-qT_s > 0$, with the close loop dynamics satisfy are given as

$$s(k + 1) = (1 - qT_s)s(k) - (\zeta + \omega) T_s \text{sign}(s(k)) + c^t b d(k) \tag{8}$$

PROPOSED DTSMC WITH DISTURBANCE REJECTION

The proposed method is discussed to improve the performance of the dynamics behaviour of the system and improve the conventional DTSMC performance. This proposed method is applicable to both the servo and regulatory problems. The tracking error vector defined with the reference and became applied the known disturbance in the system. The error vector can be represented as:

Let's consider the reference signal as

$$x(k)_{ref} = [x_{\{ref_1\}x}(k) \dots \dots \dots x_{\{ref_n\}x}(k)] \tag{9}$$

The error vector can be calculated as:

$$e(k) = x(k) - x_{ref}(k) \tag{10}$$

The formulation of the sliding surface for this case can be represented in term of error vector and the sliding gain constant c^t calculated using the pole zero placement method. The condition of the stability $s(k)=0$ as follows

$$s(k + 1) = c^t e(k + 1) = c^t (Ax(k) + bu(k) + bd(k) - x_{ref}(k + 1)) = 0 \tag{11}$$

For this case the controller is the combination of the states matrices with the sliding manifold derived as

$$u(k) = -d(k) - (c^t b)^{-1} c^t (Ax(k) - x_r(k+1)) \tag{12}$$

Comparing the equations (12), (1) with (11) representation of the error dynamics as

$$e(k + 1) = [I - b(c^t b)^{-1} c^t] Ae(k) - [I - b(c^t b)^{-1} c^t][x_{ref}(k + 1) - Ax_r(k)] \tag{13}$$

APPLICATIONS

Control engineering applications

The concept of DTSMC similar to those in continuous time systems with SMC algorithm has been introduced by [1] and application of DTSMC has been directed to solving the control systems problems.

The DTSMC law has been developed and applied to linear system in the contribution of [10] where the

simple example of state space model studied. The robustness of the system only guaranteed whenever the condition are mild in nature and the presented technique was applicable only when the computation time of control law and sampling period is not comparable.

The time delay controller has been presented in the work of [9] and the applications are validated with linear time invariant and single input single output systems. The experimentation validity was performed on servo motor to control the position by adding additional uncertainty by elastic spring that was physically attached to the rotor shaft. The real time control of uncertain dynamical system with known relative degree and constant of reaching law has been demonstrated in [11].

In the work, higher order SMC and output feedback control concepts have been used. The concept of second order recursive reaching law based on DTSMC has been presented in the contribution of [12]. In this, the control input has better continuity between sliding surface and uniformly bounded time axes which provides better and smother control signal.

The stability concepts and upper and lower bound on control signal have been studied with number of numerical examples given in [13]. In the contribution, the general method to compute the feedback gain was presented.

In [14], Euler's discretization of the equivalent SMC has been studied and for the analysis purpose with several examples were simulated with computer. The estimation of maximum chattering amplitude has been allowed the analysis of the algorithm. A Discretization effects on dynamic behaviors equivalent control-based multi-input sliding-mode control systems has been demonstrated on third order systems with two inputs [15].

The dynamical behaviors of DTSMC uncertain system has been studied in the contribution of [16] and discrete reaching law with a disturbance compensator has been presented with the concept of QSMD. The chattering-free DTSMC with state observer and disturbance rejection has been demonstrated with controller based on implicit Euler's method and it has been remarked that the controllers were easily implemented with projections on the interval $[-1, 1]$ as maintained in

[14]. In [17] developed a disturbance estimation scheme to compensate the uncertainties in nonlinear system without affecting control law. A cart inverted pendulum was used as benchmark example to verify the effectiveness of algorithm.

Robotics Applications

The design of the controller for the robotic arm is challenging because of the number of links and sensors mounted on the robotic arm. Due to this dynamics of the system is more so that uncertainty arises in the system. To cope with the problem using discrete-time sliding control coupled with an uncertainty estimator design and also, it validated and experiment result shows satisfactory tracking performance and observable robustness for the presence of uncertainty, disturbance rejection, and payload agitations [26,27]. In literature, there were many works of SMC are available with robotics applications to design a controller for robotic arm manipulators such, model predictive control, adaptive control, and continuous sliding mode control [28].

Garcia et. al.[28] reported that inverted pendulum model consider as the altitude control of a space booster on take-off period. The objective of the altitude control is to maintain position of space booster in a vertical position [28]. To applied DSMC strategy on the inverted pendulum for control the vertical position during disturbance arises. The performance of both the continuous-time and discrete-time controllers was compared through simulations and experimental validation.

In [29] presented the Motorola 6809 Microprocessor based forced controller for robotic manipulator gripping hand using VSC method. Also, given the procedure for programming algorithm steps to design DTSMC. In work of [26] reports that DSMC law has been tested on the ERICC robot arm. The experimental results show effectiveness of controller for robustness property in the presence of model inaccuracies, disturbance and payload.

The nonlinearities and uncertainties are major issue while designing any type of controller, the work of [31] focused on it with bounded parameters of uncertainties as well as nonlinearities of dynamical system and

variable structure observer has been designed for simple pendulum system.

In [32] given the new algorithm for nonlinear dynamic system based on the reaching law method and it was complemented by sliding mode equivalent technique. The derived law implemented and demonstrated on two link robotic manipulator arm. The method taken care of the reaching condition, free order switching. In the reported work, probably, first time given the clear idea of the dynamic switching demonstrated through the simulation example.

The concept of robust DSMC has been proved in the work of [26] and can be extended for simple examples similar to robotics. In [33] contribution is an extension of law given in [30] and extended results of inverted pendulum were compared discrete LQR. It has been concluded that the designed DSMC for inverted pendulum can be extended for other problems such as mobile inverted pendulum, double inverted pendulum etc.

In [34] multi-step Prediction based DSMC algorithm implemented on the inverted pendulum. In [34] experimental set-up, the position and velocity of cart, angle and angle velocity of pendulum are measurable. The results from the new DSMC approach given the good result as compare to the other traditional controllers.

The concepts of nonsingular terminal DSMC have been studied in the research of [35] and the same has been applied to robotic manipulators. The nonsingular terminal DSMC applied to control of n link rigid manipulators and analysis have been made with the algorithm can enable the elimination of singularity problem associated with conventional SMC.

The fast TSMC dynamic used to design control strategy for the single input and single output non-linear dynamic system [36]. The effectiveness of the derived control law implemented on flexible robotic joint arm. The controller strategy applied for the chaos communication and synchronization, filter design effectively observed from the given simulation results.

The magnetic suspension system is an unstable nonlinear system, and design of controller of is challenging task. In [37] work given new approach of DSMC to

calculate the distance from the state variable to the sliding surface, and it can adjust the linear or nonlinear control law according to the calculated distance. The algorithm given system to achieve a fast, accurate and stable suspension target when the system has external disturbances and internal parameter perturbations

Process and Chemical Applications

In chemical industry process involve heating and cooling of semi-batch reactors can be control is the major problem for conventional controllers because it is not consider the relative large degree of uncertainty and disturbances in process. The first order SMC can be the solution to design the controller for this problem [3]. However SMC generate the chattering due to switching function in controller. The delays present in the state or disturbance estimation in sampled data systems is an invertible phenomenon and must be consider for controller design. In Abidi et al. (2007) observed that in case of delayed disturbance estimation a worst case accuracy of $O(T)$ can be guaranteed for deadbeat sliding mode control design and a worst case accuracy of $O(T^2)$. The deadbeat control is undesirable in practical implementation due to the more control action required. The solution given by Abidi et al. (2008) designed the integral sliding mode design to avoid the deadbeat response by eliminating the poles at zero.

The contribution of [28], has been used to the real time application of chemical reactor with elimination of chattering phenomenon. The Work includes second order DSMC mode observe and the influence of the discontinuous term amplitude on the estimation performance. Adaptive DSMC of nonlinear systems described by Wiener models and applied control law to a pH chemical neutralization process has been implemented. The concept of DSMC of SISO has been extended to two input two output interactive process in the work of [8,9]. In this case, the ideal decouple has been used and decoupled subsystems have been obtained. The decoupled subsystems are converted into discrete domain and DSMC law has been developed by eliminating reaching law. DSMCr designed for Higher Order System time delay system in the work of [6], where higher order typical systems are simulated and results are studied.

NUMERICAL EXAMPLE

For effective performance of the proposed method consider the servo motor numerical example as:

$$A = \begin{bmatrix} 1.2 & 0.1 \\ 0 & 0.6 \end{bmatrix} \quad b = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

Consider the system given in the equation (2.1) can be represented in the state space form to simulate the response. Lets consider this example given in the work of [4]. The value of the initial state considered as $x=[0.3 \ 0.1]^T$. Also calculated the sliding gain constant matrix as $c^t = [4.5 \ 1]$. The example simulated for the conventional controller and the proposed controller to validate the performance with chosen the constant as $qT_s = 0.25$ and $(\zeta + \omega)T_s = 0.35$. The sampling time for the simulation selected as $5 * \exp(-3)$.

The figure (1) and figure (2) show the behaviour of the dynamics states when applied the conventional controller and the proposed DTSMC. As can be seen from figure (1) and (2) with the conventional controller dynamics of the system response observed high amplitude of the signal with stability behaviour. In other way it is observed that the proposed DTSMC states signal is stable with the less amplitude without the chattering. In the proposed DTSMC simulated result is shows that the states signal strength within the band of -0.48 to $+0.7$ for the x_1 state and the -2 to $+1$ for the x_2 state. However, if we found the simulated results from figure (1) and (2) it observed that when applied the designed controller using the conventional method the band of the strength of dynamics are in the range of -6 to $+6$ for the x_1 state and -22 to $+22$ for the x_2 . Similarly, if the simulated results for the sliding surface, it is observed that the effort of the dynamics reaches toward the sliding surface is less as compared to the conventional controller design. From figure (3) and (4) the reaching time for the dynamics variables of the system is less in the proposed DTSMC as compared to the conventional SMC. However, the designed controller performance is always analysed based on the value of peak time, settling time, rise time, and overshoot are the key parameter to validate the required controller performance. The rigorous analysis of the system parameters is done based on the transient response of the system given in table (I). Similarly, if the simulated results for the sliding surface, it is observed that the

effort of the dynamics toward the sliding surface is less as compared to the conventional controller design. From figures (3) and (4) the reaching time for the dynamics of the system is less in the proposed DTSMC as compared to the conventional SMC. We notice from these figures a considerable reduction in rejection of the disturbance and the chattering-free response validated for the proposed DTSMC. We notice from these figures a considerable reduction in rejection of the disturbance and the chattering-free response validated for the proposed DTSMC.

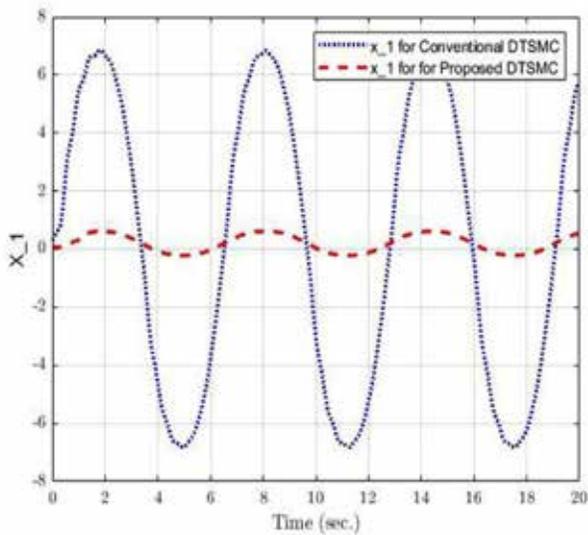


Fig 1. State variable x_1

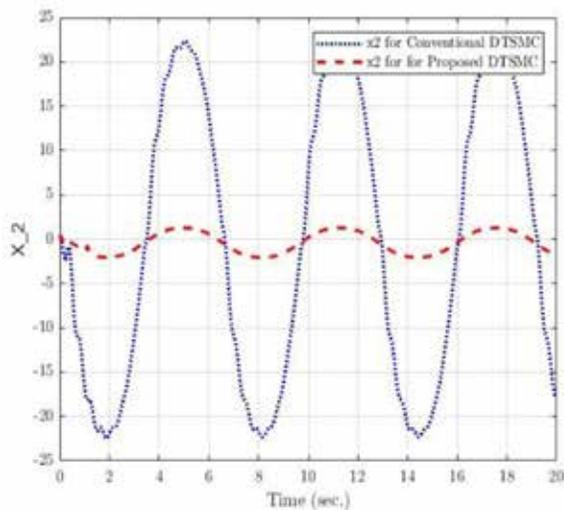


Fig 2. State variable x_2

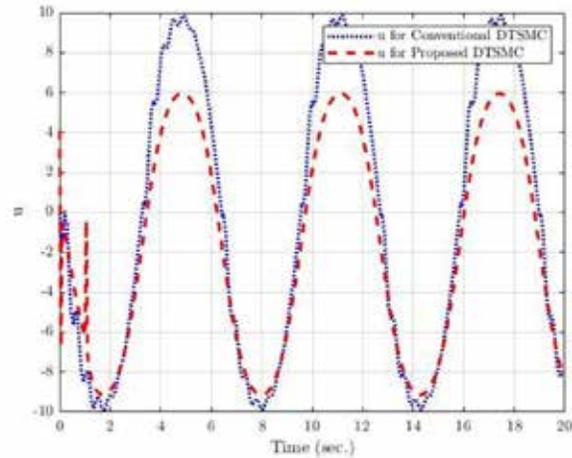


Fig. 3 Control signal (u)

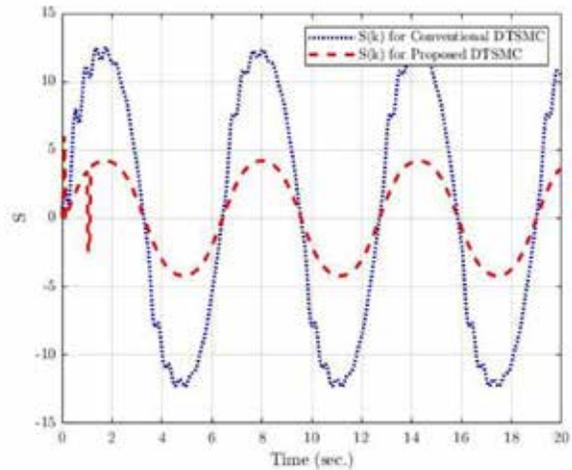


Fig. 4 Sliding surface (s)

Table 1. Time Response Analysis

Time response parameter	Control signal $u(k)$		Sliding Surface $s(k)$	
	Conventional DTSMC	Proposed DTSMC	Conventional DTSMC	Proposed DTSMC
Raise time	16.0123	21.922	15.9786	1.1532
Transient time	393.3657	396.503	393.48	396.550
Settling time	393.9025	397.105	396.22	397.307
Overshoot	22.366	11.8628	18.6505	64.9125
Undershoot	120.787	72.7191	117.1178	115.637
Peak	9.997	9.148	12.4864	6

CONCLUSION

In this paper, a new approach is proposed and design the DTSMC and it is compared with the conventional controller. A disturbance rejection strategy is address to tackle parameter uncertainties and the rejection of external disturbances. In this study, a new technique has been proposed to design the DTSMC and it is compared with the conventional controller. The present algorithm improved disturbance rejection strategy was also not affected due to parameter uncertainties and model mismatch in modelling. The proposed controller generates minimum overshoot and undershoots in the control signal. By using the appropriate state space form of the servomotor example selected for simulation. The proposed algorithm shows less reaching time and stability of the dynamic of the system. The proposed controller is guaranteed to be asymptotically stable and minimise the chattering in a close loop. From the simulated results it is observed that the control effort of the proposed controller is less as compared to others. The future work would be to combine this algorithm with a new dynamic adaptive switching gain strategy. Simulated results show the effectiveness of the proposed controller over the prevalent controller.

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Image Retrieval using Feature Extraction: A Survey

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ABSTRACT

Different real-world computer vision applications use multimedia content analysis, and a significant portion of multimedia data is made up of digital images. Over the past several years, the complexity of multimedia content, particularly visual content, has expanded tremendously. Every day, millions of images are uploaded to various sites like Twitter, Facebook, Instagram, Snapchat and Amazon. The visual search engine matches images from a large data set provided by the user query image. For a search several visual feature extraction methods have been used. The processing performance of a Content-Based Image Retrieval system (CBIR) depends on the feature representation and visual similarity measures. Descriptors are considered as a method to similarly describe all of the images in a dataset so that they can be compared. Identifying a particular object within an image data has various applications like scene retrieval, location search, and landmark recognition etc. Camera-equipped devices are a popular platform for visual search applications.

Detectors and descriptors have been studied for many years, but their applications on visual search, for large volume, low cost, embedded systems have been less till date. As a contribution to such a process, this work reviews existing methods for CBIR.

KEYWORDS: *Descriptor, Image matching, Camera-equipped device, Image retrieval.*

INTRODUCTION

The worldwide progress on technology revealed that the raise in informational digitization of all kinds, from simplest textual information to very difficult information, like a video or an image. Similarly, system which was storing data are gradually more employed, which result in widespread of database equally for specific and also for general utilization in some of the specialized regions. In contrast, the quantity of information accessible nowadays is very larger and is assessable easily; however, with the database size increase becomes a challenge to detect the information required exactly. In this circumstance, the search engines do a main role accurately and effectively, particularly while apply in professional regions, like in the field of medicine and in industrial areas. Image retrieval, a study region of Information Retrieval [1] is the method of identifying significant image from database which

consists of Text-based (TBIR) and Content-based Image Retrieval (CBIR) techniques. Image retrieval was described by global or local characteristics by considering the visual information. The property of image, like texture, color and form [2], explain the global uniqueness. Although TBIR was easy as well as quick, and very hard to explain image content that is rich manually along with huge error rate. Many systems so far designed with three essential stages in CBIR, i.e. feature selection, similarity matching, and feature extraction [13] [4]. Research performed involves CBIR system which makes use of unique feature or else simply two or more feature merged to extract features by applying various conventional CBIR methods like Edge Detection histogram (EDH).

Models like geometric moment, sobel edge detector and edge histogram descriptor are merged to obtain very important objects in the images that should not

be vary with scaling, changes, orientation and rotation [4]. Researchers developed various traditional models to study the image depend on textual annotations that should maintain the essential matter regarding the image and it should be employed for performing the work. Hence, these explanations are frequently misplaced because of the compressed image or manual error. In addition towards this, because of broad range of annotated image values within various specialized regions, explanation of an ordinary ontology was not consensual at all the time. Various works, take account of various manual annotations of images employing keywords and text search. CBIR was introduced to defeat the problems of TBIR employing manual annotation of images rely on subjective human perception and the time and labor necessities of annotation [14]. CBIR defined the complete procedure of acquiring images automatically that is related to query image obtained from huge compilation depending on their visual content [15] [16]. Particularly, feature illustration of searched image along with query image, as a result of CBIR method incorporated an investigation in the space of feature and thus to recover a ranked image set with respect to similarity (e.g., cosine similarity) to query image depiction. A major problem related with CBIR technique is to take out most important information from raw data in order to remove the so-called semantic gap [17] that results in irrelevant image retrieval [5].

Definition of semantic gap is that differentiation among low-level depiction of image and their concept of high level (perception). Generally, color is defined as an employed visual utility within CBIR as well as studied mainly in many work. The main goal of the work is that individual generally has an affinity to distinguish stimuli by line that is colored [18]. Texture, which is considered as a vital representation of the surface belonging as well as explained with comparison of visual system are very essential in exposing surface-relevant facts like clouds, bricks and tiles. Such developed methods are too appropriate in medical image retrieval. Shape descriptors will not signify the whole image shape, although this descriptor explains shape of exact area of an image. Shapes are also employed for segmentation [19] or contour detection. Many techniques employed for structure descriptors are rotation, scaling, and invariance for translation. Local image uniqueness is

employed in describing as well as in categorizing the nature of object which were extracted from the area of list points. Image retrieval from the datasets has been, by using the visual content, an extremely difficult study area [2]. This gives the attention of researchers, being the most research concentrated on the emergence of big data and on the use of deep learning techniques to improve accuracy, often at the expense of increasing running time [20] [5]. Meanwhile, deep learning to hash methods try to convert high-dimensional media data into compact binary code via a hash function [7]. However, a hybrid method should be employed for effective image retrieval.

LITERATURE REVIEW

The network complexity in this LDVS model is very low, which suggests that the model might have a simple or efficient architecture and the classification error in this model is slightly high, indicating that the model may not perform as well as desired in accurately classifying or recognizing objects [1].

This model is effective at solving nonlinear problems and pattern recognition tasks. It suggests that “Multi-class particle swarm optimization” is capable of handling complex, non-linear optimization problems and can be used for pattern recognition tasks with success, it appears that this model “failed to find the infected areas from the image.” This indicates a limitation in its performance for specific tasks related to identifying infected areas within images [2].

This image retrieval algorithm has “achieved high efficiency in image retrieval.” This suggests that the algorithm is effective at quickly and efficiently retrieving images from a database based on a query or similarity criteria. the “computational complexity of this model was very high.” This indicates that while the algorithm is efficient in image retrieval, it may require significant computational resources or processing time to perform its tasks [3]

This technique “achieved better accuracy for most similar images.” This indicates that the use of multiple features and a Support Vector Machine (SVM) as part of the approach resulted in improved accuracy, particularly when dealing with similar images, the “efficiency was slightly low for individual classes.” This suggests that

while the model may perform well in terms of accuracy, it may require more computational resources or time when classifying images into distinct individual classes [4].

This mode has “achieved high performance in a larger database.” This suggests that the combination of multi-feature extraction and deep neural networks resulted in a high level of performance when dealing with a large database of data, it’s noted that “parameterization in this model directly affected the processing time.” This means that the choice of model parameters has a significant impact on the time it takes for the model to process data. This is common in deep learning models, as hyperparameter tuning can affect computational efficiency [5].

The model has a “dimension of feature vector and feature extraction time” that is low. This suggests that the feature vectors generated by the model are of lower dimension, which can be advantageous in terms of computational efficiency. Additionally, the time required for feature extraction is also minimal, it’s noted that this model “needed many computing resources to perform in a larger dataset.” This indicates that when applied to larger datasets, the model may require a substantial amount of computational resources, including memory and processing power [6].

The “quantization error was very low in this model.” This suggests that the model is capable of generating high-quality hash codes with minimal loss of information during the quantization process, which is important for image retrieval tasks. On the other hand, the “precision rate of this model was low.” This means that the model’s ability to precisely retrieve relevant images may be compromised, possibly due to the hash-based approach used [7]

The “time for image retrieval was very low” in this model. This suggests that the model is highly efficient in terms of the time it takes to retrieve images, which can be a desirable feature in content-based image retrieval (CBIR) systems, it’s noted that this model “failed to integrate convolution network to acquire more enhanced outcomes.” This indicates that the model might not have effectively leveraged convolutional neural networks (CNNs) to improve the quality or accuracy of image retrieval results [8].

Limitations

Sensitivity to Image Variability

Feature extraction methods are often sensitive to variations in lighting, viewpoint, scale, and occlusions. This sensitivity can lead to difficulties in accurately matching features between images.

Scalability

The efficiency and scalability of image retrieval systems can be a challenge, especially when dealing with large image databases. As the size of the database increases, the time and computational resources required for feature extraction and matching can become significant.

Semantic Gap

Feature extraction methods may not always capture high-level semantic information. While they can detect low-level features like edges and textures, understanding complex semantic relationships between objects in images remains a challenge.

Real-time Constraints

Real-time applications, such as image retrieval in video streams or mobile devices, may impose strict constraints on processing time. Feature extraction methods need to be optimized for real-time performance.

Generalization Across Domains

Features extracted from images in one domain may not generalize well to images in a different domain. Adapting feature extraction models to diverse datasets and domains is an ongoing challenge.

Deep Learning Complexity

Deep learning-based feature extraction methods, such as Convolutional Neural Networks (CNNs), are powerful but require substantial computational resources for training and inference. Deploying and running deep learning models on resource-constrained devices can be challenging.

Robustness to Noisy Data

Feature extraction may be sensitive to noise or irrelevant details in images. Robustness to variations in image quality, artifacts, or irrelevant information is an important consideration.

Interpretability

Some advanced feature extraction methods, especially deep learning models, are often considered as “black boxes,” making it challenging to interpret how and why certain features are being extracted.

Performance Comparison

This survey additionally provides a performance assessment for cutting-edge image retrieval methods based on deep learning. In a collection of studies and datasets, various methods were applied for different tasks, resulting in a range of accuracy, precision, and recall percentages. Notable approaches included the ‘Learnable binary local descriptor (LDVS)’ applied to the HPATCHES Dataset, achieving a precision of 37.05 % [1]. For image retrieval, ‘Multi-class particle swarm optimization’ on the CORAL Dataset delivered high accuracy rates, particularly with SVM achieving 96.9% [2]. An image retrieval algorithm applied to the Image Library Dataset achieved an 83% recall rate [3]. Support Vector Machine (SVM) on the Wang database obtained an accuracy of 88.2% and a precision of 73% [4]. ‘Combined Multiple Features’ applied to the Global Brand Database demonstrated high precision at 93.7% [5]. A U-Net-based neural network on Corel datasets achieved accuracy ranging from 81.01% to 93.1% with corresponding precision percentages [6]. ‘Deep hash with improved dual attention for image retrieval (DHIDA)’ algorithm yielded precision percentages ranging from 72.40% to 82.13% across different datasets [7], while ‘CBIR-similarity measure via artificial neural network interpolation (CBIR-SMANN)’ obtained an 88% accuracy, 82% precision, and 78% recall, with a retrieval time of 980 ms when applied to various datasets [8].

Upon analyzing the U-Net-based architecture, it achieved an impressive accuracy of 93.1% and a recall rate of 87.23% when tested on the Coreal 1K dataset. However, it is worth noting that this model requires substantial computing resources to perform well on larger datasets [6]. Additionally, the precision rate on the Global Brand Database reached an impressive 93.7%. Nonetheless, it’s essential to highlight that adjusting the parameters of this model had a direct impact on processing time [5]. Table 1 shows the Mean mAP values achieved by various image retrieval approaches

on different dataset and Fig. 1 show average precision rates for different retrieval size of the various dataset.

Table 1: The Mean mAP values achieved by various image retrieval approaches on different dataset

Author	Dataset	Precision %
Migliorati, A., et al. [1]	HPATCHES Dataset	37.05
Garg, M. and Dhiman, G., [2]	CORAL Dataset	54.5
Desai, P., et al. [4]	Wang database	73
Jardim, S., et al. [5]	Global Brand Database	93.7
Kumar, S., et al. [6]	Corel 1K and Corel 5K dataset	91.77 84.75
Yang, W., et al. [7]	CIFAR-10, NUS-WIDE and ImageNet-100 Dataset	72.40 80.21 82.13
Ahmad, F., [8]	Collecting datasets	82

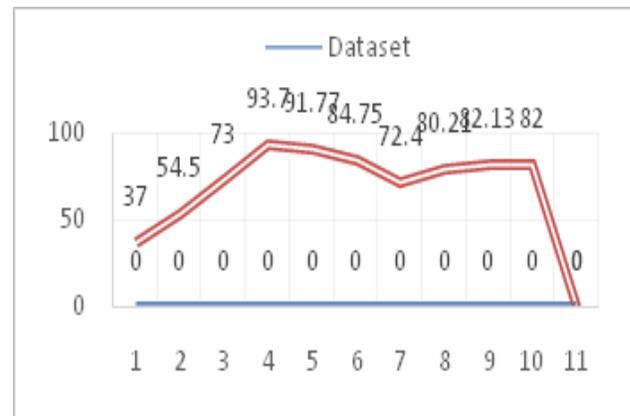


Fig. 1. Average precision rates for different retrieval size of the various dataset

Upon analysing the U-Net-based architecture, it achieved an impressive accuracy of 93.1% and a recall rate of 87.23% when tested on the Coreal 1K dataset. However, it is worth noting that this model requires substantial computing resources to perform well on larger datasets [6]. Additionally, the precision rate on the Global Brand Database reached an impressive 93.7%. Nonetheless, it’s essential to highlight that adjusting the parameters of this model had a direct impact on processing time [5].

Challenges

The challenges faced by existing techniques that are collected based on image retrieval are described as follows.

- ❖ In [1], LDVS achieved effective pair-wise image matching although; it was not able to preserve the spatial detail of the textures due to the low-resolution feature maps.
- ❖ Image retrieval algorithm developed in [3] had the ability to be convenient in image retrieval, but it failed in shape-based retrieval because the extraction, description, and matching of shapes were very difficult.
- ❖ In [4], SVM achieved high classification accuracy. However, it failed to perform in larger databases owing to affect the efficiency.
- ❖ Multi feature extraction and deep networks introduced in [5] incorporated a parallel processing block and it effectively performed with multi-image search scenario even though, relevance feedback stage was absent to specify relevant and irrelevant retrieved images.
- ❖ Image retrieval is defined as recovering appropriate image from a huge database. However, the challenging problem is how to learn discriminative, compact, local descriptors, and how to possibly integrate them in the given framework.

SCOPE

Image retrieval using feature extraction continues to be a vibrant and evolving field with ongoing research. The integration of machine learning techniques, including deep learning, and advancements in hardware capabilities are expanding the scope of what can be achieved.

CONCLUSION

The most important intention of this research is to build up a hybrid DL based image retrieval system using feature extraction. Primarily, the input is preprocessed using Gaussian filter and then the process of object segmentation is done to segment the object from the preprocessed image using CentroidNetV2-FRCNN. After that, the process of feature extraction is carried

out to extract important features from image using SURF. Similarly, for the query image, the steps like preprocessing is done using Gaussian filter then the object segmentation is done using CentroidNetV2-FRCNN and feature extraction is performed using SURF. Thereafter, indexing is performed by merging the output of both input and query image using the metric named soergal. Finally, image retrieval is done in the indexed output. This DL enabled hybrid technique achieved low computational time and high accuracy; recall, f measure and precision.

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Review of Soft Computing Approach to Examine the Effect of the Feed Temperature on the Steady-state Temperature in the Reactor

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ABSTRACT

A chemical reactor is typically the most significant unit operation in a chemical process. In order to maintain a steady state temperature in a chemical reactor, energy must either be withdrawn from the reactor or added because chemical reactions are either exothermic (release energy) or endothermic (need energy input). For design of controllers for regulating the concentration of a continuous stirred tank reactor (CSTR), it is needed to take into account rate constant in a reaction. It is needed to examine the effect of the feed temperature and the jacket temperature on the steady state concentration and temperature in the reactor. It is important to actually worry about the dependence of steady state values of the temperature on feed temperature and jacket temperature for controlling these parameters. The space velocity is also important to be considered. Steady state concentration and temperature in the reactor can be calculated by solving the mass balance and energy balance equations. These equations are simultaneous algebraic, nonlinear coupled equations. These equations can be solved by using the `fsolve` function in MATLAB by providing appropriate guess values. Given the Feed temperature and jacket fluid temperature, the effect of these two quantities is to be calculated. So it is required to know - How does the temperature inside the reactor change as the jacket temperature or feed temperature is varied. The comparison of trend of steady state reactor temperature to change in feed temperature for different parameter sets has been done. Multiplicity of steady state will not exist all the time in every case. It exists for a particular parameter sets.

KEYWORDS: *Coupled equations, Steady state reactor.*

INTRODUCTION

The most significant unit operation in a chemical process is generally a chemical reactor. Chemical reactions are either exothermic or endothermic and therefore require that energy either be removed or added to the reactor for a constant steady state temperature to be maintained. Exothermic reaction systems typically have potential safety concerns like: the possibility of unexpected behavior, such as multiple steady-states (where the output variable may have multiple possible values for a given input variable value), and rapid temperature increases, also known as ignition behavior.

In this paper perfectly mixed, continuously stirred tank reactor (CSTR), as shown in figure 1 is considered.

Depending on the temperature and concentration that is to be maintained in the reactor, the steam load is to be determined. Because of the process conditions, it is needed to determine the set point of reactor temperature and concentration. Corresponding to that temperature and concentration in the reactor following parameters need to be controlled by the control system

- Flow rate of the feed fluid
- Flow rate of the jacket fluid
- Temperature of the feed fluid
- Temperature of the jacket fluid

The case of a single, first-order exothermic irreversible

reaction $A \rightarrow B$, is studied.

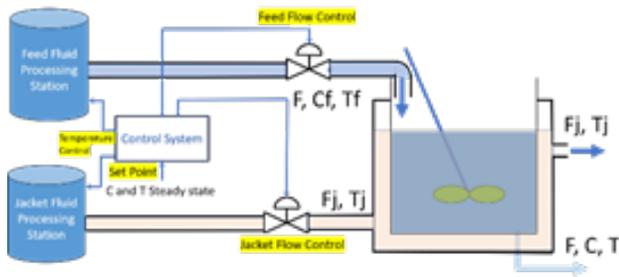


Figure 1: Schematic diagram of CSTR

In figure 1, It is evident that the reactor is continuously supplied with one fluid stream and continuously being emptied of another. Given that the reactor is perfectly combined, the outflow stream's concentration is the same, and as the fluid in the reactor. Jacket that surrounds the reactor with feed and exit streams as well. It is believed that the jacket be precisely blended while being cooled down from the reactor's temperature. Energy then passes through the reactor walls into the jacket, removing the heat generated by reaction [1]. Figure 1, illustrates a CSTR where an irreversible exothermic reaction $A \rightarrow B$, occurs. The coolant medium removes the heat from the process by passing through a jacket surrounding the reactor [2]. In this work, a soft computing approach is reviewed, discussed and simulation results have been presented.

PRELIMINARIES

When designing controllers to regulate the concentration in a continuous stirred tank reactor, the rate constant of the reaction must be taken into account. The reference [5] examines a series reaction where $A \rightarrow B \rightarrow C$. Regarding the concentration of species, A, the reaction $A \rightarrow B$ has a rate constant of k_1 , making it a first-order reaction. Similarly, the reaction $B \rightarrow C$ has a rate constant of k_2 , making it a second-order reaction concerning the concentration of species B. In this paper [5], the dynamics of the CSTR is thoroughly examined.

An Overview of CSTR

The system is a jacketed CSTR. It is equipped with heating or cooling jacket. CSTR is equipped with a stirrer. In an ideal CSTR it is assumed that there is perfect mixing and no gradient in concentration of reaction volume. With time, temperature of reaction

mixture may change. For an endothermic reaction temperature will be falling down and for exothermic reaction temperature will be increasing. The temperature is need to be maintained constant. The transients in the system are neglected. So, control system is required to maintain the system variables. At steady state these system variables should not change. Before the steady state is reached, the system would be dynamic in nature. During shut down phase also transient and dynamic behaviors of system is encountered. In a CSTR there is an inflow and outflow, so mass flow is there. Regarding energy exchange, that is input of energy and removal of energy. Exchange of energy is carried out via a convection processes.

Inlets have reactants, outlets have products and unreacted reactants. F is the inlet reactant flow rate and outlet product flow rate. As far as a steady state operation with respect to flow of mass is concerned, the system is already at steady state with respect to flow of mass is concerned. The overall mass within the system is not changing with time. Inside the tank, concentration is C . V is the volume of the reaction mixture. r is the rate of reaction. There are quantities associated with the jacket. The purpose of the jacket primarily is for heat transfer. The flow is in a steady state so inlet and outlet flow rates are the same.

Δh is the heat of reaction. Its sign depends on whether the reaction is endothermic or exothermic. It's again important to know the magnitude of heat of reaction because it is going to change the temperature of a reaction mixture. For endothermic [Large Δh] there is a large drop in the temperature so steam needs to be provided.

Mass Balance and Energy Balance Equation

There are two balance equations

- Mass balance

$$\frac{F}{V}(C_f - C) - r = 0 \quad (1)$$

$$r = K_0 e^{\left(\frac{-\Delta E}{RT}\right)} C_s \quad (2)$$

Time rate of inflow of the species is given by $(F/V) \cdot C_f$ and the outflow is given by $(F/V) \cdot C$. The difference is the time rate of change of concentration of species in the reaction mixture specifically due to reaction. At

steady state, these two need to balance out. There will be an additional dynamical term at the right side if a system is transient. Here it is considered that the system is at steady state. The Inflow to the reactor contains some reactants. The concentration of species in the feed is given as C_f and at the outlet, the concentration is C . The concentration at the outlet C is not equal to the concentration at the feed/inlet. If the concentration is changing, it is happening in the reaction chamber.

- Energy balance

$$\frac{F}{V}(T_f - T) + \left(\frac{-\Delta H}{\rho C_p}\right)r - \frac{VA}{V\rho C_p}(T - T_j) = 0 \quad (3)$$

Here there are three terms. Mass which is coming in, is bringing energy into the system. The energy exchange is the heat transfer or heat exchange that takes place between the jacket fluid and reaction mixture contents. The quantification of this energy certainly depends on the difference between jacket temperature and mixture temperature. Second term has the Heat transfer coefficient and the area of heat transfer is there.

Sign of the ΔH depends on two things-

What is the rate of reaction? And What is the magnitude of energy of reaction? Larger energy of reaction will take large energy. These equations are certainly not differential equations. These equations need to be solved for T and C . These are nonlinear algebraic equations.

If the equations are not coupled, then the single equation can be solved by itself. The rate of reaction r in equation (1), is a function of concentration as shown in equation (2). But the rate of reaction is also a function of temperature. Therefore, the first equation is not implicit. Here equations are simultaneous algebraic, nonlinear coupled equations.

SOFT COMPUTING

Palanki et. al. has provided an explanation of a software module for a regulation problem in a continuous stirred tank reactor through an Internet-mediated virtual laboratory in reference [5]. Soukkou et. al. designed the feedback loops for an exothermic continuous stirred tank reactor system using the fuzzy optimal control methodology [6]. The author offered a fresh approach to creating a fuzzy optimal controller with a smaller rule base. It is suggested to use the genetic learning

algorithm to build a reliable fuzzy controller. The study and calculations of steady state values is important for controller design and parameter settings. It is possible to significantly reduce the average calculation time using Globally Linearizing Control (GLC) without sacrificing closed loop performance [7].

Table 1: The parameter sets for simulation [2][3][4]

Parameter, Unit	Case 1	Case 2	Case 3	Case 4
$F/V, h^{-1}$	1	1	1	1
k, s^{-1}	14825	9703	18194	3122
$-\Delta H, kcal/kmol$	5215	5960	8195	30000
$E, kcal/kmol$	11843	11843	11843	30000
$\rho C_p, kcal/(m^3 C)$	500	500	500	500
T_f, C	25	25	25	21
$C_{Af}, kmol/m^3$	10	10	10	10
$UA/V, kcal/(m^3 Ch)$	250	150	750	150
T_j, C	25	25	25	25

Mathematical approach using fsolve

There are two methods to find the temperature variation of a steady-state reactor with respect to the feed or jacket temperatures. One method is to create the curve connecting the reactor temperature to feed temperature or jacket temperature by solving the nonlinear algebraic (steady-state) equations for a wide range of jacket temperatures. Two equations can be solved using the fsolve function in MATLAB. Initial guess is substituted for $f(x)=0$. In bisection method, another guess is invoked. But if the actual solution is between $f(x_1)$ and $f(x_2)$ and the solutions of x_1 and x_2 are +ve and -ve, the bracketing of the solution can be done by taking a new guess of arithmetic average of these two.

When the same thing is to be implemented for the two variables, then one variable may be close and other may be farther to the solution. Therefore, there is a need to do some optimization. Fsolve is doing the same. Fsolve is invoking the optimization. It is trying to minimize the sum of squares of errors of all of these variables by using an algorithm function. Prominently, recently nature inspired optimization techniques like hybridized grey wolf optimizer and artificial bee colony algorithms (GWO-ABC) are utilized for solving the high-dimensional constrained optimization problems [13]. In paper [14], the goal is to minimize the integral time absolute error (ITAE) in order to identify the optimal

parameters of the FO-FPID controller. In one variable or one dimension, only one variable is solved for $f(x)=0$.

To solve this coupled nonlinear problem in higher dimensions using fsolve, an initial guess needs to be provided. It is possible that there is not a unique solution. Fsolve is a local optimizer. If there are multiple solutions, then the initial guess needs to be close to the one specific solution that is interest in. When this adiabatic operation is done, there are multiple steady states. Pseudo code/Algorithm for this method is explained in the algorithm 1.

Alternative Mathematical Approach

There is another simpler way, first equation is the mass balance equation, C_f the feed concentration which is constant. The concentration as a function of reactor temperature can be readily solved. Compute the jacket temperature or feed temperature directly to determine the necessary temperature for a given reactor temperature. Then simply plot reactor temperature versus jacket temperature and reactor temperature versus feed temperature. Steady-state concentration for a steady state reactor temperature T_s , can be calculated from the material balance equation for reactant A:

$$C_{AS} = \frac{\frac{F}{V}(C_{Afs})}{(\frac{F}{V}) + k_0 e^{\frac{-\Delta E}{RT_s}}} \tag{4}$$

From the steady state temperature solution, $(dT/dt=0)$ solve for steady state jacket temperature T_{CS} .

$$T_{CS} = T_s + \frac{[F\rho C_p(T_s - T_{fs}) - (-\Delta H)Vk_0 e^{\frac{-\Delta E}{RT_s}}] C_{AS}}{UA} \tag{5}$$

If the temperature in the reactor is known, then all of the parameter values can be substituted in equation (1) to get the steady state concentration in the reactor. Fix the steady state temperature in the reactor and determine the steady state concentration in the reactor from the mass balance equation. This set of information is good enough to solve the energy balance equation to determine feed temperature T_f . Energy balance equation is rearranged to get the T_f on the left side, that is T_f is expressed in terms of the other variables and quantities.

$$T_{fs} = T_s + \frac{UA(T_s - T_{Cs}) - (-\Delta H)Vk_0 e^{\frac{-\Delta E}{RT_s}} C_{AS}}{F\rho C_p} \tag{6}$$

Pseudo code/Algorithm for the Program

Algorithm for the mathematical approach using fsolve has been shown in algorithm 1.

Algorithm 1: Procedure for solving simultaneous algebraic, nonlinear coupled equations using fsolve	
Input: Guesses and Parameter values	
Output: Steady state Concentration and Temperature	
1.	Define global variables for system parameters so that a single copy of the same variable can be shared by all functions
2.	Define guess for steady state concentration and steady state temperature.
3.	Fix value for feed temperature and solve for C steady state and T steady state
4.	Invoke fsolve function to solve the algebraic nonlinear coupled equations
5.	Iteratively determine the corresponding steady state temperature and plot.

The mass balance equation would give the steady state concentration and the energy balance equation will give the steady state temperature. Global variables are defined for system parameters so that a single copy of the same variable can be shared by all functions. Guess value for the fsolve is defined in the wide range of concentration and temperature. So assume/fix a value for feed temperature and solve for C steady state and T steady state. Change the feed temperature and correspondingly determine the quantities. This can be done over and again to determine the variation. The values for $C_{Asolved}$ and T_{solved} for all the values of feed temperature are stored for plotting. This is a conventional approach to set the jacket temperature and iteratively determine the corresponding steady state temperature and steady state concentration in the reactor.

Algorithm for alternative mathematical approach has been shown in algorithm 2.

Algorithm 2: Alternative approach to Solve for concentration as a function of reactor temperature and get feed temperature	
Input: Parameter values	
Output: Steady state Temperature	
1.	Define global variables for system parameters so that a single copy of the same variable can be shared by all functions

2.	Fix the steady state temperature in the reactor and determine the steady state concentration in the reactor from the mass balance equation.
3.	Discretize the steady state temperature in the reactor between 300 K to 400 K. Corresponding steady state feed temperature is determined
4.	This value of feed temperature which is defined as T_{fss} is used for plotting. To analyze the effect of feed temperature on the reactor temperature. Feed temperature is taken along the X-axis and reactor temperature on the Y-axis.

If the value of concentration in the reactor is known, then that can be substituted along with the other relevant system parameters to obtain the steady state temperature in the reactor. In the first equation if the value of steady state temperature is substituted, then steady state concentration can be obtained. These equations can be rearranged such that to determine the jacket temperature as a function of steady state concentration and steady state temperature in the reactor. So, the problem is inverted here.

If this concentration and this temperature is required in the reactor, then what should be the feed temperature? If the steam load is to be determined, then because of the process conditions, it is needed to determine the temperature and concentration that is to be maintained in the reactor that is the set point of reactor temperature and concentration. Corresponding to that temperature and concentration in the reactor following parameters need to be controlled.

- Flow rate of the jacket fluid
- Temperature of the jacket fluid

This is an inverse problem. After solving the problem this way, the effect of feed temperature and jacket temperature on the steady state value can be calculated. The function over here has a one-to-one correspondence between an input and output, so it can be basically conceived as a tabulated set of pairs. If one set of values is known, the corresponding set of values can be plotted and the trend of the function can be determined. The MATLAB program for the same is shown in figure 2.

```

1- clc
2- clear
3- close all
4- global h0 h_rxn rhocp UA_by_V E R F_by_V Caf Tj
5- % parameter set 1
6- F_by_V=1; h0=14825*3600; h_rxn=5215; E=11843; rhocp=500;
7- Caf=10; UA_by_V=250; Tj=25+2T; h =1.98;
8- T_reactor= [300:1:400];
9- Tfss = ctr_curve2(T_reactor);
10- plot(Tfss,T_reactor,'linewidth',3,'color','k')
11- % plot(Tfss,T_reactor,'linewidth',2)
12- set(gcf,'FontSize',16)
13- print('lab02_figure01.png','-dpg','-r300')
14- xlabel('T_f (K)')
15- ylabel('T (K)')
16- % Function to calculate i/o curve..
17- function Tfss = ctr_curve2(Temp_vec)
18- global h0 h_rxn rhocp UA_by_V E R F_by_V Caf Tj
19- for i=1:length(Temp_vec)
20-     T = Temp_vec(i);
21-     k=k0*exp(-E./(R.*T)); krate=k*Caf;
22-     Ca= F_by_V*Caf/(F_by_V+k);
23-     rate = k*Ca;
24-     %term1=F_by_V*(Tf-T);
25-     term2= rate*h_rxn/rhocp;
26-     term3= (UA_by_V/rhocp)*(T-Tj);
27-     % when Tj is held constant, Tf can be calculated
28-     Tfss(i)= T +(term3 -term2)/(F_by_V);
29- end
30- end

```

Figure 02: MATLAB program to find steady state feed temperature

DISCUSSION AND SIMULATION RESULTS

When the operating level of the continuous stirred tank reactor (CSTR) varies, it often exhibits unstable severe nonlinear behavior. The hard non-linearity of the CSTR comes from multiple likely sets of states for the same reaction under the same CSTR and continuous inlet conditions, as was previously studied [8]. Within a portion of its operating window, an exothermic reaction carried out in an adiabatic continuous stirred tank reactor (CSTR) system has multiple steady states. The author showed that both a one-state and a two-state model can accurately approximate the three-state model that represents the mass and energy balances of the system [9]. Control system designers must increasingly use controller design techniques that account for the system nonlinearity in an adequate/satisfactory manner due to stringent environmental regulations and high-performance requirements [10]. Variable loads and disturbances, along with various forms of uncertainty, accompany complex systems. Strong resistance to these deviations is required to design a controller as mentioned in [15]. The plant model that links the reactor and jacket temperatures with a measurement

delay is of the second order unstable type when a first order irreversible exothermic reaction occurs in CSTR. Controlling such plants is extremely difficult [11]. In the paper [12], a method for the continuous preparation of Atrz by CSTR is described, and the differences between Atrz production by batch equipment and CSTR were examined. When compared to batch reactors, CSTR synthesis of Atrz has advantages.

To analyze the effect of feed temperature on the reactor temperature, feed temperature is taken along the X-axis and reactor temperature on the Y-axis. Figure 3, 4, 5 and 6 shows the trend of effect of feed temperature on the steady state temperature for parameter set case 1, case 2, case 3 and case 4 of table 1 respectively.

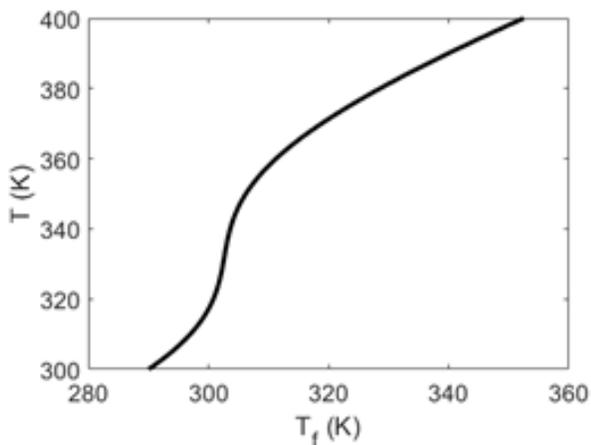


Figure 3: Steady state reactor temperature for parameter set 01

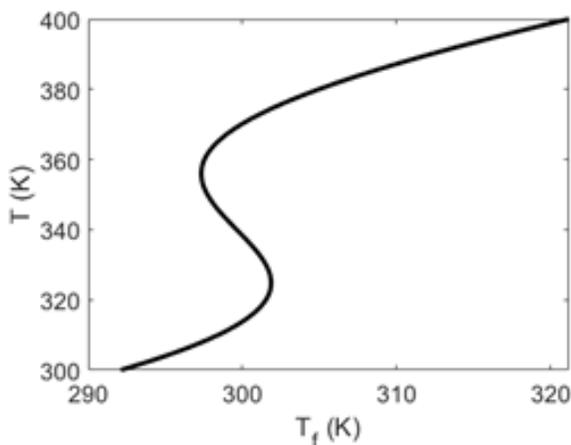


Figure 04: Steady state reactor temperature for parameter set 02

By comparing the figure 3 and figure 4, it can be observed that the reactor temperature is larger in case of parameter set case 2. The reactor temperature is 370 K for the feed temperature 320 K in the case of parameter set Case 1. Whereas for the same feed temperature of 320 K, the steady state temperature is 400 K in the set case 2.

From the figure 3, for every value of feed temperature there is a single one value of steady state temperature. For parameter set case 2, in figure 4, on the extreme right for one value of feed temperature there is corresponding one high value of steady state reactor temperature. On the extreme left, one low value of steady state reactor temperature. For the region in between 295 K to 303 K, in this narrow range of temperature, multiple steady states are shown. This means that the same value of feed temperature, there exists multiple values of steady state reactor temperatures. It is possible to have multiple steady states for a given feed temperature.

While running the reactor, for example at 300 K feed temperature, there are three steady state temperatures. But the temperature measuring sensor will indicate only one value on the display. That one value will be one of these three values 310 K. Why the other two values, 340 K and 365 K are not displayed? If something is changed in the system, do these values are indicated on the temperature measuring sensor? As the feed temperature is increased from 292 K to 298 K, the display of reactor temperature keeps on increasing. Actually, the display moves along the lower curve of this S or sigmoidal curve. When it goes beyond 302 K, as per graph it should display 370 K. When the feed temperature has been increased from 290 K to 320 K, at 302 K, the reactor steady state temperature suddenly shows 370 K. Means the steady state value in the increasing feed temperature the solution lies on the higher leg of S curve. Then if the feed temperature is reduced from 320 K to 300 K, 370 K will be displayed on the display. 340 K will never be observed, because the system is unstable in this middle region. During the lower portion of the curve and upper portion of the curve the system is stable. This stability analysis can be done based state space form and on the eigenvalue.

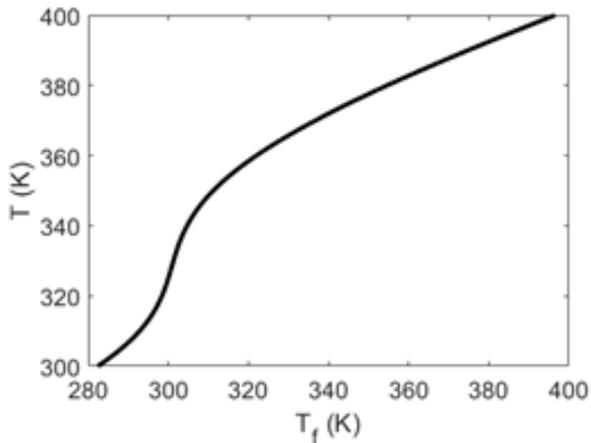


Figure 05: Steady state reactor temperature for parameter set 03

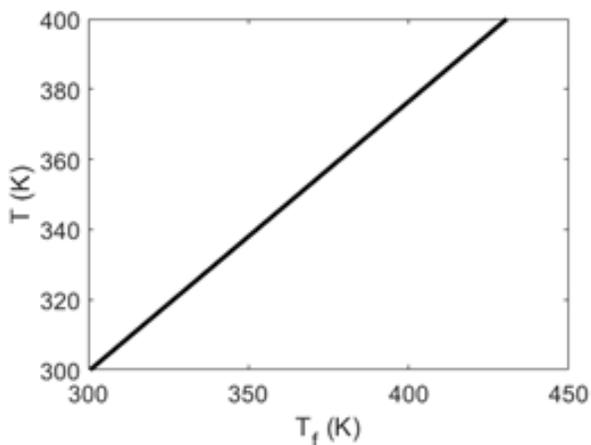


Figure 06: Steady state reactor temperature for parameter set 04

CONCLUSION

While the reactor has been designed, mass balance and energy balance analysis is done. The solution of analysis concluded that if a particular value of steady state temperature and concentration in the reactor is to be set, then the feed temperature, Feed rate, Jacket fluid temperature, Jacket flow rate are need to be controlled. When these equations are solved, it is expected that only one value of the temperature in the reactor will be calculated. In this paper, a steady state concentration and temperature values are calculated for different sets of CSTR conditions. Instead of getting steady state temperature from jacket temperature, a method is

reviewed and discussed to determine feed temperature, given the value of temperature inside the reactor and corresponding concentration in the reactor. The initial state of the system matter. From only parameter set case 2, it might have concluded that the multiplicity of steady state exists all the time in each case. However, that is not true. It is true, only for parameter set case 2. If certain values in parameter set 2 are changed, the plot shown in figure 3, 5 and 6 having one to one correspondence between the feed temperature and steady state reactor temperature are attained.

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Industrial Congenital Faults and Analysis in Statistical Process Monitoring: A Short Review

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ABSTRACT

In statistical process monitoring, fault analysis at various stages of industrial process is critically important. The faults can be occurred at feedback sensor level or initial stage of controller. In view of reliability and safety in modern sophisticated systems, faults analysis and its diagnosis are necessary to avoid unaccountable losses. The faults at various stages, its causes, methods of detection and diagnosis, fault classifications are included in this work. The comment on effectiveness methods of detection of fault and diagnosis are included for statistical process monitoring. In the process industries, systems are incorporated with monitoring capacity for detection of faults at easy stage. This paper mainly focused on advancements in fault detection and diagnosis (FDD) methods with short review of various methods. This includes system information representation, acquisition of data, signal and/or image processing, fault classification, and decision actions related to maintenance, providing a systematic overview of the current state of FDD. Furthermore, the paper underscores the pivotal roles of FDD in industrial processes, emphasizing its effectiveness in identifying faulty states and taking preemptive actions against potential failures or accidents. The discussion extends to developments of current research in FDD approaches for process monitoring, accompanied by short review of diverse and valuable FDD methodologies. The paper concludes by addressing future research trends, challenges, and prospective solutions in the dynamic landscape of fault and FDD.

KEYWORDS: *Fault types, Classification, Fault detection and diagnosis (FDD), Industrial process monitoring.*

INTRODUCTION

In the era of Industry 4.0, processes are evolving smart systems these are well equipped with advanced sensors to collect process-related data for fault detection and process monitoring. As industries embrace full automation, meticulous supervision, involving process maintenance, control and corrective actions, becomes imperative to ensure operational efficiency [1–3]. Maintaining optimal performance in industrial processes, often susceptible to various faults, is a key challenge. Among the array of FDD in process supervision techniques, is important issue of control methodology. Industries seek to enhance their process performance by leveraging advanced FDD capabilities, which primarily involve monitoring process behavior and uncovering faults, their characteristics, and root causes

[4–6]. Efficient and accurate detection and diagnosis tools are crucial for sustaining high process yield and throughput. FDD has garnered substantial attention across diverse industrial sectors and academia over several decades, offering benefits such as cost reduction, improved quality, and enhanced productivity [7]. This is particularly evident in safety-critical applications like robotics, autonomous vehicles, surveillance, and manufacturing systems, where FDD plays a pivotal role in ensuring human safety and preventing infrastructure loss. Modern systems and equipment demand the integration of FDD not only for safety but also for increased production and reliable operation. A robust FDD system, as highlighted in recent research, encompasses overall system health monitoring, diverse malfunction handling, and precise fault identification

and localization for safe component removal. Over the past three decades, extensive work has been conducted on FDD, resulting in various techniques. These range from approaches of model based such as structural graphs and observer-based to approaches of data-driven employing classification, pattern recognition, and neural networks. Model-based FDD relies on accurate mathematical models, making it suitable for smaller systems with explicit models but susceptible to disturbances and uncertainties. In contrast, method of data-driven extract information from predicted signals to predict faults, with approaches of signal-based divided into statistical methods. The advent of technology has brought intelligent systems to the forefront, posing challenges in developing knowledge bases from raw historic data. The representation of knowledge based includes explicit knowledge through production rules or expert systems and implicit knowledge in machine learning classifiers. Earlier reviews, have focused on model-based or data-driven FDD techniques, spectral approaches, and deep learning. This review provides a comprehensive overview, encompassing both traditional and signal processing-based FDD approaches, with a specific emphasis on artificial intelligence-based methods. Covering the fundamental elements of equipment FDD systems and prevalent techniques, this article contributes valuable insights to the FDD field. Challenges in real-time datasets includes the presence of outliers, which are often detected using unsupervised methods. Semi-supervised learning methods leverage both labelled and unlabelled data, providing a better choice.

Data-driven FDD methods have gained significant attention across diverse industries, playing a pivotal role in monitoring of complex industrial process. The effectiveness of these approaches relies on the quality of historical data and the analytical models employed [8].

While various data-driven FDD methods exist, PCA-based and PLS-based approaches stand out for their simplicity and efficiency in detecting and diagnosing process faults. In literature of data-driven methodologies, it has been focused on PLS-based and PCA-based monitoring of process schemes. Many academicians have addressed modifications necessary for successful

implementation and proposed an integrated adaptive residual generation technique to address uncertainty issues.

The control techniques of fault-tolerant and data driven based FDD methods have been developed by Wang et al. [9], discussing their advances and general developments. In the work, researcher presented application example and outlined direction of research work, highlighting issues of FDD [10]. It is details by the Yin et. al[10] that data driven process was fundamental monitoring and diagnosis of faults including PLS, PCA, ICA and FDA. The study covered characteristics, computational complexities, design, and algorithms of these data-driven methods. In another work of Qin [11] provided data driven approaches and applications. In the study of it has been discussed the modelling on the basis of latent variable and fault detection work which are approaches for diagnosis and identification.

This paper includes types of faults in various stages of industrial systems in section II while section III contains fault classifications and various types of fault detection and diagnosis methods which are based on data driven concepts. Section IV includes model-based fault detection and diagnosis methods and concluding remarks in section V.

CATEGORIZATION OF FAULTS

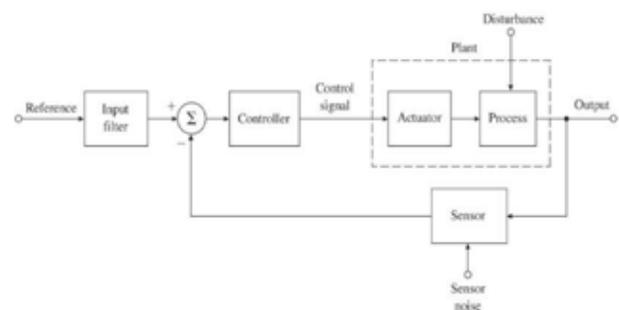


Fig. 1. General block diagram of industrial process control

Beyond system representation and redundancy, the selection of an appropriate Fault Detection and Diagnosis (FDD) system is heavily influenced by the nature of faults. A primary classification categorizes faults into software, hardware, communication and networking faults. Hardware faults encompass sensor, actuator, plant/process, and structural faults. Software faults include bit-flips, subroutine execution failures,

runtime issues, and other software malfunctions. Networking and communication faults involve protocol incompatibility, packet transmission failures, and non-recoverable data packets. The general block diagram of industrial process control system is shown in Fig. 1.

There are types of faults and malfunctions which are based on industrial systems and described below in short

Sensor Category

In sensor category, there are faulty components due to current/voltage sensor, speed, position sensor, absolute encoder type sensors or in general the fault components because of sensors which are used in industrial systems. The fault descriptions may include one or more reasons such as additive and/or multiplicative fault, abrupt voltage, power failure dropout, encoder fault, open circuit fault, multiple hard and soft failures and so on.

Actuator or final control element category

This category can be based on electrical, mechanical or hydraulic or pneumatic elements. Faults can be because of armature and field winding, fault in stator winding, defect in insulation, rotor and bearing faults, rotor axis misalignment, gear box defects, fault in electro-hydrostatic aerospace actuators. The description of actuators can be found by means of drift, open and short circuit faults, magnetic fields degradation associated with windings. There can be loss of effectiveness of actuators, defects in inner-race, outer-race and ball damage, less lubrication, excessive wear of bearing and problem in rotor axis. Also, mechanical imbalance of rotor and broken motor bar are causes of faults. Friction and leakage losses are also said to be cause of regular faults in case of mechanical systems.

Controller or Control action category

Any faulty controller output, electronic throttle controller and electric power steering controller included in this category. Fault description of controller response is partial loss of control effectiveness, degradation of throttle damping and return spring and friction loss prognosis.

Another classification focuses on the dynamics and nature of faults, distinguishing between permanent, transient, incipient and intermittent faults. Transient

faults arise from sudden changes within the system and can be disappear after some time. Permanent faults cause lasting damage, requiring repair or replacement. Intermittent faults cycle between active and inactive states, while incipient faults exhibit gradual changes in the state of faulty component variables.

This comprehensive categorization aids in understanding and addressing various types of faults and malfunctions that may impact industrial systems.

Plant/Process category

The faulty components under the category of plant/process includes engine, part of plant, intelligent in automatic wind turbine, robotic manipulator, centrifugal pump malfunction, chemical/petrochemical plant or any specific units etc. The fault description includes various reasons such as misconduct of diagnosis in engine, leakage in tank, disengagement in DC motor, mechanical and electrical motor faults, transducers, final control elements and faults in torque converter additive magnitude joint faults, bearing defects, open and short circuit faults, duct and damper leaking fan and sensor failures.

Software and hardware category

The faults may be bitflips, execution failure in routine functioning, faults of structural functioning in network, faults in communication network. The bitflips can cause detection and correction of mainly leading faults as well as dependent faults, error-probe and fault prone attributes. The network part is due to network faults on chip switches. The faulty nodes in source to destination transmission leads to communication faults which can be main reason to loss of signal or information.

FAULT CLASSIFICATION AND DATA DRIVEN BASED FAULT DETECTION METHODS

Following system representation and redundancy considerations, the next crucial factor in selecting appropriate Fault Detection and Diagnosis (FDD) systems is the categorization of faults. A common classification divides faults into hardware, software, networking, and communication faults. Hardware faults encompass sensor, actuator, plant/process, and structural faults. Software faults include bit-flips, sub-routine

execution failures, runtime issues, and other software malfunctions. Networking and communication faults involve protocol incompatibility, packet transmission failures, and non-recoverable data packets. The data driven based FDD methods are summarized below with short information.

Principal Component Analysis (PCA) Based FDD Methods

In case of highly complex industrial processes, the fault which is unknown can be detected by means of PCA based methods [12,13]. The general PCA models can be extended to get dynamic PCA (DPCA). In industrial process, methods based on approaches of data driven reconstruction techniques have been contributed for FDD [14]. In another contribution Choi et al. [15] has been presented a nonlinear fault diagnosis indices (FDI) based on the techniques of KPCA for nonlinear chemical processes, showcasing the combined fault detection statistic and confidence limits for fault detection. Sun et al. [16] introduced a new PCA-based FDD approach to improve incipient faults detectability and minimization of false alarms simultaneously. The text explores various PCA-based FDD methods, addressing challenges, proposing novel approaches, and discussing applications in different industrial processes. Overall, it provides a comprehensive overview of data-driven approaches for FDD, offering insights into their applications and advancements. Independent Component Analysis (ICA) offers an alternative approach to FDD compared to PCA and Kernel PCA (KPCA). While PCA-based methods focus on extracting fault information and reducing dimensions, they may struggle with identifying nonlinear or complex linear relationships among process variables, assuming a Gaussian distribution.

FDD methods based on ICA technique

ICA-based FDD methods prove valuable for handling nonlinear process behaviors. An approach of hybrid fault detection named Canonical Variate (CV-ICA), combining CV information for deriving CV and ICA for obtaining independent components (ICs). Another innovative method, Kernel Dynamic ICA (KDICA), specifically applied for industrial processes with nonlinear and non-Gaussian characteristics. KDICA employs ICA, kernel methods for characteristics or

dynamic extraction, and identification method like auto-regressive (AR) models for considering process dynamics. Nonlinear contribution plots aid in fault diagnosis.

In addressing non-Gaussian process monitoring, Modified ICA (MICA), termed Double-Layer Ensemble Monitoring Method (DEMICA). DEMICA incorporates multiple models (MICA) as an ensemble and employs monitoring indices by means of double-layer Bayesian inference.

Canonical Variate Analysis (CVA) based FDD methods

CVA based FDD methods emerges as another effective FDD method, particularly beneficial in identifying process dynamics when serial correlations exist among variables. Conventional PCA and ICA assumptions of single distribution and statistical independence of samples can lead to false alarms and missed detections in process monitoring.

Stubbs et al. [17] addressed an efficient CVA based state space model time domain approach for process monitoring, introducing precise estimation methods for state space matrices and dimension selection procedures for state vectors. Russell et al. [18] compared the performance of CVA and DPCA based methods of fault detection using various techniques on the Tennessee Eastman benchmark process, evaluating sensitivity, promptness, and robustness. Jiang et al. [19, 20] proposed a contribution method based on CVA to identify process variables associated with faults, creating separate contributions for residual and state spaces. Additionally, they presented CVA-FDA, a fault diagnosis method combining FDA for fault classification and CVA for dimensionality reduction, demonstrating improved and consistent performance through simulation analysis.

Further advancements include a new CVA approach by Jiang et al. for investigating correlation structures in process data using causal dependency (CD) feature representation. Ruiz-Cárcel et al. [21] given a case study assessing a CVA-and depend on CVA's FDD approach's handling in a nonlinear or complex process with varying operating conditions. In the literature,

some methods used monitoring related approach of a KCVA for nonlinear industrial processes.

FDD methods based on signal data

In order to represent the dynamics of a process and decompose sensor signal independently, a number of wavelet-based techniques have shown to be effective. In order to solve a fault detection and isolation issue for a wastewater treatment plant related to biochemical nature, Zhang and Hoo [22] introduced a bond graph network method-based FDI solution. The study used a Bayesian network to explain conditional dependence faulty areas and fault signatures, discrete wavelet transformations (DWT) for dynamic representation, and the calculating confidence intervals based on Mahalanobis distance measure for PCA which was also used for dimension reduction. An FDC system for a nuclear power plant was given by Hadad et al. [23]. It used the resilient back propagation algorithm in conjunction with a wavelet transform method based on Artificial Neural Networks (ANNs). Konar and Chattopadhyay [24] compared the performance of discrete WT-based approaches and presented a fault detection algorithm utilizing Support Vector Machines and wavelet transform for monitoring induction motor characteristics. In order to address a fault detection issue in a complex or nonlinear system, Villez et al. [25] proposed a fault diagnosis technique based on the Kalman filtering (KF), expanding its use for identifying critical faults in processes.

MODEL BASED FDD METHODS

Methods for FDD have typically been system-specific and model based, data-driven techniques are used for fault detection and monitoring in the current industrial environment because there are abundant historical and online industrial data available. The advancement of intelligent FDD methods have been made easier by the progress made in Artificial Intelligence (AI). It is possible to accomplish automatic fault diagnosis through supervised or unsupervised learning techniques [26-28].

The aim of supervised learning techniques is to approximately map for output value or data label prediction, and they require labelled data samples. Regression and classification problems are subdivided further. Conversely, unsupervised learning techniques

try to model the considered structure or distribution in the data and do not require data labels. They are separated into problems related to dimensionality reduction and clustering. Using predetermined decision criteria, supervised learning trains FDD schemes to identify and categorize system status into recognized fault classes. However, since real industrial data frequently lacks consistent labeling procedures, the application of supervised learning is constrained by the large gap in explicit data label requirements. Binary classifiers are the primary component of unsupervised learning techniques, which use unlabeled data samples to distinguish classical FDD approaches limitations have led to the exploration of model-based approaches, particularly those based on process models or mathematical models. Users typically need a deep understanding of the process model, as these approaches leverage relations among multiple process variables to detect changes due to specific faults.

There are various model-based Fault Detection and Isolation (FDI) approaches for automatic processes, emphasizing principles and techniques for robustness to modelling errors. The study delved into model-based residual generation methods, state estimation, parameter identification approaches, and observer approaches for various fault detection types. The fault Detection based on model, isolation, and reconfiguration techniques were reviewed by Hwang et al. [4], who categorized them according to techniques of residual generation, methods based on statistical decision and reconfiguration control. They investigated techniques for implementing reconfigurable control strategies, statistical residual testing for abrupt fault occurrences, and model-based residual generation methods.

A combined FDI scheme was introduced by Schubert et al. [27], combining Multivariate Statistical Process Control (MSPC) techniques with traditional model-based approaches. They used subspace model identification (SMI) to track process operations and create a suitable model. The performance of the suggested approach was shown in three applications involving actuator, process, and sensor faults.

FDD Methods based on observer

Li et al. [31] contributed to observer-based FDD methods by developing new fault detection approaches

for piecewise affine processes. Their study focused on optimizing fault detection by the application of a weighted diagnostic observer. Additionally, the authors are integrated a mode observer into the presented FDD system to enhance its efficiency. The fault diagnosis issue in systems having nonlinear and multiple incipient sensor faults was addressed by Wu et al. [29]. They put forth a novel FDD technique based on concepts of sliding-mode observers (SMOs) and total measurable fault information residual (ToMFIR). The strategy involved splitting the original systems into two subsystems one with actuator faults and the other with sensor fault by using a state and output transformation technique.

Piltan and Kim [30] presented a novel observer-based FDD technique based on a variable structure of Feedback Linearization Observer (FLO) to improve fault diagnosis performance, typically in rotating machinery. In nonlinear chemical processes, Bernardi and Adam [31] suggested two types of observers based on a Linear Parameter Varying (LPV) methods for the diagnosis and detection of faults in sensor and actuator.

Parity Equation Based FDD Method

In literature, a comprehensive review of Proportional-Integral (PI) Modified Fault Detection (PM-FD) methods and proposed modifications and integrations to enhance their effectiveness [32-34]. Zhang and Hoo [22] addressed actuator FDI by introducing an optimization in parity space-based approach. The method involved spanning all parity relations between system outputs and inputs, optimizing a transformation matrix through these relations, and using a Cumulative Sum (CUSUM) procedure for detecting changes in residual variance. They also demonstrated the method on actual and simulated aircraft control surface actuators by using technique of a pseudo-inverse actuator estimation to capture deflections in actuator. A fault detection issue in LTV (Linear Time-Varying) systems was addressed by Zhong et al. [33]. They suggested using the parity space as the foundation for an FD technique to lessen computing load. It is worth to note that the problem of fault detection is to be considered as an optimization challenge and the authors were used a uniquely Krein space system to find the optimized FD recursively in

order to achieve higher computational efficiency in FD identifying performance.

FDD Methods based on Supervised Learning

This subsection and subsection D contains the methods based on non-neural network as the subsection E is contains the survey on artificial neural network(ANN) based FDD methods. In addressing Proportional-Integral (PI) Modified Fault Detection (PM-FD) problems, Support Vector Machines (SVM) have been widely employed for pattern recognition and fault classification. In this, it is explored SVM applications for machine status monitoring and fault diagnosis, emphasizing future developments oriented toward expertise- or problem-specific approaches.

A unique method for fault by means of extraction and detection using SVM and cubic spline regression was presented by Park et al. [35]. They used SVM to construct a classifier and cubic spline regression to find step-changing points. As process features, the parameters in coefficient multiplied to each basis of the related cubic spline regression were used as inputs to build the classifier. Banerjee and Das [36] converted the issue of dynamic motor condition fault diagnosis into an evidence fusion problem by combining data from several sensors. To classify fault signals, they used SVM and the Short-Term Fourier Transform (STFT). In order to address a multiple fault classification issue pertaining to machine or mechanical gears, Bordoloi and Tiwari [37] suggested an SVM method based on frequency domain data. They optimized SVM parameters using grid-search, genetic algorithms (GA), and artificial bee colony algorithms (ABCA), assessing their effectiveness on a multiclass problem.

Finding the best Gaussian kernel parameters for the one-class SVM (OCSVM) and evaluating their effect on classification performance were the main goals of Xiao et al. [38]. They presented two techniques, DFN and DTL, that make use of decision boundary tightness detectability and distance information. The Tennessee Eastman process datasheet and the UCI process datasheet both illustrated how effective these techniques were.

In the discussion of multi-class classification, Jing and Hou [39] contrasted PCA and SVM, two popular data-

driven techniques for fault classification. A monitoring technique for multimodal processes was presented by Wang et al. [40]. It uses a Hidden Markov Model (HMM) approach to identify faults and mode transitions. They used numerical experiments that included a combined process monitoring index to show computational efficiency.

Unsupervised Learning Based FDD Methods

Fault detection techniques based on k Nearest Neighbors (kNN) have demonstrated efficacy in identifying distinctive features in industrial processes, including non-linearity and multimode batch trajectories. In order to address a problem of semiconductor manufacturing with fault detection, Verdier and Ferreira [41] presented a distance-based false alarm detection technique called k-NN Detection (k-NND), which is based on adaptive Mahalanobis distance.

Another semi-supervised fault detection and diagnosis (FDA) model called the SFDA model was introduced by Zhong et al. [42]. It takes into account both labeled and unlabeled data when classifying faults. In order to address unequal class distribution in fault detection, Kwak et al. [43] introduced the IC-FDM incremental clustering approach for online fault detection. Using simulated data from an actual semiconductor plasma etching process, they tested the method. FDC-CNN, a fault detection and classification technique based on a convolutional neural network (CNN) model, was introduced by Lee et al. [44]. They showed the efficacy of their modified convolutional layer of a traditional CNN model on semiconductor chemical vapor deposition (CVD) process data by capturing structural features of the data. A comparative analysis of fault detection based on modeling approach was carried out by Lee and Kim [45], taking into account the problem of sample imbalance by class. Using various process datasets, they assessed the performance of 117 combinations of feature extraction, feature selection, and classification algorithms, as well as the algorithms' adaptability to semiconductor manufacturing processes.

Zhou et al. [46] developed a hybrid fault detection technique to address the Principal Component Analysis (PCA) distance distortion problem for dimension reduction in semiconductor manufacturing processes. The k NN rule and random projection were combined

in the RPkNN approach to address non-linearity and multimodality problems. A fault detection method based on novel distance for multimodal semiconductor production processes was presented by Zhang et al. [47]. In order to lessen the effects of variance structure and decrease statistical autocorrelation, they made use of the weighted distance of KNNs and offered new statistics, which improved fault detectability.

AI Based FDD Methods

Artificial neural networks (ANNs) can be widely used in intelligent system-based techniques for process FDD. In their discussion of a hybrid process monitoring scheme, Jiang et al. [48,49] provided a framework for data-driven fault diagnosis in power transmission line networks. Using FPGA evaluation boards, they tested the framework's evolvability and robustness using a variety of fault diagnosis algorithms. Samy et al. [50] addressed sensor fault diagnosis of multiple nature in unmanned aerial vehicles (UAVs). For modeling, they used an EMRAN-RBF NN-based technique. A fault detection and isolation (FDI) approach for aircraft gas turbine engines was designed by Tayarani-Bathaie and Khorasani [51]. The two types of models that are dynamic NN and NN with delay time were used in the fault detection process. In their work it has been used a multilayer perceptron network model for fault isolation. ANN-based and Regression-based models were taken into consideration in a comparative study of fault detection in model-based approach for wind turbines by Schlechtingen and Santos [52]. Using time-series data from SCADA systems, they created fault detection models of normal behavior and evaluated prediction errors and early fault detachabilities.

Using FD-SR, a fault detection approach using sparse representation technique, Ren and Lv [53] improved performance of fault detection in a metal etching semiconductor process. As a fault detection classifier, representation errors between normal and faulty samples were employed.

Knowledge based FDD Methods

Knowledge-based FDD techniques leverage human reasoning, fault models, and the relationships between faults and process variables. Leung and Romagnoli [54] integrated the Multiple Subspace Projection

Method (MSPM) into a knowledge-based FD system for chemical processes, incorporating PCA principles for fault diagnosis.

Two FDI schemes based on concepts of neuro-fuzzy network for U tube steam generators were presented by Razavi-Far et al. [55] in response to the fault diagnosis issue in typical nuclear power plants. They used a neuro-fuzzy network model of Mamdani type for FDI and Takagi-Sugeno fuzzy models for fault isolation and residual generation. A Bayesian Network (BN) method based on multiple models was presented by Verbert et al. [56] for HVAC system fault diagnosis. They developed various fault diagnosis models based on BN principles, taking into account the interdependencies of system elements and multiple modes of operation.

A hybrid approach to FDD based on data and process knowledge was presented by Don and Khan [57]. They combined process knowledge and HMM results as inputs for a Bayesian network (BN), which they used for root cause diagnosis, and a hidden Markov model (HMM) for fault detection.

CONCLUSIONS:

An early fault detection is very much necessary in modern industrial systems to ensure reliability. The types of faults at various stages in process control to be identified and its diagnosis gained considerable attention from research and statistical process oriented industrial experts. The various FDD methods are developed in past years, but it is worth to note that there are implementation difficulties of FDD methods for real-time industrial system. The main reasons beyond this case are variation in industrial plants characteristics such as multivariate systems, non-linearity in systems, unstable stationary, model uncertainties in proper information and uncertainties in industrial processes. The complexity, growing scale and complexity in industrial process leads to advancements in FDD methods. There are many challenges in FDD and its implementation for real time applications and fault detection is one of the key issues. In this paper it has been attempted to focuses on various issues of faults and FDD methods.

There are always challenges in safety and reliability factors in modern industrial systems and technologies. Therefore, malfunction and fault monitoring

capabilities need to instilled in the smart system and this automated FDD trends would be future prospective for researchers and academicians. This paper addresses various developments within FDD methods and reviews of research work in this area. The prospective solutions for automated fault monitoring are the use of smart solutions by means of both models based with advancements and relatively new signal processing-based FDD approaches, with a special consideration paid to artificial intelligence-based FDD methods.

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Efficient Backtracking Algorithm for Solving Examination Timetabling Problem

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ABSTRACT

This research addresses the intricate challenges of Examination Timetabling for junior supervisors, presenting a cutting-edge solution to a complex NP-hard problem in educational institutions. The paper introduces a sophisticated backtracking algorithm designed to navigate through challenging constraints, including cadet-wise limits, departmental requirements, and dynamic supervisor availability. The contributions encompass optimized search strategies, an integrated constraint-handling mechanism, and a dynamic cadet-wise allocation strategy. Real-time dataset analyses underscore the algorithm's performance across varying complexities, shedding light on the need for adaptive solutions in educational timetabling. Empirical analysis, utilizing datasets from RIT Islampur, showcases the algorithm's efficiency under varying complexities. While Dataset 1 demonstrates functional efficacy, challenges in execution time arise in Dataset 2, emphasizing the difficulty of NP-hard timetabling problems. The research underscores the potential for future enhancements, acknowledging the demanding nature of timetabling optimization in educational settings.

KEYWORDS: *Backtracking, Block allocation, Examination timetabling, Optimization.*

INTRODUCTION

Scheduling and timetabling problems arise when there is a need to allocate scarce resources, such as time, personnel, and facilities, to a set of tasks or events. These problems are characterized by a multitude of constraints and objectives that need to be considered simultaneously. Whether it be in educational institutions managing class schedules, healthcare facilities optimizing patient appointments, or transportation systems coordinating routes, the overarching goal is to devise schedules that maximize efficiency, minimize conflicts, and meet specific criteria. The domains in which scheduling and timetabling problems manifest are diverse and encompass a wide range of applications. Educational institutions grapple with timetable creation for classes, exams, and resource allocation. Similarly, transportation systems must efficiently schedule routes and allocate vehicles. In healthcare, optimizing patient appointments, staff shifts, and resource utilization is imperative. Manufacturing processes, project

management, and sports scheduling are also domains where effective scheduling and timetabling are critical for success.

The inherent complexity of scheduling and timetabling problems stems from the intricate interplay of numerous factors and constraints that must be simultaneously considered. These challenges emerge due to the need to optimize the allocation of finite resources, such as time, personnel, and facilities, across a diverse array of activities or events. The multifaceted nature of these problems is exacerbated by the existence of various constraints, ranging from time limitations and resource availability to intricate dependencies among tasks. Moreover, real-world scenarios often introduce dynamic elements, such as unexpected disruptions or changes in priorities, further complicating the task of devising effective schedules. The sheer scale of the solution space, especially in large organizations or complex systems, contributes to the computational complexity of finding optimal solutions. Additionally,

the conflicting objectives that may arise—such as maximizing efficiency while minimizing costs or adhering to specific rules—add layers of intricacy. As a result, the complexity of scheduling and timetabling problems necessitates the application of sophisticated algorithms capable of navigating this intricate landscape to deliver practical and efficient solutions.

The Examination Timetabling Problem is inherently complex due to the vast solution space generated by the combination of exams, students, and constraints. The exponential growth in possibilities makes exhaustive search impractical for large instances. The problem involves numerous hard and soft constraints, including room capacity, instructor preferences, and avoiding conflicts, adding intricate interactions between constraints. Combinatorial optimization principles further contribute to the complexity, requiring the identification of optimal combinations from finite sets. Real-world factors, such as dynamic resource availability, human preferences, and scalability issues, amplify the challenge. The need to balance conflicting objectives, accommodate uncertainties, and address various resource constraints intensifies the difficulty of finding an optimal or near-optimal timetable. Solving this complex problem often necessitates the application of advanced optimization algorithms and heuristic approaches to efficiently navigate the intricate solution landscape. The problem of scheduling examinations poses a real-world challenge in combinatorial optimization, marked by its complexity arising from numerous constraints and the constraint of limited resources, namely time slots and rooms. Allocating a substantial number of exams within these constraints makes the solution process inherently difficult [1]. Addressing the complexities of scheduling and timetabling necessitates the application of sophisticated algorithms capable of navigating intricate solution spaces. Diverse methodologies, including heuristic approaches, metaheuristic algorithms, and optimization techniques, have been devised to grapple with these challenges. Genetic algorithms, simulated annealing, ant colony optimization, and constraint programming represent a subset of the algorithms utilized to discover near-optimal solutions within realistic time constraints. The examination timetabling problem, characterized by NP-hard complexity, has spurred extensive research

exploring stochastic methods such as heuristics and metaheuristics to identify optimal or near-optimal solutions. In earlier investigations, graph heuristic orderings were commonly employed to address timetabling problems [2–4]. Various local search metaheuristic approaches have also been documented to tackle time scheduling problems. Burke and Bykov [5] implemented late-acceptance hill climbing, a hill climbing variant, for the examination timetabling problem. This involved using a specific-length list to defer the comparison between candidate solutions and the current best solution. Paper [6] introduced the step-counting hill climbing algorithm, leveraging the current cost as an acceptance boundary for the subsequent steps. This algorithm demonstrated improved solutions compared to traditional hill climbing methods. The memetic algorithm has gained popularity for the examination timetabling problem. Adaptive co-evolutionary memetic algorithm [7], cellular memetic algorithm [8], and memetic algorithm based on Multi-objective Evolutionary Algorithm with Decomposition (MOEA/D) [8] have been reported as effective in generating high-quality exam timetables.

Examination timetabling for junior supervisors is a crucial aspect of educational management, necessitating strategic scheduling to optimize the allocation of supervisory roles. This unique domain involves assigning junior supervisors to exam sessions based on various constraints like cadet levels, department affiliations, and individual preferences. The challenge lies in preventing overburdening, avoiding conflicts of interest, and accommodating diverse cadet levels. Intelligent algorithms, including backtracking is employed to create efficient schedules that enhance fairness, transparency, and academic integrity. As educational institutions adapt to evolving demands, addressing the complexities of junior supervisor timetabling becomes imperative for the smooth conduct of examinations.

The objectives of this paper are as follows.

- Formulation of Junior Supervisor-Centric Examination Timetabling Problem: The first research objective is to develop a comprehensive understanding of the distinct challenges faced by Junior Supervisors in examination timetabling.

This involves identifying specific constraints and considerations unique to their role. By formulating the Examination Timetabling problem with a focus on Junior Supervisors, the research aims to create a problem model that optimally addresses their responsibilities, ultimately reducing the manual workload associated with scheduling.

- Design and Implementation of a Backtracking Algorithm: The second objective is to design a specialized Backtracking algorithm tailored to the needs of Junior Supervisors. The algorithm will be developed to efficiently navigate the problem space, considering the identified constraints and optimizing examination schedules. Through an iterative process, the algorithm will seek to minimize manual intervention, offering a systematic and automated solution for Junior Supervisors involved in examination timetabling.

Contributions to this paper are as follows

- Proposing and implementing optimizations to the backtracking algorithm used for solving the exam timetabling problem for junior supervisors, this could involve enhancements to the search strategy, expedite the search for a feasible solution.
- Developing a dynamic cadet-wise allocation strategy that adapts to the changing availability and constraints of supervisors. This ensures a more flexible and accommodating scheduling approach that aligns with the specific cadet levels and requirements of each supervisor.
- Investigating the scalability of the proposed solution, especially in scenarios with an increasing number of supervisors, blocks, and exam days. Evaluating the algorithm's performance under varying scales contributes valuable information for practical implementations in larger educational institutions.

In the rest of this paper, section 2 will introduce the related work in the examination timetabling. Section 3 gives the overview of the problem formulation. Section 4 describes the methodology of backtracking algorithm to solve this problem. Section 5 briefly describes the input datasets and obtained results. Finally, conclusion of paper in section 6.

RELATED WORK

This research challenges traditional exam timetabling by using batch scheduling with partial graph heuristic orderings and a modified great deluge algorithm (PGH-mGD), achieving competitive results on benchmarks [1]. Subsequently, it memorizes successful heuristics, employs knowledge discovery for improved problem-solving, and introduces an adaptive method overcoming heuristic ordering limitations, offering a faster, more general alternative with competitive results on benchmarks. The study also refines the case base using knowledge discovery techniques, demonstrating effective heuristic learning for diverse timetabling challenges [2-4]. In parallel the Late Acceptance Hill-Climbing (LAHC) algorithm offers a simple and effective search method, outperforming Simulated Annealing, Threshold Accepting, and the Great Deluge Algorithm [5]. A novel timetabling methodology surpasses the original Great Deluge algorithm [6]. An adaptive coevolutionary memetic algorithm (ACMA) achieved competitive results, while a cellular memetic algorithm, hybridized with threshold acceptance local search, improved population diversity and set new upper bounds on benchmarks [7-8]. By testing different strategies, the study found that variable and value ordering backtracking with consistency enforcement outperformed chronological backtracking and reported literature results [9]. A powerful backtracking procedure was introduced for solving duration minimization and net present value maximization problems in resource-constrained networks, emphasizing low memory requirements and rapid solution improvement [10]. The paper then addressed the permutation flow shop scheduling problem with sequence-dependent setup and controllable transportation time, proposing a multi-objective backtracking search algorithm for effective solutions. Additionally, it introduced an optimal block knowledge-driven backtracking search algorithm for the distributed assembly flow shop scheduling problem, proving effective in minimizing completion time for assembly processes. The research focused on intelligent backtracking schemes for a version of the job shop scheduling problem, demonstrating enhanced efficiency in solving constraint satisfaction problems [11-13].

The paper [14] introduced a Variable Neighbourhood Search (VNS) meta-heuristic for university examination timetabling, showcasing improvements beyond the basic VNS method. It combined VNS with a genetic algorithm for enhanced solution quality, contributing to timetabling methodologies. While [15] proposed INMGD-ABC, a hybrid approach addressing university timetabling, improving the Artificial Bee Colony (ABC) algorithm's limitations. Through experimentation, it outperformed basic ABC significantly, providing competitive results in the literature.

PROBLEM FORMULATION

Decision Variables

This section provides a detailed mathematical problem formulation for Examination timetabling problem for junior supervisors

To formulate the Junior Supervisor Time Scheduling Problem as an Integer Programming (IP) problem using the given constraints, we can define decision variables, an objective function, and constraints. Let's denote the decision variables as $x_{i,j,k}$ where:

- i represents the supervisor index,
- j represents the exam day index,
- k represents the block index.

The decision variable $x_{i,j,k}$ takes binary values (0 or 1) to indicate whether block k is assigned to supervisor i on exam day j . The objective is usually to minimize or maximize some function, but for scheduling problems, the objective is often just to find a feasible schedule. Therefore, the objective function is usually a constant.

- 1 if block k is assigned to supervisor i on exam day j
- 0 otherwise

Objective Function: Minimize 0

Constraints

- Blocks cannot be assigned to supervisors from the same department. If $x_{ijk} = 1$, the assignment is only valid if the supervisor's department

(SupervisorDep i) is different from the block's student's department (BlockDep j).

$$x_{ijk} = 0, \text{ if SupervisorDep}_i = \text{BlockDep}_k, \forall i,j,k$$

- Ensures that supervisors on holiday (SupervisorOnHoliday $ij = 1$) block cannot be assigned to supervisor on that day.

$$x_{ijk} = 0 \text{ SupervisorOnHoliday } ik = 1, \forall i,j,k$$

- Guarantees that each supervisor is assigned to at least one block on each exam day.

$$\sum_{k=1}^k x_{ijk} \geq 1, \forall i,j$$

- Limits the number of assignments for each supervisor based on their cadet-wise limit.

$$\sum_{k=1}^k x_{ijk} \leq \text{cadet-wise limit}, \forall i,j$$

- Ensures that only one supervisor can be assigned to a specific block on an exam day.

$$\sum_{j=1}^j x_{ijk} \geq 1, \forall k,j$$

Binary Nature of Variables:

$$x_{ijk} \in \{0,1\}, \forall i,j,k$$

This problem formulation ensures that blocks are assigned to supervisors only on exam days, adhering to the specified constraints to create an optimal and feasible schedule for junior supervisors.

PROPOSED METHODOLOGY

Backtracking Algorithm

Backtracking, coined by D. H. Lehmer, represents a widely recognized algorithm design technique employed to address problems involving the search for a set of feasible solutions or an optimal solution while adhering to specific constraints [9]. The approach involves a step-by-step process wherein it systematically endeavors to expand a partial solution, which already defines consistent values for certain variables. The aim is to progress towards a comprehensive assignment by iteratively selecting values for additional variables that align with the existing values in the partial solution [9]. The general pseudo code for backtracking is presented below.

```

procedure backtrack (candidates, partial_solution):
if partial_solution is a solution:
    add solution(partial_solution)
    return
for each candidate in candidates:
    if candidate is a valid choice for the current
    partial_solution:
        choose(candidate)
backtrack(updated_candidates, updated_partial_solution)
unchoose(candidate)
backtrack (initial_candidates, initial_partial_solution)

```

The above backtracking algorithm explores possible solutions to a problem defined by candidates and a partial solution. It recursively selects valid candidates, updating the partial solution, and backtracks if a solution cannot be found. The example usage demonstrates initiating the algorithm with initial candidates and a partial solution. Backtracking is a recursive algorithm that systematically explores all possible solutions to a problem, making choices and backtracking when necessary. It operates by traversing a decision tree, making a choice at each node and exploring further until a solution is found or all possibilities are exhausted. The algorithm uses a depth-first search strategy, exploring one branch of the decision tree at a time. A base case is defined to identify when a valid solution is reached. If a choice leads to a dead-end, the algorithm backtracks to the last valid decision point and continues exploration.

Backtracking finds extensive application in problems characterized by multiple decision points and constraints, including puzzles, games, and optimization tasks. It stands apart from recursion, which involves calling the same function repeatedly until reaching a base case. In contrast, backtracking is an algorithmic approach that systematically explores all potential solutions within a given set and then selects the desired solution. Rather than following a repetitive recursive pattern, backtracking navigates through the solution space, evaluating different options at each decision point until a viable solution is identified.

Backtracking Approach for Examination Timetabling problem

Backtracking is a problem-solving approach that's particularly useful for tackling complex scheduling issues, such as Examination Timetabling problem for junior supervisor. In this scenario, the goal of backtracking is to find an efficient schedule that meets certain criteria. The algorithm systematically explores different scheduling options, making decisions at each step and backtracking when necessary. In the context of Examination Timetabling problem for junior supervisor, the decision points involve assigning tasks to supervisors during specific time slots. The algorithm starts by making a choice, such as assigning a task to a supervisor on particular block. It then explores further, moving to the next block and making additional choices. If a conflict arises or the schedule violates certain constraints then algorithm backtracks to the last valid decision point and tries a different path. This process continues until a valid and efficient schedule is found. It's like navigating all tree, trying different routes and going back when you hit a dead-end until you discover the best way through. The algorithm ensures that each supervisor is assigned tasks in a way that optimizes the overall schedule. This backtracking approach is valuable for its flexibility and ability to handle the complexities of Examination Timetabling problem for junior supervisor, ensuring that tasks are allocated efficiently within given constraints.

Pseudocode for Examination Timetabling problem

```

function backtrackingSearch(row, col):
    if col > exam_days - 1 and row > no_supervisor - 1:
        displaySchedule()
        outputSolution()
        exit(0)

    for blockCode in range(0, no_blocks):
        if isAssignmentSafe(row, col, blockCode):
            placeAssignment(row, col, blockCode)

```

```

removeBlock(col, blockCode)
displaySchedule(col)

if nextSearch(row, col) == 1:
    return 1
else:
    removeAssignment(row, col)
    addBlock(col, blockCode)

return 0
function isAssignmentSafe(row, col, blockCode):
    return (
        dep_constraint(col, s_dep, bs_dep, blockCode) &&
        more_than_one_supervisor_in_block(row, col,
blockCode) &&
        supervisor_on_holiday(col, row) &&
        cadet_constraint(row, col, blockCode) &&
        atleast_one_supervision(row, blockCode)
    )

```

The backtracking search algorithm tailored for the Examination Timetabling problem for junior supervisor represents a pivotal component in the realm of examination timetabling. As a fundamental challenge in educational institutions, the efficient allocation of blocks to junior supervisors during exam days necessitates an intricate and systematic approach. This algorithm, embedded within the broader context of exam timetabling, plays a crucial role in addressing the complexities inherent in coordinating the schedules of supervisors, each with distinct cadet levels and departmental affiliations. The initialization phase lays the groundwork for the algorithm, setting up the essential variables and data structures to represent the diverse elements of the scheduling puzzle. This initialization is not merely a preparatory step; it establishes the framework for subsequent decision-making processes. The decision points, where specific block assignments are made, unfold iteratively as the algorithm explores the vast decision space. A salient feature of the algorithm is its conscientious consideration of constraints at each

decision point. These constraints encapsulate diverse aspects, including departmental affiliations, cadet-level restrictions, and the need to prevent the repetition of blocks within the same column. This constraint-aware approach aligns with the intricate nature of junior supervisor scheduling, ensuring that the resultant schedule not only meets logistical requirements but also adheres to institutional guidelines. The backtracking mechanism within the algorithm facilitates an agile response to constraint violations. Upon detecting a deviation from the predefined constraints, the algorithm seamlessly backtracks to the previous decision point, demonstrating adaptability in the face of scheduling intricacies. This iterative exploration and backtracking cycle form the backbone of the algorithm, ensuring the systematic pursuit of a solution in a complex decision space. Furthermore, the termination condition, signaling the successful completion of the scheduling process, underscores the algorithm's efficacy in solving Examination Timetabling problem for junior supervisor. The algorithm culminates in the presentation of a feasible schedule, providing valuable insights into the optimized allocation of supervisory resources during examination periods. In the broader landscape of research on examination timetabling, this algorithm contributes to the arsenal of methodologies aimed at addressing the myriad challenges posed by scheduling constraints. Its adaptability and constraint-aware decision-making position it as a valuable tool in the pursuit of efficient and effective scheduling solutions within educational institutions.

Solution Representation

In solution representation given in table 1, row represents the supervisors and column represents exam day and cell contains combined string of block-location-shift assigned to the particular junior supervisor on given day this solution might have high complexity because of combination of strings. For example, B1-L1-M is the combined string of block-location-shift assigned to the junior supervisor S1 day 1, which gives information that S1 has supervision on Block 1 at Location L1 and their supervision shift is morning shift.

In table 2, we employ an integer-based encoding scheme for the combined string representation of block-location-shift, thereby mitigating the intricacies

associated with the complexity of string representations presented in table 1. This encoding strategy reduces the computational burden of processing and comparing string data, promoting more efficient algorithmic operations and contributing to enhanced overall performance.

Table 1. Supervisor-oriented solution representation

Supervisor	Exam Days		
	Day 1	...	DD
S1	B1-L1-M	...	B1-L1-M
S2	B1-L1-EV	...	B4-L4-M
:
SN-1	BN-LN-M	...	B6-L6-M
SN	BN-LN-EV	...	B2-L2-M

Table 2 Assigning integer value to block details

Block details	B1-L1-M	B1-L1-EV	BN-LN-EV
Integer value	0	1	N

Table 3. Supervisor-oriented solution representation by assigning integer value to blocks

Supervisor	Exam Days		
	Day 1	...	DD
S1	0	...	1
S2	1	...	2
:
SN-1	3	...	13
SN	N	...	N

In solution representation given in table 3, row represents the supervisors and column represents exam days, and cell represents integer value which contains information about blocks that are assigned to junior supervisors. For this, first we have to assign integer values for given strings which is shown in table 2. By using these assigned values, the overall solution representation is shown in Table 1 For example, block 0 is assigned to junior supervisor S1 on Day 1 which means Block 1 at Location 1 in Morning shift is the supervision period for S1.

Dataset

Here a real-time benchmark dataset is taken from Rajarambapu Institute of Technology Rajaramnagar to solve Examination Timetabling problem for junior supervisor. The general description of dataset given below,

- Exam days: N (D1, D2, D3 ..., DN)
- Exam Slots: 2 (Morning-M, Evening-EV)
- Exam Blocks with locations: N (B1-L1, B2-L2, B3-L3.... BN-LN)
- Department of Students: N (SD1, SD2, SD3....., SDN)
- Total No. of blocks to be assign: N(B1-L1-M, B1-L1-EV, B2-L2-M.... BN-LN-EV)
- Number of junior supervisors: N (S1, S2, S3, S4, S5....., SN)
- Supervisor’s cadet: 3 Professor (1), Associate Professor (2), Assistant Professor (3).
- Supervisor’s cadet wise allotment: Professor-X, Associate Professor -Y, Assistant Professor -Z. (X<Y<Z)
- Supervisor’s department’s: N (Dept1, Dept2, Dept3, Dept4, Dept5 ... , DeptN)
- Supervisor’s Pre-assets: 1-Available, 0-Unavailabel

Table 4. Information of blocks

Block code	Student department
0	SD ₁
1	SD ₂
.	.
.	.
.	.
N-1	SD _{N-1}
N	SD _N

In table 4, each row in the table represents a block, identified by a “Block code” and the respective

department is specified in the “Student department” column represents the students which are allocated to block for their exam.

Table 5. Information of exam Days

Exam Day code	Block Requirements
D1	0 1 2 3 4 5...N
D2	0 1 2 3 4 5...N
.	
.	
.	
DN	0 1 2 3 4 5...N

In Table 5, the initial column signifies the exam day code, denoting individual examination days such as Exam Day 1, Exam Day 2, and so forth. The “Block Requirements” column delineates the specific blocks slated for allocation to supervisors on the respective exam days. This structuring enhances clarity and facilitates a more streamlined representation of the scheduling requirements.

Table 6. Information of supervisors

Super-visor Code	Super-visor cadet	Super-visor depart-ment	Cadet wise allocate	Pre-assets
S1	1	Dept3	10	D1..N
S2	1	Dept1	10	D1..N
.				
.	.			
.	.			
.	.			
.	.			
S8	2	Dept7	12	D1..N
.				
.	.			
.	.			
.	.			
.	.			
SN-1	3	Dept7	15	D1..N
SN	3	Dept5	15	D1..N

In table 6, first column represents the supervisor code which having range. Second column represented the cadet of supervisor such as professor, associate and assistant. Third column represents department of supervisor and fourth column represents the cadet-wise allocation of blocks to the supervisors. And last column represents the availability of supervisor.

RESULT AND DISCUSSION

This section discusses about performance of proposed solution for Examination Timetabling problem for junior supervisor using Backtracking algorithm. Program execution carried out on this on machine having processor specifications 11th Gen Intel(R) Core (TM) i5-1135G7 @ 2.40GHz 2.42 GHz. The subsequent part of this section explores the program execution carried out on two benchmark datasets provided by RIT Islampur, The comparative study of both datasets and performance of backtracking algorithm.

Small Dataset 1

The table 7 represents the structure of blocks present in sample dataset 1, here Each row in the table represents a block, identified by a “Block code” and the respective department is specified in the “Student department” column represents the students which are allocated to block for their exam. The department values range from 1 to 7. Here the total main blocks are 16 and last three blocks are dummy blocks, to get effective schedule Here 0 means Block 1 at Location 1 in Morning shift is the supervision period for S1.

Table 7. Information of Blocks in dataset 1

Block code	Student department
0	1
1	2
.	
.	.
.	
.	
17	7
18	5

Table 8. Information of exam days in dataset 1

Exam Day code	Block Requirements
0	0 1 2 3 4 5...N
1	0 1 2 3 4 5...N
.	
.	.
.	
7	0 1 2 3 4 5...N

The table 8 represents structure of exam days presented in sample dataset 1. Here first column represents the exam day code which means exam day1, exam day2 and so on. And block requirements represents the blocks which have to be assigned to supervisor on particular exam day, in this dataset 7 exam days are present.

Table 9. Information of Supervisors in dataset 1

Super-visor Code	Super-visor cadet	Super-visor department	cadet wise allocate	Pre-assets
0	1	3	10	1111111
1	1	1	10	1111111
.				
.	.			
.	.			
.	.			
.	1111111			
8	2	7	12	1111111
.				
.	.			
.	.			
.	.			
.	1111111			
14	3	7	15	1111111
15	3	5	15	1111111

The table 9 represents structure of supervisors presented in sample dataset 1. Here first column represents the supervisor code, there are 16 supervisors in given in dataset 1, second column represented the cadet of supervisor. Here we have 3 cadets such as Professor, Associate Professor and Assistant Professor. There are 5 Professors, 6 Associate Professors and 5 Assistant

Professors are available in dataset 1. Third column represents department of supervisor and fourth column represents the cadet-wise allocation of blocks to the supervisors. And last column represents the availability of supervisor. Result obtained for dataset 1 are shown in table 10.

Table 10. Result for Dataset 1

Supervisors	Exam Days						
	0	1	2	3	4	5	6
0	0	1	0	0	0	1	0
1	1	3	2	1	1	3	1
2	2	4	3	2	2	4	2
3	4	5	5	3	3	5	4
4	5	6	6	4	4	6	5
5	6	7	7	6	5	7	6
6	7	8	8	7	6	8	7
7	8	9	9	8	8	9	8
8	9	10	10	9	10	10	9
9	11	11	11	10	11	11	11
10	12	12	12	11	13	12	12
11	14	13	13	12	14	13	14
12	15	14	15	13	15	14	15
13	16	15	16	14	16	15	16
14	17	16	17	16	17	16	17
16	18	17	18	17	18	17	18

The table 10, represents the Examination Timetabling problem for junior supervisor. Here row represents the supervisors and column represents exam days, and cell represents integer value which contains information about blocks that are assigned to junior supervisors. On exam day 1 for supervisor no.1, 0 block is assigned. And it represents the combined string of block-location-shift (B1-L1-M). This solution satisfies the constraints like Supervisor should not have more than one supervision in one day, more than one supervisor in same block at same exam slot are not allowed. Supervisor should not have supervision for its own department's students, all supervisors should have supervision according to their cadet i.e., professors should have less supervision than associates and associates should have less supervisions than assistants, one supervisor should not have more than supervisions as per their cadet, one supervisor should have at least one supervision during exam, if

supervisor is on holiday, then supervision should not be allocated for them. But there is one drawback of these solution is couple of blocks are remains unassigned on particular exam days, so it is part of further research on this topic, as it comes under NP hard problem so it has no particular method or algorithm to generate optimal solution. So, this program has high future scope for further research. The recursion depth is $7 \times 16 = 112$, representing the number of decisions needed for each supervisor on each exam day. Overall Time Complexity is $16 \times 716 \times 19$. For dataset 1 we got output in 2 seconds. So, as we increase the complexity of program the available options for taking the decision for algorithm will be decreases and due to this the complexity of the program will increases. As this problem is open ended so there are more opportunities for further research to improve the efficiency of algorithm to obtained feasible solution.

Complex Dataset 2

The table 11 represents the structure of blocks present in complex dataset 2. Each row in the table represents a block, identified by a “Block code” and the respective department is specified in the “Student department” column represents the students which are allocated to block for their exam. The department values range from 1 to 12. Here the total main blocks are 24.

The table 12 represents structure of exam days presented in dataset 2. Here first column represents the exam day code which means exam day1, exam day2 and so on. Block Requirements represents the blocks which have to be assigned to supervisor on particular exam day, in this dataset there are 7 exam days are present.

Table 11. Information of Blocks in dataset 2

Block code	Student department
0	1
1	2
.	
.	.
.	
23	12
24	11

Table 12. Information of exam days in dataset 2

Exam Day code	Block Requirements
0	0 1 2 3 4 5...N
1	0 1 2 3 4 5...N
...	...
7	0 1 2 3 4 5...N

Table 13. Information of Supervisors in dataset 2

Supervisor Code	Super-visor cadet	Super-visor department	cadet wise allocate	Pre-assets
0	1	3	5	1111111
1	1	1	5	1111111
.	.			
.	.			
.	.			
.	1111111			
8	2	7	12	1111111
.	.			
.	.			
.	.			
.	1111111			
23	3	7	15	1111111
24	3	5	15	1111111

The table 13 represents structure of supervisors presented in sample dataset I. Here 1st column represents the supervisor code, there are 16 supervisors in given in dataset 2. Second column represented the cadet of supervisor, here we have 3 cadets such as Professor, Associate Professor and Assistant Professor. There are 5 Professor, 7 Associate Professor and 13 Assistant Professor are available in dataset 2. Third column represents department of supervisor and fourth column represents the cadet-wise allocation of blocks to the supervisors. And last column represents the availability of supervisor.

Now problem becomes more intensified by adjusting the cadet-wise supervision limits. Specifically, Professors were set to 5 supervisions, Associate Professors to 10, and Assistant Professors to 15. This

alteration significantly increased the intricacy of problem. Information in dataset 2 led to an escalation in the number of decisions required for allocating blocks to supervisors. Consequently, the algorithm delves into multiple decision points during the backtracking process, resulting in a more time-consuming execution. The recursion depth is $7 \times 25 = 175$, representing the number of decisions needed for each supervisor on each exam day. Overall Time Complexity is $25 \times 725 \times 25$. Due to the increased complexity of the dataset, the execution took more time- specifically, we allowed it to run for 3 hours. However, it did not provide the final output and continued running indefinitely. However, acknowledging the inherent difficulty and openness of timetabling problems, the exploration of a more complex dataset becomes crucial. As the transition to a higher level of complexity, it opens avenues for extensive research. The adaptability and scalability of the algorithm under greater complexity is challenging for ongoing improvements and advancements in the field of timetabling optimization. As this problem is open ended so there are more opportunities for further research to improve the efficiency of algorithm to obtained feasible solution.

CONCLUSION

Examination Timetabling problem for junior supervisor tackles the formidable task of assigning exam supervision duties to supervisors, a problem inherently categorized as NP-hard due to the intricate constraints involved. The paper's contributions are significant, introducing refinements to the backtracking algorithm to streamline the search for feasible solutions. The incorporation of an integrated constraint-handling mechanism enhances solution robustness by effectively managing conflicting requirements and preferences. The implemented backtracking algorithm serves as an efficient strategy for systematically exploring the vast solution space. The algorithm's initiation involves setting up the schedule, supervisor, block, and temporary pointers, establishing a structured foundation for decision-making. By meticulously considering constraints such as cadet-wise limits, departmental requirements, and supervisor availability, the algorithm navigates through potential assignments on each exam day, ensuring that each decision adheres to the stipulated constraints. The

modular organization of the code enhances its readability and maintainability, as specific functions handle distinct aspects of the problem, including constraint verification, schedule updates, and data structure initialization.

The analysis of the presented datasets sheds light on the algorithm's performance under varying levels of complexity. While the initial Dataset 1 served as a functional demonstration, showcasing efficient results, the algorithm faced challenges in execution time as complexity increased in Dataset 2. This underscores the inherent difficulty of timetabling problems, especially in NP-hard scenarios. Despite these challenges, the study emphasizes the potential for future research to refine and enhance the algorithm's efficiency, recognizing the demanding nature of timetabling optimization and the necessity for adaptive solutions in educational settings. Overall, this work contributes to the ongoing discourse on effective timetabling solutions, acknowledging complexities and laying the groundwork for further advancements in the field, with both datasets sourced from RIT Islampur.

The research provides valuable insights into the dynamic landscape of Examination Timetabling for junior supervisors, presenting a holistic framework for addressing challenges in scheduling. The findings underscore the algorithm's strengths and limitations, paving the way for future investigations to build upon this foundation and contribute innovative solutions to the intricate realm of timetabling optimization in educational institutions. Overall, the research provides a solid framework for addressing the complexities of scheduling problems, offering a stepping stone for future enhancements and a deeper exploration of algorithmic intricacies.

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A Comprehensive Fuzzy Logic Approach for Individual Investor Risk Assessment

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ABSTRACT

This research introduces an advanced fuzzy logic-based framework for individual investor share market risk assessment, strategically combining Triangular and Gaussian membership functions. The aim is to enhance accuracy by capturing nuanced behaviors and uncertainties in financial variables like income, age, and family size. Gaussian functions are effective for gradual transitions in continuous distributions, while Triangular functions suit variables with distinct boundaries. The research emphasizes the strategic selection and integration of membership functions, providing a holistic representation of real-world financial intricacies. The decision-making strategy, focusing on the weakest link in determining overall risk, aligns with the multifaceted nature of investment landscapes influenced by diverse risk factors. This contributes to an interpretable and robust risk assessment system, offering a flexible tool for decision-making in dynamic financial markets. The innovative fuzzy logic-based approach provides a promising framework for addressing complexities in individual investor risk assessment and decision support in evolving market conditions.

KEYWORDS: *Demographic factors, Investment, Fuzzy logic, Financial market, Risk assessment.*

INTRODUCTION

Calculating the share market risk assessment for individual investors holds paramount importance in crafting investment strategies that align with their financial objectives and risk tolerance. By gauging an investor's risk appetite, one can tailor asset allocations to ensure a diversified portfolio that spreads risk effectively. This assessment not only influences the selection of investment instruments but also guides decision-making during market fluctuations. Understanding risk allows for stress testing portfolios against various scenarios, facilitating the implementation of risk management strategies to mitigate potential losses. Moreover, it contributes to psychological comfort, preventing emotional decision-making during market volatility. Regular risk assessments enable investors to monitor portfolio performance, adjust strategies as needed, and stay compliant with regulatory guidelines. Overall, a thorough risk assessment is a foundational step in the financial planning process, ensuring that investment

choices align with individual preferences and long-term financial goals.

Several critical factors contribute to the calculation of an individual investor's share market risk assessment. Firstly, understanding the investor's risk tolerance is foundational, as it sets the tone for the entire investment strategy. Factors such as age, financial goals, and investment time horizon play pivotal roles, as younger investors with longer timeframes may tolerate more risk than those approaching retirement. Asset class diversification is crucial, considering that different types of investments carry varying levels of risk. Market conditions, economic indicators, and geopolitical events are also significant factors influencing risk, necessitating continuous monitoring and adjustments.

In the context of calculating individual investors' share market risk assessments, several soft computing methods prove beneficial. Fuzzy Logic stands out as a powerful tool for handling the inherent uncertainty and imprecision associated with financial markets. It enables

the representation of vague variables and linguistic terms, providing a nuanced approach to risk assessment that aligns well with the complex and dynamic nature of the stock market. Genetic Algorithms (GAs) are adept at optimizing investment portfolios by evolving and refining potential solutions over successive generations. These algorithms excel in searching for optimal configurations that balance risk and return, offering a valuable approach for individual investors seeking tailored strategies. Artificial Neural Networks (ANNs) leverage their capacity to model intricate relationships within financial data, learning from historical patterns to make predictions about future market behavior. Support Vector Machines (SVMs), a machine learning technique, can be applied to classify and predict risk, aiding investors in decision-making. The adaptability and learning capabilities of these soft computing methods make them valuable assets in the intricate task of assessing and managing share market risk for individual investors. Integrating these techniques into risk assessment frameworks can enhance the precision and responsiveness of strategies tailored to individual investor needs.

In the complex domain of financial markets understanding the dynamics of investment behavior and risk tolerance has been a subject of extensive research, with a particular focus on the influence of demographic factors. The work of Sanchez-Roger et al. provides a panoramic view through a systematic review, elucidating fuzzy logic's diverse applications in finance and underscoring its utility in addressing complex risk scenarios [1]. Singh et al. delve into the nuanced relationship between demographic factors and investment behavior among retail investors, contributing valuable insights into the intricacies of individual risk-taking abilities [2]. Zhang's investment risk model takes a step further by incorporating intelligent fuzzy neural networks, showcasing the potential of cutting-edge computational methodologies in enhancing the precision of risk assessments in financial contexts [3].

The objectives of this paper are as follows.

- Design and construct a sophisticated fuzzy logic model that seamlessly integrates demographic factors (such as age, income, family size) and financial metrics (including emergency fund, debts,

and insurance coverage) to provide a comprehensive risk assessment framework for individual investors.

- Systematically define and optimize fuzzy sets for demographic and financial parameters within the model, ensuring that linguistic variables accurately represent the imprecise and nuanced nature of these factors.
- Formulate precise fuzzy rules that govern the inference process, maximizing the model's effectiveness in capturing individual risk perceptions.

The outcomes of this paper are as follows.

- Inspired by recent trends and advancements in risk assessment methodologies, this research contributes to the evolving paradigm of financial risk assessment. The outcome is a forward-looking approach that synthesizes fuzzy logic and demographic considerations, providing a stepping stone for future research in refining risk assessment models for individual investors in the dynamic landscape of financial markets.
- By incorporating demographic factors such as age, income, and education, the study aims to provide personalized risk profiles for investors. The outcome is a tailored risk assessment that acknowledges the unique characteristics of each individual, aligning with the overarching objective of understanding the role of demographic factors in shaping investment behavior.

In the rest of this paper, section 2 presents the related work. Sections 3 and 4 are problem formulation and proposed methodology respectively. Section 5 describes result and discussion. Finally, conclusion of paper in section 6.

RELATED WORK

Various algorithms and statistical methods are instrumental in conducting share market risk assessments for individual investors. Value at Risk (VaR) is widely used, providing a quantitative measure of potential losses at a given confidence level. Monte Carlo Simulation offers a comprehensive approach by simulating numerous market scenarios. Modern Portfolio Theory (MPT) incorporates covariance

matrices to optimize portfolios based on risk and return. The Sharpe ratio evaluates the risk-adjusted return, aiding in decision-making. Capital Asset Pricing Model (CAPM) calculates expected returns considering systematic risk. Beta analysis assesses an investment's sensitivity to market movements. GARCH models forecast volatility, especially in changing market conditions. Machine learning algorithms, including decision trees and neural networks, enable sophisticated analysis of large datasets. Additionally, stress testing evaluates portfolio performance under extreme conditions. The selection of algorithms depends on factors such as investor preferences, the complexity of the portfolio, and the desired level of analysis, often involving a combination of methods for a comprehensive risk assessment strategy.

Raveendranath et al. investigated the influence of demographic factors on investors' risk tolerance in a specific city [4]. Sutejo et al. delved into the relationship between demography, financial risk tolerance, and retail investors, providing further context on the intricacies of individual risk perceptions [5]. Dickason and Ferreira's examined age and gender effects on financial risk tolerance in South Africa, contributing to the understanding of demographic influences [6]. Zhong's work introduced a fuzzy logic theory model for financial risk investment decisions, expanding the toolkit for risk assessment methodologies [7]. Córdova et al. proposed a classification of financial risk in the cooperative sector using fuzzy logic, emphasizing its applicability in diverse financial contexts [8]. Studies by Patel and Modi [9] and Subramaniam [10] offered insights into the impact of demographic factors on investment decisions, further underlining the relevance of demographic considerations in understanding risk tolerance. In the realm of risk assessment methodologies, BoloÅŸ et al. contributed to the discourse by developing a fuzzy logic system aimed at identifying project risks financed through structural funds [11]. Dourra and Siydelved into the domain of investment strategies, employing a fusion of technical analysis and fuzzy logic [12]. Escobar et al. focused on technical analysis and presented a fuzzy logic-based indicator, highlighting the integration of fuzzy logic into trading systems [13]. Jurgutis and Simutis delved into investor risk profiling using a fuzzy logic-based approach within a multi-agent

decision support system, emphasizing its potential in personalized risk assessments [14]. Cheung and Kaymak presented a fuzzy logic-based trading system, showcasing advancements in algorithmic trading strategies [15]. Korolev et al. contributed to the realm of risk management in financial intermediation, offering a comprehensive approach grounded in fuzzy logic principles [16]. Together, these studies underscored the breadth of applications for fuzzy logic in addressing complex challenges across trading systems, investor profiling, and risk management in financial contexts.

PROBLEM DEFINITION

In the realm of financial decision-making, accurately assessing an individual investor's risk-taking ability is crucial for investment success. Traditional models often fall short in capturing the nuanced and subjective nature of risk. This project addresses this gap by introducing a Fuzzy Logic-Based Risk Assessment System. The objective is to create a flexible and realistic approach to risk evaluation, considering linguistic variables such as age, income, family size, emergency fund, debts, and insurance. By leveraging Fuzzy Logic, the system aims to revolutionize risk assessment, offering a more adaptable perspective on the complex interplay of factors influencing an investor's risk profile. The inclusion of insurance adds granularity, recognizing diverse risk mitigation strategies. Ultimately, this project contributes to advancing risk assessment methodologies, providing investors with a sophisticated tool for more informed decision-making in dynamic financial markets.

- Decision Variables: Let R_{low} , R_{medium} , R_{high} represent the risk levels for low, medium, and high risk, respectively.
- Parameters: Age, Income, FamilyMembers, EmergencyFund, Debts, Insurance: Input values for each test case.

The individual investor's share market risk assessment problem can be mathematically formulated as given below.

Input Variables:={Age, Income, Family Members, Emergency Fund, Debts, Insurance}

Output Variable:={Low Risk, Medium Risk, High Risk}

The goal is to predict the output variable based on the input variables.

The complexity of the individual investor share market risk assessment problem is underscored by the multitude of diverse and interrelated variables at play. Statistical data reveals the intricate web of factors influencing investor risk tolerance, such as age, income, family size, emergency fund, debts, and insurance. For instance, a study analyzing the correlation between age and risk tolerance may find variations dependent on income levels and family size, adding layers of complexity to the relationship dynamics. The statistical nuances of financial markets, inherently characterized by uncertainty and fuzziness, necessitate the application of advanced methodologies like fuzzy logic. The strategic selection and design of membership functions, as exemplified by the statistical properties of Triangular and Gaussian functions, introduce a nuanced decision-making process into the problem. Moreover, the validation and adjustment phase of the model involves a meticulous analysis of statistical accuracy using historical data or expert feedback, demanding a keen understanding of statistical trends in financial behaviors. The dynamic nature of financial markets, reflected in statistical patterns of volatility and market fluctuations, further complicates the development of a robust and adaptive risk assessment model. Therefore, addressing the statistical complexities inherent in this problem requires a comprehensive approach that integrates diverse statistical insights and adapts to the ever-changing dynamics of financial market

METHODOLOGY AND EXPERIMENTAL DETAILS

Fuzzy System

This study employs fuzzy logic to assess the risk-taking ability of individual investors. The research design integrates Gaussian and Triangular membership functions, key components of fuzzy logic, to model the degree of membership of elements in fuzzy sets.

- Linguistic Variable Definition: Establish linguistic variables for each input and output variable. For example, linguistic variables for Age might include Young, Middle-aged, and Old.
- Fuzzyfication: Create fuzzy sets and membership

functions for each linguistic variable. Define membership functions that represent the degree of membership of each input variable to its fuzzy set. For instance, a fuzzy set “Young” might have a membership function that assigns a high membership value to individuals with ages below a certain threshold.

Parameters for membership functions:

- ageMin
- agePeak
- ageMax
- incomeMean
- incomeStddev
- familyMembersMin
- familyMembers
- PeakfamilyMembersMax
- emergencyFundMean
- debtsMean
- debtsStddev
- insuranceMean
- insuranceStddev

The chosen design is grounded in fuzzy logic, offering a flexible framework for handling uncertainty in risk assessment. Gaussian membership functions capture smooth transitions, while Triangular membership functions address gradual shifts between full membership and non-membership.

- Rule Base: Formulate a set of fuzzy rules that capture the relationship between the input variables and the output variable. These rules express the expert knowledge or heuristic understanding of how the input variables influence the risk level. For example, “IF Age is Young AND Income is High THEN Risk Level is Low.”
- $\text{ageMembership} = aM$
- $\text{incomeMembership} = iM$
- $\text{familyMembersMembership} = fMM$
- $\text{emergencyFundMembership} = eFM$

- debtsMembership=dM
- insuranceMembership=iM

low Risk = min (aM, iM, fMM, eFm, dM, iM)

medium Risk = min (aM, iM, fMM, 1 - eFM, 1 - dM, iM)

high Risk = min (1 - aM ,1 - iM , 1 - fMM ,1 - iM)

The procedure involves the application of Gaussian and Triangular membership functions to linguistic variables. Gaussian functions capture smooth transitions, while Triangular functions address gradual shifts, aligning with the principles of fuzzy logic. This methodology integrates fuzzy logic principles into risk assessment, offering a versatile and adaptable approach to capture the inherent uncertainties in financial decision-making. The utilization of Gaussian and Triangular membership functions allows for a nuanced representation of risk factors, acknowledging the complexity and subjectivity of individual investor profiles.

The Gaussian membership function is a mathematical tool used in fuzzy logic to model the degree of membership of an element in a fuzzy set. It is particularly useful when dealing with uncertainty and imprecision in data.

The triangular membership function is a type of mathematical function commonly used in fuzzy logic and fuzzy systems to model the degree of membership of an element in a fuzzy set. This function is characterized by a triangular shape, and it is particularly useful when there is a clear, gradual transition between full membership and non-membership.

- Inference Engine: Apply the fuzzy rules to determine the fuzzy output. The inference engine combines the fuzzy sets defined by the rules, taking into account the degrees of membership obtained during fuzzyfication. This step involves fuzzy logical operations such as AND, OR, and implication.
 - Aggregation: Aggregate the fuzzy outputs from different rules to obtain a comprehensive fuzzy output. This step considers the multiple rules that may be applicable and combines their outputs.
- aggregated Risk = max (low Risk, medium Risk, high Risk)

- Defuzzification: Convert the aggregated fuzzy output into a crisp value. Various defuzzification methods can be used, such as centroid, mean of maximum or weighted average.

$$\text{centriod} = \frac{\text{lowRisk} * 1 + \text{mediumRisk} * 2 + \text{highRisk} * 3}{\text{lowRisk} + \text{mediumRisk} + \text{highRisk}} \quad (1)$$

RESULT AND DISCUSSION

The results obtained from the fuzzy logic-based risk assessment, leveraging both Triangular and Gaussian membership functions, unveil critical insights into the nuanced evaluation of an individual's risk-taking capability. The discussion emphasizes the importance of these membership functions in enhancing the system's interpretability, sensitivity to input variables, and adaptability to real-world scenarios.

Gaussian Membership Function

The choice of a Gaussian (normal) membership function in fuzzy logic is often motivated by its mathematical properties and its ability to model uncertainty in a smooth and continuous manner. The Gaussian function is symmetric around its mean. This symmetry aligns with the assumption that values equidistant from the mean are equally likely or valid. Symmetry can be a reasonable assumption for certain fuzzy variables, such as income or age, where deviations from the average are expected to have a similar impact in both directions. The chosen function is employed to represent the uncertainty associated with a particular variable in the system. In this context, it is utilized to model the inherent uncertainty in income. The function's mathematical properties allow for a smooth transition in values, ensuring that changes in the linguistic variable are gradual rather than abrupt. This contributes to a more realistic portrayal of uncertainty in the system. The results obtained from the function, along with those from other linguistic variables, contribute to the formulation of rules within the fuzzy logic system. These rules guide the decision-making process based on the membership values of various variables. Figure 1 shows the Gaussian membership function for sample input shown in Table 1.

Table 1. Sample Input for taken for Gaussian membership function

Age	Emergency fund	Income
25	3800	40000
Age Mean=32	Emergency Fund Mean = 4000	Income Mean=60000
Age Stddev = 8	Emergency Fund Stddev = 2000	Income Stddev = 35000

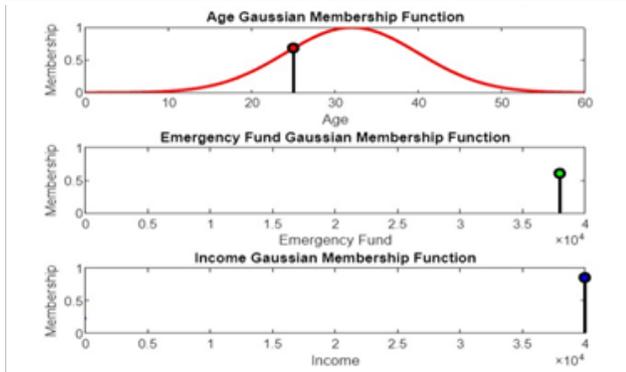


Fig. 1. Gaussian membership function graphs

Triangular Membership Function

Triangular membership functions are used to model the gradual transition of membership from non-membership to full membership for certain linguistic variables. The specific variables using triangular membership functions in this code are age and family Members. The triangular membership function is a mathematical function that assigns a membership value between 0 and 1 to an element in the variable’s range.

Age Variable

The membership value for the age variable is calculated using the calculate Triangular Membership function. The function takes the current age (x), the minimum age (ageMin), the peak age (agePeak), and the maximum age (ageMax) as parameters. The membership value is 0 for age values less than or equal to the minimum or greater than or equal to the maximum. Between the minimum and peak age, the membership value increases linearly. Between the peak and maximum age, the membership value decreases linearly.

Family Members Variable

Similarly, the membership value for the familyMembers variable is calculated using the calculate Triangular Membership function. The function takes the current

number of family members (x), the minimum number of family members (familyMembersMin), the peak number of family members (familyMembersPeak), and the maximum number of family members (familyMembersMax) as parameters.

The membership value is 0 for family members values less than or equal to the minimum or greater than or equal to the maximum. Between the minimum and peak number of family members, the membership value increases linearly. Between the peak and maximum number of members, the membership value decreases linearly.

Table 2. Input for Triangular membership Function

Age	Family Members
30	3
Age min=25	familyMembersMin =2
Age peak=32	familyMembersPeak =4
Age max=45	familyMembersMax =6

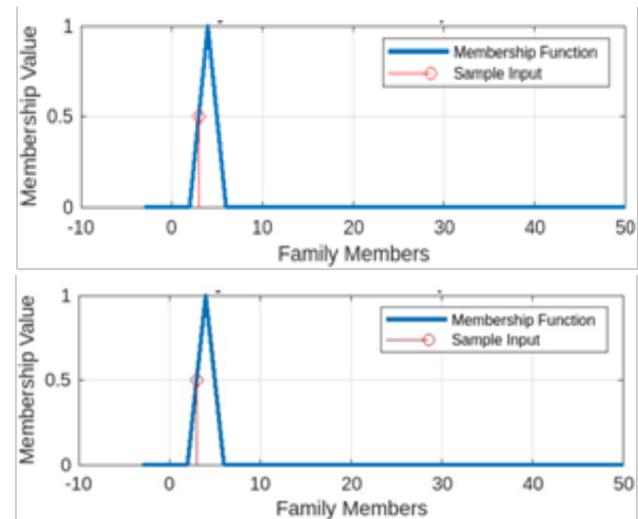


Fig. 2. Triangular membership function

Figure 2 shows the Triangular membership function for sample input shown in table 2.

Comparison between Gaussian and triangular membership

Triangular and Gaussian membership functions are both types of fuzzy sets used in fuzzy logic systems to model uncertainty or imprecision. The choice between them depends on the specific needs of the application.

Gaussian membership functions, characterized by a bell-shaped curve, provide a smoother representation

of uncertainty. They are often favored when a more nuanced and accurate modeling of membership is required. Gaussian functions are mathematically more complex than triangular ones, and their use may require additional computational resources. For risk assessment in individual investor scenarios involving factors like age, income, debt, family members, and insurance, Gaussian membership functions are often more suitable. This is because Gaussian functions provide a smoother representation of uncertainty, allowing for a more nuanced modeling of risk across multiple factors. Using Gaussian membership functions allows you to capture the distribution of risk factors in a way that reflects the real-world complexity of financial situations. For instance, income and debt levels may exhibit varying degrees of uncertainty, and Gaussian functions can better model these uncertainties with their smooth, bell-shaped curves. In contrast, triangular membership functions might oversimplify the representation of risk, potentially missing subtleties in the investor's profile.

Table 3. Sample Input

Attributes	Values
Age	30
Income	55000
Family Members	3
Emergency Fund	12000
Debts	1800
Insurance	1200

Table 4. Centroid Outputs after Defuzzification

Attributes	Values
Triangular Membership Function	2.5
Gaussian Membership Function	1.5

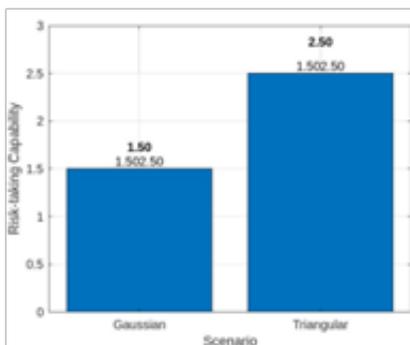


Fig. 3. Centroids obtained using Triangular and Gaussian membership function

Combined results

The use of both triangular and Gaussian membership functions allows for flexibility in modeling different types of membership distributions.

Triangular Membership Function

Triangular functions are suitable for variables that have a clear peak or central tendency. Functions like calculate Triangular Membership are used to compute the membership values for age and family members.

Gaussian Membership Function

Functions like calculate Gaussian Membership are used to compute the membership values for income, emergency fund, debts, and insurance. The combination of these two types of membership functions allows the fuzzy logic system to capture different shapes of membership distributions for different variables. Triangular functions might be appropriate for variables with clear-cut boundaries, while Gaussian functions can model variables with more continuous and gradual transitions.

Table 5. Sample Input for Combined Membership Function

Attributes	Values
Age	30
Income	55000
Family Members	3
Emergency Fund	12000
Debts	1800
Insurance	1200

Table 6. Centroids obtained

Attribute	Value
Combined Membership Function	1.5

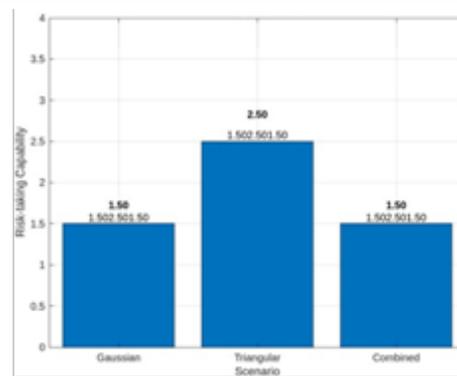


Fig. 4. Results obtain of centroid using different membership functions

This figure4 depicts that combined membership function can be helpful to find average of these outcomes. The careful selection of Triangular membership functions for age and family size and Gaussian membership functions for income, emergency fund, debts, and insurance contribute significantly to the interpretability of the risk categories. Triangular functions allow for a more intuitive understanding of risk associated with gradual changes in age and family size, while Gaussian functions provide a continuous and smooth representation of risk factors related to income and financial variables.

The choice of Triangular membership functions for age and family size reflects the understanding that these variables often exhibit a more gradual influence on risk. Triangular functions capture the uncertainty associated with these factors, providing a flexible and interpretable model. In contrast, Gaussian membership functions are employed for income, emergency fund, debts, and insurance, allowing for a nuanced representation of the inherent uncertainty in these financial dimensions.

The strategic combination of Triangular and Gaussian membership functions significantly influences the impact of fuzzy rules. The minimum operator in rule aggregation ensures that the system considers the weakest link in determining the overall risk. This approach, combined with the characteristics of the chosen membership functions, reflects a conservative decision-making strategy that accounts for the diverse nature of risk factors.

The use of both Gaussian and Triangular membership functions in the defuzzification process through the centroid method is crucial. The centroid represents the central tendency of the aggregated fuzzy values, allowing for a coherent and meaningful determination of risk categories. The complementary nature of these functions contributes to a more comprehensive understanding of the overall risk landscape. The importance of Triangular and Gaussian membership functions extends to the real-world applicability of the fuzzy logic-based risk assessment.

CONCLUSION

In conclusion, this project introduces a comprehensive fuzzy logic-based approach to individual investor share

market risk assessment, leveraging both Triangular and Gaussian membership functions. Through careful consideration of these functions' attributes, the system adeptly captures the intricate nuances and uncertainties inherent in financial variables like income, age, and family size. The results demonstrate the effectiveness of Gaussian functions in modeling gradual transitions, particularly suitable for variables with continuous distributions, while Triangular functions provide a straightforward representation for variables with clear-cut boundaries or central tendencies.

The comparison between Gaussian and Triangular membership functions underscores the strategic importance of their selection based on the characteristics of specific variables. By integrating both functions into the fuzzy logic system, the model showcases adaptability to various membership distributions, navigating the diverse landscape of individual investor scenarios. The combined membership function intelligently blends the strengths of Gaussian and Triangular functions, offering a holistic representation reflective of real-world financial complexities.

This fuzzy logic-based approach proves to be a flexible and reliable tool for decision-making and risk assessment in financial markets. Its adaptability, grounded in the complementary attributes of Gaussian and Triangular functions, positions it as a valuable asset for navigating uncertainties, variations in data patterns, and the nuanced behaviors of different variables. As the financial landscape evolves, this innovative approach offers a promising framework for addressing the complexities of individual investor risk evaluation and decision support in dynamic market conditions.

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Hybrid Genetic Algorithms and Tabu Search for Multi-Constrained Employee Scheduling

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ABSTRACT

In this paper, we proposed a hybrid approach integrating genetic algorithms and tabu search for the optimization of employee scheduling, a problem involving the assignment of employees to shifts. The complexity of the problem is compounded by its multi-constrained nature and a vast search space, classifying it as NP-hard. The problem instance considered adheres to the description provided by Millar and Kiragu, involving 8 employees, 2 shifts, and a span of 14 days. The hybridization of genetic algorithms and tabu search is employed to tackle the intricate scheduling challenge. A common solution representation and objective function are adopted to facilitate a comprehensive comparison of the performance of these two techniques. The study evaluates the application of tabu search with problem-specific initialization against a genetic algorithm with a knowledge-augmented operator. Preliminary findings reveal that tabu search, particularly when initiated with a problem-specific configuration, outperforms the genetic algorithm equipped with the knowledge-augmented operator. This performance advantage is evident in both the quality of solutions obtained and the efficiency of the algorithms in terms of execution time. The research highlights the potential of tabu search, especially when tailored to the problem at hand, to yield superior results in the context of employee scheduling. The observed comparative advantage positions tabu search as a promising technique for addressing NP-hard scheduling problems with multi-constraints, shedding light on its efficiency and efficacy in optimizing complex real-world scheduling scenarios.

KEYWORDS: *Employee scheduling, Hybrid genetic algorithm, Scheduling, Tabu search, Timetabling.*

INTRODUCTION AND RELATED WORK

The Employee Scheduling Problem (ESP) encapsulates the difficulty of devising an optimal schedule for a workforce, considering a multitude of constraints and objectives. This issue is particularly pervasive in industries characterized by a substantial workforce, necessitating the assignment of employees to diverse tasks, shifts, or locations while adhering to specified rules and requirements. The complexity of the ESP arises from the need to strike a balance between efficient resource utilization and the fulfillment of operational and organizational constraints, all while ensuring employee satisfaction and adherence to legal and regulatory standards. Industries such as healthcare, retail, and hospitality commonly grapple with the

intricate task of solving the Employee Scheduling Problem to enhance overall operational efficiency and meet both business and employee needs.

Key components of the employee scheduling problem include:

- **Shifts and Assignments:** Determining which employees should be assigned to which shifts or tasks.
- **Constraints:** Taking into account various constraints such as labor laws, contractual agreements, employee preferences, and skill requirements.
- **Objectives:** Balancing conflicting objectives, such as minimizing labor costs, ensuring fairness in assignments, and meeting operational demands.

Applications of employee scheduling problem are elaborated below.

- Retail: In retail settings, employees need to be scheduled based on peak business hours, and the schedule must comply with labor laws and individual preferences.
- Healthcare: Hospitals and healthcare facilities face the challenge of scheduling nurses, doctors, and other staff to ensure 24/7 coverage, considering individual skills and compliance with regulations.
- Manufacturing: In manufacturing environments, employee scheduling is crucial for maintaining production continuity and efficiency.
- Customer Service: Call centers and customer service operations must schedule employees to handle customer inquiries and support requests efficiently.
- Transportation: Airlines, public transportation, and delivery services need to schedule pilots, drivers, and other personnel to meet service demands.

Scheduling problems are renowned for their inherent complexities, primarily stemming from their vast search space, strict constraints, intricate representation challenges, dynamic nature, and the myriad variations found across different domains and applications [1-2]. The complexity of the Employee Scheduling Problem (ESP) arises from a multifaceted interplay of diverse factors that demand intricate considerations in the creation of optimal workforce schedules. The presence of numerous constraints, including legal regulations, union rules, and individual preferences, adds layers of intricacy to the scheduling process. Moreover, the dynamic nature of workplaces, marked by fluctuating demands and unforeseen events like employee absences, requires schedules to be adaptable and resilient. Conflicting objectives, such as minimizing costs while ensuring fairness and compliance, introduce a layer of complexity that organizations must navigate. Additionally, the sheer size of the solution space, which grows exponentially with the number of employees, shifts, and constraints, poses a computational challenge. As a result, solving the ESP involves coping with a computationally complex task that often necessitates the application of optimization algorithms or heuristics to

explore and find solutions within this intricate landscape efficiently. The complexity inherent in personnel scheduling underscored the significance of thoughtful and sophisticated approaches to address the scheduling needs of modern, dynamic workplaces. The optimization of personnel scheduling, often categorized as NP-hard combinatorial problems, poses a significant challenge in achieving optimal solutions and high-quality schedules [3]. The need for automated personnel scheduling spans various industries, demanding the generation of work schedules that adhere to legal, organizational, and personal constraints for organizational staff. The heightened attention to personnel scheduling in recent years is attributed to the increasingly service-oriented and cost-conscious nature of businesses. Service-centric sectors such as transportation (including airport ground operations, railways, and bus personnel), call centers, healthcare with the complexities of personnel scheduling [3]. A comprehensive review in [4], spanning literature from 1950 onwards, examined over 700 papers related to personnel scheduling. Ernst and collaborators meticulously categorized these papers based on the addressed problem types, explored application areas, and the methodologies employed [4]. Noteworthy application areas such as bus scheduling, nurse scheduling, and airline scheduling have been the focal points of substantial research attention over the past few decades. In their work [3], delivered a thorough review of staff scheduling and rostering, providing insights into applications, methods, and models. Additionally, [5] conducted an in-depth survey with a specific focus on the nurse rostering problem. Their survey covered commonly used terminologies, solution approaches, and key issues associated with nurse rostering.

Solving personnel scheduling challenges has been the focus of various research papers, with a common objective of minimizing total labor costs [6]. Soukour et al. [7] extended this perspective by attempting to minimize overtime costs alongside undertime, under-coverage, and employee dissatisfaction costs. Studies [8] and [9] considered an upper limit on the number of days employees should work per week. A limited number of studies considered RD preferences, such as [10] for nurses and [11] for security staff, with a focus on maximizing employee satisfaction by allowing them to choose their preferred shift and RD. Paper [12] employed

a 4-module iterative algorithm in their study to optimize shift schedules and break times with the primary aim of minimizing overstaffing and understaffing costs. The iterative algorithm utilized by the researchers was designed to refine the scheduling solutions through multiple iterations, likely incorporating feedback from prior runs. In a parallel effort, [13] developed a model using the goal programming method to optimize shift schedules, taking into account employee preferences. This approach involved formulating and solving a mathematical model with the specific goal of satisfying multiple objectives, including the consideration of individual employee preferences.

In recent years, advanced optimization techniques have gained prominence in addressing ESPs, as manual scheduling processes often fall short in achieving optimal results. Among these techniques, Genetic Algorithms (GAs) and Tabu Search (TS) have emerged as powerful metaheuristics for solving intricate scheduling problems, including ESPs. These algorithms offer the ability to explore extensive solution spaces, adapt to dynamic scheduling environments, and effectively manage various constraints.

This study aims to compare the performance of Genetic Algorithms and Tabu Search in generating high-quality schedules that meet the requirements of the Two Shift ESP. The research specifically focuses on evaluating their efficiency in terms of solution quality, computational speed, and their ability to balance both hard and soft constraints. The outcomes of this investigation provide valuable insights into the capabilities of these algorithms for addressing the Two Shift ESP, offering guidance for organizations seeking to enhance their employee scheduling processes.

In the rest of this paper, section 2 gives the overview of the problem formulation. Section 3 describes the hybrid genetic algorithm and tabu search to solve this problem. Section 4 briefly describes the input datasets and obtained results. Finally, conclusion of paper in section 5.

PROBLEM FORMULATION

The scheduling problem presented here was described by Millar and Kiragu [14] and Ikegami and Niwa [15]. It was framed as an assignment problem, wherein the

required numbers of employees, planning period, and the requirement per day per shift were known in advance. The task involved assigning employees to shifts while satisfying predetermined constraints.

In the context of optimization problems, including the Employee Scheduling Problem (ESP), constraints play a crucial role in defining the feasible solution space. Hard constraints and soft constraints are two types of constraints that are used to model different aspects of the problem and guide the optimization process.

Hard Constraints: Shift Staffing Constraint

This constraint ensures that every shift of the day must be allotted the required number of personnel from the provided employees. It is expressed as:

$$\sum_i X_{ij} = \text{required number of employees for shift } j, \forall j$$

This constraint guarantees that the minimum staffing requirements for each shift are met. A violation of this constraint would make the solution infeasible.

Soft Constraints

- Every Employee Works Exactly Seven Days.

This constraint ensures that every employee works for exactly seven days.

$$\sum_j X_{ij} = 7, \forall i$$

- Minimum of 3 Night Shifts: Employees must work a minimum of 3 night shifts.

$$3 \leq \sum_{j(\text{night shift})} x_{ij} \leq 4, \forall i$$

- Maximum of 4 Night Shifts: Employees must not work more than 4-night shifts.

$$3 \leq \sum_{j(\text{night shift})} x_{ij} \leq 4, \forall i$$

- Minimum of 3 Day Shifts: Employees must work a minimum of 3 day shifts.

$$3 \leq \sum_{j(\text{day shift})} x_{ij} \leq 4, \forall i$$

- Maximum of 4 Day Shifts: Employees must not work more than 4 day shifts.

$$[3 \leq \sum_{j(\text{day shift})} x_{ij} \leq 4, \forall i]$$

- One Weekend Off: Every employee should get at least one weekend off:

$$\sum_{j(\text{weekend shift})} x_{ij} \leq 2, \forall i]$$

- Minimum of Two Consecutive Working Days: This constraint allows employees to have a minimum of two consecutive working days.

$$X_{i(j-1)} + X_{ij} \leq 1, \forall i, \forall j > 1]$$

- Preventing Five or More Consecutive Days Off: This constraint prevents employees from having five or more consecutive days off, which can disrupt the schedule.

$$\sum_{k=j}^{j+4} (1 - \sum_i X_{ik}) \leq 4, \forall j]$$

- Preventing Five or More Consecutive Working Days: This constraint prevents employees from working for five or more consecutive days, reducing the risk of burnout.

$$\sum_{k=j}^{j+4} (\sum_i X_{ik}) \leq 3, \forall j]$$

- Preventing Four or More Consecutive Working Days: This constraint prevents employees from working for four or more consecutive days.

$$\sum_{k=j}^{j+3} (\sum_i X_{ik}) \leq 3, \forall j]$$

- Specific Pattern Avoidance: This constraint prevents a specific pattern of four working days followed by a day off and another working day:

$$\sum_{k=j}^{j+4} (\sum_i X_{ik}) \leq 3, \forall j]$$

- Consecutive Night Shift and Day Shift Avoidance: This constraint ensures that employees do not have to switch between night and day shifts on consecutive days.

$X_{i(j-1)} + X_{ij} \leq 1, \forall i, \forall j$ where j is a night shift and $j+1$ is a day shift]

All variables X_{ij} binary (0 or 1) in this integer programming formulation. The objective function aims to minimize deviations from the soft constraints,

ensuring a schedule that balances employee preferences and meets the hard constraints for shift staffing. This formulation can be solved using integer programming solvers to generate an optimized workforce schedule.

Objective Function

The objective function seeks to minimize the deviations from the soft constraints. It is defined as the sum of deviations for each employee and each shift from the soft constraints.

Objective Function = $\sum_i \sum_j$ (deviation in soft constraints for employee i on shift j)

This objective function aims to create a schedule that best satisfies the soft constraints.

METHODOLOGY

Solution Representation and Objective Function

The scheduling problem presented involved assigning personnel to shifts over a planning period spanning multiple days. The solution representation adopted was personnel-oriented, as depicted in Figure 1, where each row represented an individual personnel, and each column corresponded to a day within the planning period. The cells in this representation contained values indicating the assigned shift for each personnel on a given day. In particular, “0” denoted a day off, “1” signified a day shift, and “2” indicated a night shift.

Personnel	Shift		
	Day 1	...	Day D
P1	0	...	1
P2	1	...	2
:	
P _{N-1}	2	...	0
P _N	1	...	0

Fig. 1 A Solution Representation

By using this objective function, the optimization algorithm can aim to minimize the total objective score, which, in turn, encourages the discovery of solutions that not only satisfy the hard constraints but also seek

to minimize violations of the soft constraints. This approach allows for the fine-tuning of schedules to balance the requirements of the problem, ultimately leading to schedules that are both feasible and of high quality.

To address the complexity of generating feasible solutions, genetic algorithms and tabu search algorithms are applied to the two-dimensional solution representation. However, one challenge with this representation is the potential generation of infeasible solutions, where constraints related to shift assignments and other requirements may be violated.

To handle this issue, a combination of techniques is employed:

- **Penalty Mechanism:** When the algorithms generate infeasible solutions, a penalty mechanism can be applied. This involves assigning penalty values to the infeasible solutions to discourage their selection as optimal solutions during the search process. These penalties are typically proportional to the degree of constraint violation, and they influence the algorithms to favor feasible solutions.
- **Knowledge Augmented Repair Operator:** In addition to penalties, a knowledge-augmented repair operator can be used to transform infeasible solutions into feasible ones. This operator relies on domain-specific knowledge to modify the schedule assignments in such a way that they satisfy all the constraints. It can be designed to make intelligent decisions regarding shift reassignments and allocations, ensuring that the resulting schedule adheres to the hard and soft constraints.

Hybrid Genetic Algorithms

Genetic Algorithms (GAs) inspired by natural selection and genetic principles [16]. Operating without the need for problem-specific information, GAs excel in addressing highly constrained, combinatorial optimization problems with extensive search spaces. These algorithms simulate the evolutionary process in each generation, evaluating a population of individuals representing potential solutions. Key features include competition among individuals, where those with above-average fitness produce more offspring, leading to exponential acceleration in the search process. The

propagation of genes from “good” individuals ensures successive generations become increasingly well-adapted. Three operators—Selection, Crossover, and Mutation—drive the evolutionary process. GAs exhibit strengths in intrinsic parallelism, making them suitable for vast and intricate search spaces. They are effective in handling problems with multiple objectives, offering a versatile approach to optimization challenges. The combination of randomness and structured evolution in GAs positions them as powerful tools for addressing complex problems where traditional algorithms may face limitations.

Hybrid genetic algorithms integrate genetic algorithm principles with other optimization techniques to enhance overall performance by compensating for individual limitations [16]. This hybridization combines the strengths of different algorithms, leading to superior solutions in terms of convergence speed and solution quality. By integrating genetic algorithms with methods like local search or heuristics, the hybrid approach exploits each component’s strengths. Genetic algorithms excel at global exploration and maintaining diversity, while other algorithms may efficiently refine solutions locally. Hybridization allows the algorithm to balance exploration and exploitation, enhancing adaptability and robustness. This versatility enables the hybrid genetic algorithm to find high-quality solutions across various optimization problems. Integrating diverse techniques results in improved convergence rates, enhanced solution quality, and increased effectiveness in solving complex optimization problems compared to standalone algorithms.

The steady-state genetic algorithm described here utilizes overlapping populations. This technique is frequently employed in genetic algorithms to guarantee diversity within the population and foster exploration of the solution space. In this algorithm, various genetic operators are applied to evolve the solutions. These operators include:

- **Selection:** The algorithm tests different selection mechanisms, and it has been found that roulette wheel selection is more effective than tournament selection. Roulette wheel selection assigns individuals a probability of being chosen for reproduction based on their fitness. This approach

allows for a probabilistic selection process favoring better-performing individuals.

- Crossover: The algorithm experiments with different crossover methods and observes that EvenOdd crossover with a probability of 0.9 performs better than OnePoint crossover and uniform crossover. EvenOdd crossover involves swapping genes between two parent individuals, resulting in two offspring. It is a way of recombining genetic material to create new solutions.

Algorithm 1: Proposed Hybrid Genetic Algorithm

```

InitializePopulation()
EvaluatePopulation()
while not TerminationConditionMet() do:
    SelectedParents = RouletteWheelSelection()
    Offspring = EvenOddCrossover(SelectedParents)
    Offspring = FlipMutation(Offspring)
    Evaluate(Offspring)
    ReplaceWeakestIndividualWith(Offspring)
    ApplyRepairOperator()
    EvaluatePopulation()
end while
BestSolution = FindBestSolution()
return BestSolution

```

- Mutation: Flip mutation with a probability of 0.02 is found to be more effective than swap mutation. Flip mutation involves changing the value of a gene (e.g., from 0 to 1 or vice versa), introducing randomness in the population.
- While the genetic operators are effective in generating new solutions, there is a recognition that some of these operations may produce individuals that do not adhere to the problem's constraints. To address this, a repair operator is introduced, which leverages problem-specific knowledge. The primary objective of this repair operator is to improve the quality of solutions and enhance convergence speed by addressing constraint violations more effectively than simple penalization. The repair operator is applied after the standard genetic operators. It does

so by locating task assignments that are in violation of the problem's constraints and subsequently searching for suitable task assignments, typically involving part-time employees on the same day, to swap with the incorrect assignments. This swap operation helps in generating solutions that are closer to feasibility. It is important to note that while the repair operator improves the quality of solutions, it may not necessarily produce completely feasible solutions in all cases. However, its introduction is found to be beneficial for optimizing laboratory personnel timetabling, and it contributes to finding schedules that are more practical and align with the constraints of the problem. This repair operator is a valuable addition to the genetic algorithm, as it allows for the correction of constraint violations in a manner that is tailored to the specifics of the scheduling problem. This repair operator is also found good for laboratory personnel timetabling [17].

Tabu Search

This method, grounded in neighborhood search algorithms, exhibits versatility and applicability across a wide spectrum of optimization challenges. The typical problem addressed by tabu search involves optimizing a function $f(x)$ under the constraint that x belongs to the set X [18]. Tabu search's fundamental principles are tailored to navigate through solution spaces efficiently, overcoming obstacles like local optima. Tabu search employs a memory mechanism to prevent cycling back to previously visited solutions, designating specific moves as tabu to avoid revisiting the same regions of the search space [19, 20].

Basic terminology in tabu search includes,

- Neighborhood Structure: This neighborhood is pivotal for exploring potential improvements.
- Tabus: Tabus are constraints on certain moves designed to prevent cycling and stagnation. If reversed, these moves would negate the effects of recent moves.
- Tabu List: A short-term memory storing tabus, often implemented as a circular list of fixed length, aids the search in avoiding revisiting the same solutions.

- Probabilistic Tabu Search: Addressing the computational burden associated with evaluating every element of the neighborhood, probabilistic tabu search introduces randomness to the search process.

Algorithm 2: Probabilistic Tabu Search

```

Initialize()
NeighborhoodStructure(currentSolution)
ExplorationLimits()
TabuList()
ProbabilisticTabuSearch()
    Initialize()
    currentSolution = InitialSolution
    while not TerminationConditionMet() do:
        bestSolution = currentSolution
        for i from 1 to ExplorationLimits():
            newSolution = Neighborhood Structure
            (currentSolution)
            if newSolution > bestSolution && !TabuList()
                bestSolution = newSolution
                currentSolution = bestSolution
            TabuList()
        end while
    return bestSolution
    
```

The implementation of the probabilistic tabu search algorithm for solving the employee scheduling problem represents a methodology that combines various strategies to efficiently explore the solution space while satisfying hard constraints. Let’s delve deeper into the details of this methodology:

- Initialization Procedure: The algorithm begins its search process from a carefully selected starting point. This starting solution is chosen to ensure that it adheres to a critical hard constraint in employee scheduling: that every shift must be allocated the required number of employees. This constraint compliance guarantees that the initial solution is feasible. It avoids the need to start from a random or potentially infeasible position, saving computational resources and time.

- Neighborhood Structure: The neighborhood structure is a fundamental component of tabu search. In this algorithm, the neighborhood is defined by a swap move. A swap move involves randomly selecting any two task assignments and exchanging their values. This operation generates a new solution that represents a different assignment of employees to shifts. The swap move is a simple but effective way to explore the solution space, allowing for local search and improvements in solution quality.

- Exploration Limits: To maintain focus and prevent excessive computational overhead, the algorithm restricts the number of swap moves applied to the current best solution. Specifically, a maximum of ten swap moves is allowed to generate a new solution. This limitation ensures that the search process remains efficient and that the algorithm does not become overly exploratory, which could lead to diminishing returns.

- Tabu List: A critical feature of the algorithm is the use of a tabu list. The tabu list operates as a circular list with a fixed length of 20. It serves as a memory mechanism to keep track of moves that have been declared as tabu. Tabu moves are temporarily prohibited to avoid revisiting the same solutions and entering cycles. As the list reaches its maximum capacity, the algorithm removes the oldest tabu move based on a “first come, first served” basis. This strategy ensures that the algorithm maintains diversity in its exploration and does not get trapped in repetitive patterns. The tabu list is an essential component of tabu search, providing a balance between exploration and exploitation. It guides the algorithm to move towards promising regions of the solution space while avoiding revisiting unpromising or previously explored areas.

DATASET, RESULTS AND DISCUSSION

The problem instance provided by Millar and Kiragu entails a 2-shift scheduling problem involving day and night shifts for a workforce comprising 8 employees over a span of 14 days [21]. This scenario is characterized by a substantial problem size, determined by the number of decision variables (x_{ij}), calculated as 8 × 2 × 14 =

224. Additionally, the constraints, encompassing both hard and soft constraints, contribute to the overall complexity of the problem. As the dimensions of the problem, including the number of employees, days, and shifts, increase, the problem’s size expands exponentially, resulting in a larger solution space with an increased number of potential assignments. The exponential growth in the solution space, represented by 2^{224} , presents a computationally challenging environment, underscoring the difficulty of finding an optimal solution. Table 1 shows the obtained best result. The comparison centers around the rate of convergence, which is a crucial metric when evaluating the performance of optimization algorithms. The exponential growth in the solution space is a critical factor contributing to the computational complexity

of solving the problem. With each x_{ij} variable capable of assuming two values (0 or 1), the total number of potential solutions rises exponentially, creating a solution space of astronomical proportions. The exploration of this extensive solution space to identify an optimal or near-optimal solution necessitates the implementation of sophisticated algorithms and heuristics. Intelligent exploration methods become indispensable for efficiently navigating the solution space, ensuring the identification of schedules that adhere to the specified constraints and requirements. This inherent complexity underscores the significance of advanced computational techniques to address the intricacies of the 2-shift scheduling problem described by Millar and Kiragu [14], as well as its scalability to larger instances.

Table 1. Obtained best solution

Emp/ Day	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇	D ₈	D ₉	D ₁₀	D ₁₁	D ₁₂	D ₁₃	D ₁₄
P ₁				D	D			D	D			N	N	N
P ₂	N	N			D	N	N			D	D			
P ₃			N	N		D	D	N			D	N		
P ₄	D	D			N	N	N			D	N			
P ₅	N	N	N					D	D				N	N
P ₆	D	D	D					D	N				N	N
P ₇			D	D		D	D			N	N	N		
P ₈				D	D				D	N		D	N	N

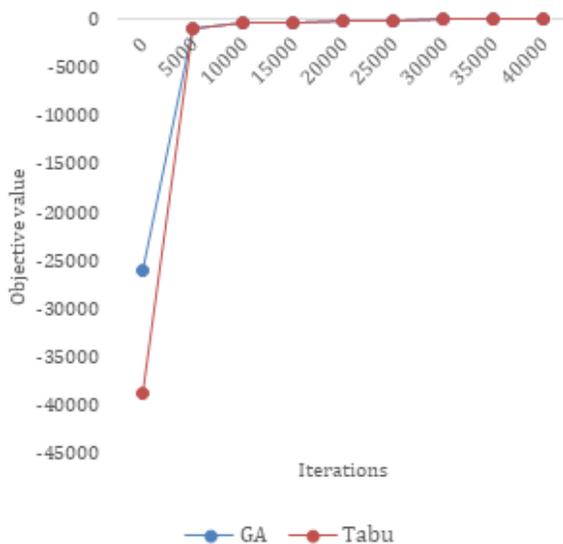


Fig. 2 Convergence of Hybrid GA and Tabu

- Rate of Convergence: In this case, the rate of convergence is assessed based on the number of generations or iterations required for the algorithms to reach a high-quality solution.
- The study examines the performance of Tabu Search and a Hybrid Genetic Algorithm through 10 independent runs initiated with different random seeds. The results suggest that Tabu Search consistently outperforms the Hybrid Genetic Algorithm in terms of convergence speed (shown in fig. 2).
- The analysis reveals that the Genetic Algorithm experiences a slow rate of convergence. After 5000 generations, there is only marginal improvement in the quality of the best solution, and beyond 10000 generations, no further progress is observed. This implies that the Genetic Algorithm, as implemented

for this specific problem instance, struggles to efficiently approach the optimal solution and may stagnate in terms of improvement.

- In contrast, Tabu Search demonstrates efficient convergence. It commences the search with an initial solution that falls within a specific range of objective values, primarily due to the problem-specific initialization method employed. The key observation is that Tabu Search consistently outperforms the Hybrid Genetic Algorithm, reaching the best solution before the 5000-generation mark.
- These findings have significant implications for selecting an appropriate optimization technique for the given problem instance. Tabu Search appears to be a more effective and efficient choice, particularly when rapid convergence to the best solution is a priority. However, it's essential to consider that the relative performance of optimization algorithms can vary depending on the specific problem, its constraints, and other factors. The study highlights the importance of empirical evaluation and selection based on the problem at hand.

CONCLUSION

In this paper, we address the complex problem of employee scheduling as described by Millar and Kiragu [14] and Ikegami and Niwa [15]. The study focuses on utilizing hybrid genetic algorithms and tabu search as potent search techniques for solving multi-constrained scheduling problems. Our results demonstrate the efficacy of these methods in finding solutions that meet the intricate requirements of the given scheduling scenarios.

Genetic algorithms, coupled with a carefully designed repair operator within the algorithmic framework, exhibit robust performance by mitigating the risk of premature convergence. The standard components of selection, crossover, and mutation work in tandem with the repair operator, enhancing the genetic algorithm's ability to navigate the solution space effectively. In the specific problem instance considered, our results indicate that probabilistic tabu search, particularly when initiated with a partially feasible solution, outperforms hybrid genetic algorithms. The utilization of tabu

search, with its inherent ability to explore and exploit the solution space while avoiding revisiting previously examined solutions, contributes to the attainment of superior results in comparison to the hybrid genetic algorithms employed.

The findings of this study highlight the importance of selecting appropriate search techniques for addressing multi-constrained scheduling problems. The synergy between genetic algorithms and tabu search, along with the strategic incorporation of a repair operator, emerges as a powerful strategy for overcoming the complexities inherent in employee scheduling. As such, this research provides valuable insights into the optimization of scheduling problems and contributes to the ongoing discourse on the selection and implementation of effective algorithms for real-world scheduling challenges.

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An Optimized Way for Implementation of Round-Robin-Algorithm for Process Scheduling

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ABSTRACT

The main aim of this research study is to provide a novel round robin scheduling method that will increase CPU effectiveness in real-time and time-sharing operating systems. For CPU scheduling, there are numerous algorithms available. However, due to high context transition rates, long waiting times, long reaction times, long turn-around times, and low throughput, we are unable to implement in real-time operating systems. The suggested technique eliminates every flaw in the straightforward round robin architecture. The paper also compares the suggested algorithm with a straightforward round robin scheduling approach. The recommended architecture fixes the problems caused by basic round robin architecture by appropriately decreasing the performance parameters and subsequently increasing system throughput.

KEYWORDS: CPU scheduling, Response-time, Round Robin CPU scheduling algorithm, Turnaround-time, Waiting time.

INTRODUCTION

Round Robin is one of the very first algorithm that using time-sharing and provided great results. The processes in this manner share the CPU time by giving each one a quantum time slice of time (Qt). If a process execution is completed and it requires more time to complete then it is move to the last of the queue. Other processes repeat this process till it is finished with their execution. In addition, a process will be deleted from the ready queue once it has finished running. The quantum is the only factor that affects how effective the RR method is. The algorithm will frequently transform into an FCFS algorithm if the quantum size is too large. The approach will run poorly and increase the overhead brought on the context changes while the Qt is too small. In order to improve performance, choosing the quantum time size is a crucial factor that should be taken into account. The RR algorithm has also been used in other situations. It is used in CPU scheduling, as was already said, to distribute CPU time among tasks. Additionally, it is utilized in the cloud computing environment to enhance system speed and the user's quality of service (QoS). It is used on two levels: the first is when assigning

resources for tasks, and the second is when scheduling CPU time in the VM among the activities.

Multiprogramming aims to increase CPU usage by allowing multiple programmes to execute simultaneously. A crucial working framework is planning. Wastefulness in multiprogramming figure frameworks is typically brought on by improper CPU use.

The most efficient use of CPU can be achieved in multi-programming frameworks by switching the CPU between holding up processes in the memory and running some function continuously. Which administrative procedure should be chosen next is a crucial decision because it affects how effectively the administration is run. It affects how useful the structure is in practise. For CPU scheduling, there are numerous algorithms available. However, due to high context transition rates, long waiting times, long reaction times, long turn-around times, and low throughput, we are unable to implement it in real-time operating systems. This Paper focuses on the existing modifications done on round-robin algorithm for process scheduling. These

techniques eliminates every flaw in the straightforward round-robin architecture. The paper also compares the algorithms with a straightforward round-robin scheduling approach.

The paper has the following structure, Section II provides a concise overview of the existing literature and tools available for the analysis of CPU metrics, Section III illustrates the different graphs and diagrams used to support the ideas presented in this paper, Section IV discusses the methodology of implementation in detail and finally Section V provides a conclusion outlining the key points of the entire paper.

LITERATURE SURVEY

The Round Robin algorithm effectively adapts to the change in time slice under many circumstances. The RR CPU scheduling algorithm's time quantum has been adjusted in some works. The review components of various authors' opinions are discussed in this section. Basically, the literature research reveals several claims on Round Robin. The round robin algorithm has undergone much development to modify its time slice. Researchers have over time created a variety of CPU scheduling algorithms that are employed for predictable CPU allocation. The following is a list of some of the significant works.

In the paper [1], which compromises of algorithm that uses shortest remaining burst time, the author offered a method SRBRR. Here the time quantum depends upon the BT of all process present in queue. median is taken as time for all the process in the queue. The use of this Technique is carefully studied to make provide good results.

The and algorithms can be coupled to form a time quantum, which can occasionally improve the scheduling approach [2]. A round robin method with a doubled time quantum over its previous time quantum was introduced by Ajit Singh et al. A dynamic time quantum's mean average value is investigated [4].

Modulus Technique can also be used to define time quantum of Round Robin [5]. To improve performance, Mohanty and other researchers created a number of round robin process scheduling techniques [6]. One

algorithm was created by combining a priority-based algorithm and RR [7], and another was created by combining SJF and RR [8].

An improvised RR Scheduling Algorithm for CPU Scheduling gives the process a enough amount of time to process and increase the queue size then move to new cycle. The RR algorithm uses a self adapting technique to set the depending upon the burst in the queue [9].

The above-discussed better Round Robin CPU scheduling is an example of some findings. The time-quantum is seen in a simple manner in the maximum enhanced round robin algorithm. As a result, many processes in the ready queue are starved to death and some processes have longer wait times. On the other hand, context flipping occurs far more frequently in a dynamic time quantum technique. Due to these restrictions, the author came up with a novel concept that minimizes context switching and manages the time quantum dynamically [10].

As the paper in [11] one processor in the CPU is mainly used to CPU intensive work and one is used for input and out put operation work. When two CPU's are used, this outperforms [4]. Adaptive Quantum is a revolutionary round-robin-based operating system scheduling technique. The TQ is the average of the all the BT it the queue. [12], and this number is then assigned as a dynamic time quantum.

RR provided more CPU utilization can be obtained by combining the shortest renaming time and standard RR algorithm. Time (SRT) approach and the RR algorithm [12]. Each time a new process enters the SRT algorithm, preemption is a possibility, and then the with lowest burst time int the queue is selected to run. The process having longest burst time has to wait for longer time and going into starvation state due to SRT. The fundamental difference between Efficient RR and SRT is that preemption with Efficient RR is only visible at the cycle. The operation with the smallest amount of BT left is always selected at the end of the cycle [9].

Each task is cyclically allotted a specific time slot with the aid of the CPU scheduling method known as Round Robin. In essence, it is the preemptive mode of the First come First serve CPU Scheduling algorithm. Circle Robin In general, CPU algorithms emphasize the Time

Sharing approach. Time quantum refers to the amount of time that a process or job is permitted to operate when using a preemptive technique.

There have been other uses for the RR algorithm. As was already said, it is utilized to distribute CPU time among jobs during CPU scheduling. In the cloud computing context, it is also used to improve system performance and user service quality (QoS). It is utilized when allocating resources for jobs and allocating CPU time in the VM among the various tasks on two different levels.

Every process or job in the ready queue is given a CPU for the duration of that time quantum; if the process is finished running during that time, the process ends; otherwise, the process returns to the waiting list and waits for its turn to run again.

The Round R CPU Algorithm has the following advantages: It is logical, easy to implement, and starvation-free because each task is allocated an equal amount of CPU time. One of the most often used methods for CPU scheduling is the core approach. Because processes are never given the CPU for more than a small amount of time, it is preemptive. Context switching costs rising is not good.

Round Robin CPU Scheduling Algorithm Benefits:

1. Since each process receives an equal part of the CPU, there is justice.
2. A round-robin scheduler typically uses time-sharing, allocating a time slot or quantum to each job.
3. A specific time quantum is allocated to various tasks when round-robin scheduling is used.
4. In this scheduling, each process has an opportunity to reschedule after a specific quantum time.

Round Robin CPU Scheduling Algorithm drawbacks:

1. The throughput is low.
2. Context switches exist.
3. If quantum time is less important for scheduling, the Gantt chart appears to be too large.
4. For instance: 1 ms for extensive scheduling.)
5. Scheduling for small quantum numbers takes a lot of time.

Figures 1, 2, and 3 shows comparison of average waiting time, turnaround time, and number of context switches variable time quantum scheduling method of simple RR CPU Scheduling Technique with varying time quantum.

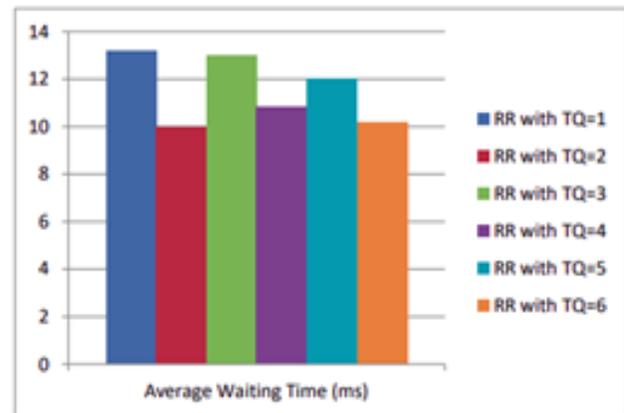


Figure 1. AWT & TQ Graph

Figure 1 show the average waiting time for Normal Round Robin with different Time Quantum. It is seen that changing the Time Quantum does effects the average waiting time of the Round Robin algorithm.

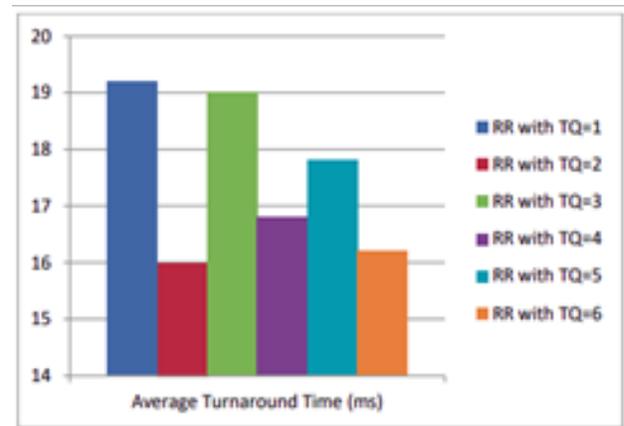


Figure 2. Average Turnaround Time& Time Quantum

Figure 2 represent the dependence of Time Quantum to the average Turn Around time. We can see the as time quantum increases the average turnaround time decreases.

Figure 3 shows the relation between the Time Quantum and the Number of Context Switches. Studying the Number of Context Switches of the algorithm is important as it use both same and computation for

context switch, which can be one of the major factor for optimizing the algorithm.

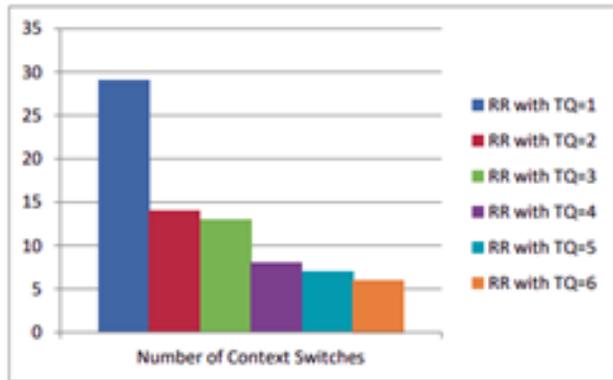


Figure 3 Context Switches & Time Quantum

METHODOLOGY

The present Round Robin configuration gives each process a fixed time slot that is assigned cyclically. It is essentially the First come First Serve CPU Scheduling method in preemptive mode. Round Robin In general, CPU algorithms emphasize the Time Sharing approach.

Time quantum refers to the amount of time that a process or job is permitted to operate when using a preemptive technique. Every process or task in the ready queue is given a CPU for the duration of that time quantum; if the process is finished running during that time, the process ends; otherwise, the process returns to the waiting list and waits for its turn to run again.

The current implementation has many benefits, but there are some drawbacks as well. For example, if 500 processes are waiting in a ready queue to use the CPU, if one of those processes is given access to the CPU, and then after some time passes, the process is about to finish, it will only take a few milliseconds of CPU processing to finish. Even so, it returns to the top of the ready queue.

Although the job now just needs a few milliseconds of CPU processing, it must still wait for 500 time quantum or so before it can request the CPU once again because each task in the queue takes a time quantum or so to finish. This lengthens the process’s waiting period. The method would be much improved if we could, for example, give a way to all such processes that just need a minute or so of CPU time to complete

but instead had to wait for the entire queue of processes to finish. We developed a straightforward solution to the same problem, which involves using two queues in the algorithm rather than simply one. One queue will function as the customary ready queue, while the other will represent a process that was on the verge of completion but was halted by time constraints.

PROPOSED SYSTEM

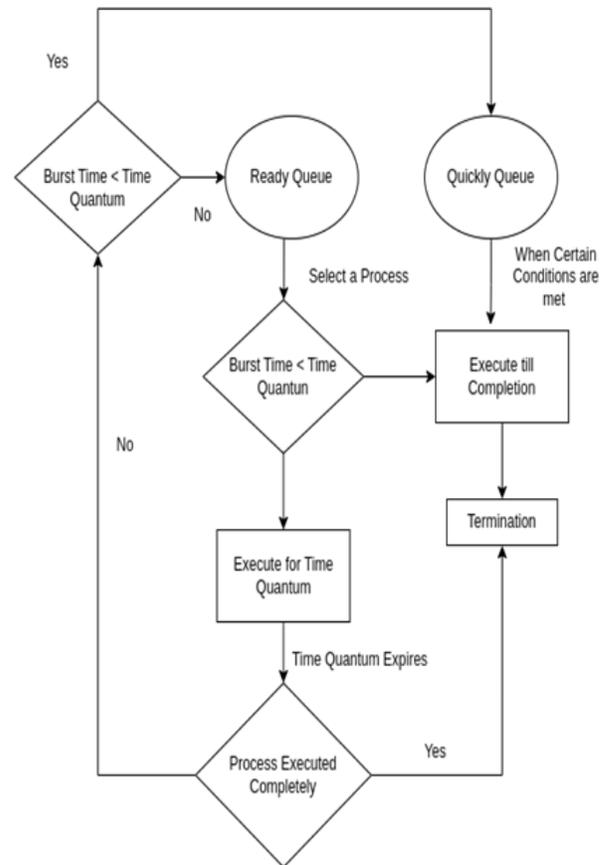


Figure 4 Proposed System

Let us consider two queue named RQ for ready queue and QQ for Quickly queue, basically its the queue of the process that can finish quickly if CPU is allotted to them.

Let us consider 100 of process having random Burst Time (BT). Let’s keep a pointer P that is point to the queue which is been processed. At first the pointer will be pointing to the RQ and works as usual Round Robin Algorithm, but if suppose it come across such a process whose turn if finished and is about to be

moved at the back of RQ we will have a simple check if If the algorithm's remaining time quantum is smaller than its own, we shall transfer the process into the QQ rather than the RQ. After, let's N time quantum the pointer moves to the QQ then its start process in the QQ as usual Round Robin Algorithm. And again after M time quantum or if the QQ is empty we will more back to RQ. Here one important thing is to make sure the the switching time N & M are not too small or not too big, because if its too small the context switching will increase which will slow down the algorithm and increase the space required. And if they are too large it will increase the waiting time which will again slow down the algorithm.

Important formulas for Round Robin,

$$TAT = CT - AT,$$

where TAT is Turn around time, CT is Completion Time & AT is arrival Time.

$$WT = TAT - BT$$

where WT is wait time and BT is the Burst Time

RESULTS AND DISCUSSIONS

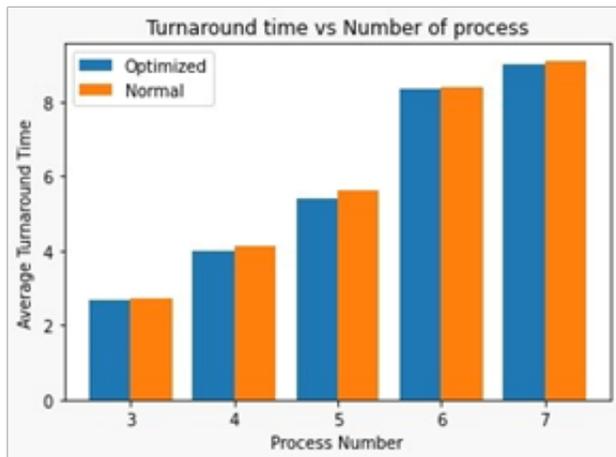


Figure 5 Optimized Normal Comparisons Turnaround Time

Table 1 Results

Process Numbers	Average Turnaround Time	
	Normal	Optimized
3	2.7	2.6
4	4.2	4

5	5.8	5.6
6	8	7.9
7	8.5	8.4

Figure 5 Represents the plot between Average Turnaround Time Vs Number Of Processes For Normal Round Robin Algorithm And Optimized Round Robin Algorithm.

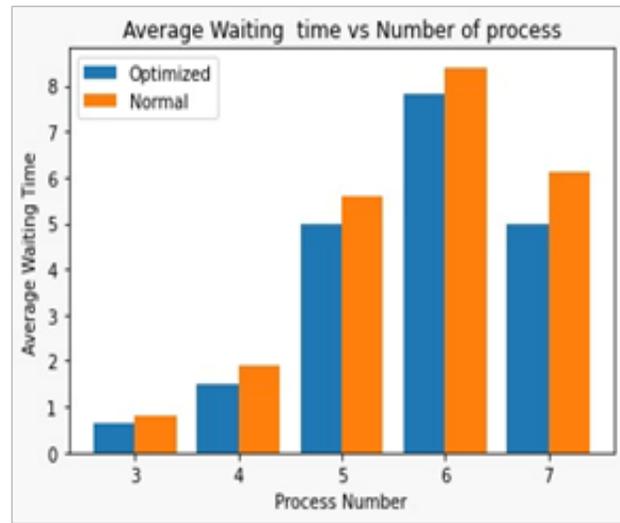


Figure 6 Average Waiting Time & Number of Process

Figure 6 Represents the plot between Average Waiting Time Vs Number Of Processes For Normal Round Robin Algorithm And Optimized Round Robin Algorithm

SCOPE OF RESEARCH

We have focused our discussion in this work on the task scheduling technique known as the round robin. In order to compare the modified round robin algorithm with the traditional round robin methods for performance enhancement, we conducted a thorough literature review. The performance of the round robin algorithm has improved as a result of the improvised method we have provided.

FUTURE SCOPE

Only the average waiting time and turnaround time are compared in this study. The number of switch cases utilized to carry out the method has not been highlighted. In the future, we will improve the work utilizing this property as well and will retrieve the results as they develop.

CONCLUSIONS

To improve and maximize the CPU's use in the operating system, resource allocation is undoubtedly a difficult task. Though the Round Robin algorithm, one of the Time Quantum-based resource scheduling solutions, faces a bottleneck, the issue has been brought up. To maximize this quantum time, various algorithms are put out in the literature currently in existence. is a straightforward Endeavor aimed at enhancing system performance and resource use. This proposed method focuses on improving throughput, decreasing waiting time, and reducing turn-around time in addition to performance.

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Design and Analysis of Millimeter Wave Microstrip Patch Antenna for 5G Applications

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ABSTRACT

Due to lower latency and high speed data transmission and connecting millions of devices, 5G networks is better than 4G technologies. In this work, a millimeter wave microstrip patch antenna resonating at 5G frequency band is investigated. Initially, a 38GHz single millimeter-wave antenna is designed with dimensions of $2.02 \times 3.12 \text{ mm}^2$ and a thickness of 0.8mm using RT/duroid 5880LZ substrate using HFSS EM software. Subsequently, it is extended to two element MIMO antenna by duplicating the single antenna with $\lambda/4$ distance. From the simulation resonating frequency, bandwidth, return loss, total peak gain(TPG), were found to be 3.6GHz, -23.8dB, 7.8dB, and VSWR, data rates (DR) are were found to be 3Gbps, 1.2 as well as broad radiation patterns are achieved. The results found from this works are better than previous works available on the literature. The outcomes demonstrate that the designed antenna is well suited for high data rate 5G applications.

KEYWORDS: Millimeter wave MIMO antenna, Bandwidth, TPG VSWR, DR.

INTRODUCTION

The present 5G wireless world looking compact wireless devices along with providing Gigabit data rate transmission systems [1]. The 5G requirements are shown in Figure 1.

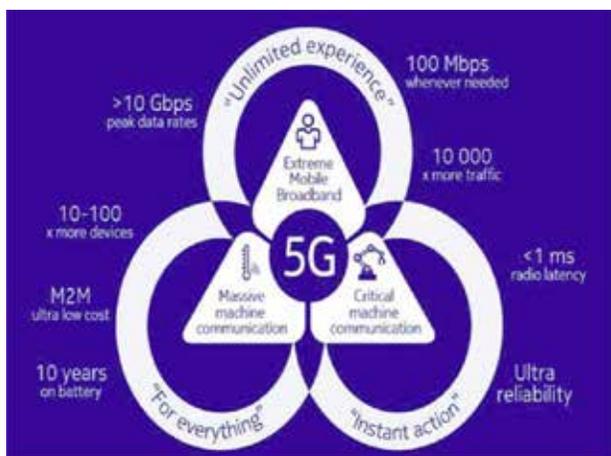


Figure-1: 5G Technology Requirements

To address these needs, numerous systematic solutions in the physical layer, network layer and application

layers of TCP/IP modules have been reported in the literature survey [1-4] and one of the better solutions can be predicted such as millimeter wave antennas to enhancing the bandwidth along with MIMO system to providing high data rate can approaches the above requirements effectively with less cost. In this work focus on the design methodology of millimeter wave microstrip patch antenna and then extended to two elements MIMO antenna system followed by antenna result discussions end with design conclusions.

MIMO ANTENNA DESIGN METHODOLOGY

Initially, a resonating frequency of 38GHz was selected for the single millimeter wave antenna. The antenna was designed using RT/duroid 5880LZ substrate material, and its specifications are shown in Table 1. The single millimeter wave antenna (SMA) structures were designed using an HFSS EM simulator and fed with a 50Ω microstrip line as shown in Figure 2 and their dimensions calculated from the following equations and summarized in Table 2 [5].

Table I. Specifications of the Substrate Materials

Material	RT/duroid 5880LZ
Relative Permittivity	2.2
Loss Factor	0.0009
Thickness	0.8mm

$$W = \frac{c}{2f_r} \sqrt{\frac{2}{2\epsilon_e + 1}} \tag{1}$$

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}} \tag{2}$$

$$L = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_{\text{reff}}}} \tag{3}$$

The single millimeter wave antenna (SMA) has been expanded to a two-element millimeter wave antenna in MIMO configuration. This configuration consists of two identical millimeter wave antennas with a $\lambda/4$ distance maintained to prevent coupling effects between the antenna elements. To improve efficiency, the size of the ground plane is set to 20mm X 20mm and their final two element millimeter MIMO antenna (TEMMA) structure is shown in Figure 3.

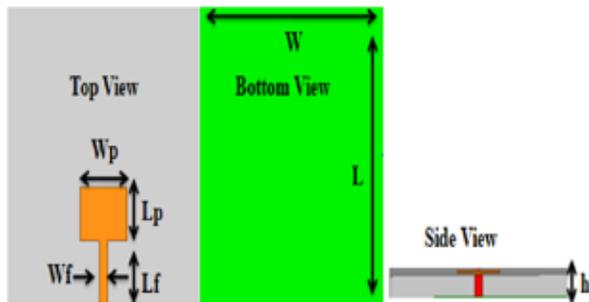


Figure-2: Structure of SMA

Table 3. Dimensions of SMA

Variables	L	W	Lp	Wp
Dimensions	10mm	10mm	2.02mm	3.12mm
Variables	Lf	Wf	h	
Dimensions	2.1mm	0.4mm	0.8mm	

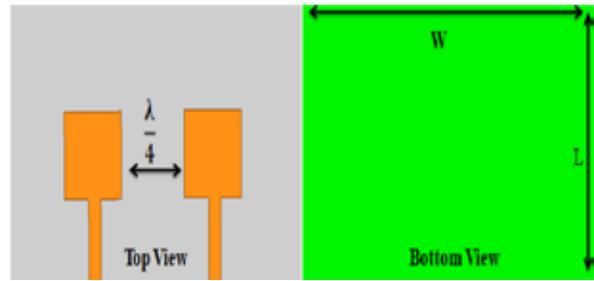


Figure-3: Structure of TEMMA

MIMO ANTENNA RESULTS

Initially, the return loss characteristics of the single millimeter wave antenna (SMA) is computed and shown in Figure 4. The SMA resonates at 38GHz with a return loss of -23.8dB and a wide bandwidth of 4.05GHz, it is a range of frequencies over which antenna resonates at 38GHz.

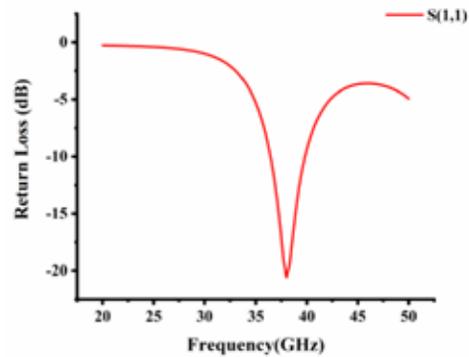


Figure-4: Return Loss Characteristics of SMA

Data rate of the single millimeter wave antenna can be calculated from the following Shannon channel capacity equation. Single antenna transceiver system is shown in Figure.5. Here we assumed the 32dB SNR, with that antenna supported 5.8Gbps data rate for the bandwidth of 4.05GHz.

$$C = B \log_2 \left(1 + \frac{S}{N} \right) \tag{4}$$



Figure-5: Single antenna transceiver system

The two element millimeter wave MIMO antenna (TEMMA) return loss characteristics are shown in Figure 6.

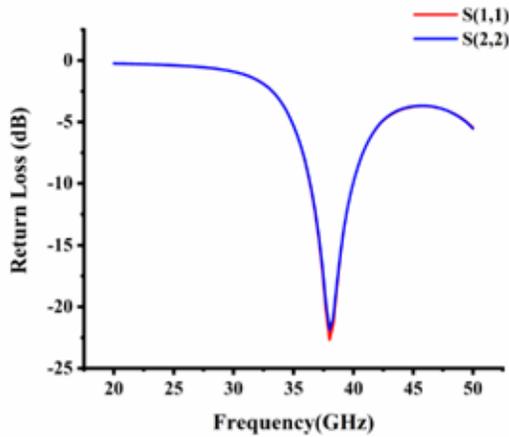


Figure-6: Return Loss Characteristics of TEMMA

This antenna also resonated at 38GHz with a return loss of -23.8dB and a wide bandwidth of 4.05GHz. But the key feature of MIMO systems is their potential ability to turn multipath propagation, for sending the information through ‘n’ different channel connecting n different transmitter and receivers. The two element millimeter wave MIMO antenna (TEMMA) antenna data rate can be calculated from the following modified Shannon equation and their MIMO antenna transceiver system is shown in Figure.7.

$$C = B \log_2 \left[\det \left(I_M + \frac{S}{N} HH^* \right) \right] \tag{5}$$

Where IM is an identity matrix and HH* is a channel matrix both matrix size depends on the number of patch antenna on both Rx/Tx side of the MIMO system.

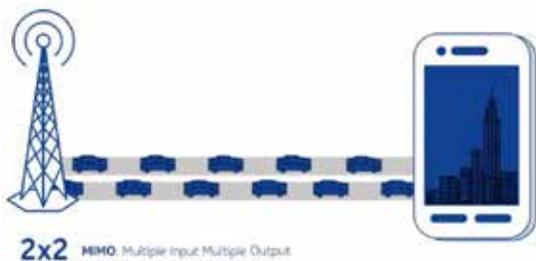


Figure-7: MIMO antenna transceiver system

From this two element millimeter wave MIMO antenna (TEMMA) observed that it gives 11.77Gbps data rate

for the bandwidth of 4.05GHz without increasing bandwidth and SNR. This is almost double the data rate as compared to single millimeter wave antenna (SMA) without enhancing bandwidth and SNR, Hence MIMO system is supported to reach the requirements of 5G technology.

The antenna total peak gain measure the ability of radiation of electromagnetic wave towards far field region. Single millimeter wave antenna (SMA) gives total peak gain of 5.45dB shown Figure.8 and two element millimeter wave MIMO antenna (TEMMA) gives total peak gain of 7.28dB shown in Figure.9 respectively. From these results observed that due to two patch elements on the same ground plane it enhance the total peak gain as compared to single millimeter wave antenna (SMA).

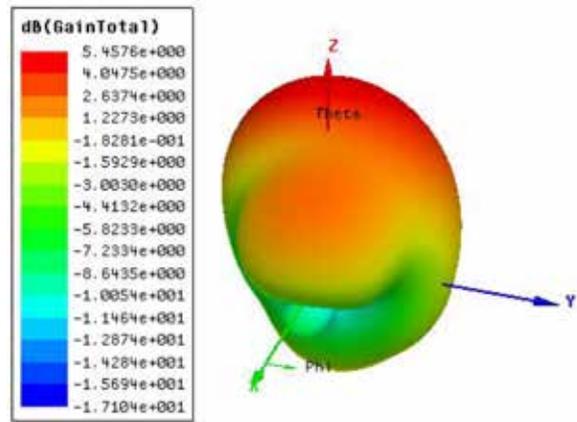


Figure-8: TPG of SMA

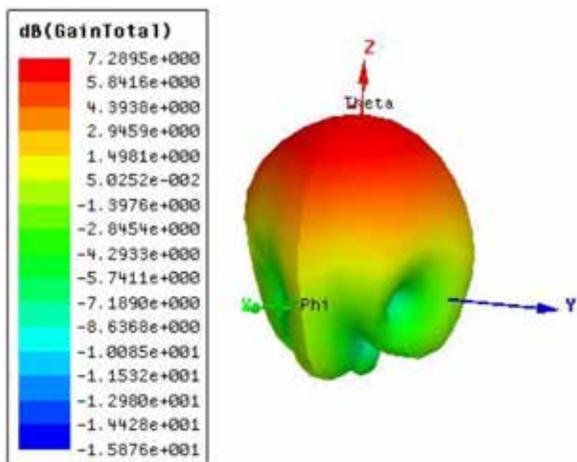


Figure-9: TPG of TEMMA

The next antenna parameters considered as voltage standing wave ratio (VSWR). It measures the efficiency of the antenna by considering the amount of radio frequency power transmitted from the antenna towards load. Smaller the VSWR indicates better the efficiency of the antenna. From Figure.10 shows the VSWR of SMA is 1.20 and Figure.11 shows VSWR of TEMMA is 1.17 respectively.

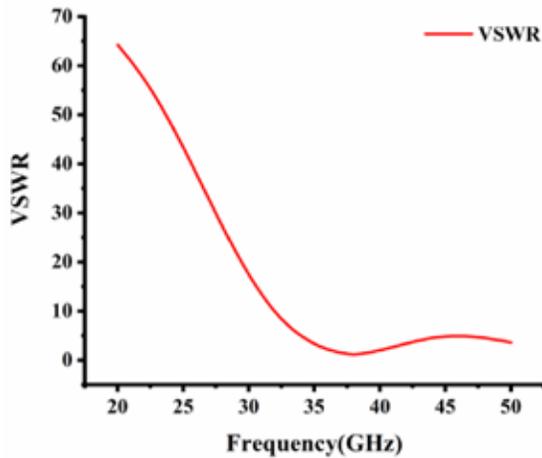


Figure-10: VSWR of SMA

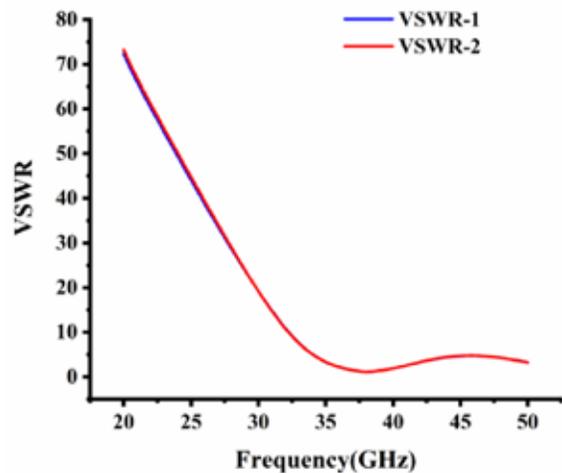


Figure-11: VSWR of TEMMA

The next antenna parameters considered as radiation pattern. It shows the graphical representation of the electromagnetic wave radiations. Figure 12 and Figure 13 shows the radiation patterns for the SMA and TEMMA. Both antenna radiation patterns almost radiate in broadside radiation patterns.

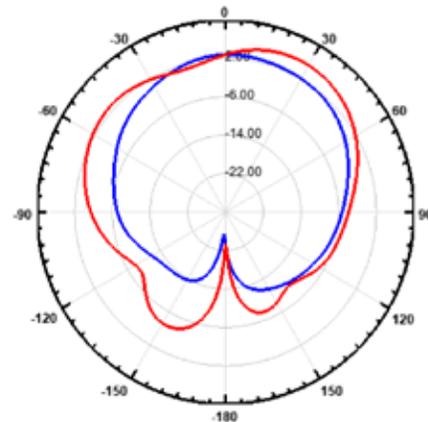


Figure-12 Radiation pattern of SMA

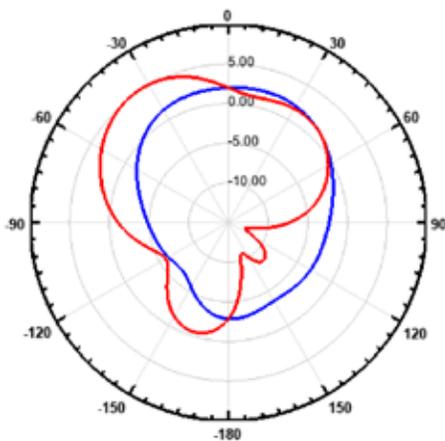


Figure-13 Radiation pattern of TEMMA

The single millimeter wave antenna (SMA) and two element millimeter wave MIMO antenna (TEMMA) results are summarized in the following Table 3.

Table 4. Tabulated Results of SMA and TEMMA

Specifications	SMA	TEMMA
Resonating Frequency (GHz)	38GHz	28GHz
Return Loss (dB)	-22.18dB	-13.95dB
Bandwidth (GHz)	4.05GHz	4.05GHz
Data Rate	5.8Gbps	11.77Gbps
TPG (dB)	5.32dB	7.28dB
VSWR	1.20	1.17

By observing the above table, two element millimeter wave MIMO antenna results more superior hence the designed antenna is well suited for 5G applications.

CONCLUSIONS

The antennas were designed using HFSS EM simulator. The two element millimeter wave MIMO antenna (TEMMA) antenna were resonated at 38GHz frequency points with wide bandwidth of 4.05GHz. This antenna also gives data rate of 11.77Gbps and total peak gain of 7.28dB. By observing all the results which obtained from the TEMMA, it shows that millimeter wave antenna with MIMO system can supports the requirements of 5G applications. Hence the designed antenna is well suited for high data rate 5G applications

ACKNOWLEDGMENT

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IoT based Continuous Monitoring System for Steam-Turbine Cogeneration Plant in Sugar Industry

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ABSTRACT

Sugarcane is a significant by product crop which is adopted by considerable farmers. It is the most prosperous and environmentally friendly agricultural venture. It also contributes to the production of bioethanol and other bio-based products, which are some renewable sources of green energy. The process of producing both heat and electrical energy from a single fuel source is known as cogeneration. India's cogeneration power plant generates more than 2000MW of electricity. To produce electricity in the steam turbine cogeneration plant, initially the temperature and pressure of the steam boiler plays the vital role. For the 36MW cogeneration power plant which is studied for this research, the temperature of the boiler (bagasse based) should be 8500C and pressure should be 109kg/cm². In this study, using IoT technology the temperature and pressure of the steam boiler remotely monitored. The authority continuously monitored the temperature and pressure by signing in on thing speak IoT cloud. For measuring high pressure and steam thermocouple and pressure sensors were used. PIC18F4550 microcontroller was used for data gathering and processing. By ESP8266 Wi-Fi module the data sent wirelessly to the IoT cloud. The technique increased overall output and productivity.

KEYWORDS: *Steam boiler, Thermocouple, Microcontroller, IoT, Cloud, Wi-Fi module.*

INTRODUCTION

An important crop, sugarcane specifically aids in energy production, refuelling, and chemical synthesis [1]. Sugarcane is considered the crop of the future since it is used to make sugar, jaggery, khandsari, and a variety of byproducts like molasses, bagasse, and press mud. It also contributes to the production of bioethanol and other bio-based products, which are some renewable sources of green energy [2]. It is the most prosperous and environmentally friendly agricultural venture. Bagasse, a waste product, is used by sugar mills to produce ethanol, electricity, and sugar. The residual mud is used as fertiliser in sugarcane fields, while the sugar mill uses the electricity generated

by bagasse [3,4]. An energy-dense byproduct of sugarcane factories, bagasse holds great commercial and technological potential for grid power generation. Bagasse-based cogeneration can provide stable grid electricity in countries where sugar refineries have been modified to increase energy efficiency [5]. India still has more than 5,000 MW of unrealized potential, even with more than 500 sugar mills producing more than 3,221 MW of power from bagasse.[7]

The sugar mills in India run their machinery and generate steam for the boilers and turbines using their own bagasse. Since thermal energy that would otherwise be lost is caught and used at the facility, an onsite co-generation system is more efficient than

a utility-operated central power plant[6,8]. India's cogeneration power plant generates more than 2000MW of electricity. The process of producing both heat and electrical energy from a single fuel source is known as cogeneration. Bagasse is used as fuel in the sugar industry. Burning bagasse produces high pressure steam in a steam boiler used in the sugar business. The high-pressure steam that is produced is sent through the superheater to warm it even further. The steam is then superheated and rapidly fed into a turbine. The steam force, or the transformation of the steam's potential energy into mechanical and then electrical energy, turns the turbine blades. [5,8]

LITERATURE REVIEW

9] This project is an industrial boiler controller that regulates a device's heating element temperature based on its needs. The power source for the system is solar energy. On the LCD panel, the set and sensed temperature readings are shown concurrently. The temperature is sensed by the temperature sensor LM35, which then uses ADC to send an electrical signal to the microcontroller. The analog-to-digital converter transforms the analogue signal into a digital representation (ADC). The 16x2-line LCD shows the temperature values that have been measured and set.

10] Ion Miciuand Florin Hărtescu presented Monitoring System for Co-generative Power Plants. The primary goal of the project is to automate the entire co-generative power plant's functioning. The initial degree of integration is completed at the equipment level. These days, it is not uncommon to see in operation equipment that uses standard or proprietary communication protocols in addition to communication channels like RS232, RS485, current loop, Ethernet, radio, and GSM. The final level of integration is provided by the system's client application. Through a single interface, the user can obtain information about the entire process at the levels of economic management, technological management, and real-time information. When this system is implemented in cogenerate power plants, the following advantages occur: high fuel economy and efficiency, little effort required to rapidly build a new application, and outstanding system performance in satisfying application demands.

11] This paper presents an embedded Internet of things monitoring system and a fuzzy PID controller method that uses a nonlinear optimization algorithm to set the initial value of control parameters in a reasonable manner. The goal of the research is to examine the shortcomings of the traditional boiler combustion air system's tuning of the PID controller. It is discovered that when the simulation process is $t = 2000$ s, the step disturbance with amplitude of 0.1 is introduced to the system input, and there will be a little disturbance in the combustion process through the simulation comparison with the standard engineering tuning PID controller. The modelling inaccuracy of the monitoring system model controlled between 10% to 25% using fuzzy PID and strong robustness support. This indicates that the nonlinear optimised PID has strong anti-interface and can meet the system's process requirements.

12] This study evaluated the effects of temperature changes in the flue gas and load on particulate matter emissions from coal-fired units. A typical ultra-low emission coal-fired power unit with varying operational loads (650, 850, and 1000 MW) and flue gas temperature (90 and 100°C) was used to collect samples of CPM and FPM. The organic and inorganic components of CPM, as well as the emission concentration of FPM, were measured. The unit with the lowest CPM emission concentration was operating at a high load and a low flue gas temperature. The concentration of SO₄ 2-emissions rose as the flue gas temperature dropped. The impact on the overall concentration of emissions was in line with the CPM effect.

[13] Tarwaji Warsokusumo et al. suggested real-time online monitoring to preserve the power generation system's energy efficiency performance. This study suggested a method for keeping an eye on the power producing system's energy efficiency. The frontline operator can quickly manoeuvre and maintain the Net Plant Heat Rate, one of the energy efficiency performance measures, using real-time online monitoring. In order to increase the energy efficiency of power generation systems, this effort constructed an online real-time performance indicator monitoring system.

[14] C. Dinakaran et al. introduced Study of Cogeneration Plant in Sugar Mill by using Bagasse as a Fuel. The article explains how sugar mills may highly

efficiently cogenerate heat and power using bagasse, the fibrous waste product of sugarcane. A case study on the sugarcane sector and an economic analysis of an advanced cogeneration power system are part of the proposed effort. The study measures the emissions from bagasse cogeneration and assesses the economic and technological feasibility of reorganising the sugar industries to facilitate cogeneration. the entire amount of electricity that can be generated and supplied to the national system, as well as the problems with the economy and pollutants.

[15] This project involves the design and remote monitoring of a small wind turbine that is powered by the electrical grid. The wind turbine is remotely monitored, supervisory tasks are carried out, energy consumption is controlled, and environmental and performance data is gathered thanks to the Internet of Things (IoT). With the help of the Internet of Things, users can gather meteorological data, acquire operational parameters, learn about energy performance, and execute energy manager activities. The Internet of Things-based system for tracking the wind turbine's long-term performance.

[16] Temperatures in the furnace were measured concurrently with the development of the USB transducer temperature monitoring system. The collected data was instantly transferred to the PC for analysis, and the furnace floor's temperature distribution was checked.

[17] In order to lower the rate of increase in electricity costs, this study describes the design and implementation of a real-time Internet of Things-based Energy Management System (EMS). The sensor unit, control unit, display unit, and switching unit are the four (4) fundamental components of the system. The two sensors that make up the sensing unit are the voltage sensor and the current transformer (CT) sensor. The voltage and current sensors sense and measure the parameters and transmit the data to the control unit. This control unit is made up of two (2) microcontrollers, an ESP32 and an Arduino Nano. For real-time monitoring, the ESP32 microcontroller and display unit get the processed data from the Arduino Nano, which analyses it after receiving it from the sensing device. Furthermore, the data processing is sent to the cloud via the ESP32 microcontroller. Moreover, the cloud provides the measured parameters to the web-based application.

[18] Wei Chen suggested an industrial internet of things intelligent manufacturing production line data monitoring system. The application of industrial Internet of things technology in manufacturing workshops is examined in this article, which also offers a recommended design and construction route for smart factories. This document presents the overall architecture and theoretical model of the system, together with an overview of the current state of affairs and the requirements of the Discrete Manufacturing Enterprise Workshop. Given the variety of production data collected on-site, the massive volume of data, the heterogeneity and variable states of the data, and the strong connections between the data, an industrial Internet of things solution for manufacturing workshops is offered. Additionally, key technologies like RFID and WSN are integrated. The multi-thread real-time data collection, storage technology, and product tracking monitoring of the workshop are researched. Finally, a high-quality, real-time performance analysis of the system is carried out. The results show how effectively the system tracks data from production lines.

[19] Oscar Bautista Gonzalez and José Chilo are worked on WSN IoT Ambient Environmental Monitoring System. A web-based environmental monitoring system based on WSN technology is presented in this research. Three different environments were used to test the WSN IoT environmental monitoring system, and the MQTT and SSH protocols were configured to permit access to the gateway. The WSN IoT system, which consists of sensors, repeaters, and a gateway, uses user-friendly interfaces. Using the Node-Red programming tool, the operating system of the GW has constructed the data collection, processing, storage, and presentation. The gateway and WSN can be controlled and data can be monitored by using software that provides user-friendly interfaces in conjunction with the web server that runs across the gateway. The data visualisation is displayed on a live data dashboard. The technology is tested in two industrial environments as well as at a university.

Need of the System

A byproduct of sugar cane called bagasse is burned in boilers to provide process steam. The pressure and temperature at which steam is produced in a boiler determine how much bagasse is used. Higher boiler

pressure in cogeneration plants reduces bagasse computation, which extends operating days. There are specific implant measures that must be followed in order to do this. Studies conducted in numerous sugar plants show that high-pressure boiler use makes these power projects extremely profitable.[20]

To produce electricity in the steam turbine cogeneration plant, initially the temperature and pressure of the steam boiler plays the vital role. for the 36MW cogeneration power plant which is studied for this research, the temperature of the boiler (bagasse based) should be 8500C and pressure should be 128kg/cm². The temperature and pressure of the boiler should not be exceeded from the above limit for the proper functioning of the steam turbines. therefore, continuous monitoring of the temperature and pressure of the steam boiler is essential. In proposed system, the wireless remote monitoring of the temperature and pressure of the steam boiler is achieved by the application of Internet of Things.

MATERIALS AND METHODS

The below fig.1 shows the block diagram of the system. To monitor remotely the temperature and pressure of the steam boiler IoT platform is used. By implementing Internet of Things in the co-generation plant the user can remotely monitor the temperature and pressure of the steam boiler.

System Architecture

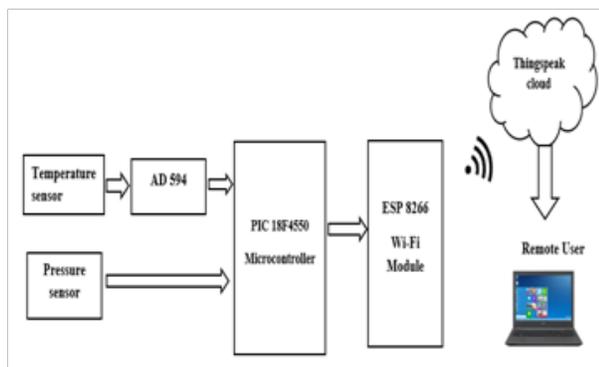


Fig. 1 system architecture of the system

A network of physical objects is called the Internet of Things, or IoT. These gadgets are capable of exchanging data without the need for human involvement. Machines and computers are not the only types of IoT

devices. Everything with a sensor that has been given a unique identification can be a part of the Internet of Things (UID). Developing self-reporting gadgets that can interact in real time with people and each other is the main objective of the Internet of Things. With billions of devices online, a vast amount of data is being gathered and exchanged. They range from military-grade surveillance equipment to smart home settings like smoke alarms and culinary appliances.[21]

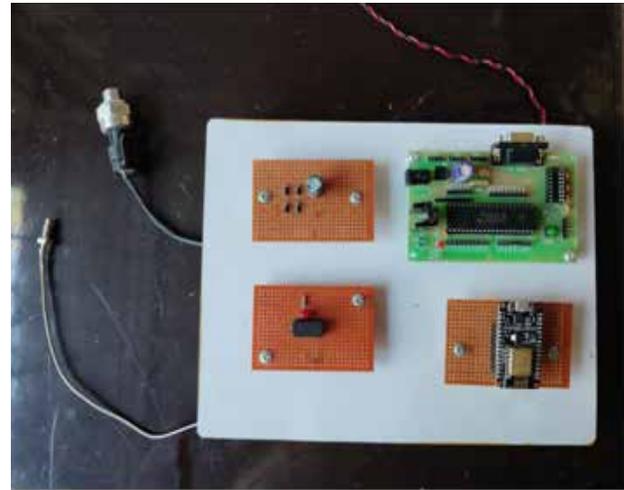


Fig. 2 Hardware of the system

Fig. 2 shows the actual developed hardware for monitoring the temperature and pressure of the steam boiler. The system is continuously monitoring the temperature and pressure of the steam boiler. The delay of 60 seconds is set in the programming. So, after every minute the temperature and pressure data are updated on the thing speak website. To measure the high temperature of the steam boiler, k-type thermocouple and diaphragm type pressure sensor is used. Thermocouple and pressure sensor measures the temperature and pressure of the steam boiler. The voltage produced by thermocouples is temperature-dependent due to the thermo effect. The instrumentation amplifier AD594 has a cold junction compensating feature. The K-type thermocouple is compatible with the AD594. The pre-calibrated amplifier and ice-point reference are combined to generate a high-level output (10mV/0C) straight from the thermocouple output. The pressure sensor is directly connected to the ADC channel AN0/RA0 of the PIC 18F4550. PIC 18F4550 has inbuilt 10-bit 13 channel ADC.

An 8-bit microcontroller with improved flash, USB connectivity, and fast performance is the PIC18F4550. This 40-pin microcontroller has a number of capabilities, including an enlarged instruction set, self-programmability, addressable USART, an improved CCP module, and a 10-bit ADC (Analog to digital converter). It is composed of 13 channels for ADC, ADC comparators, and other peripherals, as well as 4 timers or an external oscillator interfaced for clocking reasons. The role of the microcontroller in the system is to gather and process the data and send it to the trans receiver section. PIC microcontroller collects the temperature and pressure sensor data convert it into digital form through ADC channels and transfers it to the ESP8266 Wi-Fi module through RC6/TxD and RC/RxD. An inexpensive standalone wireless transceiver suitable for end-point Internet of Things applications is the ESP8266 module. Internet access for embedded applications is made possible by the ESP8266 module. For communication purposes, it connects to the server or client via the TCP/UDP protocol.

A set of AT instructions must be used by the microcontroller in order to communicate with the ESP8266 module. The microcontroller uses UART with a predetermined Baud rate to interact with the ESP8266-01 module. The ESP8266 module is configured by PIC18F4550 to function as a TCP client, and it uses Wi-Fi to receive and send data to and from the server. The Thing speak server is utilised here as a TCP client. With the open IoT platform Thing speak, anyone may view and examine real-time data from their sensor devices. Additionally, data analysis can be done using Thing speak MATLAB code on data uploaded by distant devices. Just by signing up and creating a channel one can send and receive the data. By sign up the platform shows the channel id and write key. Tick the make public field in the thing speak channel's channel setup option to make the channel accessible to the public. This makes it possible for any user to access channel data without a password or username. By accessing the thing speak platform on the internet the user remotely monitors the temperature and pressure values in the steam boiler.

RESULT AND DISCUSSION

The proposed solution uses Thing speak cloud to successfully send the temperature and pressure readings from the steam boiler to the distant user. The Internet of Things system facilitates end users' labour and efforts.

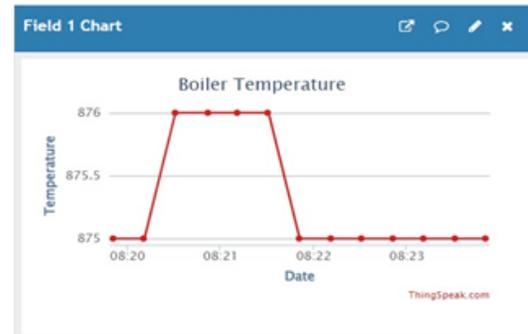


Fig. 3 Boiler Temperature output

Figure 3 illustrates the output of the boiler temperature on the Thingspeak website

The model is validated by manually raising the ambient temperature, and the webpage displays the result based on the input variables. At first, the temperature is between 280C and 300C, but when the ambient temperature rose, changes in both temperature and pressure happened. The graph of the temperature and pressure monitoring is displayed in field charts 1 and 2. The required temperature and pressure for the steam boiler for proper functioning of the steam turbine is 8500C and 128kg/cm² respectively. It is successfully measured by the sensors and processed by the microcontroller. The output of thermocouple and pressure sensor is successfully updated on the IoT cloud with regular interval.

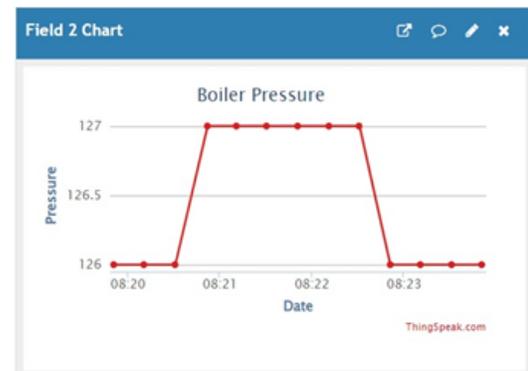


Fig. 4 Boiler Pressure output

Figure 4 shows the output of the boiler pressure on the Thingspeak website.

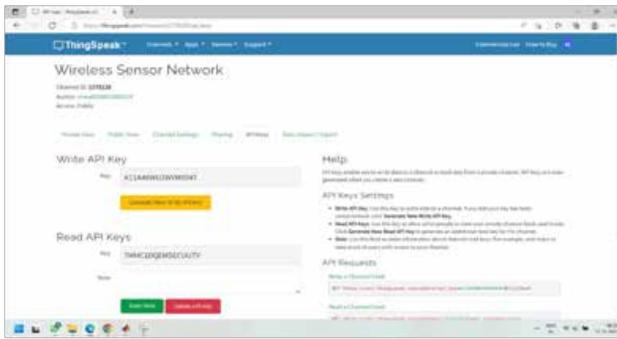


Fig. 5 channel created on Thingspeak cloud

The figure above illustrates how a Thingspeak channel was set up for remote temperature and pressure monitoring. An application can write data to a channel by using a write API key, which is a 16-digit code. And An application can access the data stored in a channel by using the read API key, which is a 16-digit code.

CONCLUSION

Once the technology is installed in the steam boiler, the appropriate authority remotely keeps an eye on changes in pressure and temperature. The system was set up in the steam boiler. The gadget can be used by users to safeguard against changes in pressure and temperature. IoT-based systems transform conventional systems into intelligent systems. Real-time technology boosts productivity and profit by increasing efficiency. The system is a remedy for the steam boiler plant's temperature and pressure variations. The mechanism does not allow for human intervention. The user's time and effort are saved by the automated system. The technique increase output overall and productivity.

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Navigating Breast Cancer Detection: A Comparative Review of Deep Learning Techniques

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ABSTRACT

In the modern world, breast cancer poses a serious disease to health since it disproportionately affects women and has high fatality rates. For starting the right treatment, accurate early diagnosis and exact categorization are essential. However, it has been difficult to understand the causes of this malignancy by feature extraction using conventional machine learning methods. These traditional models work better with unprocessed data that have well-defined properties. Contrarily, new developments in deep learning have opened the path for accurately identifying breast problems utilizing a variety of imaging modalities, including mammography, magnetic resonance imaging, and ultrasound. This review throws light on the limits of traditional machine learning models while emphasizing the advent of efficient prediction models produced through novel deep learning approaches. The paper also compares traditional machine learning, deep learning models, transfer learning, and hybrid models in terms of their strengths and drawbacks in addressing breast cancer detection.

KEYWORDS: *Machine learning technique, Deep learning technique, Breast cancer classification, Image classification, Healthcare.*

INTRODUCTION

Cancer is a major public health problem around the world right now. Breast cancer is a type of cancer that starts in the breast and spreads to other parts of the body. Breast cancer is one of the most common types of cancer in women that kills them. Cancer arises when cells grow out of control [1]. Since cancer does not cause pain right away, it is not discovered until major health problems start to appear. Breast cancer is a common and possibly fatal condition that requires a precise and prompt diagnosis in order to get appropriate treatment. Early detection of breast cancer increases the likelihood that patients will receive the appropriate treatment and survive.

Various imaging modalities, such as magnetic resonance

imaging (MRI), diagnostic mammography (X-rays), thermography, and ultrasound (sonography), may be used for the detection and analysis of breast cancer. The proposed investigation utilizes ultrasound images. Breast cancer may be classified into two distinct categories: benign and malignant. Benign neoplastic cells have limited proliferation and exclusively localize inside the mammary gland. A malignant tumor consists of cancerous cells that possess the ability to undergo uncontrolled proliferation, metastasize to distant anatomical sites, and infiltrate adjacent tissues. The task of automatically detecting and localizing cancer cells in breast cancer images has significant challenges due to the inherent variations in size, shape, and spatial distribution of cancer cells. The multiple datasets used for breast cancer categorization are shown in Figure 1.

The significance of leveraging deep learning techniques to enhance breast cancer prediction, classification, and diagnosis is helpful according to the study by [2] [3] [4]. The CAD method relies on many intermediate phases, including pre-processing of raw pictures, feature learning and extraction [7], feature selection and reduction [10] [11], and classification [15] [19]. During the pre-processing phase, the researcher tries to generate high-quality pictures and mitigate any potential noise that may be present. The primary aim of pre-processing is to enhance the visibility of the tumor area, hence facilitating the precise identification of a region of interest (ROI).

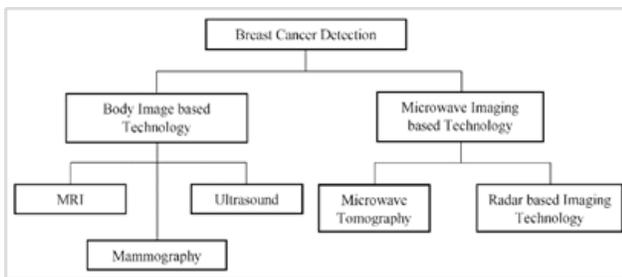


Fig. 1. Breast Cancer Detection Dataset

The use of machine learning and deep learning methodologies in the field of breast cancer detection has shown significant progress. These methodologies include the examination of medical breast mammography and the incorporation of diverse data sources such as clinical, genomic, and histopathological data, resulting in enhanced diagnostic capabilities. The literature has documented several traditional methods for detecting regions of interest (ROI), including fuzzy, clustering, and saliency-based strategies, among others [36]. The subsequent crucial stage is feature extraction, whereby the relevant characteristics of each picture are calculated. The literature introduces many traditional feature extraction approaches, including form, texture, and point features. Certain researchers have also directed their attention on the reduction and selection of features in order to enhance accuracy and save computing time. The last crucial stage in the field of artificial intelligence is the use of machine learning and deep learning methodologies to categorize malignant areas into appropriate groups, either cancerous or non-cancerous. The introduction of deep learning and convolutional neural networks (CNNs) [23] [25] [38]

has brought about a significant transformation in the field of medical image analysis, namely in the area of mammography for the purpose of breast cancer diagnosis and characterisation. In recent times, the use of convolutional neural networks (CNNs) has shown a noteworthy efficacy in the field of medical imaging, namely in the detection and classification of cancerous conditions. The efficacy of deep learning models is often contingent upon the magnitude of the training datasets. The traditional methodologies shown suboptimal performance when applied to datasets with intricate characteristics. Conversely, the deep learning-based approaches demonstrated remarkable efficacy.

Following figure 2 shows the various machine learning classification algorithms used for medical image data classification. The algorithms include SVM, Random Forest, CNN, LSTM, KNN, etc.

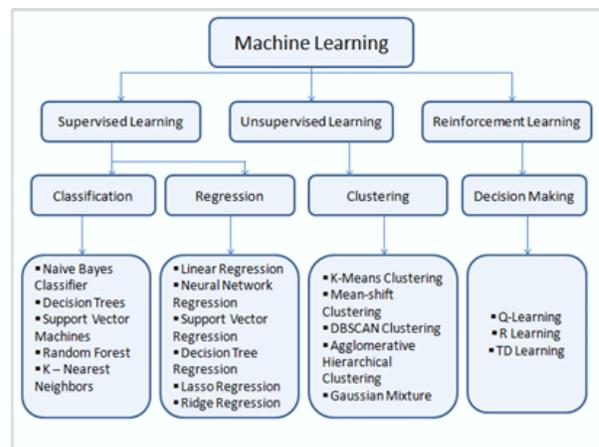


Fig. 2. Machine Learning Algorithm

Several authors contribute to advancing breast cancer diagnosis and classification through innovative approaches. Authors at [13] emphasize the importance of hybrid deep transfer learning in breast lesion diagnosis using mammograms, showcasing the significance of model pre-training and feature extraction techniques. On the other hand, authors [14], highlight the value of integrating diverse data sources for breast cancer subtype classification, underscoring the importance of a holistic approach in understanding and categorizing breast cancer. These studies collectively shed light on the potential for enhanced breast cancer diagnosis and classification, urging further research in this critical domain.

The main contributions of this study are as follows:

- Summarizing the methods that are often used to find breast cancer: feature extraction, feature selection, and feature fusion.
- Finding the best machine learning, deep learning, transfer learning, and mixed classification methods for diagnosing breast cancer.
- Looking into the datasets that are often used in deep learning-based methods for diagnosing breast cancer.
- Using deep learning-based methods to sum up the review scores used to diagnose breast cancer

The rest of the article is designed as follows: Section 2 describes the research methodology. Section 3, describes the literature review, Section 4 present the result analysis. Finally, Section 5 is the conclusion of the paper.

RESEARCH METHODOLOGY

This part of the article talks about the study that is done in the present systems. Scopus/SCI Journals is where most of the papers are linked to. The study of the number of Scopus and SCI documents that this poll talks about is shown in table 1 and figure 3.

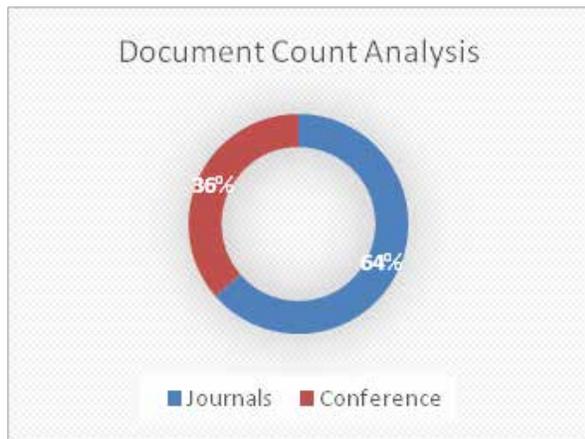


Fig. 3. Document Count Analysis

Table 1. Document Count Analysis

Publication Year	Conference	SCOPUS / SCI Journal
2023	3	5

2022	2	4
2021	1	4
2020	1	3
2019	2	2
2018	2	4
2017 to 2000	3	6
Total Count	14	28

Total Document Used Per Year Count

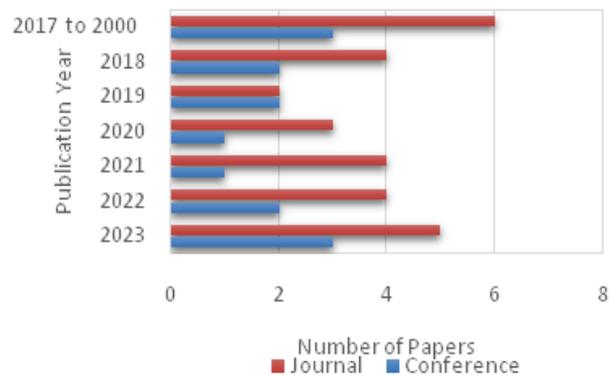


Fig. 4 Total Document Used Per Year Count

LITERATURE REVIEW

Breast cancer remains a significant global health concern, prompting ongoing research and advancements in diagnostic and predictive methodologies. Recent studies have explored the integration of machine learning, deep learning and Artificial Intelligence techniques to enhance the accuracy and efficiency of breast cancer prediction and diagnosis. This literature review focuses on number of papers that delve into the application of machine learning, deep learning, transfer learning and AI methods in the context of breast cancer detection and classification.

In their work, Shanthi et al. [2] conducted an investigation into a range of deep learning approaches with the aim of predicting different forms of breast cancer. This work utilizes deep learning algorithms to classify breast cancer into distinct subtypes, hence providing valuable insights into tailored treatment approaches. The authors highlight the potential of deep learning in aiding clinicians in making informed decisions based on accurate cancer type predictions. The findings of this study underscore the importance of leveraging advanced

machine learning approaches for enhancing breast cancer classification, contributing to personalized and optimized treatment plans. In their study, Nasser et al. [3] undertook an extensive systematic evaluation with a specific emphasis on deep learning-based approaches for the detection of breast cancer. The study offers a comprehensive examination of the existing condition of deep learning applications in the field of breast cancer diagnostics, offering a consolidated overview of several methodologies and their respective efficacy. The authors provide an analysis of the merits and limitations of several deep learning models, offering insights into possible avenues for future advancements within this field. This systematic review has significant value for academics and practitioners who want to comprehend the current state of deep learning approaches in the context of breast cancer detection and identify potential directions for future study. Another researcher, Ramadan [4], provides a comprehensive analysis of the methodologies used in computer-aided diagnostics for the identification of breast cancer using mammograms. The study provides insights into existing approaches and techniques employed to enhance the accuracy of breast cancer detection, focusing on the use of mammographic images. By evaluating the strengths and limitations of these methods, the paper aims to guide the development of more effective computer-aided diagnostic systems. This study serves as a helpful resource for scholars and practitioners who are interested in gaining a comprehensive grasp of the various approaches used in computer-aided breast cancer detection and diagnosis.

Guo et al. [5] and Yassin et al. [6] focusing on ultrasound imaging technologies and machine learning techniques for breast cancer detection and management. Guo et al. [5] present a comprehensive review of ultrasound imaging technologies as powerful tools in breast cancer detection and management. The authors emphasize the advantages of ultrasound, including its non-invasiveness, real-time imaging capabilities, and lack of ionizing radiation exposure, making it an attractive modality for breast imaging. The authors discuss various ultrasound-based approaches for breast cancer diagnosis, highlighting the significance of features such as vascularity, texture analysis, and elasticity in improving the diagnostic accuracy. The study conducted by Yassin et al. [6] explores the use

of machine learning in computer-aided detection of breast cancer, offering a comprehensive analysis of the existing literature in this area. Yassin et al. conducted a comprehensive systematic study that rigorously evaluates a range of machine learning methodologies, including deep learning, support vector machines, neural networks, and other classification techniques. This research elucidates the amalgamation of many image modalities, including mammography, ultrasound, and magnetic resonance imaging (MRI), in conjunction with machine learning models, therefore showcasing the progressions in computer-aided diagnosis. In addition, Yassin et al. (year) examine the problems and potential future developments associated with the integration of machine learning techniques into clinical settings for the purpose of diagnosing breast cancer.

Feature Selection Techniques

In the study by Hekal et al. [7] the authors propose an automated system for early breast cancer detection and classification. Utilizing Signal Image Video Processing techniques, the system demonstrated promising results, achieving effective breast cancer classification. Their methodology contributes to the growing body of work aimed at leveraging technological advancements for accurate breast cancer diagnosis.

Jabeen et al. [8] present BC2NetRF, a Breast Cancer Classification model designed for mammogram images. This research paper presents a novel approach to increase deep learning features and utilizes Equilibrium-Jaya Controlled Regula Falsi-Based Features Selection method in order to boost the accuracy of classification. The integration of advanced feature selection techniques showcases a strategic approach toward enhancing breast cancer classification from mammographic data.

Pereira et al. [9] focus on feature selection for breast lesion classification in thermographic images, employing a Dialectical Optimization Algorithm. The study emphasizes the importance of feature selection in improving classification accuracy and highlights the potential of innovative algorithms in breast cancer research. The approach proposed by Pereira et al. presents a novel perspective on optimizing feature selection strategies for thermographic image analysis.

These studies by [7], [8], [9] collectively highlight the evolving landscape of automated breast cancer detection and feature selection techniques. Leveraging advanced technologies, such as deep learning and optimization algorithms, researchers continue to make significant strides toward enhancing the accuracy and efficiency of early breast cancer diagnosis. The integration of innovative methodologies and feature selection techniques underscores the ongoing commitment to improving breast cancer detection, ultimately leading to improved patient care and outcomes.

Feature Fusion and Hybrid Techniques

In their study, Jabeen et al. [10] introduced an innovative methodology for the categorization of breast cancer by using ultrasound pictures. The authors placed emphasis on the use of probability-based optimum deep learning feature fusion as a means to augment the accuracy of categorization. By integrating probability-based feature fusion techniques into the deep learning architecture, their method showed promising results, demonstrating the potential of feature fusion in improving breast cancer classification accuracy.

The authors Awotunde et al. [11] proposed a hybrid methodology for the detection of breast cancer, which included integrating rule-based feature selection with a deep learning algorithm. The present study used a combination of conventional feature selection approaches and deep learning methodologies in order to improve the precision of breast cancer detection. The study presented in their research demonstrates the efficacy of incorporating domain knowledge by means of rule-based feature selection in order to enhance the performance of deep learning models for the classification of breast cancer.

In their study, Umer et al. (2012) introduced a novel multi-class classification methodology for breast cancer using 6B-Net. This approach included deep feature fusion and selection techniques. The authors incorporated a specialized deep learning architecture and employed fusion and selection techniques to optimize the classification performance. The study demonstrated the significance of deep feature fusion and selection in improving the accuracy of multi-class breast cancer classification.

Samee et al. [13] present a hybrid deep learning approach, integrating Convolutional Neural Networks (CNNs) with Low-Rank Principal Component Analysis (LR-PCA), for breast lesion diagnosis using medical breast mammograms. The use of transfer learning, a technique leveraging pre-trained models, is a notable aspect of this study. Transfer learning allows the model to leverage knowledge gained from pre-training on a large dataset, enhancing performance with a limited target dataset. The integration of LR-PCA complements the CNN-based approach, aiding in feature extraction and improving the model's ability to discriminate breast lesions. The methodology presented in this paper showcases the potential for enhancing breast cancer diagnosis through innovative fusion of deep learning techniques and dimensionality reduction methods.

El-Nabawy et al. [14] propose an integrative framework for breast cancer subtype classification using a fusion of clinical, genomic, and histopathological data. The study focuses on the Molecular Taxonomy of Breast Cancer International Consortium (METABRIC) dataset, aiming to classify breast cancer subtypes effectively. Integration of various data sources, including clinical, genomics, and histopathological data, is a key strength of this work. The feature-fusion approach leverages the distinct information from multiple domains to enhance classification accuracy and provide a more comprehensive understanding of breast cancer subtypes. This integrated framework demonstrates the potential of leveraging heterogeneous data sources for improved breast cancer subtype classification.

The studies in [10] – [14] collectively underscore the significance of integrating deep learning techniques with feature fusion and selection methods to enhance breast cancer classification accuracy. The approaches presented in these works emphasize the importance of leveraging domain knowledge and specialized architectures to optimize deep learning models for more accurate and reliable breast cancer diagnosis. These research contributions are significant steps towards developing automated and accurate diagnostic tools, which can assist healthcare professionals in early and precise detection of breast cancer, ultimately leading to improved patient outcomes.

Machine Learning Techniques

Baccouche et al. [15] introduced an integrated framework for breast mass classification and diagnosis using a stacked ensemble of residual neural networks. Their approach represents a significant step towards harnessing the power of deep learning techniques in breast cancer diagnosis. By leveraging a stacked ensemble model, which combines multiple neural networks, they achieved remarkable classification accuracy. Their work highlights the potential of deep learning for improving breast cancer diagnosis accuracy.

Atban et al. [16] explored the application of traditional machine learning algorithms for breast cancer image classification with optimized deep features. This research acknowledges the significance of feature engineering and optimization in machine learning. By combining deep features with traditional algorithms, they provided an alternative approach to breast cancer classification. Their work contributes to the ongoing discussion regarding the choice between deep learning and traditional methods in medical image analysis.

Michael et al. [17] proposed an optimized framework for breast cancer classification using machine learning. The optimization aspect of their work is crucial, as it addresses the need for efficient and scalable models in clinical practice. By focusing on optimizing existing machine learning algorithms, their research offers a pragmatic approach to enhancing breast cancer classification. Their efforts align with the practical constraints of real-world healthcare settings.

Kumar et al. [18] introduced an optimized stacking ensemble learning model for breast cancer detection and classification using machine learning. Stacking ensemble models have gained popularity for their ability to combine the strengths of multiple algorithms. In this study, the authors emphasized the significance of ensemble learning for enhancing the accuracy of breast cancer detection. Their work showcases how ensemble techniques can be fine-tuned for optimal performance.

The reviewed papers [15] – [18] collectively contribute to the ongoing efforts to improve breast cancer classification and diagnosis. Authors highlight the potential of deep learning, considering the role of traditional machine learning, emphasize optimization,

and explore ensemble methods. These diverse approaches enrich the landscape of breast cancer detection research, offering insights and solutions that can ultimately lead to more accurate and efficient diagnostic tools using machine learning algorithms.

Table 2 shows the comparative analysis of machine learning techniques performance of researcher work in the field of breast cancer detection.

Table 2. Shows The Comparative Analysis Of Machine Learning Techniques Performance Of Researcher Work In The Field Of Breast Cancer Detection

Refrence	Algori-thms	Methodology Used	Accu-racy
Jabeen et al. [8]	Efficient Net	Enhanced Deep Learning Features, Equilibrium-Jaya Controlled Regula Falsi-Based Features Selection	99.7 %
Pereira et al. [9]	KNN	Feature Selection Based on Dialectical Optimization Algorithm	85 %
Jabeen et al. [10]	CNN, DarkNet- 53	Probability-based optimal deep learning feature fusion.	99.1%
Awotunde et al. [11]	Hybrid feature selection	Hybrid rule-based feature selection with deep learning algorithm	99.5%
Umer et al. [12]	6B-Net deep CNN model	6B-Net with deep feature fusion and selection method for multi-class classification	94.20%
Samee et al. [13]	LR- PCA, CNN	Hybrid deep transfer learning of CNN-based LR-PCA for breast lesion diagnosis	98.80%
El-Nabawy et al. [14]	Linear-SVM	Feature-fusion framework of clinical, genomics, and histopathological data	97.1%
Baccouche et al. [15]	ResNet 50V2, ResNet101V2, and ResNet152V2	Stacked ensemble of residual neural networks	99.20%

Atban et al. [16]	SVM - RBF	Traditional machine learning algorithms with optimized deep features	97.75%
Michael et al. [17]	KNN	Optimized framework with machine learning classification	99.86%
Kumar et al. [18]	AdaBoost	Optimized stacking ensemble learning model	99.45%

Deep Learning Techniques

Li et al. [19] proposed a deep learning-based approach for the classification of breast masses in mammograms using a two-view imaging perspective. Their study showcased promising results, demonstrating the efficacy of deep learning in automating breast cancer diagnosis, thereby potentially reducing the burden on radiologists and improving diagnostic accuracy. Wang et al. [20] presented an innovative application of deep learning in refining breast cancer histological grading. By utilizing deep learning models, the authors achieved an enhanced histological grading system, contributing to a more precise assessment of breast cancer severity. This advancement could have a significant impact on treatment planning and prognosis prediction. In a similar vein, Zahoor et al. [21] proposed a novel approach integrating deep neural networks and entropy-controlled whale optimization algorithm for breast cancer mammogram classification. Their research showcased promising outcomes, highlighting the potential of combining deep learning with optimization algorithms for enhancing breast cancer classification accuracy.

In the broader context of medical science, Bhatt et al. [22] provided a comprehensive overview of the state-of-the-art deep learning models applied in medical science, encompassing breast cancer detection. They discussed the challenges associated with implementing deep learning in medical research and emphasized the need for robust models and methodologies to ensure reliable and accurate diagnostic outcomes.

The reviewed papers [19] – [22] collectively emphasize the potential of deep learning in revolutionizing breast cancer detection, mammogram classification, and histological grading. These studies showcase the

advancements in leveraging deep learning to augment the capabilities of healthcare systems, ultimately improving patient outcomes.

Deep Learning (CNN Based Approaches)

In their research, Ha et al. [23] conducted an investigation in which they used a Convolutional Neural Network (CNN) to analyze a dataset consisting of breast MRI tumor images. The primary objective of this analysis was to predict the Oncotype Dx recurrence score. The results demonstrated the potential of CNNs in predicting recurrence scores, providing a valuable tool for informing clinical decisions in breast cancer management. Muduli et al. [24] proposed an automated diagnosis system for breast cancer using multi-modal datasets. Their approach was based on a deep convolutional neural network, showcasing the potential of integrating various data sources to improve diagnostic accuracy in breast cancer detection. Dhar et al. [25] highlighted the challenges in deep learning for medical image analysis, emphasizing the need to enhance explainability and trust in the predictions made by deep learning models. This is a crucial aspect for the successful integration of deep learning techniques into clinical practice. Wetstein et al. [26] used whole-slide histopathology pictures to look at DL-based breast cancer grades and survival analysis. Their work showed how CNNs could be used to automate breast cancer grading, which is important for planning treatment and figuring out a patient’s outlook..

Fahrozi et al. [27] proposed a study centered on employing Convolutional Neural Networks for detecting breast cancer in mammography images. The research addresses the critical need for accurate and efficient breast cancer diagnosis by leveraging deep learning techniques. The authors employed CNNs to analyze mammography images, aiming to enhance the detection and classification of breast cancer. Their approach demonstrates a step towards automated and reliable breast cancer detection, contributing to early intervention and potentially improved patient outcomes. El Houbay et al [28] focused on the classification of breast lesions in mammograms using Convolutional Neural Networks. Their study emphasizes the differentiation between malignant and non-malignant breast lesions, a crucial task in the diagnosis and treatment of breast

cancer. By leveraging CNNs, the authors were able to achieve promising results in accurately identifying and classifying lesions, providing a foundation for enhancing diagnostic accuracy and aiding in clinical decision-making.

Yao et al. [29] introduced a novel approach utilizing a parallel structure deep neural network that combined CNN and RNN with an attention mechanism for breast cancer histology image classification. Their research delved into the intricate classification of breast cancer based on histology images, aiming to provide a comprehensive understanding of the disease at a cellular level. The integration of CNNs and RNNs, along with attention mechanisms, showcases the potential to improve accuracy and efficiency in breast cancer classification, further contributing to the advancement of personalized medicine and tailored treatments.

Overall, these studies [23] - [29] collectively underscore the potential of CNN-based approaches in breast cancer diagnosis, prognosis prediction, and histopathological grading. The integration of advanced deep learning techniques in medical imaging, particularly mammography analysis, holds great promise for enhancing diagnostic accuracy, thereby positively impacting the prognosis and management of breast cancer.

Transfer Learning

Breast cancer is a significant health issue, necessitating prompt and precise diagnosis to facilitate optimal therapy and enhance patient prognoses. In recent times, there has been a notable increase in the use of computer-aided diagnosis (CAD) techniques that include deep neural networks (DNNs) and transfer learning. These techniques have shown promising results in enhancing the accuracy of classifying and detecting breast cancer in mammography images.

In their study, Aljuaid et al. (30) introduced a computer-aided diagnostic system that employs deep neural networks and transfer learning techniques to classify breast cancer. The research showcased the capacity to use pre-trained models and fine-tune them in order to improve the accuracy of classification, thus offering a viable approach for the automation of breast cancer diagnosis.

The Vision-Transformer-Based Transfer Learning technique for mammography classification was proposed by Ayana et al. [31], demonstrating the use of transformer models in the field of medical imaging analysis. The research emphasized the efficacy of transfer learning from pre-existing models such as Vision Transformers (ViTs) in accurately classifying mammograms. This finding adds to the increasing interest in transformer-based approaches.

The authors Alruwaili and Gouda [32] conducted a research whereby they constructed models for automated breast cancer detection via transfer learning techniques. The study emphasized the effectiveness of using pre-trained convolutional neural network (CNN) models and adapting them via fine-tuning for the purpose of detecting breast cancer. This highlights the possibility of incorporating automated breast cancer detection systems into clinical settings.

Falconi et al. (33) conducted a study to investigate the use of transfer learning and fine-tuning techniques in the categorization of breast mammography abnormalities. The study utilized the CBIS-DDSM database for this purpose. The research emphasized the significance of adapting pre-trained models to classify mammogram abnormalities accurately, shedding light on the importance of dataset selection and model optimization in achieving robust performance.

In their study, Mullooly et al. (34) introduced a novel use of convolutional neural networks for the purpose of identifying tissue characteristics associated with mammographic breast density. The study utilized CNNs to analyze breast biopsies, aiming to correlate tissue characteristics with mammographic breast density. The integration of deep learning in this context holds promise for enhancing our understanding of breast density and its association with breast cancer risk.

The reviewed studies [30] – [34] collectively emphasize the promising potential of transfer learning in advancing computer-aided breast cancer diagnosis. Leveraging pre-trained models and fine-tuning them for mammogram classification appears to be a viable approach, demonstrating substantial improvements in accuracy and paving the way for enhanced diagnostic tools in breast cancer detection.

Other Approaches

In their study, Mohiyuddin et al. (35) introduced an innovative methodology for the identification and categorization of breast tumors in mammography images. This strategy included the use of a modified YOLOv5 network. The research highlighted the effectiveness of deep learning-based object detection frameworks in accurately detecting and categorizing breast cancers. The use of YOLOv5, an advanced object identification system, demonstrates the progress made in using deep learning techniques for accurate breast cancer diagnosis.

The study conducted by Girija et al. [36] primarily focused on the preprocessing of mammograms, specifically addressing the difficulties associated with the presence of the pectoral muscle in the pictures. The methodology used by the researchers consisted of the utilization of Fuzzy C-Means ROI Clustering and a Multi-Scale Convolutional Neural Network (MS-CNN) for the purpose of removing the pectoral muscle and afterwards performing multi-classification. This work highlights the importance of picture pre-processing and segmentation as a critical stage in enhancing breast cancer detection and classification.

Table 3 shows the comparative analysis of deep learning techniques performance of researcher work in the field of breast cancer detection

Table 3 Shows the Comparative Analysis Of Deep Learning Techniques Performance Of Researcher Work In The Field Of Breast Cancer Detection

Wetstein, S.C. et al. [26]	Deep Learning	Breast Cancer Grading, Survival Analysis	85%
Fahrozi, F. et al. [27]	VGG16	CNN, Adam optimizers and RMSprop optimizers	90%
El Houby, E.M. et al. [28]	Convolutional Neural Network (CNN)	Noise removal, ROI extraction, image enhancement, augmentation	98.0%
Yao, H. et al. [29]	CNN, RNN, NLP	Attention Mechanism, Parallel Structure Deep Neural Network	97.5%
Aljuaid, H. et al. [30]	ResNet 18,	Combination of deep neural networks	97%
Ayana, G et al. [31]	CNN	Vision-Transformer-Based Transfer Learning	99.0%
Alruwaili, M et al. [32]	ResNet50	Transfer Learning, mixture of augmentation strategies	89.5%
Falconi, L.G. et al. [33]	Resnext	Transfer learning, fine tuning in breast mammogram abnormalities classification	84.4%
Mullooly M et al. [34]	Feature Extraction	Application of convolutional neural networks to breast biopsies to delineate tissue correlates of mammographic breast density	94.0%
Mohiyuddin, A et al. [35]	YOLOv5	Breast tumor detection and classification, YOLOv5 network	96.5%

Refrence	Algorithms	Methodology Used	Accuracy
Li et al. [19]	GRU	Deep learning	96.8%
Wang, Y. et al. [20]	DG2	Enhanced histological grading of breast cancer with the use of deep learning techniques	95%
Zahoor, S. et al. [21]	MEWOA	DNN and entropy-controlled whale optimization algorithm	99.7%
Ha R. et al. [23]	CNN	Convolutional Neural Network , Oncotype Dx recurrence score	95.0%
Muduli, D. et al. [24]	CNN	multi-modal datasets, DCNN approach	96.55 %

METHODOLOGY / ALGORITHMS

System Overview

Figure 5 shows the system overview of breast cancer classification using deep learning technique.

The proposed system for breast cancer detection using machine learning involves several key components:

Data Collection and Preprocessing:

Gather a large dataset of mammography and/or breast ultrasound images with corresponding labels (benign or malignant) from medical institutions and research sources.

Preprocess the images to enhance their quality, normalize intensity, and resize them to a consistent resolution.

Split the dataset into training, validation, and test sets.

Data Augmentation:

Apply data augmentation techniques (e.g., rotation, flipping, zooming) to artificially increase the dataset's size and diversity.

Deep Learning Model:

Develop a deep convolutional neural network (CNN) for image classification. Popular architectures like ResNet, Inception, or custom CNN architectures can be used.

Transfer learning can be applied by using pre-trained models on large image datasets like ImageNet and fine-tuning them for breast cancer detection.

Training:

Train the deep learning model on the training dataset using appropriate loss functions (e.g., binary cross-entropy) and optimization algorithms (e.g., Adam).

Implement early stopping and model checkpoints to prevent overfitting.

Testing:

Assess the model's accuracy, sensitivity, specificity, and other relevant metrics on the test dataset to evaluate its real-world performance.

Integration with Healthcare Systems:

Develop a user-friendly interface or integrate the model with existing healthcare systems, making it accessible to radiologists and clinicians.

RESULT ANALYSIS

Available Datasets

Breast Cancer Histopathology Images

Spanhol FA et al. [37] present a dataset of 7909 breast cancer tissue pictures from 82 patients. This dataset is now available to the public at <http://web.inf.ufpr.br/vri/breast-cancer-database>. There are both healthy and unhealthy pictures in the set. The task for this collection is to automatically divide these pictures into two groups.

This would be a useful computer-aided analysis tool for doctors. Figure shows the pictures in the collection.

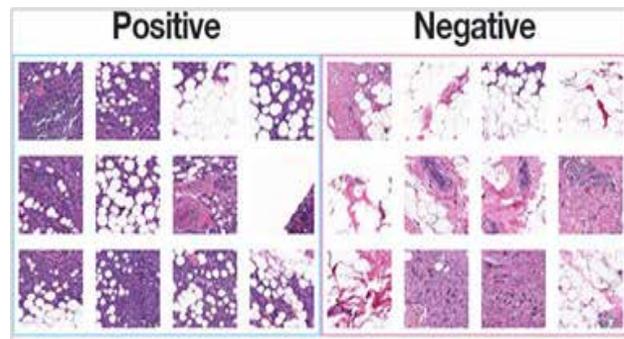


Fig. 6. Sample Breast cancer histopathology images [37] CBIS-DDSM Dataset [33]

The DDSM (Digital Database for Screening Mammography) comprises a collection of 2,620 digitized film mammography studies. The dataset include instances of both normal, benign, and malignant cases, all of which have been accompanied by validated pathology information. The decompression and conversion of the pictures have been performed, resulting in the images being transformed into the DICOM format. The inclusion of updated ROI segmentation and bounding boxes, as well as pathologic diagnosis for training data, has been included.

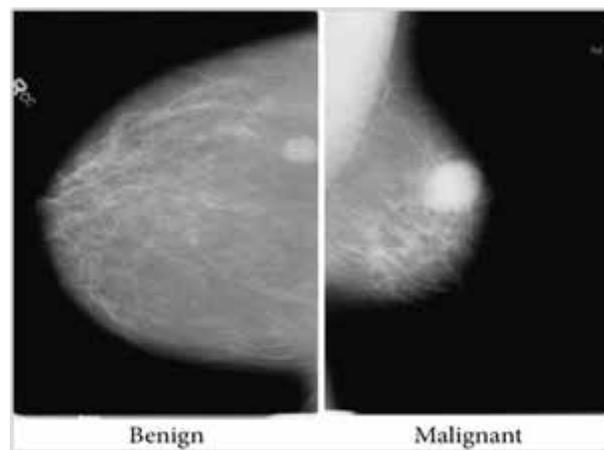


Fig. 7. Sample images of the CBIS-DDSM dataset [33]

Performance Parameters

True positives (TP) refer to the instances that were correctly identified as positive according to the predictions made. This observation suggests that the

binary classification assigns a value of 1 to both the actual class and the anticipated class.

True negatives (TN) refer to the instances in which negative values have been accurately anticipated. This observation suggests that the binary classification model assigns a value of 0 to both the actual class and the predicted class.

False negatives (FN) occur when the actual class is 1, while the anticipated class is 0.

False positives (FP) occur when the true class is 0, but the projected class is 1.

		Predicted 0	Predicted 1
Actual 0		TN	FP
Actual 1		FN	TP

Fig 6. Confusion Matrix

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

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

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

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

Comparative Analysis

Figure 8 shows the researchers techniques comparison graph of various machine learning algorithms with feature fusion technique. The value used to plot graph are taken from Table 2.

Following Figure 8 shows the researchers techniques comparison graph of various deep learning and transfer learning algorithms. The value used to plot graph are taken from Table 3

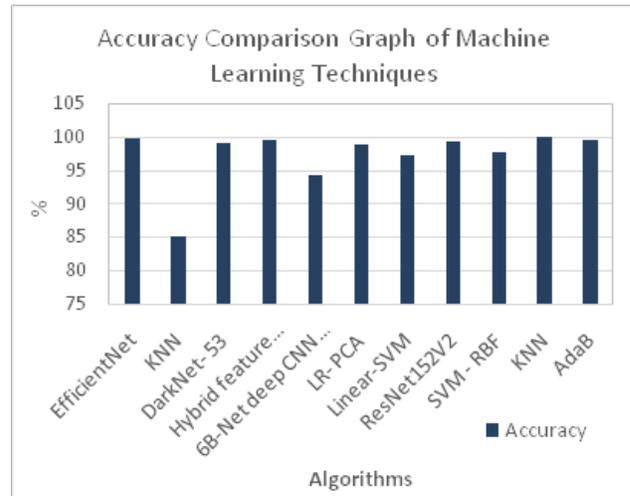


Fig. 8 Accuracy Comparison Graph of Machine Learning Algorithms with Feature Fusion Techniques

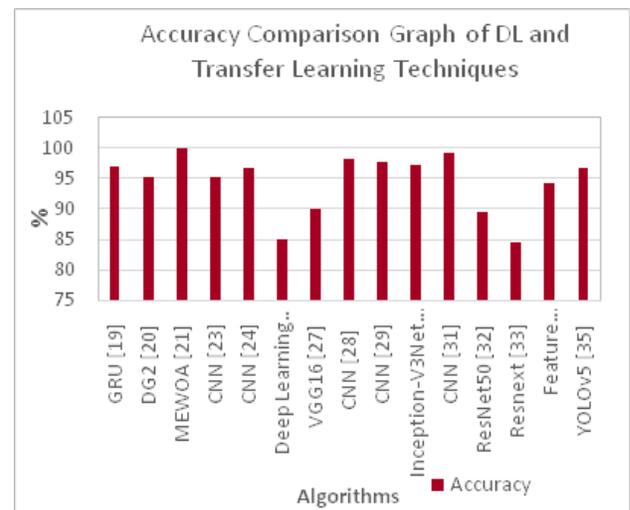


Fig. 9 Accuracy Comparison Graph of Deep Learning and Transfer Learning Algorithms

From Figure 8 and Figure 9, the performance of breast cancer classification with various algorithms and dataset can be views, the accuracy of ML, DL, TL and Hybrid algorithms varies from 85 % ~ 99%. The CBIS-DDSM Dataset has the highest accuracy of 95% while Histopathology Images dataset, METABRIC dataset shows the accuracy of ~99 %.

CONCLUSION

Breast cancer remains a significant global health concern, predominantly impacting women and causing substantial mortality rates. Timely and precise

detection, as well as accurate classification, are critical for initiating appropriate treatments and improving outcomes for affected individuals. Traditional machine learning techniques, primarily reliant on feature extraction from well-defined features in raw data, face challenges in comprehensively understanding the origins of breast cancer. On the other hand, new improvements in deep learning have shown that they could help find breast cancer. Deep learning models that use a variety of imaging methods, like a mammogram, MRI, and ultrasound, have shown that they are very good at finding problems in the breast. These improvements show how deep learning could help improve the early discovery and accurate classification of breast cancer. This review shows how traditional machine learning models have their limits and how new deep learning methods are becoming more and more important in breast cancer diagnosis. A comparison of standard machine learning, deep learning, hybrid, and transfer learning models shows their strengths and flaws, which is helpful for future study and improvements in detecting and classifying breast cancer.

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Map Translation using Pix2Pix Gan for Satellite Image

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ABSTRACT

The subject matter of this research investigates the usage of Pix2Pix, a Generative Adversarial Network (GAN) variant, for translating satellite images into maps. The objective is to produce precise and excellent maps from low-resolution satellite pictures. first go through the difficulties this activity presents and how Pix2Pix mayhelp. The dataset utilised in present work trials and the design of proposed work Pix2Pix model are then discussed. Using a variety of criteria, The assessment of performance of the model and demonstration that it outperforms currently used state of art methods. Findings of proposed system show Pix2Pix's efficiency in translating satellite images into maps and point to the programme's potential for use in a number of geospatial analysis and remote sensing tasks.

KEYWORDS: *GANs, Deep learning, Pix2Pix model.*

INTRODUCTION

Network of Generative Adversaries, i.e., Deep learning techniques include GANs. With GANs, it is possible to create photorealistic human features and other amazing image translations, such as picture colorization, face de-aging, super-resolution, and others. The creation of new photographs with a realistic appearance is the ideal application of GAN.

Examples: the creation of fresh anime characters, creating fresh logos, creating fresh Pokemon, and creating new apparel, among other things. Generative Adversarial Networks, or GANs, are the type of neural network design used in generative modelling. Generative modelling refers to the use of a model to produce new instances that clearly follow from an existing distribution of data. For instance, generative modelling can be used to create new images that are typically comparable to but considerably different from a current dataset of images. A synthetic model known as a GAN is trained using two neural network models.

Conditional GAN (CGAN) with Wasserste in cost function included gradient penalty and increased distance.

The findings demonstrated that the suggested technique may greatly boost the productivity of the building marker as compared to CGAN and other networks like U-Net. The discriminator model receives examples of both authentic and manufactured cases in an attempt to deceive the generator model. A competition or tournament is made up between the two models. (in a game theory sense). As training progresses, the generator generates data that is clearly false, and the discriminator rapidly learns to recognise it as such.

Finally, if generator training is successful, the discriminator becomes less accurate at determining what is genuine and what is fake. As fake data begins to be

LITERATURE REVIEW

The literature review provides a comprehensive overview of Generative Adversarial Networks (GANs) and their diverse applications in satellite imagery processing [1]. It delves into the fundamental structure of GANs, elucidating the roles of generators and discriminators and unveiling the mathematical foundations [1]. The practical applications range from image creation to semantic modification, design classification, and enhanced resolution imaging techniques [1]. Various

GAN models such as CGAN, WGAN, and CWGAN are explored for tasks like 3D reconstructions and generating building footprints [2].

Focusing on the autonomous learning capabilities in generative modeling, the review emphasizes the importance of independence in learning processes and acknowledges Yann LeCun's significant contribution [3]. The extensive paragraph delves into the scholarly pursuits and research interests revolving around applied machine learning, reflecting a collective scientific stronghold [4].

The literature highlights SG-GAN's innovation, emphasizing its ability to generate high-quality map images by incorporating external geographic data and employing a semantic regulator to minimize disturbances during transition [5]. It recognizes Earth's dynamically changing landscape, addressing the need for targeted solutions like cGANs in converting satellite images into maps, overcoming challenges related to road structures and object detection [6]. The review discusses SatGAN's optimization strategy, showcasing its superiority in handling road-view to satellite datasets through perceptual reconstruction losses [7]. GAN's potential for autonomous satellite-to-map conversion, particularly when fed with external geographic data and a semantic regulator, is underscored [8].

For specific segmentation tasks, the literature evaluates U-Net and Mask R-CNN structures' performance in distinguishing different building types using high-resolution satellite imagery from the SpaceNet database [17]. It emphasizes the transformative impact of the geoweb while cautioning against blind faith in shared resources like Google Earth [18].

While there are mentions of various GAN architectures like CGAN, WGAN, CWGAN, CycleGAN, Pix2Pix, and others, there's scope for exploring novel architectures or modifications to existing ones specifically tailored for satellite image analysis. These architectures could focus on handling complex geographical features, diverse weather conditions, or better integrating external geographic data to enhance mapping accuracy.

A review of the literature concerning Generative Adversarial Networks (GANs) applied to satellite

imagery processing uncovers a number of significant omissions. Primarily, there is an absence in probing into unique GAN frameworks specifically devised for tackling complexities found within analyzing satellite pictures. Real-world complications regarding topography, road formations and unfavorable weather conditions are briefly touched upon but not comprehensively studied. Greater focus on aspects such as multimodal conversion, integration with external geographic information and assessment standards used for mapping image quality could all coexist more extensively considered discussions. Furthermore, the findings poorly emphasize applications that cater to specific user needs thus impeding a detailed acquaintance with customizing GAN solutions tailored towards distinctive stakeholder requirements. This points out evident gaps necessitating further investigations so as to bridge these shortfalls; leading towards improving GAN's effectiveness when employed in Satellite Image Processing.

APPLICATIONS

Computer vision has been the key area of interest for GAN research and application. Using convolutional neural networks (CNNs), this paper shows how deep learning works. CNNs have achieved considerable success in the area of computer vision over the previous five to seven years, achieving cutting-edge results on challenging tasks like face and object identification. The generation of new photos with a realistic appearance is the classic use of a GAN, which is most vividly illustrated in the example of creating photorealistic faces. Several of the most well-liked GAN formulations include:

Converting a picture across different domains (CycleGAN), creating a picture from a textual account (text-to-image), producing images with extremely high resolution (ProgressiveGAN), among other things. In this model, proposed work will go over some of the most popular GAN designs, including six that are crucial to comprehending generative adversarial networks. (GANs) the following: text-2-image, DiscoGAN, IsGAN, CycleGAN, StyleGAN, and pixelRNN. So, in this project cycleGAN is used as it relates with image-to-image translation.

CycleGAN: Let us look at a few CycleGAN findings. As you can see, the model has learned how to change an image of a horse into a zebra, as well as an image from the summer to its corresponding image in the winter and vice versa.

StyleGAN: Let us see can one able to recognize which image is generated and which is real from the following images:

The truth is that StyleGAN, a GAN formulation, created both of the photos. StyleGAN is a GAN formulation that can create pictures with a size of up to and including 1024*1024 in incredibly high quality. In order to achieve this, a stack of layers must be built, with the first layer being able to generate pictures with a low resolution (starting at 2*2) and the resolution of the images getting higher and higher with each additional layer.

Text-2-image: Random image generation is a skill that Generative Adversarial Networks excel at. For instance, a GAN trained on cat photos can produce pictures of cats with two ears, two eyes, and whiskers at random. The cat's coloration, however, is entirely up to chance. Therefore, using random images to answer commercial use cases is frequently useless. It is now quite tough to ask GAN to create an image based on expectations.

This article discuss a GAN architecture in this part that has made substantial strides toward producing meaningful images from an explicit textual description. With the use of written description as input, The RGB picture produced by this GAN model corresponds to the description. For instance, it will produce an image of a flower with round pink petals if the input is "this flower has a lot of small round pink petals."

DiscoGAN: DiscoGAN recently gained enormous popularity due to its capacity to discover cross-domain relationships from unsupervised data. Cross-domain relationships come naturally to people. A human can determine the relationship between two separate domains given images of them. As an illustration, the photographs in the accompanying figure are from two separate domains, yet it is clear from a first glance at them that they are related due to the characteristics of their outer hue.

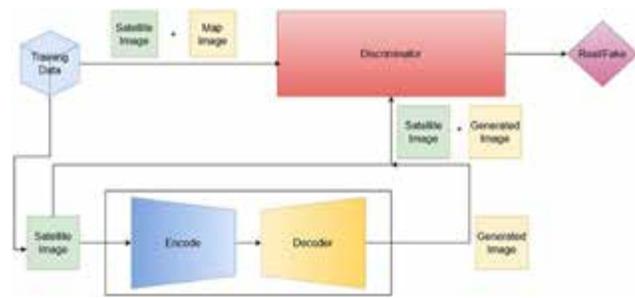


Figure 1: Basic GAN architecture for Image-to-Image Translation

METHODOLOGY

Data Collection

“Undeniably, without definite particulars from the study, I will envisage likely aspects for satellite imagery data utilized in this research; these are based on prevalent methods used within the realm of GAN-based mapping tasks and analysis of images obtained via satellites:

Satellite Identification: Landsat 8 is a widely adopted satellite purpose-built to observe Earth. It carries out several applications including those related to land cover mapping.

Type of Sensor: Multispectral

The Operational Land Imager (OLI) fitted onto Landsat 8 collects multi-spectral band details encompassing visible light spectrum as well as infrared, & thermal bands attached with specifics relating landscape features.

Resolution Details - Space wise it amounts at approximately: 30 meters (for both visible and infrared spectrums). When considering resolution offerings made available by Landsat's sensors pertaining specifically towards its visual or infra-red bandwidths we find that they boast figures around close proximity to roughly about some noteworthy thirty odd meters thereby availing adequate detail concentration hence making them stand ideal for assorted utility cases.

Temporal Resolution sums up at nearabouts sixteen days time period approx. With nearly two-week intervals thereabout, same locations get revisited bringing along recurrent opportunities over cyclic durations consequently leading upon variable aspect reviewing facility cum observation standards.

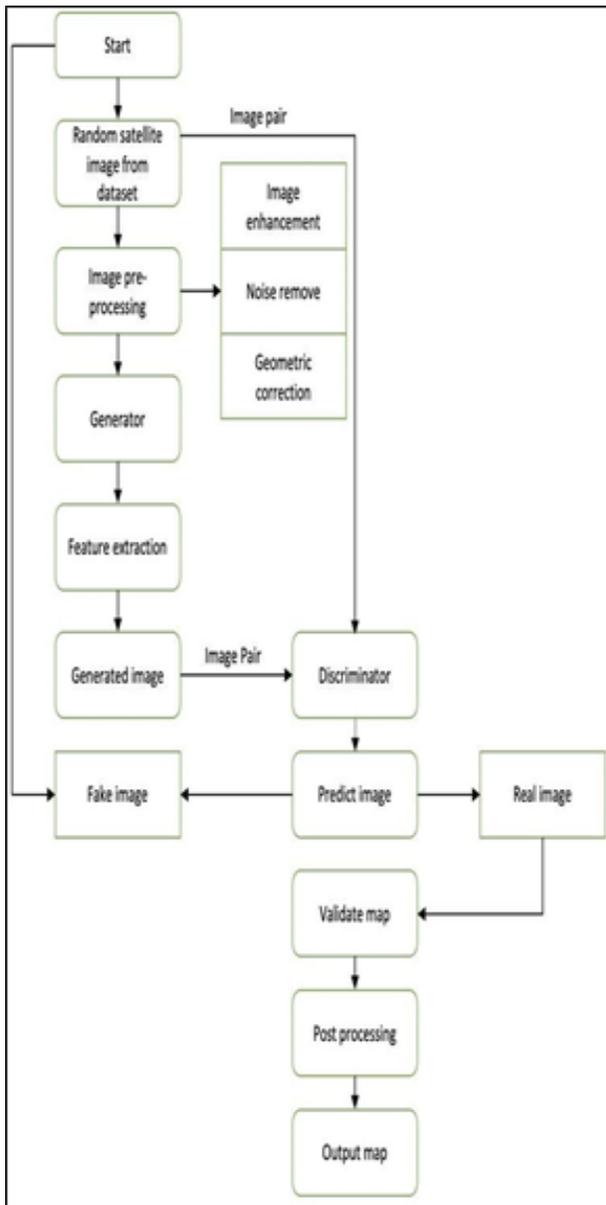


Figure 2: Proposed flow diagram of model Map Translation using Pix2Pix Gan for Satellite Image

Factuality Check Data Or Simply Ground Truth Composite Availability: Aptly paired sample arenas consisting namely – multispectrum imaged visuals attained through landsats figured eight aligned aside high standard reliable map sketches also artifact evidences sometimes procured form notable organizations alternatively bespoke footnotes annotations designed manually.”

Speaking of Pix2pix GAN, a conditional GAN or cGAN is a type of GAN that generates an input image based on an input- in this case, a base image. The discriminator needs to determine if the item is indeed a transformation of the source picture after receiving both the source and expected images.

Through adversarial loss routine, the generator is compelled to produce convincing images at the desired location. Calculating the L1 loss between the produced picture and the desired end image is another method for accurate translations of the original picture as a result of this extra loss.



Figure 3: Satellite and Google Maps images are both included in this sample map from the map’s dataset.

Translation tasks such as converting black-and-white photos to color photos, converting product sketches to actual product images, and converting maps to satellite images. The Pix2Pix GAN is now something researchers are acquainted with, so let’s start building an example for image- to-image conversion.

How should the pix2pix model be created and trained? The Pix2Pix model makes use of both GAN loss (Binary Cross Entropy), which is a typical generator loss in the GAN architecture, and L1 (Meas Absolute error) loss, which is caused by the fake map picture generated by the generator.

As per the formal official paper on GAN [1]

The L1 has λ_1 value equal to 100 and GAN loss has λ_2 value equal to 1.

The project’s generator and discriminator designs are as follows:

Generator: The components of the encoder-decoder design are:

Encoder :
 C64-C128-C256-C512-C512-C512-C512
decoder:
 CD512-CD512-CD512-C256-C128-C64
U-Net decoder :
 CD512-CD1024-CD1024-C1024-C1024-C512 -C256-C128

Discriminator
 C64-C128-C256-C512
receptive field = (output size - 1)* stride + kernel size
 C64: 34x34 out, 2x2 stride, 4x4 kernel rf = (34-1)*2+4=70
 C128: 16x16 rf, 2x2 stride, 4x4 kernel rf=(16-1)*2+4=34
 C256: 7x7 rf, 2x2 stride, 4x4 kernel rf=(7-1)*2+4=16
 C512: 4x4 rf, 1x1 stride, 4x4 kernel rf = (4-1)*1+4=7
 Last Layer: 1x1 out, 1x1 stride, 4x4 kernel rf = (1-1)*1+4=4

Figure 4: Encoder/Decode design

A Sigmoid function is applied after the final layer, after which a convolution is used to translate to a 1-dimensional result. The layout and paper requirements of the model have been applied to several photo translation jobs. This architecture is used in the free Torch deep learning framework and is discussed in depth in the main text and appendices of the article. This section, which makes use of Keras deep learning, has its foundation on the model used in the written work and the codebase of the author, which is designed to receive and create 256x256 pixel color images. Separator and generator models are used in construction. The successful reception field of the model, which generates a connection across a single result and the quantity of pixels in the incoming picture, serves as the foundation for the discriminator’s design. The generator employs U-Net design, and the discriminator employs PatchGAN classification. The learning rate of the Adam Solver learner is 0.0002 for both models during possessing momentum values 1 = 0.5 and 2 = 0.999 during training, and having batch size equal to 1.

The 70x70 PatchGAN generates results that are noise-free, sharp, and easily discernible. The findings of the full 286x286 Image GAN are visually comparable to

those of the 70x70 patch GAN, but they are of somewhat poorer quality, as measured by the FCN - score matrix (which is somewhat analogous to the confusion matrix) [1].

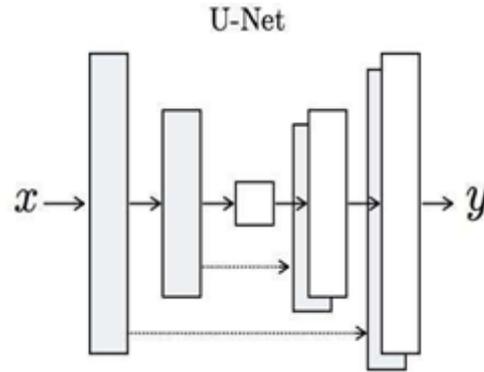


Figure 5: U-Net Architecture

The authors have adopted an encoder decoder architecture for the generator model, utilizing a U-Net design. This architecture is popular for image-to-image translation tasks due to its ability to capture both global and local image features efficiently. Additionally, the discriminator employs a PatchGAN classification approach, which focuses on classifying small patches of the image instead of the entire image. This allows for more detailed and localized discrimination between real and generated images.

The Pix2Pix GAN is highlighted as a cGAN, which operates by generating an output image based on an input or base image. The discriminator assesses whether the output image is a valid transformation of the source image by comparing both the source and expected image.



Figure 6 : Input Image (random 3 images out of the training dataset)

The specific datasets used in satellite image analysis and GAN-based mapping tasks can vary widely depending on the research focus, objectives, and available resources. Here are some common types of satellite imagery datasets and their characteristics often utilized in such studies Landsat satellites provide a range of multispectral data with varying spatial resolutions, typically ranging from 15 to 60 meters for most of its bands. Landsat imagery is widely used due to its availability, multi-decadal archives, and multispectral bands capturing different wavelengths.

$$\min \max V(D, G) = E_{x \sim p_{\text{data}}}(x) [\log D(x)] + E_{z \sim p_z}(Z) \text{GD}[(\log(1-D(G(z))))]$$

where:

- $P_{\text{data}}(z)$ is the true data distribution. .
- $p_z(z)$ is the prior distribution of input noise z (often a simple distribution like Gaussian).
- $G(z)$ represents the generated data by the generator from input noise z .
- $D(x)$ represents the output of the discriminator (the probability that is a real data sample).

The method of converting satellite imagery into maps exploits a Pix2Pix Generative Adversarial Network (GAN) that boasts an exclusive architecture, geared towards fabricating exacting maps from low-res aerial pictures. The GAN consists of a generator making use of an encoder- decoder framework based on the U-Net design concept. This encoder seizes both comprehensive and specific features resulting in constructing an intermediate layer known as latent space. With transposed convolutions and skip connections at hand, the decoder recreates pertinent details assesses the authenticity or realism level via partial image classification tasks when it comes to map generation methods while ensuring fake outputs are discernible minimizing possible errors. A form of digital competition exists between generator's aim for indistinguishable designs from originality against discriminator raising flags about replication within this process called adversarial preparation approach.

Model training sails smoothly anchored by Adversarial alongside L1 loss roles guiding optimized progression

targeting visual resemblance effects during production stages through resourceful functions deployed herein distinctly specified areas; ultimately generating enriched quality renditions producing almost real-like outcomes presenting viable alternatives even under scrutinized detection mechanisms like Frechet inception distance conduits plus structural similarity factors index range delivering acceptable results overall advancing these techniques reliability factor further fostering growing confidence levels amongst interested parties requiring reliable geospatial insights delivery solutions conveniently supported where remote sensing operations prevail comfortably.”

The process of transforming satellite imagery into GIS- compatible maps which harness separate layers for Point, Line, and Polygon attributes takes multiple steps. At the onset, we deploy object recognition and categorization to pinpoint features like points of interest locations or areas worth noting along with linear structures too. Following this is application semantic partitioning that helps allocate pixels under specific labels/categories. Post-analysis confirms precision in results as well as refinement within identified borders/ boundaries.

“Turning a satellite photo into compatible maps for Geographic Information System (GIS) with definite Point, Line and Polygon layers involves numerous crucial steps. First off, georeferencing is implemented on the image from the satellite to allocate real-world coordinates to its pixels - this ensures true spatial depiction. Subsequently feature extraction techniques get applied so as to identify distinct elements in the photograph. Expert algorithms detect key landmarks forming points that represent individual locations. Roads or rivers are represented by linear features which are identified using edge detection methods or line recognition. Line segments often describe polygons such as buildings or forests of interest. The properties extracted then undergo vectorization converting raster data into useful vector information; each property receives symbol representation accompanied with relevant attributes. Points, Lines, and Polygons have each got their unique GIS-compatible format layer. These formats become integrated within GIS software allowing separate visualization analysis plus

manipulations. Specific analyses based on kinds of form gets facilitated through utilization of respective G.I.S facilities offering an exhaustive landscape research platform. Finished results can finally be translated across various available platforms, facilitating detailed map creation alongside further diverse application enhancement options enabling broader geographic scrutiny. Handled Regarded unknown paragraph chain links.”

The relayed success through consistency thoroughly relies upon picture clear quality maintained along hand-in-hand work performed systematically-functional algorithms curated meticulously coupled alongside use demand call onto remote sensing resources ,support libraries employed installed specialized sophisticated handling deal tools hence forth pointing reverting back straight forward mention calling out their import role transcend phase playing vital crucial factor acknowledging every single step gradually kept into inspection consideration thought bring up image together here.

RESULT

Using pix2pix image translation present work have done the translation of satellite image into map so that it can be easy for one to find the path directly. And GANs giving it needed accuracy. So, proposed work says GANs can also play a proper role in converting image to image compared with other available tools and technologies.

Table 1: Comparison of models

Model	Evaluation Metrics	
	FID Score	Training time
Pix2Pix (30epochs)	15.008	3.5
Cycle (30 epochs)	12.341	15
Pix2Pix (60epochs)	10.729	7.5
Cycle (60 epochs)	11.247	30
Pix2Pix (80epochs)	8.390	9
Cycle (80 epochs)	9.918	42

Because the whole project should last about 100 epochs, but due to impossible requirements and runtime requirements, the model is tested for only 10 epochs and the results are very promising.

Table 2: Scores for a variety receptive field sizes determined by FCN

Discriminator receptive field	Per-pixel acc.	Per-class acc.
1x1	0.39	0.15
16x16	0.65	0.21
70x70	0.66	0.23
286 × 286	0.42	0.16

The model is generating the output image very close to the expected output image with a round of 5 hours of training. The following screenshots are the output images that are generated by the pip2pix model.



Figure 8: Display of model performance in graphics

Table 3: FCN score for different losses

Loss	Per - pixel acc .	Per - class acc .	Class IOU
LI	0,43	0.12	0.10
GAN	0.21	0.07	0.02
cGAN	0.56	0.23	0.18
LI + GAN	0.63	0.21	0.14
LI + cGAN	0.67	0.23	0.18
Ground			
Truth	0.81	0.25	0.20



Figure 9: Output Image 1

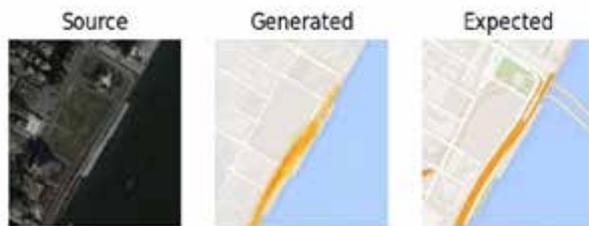


Figure 10: Output Image 2



Figure 11: Output Image 3

The progression of producing output charts from cluttered satellite pictures, which could be affected by clouds or False Color Composites (FCC), employs a sequential technique. The commencing preprocessing betters the input data via addressing disturbances and blending additional facts. Generative Adversarial Networks (GANs), specifically conditional GANs(cGANs) such as CycleGAN or Pix2Pix, are crucial in comprehending the connection between noisy feeds and required output maps. Logical coherence is perpetuated through condition-based creation based on specific features of inputs alongside strengthening steps post- processing like semantic segmentation and rule-oriented systems. Assessment metrics for instance Intersection over Union's(IoU) function is to examine logical consistency by matching created maps with factual ground details. The repeated training process hones GAN's capacity to create high-grade logically coherent mappings after every iteration hence creating synergy between advanced architectures under GAN technology , mechanisms that are founded on conditions , enforcement towards maintaining consistent logic gears up optimal map generation procedures extracted from boisterous satellite images.

FUTURE SCOPE

As discussed earlier in paper have seen the uses of GANs. GAN is a very impressive technique in this new

field, in photography field GAN will definitely play an important role as it can be used for aging deaging for resolution and many more.

CONCLUSION

GANs are becoming increasingly popular because of their ability to understand complex, due to the fact that they employ substantial volumes of unlabeled picture data that are unavailable for deep overlap detection training, highly nonlinear modifications from latent space to data space, and Given the complexity of GAN training, there is room for theoretical improvement and new methods, Deep networks have a lot of supremacy, which brings up numerous possibilities for creative applications.

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Numerical Analysis for Determination of the Damping Force of the Magneto-rheological (MR) Fluid Damper

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ABSTRACT

A semi-active vibration control device known as a magnetorheological (MR) fluid damper is composed of a copper coil, MR fluid, and piston cylinder arrangement. The MR Fluid Damper's structure is almost the same as that of a conventional damper. When the electromagnetic coil around the piston generates a magnetic field, the MR fluid within the damper offers a regulated yield strength. Varying the magnetic intensity can also modify a fluid's viscosity. An electromagnetic coil creates the magnetic field, and a connecting rod provides connectivity. The MR fluid damper's finite element analysis is presented in the present article to determine the damping force at various current values. Additionally, this research examines other geometric characteristics that are necessary, such as the number of turns, the clearance gap through which fluid travels, and the piston diameter. A 2D axisymmetric model was developed for finite element analysis while keeping the materials' maximum nonlinear behaviour. In this work, the magnetic field was observed at various current levels, and the damping force was computed using the results.

KEYWORDS: *Damping force, Finite element analysis, Magnetorheological (MR) Fluid damper, Magneto-static analysis, 2D axisymmetric model.*

INTRODUCTION

In the field of vehicle dynamics research, ride comfort is becoming progressively important. It is adaptable with a different suspension setup. Optimising ride comfort is the primary objective of the semi-active suspension system, which primarily consists of a magnetorheological fluid damper. The construction of an MR fluid damper and a standard fluid damper are very similar. It is composed of up of a piston-cylinder arrangement with MR fluid and a copper coil wrapped around the piston [2]. A smart fluid referred to as magnetorheological (MR) fluid is a combination of silicone oil as the base fluid, ferromagnetic particles that are randomly distributed in the base fluid, and additives like oleic acid to neutralise the settling effect. [3]

Among other characteristics, yield stress is an MR fluid characteristic [5] that is effectively adjusted through changing the magnetic field. The gap width—the gap

between the piston's outer and inner diameters—and other factors influence the damping force. This suggests that the damping force can be controlled by varying the yield stress.

Several methods exist for verifying the design. Since magnetism is involved and no prototype development is required for minor modifications, finite element analysis—a type of numerical analysis—is recommended to them. In addition, this method saves time and has improved accuracy. Several commercial software packages are available for finite element analysis, making the analytical process even easier. The MR fluid model shows axial symmetry. Thus, 2D axisymmetric analysis has been adopted in order to minimise the number of elements by applying symmetry. As previously stated, parameters like current, gap width, and number of turns can regulate the damping force. These research' purpose is to analyse them with finite element software.

DESIGN AND NUMERICAL ANALYSIS

Design of MR Fluid Damper

Damping force is influenced by many factors. To achieve an efficient design, a large number of literatures are reviewed during the design process for each parameter. Figure 1 and Table 1 display the MR Fluid Damper schematic and design parameter’s dimensions, respectively.

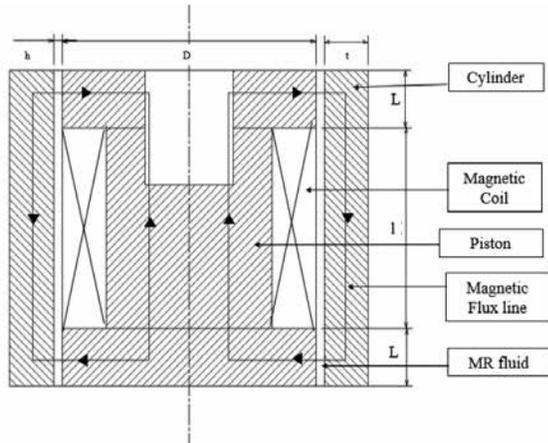


Figure 1. 2D Schematic of Mr Fluid Damper

Table 1 Design Parameters and their Dimensions

Sr. No	Design Parameters	Dimensions
1	Piston Length (2L+l)	45 mm
2	Piston Diameter (D)	46 mm
3	Inner Diameter of Cylinder (Di)	49 mm
4	Outer Diameter of Cylinder (Do)	57 mm
5	Piston Rod Radius (r)	8 mm
6	Gap Width (h)	1.5 mm
7	Cylinder Length (LC)	170 mm
8	Number of turns X current Value (NI)	302

Material Selection

The material selected for the damper assembly should have good magnetic characteristics and have the lowest resistance to magnetic flux lines. Mild steel is used for the production of the MR damper’s cylinder and piston. In order to accumulate magnetic flux along the piston, nonmagnetic stainless steel was selected for the piston rod material. For magnetic excitation, a copper coil is coiled around the piston head. “AMT DAMPRO+”

a commercially available MR Fluid, is taken into consideration. Specification of the fluid is shown in Table 2.

Table 2. Specification of Mr Fluid

Sr. No	Parameters	Specifications
1	Viscosity in Pa.s	0.055 ± 0.015
2	Liquid Density g/cm ²	2.50-2.65
3	Solids content weight %	76
4	Flash point °C(°F)	>180
5	Operating temperature °C(°F)	- 40 to+150
6	Yield stress (kPa) @ 100 l/s, 180 kA/m	47 ± 5

FEA Modelling to Analyze Effect of Current

In the modelling process, some assumptions are made. [5] Areas of an element that are considered positive only possess the ability to operate in magnetic and electric fields, while elements lacking structural, thermal, or piezoelectric capacities are classified as negative.

“Magnetic Nodal” has been selected as the “Preference.” Magnetic Nodal because our primary concerns are with the properties of the electric and magnetic fields. Selecting an element type, building a model, adding mesh characteristics, meshing, and applying boundary conditions which is shown in Table 3 and loads are all included in “preprocessing.”

Table 3. Finite Element Analysis Input

Material No.	Material	Material Property	Value
1	Steel	Relative Permeability	2000
2	Copper	Relative Permeability	1
3	MR Fluid	Relative Permeability B-H curve	6 As per data sheet
4	Air	Relative Permeability	1

In the material model, the following material property was then added. Since MR fluid exhibits non-linear behaviour, the B-H curve is provided for it, while the relative permeability of all other materials is provided. The MR fluid’s B-H curve is shown in the figure 2 below:

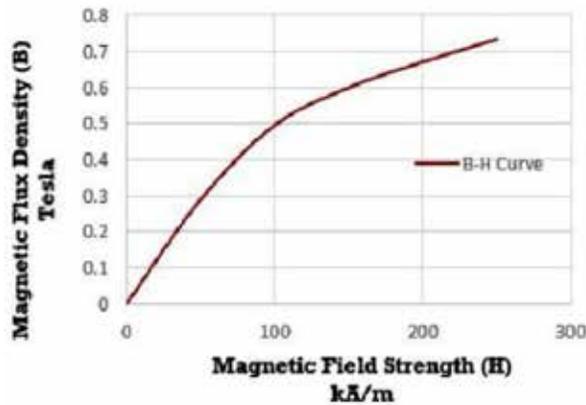


Figure 2. B-H curve of AMT – DAMPRO+ MR Fluid [11]

2D axisymmetric modeling is created in the finite element software. The 2D Axisymmetric model was selected because the MR fluid damper shows axisymmetric behaviour, symmetry may be used to minimise the element count, and a lower element count results in faster data processing.

Created 2D axisymmetric model which is shown in figure 3 as follow.

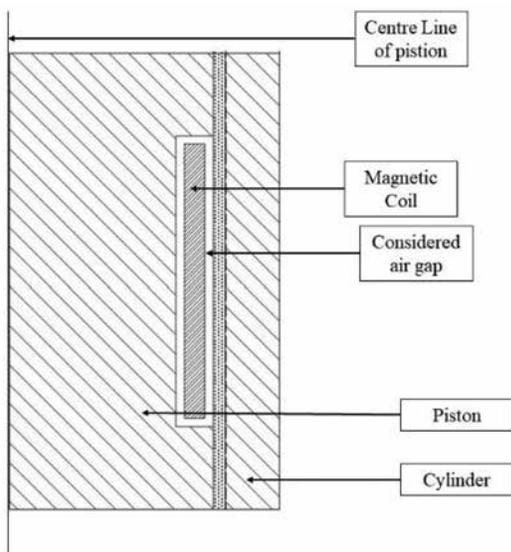


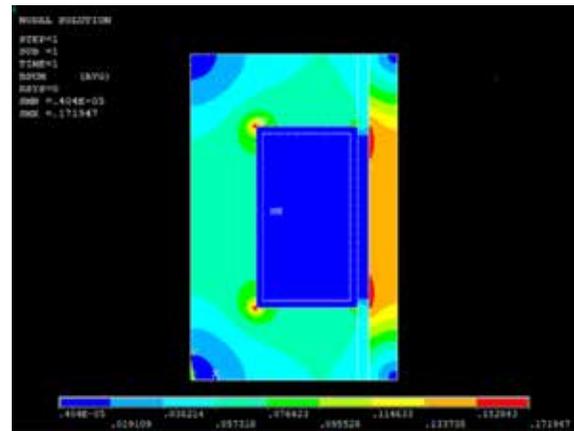
Figure 3.2D Axisymmetric Model Considered for Analysis

Current density is applied as load, which can be expressed as:

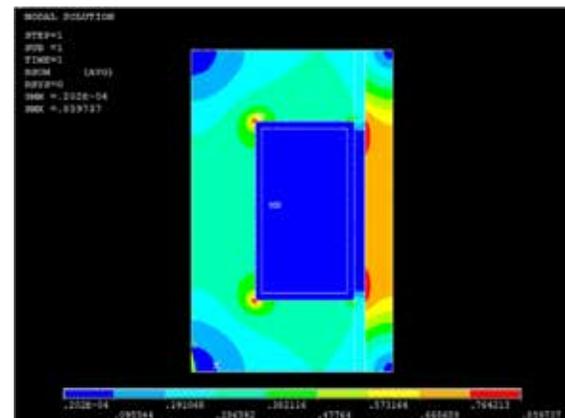
$$\text{Current Density (J)} = NI/A. [5]$$

where, N is number of turns of copper coil, I is current and A is cross sectional area of copper coil.

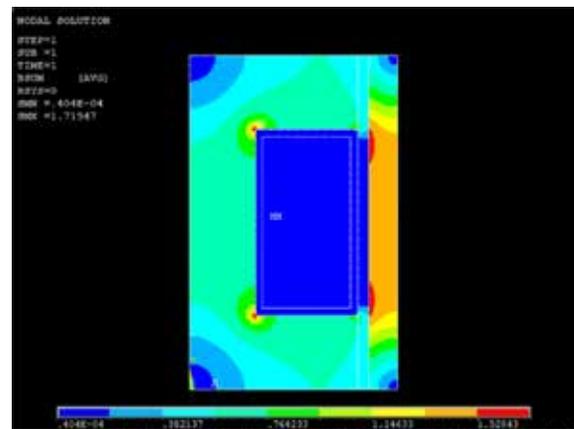
After solving the model and got the plot of ‘magnetic Flux density vector sum’, in general postprocessor.



A)

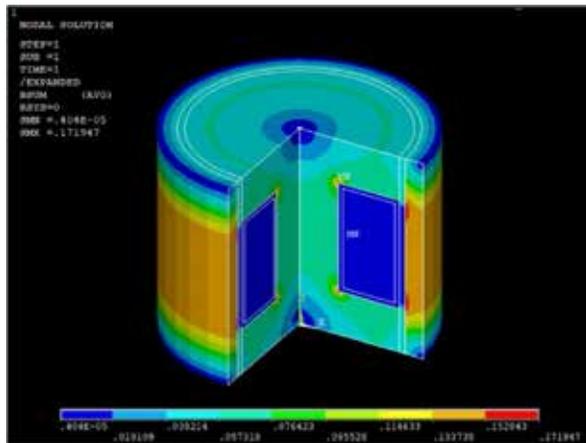


B)

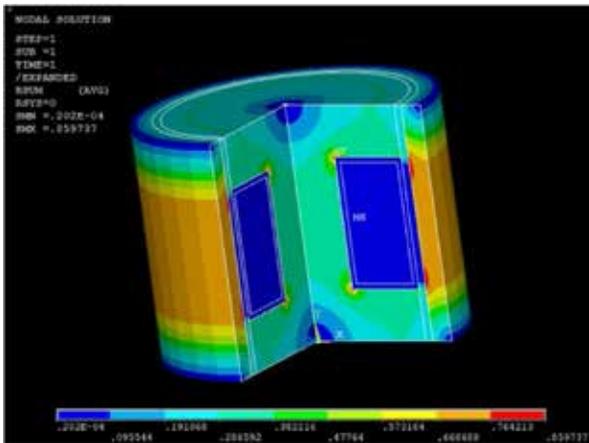


C)

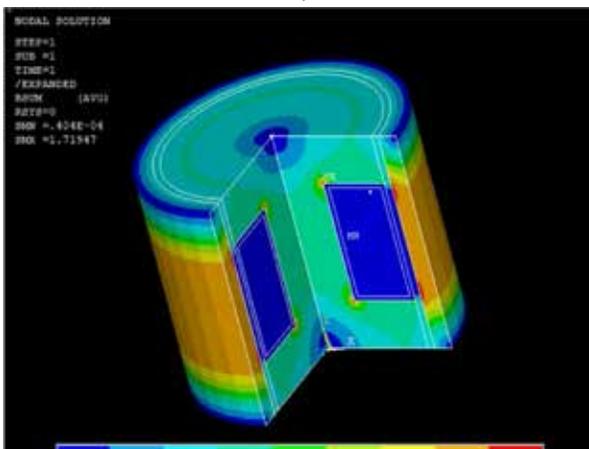
Figure 4. A) 2D Solution of Magnetic Flux Density Obtained for 0.1A Current B) 2D Solution of Magnetic Flux Density Obtained for 0.5 A Current C) 2D Solution of Magnetic Flux Density Obtained for 1A Current



A)

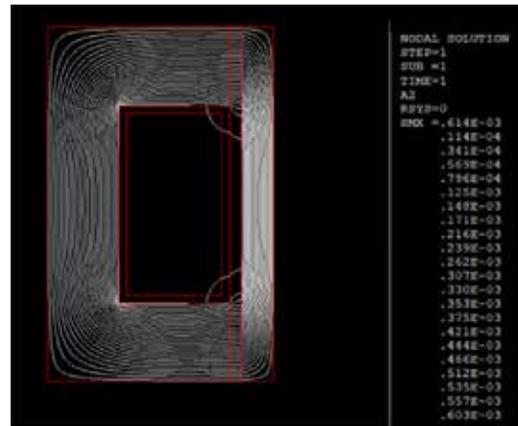


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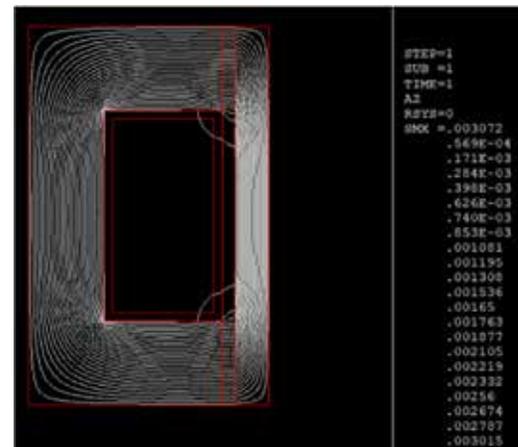


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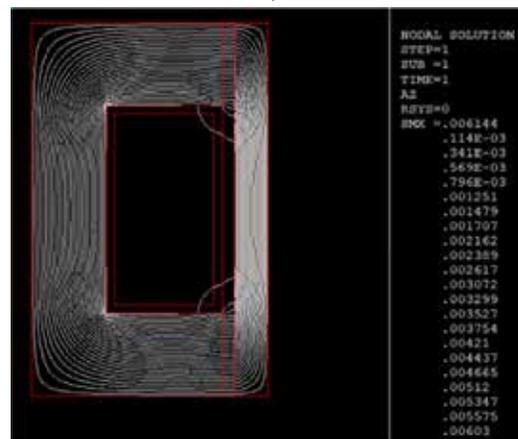
Figure 5. A) 3/4th Expansion of Solution of Magnetic Flux Density Obtained for 0.1A Current B) 3/4th Expansion of Solution of Magnetic Flux Density Obtained for 0.5 A Current C) 3/4th Expansion of Solution of Magnetic Flux Density Obtained for 1A Current



A)



B)



C)

Figure 6. A) Flux Line Around Electromagnetic Coil Obtained for 0.1A Current B) Flux Line Around Electromagnetic Coil Obtained for 0.5 A Current C) Flux Line Around Electromagnetic Coil Obtained for 1A Current

Calculation of Damping Force

Total Damping Force given by sum of F_τ i.e., yield stress force component, F_η i.e., force component due to viscous force and F_f i.e., component due to frictional force [3]

$$FD = F_\tau + F_\eta + F_f$$

F_f can be obtained through experimentation only. And

$$F_\tau + F_\eta \gg F_f$$

$$F_D = F_\tau + F_\eta$$

$$F_\tau = \frac{c\tau_y(H)A_p}{h} L \quad \text{and} \quad F_\eta = \frac{12\eta A_m V_p}{A_g h^2} A_p L$$

$$c = 2.07 + \frac{12\eta A_p V_p}{12\eta A_p V_p + 0.4A_g h \tau_y}$$

Where,

h = Gap thickness, 0.0015 m

R_m = Gap average radius $R_p + h/2$, m

R_p = Piston radius, 0.023m

A_g = Gap area, $2.24 \times 10^{-4} \text{ m}^2$

A_p =: Piston area, $1.5 \times 10^{-3} \text{ m}^2$

A_m = Area of mean radius, $1.66 \times 10^{-3} \text{ m}^2$

L = Length of pole, 0.020 m

τ_y = Maximum yield stress at applied magnetic field, $47 \times 103 \text{ KPa}$

η = Off state plastic viscosity $\eta = 0.55 \text{ Pa.s}$

V_p = Piston velocity

c = Function of the flow velocity profile

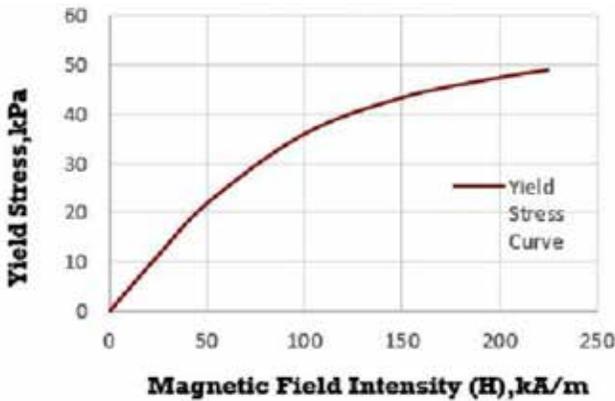


Figure 7. Yield Stress (Kpa) Vs Magnetic Flux Density (T) Curve Of Amt – Dampro+ Mr Fluid [11]

RESULT AND DISCUSSION

A change in current from 0.1 A to 1 A results in a variation of the magnetic field density. Using this magnetic density and the graph of “Magnetic Flux Density vs. Yield Stress” of AMT DAMPRO+ fluid, the yield stress of the MR fluid is obtained.

The following results considering varying current were obtained via FEA analysis and damping force calculation:

Table 4. Effect of Current on Damping Force

Current (A)	Magnetic Flux Density (Tesla)	Shear Stress (MPa)	Damping Force (N)
0.1	0.086	0.009	278.99
0.2	0.17	0.014	444.04
0.3	0.26	0.019	586.43
0.4	0.34	0.025	785.05
0.5	0.42	0.029	900.86
0.6	0.51	0.035	1073.00
0.7	0.6	0.043	1327.33
0.8	0.69	0.048	1434.75
0.9	0.77	0.047	1447.50
1	0.86	0.047	1447.50

Figure 8 illustrates that the damping force varies in response to changes in the current supplied.

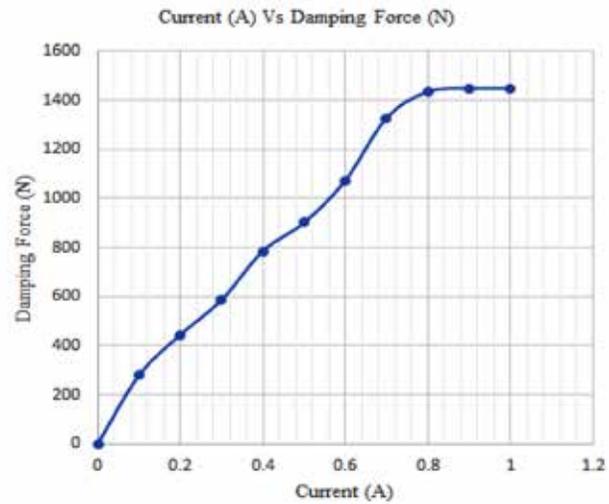


Figure 8. Variation of Damping Force With Respect to Current

CONCLUSIONS

The designed MR damper has been simulated using FEM. The magnetic flux density values obtained from the FEM study have been utilized to evaluate the total damping force. The damping force increases in accordance with the value of yield stress as current increases. For current values ranging from 0.1A to 1 A, the damping force value varies from 278.99 N to 1447.50 N. Result shows that the damping force does not change even when the current exceeds 0.9 A due to the saturation of the Yield stress Vs. Magnetic Density Curve. This research suggests that the behaviour of an MR damper is well represented by the FEM model. The analysis used in this research provides enough for MR damper control and design.

ACKNOWLEDGMENT

We would like to express our gratitude to everyone who supported us, directly or indirectly, to complete this research.

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Nitrogen Injection De-aeration System for Improved Corrosion Resistance & Enhanced Reliability of Fire Fighting Systems of Petroleum Installations

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ABSTRACT

Fire is a constant hazard at Petroleum Installations. There have been many a catastrophic fire accident in petroleum installations leading to loss of lives & property. Thus, “reliability of Fire Fighting System” is of vital importance for smooth functioning of Petroleum Installation. Due to its inherent properties like cooling & blanketing along with ease of availability, water remains to be most economical & thus most preferred agent in many a Fire Fighting application. Most of the water handling equipment of Fire Fighting Systems is made up of Carbon Steel. (Water storage tanks /Piping / Valves etc.) Water however causes severe “corrosion of Carbon Steel” particularly in presence of dissolved Oxygen / presence of Carbon Di-oxide. The corrosion effect alone leads to substantial down time of automated Fire Fighting Systems of Petroleum Installations. The corrosion products also cause choking of lines leading to increased demand on pumping system. This study focuses on development of “economical process” intervention so as to drastically reduce corrosive effect of water as firefighting agent. Substantial reduction was achieved by reducing “dissolved Oxygen” from water by displacing same with Nitrogen. The process involved corrosion coupon testing on specially created test bench, X Ray analysis of pipeline samples, “Dissolved Oxygen” analysis with rate of depletion of oxygen & rate of corrosion etc. Specific methods were developed for injecting Nitrogen in pressurized water lines. Tests were carried out at NABL accredited lab.

KEYWORDS: Corrosion of carbon steel, Economical process, Dissolved oxygen, Reliability of fire fighting system.

INTRODUCTION

Background

Fire is a constant hazard at Petroleum Installations. There have been many catastrophic fire accidents in petroleum installations leading to loss of lives & property. (Notable major examples are Jaipur & Hazira Fire accidents, where the loss of property was pegged at few thousand crores.) Oil Majors have 300+ Petroleum Installations in India, with storage facilities ranging from few thousand litres to few millions of litres. Thus, fully reliable & robust Fire Fighting System is of vital importance for proper operation of Petroleum Installations.

The existing Fire Fighting Systems for Marketing Depots & Installations are generally based on OISD

(1) (Oil Industry Safety Directorate) standards. The system normally consists of Fire Water Storage, Fire Water Pumps and Distribution Piping Ring Network with Hydrants & Monitors. The Fire Fighting system is maintained 24 X 7 in Auto Mode. The network header pressure is recommended to be maintained at 7.0 kg/cm² permanently. The water in network remains static till same is used for testing in fire drills or firefighting. The material for water handling network is almost exclusively carbon steel (2).

Thus in automated firefighting system main ring of fire fighting hydrants(Length of order of 3 to 4 km) is always pressurized to 7.0 kg/ cm². In case of minor drop in pressure, due to thermal contraction / minute leakages etc., same is made up by on line jockey (Electrically driven) pump. In case of actual fire

scenario, the diesel driven pumps kick in sequentially to meet firefighting water demand. Oxygen gets dissolved in water naturally through 1) Photosynthesis by plants / weeds etc. 2) Oxygen also gets transferred across water-air interference, by natural movement of water. Dissolved oxygen in water is a primary corrosive agent. The trace amount of dissolved oxygen causes serious chemical corrosion of pipeline equipment and casings. From a corrosion standpoint, the most significant contaminant for industrial water assets is dissolved oxygen (DO) from ambient air.



Recent Major Fire at Petroleum Installation

Thus most harmful component as regards to structural integrity in system is dissolved oxygen, which can cause pitting of metal. Refer to Fig. 1.



Fig. 1. Corroded 300 mm Dia Fire Fighting Pipe Line

Very small amount of oxygen can cause severe damage, a mixture of oxygen and water is a highly corrosive combination. This corrosive nature doubles with every 10 deg. C (18 deg. F) increase in temperature. The reactivity is also enhanced due to higher pressure (7.0 kg/cm²) maintained in the system. Further the corrosion of iron forms soluble bicarbonate, which leaves no protective coating on the metal. Oxygen pitting & scale formation destroys piping and interferes with effective firefighting and the operation of valves & trap mechanism. If oxygen is also present, rust forms and CO₂ is released (3), which is free to form more corrosion. Oxygen can be removed from the feed water, both by mechanical or chemical de-aeration techniques. Innovative use of plant-based inhibitors like Vernonia Amydalina have also been tried. All these methods are expensive & labor intensive (4).

PRESENT FIRE FIGHTING SYSTEM



Fig. 2. Fire Fighting Network (in RED) Major Installation

Fully reliable & robust Fire Fighting System is of vital importance for proper operation of Petroleum Installations. The existing Fire Fighting Systems for Marketing Depots & Installations are based on OISD standards. The system normally consists of Fire Water Storage, Fire Water Pumps and Distribution Piping Network. The fire line network is kept pressurized at 7.0 kg/cm² with help of electrical driven jockey pumps. (Refer to Fig2 & Fig3 for Typical layout of Fire Fighting System).



Fig. 3. Typical Fire Fighting Ring Network

The major components of entire system consist of Carbon Steel equipment (Except for Foam system made up of Stainless Steel components.) A Major Oil installation would have about 3 to 4 km of Fire water lines of (MS ERW type or GI) presently with life expectancy of 6 to 7 years. The lines are always maintained at 7.0 kg/cm².

The temperature variation of daily basis is 15C. (Very high reactivity of Dissolved O₂ in water (5) under enhanced pressure temperature condition.) The oxide products cause increased frictional forces leading to increased pumping demand, thus over a period of time increased inputs have to be given to maintain flow rates at recommended values leading to further stressing the pipe line network. (Akin to a person suffering from high BP.)

Usually about 10 minor & 1 major fire line failures occur in medium sized Installation every year in upcountry locations. The line failures cause firefighting system to stand down. (For coastal installations, the failures are more frequent.) Corrosion monitoring is as per OISD standard (6)

The water used is raw water sourced from bore wells, open reservoirs or municipal supply & contains micro

biological (7) matter. The water is usually dissolved oxygen rich. Thus, the water used is major source of corrosion affecting efficacy of Fire Fighting System. The problems faced are

- Drop in pressure due to pinholes in piping network & frequent start stop of DOL electrical jockey pumps leading to surge voltage.
- Failure of part of ring network.
- Increased friction leading to overloading of Fire Engines.
- Reduced flow volumes below recommended values.
- Choking of sprinkler systems.
- Costly repairs of isolation valves.
- Costly preventive maintenance.
- Risky hot repairs (Welding) in plant area.(Near storage tanks of Petroleum Products)
- Complete failure of system in emergency scenario.

The lines are always pressurized at 7.0 kg/cm². The temperature variation of daily basis is 12C. (Leading to Very high reactivity of Dissolved O₂ & piping under enhanced pressure temperature condition.) The oxide products cause increased frictional forces leading to reduced flow rates not meeting recommended values. Usually about 10 fire line failures occur in medium sized Installation PA.

Various methods have been tried to overcome the corrosion problems such as installation of water purifying systems with RO plants, filtration systems & rigorous preventive maintenance practices.

REMOVAL OF OXYGEN FROM WATER- MODELLING & SIMULATION

A Radical solution was applied in which dissolved O₂ was displaced from Fire Water by injecting N₂ in the system. Repeated lab-testing shows that O₂ levels can be easily reduced to 1.8 mg/L. During the study period, line failures came down from about 10 a year to NIL a year. Added advantage of increased nitrogen in system is formation of protective nitrides in surface region. Carbon Steel Corrosion Products do not form protective

film in Carbon Steel. (X-ray analysis of components was carried out for confirmation.)

METHODOLOGY USED - REMOVAL OF OXYGEN FROM WATER

A Radical solution was applied in which dissolved O2 was successfully displaced from Fire Water of Distribution Piping Ring Network by injecting N2 in the system. Initially samples were drawn from test rig specially created for study using same carbon steel piping with corrosion coupons. Samples were also taken from live system with & without de-aeration & lab tested for dissolved oxygen. It is generally found level of dissolved Oxygen ranges from 4.5 to 6 mg/L of raw water. It is generally found level of dissolved Oxygen goes to only 1.5 mg/L of water after above de-aeration process.

This substantial reduction of Oxygen level lead to reduced corrosion & consequently improved reliability of Fire Fighting System at very economical costs To analyze measurable effect of quantum of oxygen on rate of corrosion a test rig containing identical sealed containers made from virgin pipeline pieces (300mm dia X 300mm) were fabricated & placed under identical condition in location lab. (Refer to Fig4)

The containers had identical corrosion coupons suspended inside.



Fig. 4. Test Rig 300 mm Dia pipe line

TRIALS CONDUCTED – TEST BENCH

Equal quantity of raw water sourced from firewater tank was filled in the containers. One test container was

treated with nitrogen & oxygen levels in both containers was measured from certified lab. Both the test containers were sealed & kept in isolation for fortnight without disturbing (8,9)

After a fortnight, water samples were again tested in lab as also containers were visually checked for corrosion activity. Coupon samples were subjected to visual inspection & X-ray analysis.

Table 1 Rate of Corrosion with different levels of dissolved oxygen

Pipe materials	Initial corrosion rate of pipe materials by DO concentration	
	Corrosion rate (mg/cm ² /d) ^a	
	DO: 9 mg/L	DO: 2 mg/L
Ductile cast iron	6.54±0.53×10 ⁻¹	1.81±0.33×10 ⁻¹
	4.14±0.49×10 ⁻¹	1.63±0.44×10 ⁻¹
Carbon steel	3.64±0.43×10 ⁻¹	8.86±0.67×10 ⁻²
	2.42±0.31×10 ⁻¹	7.45±0.56×10 ⁻²

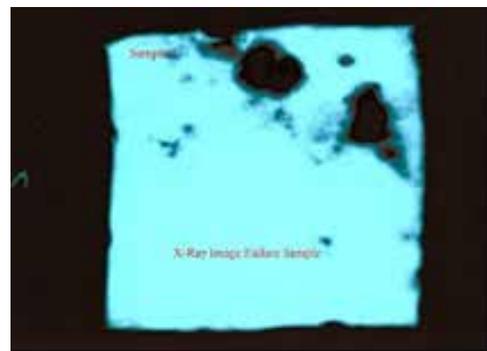


Fig 5. X-Ray Image Low Oxygen Corrosion

The observations for test bench are

Table 2 Text Bench Observations

	Container 1(N2 Rich)	Container 2 (Natural Water)
Initial O2 values	1.8mg/l	5.6mg/l
O2Values after fortnight	1.2 mg/l	3.9mg/l

TRIALS CONDUCTED – LIVE SYSTEM

As test bench results were very encouraging, oxygen displacement from firewater main tank was carried out with injection of nitrogen for 8-minute cycle. (10, 11)

Refer to Table 3 for effect of Nitrogen Injection in 10000 m3 water tank.

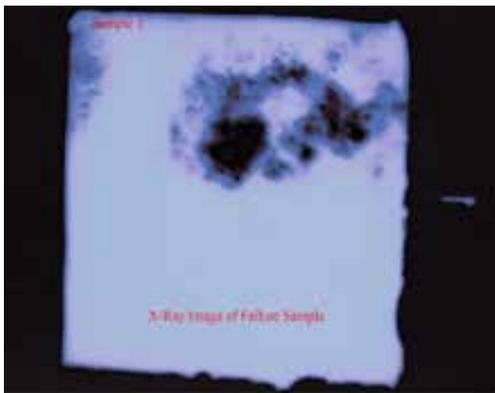


Fig 6. X-Ray Image Natural Water Corrosion

	TK01 Fire water tank
Initial Oxygen level	6.0 mg/l
Post nitrogen injection	3.2 mg/l

Table 3 Oxygen level in main 10.000 m3 water tank

Above method of oxygen displacement was not very effective as network pressurized water in firefighting system network is usually static, isolated from main tank by NRV. A pressurized injection system after tank network isolation was developed to inject nitrogen into pressurized water just after NRV / jockey pumps. The nitrogen is now being injected in the line & displaced oxygen along with extra nitrogen is bubbled out from farthest points.(12)



Fig 7. Nitrogen injection in pressurised fire fighting ring network

The system oxygen nitrogen composition was periodically checked & it was found that residual oxygen (1.8mg/l) depleted at very slow rate indicating large reduction in corrosion. The indicative results are

conclusive & yearly pinhole reporting has reduced from 10 a year to nil a year.

IN HOUSE DO TESTING –WATER ANALYSIS

Month	Number of samples tested	Test Results of Dissolved Oxygen (PPM)	
		Raw water	Nitrogen Treated Water
Aug.'22	3	5.2	1.8
Sept.'22	5	6	3
Oct.'22	5	5	2.5
Nov.'22	3	5	2

Table 4 Dissolved O2 Levels

RESULTS AND DISCUSSION

The results obtained through various lab tests, practical data obtained conclusively indicate that displacement of dissolved oxygen from pressurized firefighting water is economical & easy way to counter corrosion effects on firefighting system to make it much more reliable. Further course of investigation should focus on optimum nitrogen dosage for doping & periodicity of injection of nitrogen. Effects of nitrides formed during idle period need also to be investigated. As nitrides would form protective film on carbon steel, this effect should further enhance pipeline protection.

Financial Impact

One PIN HOLE repair	Catastrophic Line Failure in Emergency	Cost of Intervention	Effect on System	Savings
• Rs 5000/- + 4 hour down time. (10 repairs per annum)	• Business Continuity Risk.	• Rs 500/- per Nitrogen injection, ideally done once a month.	• At least doubling of Fire Line life.	• 81 Lakhs over life cycle at every location.

Table 5 Financial Impact

No. of (BPCL) Retail Locations in India	Water Line needs to be repaired per year (km)	Total expenses on repair of water line per year (@ 1 lakh/km)	Total expenses (treatment/year) on N ₂	Total savings per year
89	82 km	82 Lakh	0.12 Lakh	81.88 Lakh

CONCLUSIONS- ENHANCED RELIABILITY OF FIRE FIGHTING SYSTEM

The innovation effects enormous increase in reliability of Fire System. (The tangible losses in past petroleum fires have been pegged at few thousand crores)

As there would be reduced oxygen content in entire P/L network, organic matter like algae is likely to reduce & after further studies frequency of tank cleaning cycle periodicity can be further increased.

Due to reduced corrosion products & consequent reduction in frictional losses, required flow rates can be maintained with less strain on entire Fire Fighting System.

- Process would effect saving of lacs of Rupees per location.
- There is no environmental impact, as Chemical Additives are not added to water.
- N₂ is Cheap& easily available.
- N₂ is completely non-toxic & inert, will not affect Fire Fighting characteristics
- No need for added cost of retreatment. Enhanced Reliability of Fire Fighting System.

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The Role of ML Techniques and Distributed Controller for Electric Vehicle Condition Monitoring in Smart Grid and Internet of Vehicle Paradigm: A Study

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ABSTRACT

Electrical Energy consumption is increasing day by day for consumers, industries, and future electric vehicles (EVs). Conventional energy and renewable energy resources meet the load characteristics of the smart grid. Smart grid technology plays a vital role in balancing energy demands by incorporating frontline technologies such as the Internet of Things, Artificial intelligence, and real time embedded boards. Load balancing information through the Controller (Data Aggregator), centralized scheduling, if not managed smartly, is prone to processing bottlenecks and seriously disrupts the functioning of critical and non-critical loads as far as large-scale nodes and interconnected elements in smart grid infrastructure are concern. Electric vehicles and Internet of Vehicle (IoV) have gained considerable attention, and providing electric energy in remote places as a critical load is a key challenge. To bring customer centric load sharing approaches to complex grid infrastructure. This research work proposes a distributed network model consisting of embedded platforms, IoT, ML and IoV. Distributed nodes communicate/talk with each other to sense the power grid condition, critical and non-critical loads, and EV energy status to provide effective information for efficient and reliable load prediction and balancing in the smart grid environment through Internet of Vehicle approach.

KEYWORDS: Demand Side Management (DSM), Electric Vehicle (EV), Internet of Vehicle (IoV), Machine Learning (ML), Internet of Things (IoT), Embedded System, TCP/IP.

INTRODUCTION

Nowadays, Smart Grid (SG) Technology and Electric Vehicle (EV) are emerging research area around the world. Improvement of the electrical delivery system (Smart and Intelligent) so that it keeps track of, defends, and automatically improves the performance of its interrelated components [1]. There are numerous obstacles and problems with clean energy promotion for environmental preservation and scheduling energy consumption patterns to meet its rising demand for deployment and implementation in emerging countries [2]. Due to advent of Internet of Things (IoT), embedded platforms, machine learning technology, the implementation of customer domain appliances into the smart grid infrastructure will bring customer centric load demands into the smart grid system, which

will allow greater transparency, operation, control, and performance and provide sustainable, reliable, and efficient energy for the commercial and industrial customers shown in figure 1 [3].

In recent days, Demand Side Management (DSM) in smart grids has played an important role in balancing the energy demand (Load Control), reducing emissions, and increasing efficiency by modernizing the generation, transmission, and Distribution of existing grid systems [4].

Communication networks, IoT plays an important role in the development of the smart grid to Internet of Vehicle (IoV). The IoT infrastructure, on board processing capability and AI ecosystem are the emergence of the smart grid. Energy consumption is increasing day-by-

day life for consumers, industries, and future electrical vehicles (EV).

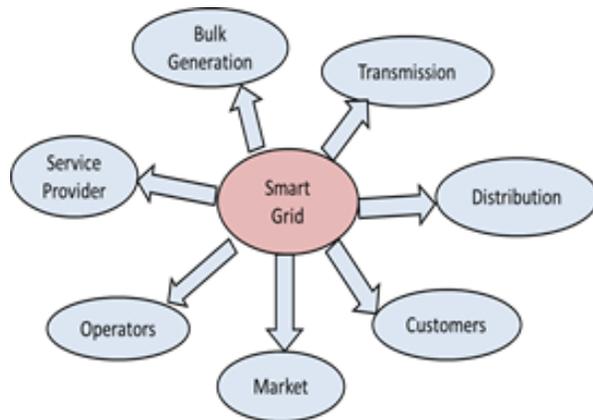


Fig. 1. Generalised architecture of smart grid

Electric Vehicle (EVs) mobility is gaining attention in automobile industries. EV plays a vital role for sustainable environment over Internal Combustion (IC) driven vehicles. An efficient and reliable communication network plays a key role in the realization of Vehicle to Grid (V2G) in smart grid to meet EV load profile. Large number of EV penetration into market leads to power hungry and put stress on grid. Electricity flow management necessities to meet the energy demands in the utility grid.

The research paper presents a case study on a new distribution network architecture that, in the context of Internet of Vehicle (IoV) appears smarter for load forecasting and balancing through real-time adoption of Smart grids mechanisms. The proposed work considered a cluster-based model consisting of a few nodes comprising of intelligent event driven controller. The distribution of controllers in cluster continuously monitors each other over the dedicated network. The nodes update information to one another and can make decisions if needed. Simultaneously updated the status to cloud. This scenario avoids cloud-based decisions and reduces the latency, bandwidth, and network related issues.

The operators who engage in the electrical markets must calculate the optimal price for the final user of electricity to optimize load disaggregation.

Therefore, it would certainly be possible in the presence of dedicated node architecture for micro-grids or

remote nano-grids with emerging technology to control load in a better way as compared to conventional utility structures.

RELATED WORKS

The application of Android on mobile devices to manage consumption of energy by providing information to and from the utility grid (the central controller) to support decision and control storage through schedules of home appliances [5]. Studied energy consumption and optimization through smart meters, centralized scheduling, and distributed algorithms to update user strategies to reduce the peak load of the system, respectively [6-7].

The Real-Time information-based DSM imposed bottlenecks (increased processing) using advanced communication network dynamics and local computation schemes [8] for power usage during peak demand for Smart Home Technology in Micro-grid (Renewable Energy Resources) environment [9]. Appliance scheduling and direct load control with sharing of renewable resources and storage systems minimize the demand supply gap [10]. The author proposed a Real demand response model based on a pricing algorithm to reduce peak demand from the energy supplier [11] and tariff plan based on load classification [12]. To achieve energy management, the substation operation and control strategy needs to be smart [13] for efficient load management at consumer level through Advanced Metering Infrastructure (AMI) [14].

Proposed different strategy for Demand side management, communicating over network bisectionally between consumers, Micro-grid control, Fuzzy Control, Data acquisition, control, and supervision (SCADA) [15], and power grid (Central Controller) shown in Fig. 2. [1-14]. The data collection and information processing at the aggregator and control center are prone to processing bottlenecks as far as large-scale nodes and links are concerned. Proposed resource allocation optimization technique using the cloud computing platform, which leads to high processing constraints for big data analysis and control of load profiles in DSM [16]. Information and communication networks play an important role in the development of the smart grid to Internet of Vehicle (IoV). The IoT infrastructure

is the emergence of the smart grid. However, IoT implementation in various nodes and links is prone to security threats and vulnerability to cyber-attacks for large-scale deployment and implementation for reliable operation and control through central controlling stations [17-18]. Energy consumption is increasing day-by-day life for consumers, industries, and future electrical vehicles (EV) [19-21]. Therefore, in demand side management programs, peak and off-peak load profiles become an essential component in a smart grid environment. Adding new generation plants to the utility grid requires high installation costs and time. To reduce emissions (Due to Thermal generation) and global warming issues, we must incorporate renewable energy resources into the grid system to meet load characteristics (peak demands). However, renewable resources may be insufficient to provide load during peak demand and with the utility grid in hybrid smart grid environment through smart grid technology.

[22] Proposed the DSM program in AC/DC hybrid system through DSM controller, smart meter, and ICT medium to optimize the operation of load characteristics (Critical and Non-critical loads) when the utility experiences peak demand. A load demand is an event that, if not managed smartly, seriously disrupts the functioning of critical or non-critical loads and causes economic or environmental losses. Using Smart AC and Micro DC grids to cater to the DC load for efficient operation. Optimal load shifting of AC devices in presence of DC Micro-grid is possible through DSM strategies [23].

There are several real time challenges to matching renewable energy sources with peak load characteristics in Hybrid Micro-grids (HMGs). One of the key objectives of smart grid is the load variation of the renewable generation with the main grid in hybrid AC-DC smart environment. By utilizing scalable and processing strategies and optimizing sensitive parameters (AC/DC bus health, converter status), and control mechanisms for automatic load shifting (such as load curtailment and off-maximum power point tracking (MPPT status), an adaptive energy management scheme needs to be adopted [24] in grid connected and Islanded modes of operation [25, 26]. Demand Response (DR) is an important characteristic of smart grid. Proposed the automatic interconnection based on Droop Control

characteristics between different sources in islanded mode in critical condition [25] and [26] an optimal based DR control algorithm for dynamic electricity price for minimizing electricity cost of the system developed.

Supervisory controller for bidirectional power flow of converter - inverter between AC and DC Micro grids [27]. For optimal power flow, a crucial challenge is the conversion loss phenomenon [28]. Proposed the master and slave controller strategy to achieve power sharing between different load conditions through dynamic operational control of micro grids [29]. In AC/DC Hybrid micro-grids (HMGs) are made up of distributed generators (DGs) with droop controllers with predictive model of real load profile with constraints [30].

The literature review [1-30] presented the energy scenario of DSM by experiencing different strategies and proposing work for load characteristics of utility distribution systems in smart grid.

Figure 2 shows monitoring of power systems with adaptive protection schemes using WAMS technology. However, adding more renewable resources to existing grid systems leads to more complex systems as far as synchronization, operation, and processing are concerned through aggregators.

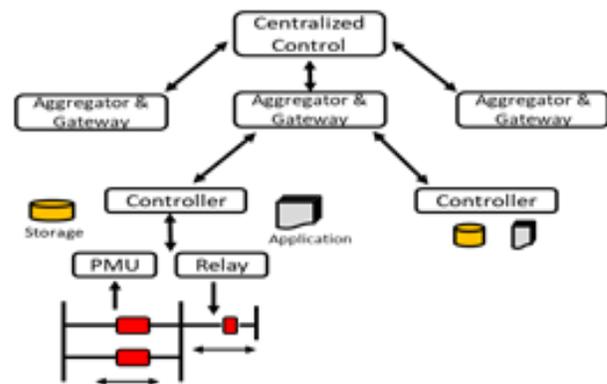


Fig. 2. Information flow in utility grid

The load sharing approaches presented by incorporating tariff programs and consumer participation activities with emerging technology are also proposed to meet load characteristics. The load information is collected and communicated from different resources (DGs, utilities, Main grid, renewables, Control stations, etc.) at aggregator node (Central controller) to optimize and meet load characteristics in grid connected and island

modes of operation. However, the aggregator takes observations from the consumer and other resources and accordingly plans to design a new load curve in the smart grid environment.

So dynamic protection and centralized control for hybrid micro-grid is another research area.

Electric Vehicle (EVs) mobility is gaining attention in automobile industries. EV plays a vital role for sustainable environment over Internal Combustion (IC) driven vehicles.

The combination of cutting-edge EV technology and smart grid environment for bidirectional electricity transportation in Vehicle-to-Grid (V2G) is also evident to drive the growth of EV [31]. Addition of computer processing, and advanced communication in Smart grid technology pertaining to key challenges—communication requirement, Authentication protocols and security. [32] presented role of wireless communication for multiple charging station (SC) connected to sub-feeder nodes and multiple nodes of distributed subsystem. The data transfer between EV and grid is realized through communication. EV charging station information collected through distributed aggregator at central substation aggregator. The impact of communication is studied on node voltage based on fuzzy logic controller.

Simultaneously charging large EV provokes utilization and management of critical and non-critical loads connected to grid architecture. Smart charging techniques [33] and intelligent control to deal the balancing the charging demand by the EVs and grid available power. Adding renewable sources with machine learning algorithm will be effective in Internet of Vehicle (IoV) ecosystem. The single bus and three bus voltage profile studied with variation in EV capacity. The centralized electric vehicle charging scheme control shows grid stability and EV flexibility [34]. The large grid architecture and higher electric vehicle communication are prone to complexity at central aggregation. Unidirectional flow power in smart V2G architecture for large EV charging application deteriorates the load demand of grid. [35] proposed the bidirectional flow of power to meet the load demand of grid providing energy from battery of EVs in idle condition. the flow control and monitor the data between fleet EVs, smart grid station and charging management system [36] and

extends the approach to load forecasting by applying advance techniques like AI, ML, and IoT to reduce computational Burden at central level.

To meet load demand profile in E-vehicle to smart grid connectivity, the battery health monitoring, state of charge (SOC) of EV is essence. [37] proposed event driven capacity estimation techniques. The energy health status of battery in IoT enable E-vehicle [38], charging station information [39] to improve forecasting accuracy with integration of ML techniques [40] for additional load profile.

Over the communication network infrastructure in E-vehicle to smart grid to meet load demand profile at central control station is challenging. At the edge, data offloading in distributed nodes prone to bottle neck. [41] reduces processing delay using reinforcement learning algorithm in IoV. [42] proposed edge centric three tier load prediction model through machine learning, limited on board processing capability, less response time for autonomous vehicles connectivity.

WORKING METHODOLOGY

The Addition of new renewable sources makes hybrid systems more complex as far as load balancing and information networks are concerned. Execution of DSM with Distributed Energy resources (DERs) and distributed controllers is not simple because the customer, who is the real controller of the loads, may not listen to the utility every time [10-14]. However, it is not guaranteed that the utility will experience a peak reduction or minor fluctuation in any load scenario.

This research effort suggested a real-time distributed embedded controller used for action planning and learning within the framework of machine learning and computing algorithms for improved power usage in Internet of Vehicle. This distributed intelligent architecture, which creates a mesh network, is also useful for gathering information about the charging status of electric vehicles (EVs) at various physical locations and for providing coordination for EV driving range improvement to nearby charging stations (nodes), which are also components of the distributed architecture. The economical and efficient operation within smart grid achieved through an embedded system (Node) having Machine Learning Algorithms is at different places, so

that it will help the system operate efficiently with the grid during peak and off-peak conditions, and when the grid is experiencing critical situations.

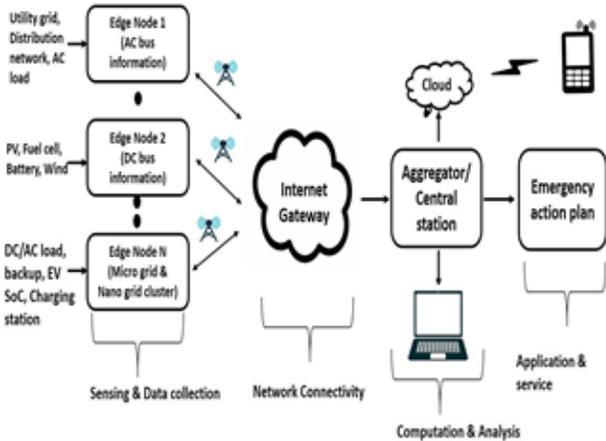


Fig. 3. Distributed Network Node Controller Architecture

The proposed work overcomes various challenges of DSM, whereas aggregators and control mechanisms are in place for making decisions. Figure 3 depicts a flexible embedded heterogeneous working model of AC-DC micro-grids with communication nodes at places to exploit connectivity, services, and smart governance.

A capacity for extracting features utilizing an embedded platform on board is provided by machine learning (ML)/ deep learning (DL) based algorithms to estimate the properties of maps for load forecasting and emergency response. However, to make crucial judgments in real time, DL algorithms necessitate massive learning data sets and high processing demands, which impose latency limits on inference and lead to fidelity issues if data sets are insufficient.

Figure 3 is the design plan showing distinctive entity nodes (such as DERs, distributed charging stations, Micro-grids, Aggregators, EVs etc.) offering smart information in the context of emerging communication technologies. The synergy of real time embedded systems, IoT, Artificial Intelligence and smart networks is requisite for event detection, data aggregation, data processing, data analytics, and load forecasting in DSM scenario [43].

Distributed nodes in IoV communicate/talk with each other to sense the grid condition, EV battery status, critical and non-critical loads, etc. to provide effective

information for efficient and reliable load balancing in the smart grid environment.

As the node structure is more complex, the study of optimization, in addition to large-scale deployment security, vulnerability [17, 18], and interoperability as far as wireless and wired communication networks are concerned.

EMBEDDED PLATFORM WITH TINY ML ALGORITHM

Through this study, lightweight Convolutional Neural Network (CNN) architecture is proposed for each node. Deep convolutions to handle multi-resolution data are effective on low-power embedded platforms, achieving improved performance with less memory usage and execution cycles.

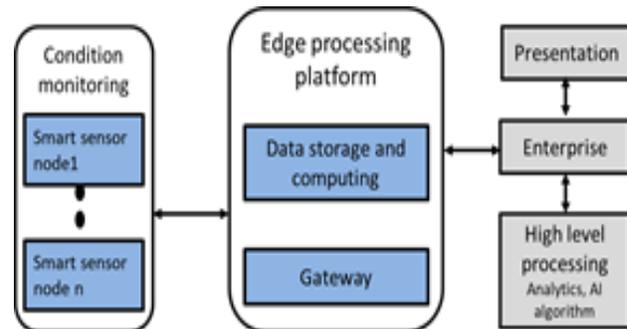


Fig. 4. Hardware prototype

Due to privacy or latency issues, or operation in remote locations with little to no connectivity, many applications prefer local embedded processing close to the sensor over central processing. A small CNN [44] for near-sensor (edge) processing to perform the crucial information is hence extremely appealing for battery powered onboard use.

The virtual environment of two nodes (client.vi and server.vi) with simplex communication is created to disseminate the energy information based on TCP/IP protocol in LabVIEW software. The Python function is incorporated to collect voltage and current information to calculate the energy usage. And continuously store energy information as unsupervised training data, as shown in figure 5. An appropriate dataset for this assignment must first be gathered before training a tiny Machine learning algorithm (tiny ML) for situational awareness and ideal load balancing applications. For

training the network node, dedicated data sources and data from nearby nodes are evident.

Figure 5 (a) and (b) show the client node considered an Electric Vehicle (EV). The embedded controller with sensors monitors the real time current and voltage signals continuously. In the virtual scenario, the energy status of the battery is monitored for a time step of 1 hour, 2 hours, and so on. If the calculated energy is less than 100 Wh at each time step, then the EV status is sent to nearby available energy sources (Renewable, AC/DC, micro -grid, etc.) to seek help.

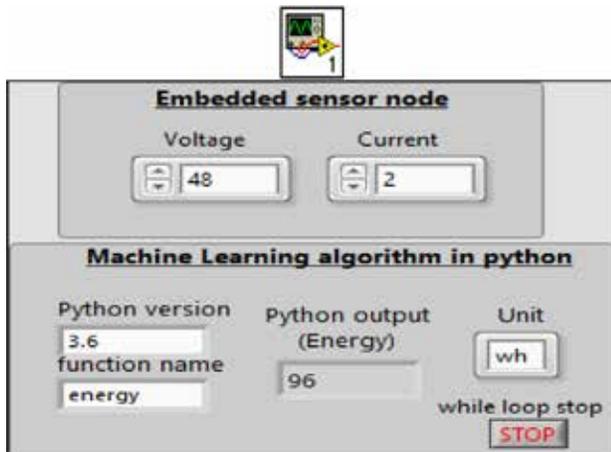


Fig. 5(a). Client.vi Node Front Panel

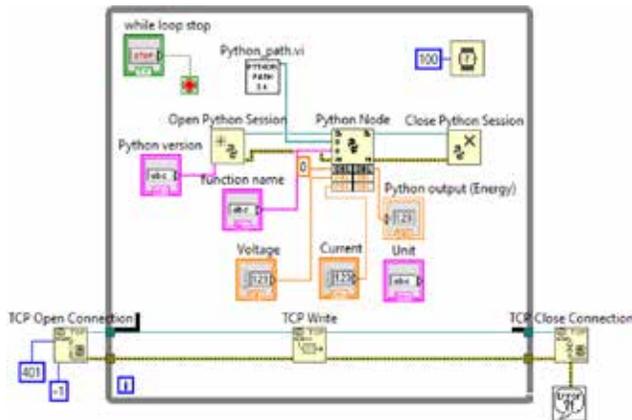


Fig. 5(b). Client.vi Node software prototype

The power information is also stored and sent to the cloud through a gateway in embedded sensor nodes as training data and for future analysis, respectively. The server node considered is the renewable energy source, and client information is updated as shown in figures 6 (a) and (b).

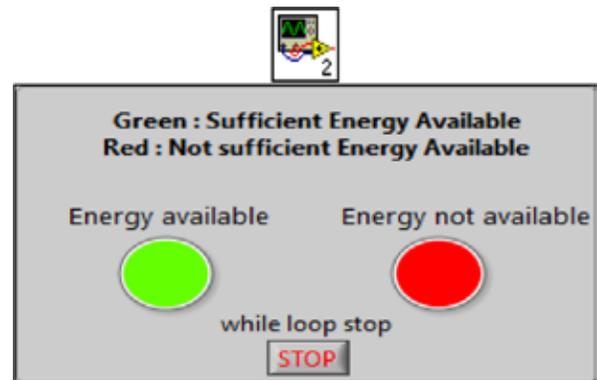


Fig. 6 (a). Server.vi Node Front Panel

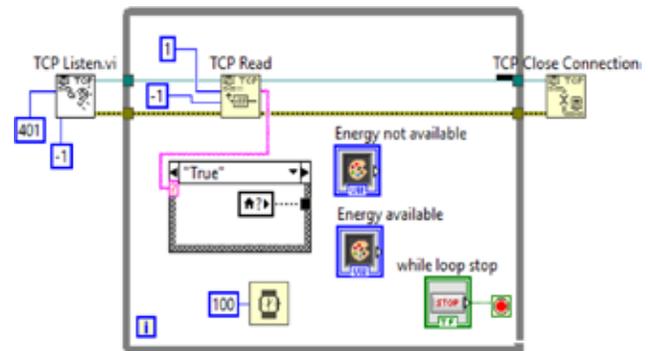


Fig. 6 (b). Server.vi Node software prototype

The microcontroller unit for Predictive Maintenance Systems and Condition Monitoring is depicted in Fig. 4 (source: STMicroelectronics). This unit is used to control numerous smart sensor nodes that are integrated into the equipment and can be directly connected to the cloud or indirectly through intermediary gateways. Depending on the expected delay and destination of the raw data, computations are done at the smart sensor node or on the local microprocessor unit, either at gateways or in the cloud. The processed data is delivered across connections. To save processing power and guarantee data privacy, edge processing happens when computation of data is done directly at the smart sensor node or at the gateway. This enables businesses to evaluate crucial data at the node level and shorten the time it takes to detect anomalies.

The proposed MCU board benefits real-time distributed applications and reduces the requirement for sophisticated systems by enabling real-time distributed applications and optimizing power management solutions for industrial gateways.

PERFORMANCE AND RESULT ANALYSIS

The proposed client server architecture with suitable optimized libraries that may be used to develop AI algorithms at the level of distributed embedded applications, and it supports several deep learning frameworks. Two node virtual situations are created in LabVIEW software. Performance and results were not evaluated on the hardware board. When implementing neural networks in hardware, the tradeoff between learning new data sets, complexity of external variable interference, network security, and communication bandwidth to implement tiny mathematical frameworks at various layers of hardware abstraction layer must be considered. In battery-operated devices with little storage space, emphasis is placed on the software rather than the hardware.

In AI ecosystem to enrich the work, the data collection, software, hardware capability, decomposition of tasks, control and communication of nodes, and pre-trained ML algorithms need to be tested in vehicle-to-vehicle communication for real time power applications.

CONCLUSION AND FUTURE SCOPE

This study proposed machine learning (ML) techniques and dedicated embedded controller for analysis and optimization of grid information, Renewable energy information, and EV run-time energy status at local nodes in the smart grid and IoV environment to improve accuracy of load forecasting and load shifting, balancing, etc. The use of ML algorithms to study grid uncertainties for adaptive protection and predictive control of remotely sensed data through resource constraints embedded in a node: in a real - time environment is also discussed. The literature work presented requires simulation of data collected from distributed nodes in a cluster to forecast load characteristics for micro-grid applications in micro grid clusters regardless of whether it is sent to the central controller, which is prone to delay.

For load characteristics, an optimized ML is evaluated for identification of bus grid status, DERs, EV SOC in embedded architecture. Implementation of ML programs on chip level, Deployment of nodes, set of

communication paths between nodes, consistency, and network security planning in the power system are the major challenges. However, home area networks, residential places, remote places, small regions, city networks, Electric vehicles, etc. are the application areas in the smart grid domain.

This research work also helps energy management in a smart city environment, EV charging infrastructure at remote locations, V2V, and predictive models for real time information using ML techniques are the future scope of this case study.

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Applications of Nanofluids in Machining: A Review

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ABSTRACT

In typical cutting fluid, nanofluid is a colloidal dispersion of nanometer-sized (<100 nm) metallic and non-metallic particles. Nanofluids are being evaluated as promising metal cutting fluids because of their superior heat transfer and tribological capabilities. Researchers have lately been interested in nano-enhanced cutting fluids because of its potential uses, particularly in metal cutting operations. This article provides a review and synopsis of several key research papers on the use of single particle nanofluids and hybrid nanofluids in various machining processes. Hybrid nanofluids are a novel kind of nanofluid created by mixing two distinct nanoparticles together in a suitable base fluid. It has been found that, the heat transmission capacity, thermal and physical properties of hybrid nanofluids are far better than conventional cutting fluids such as oil, water, and ethylene glycol and single nanoparticle nanofluids. The effect of several kinds of single particle and hybrid nanofluids on machining performance metrics such as cutting temperatures, surface finish, cutting forces and tool life of machined components have been addressed in this review study. According to the literature review, factors such as size of nanoparticle, its concentration level in base fluid, type of lubrication (such as flood or minimal quantity lubrication), orientation of fluid spraying nozzle, nozzle tip distance, and air pressure have a considerable impact on machining performance characteristics when using nanofluids. Limited research work has been available on applications of hybrid nanofluids in machining. There exists a great scope for development of more stable hybrid nanofluids to improve the machining performance of difficult to cut category materials.

KEYWORDS: *Cutting fluids, Hybrid nanofluids, Machining, Minimum quantity lubrication.*

INTRODUCTION

Machining is a significant industrial process in the today's era. This manufacturing method, which removes excess material in the form of chips to get the desired shape, size, and surface finish, could prove to be most flexible. Cutting fluids carries out crucial tasks in machining, such as cooling the cutting tool and work piece, clearing chips from the cutting area, and lubricating the tool-work piece interface. It has been discovered that using cutting fluids during machining increases tool economy, maintains tight tolerances, and protects surface characteristics from damage. Both during use and disposal, cutting fluids based on mineral oil have shown to have detrimental effects on human and environmental health.

Cutting fluid expenses are estimated to account for roughly 16 % of overall production costs, with costs

reaching 20–30 % when machining difficult-to-machine materials. This is significantly greater than tooling expenses, which account for around 2–4% of overall production costs [1]. As a result, excessive usage of these mineral fluids (flood lubrication) should be prevented, with least amount lubrication (MQL) being one of the options. Machining difficult-to-cut advanced engineering materials often results in higher cost of cutting and lower productivity. This is owing to significant heat produced at the cutting area and issues with heat evacuation due to these materials' poor heat transmission capacity. Shorter life of tool and inferior quality of surface finish are perhaps caused by excessive tool wear, high material hardness and toughness, and elevated heat in the cutting zone.

In today's globalised competitive contexts, machining performance and surface integrity are crucial. The machining process must be clean, cost-effective,

environmentally friendly, human-friendly, and energy-efficient. Industry often uses conventional mineral oil based cutting fluids; however, these fluids have weak thermo-physical qualities. In traditional machining, a considerable volume of cutting fluid is used to reduce thermo-related difficulties caused by friction and wear during the machining process. Excessive use of cutting fluid, on the other hand, is uneconomical and damaging to human and environment [2].

Government regulations seek to minimize the use of metal working fluid in the interest of public health and environmental protection. The thermo-physical properties were enhanced by using nanofluid, a novel type of cutting fluid. The nanofluid is a colloidal mixture of a base fluid with nanoparticles with sizes ranging from 1 to 100 nanometers. The pace at which heat is transferred is greatly increased when machining with a nanofluid that contains a small amount of nanoparticles. Nanoparticles have a large surface area to volume ratio, excellent thermo-physical properties, and good suspension stability. Tool wear, cutting forces, and heat generation at the cutting area may all be considerably decreased by using nanofluid with the MQL technique due to its enhanced heat transmission and tribological properties. It has been discovered that machining performance increases significantly when a nanofluid, like mist, penetrates the grinding zone.

LITERATURE REVIEW

A comprehensive literature review has been conducted to understand the current state of nano-fluid synthesis, characterization, stability mechanisms, and applications in machining, as shown below.

Sidik et al. [3] proposed a hybrid nanofluid, a novel kind of nanofluid created by dispersing two distinct nanoparticles in suitable base fluid. Conventional cutting fluids including mineral oil based cutting oils, water, ethylene glycol and single particle nanofluids perform poorly in terms of heat transfer and temperature dependent characteristics when compared to hybrid nanofluids. According to scientific studies, Single particle nanofluids can be replaced by hybrid nanofluid because it improves heat transmission, particularly in the automotive, electro-mechanical, HVAC, and solar energy applications. The authors of this review article outline recent advancements in hybrid nanofluid

fabrication techniques, issues impacting their stability, approaches for improving thermal characteristics, and recent applications of hybrid nanofluid applications. Hybrid nanofluids have exhibited noteworthy properties in terms of heat transmission characteristics, but their development as a new kind of machining fluid faces certain obstacles. Numerous problems that exist with hybrid nanofluids includes a lack of consistency in research findings from different researchers, the inability to accurately forecast the performance of hybrid nanofluids, and differences in manufacturing techniques for a given nanofluid and volume fraction..

Venktesan et al. [4] reported better machining performance with identified cutting speed and feed rate values in order to optimise the response variables when machining Inconel X-750 with nanofluids prepared by 1% wt. concentration of alumina in coconut oil as a base fluid under MQL with optimized values of factors such as cutting speed of 87.2 m/min and feed rate of 0.15 mm/rev.

Pare and Ghosh [5] employed an Artificial Neural Network (ANN) model to calculate the thermal conductivity of nanofluids made from 0.02 to 2% weight concentrations of alumina, copper oxide, and zinc oxide nanoparticles in distilled water. Using ANN and confirmed experimental data, they used a statistical technique to determine the coefficients in the suggested connection. They discovered that the ANN model predicted data matches the experiments rather well. The suggested theoretical correlation may be used to evaluate the thermal conductivity ratio of nanofluids across a broad range of particle densities and temperatures.

Kumar and Krishna [6] used coconut oil as a base fluid to machine AISI1018 steel with copper oxide and alumina hybrid nanoparticles with MQL. The researchers utilised 50:50, 25:75, and 75:25 combinations of copper oxide and alumina hybrid nanofluid in their experiments. The authors used an L18 orthogonal for optimizing factors such as fluid combination, speed, feed, depth of cut, and volume concentration of nano-particles for surface finish as response variable. Disposable hybrid nanofluids containing copper oxide and alumina (50:50) composition has enhanced surface finish by 13.72 %, according to machining data.

Chaudhary et al. [7] investigated the heat transmission properties of alumina and copper oxide nanofluids in the context of machining. The authors utilised 0.05, 0.15, 0.30, 0.5, and 1 % volume concentrations of nanoparticles in their experiments. Authors found that, the thermal conductivity ratio of Alumina and Copper Oxide nanofluids is increased by 19.77 % and 36.24 %, respectively, at 1 volume fraction % concentration. The absolute viscosity ratio is also up by 29.81 % and 48.74 %, respectively. For combined evaluation of thermal conductivity and viscosity, the superior heat transfer capabilities fluid for metal cutting application is produced at ideal values of 0.31 volume percent of alumina and 0.15 volume percent of copper oxide nanofluid compositions. It has also been discovered that the viscosity of nanofluid significantly rises, above 0.50 vol. % concentration, affecting its thermal conductivity and resulting in poor thermal performance.

Singh et al. [8] used alumina-graphene hybrid nanofluids generated with 0.25, 0.75, and 1.25 volume % concentrations of nano-particles in servocut S as the base fluid to machine AISI 304 steel with MQL. The findings revealed that hybrid nanofluid outperforms alumina-based nanofluid and base fluid in terms of wettability. The use of hybrid nanofluid performed better than alumina nanoparticle mixed cutting fluid while machining AISI 304 steel using the minimal quantity lubrication (MQL) approach. Blending graphene nanoparticles with alumina improves the performance of hybrid nanofluids, according to the research. Surface finish is enhanced by 20.29 %, and cutting, thrust, and feed force are reduced by 9.95 %, 17.39 %, and 7.23 %, respectively, when hybrid nanofluid is used with MQL.

Sharma et al. [9] used alumina-molybdenum di-sulfide hybrid nanofluids produced with an oil in water emulsion as the base fluid to machine AISI 304 steel with MQL. The researchers employed nanoparticle concentrations levels of 0.25, 0.75, and 1.25 volume %. Researchers found that, the hybrid lubricant outperformed oil-water emulsion as base fluid and the monotype lubricant of alumina based. The experimental findings show that increasing nanoparticle concentration reduces wear and friction coefficient. In comparison with monotype nano-lubricant and base fluid, the use of hybrid nanoparticles dramatically lowers tool flank wear.

Hegab et al. [10] studied the effect of distributed multi-wall carbon nanotubes (MWCNTs) and aluminium oxide gamma nanoparticles on the cooling and lubrication capacities of the minimal quantity lubrication (MQL) approach while turning Inconel 718. Machining studies were carried out with various design factors such as cutting speed, wt. percentage of nano-additives and feed velocity. Machining was done using a nanofluid comprising 2% MWCNT and 4 % alumina in vegetable oil ECOLUBRIC 200 as the base fluid. The use of nano-fluids enhanced the machinability, according to the findings of the experiments. Furthermore, it was observed that nanotube additives outperformed Al₂O₃ nanoparticles in terms of performance.

Sharma et al. [11] developed nano fluid by incorporating Al₂O₃ nanoparticles in traditional cutting fluid using vegetable oil water emulsion as the base fluid at various concentrations ranging from 0 % to 2 % and performing machining experiments.

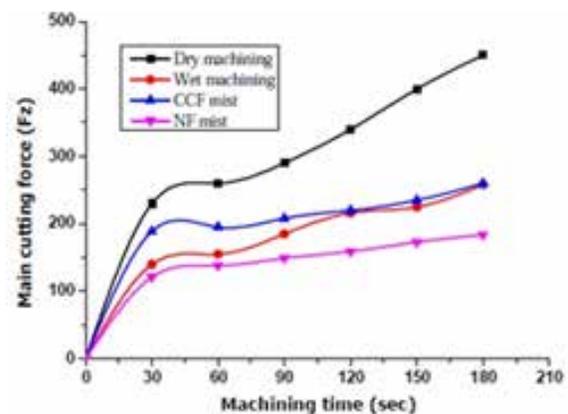


Figure 1a. Cutting Force (Fz) W.r.t. Machining Time [11]

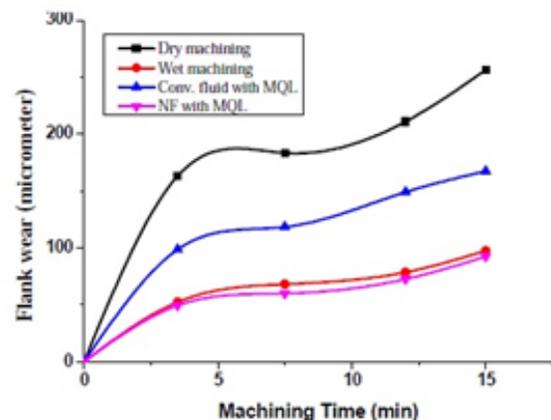


Figure 1B. Tool Flank Wear W.r.t. Machining Time [11]

They compared the outcomes of the experiments to those of dry, wet and MQL machining employing traditional cutting fluid. The experimental analysis clearly shows that Al₂O₃ nanofluid outperforms dry, wet machining with conventional mineral oil based cutting fluid, and MQL utilising traditional machining fluid in terms of surface finish, tool wear, cutting force, and chip morphology. Turning with nano cutting fluids decreased cutting force by 59.15 %, 29.24%, and 28.67 %, respectively, in comparison with dry, MQL and wet machining, as illustrated in fig. 1 (a). Nano cutting fluids increased machining performance by lowering tool wear by 63.93 %, 44.96 %, and 5.33 %, respectively, when compared to dry, standard mist, and wet machining, as illustrated in fig. 1 (b). In comparison with dry, standard mist, and flood machining, a decrease of 47.87 %, 29.19 %, and 25.57 % in surface finish of machined component was achieved employing nano cutting fluid with minimal lubrication. Heat transfer capacity, viscosity, and density of nanofluids were also found to improve as nanoparticle concentrations increased, however specific heat decreased as nanoparticle concentrations increased.

Singh et al. [12] developed a variety of nanofluids at room temperature by suspending titanium dioxide (TiO₂), silicon oxide (SiO₂), and aluminium oxide (Al₂O₃) nanoparticles in a vegetable oil water emulsion. The nanoparticles are incorporated into an oil water emulsion at various volumetric concentrations ranging from 0.25 to 3% as 0.5, 1, 1.5, 2, and 3 %. The thermal conductivity and specific heat of the nanofluids are determined at various temperatures and volumetric concentrations of nanoparticles. With increase in the concentration level of nanoparticles in the base fluid, thermal conductivity was enhanced. Additionally, it has been found that, Al₂O₃ has superior thermal characteristics than TiO₂ and SiO₂ based nanofluids.

Chaitanya et al. [13] have developed vegetable based nanofluids using nano particles like graphite, molybdenum disulphide and mixture of both particles in vegetable oil matrix such as coconut, soya bean and rice-bran oil, which are used as lubricants during turning of AISI1040 steel with carbide tool. The results exhibit the improvement of the surface finish and material removal rate (MRR) of the work piece

during turning for different weight % of nano particles in different matrix of oils. From the experimentation, they found that MoS₂ nano particle inclusions in soya bean oil exhibits good surface finish as compared with that of graphite nano particles. The Hybrid mixture of nanoparticle inclusions exhibits even better surface finish than individual MoS₂ nano particle inclusions in soya bean oil. There is no much effect of hybrid mixture of nanoparticle inclusions as compared to individual MoS₂ nanoparticle inclusions for best MRR value in soya bean oil as base cutting fluid.

Rahman et al. [14] used nanofluids such as alumina, molybdenum disulphide, and rutile titanium oxide produced in canola oil and extra virgin olive oil as a base fluid to machine Ti-6Al-4V ELI. They created these various nanofluids by using nanoparticle concentrations of 0.5, 2, and 4% by volume in base fluid. The lowest Ra value (0.248 microns) was obtained using a 0.5 volume % Al₂O₃-CAN nanofluid, which is 73.1 % and 57.95 % less than the values obtained using dry cutting and M-MQCL modes at a cutting speed of 55 m/min, respectively. It has been observed that, by utilizing 0.5 volume percent of MoS₂ in base fluid, lowest temperature and lower value of surface finish was obtained. This resulted in considerable amount of reduction in the cutting forces. MQCL was supported by nanofluid in reducing abrasion wear and controlling the flank wear excursion of the cutting insert. Additionally, the findings indicate that increasing the nanoparticle concentration decreases the efficiency of nanolubrication, and that canola oil is a better base fluid choice than extra virgin olive oil.

Gajrani et al. [15] machined AISI H-13 steel with minimal lubrication using a vegetable oil-based green cutting fluid (GCF). The authors conducted research on the performance of green cutting fluid under MQL settings. Machining findings indicate that by optimizing minimal quantity cutting fluid (MQCF) process parameters namely force required for cutting and feed, frictional coefficient and surface finish of the components were decreased. Additionally, the MQCF approach with GCF enhanced machining performance in comparison with flood and dry machining. The same authors also investigated the effect of flood cooling and MQCF techniques on the factors like force required for

cutting and feed, frictional coefficient and surface finish while performing machining using biodegradable green cutting fluid (BCF) and mineral oil with shop floor values of cutting speed and feed. Due to the optimized process parameters and superior lubricating qualities of BCF, it has been observed that the pressurized mist jet of MQCF decrease in contact length of cutting zone. Experimentation results reveals that, MQCF exhibits a considerable decrease in cutting force, feed force, coefficient of friction, and surface finish [16].

Padmini et al. [17] investigated the machining of AISI 1040 steel under MQL conditions utilising nanofluids produced from nanomolybdenum disulphide in coconut, sesame, and canola oils as the base fluid. These nanofluids were generated with nanoparticle concentrations of 0.25, 0.5, 0.75, and 1% in base fluids. Experiments have shown that basic properties, with the exception of absorbance, have risen as the number of nanoparticles increased, as indicated in fig. 2. Compared to all other lubricant conditions, 0.5 % Coconut + nMoS₂ exhibits superior machining performance. Employing Coconut oil + nMoS₂ at a 0.5 % nanoparticle inclusion reduces cutting forces, temperatures, tool wear, and surface finish by 37.2 %, 21.3 %, 44.21 %, and 39.43 %, respectively, in comparison with dry machining.

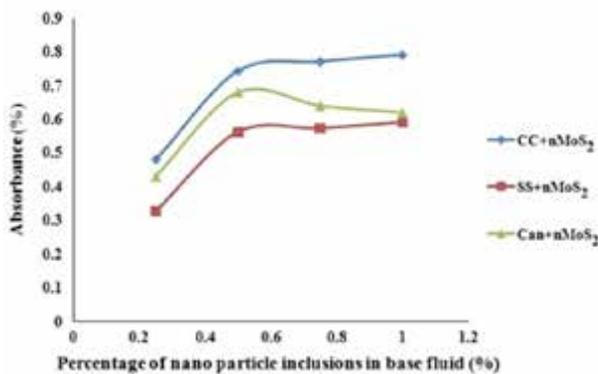


Figure 2. Absorbance of Nanofluids With varying NPI [17]

Furthermore, the same authors used Grey Relational Analysis for determining the optimal machining settings. The authors asserted that coconut oil + 0.5 % nano molybdenum sulphide increased machining performance when used at a cutting speed of 40 m/min, a feed rate of 0.14 mm/rev, and 0.5 % concentration of nanoparticle. The order in which input parameters

have an effect on machining performance is as follows: type of base fluid, nanoparticle inclusion level, cutting speed, and feed [18].

Gupta et al. [19] investigated the machining performance of Titanium alloy (grade 2) under MQL conditions utilising nanofluids comprised of alumina, molybdenum disulphide, and graphite in a vegetable oil base fluid. Evolutionary approaches such as Particle Swarm Optimization (PSO) and Bacterial Foraging Optimization were used to optimise the parameters (BFO). Evolutionary approaches such as PSO and BFO perform much better than the conventional desire function approach. Evolutionary approaches have been proven to be more successful in determining the optimum machining parameters.

Gajrani et al. [20] machined AISI H-13 steel in MQL utilising a hybrid green nanofluid composed of molybdenum disulphide and calcium fluoride at concentrations of 0.1, 0.2, 0.3, 0.4, and 0.5 weight % nanoparticles in green cutting fluid as a base fluid. Experimental results demonstrate that a 0.3 weight percent of hybrid nano green cutting fluid with Molybdenum disulphide outperforms other cutting fluids in terms of coefficient of friction between tool and work piece interface, force required for cutting, feed force, and surface finish. Authors have studied the effect of several kinds of cutting fluids on cutting and feed forces, including mineral oil (MO), green cutting fluid (GCF), and hybrid nano green cutting fluid (HN-GCF). When machining with HN-GCF-0.3M, the a reduction of 17% and 28% in cutting and feed force, respectively, when machining with MO have been observed. Additionally, an 11.12 % decrease in the frictional coefficient between the tool and the chip was found during machining using HN-GCF-0.3M, as well as a 37% increase in surface quality. Elemental analysis of the cutting tool indicates that HN-GCF-0.3M results in reduced work piece material adherence on the cutting tool rake face.

Pasam et al. [21] investigated the machining performance of AISI 1040 steel using nanofluids made from boric acid and molybdenum disulphide at a concentration of 0.25 % by weight in coconut oil as the base fluid. The authors utilised two distinct solid lubricants such as boric acid (H₃BO₃) and molybdenum disulphide (MoS₂) micro/

nanoparticles mixed in coconut oil. At high cutting speeds, nanofluids outperformed microfluids, but at lower speeds, the performance was comparable. The viability of the fluids was determined using optimization and cost assessment. Although nanofluids perform better but microfluids are less expensive than nanofluids. The results can be used to select the appropriate machining fluid based on the lubricant's desired performance.

Najiha et al. [22] machined aluminium alloy AA6061, T6 under MQL conditions using titanium oxide nanofluid produced in de-ionized water as the base fluid with a volume fraction of nanoparticles of 0.5, 2.5, and 4.5 %. Through experimentation, it has been determined that the key wear processes are micro-abrasion, attrition, and adhesion. Enhanced feed rate and depth of cut resulted in increased adhesion and edge chipping. Increased MQL flow rate reduced adhesion and edge integrity. A deposited coating on the flank face characterises aluminium machining. Nanofluids containing extremely small concentrations of nanoparticles, less than 0.5 %, result in built-up edges due to insufficient lubrication. Nanofluids with a greater nanoparticle fraction of 4.5 % also do not achieve the required level of effective lubrication due to their increased density and constant pressure pumping. 2.5 % nanoparticle % fractions seem to be more viable in terms of tool damage.

Hegab et al. [23] used MWCNT as a nano material for nano-fluid machining in MQL conditions on Titanium alloy Ti-6Al-4V. Cutting speed, feed rate, and additional nano particle % in weight were the process factors considered in the analysis. For performing experimentation, authors have used L9 orthogonal array. The impacts of identified process parameters on machining performance were investigated using analysis of variance. It has been found that, surface roughness is improved by 38 % with 4 wt % MWCNTs nano-fluids compared to tests without nano-additives, and surface quality is improved by 50 % with 2 wt % MWCNTs nano-fluids.

Liew et al. [24] investigated the machining of AISI D2 steel using a nanofluid composed of carbon nanofibers suspended in de-ionized water as the base fluid. The Response Surface Methodology has been used in this study to determine the optimal settings for multi-response. Cutting speed was shown to be the

most significant factor determining tool wear. Surface finish was affected by feed rate. The optimal setting for multiple responses such as flank wear and surface roughness was 144. 48 m/min cutting speed, 0.15 mm/rev feed rate, and a coolant of carbon nanofiber (CNF) nanofluid.

Satishkumar and Rajmohan [25] studied the performance of 0.2 weight % multi-walled carbon nanotubes in mineral oil cutting fluid (SAE 20W40) used as the base fluid for machining AISI 316 L stainless steel. The influence of input factors on performance characteristics such as surface finish and cutting temperature has been investigated in this research work using a desire function-based technique. According to experimental results, feed rate has the greatest influence on performance characteristics, followed by depth of cut, cutting fluid type, and spindle speed.

Kumar et al. [26] investigated the performance of a nanofluid containing between 1% and 4% by weight of copper oxide nanoparticles in mineral oil as a base fluid during MQL machining of Nicrofer C263. Researchers conducted an experimental investigation under three distinct circumstances - dry, MQL, and MQL + CuO Nanoparticles. When compared to other situations, it has been revealed that combining Nanofluids with MQL results in a greater surface finish with intuitive temperature dissipation in the cutting zone. Cutting forces are lowered, which result in decreased tool wear.

Patole and Kulkarni [27] used multiwall carbon nanotubes as nanoparticles in ethylene glycol as a base fluid to machine AISI 4340 steel under MQL conditions. To optimise process parameters such as tool nose radius, depth of cut, cutting speed and feed, the Taguchi technique of design of experiments has been adopted. Experiments were conducted using a L60 orthogonal array. ANOVA has been used to analyze the results. According to the results analysis, feed rate was the most important factor in achieving lower surface finish, succeeded by depth of cut, but cutting speed had the least effect on achieving lower surface finish with MQL employing nano cutting oil. The authors discovered that MQL with nano fluid (MWCNT) produced the smoothest surface in comparison with flood lubrication.

Chetan et al. [28] conducted machining experiments on Nimonic 90 alloy with MQL using nanofluids

composed of alumina and silver nanoparticles. The nanofluid results were compared to those achieved using biodegradable emulsions and dry machining. Alumina nanofluids' short contact angle, increased spreadability, and small droplet size led to reduction in cutting forces, wear of tool and curling of chip. Tribo-film formation was also found when alumina nanofluid was used to protect the rake face. Silver nanofluids nano-ball bearing action resulted in a smooth surface finish and less abrasion wear. Fig. 3 illustrates the impact of MQL flow rate variation on flank wear.

Ranga Babu et al. [29] conducted a comprehensive review on the applications of nanofluids, the synthesis methods for hybrid nanoparticles, the preparation and stability of nanofluids, the estimation of nanofluid thermophysical properties, the heat transfer characteristics of nanofluids, and the pressure drop and friction factor of hybrid nanofluids. Researchers concluded from this review that current research on hybrid nanofluids is very restricted and that systematic experimental studies are needed to determine their thermophysical and hydrodynamic properties in order to employ them for particular engineering applications. Thermal conductivity and heat transfer properties were improved when hybrid nanofluids were used instead of mono nanofluids. The authors argued that the conventional methods used to estimate the rheological and heat transport characteristics of mono nanofluids do not accurately predict the properties of hybrid nanofluids.

Revuru et al. [30] employed nanofluids in combination with MQL. The authors examined the performance of nanofluids generated by dispersion of boric acid and MoS₂ nanoparticles in coconut oil as a base fluid through experimentation. Additionally, the researchers investigated the influence of nanofluids on machining factors such as cutting forces, temperatures, and surface quality. Furthermore, they developed a finite element model for predicting factors such as cutting forces and temperatures. Fig. 6 shows the geometric assembly and machining process simulation. When the findings of the FEA model are compared to the experimental data, it is revealed that the FEA model can predict the values of specified machining parameters with an accuracy of 8% when compared to the experimental results.

Khatai et al. [31] reviewed the literature on the use of metal oxide-based nanofluids in turning and grinding operations. The researchers revealed that nanofluids based on Al₂O₃ and TiO₂ are often used in turning and grinding operations. SiO₂ is a very inexpensive

nanoparticle, however it is seldom employed in grinding. While nanofluids dispersed in Fe₂O₃ are used infrequently in machining. Despite their superior thermal conductivity and low cost, limited study has been undertaken on Fe₃O₄-based nanofluids. Similarly, the application of nanofluids based on CuO and ZnO as machining coolants is quite limited. ZrO₂ nanoparticles have the lowest heat conductivity and the largest density, limiting their use as a nanocutting coolant in machining.

Thakur et al. [32] evaluated the performance of various machining environments, including dry, Al₂O₃ nanofluids-based MQL, CuO nanofluids-based MQL, and Al-CuO hybrid nanofluids-based MQL, on machining performance characteristics such as surface finish, cutting force, and cutting temperature during EN-24 turning. The nanofluids and hybrid nanofluids were generated by varying the weight % of alumina, copper oxide, and Al₂O₃/CuO in the soluble oil base fluid with concentration levels of 0.5, 1 and 1.5 wt. % . For optimizing process parameters like cutting fluid type, cutting speed, feed and depth of cut, response surface methodology has been adopted. To determine the significance of the created model, ANOVA has been used. The optimization of multiple responses was carried out using the desirability function technique. The thermal conductivity of Al-CuO hybrid nanofluid at a weight % of 1.5 is the greatest when compared to other nanofluids. The lowest values of surface roughness height (Ra, mm) were achieved while turning EN-24 steel using alumina-copper oxide hybrid nanofluids based MQL . Cutting temperatures decreased by 80.55 %, 33.96 %, 22.2 %, 16.6 %, and 10.25 % when EN-24 steel was turned using hybrid nanofluids based MQL, respectively, as compared to dry, wet, MQL, alumina nanofluids based MQL, and copper oxide nanofluids based MQL.

Table 1 indicates summary of various nanomaterials with their sizes, concentration used for machining experiments by various researchers,

Table 1. Summary of Nanomaterials and their Concentration

Ref. No.	Nano material used and its size	Concentration of nano particles
4	Alumina	1 % weight fraction
6	CuO-Al ₂ O ₃ hybrid	50:50, 25:75, 75:25 weight percentages
8	Alumina-graphene Hybrid, Size: Alumina 45 nm, Graphene: 5 microns	0.25, 0.75 and 1.25 vol. %
9	Alumina- MoS ₂ hybrid Size: Alumina (45 nm), MoS ₂ (30 nm)	0.25, 0.75 and 1.25 vol. %
10	Alumina and MWCNT's	2 wt. % of MWCNT and 4 wt % of Alumina
11	Alumina (45 nm)	Volume fraction varied between 0-2 %.
12	Nanofluids of Alumina (45 nm) Titanium oxide (25 nm) Silicon oxide (10 nm)	Volume % varied between 0.25 to 3.0 % as 0.25, 0.5, 1.0, 1.5, 2.0 and 3.
13	Graphite and MoS ₂	Weight % of 0.25, 0.5, 0.75 and 1 %.
14	Separate nanofluids of Alumina, MoS ₂ , rutile TiO ₂	Volume % of 0.5, 2 and 4 %
17, 18	Nano molybdenum-disulphide (nMoS ₂)	Weight % of 0.25, 0.5, 0.75 and 1 %.
19	Alumina, MoS ₂ and Graphite (size: 40 nm of each)	3 % weight fraction
20	MoS ₂ and CaF ₂ Hybrid	0.1, 0.2, 0.3, 0.4 and 0.5 % by wieght
21	Boric acid and MoS ₂ (Average dia. 90 nm)	0.25 % by weight %
22	TiO ₂	0.5, 2.5 and 4.5 % volume fraction
23	MWCNT	0, 2 and 4 % weight fraction
24	Carbon nano fiber	0.1 % by weight fraction
25	MWCNT	0.2 % by weight

26	Copper oxide	1 and 4 % by weight
27	MWCNT	0.2 % by weight
28	Alumina (40 nm) and Silver nano particles (10 nm)	Alumina: 0.1, 0.5 and 1 % by volume fraction Silver nano particles: 5, 10 and 15 % by volume fraction
24	Carbon nano fiber	0.1 % by weight fraction
25	MWCNT	0.2 % by weight
26	Copper oxide	1 and 4 % by weight
27	MWCNT	0.2 % by weight
28	Alumina (40 nm) and Silver nano particles (10 nm)	Alumina: 0.1, 0.5 and 1 % by volume fraction Silver nano particles: 5, 10 and 15 % by volume fraction

Table 2. Summary of Base Fluids and Workpiece Materials

Ref. No.	Base fluid	Workpiece material
4	Coconut oil	Inconel X-750
6	Coconut oil	AISI1018 steel
8	Servo cut S	AISI 304 steel
9	Oil-water emulsion	AISI 304 steel
10	Vegetable oil ECOLUBRIC E200	Inconel 718
11	Vegatable oil- water emulsion (5 % oil in water)	AISI 1040 steel
12	Vegatable oil- water emulsion (5 % oil in water)	AISI 1040 steel
13	Vegetable oils like coconut oil, soya been oil and rice bran oil.	AISI 1040
14	Canola oil, extra virgin olivine oil	Ti-6Al-4V ELI
17, 18	Coconut oil, sesame oil and canola oil	AISI 1040 steel
19	Vegetable oil as base fluid	Titanium alloy (GrII)

20	Green cutting fluid , Mineral oil (1: 16 oil in water emulsion)	AISI H-13 steel
21	Coconut oil	AISI 1040 steel
22	De-ionized water	Aluminum alloy AA6061, T6
23	Vegetable oil	Ti-6Al-4V
24	De-ionized water	AISI D2 steel
25	Mineral oil cutting fluid (SAE 20W40)	AISI 316 L stainless steel
26	Mineral oil	Nicrofer C263
27	Ethylene glycol	AISI 4340
28	Sunflower oil in water with varied volume fractions of 1, 5 and 10 %	Nimonic 90 alloy
24	Mineral oil cutting fluid (SAE 20W40)	AISI 316 L stainless steel
25	Mineral oil	Nicrofer C263
26	Ethylene glycol	AISI 4340
27	Sunflower oil in water with varied volume fractions of 1, 5 and 10 %	Nimonic 90 alloy
28	Mineral oil cutting fluid (SAE 20W40)	AISI 316 L stainless steel

SUMMARY

This paper presents an extensive review on applications of single and hybrid nanofluids in machining and their effect on performance measures of machining of difficult to cut materials. From this review of literature, following key points have been identified in regards with single and hybrid nano cutting fluids;

The type of nanoparticle, its size, and concentration levels in the base fluid have a significant effect on the machining performance parameters of machined components such as surface finish, tool life and cutting force.

Higher nanoparticle concentration in nanofluids results in increased tool life (due to reduced cutting forces) but decreased nanofluid stability.

Nanofluids have not been fully commercialized due to their stability problems and production costs.

Limited research work has been reported on hybrid

nanofluids.

The thermal properties of hybrid nano fluids were seen to be superior to those of base fluids and single nanoparticle nanofluids.

There is great scope for development more stable hybrid nanofluidics to improve the machining performance of difficult-to-machine materials. The most often employed nanoparticles for the preparation of nanofluids for machining applications are alumina and titanium oxide.

Metal oxide nanoparticles such as copper oxide, zinc oxide, and ferrous oxide as the base for nanocutting fluids should be investigated further in a variety of machining applications.

Stability of the nanofluids depends upon type of surfactant, magnetic stirring and sonication time. From the study, it seems that, by using proper dispersant, magnetic stirring, temperature and sonication time, stability of nanofluids can be improved.

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Process Parameters Optimization of In-House Developed Dual-Nozzle 3D Printer

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ABSTRACT

The solidification technique used for 3D printing is called fused deposition modelling (FDM). This research led to the development of a 3D printer known as the Dual-Nozzle, which reduces errors by installing two nozzles and operating on the FDM method. Two nozzles can be used to end the operational procedure and use filament of two separate colors or materials. Various process parameters in FDM have an impact on printed component quality. To determine the surface roughness and dimensional accuracy of the printed component, layer thickness, print speed, and orientation angle are optimized. The specimens are created using Taguchi's L9 orthogonal array, which minimizes the number of trials and offers many combinations of different parameters and their values for every experiment.

INTRODUCTION

Additive Manufacturing (AM) includes 3D printing technology that creates objects of almost any shape from a 3D model. 3D printing works by layering materials together to create a three-dimensional part [1]. The process of extruding thermoplastic filament using a nozzle that moves across a heated bed platform while following the geometry of a part is known as fused deposition modelling (FDM). Typically, a building material is supplied in the form of filament wound on a spool, fused inside the heating chamber, and then extruded layer by layer until the part is completed [2]. When the fused material is extruded, it hardens quickly and gets attached to the layers that have already been extruded. The molten material is deposited in a continuous 2D layer, and each subsequent layer is added on top of the previous layer, eventually forming a 3D object. Once a layer is created, the heated bed platform is lowered to the layer thickness. A computer operates both the nozzle and the base, converting an object's dimensions into the X, Y, and Z coordinates that the nozzle and base will use during printing [3].

FDM Process for a Dual-Nozzle 3D Printer is shown in Fig. 1. Multi-color, multi-material printing is possible with the development of Dual-Nozzle 3D printer. The

second nozzle can also be used to print the support material. and cost. Due to the vast number of competing variables that might affect component quality and material properties, optimum parameter settings need to be identified for Dual-Nozzle 3D printer.

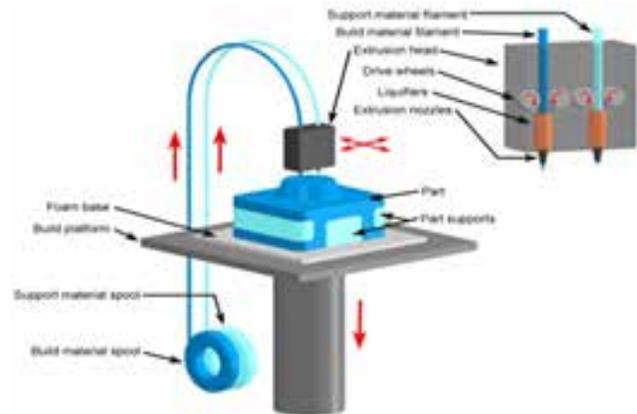


Fig. 1. FDM concept [3]

The quality of the component and the mechanical properties of the produced part are both affected by the process parameters as shown in Fig. 2. The parameters under consideration are:

- Layer Thickness – The substance and tip size have an impact on the layer thickness that is deposited

by the nozzle tip as well as the measurement of layer thickness.

- Print Speed - While extruding, this is the distance moved by the extruder along the XY plane per unit time. Printing time is determined by print speed, which is measured in mm per sec.
- Orientation angle - The angle of the part that is maintained while it is built layer by layer.

In this work, FDM based Dual-Nozzle 3D Printer is developed and a component is printed. Further, the optimization of considered process parameters for response variables dimensional accuracy and surface roughness is carried out. GRA method is used to determine the values of optimum process parameters.

RELATED WORK

Comb et al. [1], focused on material selection according to applications in the FDM process and reviews the role of several of these parameters in the process. Schubert et al. [2], described the various applications of 3D printing in daily life through the innovations in FDM technology. Shedage et al. [3], characterized a 3D printer's design by lowering its cost to the optimum level. The study discusses about 3D printer's design calculation and elements that lower the overall cost of the additive manufacturing machine. Chang [4], patented the multi-colour or multi-material 3D printing. He proposed the use of a heating chamber for heating and combining different colour filaments and extruding it through a single extruder. In the work, C.A. Griffithsa et al. [5], the impact of building parameters on performance and efficiency was quantified using an experimental design technique. This method, which may be used to produce prototypes and parts, can help designers reduce costs and improve performance. Wilson et al. [6], the study related to design and manufacture of 3D printers that improve the quality of manufactured parts and make them cheaper was carried out. By lowering the layer thickness, this high-quality result can be achieved. Rosli et al. [7] described the basic construction, procedure, and operation for developing a low-cost 3D metal printer, as well as material costs and electronic part connection. Amita and Ranga [8], stated that Additive manufactured objects can be used everywhere in the product lifecycle, from pre-production (quick prototyping) to full-scale production (rapid production), as well as custom and

tooling applications after production. In the research paper, Hatwar et al. [9], proposed the study of a 3D printer with two different nozzles in order to reduce deficits. The proposed work enables printing of two different materials at the same time without having to halt the operation to change filaments. Abilgaziyeve et al. [10], have developed the extrusion model with five nozzles. The proposed extrusion paradigm allows for simultaneous printing of five distinct colours and materials without having to interrupt the printing process to swap filaments.

Baumann and Roller [11], the findings in this paper show how diverse strategies and methods in these disciplines have progressed scientifically between 2002 and 2016. In the paper, Mohameda et al. [12], using Q-optimal response surface approach, the effects of essential FDM parameters such as layer thickness, raster angle, road width, build orientation, air gap, and number of contours on build time, feedstock material consumption, and dynamic flexural modulus were explored. Akande [13], determined optimum parameters for the parts with good surface finish and dimensional accuracy by using factorial design of experiments and desirability function. Raut et al. [14], the impact of mounting direction on FDM component mechanical characteristics and total cost was investigated.

METHODOLOGY

The dual Extruder's head is equipped with two nozzles, and the extrusion process is identical to that of a single nozzle extruder. The use of numerous extruders is mostly for the purpose of speeding up the printing process. There is no need to spend additional time replacing filaments because the extruder can be continuously operated to shorten the printing time. A second twin extruder is usually utilized to print the supporting materials that hold the suspended volumetric parts of objects for complex 3D designs. The concept of a multi-nozzle extruder is introduced to speed up the printing process. Various design considerations are required to be done for development of Dual-Nozzle 3D printer.

Design Consideration and Components

The design of the 3D printer and component selection is carried out for final Dual-Nozzle assembly. The various elements are as mentioned below.

- X-axis and Y-axis Guide ways - The guides will fail under bending. The rod must have strength enough to withstand the loads.
- Z axis Guide ways - The guides are subjected to buckling and compressive/tensile load.
- Lead screw - The lead screw must perform throughout the desired life. Also, it should withstand the various loads, e.g. buckling, compressive, tensile loads, etc.
- Extruder - The extruder selected is compatible with both 1.75mm and 2.85mm diameter filament wires.
- Base plate – Base plate, mainly made up of acrylic for heat-bed, which may fail under self- weight bending or bending due to weight of heat-bed, 3D printed part.

Mechanical assembly can be interfaced with the electronic controllers. Further all constant and variable parameters can be selected through software so that actual printing and calibration can be done. The power cables of parallel connection can be put together using connectors or extensions. The electronic components consist various elements such as stepper motors, stepper drivers, thermistors, LCD Controller, end stops, heated bed platform, power supply and controller board.

- Controller board - All of the logic underlying 3D printing is handled by controller boards, which parse G-code files, regulate temperature, and, most significantly, control motion. The MKS Gen V1.4 controller board is selected for Dual-Nozzle 3D printer.
- Interfacing of Controller - The hot end thermistor, heat bed thermistor, and the motors have bare wires hence it is required to attach connector shells and crimp the connectors. Then connect each driver to MKS Gen V1.4 motherboards. The installation driver prompt will display after the motherboard is connected to the computer, select the COM port on device manager. Further upload the Marlin Firmware and modify it.
- Firmware - Marlin is an open-source firmware that controls all machine actions in real time and communicates with heaters, steppers, sensors,

lights, LCD displays, and other components used in 3D printing process.

- Software - 3D models of object to be printed are modelled using Catia V5R21 software. The G-codes of these models are developed in Ultimaker Cura software which is used for slicing the component to be printed. The interface of Cura software is shown in fig 3 in which user can choose from over 400 distinct setting options in the custom setup.

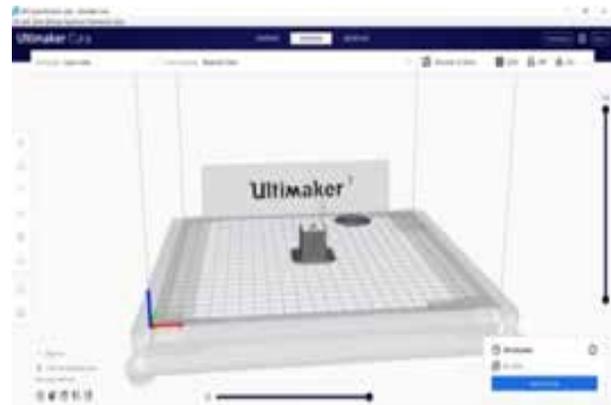


Fig. 3. Cura Interface

Calibration

Carrying out calibration procedure correctly is crucial, since a good calibration ensures a good performance of the hardware during printing. Calibration of Dual-Nozzle can be performed by printing the calibration cubes. Calibration cubes are simple cubes that assist in fine-tuning the settings of a 3D printer. They allow for a method that ensures the highest level of precision and accuracy in the prints. Fig. 4 shows simple calibration cube of 20mm x 20mm printed on the developed printer.



Fig. 4. Calibration Cube

EXPERIMENTAL WORK

Plan of Experimentation

Polylactic Acid (PLA), a thermoplastic material, is used to make the model and to support the FDM part. A model with different geometrical shapes having total length 105.6 mm, width 58.4 mm and thickness 9.6 mm is designed by considering ISO 1101:2005 Geometric Product Specification (GPS) – Geometrical tolerancing standard for designing and developed using CATIA. The majority of the important elements, such as staircases, holes, cylinders, and triangles, are included in this benchmark model. The benchmark component is sliced using slicer software and printed. Nine samples are printed according to L9 Orthogonal array. Fig 5 shows the CAD model of the benchmark component.

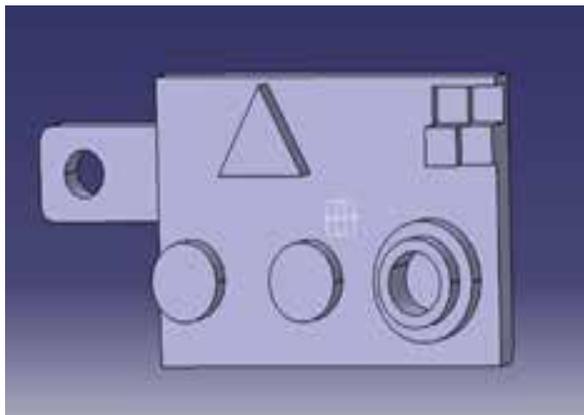


Fig. 5. Benchmark Component

Experimental design and procedure

The Taguchi approach entails using a robust design of experiments to reduce process variance. Process variables selected for printing of benchmark component are layer thickness, print speed and orientation angle; and response variables chosen are surface roughness and dimensional accuracy. The constant parameters for the set of experiments are; infill density 40%, wall thickness 1.4 mm, Nozzle diameter 0.4 mm. This setting is altered through Ulti maker CURA software and has much influence on the final print of the object. After defining the process parameters, slicing of the component is done by using the CURA software. Table 1 and Table 2 show the levels of the selected parameters and the Taguchi L9 array, respectively, for experimental design.

Table 1. Input Process Parameters and their Levels

Input Parameters	Level 1	Level 2	Level 3
Layer Thickness (mm)	0.12	0.24	0.36
Print Speed (mm/s)	20	40	60
Orientation Angle (°)	0	45	90

RESULTS AND DISCUSSIONS

Taguchi Method and ANOVA

Table 2 shows the results of the experiment performed according to L9 Orthogonal Array, where %ΔL is percent change in length, %ΔW is percent change in width, %ΔT is percent change in thickness and SR is Surface Roughness. On the basis of that result analysis is done by using ANOVA. ANOVA is the best tool to analyze the results and, also it provides the significance of various process parameters with their levels on the response variables.

Table 2. Experimental Results

Layer Thickness	Print Speed	Orientation Angle	% ΔL	% ΔW	%ΔT	SR (μm)
0.12	20	0	3.556	2.661	2.552	3.32
0.12	40	45	3.333	2.443	1.708	7.88
0.12	60	90	3.119	2.083	0.875	5.39
0.24	20	45	3.014	2.462	1.114	12.15
0.24	40	90	2.902	2.662	3.395	8.47
0.24	60	0	3.347	3.258	16.062	7.95
0.36	20	90	3.347	4.453	3.358	9.87
0.36	40	0	3.125	3.058	13.166	9.56
0.36	60	45	3.229	3.258	2.208	15.14

The average response values for each level of a design parameter or process variable are shown in Fig 6 i.e. main effects plot for means which shows ‘smaller the better’ characteristics. The minimum value obtained in graph for each process parameter is the optimum value for the respective process variable. Fig. 6 (a, b, c, d) includes the experimental graphs of main plots effect for %ΔL, %ΔW, %ΔT and SR respectively.

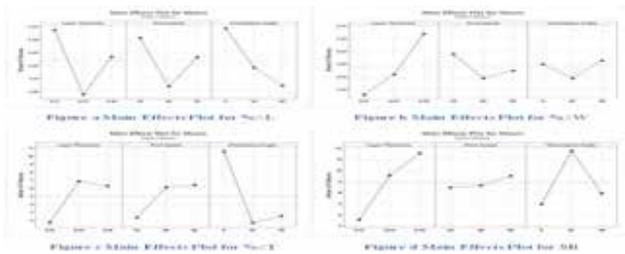


Fig. 6. Main Effects Plot

Table 3 indicates the ANOVA results for various response variables, %ΔL, %ΔW, %ΔT and SR giving P and F values which represents the impact or influence of different factors on process parameters. To determine the significant process parameters, the F-test is performed. High F value indicates that the factor has a strong impact on the response variables.

Table 3. ANOVA Results for %ΔL, %ΔW, %ΔT and SR

Source	D F	%ΔL		%ΔW		%ΔT		SR	
		F	P	F	P	F	P	F	P
Layer Thickness	2	0.94	0.514	2.01	0.332	1.69	0.372	143.58	0.007
Print Speed	2	0.53	0.654	0.32	0.760	1.08	0.480	4.79	0.173
Orientation Angle	2	0.77	0.566	0.18	0.848	5.16	0.162	98.50	0.010

Optimum Parameters

Layer thickness is found to be the most significant element influencing dimensional accuracy and surface roughness. Figure 8 shows the order of significant effects of the investigated factors. The findings also show that each measured response’s level of significance is different from the others. Print Speed does not have much effect on surface roughness. It is necessary to create a combined optimum parameter set for both qualities since the required optimum process parameter sets for dimensional accuracy and surface roughness differ. The optimum global solution for dimensional accuracy and surface roughness is reported in Table 4.

Table 4. Optimum Parameters

Input Parameters	Values
Layer Thickness (mm)	0.12

Print Speed (mm/s)	60
Orientation Angle (°)	90

CONCLUSION

With the development of Dual-Nozzle 3D printer, multi-material object printing is possible for the materials whose required nozzle and heat-bed temperature for printing fall in same range. 3D printing of intricate objects with multiple overhangs can be possible by Dual-Nozzle 3D printer as one nozzle can be used to print the main component and other nozzle can be used to print the supporting material. The impact of process parameters like layer thickness, print speed, and orientation angle on the dimensional accuracy and surface roughness of FDM components has been studied. Different effects of the process variables are seen on such attributes. The experimental results are confirmed from set of experiments in Table 4, which states that experimental set 3 gives optimum process parameters.

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A Review on Organic Rankine Cycle

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ABSTRACT

In the current global energy scenario, characterized by increasing energy demands and environmental concerns, the Organic Rankine Cycle (ORC) has emerged as a transformative technology in the realm of sustainable energy. This is a thermodynamic process that uses organic fluid instead of water as the working fluid in a rankine cycle, a well-known and widely used cycle in power generation. It has gained significant attention in recent years as a promising technology for energy conversion and waste heat recovery, particularly in the context of sustainable energy solutions. This abstract presents a comprehensive overview of the Organic Rankine Cycle, highlighting its diverse applications, thermodynamic principles, and environmental benefits. The study investigates the latest advancements in ORC technology, the selection of system components, innovative working fluids, optimized configurations, and innovative technology that has garnered significant attention due to its ability to harness low-to medium-grade heat sources, thus transforming waste heat into usable energy and all tailored to maximize the efficiency of ORC systems across various applications. Additionally, the environmental impact and eco-friendly nature of organic fluids used in the ORC process are emphasized, showcasing the cycle's potential to reduce greenhouse gas emissions and mitigate climate change.

KEYWORDS: *Energy scenario, Environmental impact, Organic rankine cycle, Waste heat recovery, Sustainability.*

INTRODUCTION

In our current energy scenario, the power demand continues to surge, driving the need for innovative solutions to meet this ever-growing requirement. Traditional power plants, while indispensable, generate a significant amount of waste heat during their operations. This waste heat not only represents a lost opportunity for energy utilization but also contributes substantially to the carbon footprint, exacerbating environmental concerns. Amidst these challenges, the Organic Rankine Cycle (ORC) emerges as a transformative technology, offering a sustainable and efficient way to harness this waste heat.

The Organic Rankine Cycle operates on the principle of converting low-temperature waste heat into usable energy. Unlike conventional steam cycles, ORC systems use organic fluids with lower boiling points, allowing them to generate power from heat sources at temperatures as low as 70°C. This versatility makes ORC technology exceptionally suited for capturing

waste heat from various industrial processes, exhaust gases, and even geothermal reservoirs.

By harnessing this waste heat, the ORC not only optimizes energy efficiency but also significantly reduces the carbon footprint of power generation. This is crucial in our efforts to mitigate climate change and promote a greener environment. The advantages of ORC are manifold: it enables the efficient use of low-grade heat, operates at lower temperatures, and offers higher efficiency, making it an environmentally friendly alternative to traditional power generation methods.

In large-scale applications, ORC systems play a pivotal role in enhancing the sustainability of power plants and large industrial processes. They can be seamlessly integrated into existing facilities, improving overall efficiency and minimizing wasted thermal energy. Moreover, ORC technology finds extensive application in renewable energy sectors, such as geothermal power plants, where it harnesses the Earth's natural heat to produce clean and sustainable electricity. Also, there

are different applications such as Waste heat Recovery, Solar Thermal Power, and Biomass Power Plants. In summary, the Organic Rankine Cycle stands at the forefront of green technology, offering a promising avenue to reduce waste, lower carbon emissions, and usher in a more sustainable energy future, particularly in large-scale industrial applications.

ORGANIC RANKINE CYCLES IN WASTE HEAT RECOVERY: A COMPARATIVE STUDY

In this study, researchers have conducted a theoretical analysis of Organic Rankine Cycles (ORCs), which are systems used to convert waste heat into usable energy. They focused on three distinct waste heat sources commonly found in industrial processes, each varying in energy output, ranging from approximately 10 kW to 10 MW.

The study simulated the performance of the ORC under various operating conditions and with different types of working fluids specific to each heat source. The three waste heat sources studied were:

1. Full-load Diesel Engine Exhaust: Waste heat generated from the exhaust of a diesel engine operating at full load.
2. Ninian Oil Field (Hot Brine): Waste heat produced by hot brine at the Ninian oil field, a byproduct of oil extraction processes.
3. Industrial Processing Plant (Saturated Steam): Waste heat emanating from saturated steam used in an industrial processing plant.

The researchers analysed how the ORC system behaved under different circumstances for each heat source. They considered factors like temperature, pressure, and working fluid properties to model the ORC's performance accurately. Additionally, they explored multiple working fluids tailored to the specific characteristics of each heat source. By comparing the results from these different heat sources, the study aimed to understand how the unique characteristics of each source influenced the optimal design of the ORC. Essentially, the research provided valuable insights into

how waste heat from diverse industrial processes could be effectively utilized through ORC systems, offering potential solutions for harnessing energy and promoting sustainability.

- a. I.C. engines: Several ORC waste heat recovery (WHR) systems exploiting the waste heat available from IC engines are currently under development, e.g., the US Department of Energy (DOE) funded Super Truck Programme. This discusses the development of Organic Rankine Cycle (ORC) waste heat recovery systems for Internal Combustion (I.C.) engines, particularly in heavy-duty vehicles like Class 8 trucks. These systems aim to utilize waste heat from engines to improve fuel efficiency, which is crucial for the trucking industry due to tight profit margins. The U.S. Department of Energy's Super Truck Program focuses on enhancing fuel efficiency in these trucks by 10% by capturing and utilizing the 31% of energy that engines typically reject as heat. The study examines a specific case involving a plant with various waste heat sources, exploring the potential power generation from an ORC system utilizing low-pressure waste steam.
- b. Hot Brine: In aging oil wells, water is injected to maintain pressure and extract oil. The mixture from these wells, located deep in the North Sea, is hot (temperature within a specific range). This process generates a lot of hot water (around 1000 kg/s), which can be used to produce power through low-grade heat energy recovery systems. Currently, platforms burn gas to power water injection pumps, but as gas production decreases, importing more becomes expensive. Organic Rankine Cycle (ORC) technology offers a solution by utilizing the waste heat from hot brines to generate power. While using wastewater injection brine is a new idea, ORCs powered by geothermal heat are well-researched and operational. Previous studies suggest improving efficiency by employing ORCs powered by waste heat from existing gas turbines on platforms. This study explores the potential power production from an ORC system supplied with heat from hot brines, with a specific example from the Ninian oil field.
- c. Industrial plant: Many industrial processes produce waste heat, for example, the manufacture

of cement, textiles, and electricity production. The study focuses on a specific industrial plant supplying steam and electricity to nearby chemical processing units. The plant utilizes steam from boilers fuelled by gas and biomass to generate thermal and electrical energy. Various waste heat streams are present, including flue gas, low-pressure, and intermediate-pressure steam. The study explores the potential power generation using an Organic Rankine Cycle (ORC) fed by a single stream of low-pressure waste steam, with specific characteristics.

- d. Rankine Cycle model: The model has been developed to evaluate ORC performance for any waste heat source and heat sink. A schematic diagram of a standard Rankine cycle is shown in Figure 1a and the subcritical cycles operating with superheated vapor throughout the expansion in the turbine is shown in Figure 1b. The model can assess ORC performance using various waste heat sources and heat sinks. It can simulate different types of organic cycles, including Trilateral Flash Cycles and subcritical cycles with superheated vapor expansion. The model offers maximum flexibility, allowing users to specify any heat source and sink conditions and simulate any ORC cycle within defined operational limits. Standard thermodynamic equations are used to describe components like pumps, heat exchangers, turbines, and condensers. Additionally, the model utilizes FluidProp to calculate the thermodynamic properties of the working fluid used in the cycle.

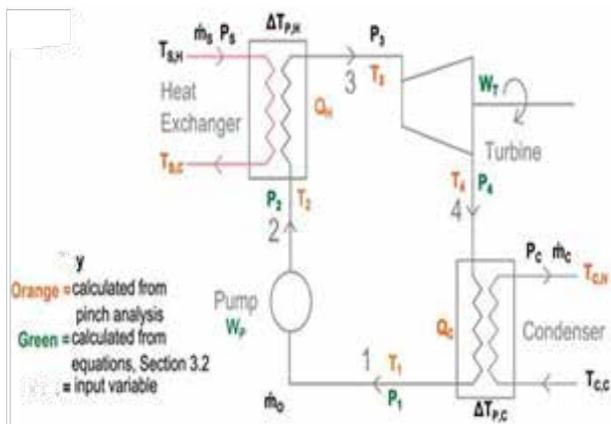


Fig 1. Standard Rankine Cycle

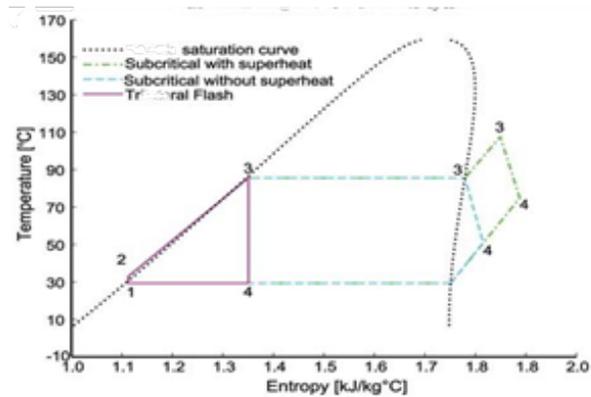


Fig 2. Subcritical cycles operating with superheated vapor throughout the expansion in the turbine

The results indicate that for a fixed ORC working fluid mass flow rate, fluid selection does not have a strong influence on the ORC's ability to recover waste heat. But ORC working fluid choice does influence the TIP (Turbine Inlet Pressure) at which the maximum work output is achieved.

SELECTION AND COMPARATIVE STUDIES OF WORKING FLUIDS FOR ORGANIC RANKINE CYCLE (ORC)

This research paper conducted by Mr. Vipin K and Mr. Anil Kumar B.C. delves into the crucial role of working fluids in Organic Rankine Cycle (ORC) systems, which are vital for energy conversion. They thoroughly analyse and compare the performance of 30 different working fluids in various ORC setups, considering factors like thermal efficiency and volumetric flow rate. Their study provides valuable insights into selecting appropriate working fluids based on different conditions, making it valuable for engineers and researchers in renewable energy. However, the paper lacks a detailed discussion on the environmental and safety aspects of these fluids, which are vital in practical applications. Despite this, the research lays a strong foundation for future studies aiming for more efficient and sustainable energy conversion technologies.

Certainly, here is some conclusive information based on the research paper:

- a. Fluid Selection is Crucial: The research underscores the critical importance of selecting the appropriate working fluid for Organic Rankine Cycle (ORC)

systems. The choice of working fluid significantly impacts the system's efficiency and overall performance.

- b. **Performance Variability:** The paper reveals that different working fluids exhibit varying levels of performance under different operating conditions. Therefore, it's essential to carefully consider the specific requirements and constraints of an ORC application when selecting the fluid.
- c. **Environmental and Safety Considerations:** While the research provides valuable insights into the thermodynamic properties of working fluids, it falls somewhat short in addressing the environmental and safety aspects. Future studies should place a stronger emphasis on assessing the environmental impact and safety implications of these fluids, as these factors are paramount in real-world applications.
- d. **Optimal Fluid Selection:** Despite the complexity of the fluid selection process, the research identifies certain fluids that perform well in specific ORC configurations. For instance, R125 is highlighted as a suitable fluid in subcritical cycles within a specific temperature range, while R22 is preferred for subcritical cycles with varying evaporator pressures. R134a, on the other hand, is recommended for transcritical cycles within a defined temperature range.
- e. **Foundation for Further Research:** This paper serves as a solid foundation for future research endeavours aimed at improving the efficiency and sustainability of ORC systems. Researchers and engineers can build upon this work to make more informed decisions regarding working fluid selection in renewable energy applications.

In summary, this research paper provides valuable insights into the selection of working fluids for ORC systems, emphasizing the need for a well-balanced consideration of thermodynamic properties, environmental impact, and safety considerations in fluid selection. It offers a starting point for further research in the pursuit of enhanced energy conversion technologies.

POTENTIAL WORKING FLUIDS FOR LOW-TEMPERATURE

ORGANIC RANKINE CYCLES IN WASTE HEAT RECOVERY

This paper discusses the selection of working fluids for low-temperature Organic Rankine Cycles (ORC) in waste heat recovery applications, particularly in the context of exhaust heat from internal combustion engines (ICE). The authors emphasize the importance of choosing working fluids with favourable properties such as safety, environmental impact, thermal stability, chemical compatibility, and material compatibility.

The paper identifies various classes of potential working fluids, including CFCs, HCFCs, PFCs, siloxanes, alcohols, hydrocarbons, ethers, amines, fluids mixtures, HCFOs, and HFOs, and evaluates them based on criteria like toxicity, flammability, ozone depletion potential (ODP), and global warming potential (GWP). CFCs and PFCs are ruled out due to their ODP and GWP concerns, while ethers and amines are considered unsuitable due to reactivity and toxicity issues.

Two novel hydro-fluoro-olefin (HFO) based fluids, DR-2 and DR-12, are highlighted as promising candidates for low-temperature ORC applications. These fluids exhibit good thermal stability, low toxicity, and non-flammability. The authors present data on their thermal stability, showing that they perform well at elevated temperatures. Material compatibility is also considered, and a study on DR-2 indicates mild interactions with various plastics and elastomers, suggesting its suitability for use.

In summary, the paper underscores the importance of selecting working fluids that meet both performance and environmental criteria in waste heat recovery applications. The HFO-based fluids, DR-2 and DR-12, stand out as promising options with desirable properties, including low GWP and no ODP, making them attractive choices for low-temperature ORC systems. This research provides valuable insights for engineers and chemists in the field of heat recovery systems and highlights the need for comprehensive evaluations when choosing working fluids for specific applications.

CONCLUSION

In the realm of waste heat recovery, the Organic Rankine Cycle (ORC) has emerged as a promising technology, as evidenced by the studies discussed. The first research tackled the comparative analysis of ORC systems utilizing diverse waste heat sources like full-load diesel engine exhaust, hot brine from the Ninian oil field, and saturated steam in an industrial processing plant. This highlighted the versatility of ORC in handling various heat streams. The second study focused on the critical aspect of working fluid selection, emphasizing the need for efficient and practical choices to enhance the overall performance of ORC systems. Lastly, a specific implementation using ammonia (NH₃) in an ORC system for low-temperature waste heat recovery was explored, showcasing a practical application of the technology. These studies collectively underscore the adaptability, efficiency, and real-world potential of the Organic Rankine Cycle in harnessing waste heat from diverse industrial sources, paving the way for more sustainable energy solutions.

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Gesture Recognition for Deaf and Dumb People

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ABSTRACT

A different part of the body plays a role in nonverbal communication. To communicate the message these part gestures need to be used for effective communication. Movements of hand, face, overall body forms the gesture. This paper proposes a method to recognize different hand gestures used by deaf and dumb people. Scale-invariant feature transform (SIFT) algorithm is used to communicate with deaf and dumb people.

The algorithm will facilitate improved communication between regular people and the deaf and dumb. Colour markers and gloves for gesture identification have been employed in literature, although they sometimes cause processing delays and are inconvenient. SIFT algorithm in the proposed system is used for extracting features while the K-Nearest Neighbour is used as a classifier to distinguish between classes. The proposed system focuses on hand gesture recognition and human computer interface (HCI) systems with accuracy, real time usage of gesture processing and faster processing time.

KEYWORDS: *Gesture recognition, Image processing, Image accuracy, Scale invariant feature transform (SIFT), A human-computer interface (HCI), K-nearest neighbour algorithm.*

INTRODUCTION

The Sign language is the language utilized by auditory impaired and imbecilic people and it is a communication adeptness that utilizes hand gestures in lieu of gloves [1] or sounds to convey the designation and make the person more comfortable with the avail of hand shapes and forms of kineticism of both the hands. The main challenge of the physically incapacitated people is the denouement language they used is not understandable to mundane people which engender a quandary for such types of people to connect with others. Paper endeavored to determine the quandary by utilizing a simple hand gesture apperception system which will be cost efficient and facile to access to all persons. A gesture in a denouement language is concretely a kineticism of hands which will be captured through the camera and further processed for displaying a designation full words or sentences. We utilizes the SIFT algorithm which will be more consequential and will achieve high precision and additionally will reduce the processing time as compared to aforetime used hand gloves for gesture apperception. Then again, correspondence with average

people is a noteworthy obstacle for them since few out of every odd conventional individual grasp their signal based correspondence. To beat the issue, gesture-based communication acknowledgment framework is relied upon to help the hard of hearing and quiet individuals to speak with ordinary individuals. In India, Indian Sign Language (ISL) is the correspondence by means of signals that are commonly used by the hard of hearing network. Thus, the structure of the communication through signing the acknowledgment framework will be founded on the ISL, so as to suit the neighborhood individual's condition.

DESIGN METHODOLOGY

Proposed system resolves three significant objectives. Right off the bat to build up a system which is more accurate and adaptable to every condition to actualize a successful hand gesture recognition system without using colour markers or gloves. Next, we can see that the various peoples had a variety of size of hand and different states of gestures so exactness in acknowledgment changes. This problem is likewise been settled. Thirdly the prior planned system is

moderate. The system proposed has been tried and it is quicker than the prior systems. The proposed system chips away at three principles that are Image Pre-preparing, Features extraction utilizing scale-invariant feature transform (SFIT) calculation and in conclusion classification of the image.

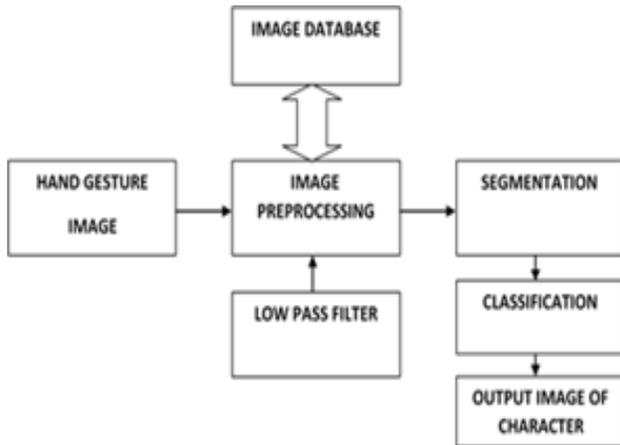


Figure 1. Proposed system block diagram.

Image Pre-Processing

In this part of the proposed system the noise and distortion is removed from an input image is known as image pre-processing. Here we have to create a dataset of various hand gestures used in ISL. Proposed system has to first remove the noise and also reduce the distortion as well as resize the image as MATLAB uses default size of image In image prepositioning, we need to build a database with various hand gestures as utilized in ISL. So to resize the image we are going to use the Bicubic method while to remove the noises we can use a low pass filter. Block diagram of the proposed system is shown in figure 1.

Segmentation

In this phase of the proposed system the features are extracted from an image. Segmentation actually means collecting the information of an image in the matrix vector form. Segmentation can be done on two types of images one is static images and another one is dynamic one. Depending on the image the static segmentation and dynamic segmentation is introduced. Static segmentation means extracting a feature of a still image while in dynamic segmentation the moving images are captured in frames then the segmentation

is outperformed on that images. Here we are using dynamic segmentation. Segmentation is extracting the feature from an image, but the input image is present in RGB form means it is 24 bit depth image so before going the segmentation process the RGB image is converted into 8 bit depth image which means the colored RGB image is firstly converted into gray scale image. Below figure 2 shows the input image and figure 3 shows the converted gray scale image.



Figure 2. Input Image Gesture



Figure 3. Grayscale image

System Operation

Once the image pre-processing and segmentation is done then the classification of features extracted is done. For extracting a feature vector first we calculate the scale space of an image then apply the difference of Gaussian function to it then apply further algorithm to get key points as shown in figure 4. So the main thing is to localize the key points. Then the direction of the key points must be given to the key points and then that key points is elucidated as the scale space of the image. Now the maxima and minima is to be determined by testing every pixel. Taylor series approximation calculation is likewise executed to determine the maximum and minimum value of image pixel which will improve the

coordinating strength of the calculation. At that point based on the image included, the direction is given to the intrigue focuses which are steady. In the key point subtitle, a 128 bytes structure of the element vector is created. For all the steady key points 128 bytes are evaluated.

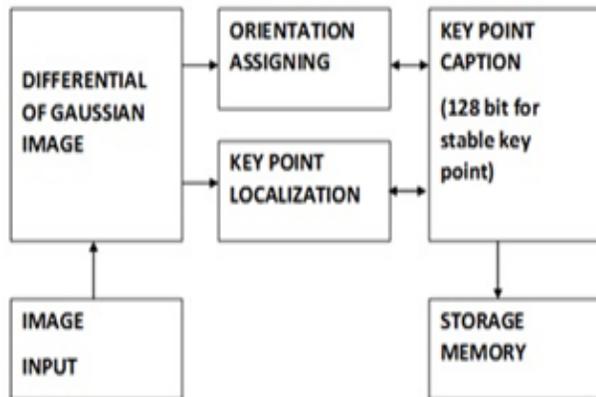


Figure 4. SIFT block diagram.

GESTURE RECOGNITION

To coordinate the ISL, the feature vector is stored. At the point the Image undergoes the calculation part that means the testing is done as shown in figure 5. Then we actualize the scale invariant feature transform for calculation to compute the source feature extracted for the vector matrix. Least Euclidean separation among each element vector of the source picture is found. The picture containing least Euclidean separation [6] to a source feature extracted for the vector matrix is suggested. At that point all the element source features extracted for the vector matrix are contrasted and the ISL gestures in the dataset. Alphabets in order with the most astounding amount of the equal in highlighted feature vectors are prescribed; however there is an alternative gesture with the second most noteworthy amount of equal. So the clashing gesture with the prescribed gesture is analyzed and the contrast amongst them is calculated. In the event that the thing that matters is a bigger worth contrasted with limit than the acknowledgment of the image is fruitful in likening to the most noteworthy prescribed image however in the event that the thing that matters is of less incentive than the edge, at that point acknowledgment isn't done or "NO MATCH" is given as result.

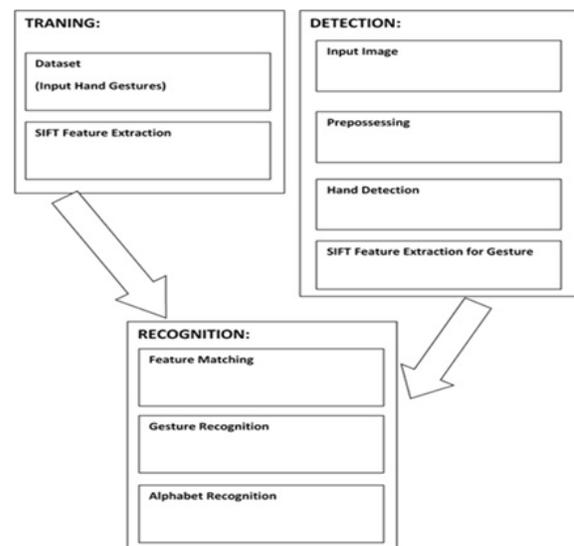


Figure 5. Proposed flow chart

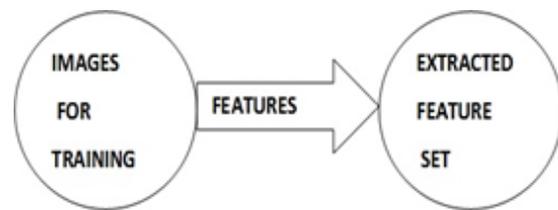


Figure 6. Dataset

The dataset we are creating here of various hand gestures is divided into 26 classes based on the alphabets present in the English language as shown in figure 6. So here we have taken 15 images of hand gestures for each alphabet so we have 390 images in total. Then we will divide those 390 images into 260 and 130 where 260 images are for training and the remaining 130 images for testing.

Gestures for Alphabet 'A':



Gestures for Alphabet 'B':



Similarly, the hand gestures for all other alphabets are captured as an input image shown in figure 7.

Below are the Gestures for Remaining Alphabets

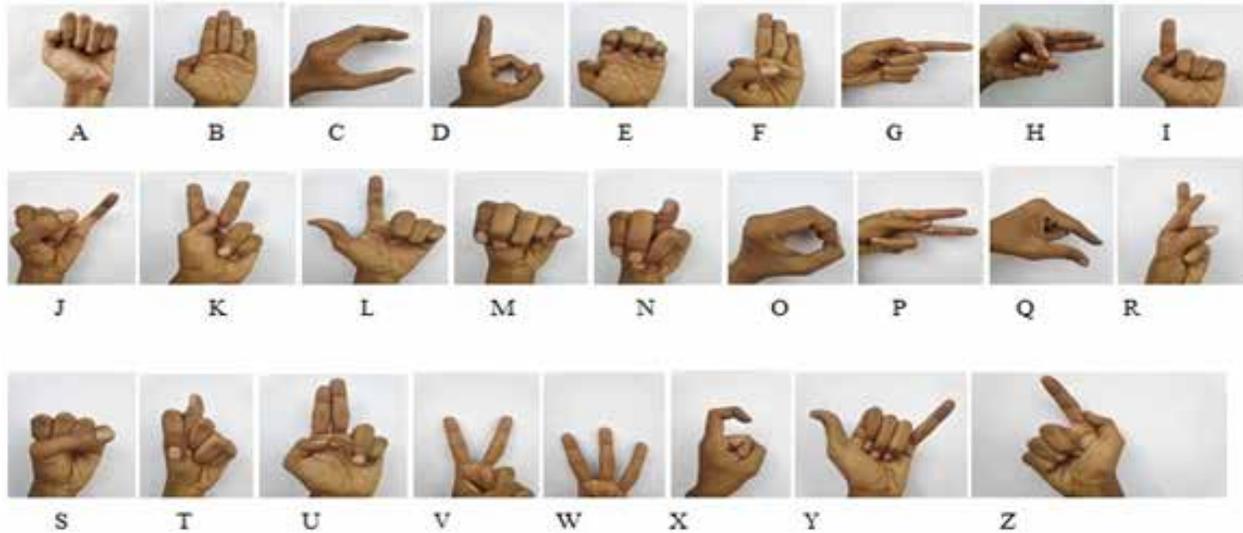


Fig.7. All Hand Gesturers included in Dataset

Feature Extraction

Scale-Invariant Feature Transform

SIFT is a scale invariant feature transform algorithm used to extract the features of an image. This algorithm is scale independent means the depth of the image is not a concern this algorithm is also robust and efficiently effective for extracting features of an image. Using the SIFT algorithm we can get the features as well as a descriptor matrix vector which gives us accurate hand gesture results.

Classification

KNN

KNN is a mainstream arrangement technique these days. It functions admirably with high measurement information and KNN can utilize bit work that can delineate information to be higher dimensionality. As opposed to another grouping strategy, KNN does not utilize the majority of the information to be learned in the learning procedure, however, only a few picked information is added to building a model in learning expositions. This examination utilizes KNN on the grounds that highlights utilized have enormous dimensionality relying upon the quantity of vocabulary.

EXPERIMENTAL ANALYSIS AND RESULTS

Experimental Analysis

In the experimental procedure, we have taken images of various hand gestures for every alphabet in order which incorporates every single English alphabet set with standard size 480x640 pixels which are commonly utilized in ISL. We have made the database utilizing these images to be examined in the investigation. Above in Fig 7 demonstrates the database pictures utilizing 480x640 pixels. First, we extract the features of each gesture and create a mat file from the features extracted from images and given to the classification process.

Experimental Results

In the experimental result stage, we have taken each gesture and caught a few images with variety to break down the result of the procedure. We have demonstrated 26 pictures above in fig 8 of various gestures for which we have made the database before.

Hand Gesture for image ‘A’ is shown below on which we perform the SIFT algorithm. First, the input image will display then the input image is converted into

grayscale. Then the Features are extracted as shown below in fig 9.

The figure 8 shows the Graphical User Interface with those two options as Feature Visualization and Alphabet Recognition.



Figure 8. Graphical user interface (Feature and alphabet)

Feature Visualisation option is results shown in figure 9. Features of Alphabet ‘B’ are shown below.

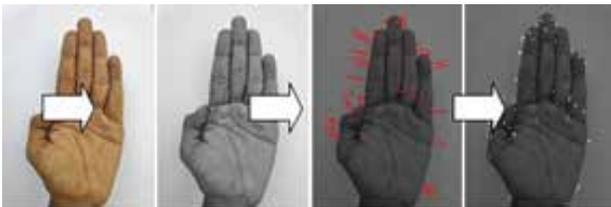


Figure 9. Feature Visualisation

Alphabet Recognition option is selected the results for alphabet ‘C’ and alphabet ‘Y’ are shown in figure 10.

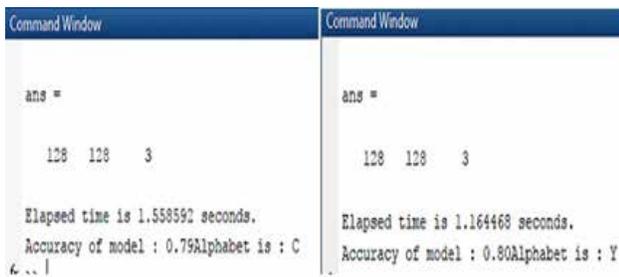


Figure 9. Alphabet Recognition (C and Y)

Once the feature is extracted, the images from the test folder or the images which we have to test are taken and the accuracy, as well as the time taken, is calculated for recognition of the image. Below are the table 1 showing

the validation accuracy as well as time taken by all 26 alphabet test images to recognize the alphabets.

Table 1: Hand gesture recognition rate table for five database images of each hand gesture

Input	Count	Rate	Output	Accuracy (%)
	3	0.85	A	60
	4	1.03	B	80
	5	1.51	C	100
	5	1.18	D	100
	5	1.02	E	100
	5	0.84	F	100
	4	0.78	G	80
	3	1.04	H	60
	4	1.05	I	80
	3	1.06	J	60
	4	1.34	K	80
	1	1.24	L	20
	2	1.22	M	40

Input	Count	Rate	Output	Accuracy (%)
	5	1.24	N	100
	4	1.18	O	80
	4	0.95	P	80
	2	1.35	Q	40
	5	1.11	R	100
	5	1.12	S	100
	5	1.20	T	100
	4	1.04	U	80
	4	0.90	V	80
	4	0.94	W	80
	5	1.11	X	100
	5	1.10	Y	100
	2	0.96	Z	40

CONCLUSION

The hand gesture recognition system proposed in this paper utilizes the SFIT algorithm for feature vector usage and Euclidean separation for vector examination. ISL is perceived through sign images which will help in correspondence with individuals who don't have its learning. The SFIT calculation has been utilized for decreasing the response time and expanding the exactness in results. The proposed system likewise shows the contortion decrease in the images so the exactness of the gesture recognition can be kept up. This work can be additionally produced for one extraordinary system with other diverse communication through signing gesture recognition by building up the database and discourse transformation can likewise be implemented. In future scope, further processing speed can improve use of GPGPU based parallelism in gesture processing.

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Pneumonia Disease Detection in Chest X-Rays using Deep Learning: A Survey

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ABSTRACT

Pneumonia is disease casus an infectious that frequently results from an infection due to bacterium in the alveoli of the lungs. People often get it when they have Streptococcus pneumonia, which frequently affects one or both lungs. Lung X-rays or respiratory sounds are used to quickly identify pneumonia and must be examined by radiotherapists with extensive expertise. Therefore, developing an automated approach for identifying pneumonia may aid in providing prompt treatment, particularly in different places. In this study, the screening of pneumonia using a few computer-aided approaches is surveyed and examined. In this paper, a thorough literary analysis is conducted to determine how one may integrate hospitals and healthcare organizations to train machine learning models from their datasets, allowing the ML algorithms to identify disease more accurately and efficiently. Purpose of this paper is to study different deep learning and machine learning models that are truly based on detecting pneumonia disease by taking various parameters into consideration and comparing the performance of those with various parameters like accuracy, precision and algorithms. Analysis from the whole survey is that Convolutional neural networks (CNNs) become more common for classifying illnesses as a result of deep learning algorithms effectiveness in examining medical graphics images but a machine learning model with combined input of both respiratory sound and images can be developed to detect pneumonia more correctly.

KEYWORDS: Convolutional neural network, Pneumonia, Transfer learning, Model training, Images, Deep learning.

INTRODUCTION

Acute pulmonary inflammation known as pneumonia can be caused by infection triggered by bacteria, viruses, or fungi affects the lungs. This lungs results in inflames of the air sacs and leads to thoracic swelling, an illness where the pulmonary system becomes swamped via fluids. It is responsible for over 15 percent of deaths in children under the age of 5 years [1]. Pneumonia is especially common in poor developing countries, because of worse by crowded living conditions, contamination, and hazardous lifestyle factors, while healthcare sources are scarce. Because of its intensity, a significant clinical diagnosing method is developed and carried out, among which one of the medically proven techniques is detecting pneumonia using a chest X-ray (radiograph) [2].

Because X-rays may reach soft tissue, radiography will show a somber color. Eroding X-ray intensity on hard tissues like bones results in vibrant colors. Figure 1 demonstrates here that the thoracic cavity is easily detectable (dark color), though most lung cavities are filled with air. While in individuals with pneumonia, fluids occupy the air passages, making the thoracic cavity seem lighter on radiographs as seen in figure 1. Pneumectomy, cancer cells, swollen blood vessels, heart problems, and other anomalies may all contribute to the thoracic cavity's lighter hue.

In a conventional diagnosis, a qualified radiologist evaluates the lung infection and determines the necessary course of therapy to be administered in order to cure the infected person. The radiographic physical identification of pneumonia takes time and frequently

results in biased disparities that may influence the conclusion. Additionally, radiological pictures of the illness level may not clearly show it, which will extend the time needed for diagnosis. An innovative yet straightforward technique is presented to effectively carry out the best classifier using deep neural network architecture in order to solve this issue. Approaches for computer assisted evaluation have recently been developed to assist doctors in determining the incidence of infection using chest radiographs.



Fig. 1. Chest X-Rays of normal, bacterial and viral pneumonia [32]

With the improvement of computer engineering, computing with Graphics Processing Unit (GPU) considerably boosts computational capacity, and the implementation of deep learning. This learning method for data processing demonstrates a significant uptrend [3]. Deep learning methods, notably convolutional neural networks, are widely employed for image categorization. Nevertheless, these systems only operate at their best if they are given a great deal of information. It is challenging to obtain a really substantial number of labeled data for biomedical image recognition challenges since doing so necessitates paying costly and time-consuming healthcare practitioners to categorize every image.

LITERATURE REVIEW

In [4], researchers describe deep learning knowledge of total procedures for locating and identifying X-ray pictures of pneumonia across the chest. They used the dataset of Radiological Society of North America (RSNA). From their assessments, they found that Mask R-CNN acted better in prediction responsibilities. They've applied the base community of Mask-R CNN pre-skilled on COCO weights2 using common residual CNN (i.e., ResNet50 and ResNet101) to obtain the functional properties of actual human lungs, Region of Interest Align (ROI Align) as a predictor and using the bounding box as a regressor They successfully

completed pixel-detailed segmentation of lung opacity selected using ROI classifier, which permits scaling during inference and loss. For training their version (identifier and classification), they employed a multi-challenge penalty and they anticipated hyperparameters based on a 10% stratified trend from the validation data. After closer inspection, it was found that the difference between the occurrence of pneumonia in pictures is quite slight. Massive photographs may be extra advantageous for deeper statistics. But the evaluation cost also difficulties while dealing with huge photographs increase rapidly. They suggested a structure with local context, which includes mask-RCNN, provided more context for producing correct outputs. Also, the use of thresholds in the historical past even as education tuned our community to perform well.

In [5], the paper proposes a computer-aided gadget, which mostly relies upon deep learning, for the diagnosis of various tuberculosis (TB) lesions in radiographs. In order to do the auxiliary analysis and figure out the probability of TB, the suggested computer-aided machines can automatically fragment the lung region. As a result, it can be extremely essential in determining a radiologist's second judgment. Due to patient privacy concerns, the chest radiograph data that was required to enhance the results of this investigation has now been withheld. The suggested computer-assisted deep learning system incorporates trained categorization and identification patterns and may be used with standard computers. The technique may be used in research projects to aid radiologists in detection and public health organizations in TB screening in regions where the disease is widespread. This technique may be extremely practical and financially advantageous for TB diagnosis in low- and middle-income nations having significant tuberculosis occurrence.

In [6], an author proposed a CAD system based on For the classification of pneumonia, the outputs of three deep CNN models that served as the foundation learner were combined based on the weighted sum rule. In their suggested method, 3 different Deep CNN algorithms (ResNet-18, Google Net, and DenseNet-121) are trained in an ensemble using a weighted mean ensemble methodology and a five cross-validation approach. For this study, 2 publicly accessible datasets were used (Pediatric-CXR and RSNA-Pneumonia-CXR).

Deep learning algorithms frequently assign very high probability values to cases involving misclassification, which is one of the key issues with this approach. Because of redundant characteristics that have been learnt inside its deeper layers, this behavior is noticed. The researchers gave the weight to the classifier that was utilized for classification, although this weight could not be useful. On the Pediatric-CXR dataset, the suggested model had an accuracy of 98.81%, while on the RSNA-Pneumonia-CXR dataset had an accuracy of 86.86%.

In [7], researchers proposed a Deep ConvDilatedNet approach, inclusive of the statistics processing, the shape of community, and the soft-efficient NMS's enhancing impact. The dataset used for this is from Kaggle, all 6012 photos have pneumonia; amongst them, pneumonia was present in 3265 occurrences, which represented the highest proportion of the sample. There may additionally be an area in 2617 pics, 3 regions in 118 instances, and 4 Areas in 12 cases. Due to the turbulence of the pneumonia, the image was also enhanced using the CLAHE algorithm to enhance the target place more spectacularly. Within the RPN, they've used the smooth-NMS set of rules to clear out the anchor field and make certain of its exceptions. To expedite the collection of criteria' convergence and decorate the effectiveness of the forecasting goal location, they also utilized the good enough-way set of rules in YOLOV3 to reap the initial anchor field size. They inserted Deconvolutions in Featured Pyramid Network (FPN) to vary scale and subsequently promote reputation via capabilities calculated with only one input scale. Eventually, they were given the result of that technique. Merging the distinctive groups of labor finished in every network, the capacity of the set of rules to find out pneumonia correctly inside the RSNA Dataset is more potent. To confirm the authenticity of the version, additionally they have compared it with elements in the conventional DetNet59, ResNet50, ResNet101, and VGG16 networks and compared them with other notable outputs; their set of regulations does a precise undertaking on that venture. The classification performance is not really the highest since networks outside of the dilated bottleneck shape lost some functional details within the Deep community.

In [8], researchers describe the usage of deep learning for classification of virtual snapshots of chest X-rays in two categories. The application became based on the CNN model, the use of Python and some specific tools. The dataset used was provided by Guangzhou girls and children's medical center, Guangzhou and is available on Kaggle. The data consists of 5856 chest X-ray radiographs. It is categorized into three parts (i.e., train, Val, and test), which are used for training, testing, and experimenting. Initial experiments show promising consequences, but greater studies are needed. Despite the model accuracy being obviously high, about 90%, there is a risk of overfitting due to the volume of the data. Additionally, the 90% precision approach that the classifier ought to probably be utilized as a choice support tool. The right prognosis of any type of disorder nonetheless calls for the involvement and presence of scientific experts. It is critical to collect as much information as possible in order to build a fantastic and trustworthy image categorization model.

In [9], researchers describe a CNN-based algorithm that aims to recognize pneumonia from a series of chest X-ray images. The suggested dataset for evaluating performance of the proposed model comprises generic 5786 X – ray images from the Kaggle challenge. Furthermore, the dataset is divided into three folders (train, test, and Val) and sub-folders for every photograph class (i.e., Pneumonia/normal). Every thoracic X-ray picture was taken from one to five years olds. Firstly, the Dynamic Histogram Equalization (DHE) approach was used by the researchers to boost the visual contrast. This approach can improve image evaluation without distorting the image resulting in checkerboard effects. Then, they developed an easy VGG-primarily based CNN version for feature extraction from source photographs or already generated function maps, which included at best 6 layers merging ReLU activation characteristic, drop operation, and max pooling layers. The output of the acquired accuracy charge of 96.07% and precision charge of 94.41%, indicates that their suggested version plays nicely in contrast to brand new CNN version architectures.

In [10], to recognize the best deep learning strategy for identifying the different COVID-19 manifestations, unique pre-trained deep learning systems were

employed. Datasets utilized during the research were acquired from J. C. Montreal (2020) and COVID Chest X-ray Database and COVID19. Many experiments have been performed by making use of the CXR dataset to apprehend which layer is capable of extracting the top attributes to reach outstanding overall results. Deep networks scored well in distinguishing COVID-19, viral pneumonia, and healthy CXR images, particularly the MobileNet and VGG16 systems, which outperformed comparable models in all parameters. The outcomes additionally confirmed the prevalence of DenseNet169, InceptionV3, VGG16, and MobileNet in figuring out COVID-19 CXR photographs with excessive accuracy and sensitivity. However, aside from VGG16 with extreme accuracy, superiority in high overall performance persisted. The category accuracy, precision, F1 score, precision, sensitivity, and specificity of COVID-19 have been 98.72%, 97.59%, 96.43%, 98.7%, and 98.78%, respectively. This analysis showed that deep learning with X-ray photographs is likely capable of extracting significant characteristics that are linked to the COVID-19 condition.

In [11], the author demonstrated that a smaller architecture may achieve higher accuracy than numerous transfer learning-deployed bigger models that have been pretrained. Contrary to most current designs, which only utilize dropouts in the network's completely connected area where most of the metrics are learned, this architecture uses dropouts throughout the network. This study establishes the suggested model's ability to perform classification results even with a small number of training factors, and it also shows how this characteristic might increase models' performance. The standard dataset used for this work is taken from Kaggle, included 5856 annotated photos, 4273 of which revealed pneumonia and 1583 of which were healthy. 70% of available CXR pictures were utilized for training, ten percent for validation and the twenty percent remaining were used for testing. All visuals have been altered to conform to the format 224*224*3 required by the majority of CNN network architectures. Rather than using transfer learning to implement pre-trained model systems, they built a CNN structure from the ground up. Along with faster training convergence, it also results in greater prediction and validation accuracy. The accurateness indication of the suggested

network model is located in the gap seen between the highest reported scores, ranging from 97% and 98%.

In [12], is to assess system efficiency of transfer learning-based pre-trained networks that have been chosen to aid in the choice of an appropriate system for image analysis. To achieve the aim, they compared and evaluated the efficiency of pre-trained models including Darknet-53, ShuffleNet, Inception-V3, GoogleNet, SqueezeNet, and making use of confusion matrices with different epochs, mini-batch sizes and training rates. The 32×32 color pictures in the CIFAR-10 dataset are split into 10 classes, every class having 5,000 training photos and 1,000 test images. Five out of ten classes have been selected to take part in the experiment. For each of the five classes, 3000 training photos are chosen from the training dataset. The whole training process was done in MATLAB R2021a. The results show that on small batch sizes of thirty-two and epoch thirty, all five pre-trained models produced good outcomes. With an accuracy of up to 94.70% for Learning Rate (LR), Darknet-53 produced remarkable outputs with LR-0.0001. Ultimately, the Inception-V3 model had the best accuracy with LR 0.001 and was 96.98%.

In [13], researchers tested the efficiency of the various deep convolutional neural models. VGG19, VGG16, InceptionV3 and ResNet50 these four models were utilized. Normal and pneumonia X-ray images were trained into these four deep CNN models. A total of 5840 radiographs were used for preprocessing, out of which 624 were used for model testing and 5216 chest X-ray images were used for training. Given that the InceptionV3 model achieved the highest values for all assessment criteria, including accuracy and F1-score, it can be concluded that it outperformed the ResNet50, VGG19 and VGG16 models. Although ResNet50 scored better in recall than InceptionV3, the analysis revealed that the Inceptionv3 model performed at the top with a 72.9% accuracy rate, a 93.7% recall rate, and an 82% F1-Score.

In [14], researchers proposed to use three well known pre-trained CNN models (DenseNet169, MobileNetV2, and Vision Transformer). The chest X-ray data set from Kaggle having 5,863 X-Rays with category Pneumonia and category Normal, serves as a training set for these models. At the end of the experimental stage, the findings

are derived by merging the features that were gathered from these three models using a probabilistic ensemble method for improving the efficacy of categorization. After the convolutional layers were combined, a global average pooling layer was added to preserve the image's spatial features. Fully connected layers were utilized in the suggested method's classifier step. The suggested Ensemble Learning (EL) strategy performs better and achieves an accuracy of 93.91 percent.

In [15], the transformer Encoder method was integrated with two ensemble learning foundations, namely ensemble A (VGG16, GoogleNet and DenseNet201

models) and ensemble B (InceptionResNetV2, Xception and DenseNet201). Mendeley (binary classification) and Chest X-ray (multi-class classification purpose) datasets were used to train, verify, and test the suggested deep learning models. As a consequence, for binary classification, group A obtained an accuracy of 97.22% and group B an accuracy of 96.44%. For binary classification, the suggested hybrid model recorded 99.22% performance for classification. In terms of heat maps or saliency maps, the suggested hybrid XAI model demonstrates its capacity to deliver superior and more precise comprehensible identification results. Table 1 shows summary of existing work.

Table1 : Review of Existing work

Publi- shed Year	Problem definition	Processing Technique	Algorithm	Accuracy	Dataset	Strengths	Weakness
2019	Detection of pneumonia [4]	used the standard residual convolutional neural network (i.e., ResNet50 and ResNet101) to create the basic network of Mask-RCNN pre-trained on COCO weights ² for feature extraction of genuine human lungs, using ROIAlign as a predictor as well as bounding box as a regressor.	Mask-R CNN (ResNet50) Mask-R CNN (ResNet101)	81% for ResNet50 and 86% for ResNet10 1	Chest X-ray datasets provided by the Radiological Society of North America, & computational infrastructure support offered by Kaggle	The deep neural network Mask- RCNN helps in easy interpretations of CXRs using critical modifica-tions.	Training set results are not good.
2020	Detection of multicategory Pulmonary tuberculosis in Radiographs [5]	Automatic lung segmentation from chest X-rays is accomplished using a fully convolutional neural network.	CNN	78%	JSRT	Greater precision with huge datasets	The process constitutes smaller datasets
2021	Pneumonia Detection [6]	Using designed ensemble three classifiers, employing a combination of weighted averages method where the classifiers' weights are created using a cutting-edge method to predict the probability of class	GoogLeNet ResNet-18 DenseNet- 121	98.81% & 86.86% in Kermany and RSNA dataset respect-ively	Kermany and RSNA	The suggested ensemble method is not dependent on domain, has good results, and can be utilized for a wide range of computer recognition systems.	The ensemble framework was unable to accurately categorize some of the data samples.

2021	Pneumonia Detection [7]	researchers proposed Deep ConvDilatedNet approach, inclusive of the statistics processing, the shape of community, and the effective enhancement effect of soft-NMS	ResNet50 ResNet101 DetNet59 and VGG16 networks	90%	6012 Chest X-Ray Images (Pneumonia) From Kaggle	Efficient performance of DeepConv-DilatedNet	accuracy is not much better.
2021	Pneumonia Detection [8]	Applying scientific techniques and Python programming, the implementation was based on the CNN model.	CNN	88.90%	Guangzhou Women and Children's Medical Center	Classifies images based on changes consistent with pneumonia.	Overfitting problems may arise when the dataset is large.
2021	Detection of Pneumonia [9]	Dynamic Histogram Equalization (DHE), a powerful picture enhancing technique, is applied.	VGG-16, ResNet50, MobileNet, Inceptionv3, DenseNet12 1	96.07%	Mendeley database as well as Kaggle	The sharpness is improved by preprocessing the photos with the Dynamic Histogram enhancement method.	More accurate classification models are available.
2021	Detection of COVID-19 [10]	distinctive built-in deep learning networks were implemented to perceive the first-rate deep learning method	VGG16, MobileNet, DenseNet16 9, and InceptionV3	98.72%,	covid19-radiography-database [18]	Efficient performance	Larger dataset is required
2022	Detection of Pneumonia [11]	Images fed to the network resized to dimensions 224*224*3. Batch normalization. To enable the best convergence and the shortest training period, two methods were implemented. SoftMax activation Image classification	Slightly replicates the VGG-16 architecture, a unique integration of a dropout layer placed in the convolutional part of a CNN architecture	97.2 %	Chest X-Ray Images (Pneumonia) by PAUL MOONEY from Kaggle	Despite having less learned parameters, give accurate classification, and may even profit from this characteristic in terms of efficiency. Highly efficient	It exclusively uses CXR information rather than CT pictures.
2022	Performance evaluation of the pre-trained deep convolutional neural networks using TL [12]	Prepare and load data Load retrained network Replace final layer Freeze initial layers Train network Classify images Reset GPU	SqueezeNet GoogleNet ShuffleNet Darknet-53 Inception-V3	Inception-V3 with highest accuracy of 96.98%	C I F A R - 1 0 [17]	NA	Limited dataset was used

2022	Pneumonia Detection [13]	Input from dataset Preprocessing of dataset Training with all 4 models Fully connected Image classification Performance comparison of 4 models to determine best one.	VGG16, VGG19, ResNet50, and InceptionV3	Best performance Inception V3 72.9% accuracy	Total of 5840 images were used	The Inceptionv3 model is the best performing model in terms of accuracy	Limited amount of dataset was used
2022	Pneumonia detection [14]	Input image is fed simultaneously to all 3 functional layers Dimensionality reduction. Batch Normalization Fully connected layer Dropout layer Image classification	DenseNet16 9, MobileNet V2, and Vision Transformer	93.91%	Offered by Kermany and Goldbaum [16] on Kaggle	more reliable and robust	TL necessitates calculating the amount of fully connected layers, the quantity of frozen layers, as well as an acceptable pre-trained CNN algorithm for a specific problem. The recommended EL approach must have a high level of bias as well as variation.
2022	Hybrid ensemble transformer encoder for Pneumonia detection [15]	Data pre-processing Deep feature extraction from 6 Pre-trained DL models combining the chosen pre-trained models for more detailed characteristics and reliable output Generalization the network's core is a finely tuned Transformer encoder with ensemble model characteristics. Image classification	EfficientNet B7 DenseNet 201 VGG16 Inception ResNetV2 Xception, GoogleNet network Transformer encoder	For binary classification 99.22% and for multi-class classification 98.18% accuracy	Mendeley dataset [15] and Chest X-ray dataset [19]	In terms of heat maps or saliency maps, the suggested hybrid XAI model delivers excellent and more precise and easily interpretable prediction output. than other present ones.	The thoracic X-ray image's depiction of the precise impacted pneumonia location was insufficient.

METHODOLOGY

In this section, the task of pneumonia detection has been divided into three subsections, namely pneumonia classification, detection, and segmentation, as shown in Figure 2. All of these parts have a collection of techniques for the identification of respiratory infections, along with the existing research on each of these algorithms. An overview of recent developments in CNN algorithms used for pneumonia prediction is provided as well as, in the aforementioned research summary, new developments like RNNs/LSTMs, Vision Transformer for data in sequence, and GANs were addressed. Furthermore, additional issues about confidentiality of data and the shortage of the training dataset are examined.

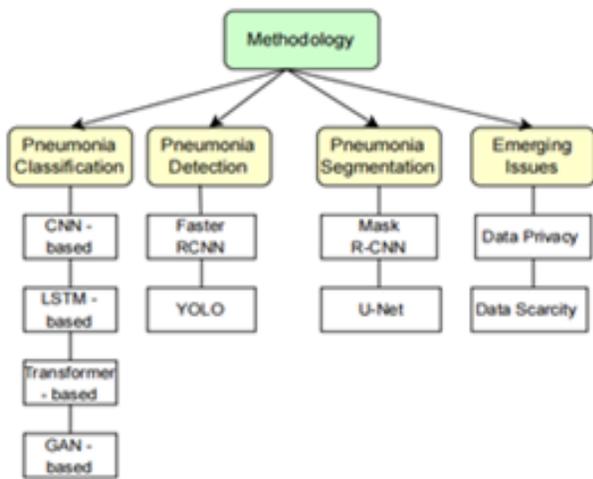


Figure 2. Methodology

Pneumonia Classification

CNN based classification

Advanced CNNs have been mainly credited with recent developments in artificial intelligence for vision (CV). The layer that outputs data forecasts the right category tag, whereas the layer that provides input gets visual data derived from a picture. The amazing thing occurs while extracting features and training take place—in the layers that remain concealed. The transfer learning approach is a method that leverages algorithms based on deep learning that have already been trained as the basis for completing relevant or comparable CV tasks, for instance those in the medical industry. Improved accuracy in predicting and automated

without supervision from humans are two benefits of employing CNNs. But developing a predictive model with CNNs takes a lot of information, duration as well as computational power [4][8][5].

LSTM-based Classification

Artificial neural networks (ANNs) of the type known as RNNs are typically employed for the analysis of data that is ordered. RNNs are made to keep a state within them that, for a set amount of context-specific data as well as data about previous duration, can reflect both context-specific data as well as data about previous contributions. RNNs suffer from the issue of gradients that diminish, which was addressed by the Long Short-Term Memory (LSTM) method [20]. The capacity of RNN/LSTM technology to store knowledge over a period of time is one of its main benefits. The issue of vanishing gradients arises because RNN/LSTM models cannot read extremely lengthy chains, which is a hurdle. Inputs for a fixed period. The Long Short-Term Memory (LSTM) algorithm is a type of RNN.

Transformer-based Classification

Experts have tried a number of different approaches to develop CNN substitutes, but their achievement has proven constrained since CNNs are still growing in strength and complexity. Nevertheless, Dosovitskiy et al.'s [21] demonstration of the potential of the transformer-based Vision Transformer (ViT) design for the classification of images despite the need of CNNs showed that it was promising. Utilizing ViT has a number of benefits, among which is its capacity to accommodate extremely long sequences of data. ViT might need additional data to develop an efficient model than CNNs, which could be a major drawback.

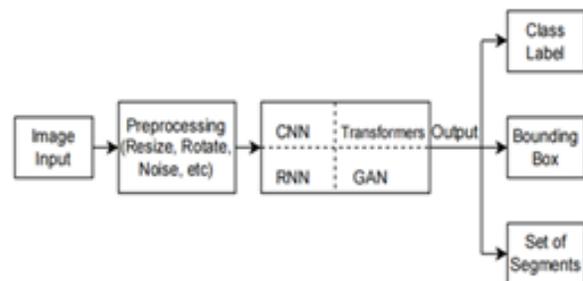


Figure 3. General Workflow of Pneumonia Classification

Pneumonia Detection

The most popular are CNNs. There have only recently been a few developments that have concentrated on localizing COVID-19 pneumonia in X-rays and CT scans. The existing research on COVID-19 pneumonia detection is summarized in this part, along with a brief review of object identification techniques. R-CNN is a two-phase area-based method for challenges involving detecting objects and segmentation. The program identifies suggested areas by particular search, forecasts labeled output via bounding boxes, and recommends areas via selective search. R-CNN's developers created the fast R-CNN approach to overcome this problem because R-CNN was generally slow. The main distinction was that all suggested regions were classified using a convolution version of the window sliding method.

YOLO is a one-stage algorithm used for real-time object detection. It creates numerous grids out of an image's contents, every one of which suggests bounding boxes with confidence scores. The category of an image is subsequently determined using the probability of each class.

Pneumonia Segmentation

Modern image segmentation challenges are performed using the Mask R-CNN technique. It has the ability to recognize images and provide excellent masks of segmentation for all instances. Mask R-CNN provides a number of benefits, such as becoming simple to develop, working better than current object segmentation methods, requiring little modification to Faster R-CNN, and being simple to generalize for various applications. For the purpose of segmenting contaminated areas in biomedical imaging, the Net is a deep learning method. A combination of its encoder-decoder architecture as well as sophisticated CNN feature extraction capabilities, it was initially proposed by Ranneberger et al. as well has attained excellent accuracy for segmentation. The U-Net design enables concurrent use of both position and context-related data on a worldwide basis. But the U-Net architectural design's congestion in the middle portion can make learning more difficult.

Issues in Pneumonia Detection

Data Privacy

To train a deep learning model, it requires a huge amount of data. For efficient training real time data is required. But because of General Data Protection Regulation (GDPR) [22], it is not possible to get real time data of patients from medical institutions and hospitals. It is a big challenge to maintain confidentiality of data following GDPR rules. So to overcome this problem, there is a need for certain frameworks to use real-time dataset. There are some technologies to overcome this problem such as blockchain, gossip learning, federated learning, etc. A machine learning method called "gossip learning" uses completely dispersed information without centralized management [23]. The goal is to jointly develop a machine learning model that simulates the situation in which the data set is kept centralized. The information, which included mobile coverage and network anomalies, was extracted from cellular phones. The information was then utilized to train the ML model within both the federated learning (FL) as well as gossip learning frameworks. FL is a brand-new type of Artificial Intelligence which relies on decentralized training and input to deliver learning to the edge or right on the gadget [24]. FL is favored in use-cases when confidentiality and safety are the main considerations. By having a detailed awareness of the risks involved, a FL developer or consumer may effectively create a safe environment. Comparison of federated learning and gossip learning is given in various research [25].

The revolutionary technology of blockchain maintains a distributed data record among users of a decentralized network. It ensures that the correctness and uniformity of every individual's log data are verified [24]. The unique properties of blockchain help to increase the robustness of the deep learning models by defending the data against different types of attacks by adversaries. Blockchain is a tamper-proof and tamper-resistant system by definition, helping to trace the information to ensure it hasn't been altered since it was created [25,26]. Data integrity, availability, privacy, authenticity, and operational exposure are datasets with large volumes of images that need to be used. The survey done can be used in deciding the algorithms, datasets, and architecture to be used to make a model for pneumonia detection.

Patient records include a significant amount of sensitive patient data, thus there are some privacy concerns. So one can take into account federated learning and divergent security to solve privacy issues since they enable some of the best parts of emerging. blockchain systems, and the decentralized and peer-to-peer (P2P) architecture of blockchain foresees these advantages. In studies [27], there are some limitations, including a slower procedure that is processor-intensive, has technical challenges, and is inadequate when legitimate datasets are taken into account.

Scarcity of Data

By standard, clinical data exchange is forbidden for user privacy. It brings up the issue of insufficient training data, which is frequently a barrier to building strong prediction models. Recently, experts have thought of using self-supervised learning to address this problem as a solution.

Self-supervised training refers to the idea that computers can acquire knowledge on their own without such aid of human annotations. A system's ultimate objective in diagnostic imaging is to automatically generate labels from the set of data. The decrease in the quantity of labeled data needed is self-supervised learning's biggest benefit. A model may experience overfitting, though, if the input is sparse. The issue of poor labeling and inadequate data in diagnostic imaging was noted by the authors in [28]. To solve the aforementioned problems, the findings suggest inadequately supervised learning with self-supervision and various instances of data enhancements. The Inf-Net model was enhanced by researchers in [29] by using self-supervision to separate coronavirus lesions from unprocessed CT images. Confidentiality of data following GDPR rules. So, to overcome this problem, there is a need for certain frameworks to use real-time datasets. There are some technologies to overcome this problem such as blockchain, gossip learning, federated learning, etc. A machine learning method called "gossip learning" uses completely dispersed information without centralized management [23]. The goal is to jointly develop a machine learning model that simulates the situation in which the data set is kept centralized. The information, which included mobile coverage and network anomalies, was extracted from

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DISCUSSION

Computer aided diagnosis of diseases helps doctors in saving time and gives results more accurately. This paper studies and compares different models built to detect and classify lung images in different classes like pneumonia COVID-19 and normal. Different models have been built using different approaches but the ones using machine learning/deep learning proved to be more effective, accurate and reliable. Different architectures and algorithms are used for examining the X-ray images. To achieve better results different types of datasets with large volumes of images need to be used. The survey done can be used in deciding the algorithms, datasets, and architecture to be used to make a model for pneumonia detection. Patient records

include a significant amount of sensitive patient data, thus there are some privacy concerns. So one can take into account federated learning and divergent security to solve privacy issues since they enable decentralized model training by providing certain interference while protecting patient confidentiality. The privacy concerns and the data constraint dilemma will require further study and emphasis in the future. Moreover, from the survey it can be analyzed that one can combine both respiratory sound and lung radiograph as an input to a machine learning model to get more accurate results. Furthermore, a substantial field of study continues to focus on the generalizability of the current model.

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3	Mechanical Engineering	1955	60
4	Industrial Electronics	1970	40
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2	Mechanical Engineering	1955	60
3	Electrical Engineering	1955	60
4	Electronics Engineering	1986	60
5	Computer Science Engineering	1986 2000	60 90
6	Information Technology	2001	60
Post-Graduate			
1	Civil-Environment Engineering	1971	18
2	Civil-Structural Engineering	1971	30
3	Mechanical-Production Engineering	1995	30
4	Mechanical - Design Engineering	1971	30
5	Mechanical-HeatPower Engineering	1971	18
6	Electrical-Control Systems	1971	18
7	Electrical-Power Systems	1971	18
8	Electronics Engineering	1987	30
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10	CSE-Information Technology	2012	18

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Shri. Ajit Gulabchand (born 1948) is an Indian industrialist and Chairman of Hindustan Construction Company. He serves as chairman of the board of governance at National Institute of Construction Management & Research (NICMAR) and as chairman of Walchand College of Engineering, Sangli. He serves as director of Hindustan Finvest, HCC Infotech, Hincon Technoconsult, Hincon Realty, Hincon Holdings, Ucchar Investments, Western Securities, Motor Association of India, Constructmall.com, Champali Garden, Shalaka Investment, Gulabchand Foundation and as an independent, non-executive director of Bajaj Electricals. He is a founding member of the World Economic Forum's Disaster Resource Network and a member of the National Council of Confederation of Indian Industry (CII).

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