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RECENT ADVANCES IN ENERGY HARVESTING & APPLICATIONS (RAEHA 2025)



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PREFACE

Rayat Shikshan Sanstha, Satara is one of the largest and foremost educational institutions in Asia, established by late Padmabhushan Dr. Karmaveer Bhaurao Patil in 1919 with the motto "Education through self-help". It caters to the educational needs of the downtrodden and economically weaker sections of society. The college was established as Arts, Commerce College in June 1966, and it became a full-fledged institution with the inception of the science faculty in June 1983. The college is affiliated with Savitribai Phule Pune University, Pune. Now it is a well-flourished institution imparting higher education in Bachelor's and Master's Degrees in various streams. It is committed to the upliftment of poor and rural students in the vicinity. The college authorities take utmost care and make every possible effort to maintain the academic standard of rural students. It has well-qualified staff, good location, spacious & well- equipped laboratories, huge infrastructure, enriched library, well-equipped Gymkhana, girls' hostel, Computer training centre, beautiful landscaping with Botanical Garden & Poly-house. Presently, the college runs 18 UG and 8 PG courses, including Organic Chemistry, Analytical Chemistry, Physics, Botany, English, Economics, Marathi & Commerce. The Department of Chemistry, Botany, and Commerce has recognised research centres of the Savitribai Phule Pune University. The college has received the "Best College Award – in the year 2018. The college was reaccredited with an 'A' Grade with a CGPA of 3.06 in the 4th Cycle by NAAC. The Department of Electronic Science was established in 1985 with a UG course. It has a well-equipped and spacious laboratory along with a departmental library facility. In the dynamic scenery of science and technology, where innovations shape our world at a unique pace, it is essential to continually explore emerging trends that redefine the boundaries of human knowledge and capability. This Conference Proceeding book, **"Recent Advances in Energy Harvesting & Applications (RAEHA 2025)",** endeavours to capture the spirit of innovation and discovery that boosts our civilisation forward. This conference Proceeding book is published in the expectation of sharing the enthusiasm found in the study of science and technology. Science and technology can help

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us unravel the mysteries of our universe, but beyond that, it can be personally satisfying. We developed this conference proceeding to help people realise the feeling of accomplishment. The aim of the National Conference on “Emerging Trends in Science and Technology” is to stimulate the quickening of the development taking place in all spectrums. The theme for this conference is centred around "Dissecting all paradigms of contemporaneous research being carried out across Science and Technology. It is the premier event that brings together renowned experts, researchers, academicians and students. This conference covers different areas of Science and Technology as follows: the power of innovation in the Physical and Mathematical Sciences industry to address global challenges, such as Healthcare access, and Smart Technology like AI & IoTs. To highlight the latest technological advancements, research breakthroughs, and innovative products and services in the Physical and Mathematical Sciences sector, providing attendees with insights into emerging trends and opportunities.

I, Principal Dr. N. S. Gaikwad, Ms. A. M. Dange, Head, and Co-Ordinator and Dr. S. T. Shinde, Co-editor, express our esteem gratitude to all the patrons, Advisory Committee, organising committee and all researchers who have contributed to publishing research work.

-Editors

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An overview of Machine Learning Techniques for Flower Classification, Biometric Identification, Clustering, and Identity Verification

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Abstract

Machine learning (ML) has revolutionised various domains, including image classification, biometric identification, clustering, and identity verification. This paper explores the implementation of ML models for flower classification, biometric identification, clustering, and identity verification, focusing on different algorithms and techniques used to construct a robust predictive system. Key methodologies such as Convolutional Neural Networks (CNNs), K-Means clustering, Principal Component Analysis (PCA), and Support Vector Machines (SVM) are discussed. The study also highlights challenges and future directions for improving accuracy and efficiency in ML-based classification and verification systems.

Introduction

Machine learning provides a powerful approach to solving classification and recognition problems across various domains. The rapid advancement of ML techniques, particularly in deep learning, has enabled the development of highly efficient and accurate models for classification and verification tasks. The ability to automatically extract features, recognize patterns, and make data-driven predictions has contributed to significant improvements in applications such as flower classification, biometric identification, clustering, and identity verification.

Flower classification, for example, plays a crucial role in botanical research, agriculture, and environmental monitoring. By leveraging ML models, researchers can accurately identify plant species, monitor biodiversity, and optimize crop management strategies. Similarly, biometric identification has become a fundamental technology in security and authentication systems. By analyzing unique physiological and behavioral traits, ML-driven biometric systems enhance security measures across various domains, including finance, healthcare, and border control.

Clustering techniques, on the other hand, allow for the segmentation of complex datasets into meaningful groups. These methods are widely used in data analysis, customer segmentation, and anomaly detection. Identity verification systems further utilize ML algorithms to improve authentication processes, ensuring secure access to sensitive information and resources.

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This paper examines the various ML techniques employed in these domains, their implementation challenges, and potential advancements that can further improve efficiency and accuracy. The discussion will provide insights into the role of ML in shaping the future of classification and verification systems.

2. Flower Classification Using Machine Learning

Flower classification involves recognizing different species based on image features. ML models such as:

- **Convolutional Neural Networks (CNNs):** Extract hierarchical features for high accuracy in classification, particularly in large-scale flower datasets like Oxford 102 Flowers Dataset.
- **Support Vector Machines (SVM):** Effective for high-dimensional feature classification and commonly used with feature extraction techniques such as Histogram of Oriented Gradients (HOG) and Local Binary Patterns (LBP).
- **Random Forest:** A robust ensemble method that enhances classification performance by aggregating multiple decision trees, improving generalization to new flower species.
- **Deep Learning Models:** Pre-trained architectures such as ResNet, VGGNet, and InceptionV3 have demonstrated exceptional performance in flower classification by leveraging large-scale image datasets and transfer learning techniques.
- **Feature Engineering:** Techniques such as color histogram, texture analysis (Gray-Level Co-occurrence Matrix - GLCM), and shape descriptors (Hu moments) enhance model performance by improving feature representation.
- **Data Augmentation:** Strategies like rotation, scaling, flipping, and color jittering are applied to artificially expand training datasets, reducing overfitting and improving model generalization.
- **Hybrid Approaches:** Combining multiple classifiers, such as CNN-SVM models, can enhance classification accuracy by leveraging the advantages of deep feature extraction and traditional classification methods.

3. Biometric Identification and Identity Verification

Biometric identification involves using physiological or behavioral characteristics to verify identity. ML-based biometric identification techniques include:

- **Face Recognition:** Utilizes deep learning architectures such as CNNs, Res Net, and Face Net to extract facial features for precise recognition. Preprocessing techniques such as histogram equalization and facial landmark detection improve accuracy.
- **Fingerprint Recognition:** Employs image processing techniques like Gabor filters and minutiae extraction, combined with classifiers such as SVMs and deep neural networks (DNNs) for fingerprint verification.
- **Iris Recognition:** Features are extracted using wavelet transforms, Gabor filters, and deep learning models, ensuring high accuracy in security applications.

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- **Voice Recognition:** Uses spectrogram analysis, Mel-frequency cepstral coefficients (MFCCs), and recurrent neural networks (RNNs) or transformers for speaker identification and verification.

Identity Verification Techniques:

- **Multimodal Biometric Systems:** Integrates multiple biometric modalities (e.g., face and fingerprint) to enhance security and reduce false acceptance rates.
- **Anomaly Detection Models:** Machine learning models such as Isolation Forests and Autoencoders are used to detect fraudulent activities in identity verification.
- **Real-Time Authentication:** Deep learning techniques, combined with real-time data analysis, enable continuous authentication in high-security environments.
- **Liveness Detection:** Prevents spoofing attacks by distinguishing between real and fake biometric inputs using advanced AI techniques.

Identity verification systems integrate ML models for enhanced security in various applications, including banking, border control, and secure access systems.

4. Clustering Techniques for Data Segmentation

Clustering methods help in grouping similar objects based on features. Common clustering algorithms include:

- **K-Means Clustering:** Partitions data into k groups based on feature similarity, widely used for image segmentation and document clustering.
- **Hierarchical Clustering:** Builds a tree-like clustering model, useful for visualizing relationships between clusters without requiring a predefined number of clusters.
- **DBSCAN (Density-Based Spatial Clustering of Applications with Noise):** Efficient for detecting clusters in datasets with varying densities and handling outliers effectively.
- **Gaussian Mixture Models (GMM):** A probabilistic clustering method that assumes data is generated from multiple Gaussian distributions, ideal for complex and overlapping clusters.
- **Self-Organizing Maps (SOM):** A type of artificial neural network that performs unsupervised clustering by mapping high-dimensional data into a lower-dimensional space while preserving structure.
- **Spectral Clustering:** Uses eigenvalues of similarity matrices to perform clustering, often applied in image segmentation and graph-based data.
- **Fuzzy C-Means (FCM):** Allows soft clustering where a data point can belong to multiple clusters with varying degrees of membership, useful in medical imaging and pattern recognition.

These clustering techniques are widely applied in diverse fields such as market segmentation, anomaly detection, document clustering, and image segmentation, providing valuable insights for data-driven decision-making.

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5. Model Construction and Training

Constructing and training an ML model involves several key steps:

- **Data Collection and Preprocessing:**
  - Data acquisition from various sources (datasets, sensors, real-time feeds)
  - Image enhancement, noise reduction, normalization, and augmentation to improve model robustness
  - Data labeling and annotation for supervised learning models
- **Feature Extraction and Selection:**
  - Deep learning-based feature extraction using CNNs, autoencoders, or transfer learning
  - Handcrafted feature techniques like edge detection, texture analysis, and principal component analysis (PCA)
  - Feature selection using statistical methods like mutual information and recursive feature elimination
- **Model Training and Optimization:**
  - Selection of an appropriate model architecture (CNN, SVM, Decision Trees, etc.)
  - Hyperparameter tuning using grid search, random search, or Bayesian optimization
  - Loss function optimization using stochastic gradient descent (SGD) or Adam optimizer
  - Handling class imbalance using oversampling, undersampling, or synthetic data generation (SMOTE)
- **Evaluation and Validation:**
  - Performance assessment using accuracy, precision, recall, F1-score, confusion matrix
  - Cross-validation techniques like k-fold cross-validation
  - Model explainability through SHAP (SHapley Additive exPlanations) or LIME (Local Interpretable Model-Agnostic Explanations)

6.Challenges and Future Directions

Despite advances in ML, several challenges remain:

- **Data Scarcity:** High-quality, labeled datasets are often difficult to obtain, necessitating data augmentation, transfer learning, or synthetic data generation.
- **Model Interpretability:** Many deep learning models act as black boxes, making it challenging to understand and interpret their decision-making processes. Explainable AI (XAI) techniques should be explored.
- **Computational Complexity:** Training deep models requires significant computational power and resources. Research into lightweight models and optimization techniques is necessary.

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- **Adversarial Attacks:** ML models are vulnerable to adversarial examples that can deceive classification systems. Robust security measures and adversarial training are essential to mitigate this risk.
- **Generalization and Bias:** ML models often struggle with generalization when applied to unseen data. Techniques like domain adaptation and fairness-aware learning should be explored.
- **Scalability and Real-Time Processing:** Real-time applications, such as biometric authentication, require highly efficient models with low latency. Advances in edge computing and distributed processing can address this challenge.

Future Directions:

- **Federated Learning:** A promising approach for training models across decentralized devices while preserving data privacy.
- **Self-Supervised Learning:** Reduces reliance on large labeled datasets by leveraging unsupervised pretraining.
- **Neuro-Symbolic AI:** Combining neural networks with symbolic reasoning for enhanced decision-making and interpretability.
- **Automated Machine Learning (AutoML):** Streamlines model selection, hyperparameter tuning, and feature engineering, making ML more accessible.
- **Integration with Blockchain:** Enhancing security and trustworthiness in ML-based identity verification systems.

7.Conclusion

ML-based classification, biometric identification, clustering, and identity verification offer promising applications in security, healthcare, and environmental studies. With continuous advancements in ML algorithms and computing power, these applications will become more accurate and efficient.

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Prepackaging Classification of guava fruits *(Psidium guajava)* using E-Nose

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Abstract

In this study, a nondestructive electronic nose (e-nose) system was developed to address these drawbacks by classifying and predicting guava ripeness at harvest. The system utilizes a metal-oxide semiconductor (MOS) sensor array along with radar plots and principal component analysis (PCA) to effectively distinguish among four ripening stages: green, ripe, overripe, and spoiled. Radar plots revealed unique odor signatures for each stage Additionally, PCA scatter plots demonstrated a clear separation between the four classes. A feed-forward neural network with a back propagation algorithm further enhanced the prediction accuracy for unknown samples. Overall, the results indicate that the e-nose system is not only capable of accurately classifying guava fruits but also holds promise for practical, real-world applications.

Keywords: Electronic Nose, Guava fruit, Fruit classification, PCA, Ripening stage, Fruit sorting, ANN.

1. Introduction

Guava is a small tropical tree whose fruit is often referred to as the "poor man's apple" of the tropics. Celebrated for its exceptional food quality and nutritional richness, guava is commercially cultivated on a large scale due to its unique flavor and aroma. The fruit is a powerhouse of essential nutrients, serving as an excellent source of vitamin C, niacin, riboflavin, vitamin A, calcium, and phosphorus, along with antioxidant-rich polyphenolic and flavonoid compounds that help combat cancer, infections, and the effects of aging. In fact, guavas boast up to five times more vitamin C than oranges [1-2].

Traditionally, guava fruits have been classified by trained human graders who assess them based on odor and skin color. However, this method is subjective, inconsistent, and limited by human factors such as sensory fatigue and potential impairments like color blindness [3].

To address these challenges, researchers have developed various new techniques for fruit classification. These methods include both destructive and non-destructive approaches. Destructive techniques often involve physically altering the fruit—through puncturing, crushing, or slicing—or applying chemicals, which can pose health risks. For example, testing firmness with a penetrometer

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requires damaging the fruit, and methods that measure chemical species, pH, total soluble solids (TSS), titratable acidity (TTA), or ethylene content typically require the fruit to be crushed for juice extraction using high-performance liquid chromatography (HPLC) or gas chromatography-mass spectrometry (GC–MS) [4-5].

Although non-destructive techniques such as nuclear magnetic resonance (NMR), proton magnetic resonance (PMR), vision systems, and acoustic methods are available [5-8], these conventional methods tend to be complex, time-consuming, labor-intensive, and costly due to the need for specialized skills. Therefore, there is a clear need for a simple and reliable method for classifying guava fruits.

An electronic nose (e-nose) system, which uses a specially designed array of gas sensors to rapidly detect and differentiate complex fruit odors, has proven effective for classifying various fruit aromas [7]. Over the years, electronic noses have been developed for the classification and recognition of diverse food products including fruits [8], coffees [9], meats [10], fishes [11], oils [12], cheeses [13], spirits [14], wines [15], dairy products [16], and even environmental samples [17]. However, until now, no effort has been made to apply an electronic nose for the classification of guava fruits. This paper details the design and development of an application-specific e-nose system for guava fruit classification.

This paper describes the development of a low-cost, application-specific portable e-nose system and evaluates its performance in classifying guava fruit cultivars compared to conventional methods. The classification results demonstrate that the e-nose effectively addresses many issues associated with human sensory panels—such as individual variability, adaptation, fatigue, infections, mental state, subjectivity, and exposure to hazardous compounds. In fact, the electronic nose can generate odor exposure profiles that surpass the capabilities of human panels or GC/MS techniques. To meet the demands of detecting multiple contaminants cost-effectively, we selected eight TGS series MOS gas sensors from Figaro Inc. (Japan) for their affordability and cross-sensitivity. In this study, both the hardware and software of the e-nose system were tested on guava fruit cultivars, classifying them into four ripening stages: green, ripe, overripe, and spoiled.

2. Materials and methods

2.1 Experimental design

Guava (Psidium guajava) fruits of the 'Lucknow 49' variety were sourced from an orchard located at an altitude of 504 m (19.76° N, 74.48° E). Fruits were selected based on uniform size, color, and absence of blemishes. A trained human grader harvested the fruits and sorted them into four categories—green, ripe, overripe, and spoiled—ensuring approximate consistency in size, weight, and color. After harvest, the fruits were washed under running water and disinfected by immersion in a 1% sodium hypochlorite solution at 25 °C for 5 minutes. Once dried, they were packed in carton boxes and stored under controlled laboratory

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conditions at 26 ± 1 °C and 41 ± 5% relative humidity. The experimental design was completely randomized (CRD) with two treatments applied to each fruit sample, each repeated 10 times. For the training phase, 15 fruit samples from each category were used, yielding 300 observations per class and a total of 1,200 observations across all four ripening stages. For validating the trained artificial neural network (ANN), 5 fruit samples per class were used, resulting in 100 observations per category. All fruits were evaluated on the day of harvest (day 0) using the developed electronic nose technique.

2.2 Electronic nose data acquisition and processing.

Figure 1 illustrates the schematic diagram of the e-nose system used in this study [2]. The system operates sequentially through four key components: a fruit sample handler (referred to as the concentration chamber), an array of eight different MOS gas sensors, a signal conditioning unit, and a DAQ card connected to a laptop. The laptop runs a custom-developed GUI for data acquisition and pre-processing, programmed using LabVIEW2012 software.

For each test, a fruit sample is placed in a 1 L airtight plastic jar (the concentration chamber) and allowed to equilibrate for 30 minutes until a steady headspace is established. The headspace gas is then drawn by an aquarium air pump at 3.2 L/min through a rubber tube and non-return solenoid valves into a 0.6 L airtight measurement chamber. Here, the gas flows over the MOS sensor array, which is connected to an external signal conditioning unit. Airflow is maintained at a constant rate for 30 seconds, after which the measurement chamber is sealed using solenoid valves to allow the sensors to reach a steady state over the following 60 seconds. Electronic valves, controlled by a LabVIEW program, direct the airflow as required.

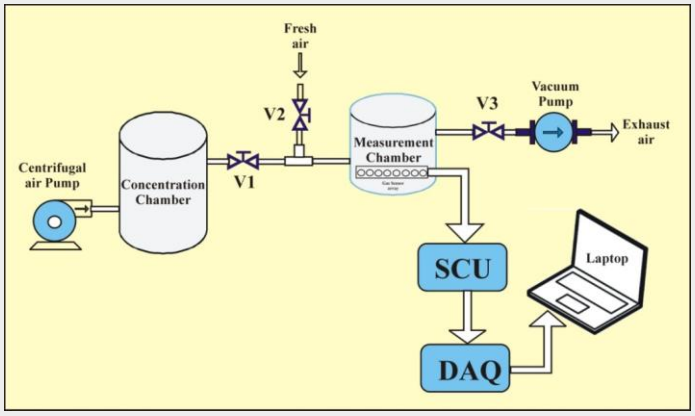


Figure 1: Schematic diagram of developed E-nose system measurements and gas flow during experiment.

When exposed to the odorant gas, the sensors produce a transient response as VOCs interact with the active material; a steady state is achieved within seconds to minutes depending on the sensor type. Each guava fruit sample is analyzed for 100 seconds with data recorded at one-second intervals. The entire measurement process is automated using our LabVIEW2012 software, and sensor outputs are collected

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via an NI USB6009 DAQ card into a laptop. According to the experimental design, each guava fruit cultivar is measured twice, and the resulting data—stored as an 8-column matrix (corresponding to the eight MOS sensors) in an Excel file is later used for statistical and neural network analysis using LabVIEW2012 and MATLAB 10a.

After each measurement, the sensor housing chamber is flushed with clean air, aided by a vacuum pump, to remove any residual odorant mixture from the sensor surfaces and reset the system to its baseline state. This cleaning process, directed through electronic valves, ensures that both the measurement and concentration chambers are cleared of volatiles. All experiments were conducted at an operating temperature of 24 °C and a relative humidity of 40–45%. Figure 2 shows a photograph of the developed e-nose system and its software interface.

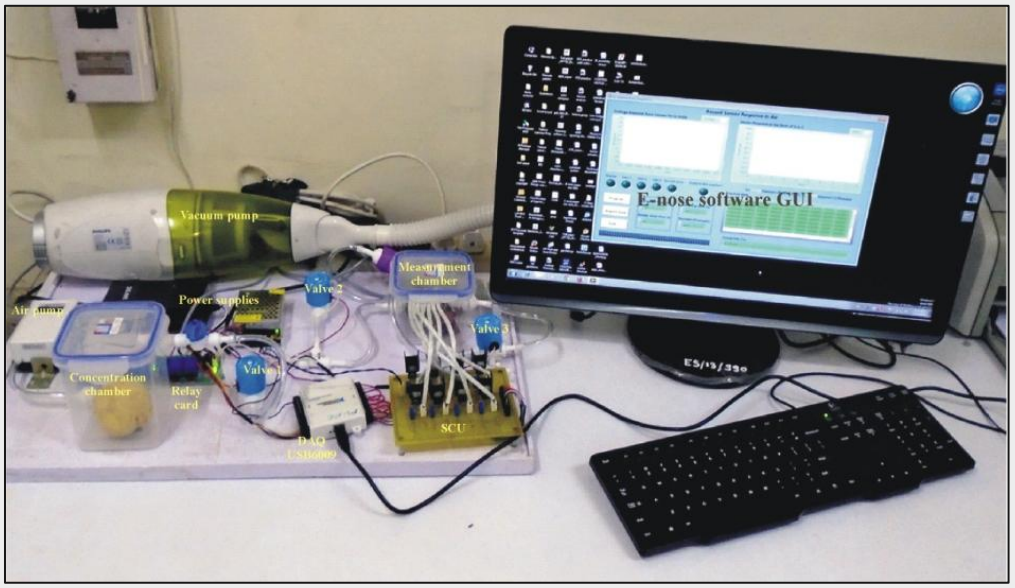


Figure 2: Developed e-nose system

The odor flow system shown in fig.1 operated using below procedures.

(1) The LabVIEW program set to data acquisition mode. Select file name and path.

(2) Valve1 was closed, and Valve2 and valve3 are opened. The vacuum pump was turned on for 30sec. for cleaning the circuit and return gas sensors to their baseline and then OFF. The valve V1 and V2 now close and give sensor to reach its steady state for 60s. Record air response using GUI designed for it.

(3) Valve2 and valve3 are closed now then start the air pump and valve1 is opened .The headspace gas was pumped from concentration chamber to measurement chamber for 30 sec.

(4) Valve1 was closed, and the sensors resistance was given 60s to reach a steady state. The 100 data points were recorded with collection interval of 1s. Sensors response was recorded using specially designed software GUI.

(5) After measurement the valve2 and Valve3 was turned on for pushing residue odor out of the

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measurement chamber and aired with fresh air for two minutes, before returning to Step 1 for the next measurement operation.

2.3 Sensors array

The sensor array is composed of eight metal oxide semiconductor (n-MOS) type chemical sensors. Commercially available tin oxide gas sensors made from Figaro Inc. Japan were chosen to form the chemical sensor array. Table 1 specifies the sensors used in the array and their primary target application gases. The MOS sensors conductivity changes due to adsorption of molecules in the gas phase, and on subsequent surface reactions. They consist of a ceramic substrate coated by a metal oxide semiconducting film, and heated by a wire resistor. These sensors show a certain degree of affinity towards a specific gas but are sensitive towards a wide spectrum of gas types with overlapping sensitivities. These sensors housed in a stainless steel sensor chamber.

Table 1: E-nose Array sensors and their application gases

Sensor No.	Sensor Model	Target Gas Sensitivity
1,3	TGS2602	VOCs, ammonia, H2S, etc
2	TGS2600	hydrogen, ethanol, etc.
4	TGS2611	Methane
5	TGS2620	Alcohol, Solvent vapors
6	TGS822	Organic Solvent Vapors
7	TGS813	LPG, Methane
8	TGS832	Chlorofluorocarbon

The measuring circuit of each sensor was also shown in fig.3. A load resistor is connected in series with each sensor and a common power supply of 5 V is used for both the heater voltage and the voltage applied to the voltage divider formed by the sensors and the load resistances. The voltage across the load resistor was used as response of the sensor.

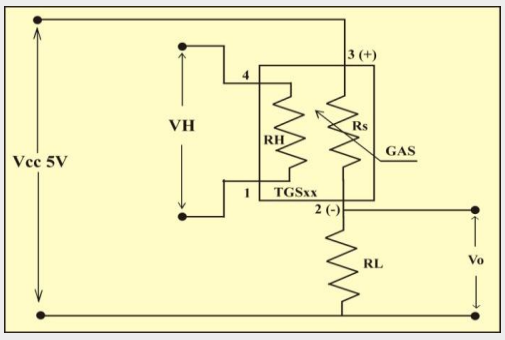


Figure 3: Unit cell circuit diagram of e-nose array

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The relationship between sensor resistance and the concentration of deoxidizing gas can be expressed by the following equation over a certain range of gas concentration:

$$Rs = A[C]^{-}$$

Where:

Rs = electrical resistance of the sensor

A = constant

[C] = gas concentration

□ = slope of Rs curve

2.4 Data acquisition system and its control

A complete library of VIs for data acquisition, signal pre-processing, storage, feature extraction, normalization and pattern recognition, instrument control are contained in the developed e-nose software tool. This software is based on state machine technology and programmed in LabVIEW2012. Particular states are available to user for do specific work. Individual buttons are provided for the particular operation on the main menu VI as shown in Figure 4a. An Exit or Back button on each VI is provided to return to the main menu VI.

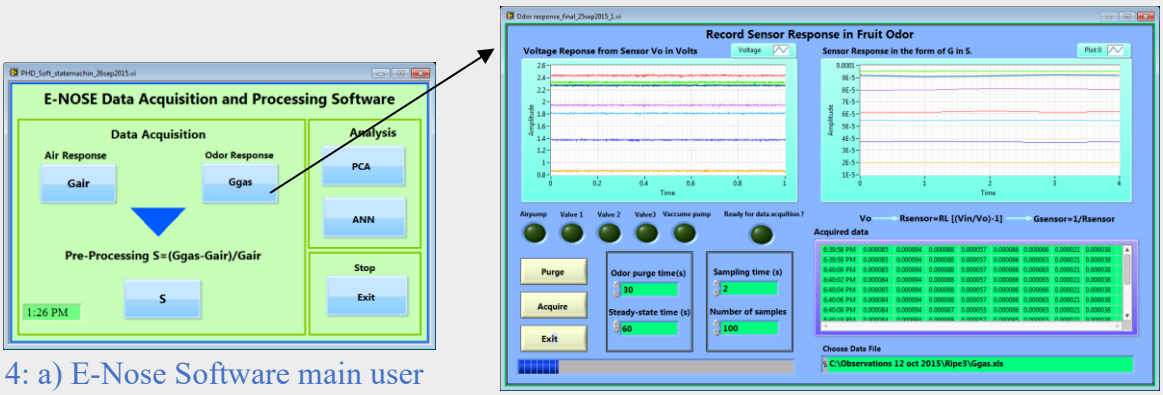


Figure 4: a) E-Nose Software main user interface b) Data acquisition interface for odor

In main user interface, user first record the sensor response in air then record the sensor response in odor gas and finally do the pre-processing on stored data. The pre-processed data will be saving for analysis and pattern recognition purpose. The PCA is available for pattern recognition statistically. The user has choice to enter number of samples and sampling time in seconds. The acquired data displayed on waveform graph as time Vs sensor response as shown in fig. 4b. In calibration the voltage response was converted into change in conductance of sensor (G) using below formulas. (2-5)

$$Vo = \frac{RL}{RL+Rs} * Vcc \qquad \text{.....(2)}$$

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[Vcc=5V constant, RL=10K constant, Vo =Sensor response in V]

$$Rs = RL\left[\frac{Vcc}{Vo} - 1\right] \quad \text{..... (3)}$$

Rs=sensor resistance in Ω

$$G = \frac{1}{Rs} \quad \text{..... (4)}$$

[G=Conductance of sensor in Siemens]

Thus sensor array data was calibrated and converted into sensor conductance. After calibration the eight channel data was collected in the form of matrix array and stored in an excel sheet for further processing. The acquired sensor responses were displayed with color codes as voltage and conductance with respect to time on the front panel of VI as shown in fig.4b. The numerical value of the acquired data at a particular instant was also displayed.

Each sensor produces a steady state response which evolves, as the target odor vapor exposed to the sensor array. There are several interfering inputs which affect the responses of the sensor. Drift problem occurs in the pre-processing and the recognition stage .The standard methods applied for data preprocessing is relative response (S) to a target odor. The separate VI is developed for pre-processing accessible from main user interface.

The relative response (S) to a target gas is defined as the ratio of the change in conductance of a sample upon exposure of the gas to the original conductance in air. The relation for S is given as

$$S = \frac{Ggas - Gair}{Gair} \quad \text{..... (5)}$$

Where:

S=Relative response of sensor,

Ggas=Conductance of sensor in gas environment, (ref.exp.4)

Gair=Conductance of sensor in air environment.

Specificity or selectivity is defined as the ability of a sensor to respond to a certain gas in the presence of different gases.

3. Result and Discussion:

The e-nose data was analyzed using radar plot technique shown in fig.5. The different odor signature for distinct class of ripeness was observed from the analysis. The magnitude of each axis indicates the relative response of individual sensor to the fruit odor. A unique odor-print was obtained for four ripening states of guava fruit as green, ripe, overripe and spoiled. This indicates the use of non-specific selective gas sensor arrays to construct an odor database.

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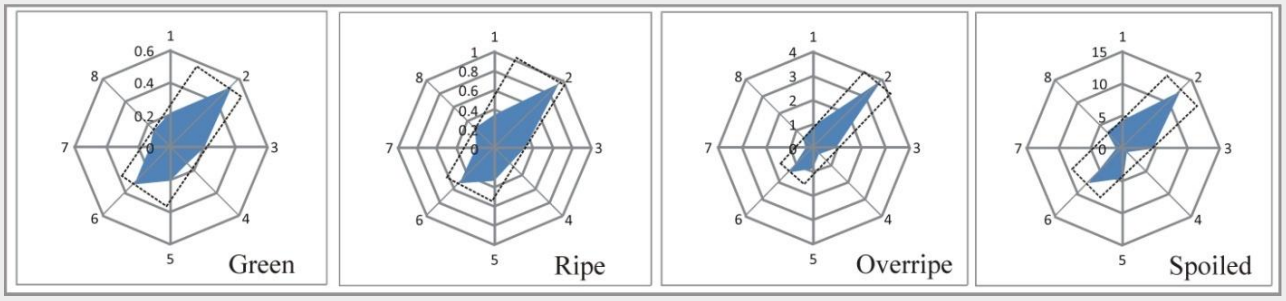


Figure 5: Radar plots explaining the discriminating power of developed e-nose for green, ripe, overripe and spoiled class of guava fruits.

The discrimination ability of e-nose was tested using PCA analysis shown in fig 6. PCA analysis was applied to 400x8 data samples (100x8 data points of each group). PCA is a linear combinatorial method, which reduces the complexity of the dataset. The inherent structure of the dataset is preserved while its resulting variance is maximized. PCA has been performed to describe the aroma changes during the ripening process.

The two principal components $\{PC_{1,n}, PC_{2,n}\}$ was obtained and has the two greatest variances: 80.22% and 17.59% (or total cumulative variance of 97. 81%) of the variance in the input variables, respectively. The scores of the four groups of fruits was plotted for principal component 2 (F2) versus principal component 1 (F1). The discrimination between the four ripening states of guava as green, ripe, overripe and spoiled can be clearly seen from the figure. The processed data show a shift of the different ripening states which coinciding with the classification by trained human graders. The four clusters from left to right indicate the discrimination of fruit classes from green to spoil. A strong pattern separation was found between the different ripening classes of guava. This agrees well with human expert grading results.

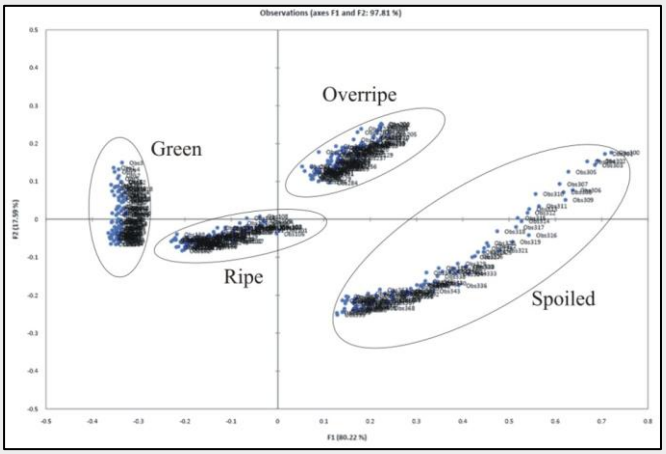


Figure 6 Two dimensional PCA plot for the response of sensor array to four ripening classes of guava fruit

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4. Conclusion

The results demonstrate that the application-specific e-nose system can accurately classify guava fruit cultivars. The odors of guava fruits at different ripening stages were evaluated using the e-nose, and the fruits were sorted into the same four categories as those identified by human experts. This confirms that the system effectively discriminates between various ripening stages. Consequently, the developed e-nose offers a simple, fast, and cost-effective method for guava fruit classification. In our experiments, the sensor array's response to fruit aromas, along with radar plots and PCA-based classification, successfully separated the fruit samples into four distinct clusters with adequate accuracy and resolution. The uniquely designed dynamic headspace sampling technique proved particularly useful, as the prolonged accumulation of fruit vapors yielded stronger signals. Overall, the results confirm that our e-nose system reliably determines the ripening stages of guava fruit.

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Smart Automatic Energy Meter with IoTs Integration for Billing System

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Abstract:

The time and effort needed to obtain data from energy utility meters. Power monitoring, energy consumption data collection, and quick, inexpensive communication are all made possible by the Internet of Things (IoT). The primary goal of this project is to use IoT to measure the electricity use of household appliances and automatically produce bills. A distributed topology that can dynamically absorb various energy sources must be used while building the energy grid. Numerous smart grid applications, such as distributed energy plant meters, smart energy meters for energy generation and consumption, demand-side management for energy, and various energy production domains, can be implemented using IoTs. The quantity of energy used and the consumers' reported usage would be continuously shown on the mobile IoT app. This technology allows consumers and utility companies to monitor electricity consumption remotely. Customers and the utility business can remotely monitor use and double-check revenue, making the system effective.

Keywords: IoT System, Google Firebase database, Smart Energy Meter

Introduction:

This project describes the digitalization of load energy usage readings via the Internet. The potential for human error in the upkeep of electricity is eliminated by the suggested system architecture. By entering the channel ID of the load, the user can utilize a webpage to monitor energy consumption in watts.

To provide a more thorough explanation and visual representation of the energy usage statistics, the website uses Google Firebase analytics to analyze energy usage. The Internet of Things is enabled by the Wi-Fi unit by transmitting energy data from the load to a webpage that can be seen using the device's channel ID. Consumers can manage their energy consumption in the proposed system by tracking their energy usage over time. An ESP32 microcontroller is used in this system.

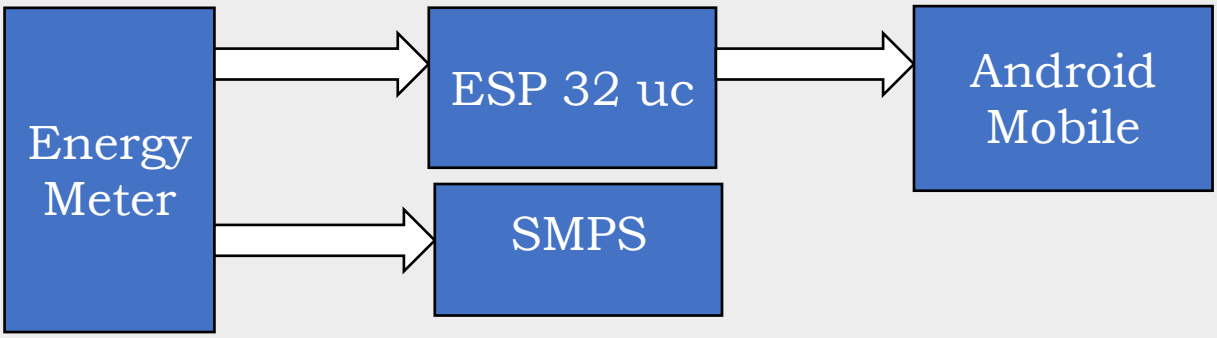
Through the Wi-Fi module, the generated unit can be displayed on the webpage.

Objectives:

1. Using Wroom ESP32, send the measured motor pulse values to the IoT cloud.
2. Measure and monitor power usage from anywhere
3. Using JavaScript, the web page analyses energy usage using Google Firebase analysis. Block Diagram:

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Block Diagram:



Working:

In the proposed work, I have designed an energy meter with an ESP32 microcontroller with gets electric pulses with the help of energy that is interfaced with the IoT cloud. In the proposed model, Firebase cloud is utilized to supply secured communication between the power boards to the meter.

It reduces human interference in collecting the monthly reading, and it also saves time and money. To drive the ESP32 uc and the current sensor, a controlled supply. The ESP32 module is utilized as a central controlling and checking framework for all gadgets. Hand-off will come into the picture when the charge isn't paid to cut off the control supply.

In the proposed model, Firebase cloud is utilized to supply a secured communication between the power board to the meter, and the same is utilized to alert the shopper when the charging time is come; moreover to send charge subtle elements Hub MCU is interfaced with the current sensor to detect control use. By the end of the month, the customer can access the dedicated app on their smartphones to obtain information on energy consumption, related loads, and the corresponding billed amount. At that point, one can specifically pay our charge through that app.

In case the charge was not paid at that point the meter will naturally get turned off. To turn off the meter a few limits esteem can be set for that. Consequently, we can effectively control data. Through this Project To sum up, we receive a bill from the power board via the system's display device after putting the Intelligent Power Metre system into place.

With this method, a wireless module allows communication between the power board and the metre. When there is a power outage, a meter complaint, or any other defects with the system, it reports to the electrical board via the wireless module. In the same way, the electricity board has a server system. It comes with both a receiver and a transmitter is in constant communication with each customer's power metre.

Conclusion:

In this project an Android application for the IoT using a Java script programme and a Google Firebase interface as part of this suggested system. Using the ESP32, we're developing a metre reading programme in Google Firebase. These programmes interface with Internet of Things (IoT) programmes. Any pulse that

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consumes metres can be computed and shown on a phone application running on Android

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Mathematics plays a crucial role in enabling and optimising IoT applications in wineries

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Abstract:

In Industry 4.0 generation, Industrial Internet of Things (Industrial IoT) is revolutionizing various industries, and wine industry is no exception. Mathematical and statistical analysis for **Data Acquisition, Sensor Calibration, series Analysis,** Process Optimization and Control, modelling. Sensor data, temperature, humidity, alcohol, Brisk levels, etc.is inherently noisy. Statistical methods like mean, median, outlier detection and, standard deviation are used to clean and pre-process the data. Sensors calibration is needed to provide accurate readings. Mathematical models linear, exponential, etc. are used to create calibration curves that map raw sensor readings to actual values. Data collected over time, temperature, brisk,humidity, alcohol changes in fermentation tanks is analysed using time series techniques. Mathematical models e.g. differential equations etc. are used to simulate and understand the complex biochemical reactions during fermentation to optimize and Control temperature, yeast addition, and oxygen levels for optimal results. Real time data of winery, collected by sensors is sent to the cloud for advanced data analysis and publish as an open source. The Mathematical analysis and statistical representation are done with the help of MATLAB software present on cloud. The application of these mathematical tools is transforming the winemaking process, improve the wine quality and consistency, control, and ultimately, the production of superior wines. It reduces the production cost, increase the efficiency, improve safety and security of winery.

Keywords: Winery, IoT, Mathematics and statistics, MATLAB.

1.Trditional process of wine making

Traditional winery produces wine using time-honoured methods and techniques, reflecting the cultural heritage and practices of the region where it is located. These wineries are located in regions with a favourable climate for grape growing, typically known as wine regions, in Maharashtra most are located in Nashik region. Wineries cultivate specific grape varieties that are native or historically significant to the region. For example, Chardonnay, cabernet sauvignon Syrah, pinot in Nashik. Grapes are typically hand-harvested to ensure quality. The time of the grape harvest is crucial, as it impacts the sugar, acidity, and overall flavour and colour of the wine.After harvesting, depending on the type of wine whether it is red or white, grapes are crushed and pressed to separate the juice from the skins. The grape juice known as "grape must" is allowed to ferment using wild yeasts naturally present on the grape skins or the cultured yeast externally added in the winery environment to convert sugar into alcohol. The yeasts begin to metabolize the sugars in the must, producing alcohol and carbon dioxide. Fermentation is often carried out at ambient temperatures, which can lead to varying fermentation rates and it also varies complexity in Flavors. Although fermentation can be less predictable than using cultured yeasts, winemakers closely monitor the process for signs of fermentation activity, such as bubbling and temperature changes. Wines are often aged in oak barrels; the aging period can vary greatly depending on the wine type.

2. Overview of IoT and IIoT

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2.1 Internet of Things

The Internet of Things (IoT) refers to the network of physical objects, devices, "things" that are embedded with sensors, software, and connectivity capabilities to collect and exchange data over the long distance by using the internet. IoT enables these objects to communicate with each other and with centralized systems, leading to enhanced data collection, analysis, automation, and improved user experiences. The "things" in IoT, which can range from simple sensors to complex devices. Examples include smart thermostats, wearable health monitors, industrial machinery, connected home appliances etc. Devices use various communication protocols to connect to the internet or to each other. Common technologies include Wi-Fi, Bluetooth, Zigbee, cellular networks (like 4G and 5G), and LPWAN (Low-Power Wide-Area Network) technologies. Data collected from IoT devices needs to be processed. This can occur locally (edge computing) on the device itself or sent to centralized cloud systems for analysis. End-users interact with IoT systems through applications or dashboards that display collected data and provide control over devices. This can include mobile apps, web interfaces, and voice-activated systems.

2.2 Industrial Internet of Things

IIoT refers to the extension and use of the Internet of Things (IoT) in industrial sectors and applications. IIoT involves the integration of sensors, machines, devices, and data analytics in manufacturing and industrial environments to improve efficiency, productivity, and safety. IIoT is a transformative approach that leverages digital technology to enhance industrial processes, leading to smarter manufacturing and operational efficiency. The massive amounts of data generated by these connected devices can be analysed to gain insights, optimize operations, and predict maintenance needs (Predictive Maintenance). IIoT enables greater automation of industrial processes, which can lead to reduced costs and increased efficiency. Operators can monitor processes remotely, allowing for quicker responses to issues.

3.Role of Mathematics and statistics in the Internet of Things (IoT)

Enabling data analysis, optimization, modelling, and the design of algorithms that drive IoT applications is possible due to the mathematics and statistics. **Linear Algebra** is essential for handling multidimensional data, transforming data sets which can represent sensor readings and other IoT data. **Graph Theory** helps in understanding and analysing relationships between devices in a network, optimizing the topology of sensor networks, and routing data effectively. **Optimization**, involves minimizing costs, such as energy consumption in networked devices, or maximizing efficiency in data transmission and storage. **Descriptive Statistics**, summarizes and describes the features of a dataset, including measures of central tendency (mean, median) and measures of dispersion (variance, standard deviation), which help in understanding sensor data. Concepts like Bayesian probability are used in decision-making processes in IoT systems. **Time Series Analysis**, critical for analysing temporal data collected by IoT devices over time, enabling predictive analytics, anomaly detection, and trend analysis. **Machine Learning and Data Mining**, involves algorithms and models to identify patterns and make predictions based on data collected from IoT devices.

3.1 Useful Mathematical and statistical Tools and Technologies in IoT

Python, R, and MATLAB are popular for statistical analysis and machine learning in IoT applications. Tools like Tableau, Power BI, or libraries like Matplotlib and Seaborn (in Python) to visualize IoT data. SQL and

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NoSQL databases for storing large volumes of time-series data generated by IoT devices. Apache Hadoop, Spark for processing and analyzing large datasets.

4.MATLAB and IoT integration

MATLAB, short for "MATrix LABoratory," is a high-level programming language and interactive environment used primarily for numerical computation, data analysis, algorithm development, and visualization. Developed by MathWorks, MATLAB is widely utilized in engineering, scientific research, and mathematics due to its powerful computational capabilities and extensive built-in functions. It has numerous specialized toolboxes that extend its functionality for various applications. MATLAB provides strong graphical capabilities to create 2D and 3D plots, which help in analysing data and presenting results. It features an interactive environment that allows users to execute commands and see results immediately, which is useful for prototyping and exploratory analysis. It can interface with other programming languages like C, C++, Java, and Python, and it can communicate with hardware and devices for real-time data acquisition and control. MATLAB is a powerful programming environment that can be utilized for various Internet of Things (IoT) applications. It provides a range of tools for connecting and analysing data from IoT devices. We can interface with sensors, gateways, and cloud services. We can work with the components: **Data Acquisition, Signal Processing, Machine Learning,Visualizations.**

5. IoT based wine fermentation monitoring system

Here's a brief outline of a IoT based wine fermentation monitoring system

a. **Components**: ESP 32 with a temperature and humidity sensor (DHT 11), alcohol sensor MQ3
b. **Data Collection**: Collect temperature, humidity and alcohol data periodically.
c. **Data Processing**: Analyse or process the data for trends.
d. **Visualization**: Create a graphical representation of temperature, humidity and alcohol over time.
e. **Reporting**: Send alerts if temperature, humidity and alcohol exceeds a certain threshold.

5.1 Data Acquisition

IoT sensors (temperature, humidity, alcohol, etc.) are used to monitor the wine fermentation. These sensors are deployed to collect real-time data. Controller connected to these sensors used to retrieve data, primary edge computing and processing of data is done by the C program written in the controller chip. Further it is communicated to with IoT devices through gateways using protocols like MQTT or HTTP.

5.2. Data Analysis and Visualization

Think speak cloud developed by Math Works in which MATLAB is integrated as mathematical tool is used for conducting exploratory data analysis to identify trends or anomalies in the collected data. MATLAB's plotting functions are used for the visual representation of the data. This help in understanding the conditions in the fermentation over time, such as temperature, humidity and alcohol variations.

5.3 Automation and Control

This mathematically processed data is served to the app developed by IFTTT to provide alerts and significant

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controls. Winery uses these alerts for automation (temperature or humidity controllers), MATLAB help to design algorithms that initiate actions based on sensor data (e.g., turning on cooler when temperature rises above a certain threshold).

5.4 Wine Quality Control

Wine colour and wine test are the most sensitive parameters in wine production. Gather data from fermentation tanks using sensors and analyze it using MATLAB to ensure consistency and quality in wine production.

5.5 Reporting and Decision Support

Generate automated reports on fermentation conditions, equipment status, and predicted outcomes for decision-makers in the winery using MATLAB's reporting capabilities is possible. Decision support tools that assist winery managers in making informed decisions based on data analytics is done with the help of Mathematical and statistical analysis.

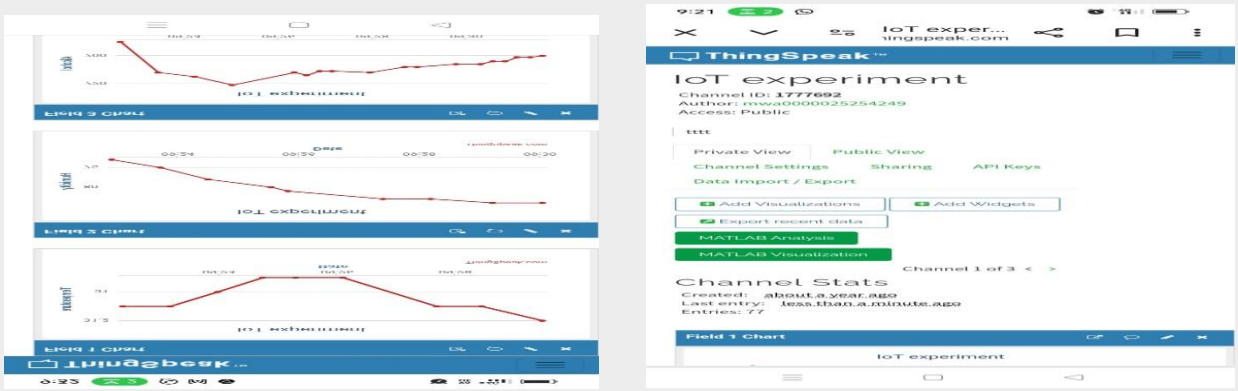


Figure: 5.1 Visual representation of data generated at wine fermentation by using thingspeak cloud with the help of MATLAB.

6. Conclusion

Using MATLAB's Mathematical and Statistical Tool we can predict outcomes based on historical data. Predicting the time for fermentation or identifying potential risks such as wine colour or aroma is essential in winemaking. IoT is revolutionizing the industrial automation and to achieve this mathematics and statistical analysis plays vital role.

7. Future Scope

a. Integration of AI can enhance data analysis, enabling smarter decision-making based on IoT data.
b. The rollout of 5G networks promises faster and more reliable connectivity, which can support a higher number of connected devices with lower latency.
c. Processing data closer to where it is generated can reduce latency, improve response times, and reduce bandwidth usage.

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AI-Driven Home Security: The Future of Intelligent Safety in India

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Abstract:
By offering cutting-edge safety solutions and real-time monitoring, artificial intelligence (AI) and the trends, obstacles, and potential future developments in India related to AI-driven home security. It examines Internet of Things (IoT) are revolutionizing home security in India. This study examines industry current acceptance rates, industry growth, and security concerns using data from secondary research, emphasizing how AI might improve the effectiveness and efficiency of home security.

Keywords:
AI driven security, smart home technology , IoT, biometric authentication , cybersecurity , home automation.

Introduction:
The smart home market in India is growing quickly by 2025; it is expected to generate almost USD 7.3 billion in sales (Statista, 2025). The growing use of AI-driven security solutions, which provide automated threat detection, real-time monitoring, and facial recognition, is a major driver of this expansion and strengthens and improves conventional security procedures. The advantages of automated home security systems that utilize AI are effective security management, minimized threat response time, and improve ease of use for the homeowner. However issues like data privacy, cyber attacks and the absence of a suitable legal framework pose obstacles for the effective use and application of these technologies. This study analyzes the current level of AI home security, impact , and future potential.

1] AI-Driven Home Security Technologies

1.1. Smart Surveillance Cameras:
These rely on motion detection and facial recognition to avoid false alarms, determining the difference between known entities and potential adversaries. These cameras can differentiate between family members, visitors and intruders reduce false alarms and enhance the security. Companies like CP plus and Godrej are offering AI – integrated security solution for Indian consumers.

1.2. Digital & Biometric Locks:
Smart lock method like fingerprint scanning, facial recognition, voice recognition are gaining the popularity between the users. this increase the security by allowing access to only authorized person. Also mobile app controlled locks allow homeowners to control & monitor through remotely. AI-driven locks effectively restrict access to vetted parties.

1.3. Intruder Alarm Mechanism:
Smart AI-powered motion sensors, door and window sensors generate early real-time alarms when abnormal behavior is detected.

1.4. Smart Security Response:
AI can automatically alert homeowners or law enforcement agencies when it detect some security breaches.

2] Trends of Adoption and Growth in India:
Revenues from India's electronic security market are expected to grow from US$ 3.16 billion in 2025 to US$ 9.11 billion by 2030. Key growth drivers are:

2.1. Urbanization and Smart Cities:
Growing urban populations are driving the need for newer, more sophisticated security solutions.

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Government initiatives like Smart Cities Mission are increasing the adoption of AI driven security solution in urban areas

2.2. Consumer Awareness on the Rise:

Households are investing more on AI-based security technologies for better security.

2.3. E-commerce growth:

Amazon and Flipkart online marketplaces developing AI based security solution which is more accessible to Indian households.

As per the report of NielsenIQ report , nearly 30% of Indian homeowners are planning to adopt AI power security cameras and smart locks in next five years.

3] Challenges & Concerns

3.1. Privacy & Data Security:

Privacy & Data security is the regulatory structure around data safety in India is still emerging a lot of concern is associated with data on personal security.

3.2. Cybersecurity Risks:

AI powered smart home devices could be prone to attacks if not secured appropriately.

3.3. Compatibility problems:

Due to lack of standardization in IoT security devices causes to integration challenges between various brands and platforms .

4] Enhancing AI-Driven Home Security

4.1. Stronger Security Features for Encryption:

We may have to implement much stronger encryption and AI based threat detection.

4.2. Legal & Regulatory Development:

IoT Security and Data Security as a form of revenue for user protection

4.3. Consumer Education:

Homeowners need to be educated on the best security practice to employ to prevent security breaches.

AI Future in Home Security

AI-Powered Home Security Market in India is projected to reach USD 7.36 billion by 2029. Delivering preventative and predictive residence defense will be enabled with developments in Machine Learning and Edge Computing.

Research Methodology:

To achieve this, the study adopts the the data used in this research is secondary data obtained by several credible sources like reports from Statista(2025) and Mordor intelligence (2025) . NielsenIQ(2023) study AI driven home security adoption trends. Nabto(2023) and Electronic Era (2023) study about security regulations and AI driven CCTV market growth .

Conclusion:

Artificial intelligence is entirely revolutionising home security systems in India with real-time protection & intelligent surveillance. Well, as this industry affected data privacy and cyber attacks, so the evolution of these technologies and tighter laws would eliminate such issues. AI are about to enter every house in India, thereby enhancing the whole ecosystem making it more intelligent and secure.

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Adsorption Of Congo Red Dye By Activated Material Prepaired From Agro Waste *of CAESALPINIA PULCHERRIMA SEED PODS*

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Abstract

Caesalpinia pulcherrima seed pods has been searched as a low-cost adsorbent for the removal of Congo red (CR) from wastewaters. Activated carbon was prepared using Sulphuric acid (ACSCP). Surface morphological and physico-chemical properties of *Caesalpinia pulcherrima* seed pods were analyzed using scanning electron microscopy (SEM), elemental analysis (EDS) and X Ray Diffraction (XRD). Adsorption studies were carried out using batch method to study various parameters such as, pH (2–10), temperature (15–45°C), initial concentration (15-30 mg/L) effect of contact time (0 to 120min), adsorbent dosage (25–100mg/25ml). Adsorption equilibrium was attained at pH 6 within 10 mins, concentration 20 ppm and biomass dose 50 mg at 25°C temperatures with efficiency of up to 90%. From all these results it is confirmed that ACSCP is an eco-friendly and affordable biomaterial for CR removal from industrial effluents.

Key Words: Adsorption, *Caesalpinia pulcherrima*, Congo red, Langmuir, Freundlich, Temkin.

1. INTRODUCTION

Synthetic dyes play an important role in textile industries for colorings of fabric. Different shades of colors are due to presence of chemical groups such as xanthene, nitroso (NO), thiocarbonyl (CS), quinoid, carbonyl (CO) and auxochrome groups [1, 2]. This dyeing process discharges colored wastewater that contaminates water resources [3]. Various diseases caused due to contaminated water constitute a major health hazardous in developing countries [4]. Textile industries effluents are characterized by variations in most of the parameters such as colour, COD, BOD, pH, turbidity, salinity and odor [5]. Azo dyes like Congo red, Direct Red 2 and Direct Blue15 are responsible for their health hazards because of their carcinogenicity, toxicity and mutagenicity [6,7]. It also damages aquatic biota affecting aquatic flora and fauna [8,9]. Congo red dye are utilized extensively in textile industries due to strong attraction of dye towards cellulose fibers.

Textile dye effluent treatment is important, currently various techniques are available such as adsorption [10], biological [11], membrane filtration [12], photo degradation [13], ion exchange [14], biodegradation [15], catalytic ozonation [16] and electrochemical oxidation [17]. But adsorption is one of the most promising techniques due to its efficacy, non-toxicity, easy operation, mild reaction condition and

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simplicity [18].

Activated carbon is mostly utilized in the form of adsorbents because of its high capacity and efficiency to absorb contaminants [19]. But due to its initial cost and difficulty in regeneration made it difficult as an adsorbent. For these reasons, research have been carried out to find affordable and eco-friendly substitute adsorbent materials. Different low-cost adsorbent like waste furnace slag [20-26], Chitin, activated sludge, , Fe3O4 nanoparticles coupled with flower-like MoSe2 nanosheets copper-doped zinc sulfide nanoparticles , activated macadamia nutshell , macadamia seed husks , cerium zirconium oxide nanocomposites and natural clays [28] have been investigated.

2. MATERIALS AND METHODS

Caesalpinia pulcherrima is flowering plant belongs to the pea family Fabaceae. This plant has widespread cultivation. Common names for this species are red bird of paradise, Mexican bird of paradise, poinciana, pride of Barbados, peacock flower, dwarf poinciana, flos pavonis, and flamboyant-de-jardin. It is a shrub and grows to 3 m tall.

Several parts of this species, such as the bark, leaves, fruits, and seeds, have medicinal value but seed pods are totally waste material and it can be used as adsorbent. Seed pods shown in Fig.1 are found all over the Maharashtra and collected from Manchar.



Fig.1: Seed pods of *Caesalpinia Caesalpinia Pulcherrima*

Adsorbate:

Congo red (CR) (Direct Red 28, C.I. 22120, azo dye, $C_{32}H_{22}N_6Na_2O_6S_2$, molecular weight 696.7) was selected as anionic dye. The pH of dye solution of desired concentration was adjusted with 0.1M NaOH or 0.1M HCl solutions. All chemicals were of analytical grade. The dye solutions (15–30 mgL^{-1}) were prepared by diluting a stock CR solution (100 mgL^{-1}) with distilled water.

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3. EXPERIMENTAL

The batch adsorption experiments were performed in a set of 250 ml of Erlenmeyer flask containing adsorbent ACSCP and 100 ml of CR solution with various initial concentrations. These solutions were agitated at 100 rpm and 27^0C until the equilibrium is attained. After filtration, the remaining dye concentrations of the solution were measured at 498 nm using UV-visible spectrophotometer. The amount of CR dye adsorbed, and percentage removal of CR were calculated using Equations. (1) and (2), respectively

$$qe = (Co\text{-}Ce)\frac{v}{m} \quad (1)$$

$$\% \text{ Removal} = \frac{Ci - Ce}{Ci} \quad (2)$$

3.1. Biosorbent:

The seed pods of *Caesalpinia Pulcherrima* were collected from the locally available garden, dried and washed several times with distilled water to remove impurities from its surface then it was milled and sieved through a mesh 300-micron particle size. The obtained biomass was soaked in sulphuric acid for 6 hours. Then washed with distilled water several time to remove acid, dried at 100^0C for 3 hrs. Sulphonated material was burned in muffle furnace at 500°C in inert nitrogen atmosphere for 1 hour. The resulting activated carbon of *Caesalpinia pulcherrima* (ACSCP) was preserved in dry containers and used as an adsorbent. Beer-Lambert law was used for determination of CR concentration. The CR Absorbance measured at 660 nm on double beam UV-Visible spectrophotometer.



Fig.2: Activated carbon prepared from Sulphated Biomass of Caesalpinia Pulcherrima (ACSCP)

3.2. Batch Biosorption:

Adsorption experiment was carried out using batch method in 250 mL conical flasks and 25 mL of CR dye

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solution of desired initial concentration (15 mg L^{-1}). A weighed amount (25-100mg) of biosorbent was added to the solution. The flasks were stirred with a magnetic stirrer by maintaining contact time. The effect of pH was studied from 2-10. Initial dye concentration varied from 15-30 mg $L^{-1,}$ with biosorbent dose 25mg-100mg and temperature 288-318K were evaluated during current study. Samples were collected at regular time intervals and the dye concentration in the solution was studied at maximum wavelength of 498 nm using UV-Visible Spectrophotometer.

4. CHARACTERIZATION

XRD of ACSCP used to provide the basic structural information. SEM/EDS systems are used in image forming for morphological analysis and surface characterization as well as X-rays that are utilized for identification and quantification of chemicals present at detectable concentrations. EDS can search for major and minor elements with concentration.

4.1 SEM of ACSCP:

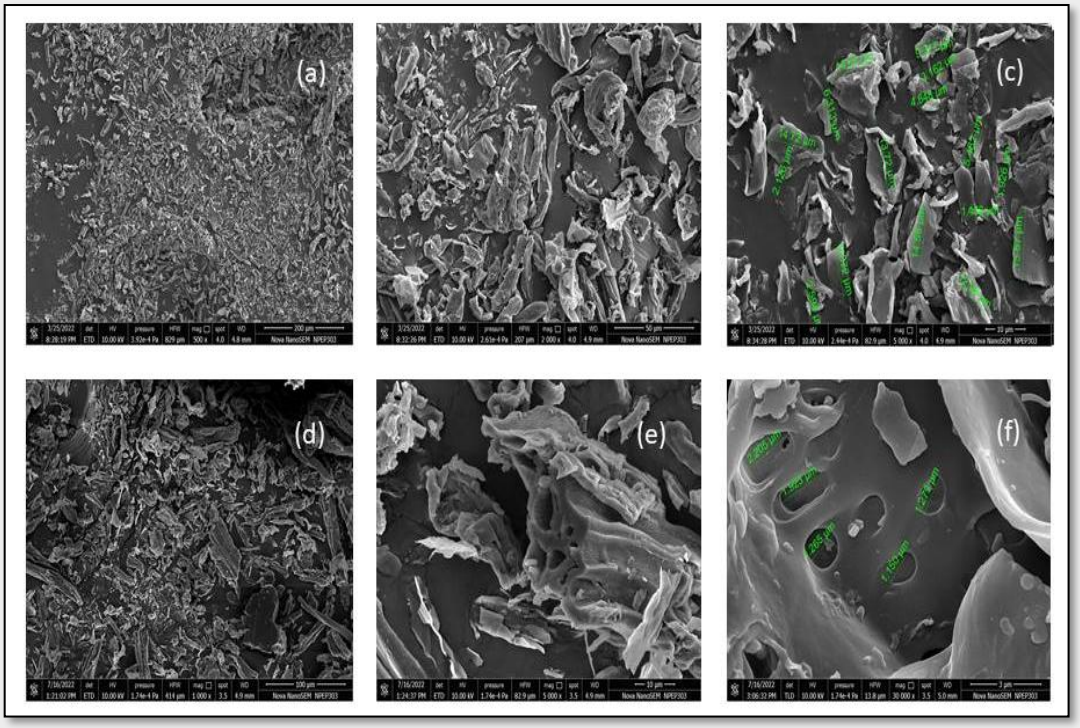


Fig. 3: SEM images of ACPTS (a) before and (b) after CR adsorption

4.2 XRD of ACSCP:

XRD analysis is useful for determining the chemical composition and crystallographic structure of the adsorbent. We used a Siemens D 5000 powder X-ray diffractometer for this study by generating 1.5406 Å wavelength with a Cu Kα source. The diffraction angle was changed from 20° to 80°. Fig. 4 shows X-ray

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diffraction forms of ACSCP (a) after adsorption of CR (b) before adsorption of CR. Fig. 4a shows presence of a characteristic main broad peak at 2θ = 25.34° was searched as carbon diffraction and an amorphous state of the biosorbent. Another typical diffraction related to graphite was detected at 2θ = 44.28° proves that ACSCP was amorphous carbon with graphite crystal.

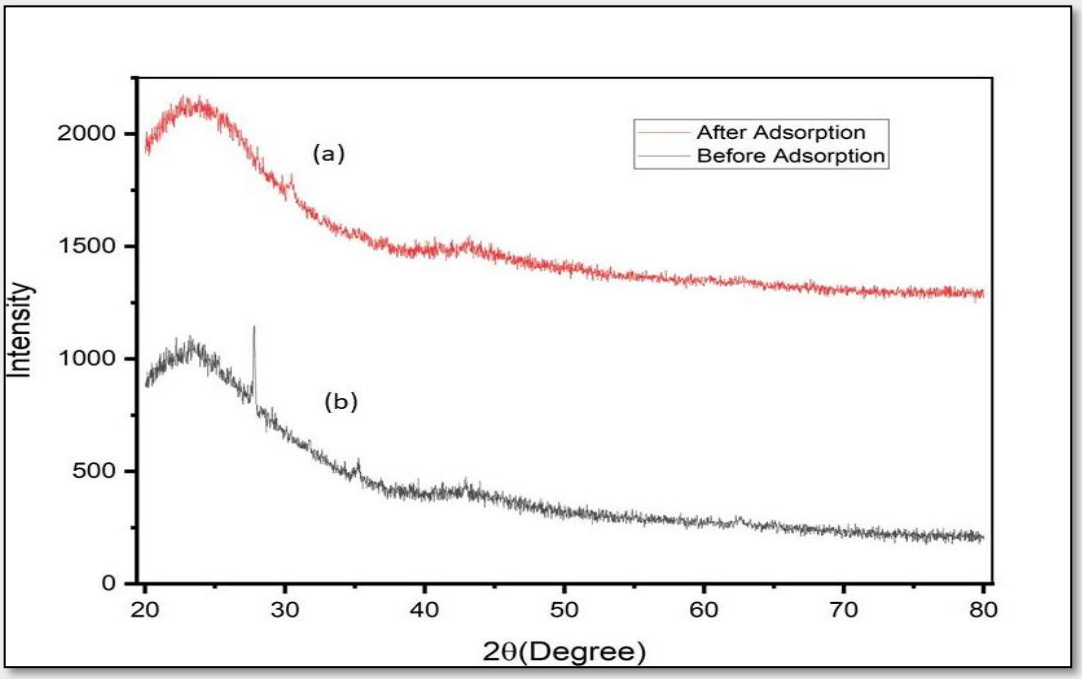
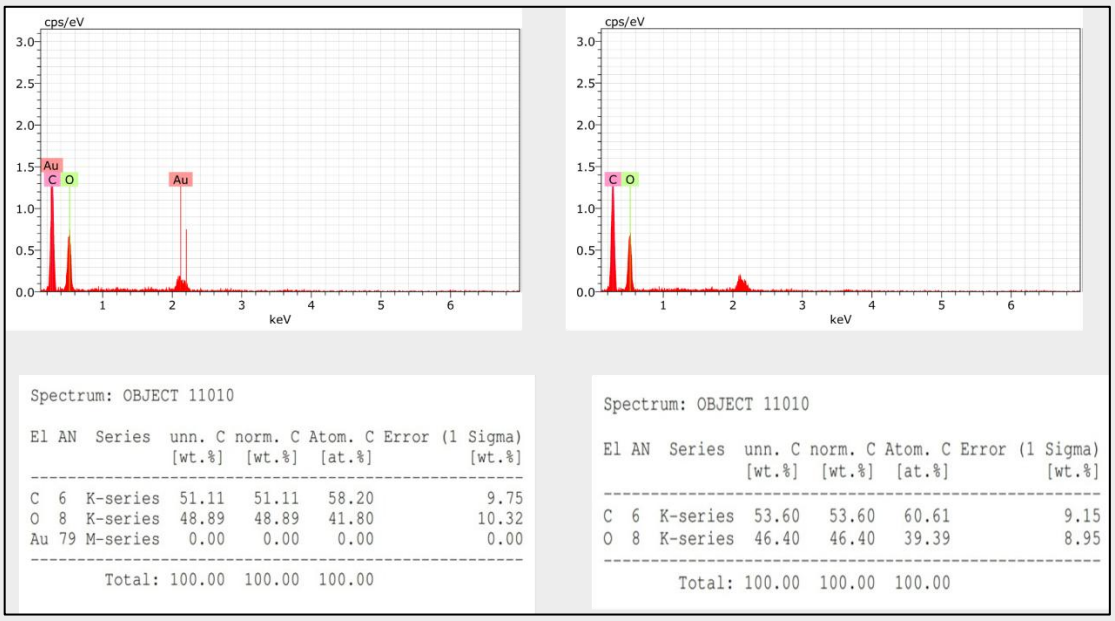


Fig.4: X-ray diffraction forms of (a) before (b) after adsorption of CR on ACSCP.

4.3 EDS of ACSCP:



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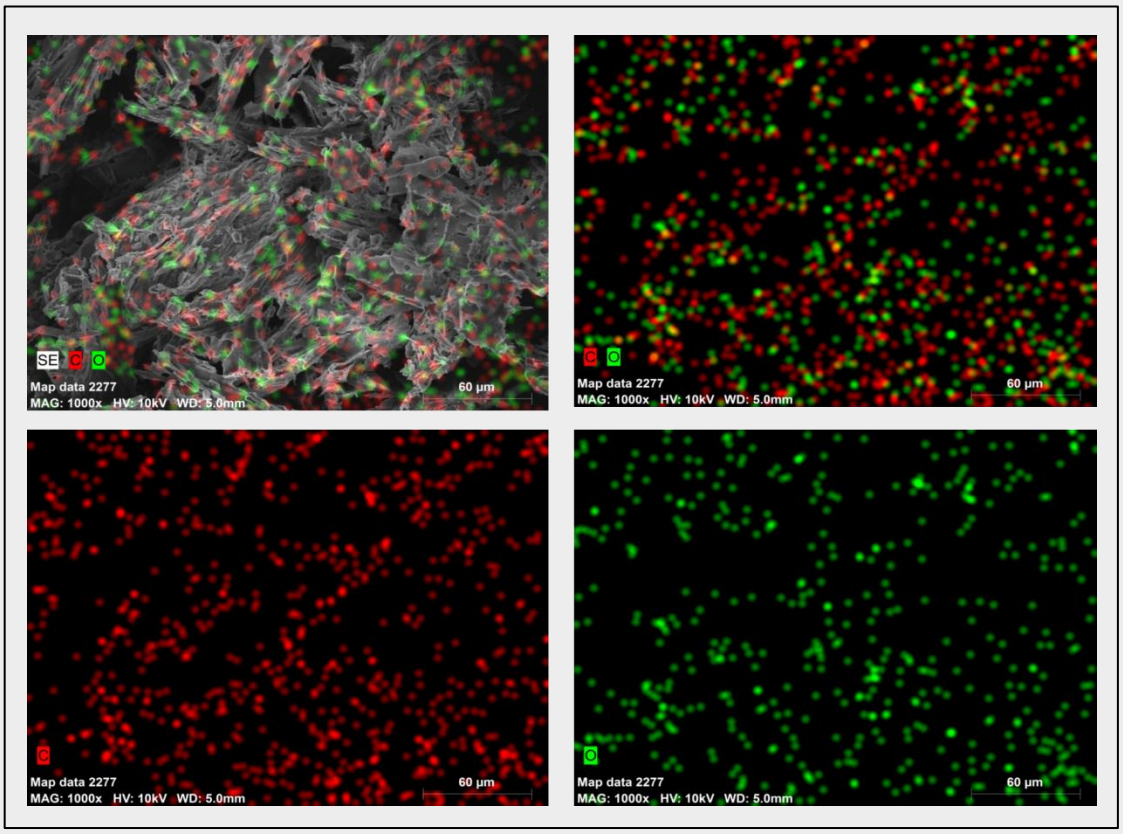


Fig. 5: EDS images of ACSCP after CR adsorption.

5. RESULTS AND DISCUSSION

To design a user-friendly and effective adsorption model it was necessary to carry out adsorption by varying different parameters such as pH, temperature, effects of contact time and initial CR concentration on the uptake rate of the CR dye were monitored very carefully.

5.1 Effect of Material Dose and Contact Time:

The effect of adsorbent dose on adsorption of CR by ACSCP was studied. Adsorbent dose was varied from 25 to 100 mg in 25 mL CR dye solution, while all the other variable parameters such as pH, temperature, concentration and contact time, were kept constant. Data obtained from the experiments are presented in Fig.6. With increase in adsorbent dose from 25mg to100 mg, the CR dye removal efficiency increases from 87 to 95.9 %, which may be due to an increase in the number of binding sites available for adsorption. The effect of contact time on the removal of CR is shown in Fig. 7 and about 92.29% dye removal takes place in 10 min by ACSCP. The equilibrium was attained after 5 minutes (Fig.2).

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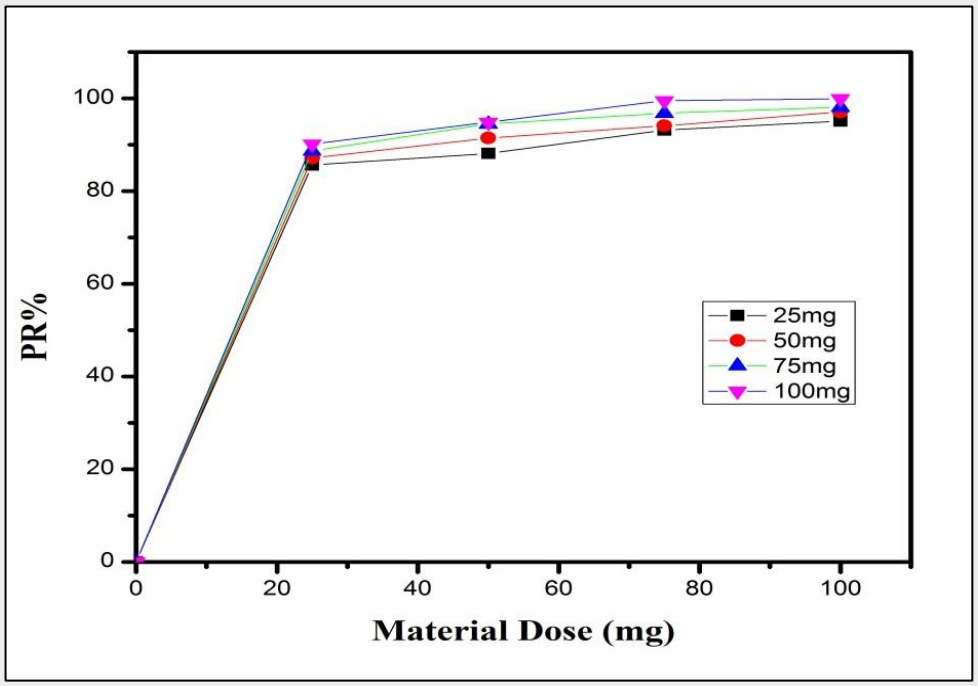


Fig.6: Effect of Biomass dose.

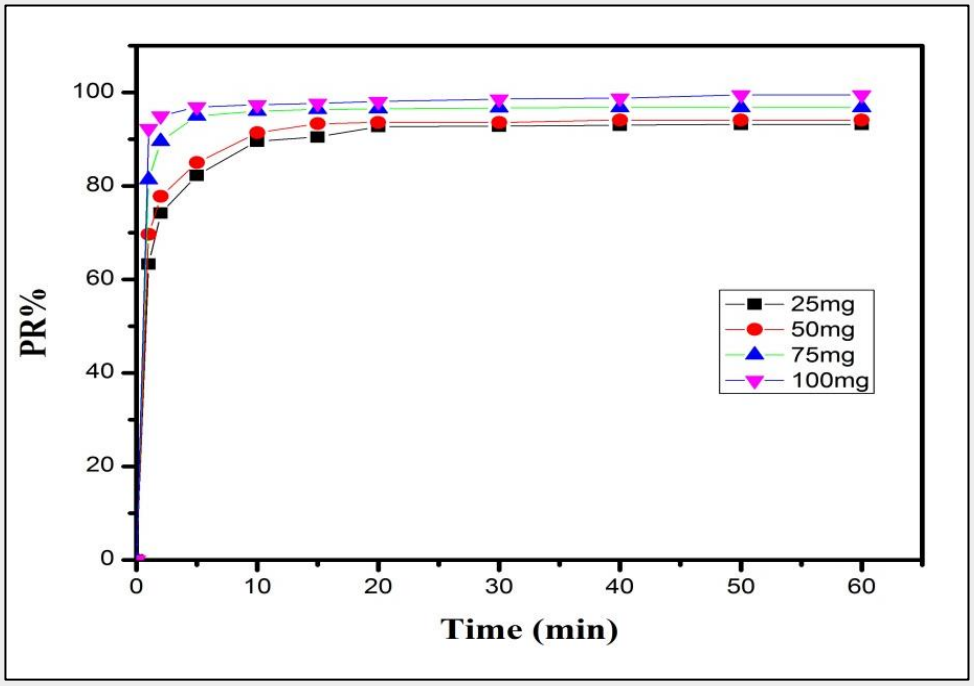


Fig.7: Effect of Contact Time on CR Removal

5.2 Effect of pH:

Solution pH is important monitoring parameter to study adsorption behavior of adsorbate onto biosorbent. In this research work the effect of pH was studied over a pH range of 2–10. Results are shown in Fig. 8. The amount of CR dye removal decreases with decreasing pH, Maximum removal is observed at pH 2.0. With further increase in pH, there is no significant increase in the amount of dye removed.

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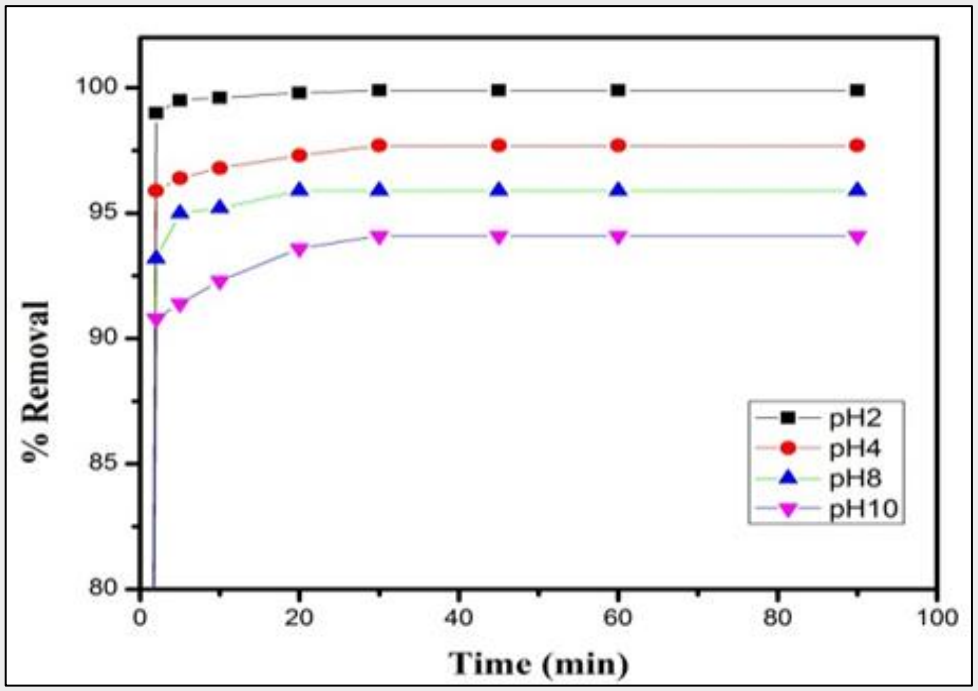


Fig.8: Effect of pH on CR Removal.

5.3 Effect of Initial Dye Concentration:

Biosorption of CR onto ACSCP was also studied at different initial dye concentrations 15, 20, 25, and 30 mg L^{-1} and the results are shown in Fig.9. It was shown in the figure that the amount of adsorption increases with increasing concentration. Initial dye concentration gives an important driving force to overcome all mass transfer resistances of all molecules between the solid and aqueous phases. Therefore a greater initial dye concentration of dye will increase the adsorption process.

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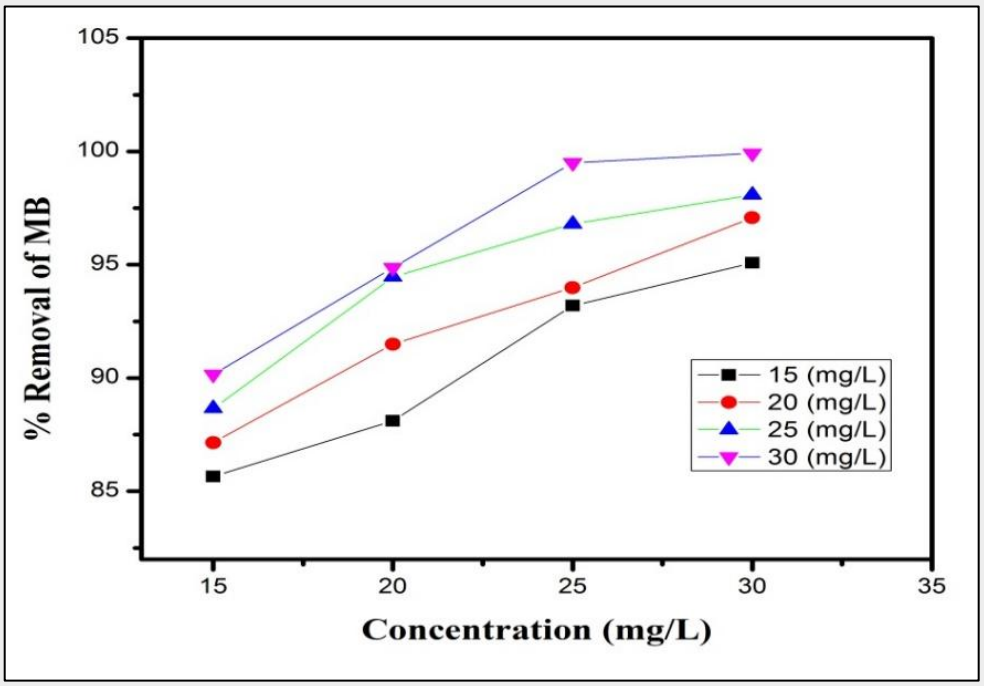


Fig.9: Effect of Concentration on CR Removal

5.4 Effect of Temperature:

Temperature plays important role in removal of dyes from aqueous solutions and it was studied in the range of 288 to 318 K, the results are explained in Fig. 10. The figure proves that the CR dye adsorption capacity decreases with increasing temperature which confirmes exothermic nature. It may be due to the weakening of bonds between the active site of the biosorbent and dye molecules. Also, the solubility of CR increases with increasing temperature. Therefore, the interaction between the solvent and solute is stronger than those between the solute and the biosorbent. This results in lower adsorption.

6. CONCLUSIONS

In this research work of ACSCP shows promising adsorption capacity for Congo red removal. The maximum sorption for CR solution concentration was 30 mg/l/25ml, adsorbent dosage 100 mg/25 ml, contact time 10 min and temperature 288 K were observed. The maximum removal of Congo red dye was attained at pH 2.0. From all these results it is confirmed that ACSCP is an eco-friendly and affordable biomaterial for CR removal from industrial effluents.

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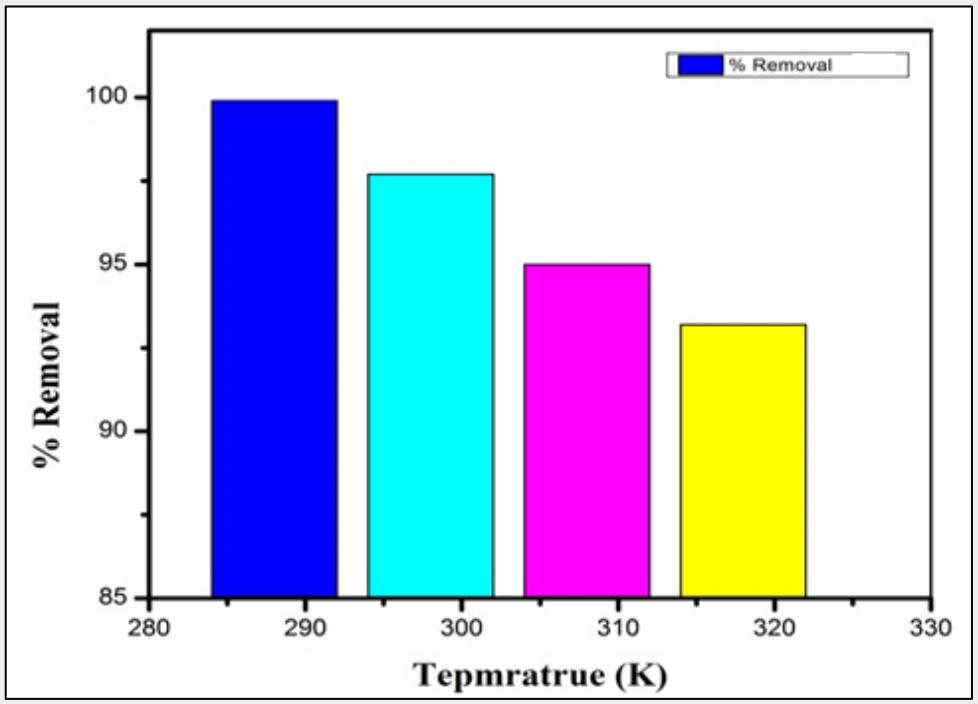


Fig.10: Effect of Temperature on CR Removal

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8. CONFLICT OF INTEREST:

The authors would like to declare that no funding was received to assist with the preparation of this manuscript.

9. ETHICAL APPROVAL:

The research does not involve the participation of humans or animals.

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Design and Development of Smart Water Level Monitor and Control System

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Abstract:

The water is a vital resource on the Earth, and effective management of water levels is crucial for various applications *viz.,* agriculture, industrial processes, and municipal water supply. The traditional methods of monitoring and controlling water levels can be inefficient and prone to human error. Hence the concept of the smart water level monitor and control system becomes the prime solution for that. The aim of the present work is to develop an automated solution that efficiently regulates and monitors water levels in reservoirs or tanks. By utilizing sensor technology and real-time data analysis, the system seeks to enhance water resource management, prevent overflow, and ensure optimal water supply for various applications. The proposed system will also help to provide an efficient solution for managing water resources in various applications. Utilizing advanced sensor technology, the system continuously monitors water levels and automatically regulates inflow and outflow to prevent overflow and ensure optimal usage. It is also a user-friendly interface displays real-time data, enabling effective tracking and management. Additionally, an alert system notifies users of critical changes, promoting timely responses. From the overall work it is concluded that the proposed system not only enhances water conservation efforts but also contributes to improved operational efficiency in water management.

1. Introduction:

The water is a vigorous resource on the Earth and effective management of water levels is vital for various applications, *viz.,* agriculture, industrial processes, and municipal water supply etc. Traditional methods of monitoring and controlling water levels can be inefficient and prone to human error. This project presents a water level monitoring and controlling system that leverages modern sensor technology and automation to enhance water management practices. By continuously monitoring water levels in real time, the system ensures optimal usage and prevents issues such as overflow or depletion [1].

There are many researchers work on proposed system and their related work with the water. K. Murphy et al. [2], collected data of water quality parameters from sensors to a remote server using a GPRS network order to enable the end-users view the data remotely. However, unfortunately, one of the nodes failed to work, and the course path of data transmission was lost. Satyam et al., [3] on the other hand, proposed the smartphone-based water quality analysis in which a water impurity warning would be sent to the users via social network sites. In this research, they proposed a handheld embedded system by connecting mobile applications via a Bluetooth model. One of the challenges they face is the power consumption in

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Bluetooth- based localisation. Additionally, MarcoTeránet et al [4] also, showed that a Bluetooth is a low energy technology. Nazleeni Samiha Haron et al. [5], proposed a remote water quality monitoring system using wireless sensors for the eradication of cost-consuming works of manual monitoring. They implemented a GSM modem. The limitation of this system is that it is not suitable for long- distance.

The integration of a user-friendly interface allows for easy data visualization and management, while an alert system keeps users informed of critical changes. Ultimately, this project aims to promote sustainable water usage and improve operational efficiency in water resource management. The system is designed to be scalable and adaptable, making it suitable for various environments, from small-scale residential tanks to large industrial reservoirs. By incorporating features such as remote monitoring and control, users can manage water levels conveniently from any location [6-8]. Additionally, data analytics capabilities enable users to identify trends and make informed decisions regarding water resource management. Through this innovative approach, the project not only addresses immediate water management challenges but also supports long-term sustainability efforts [9-11].

2. Methodology:

In the proposed system Microcontroller STM32G030C6T6 was used. It is also embedded with the RTC module. For sensing water level there was upper and lower tank was installed each with specific levels. The 4 LEDs used for indicating the levels. The overall system design for water monitoring and controlling is shown in the following figure 1.

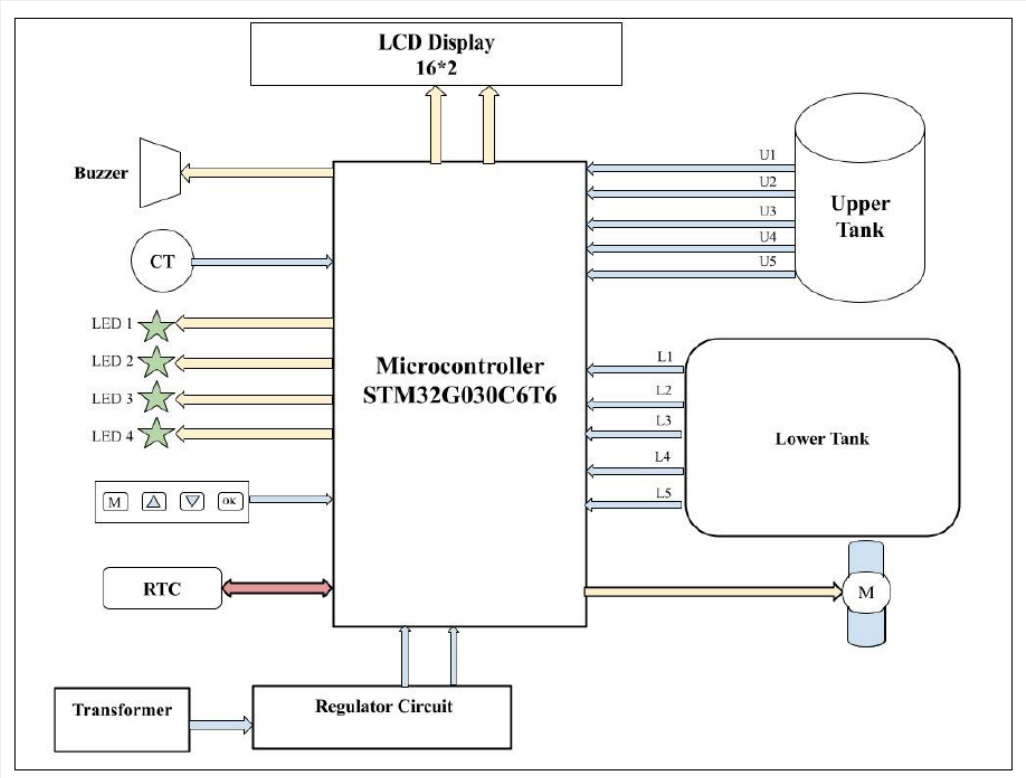


Figure 1: Proposed Design for Smart Water Level Monitoring & Controlling System

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Using above system design development, the water level monitor and control using said micron troller. For the prosed system the flowchart for designing is shown in following figure 2.

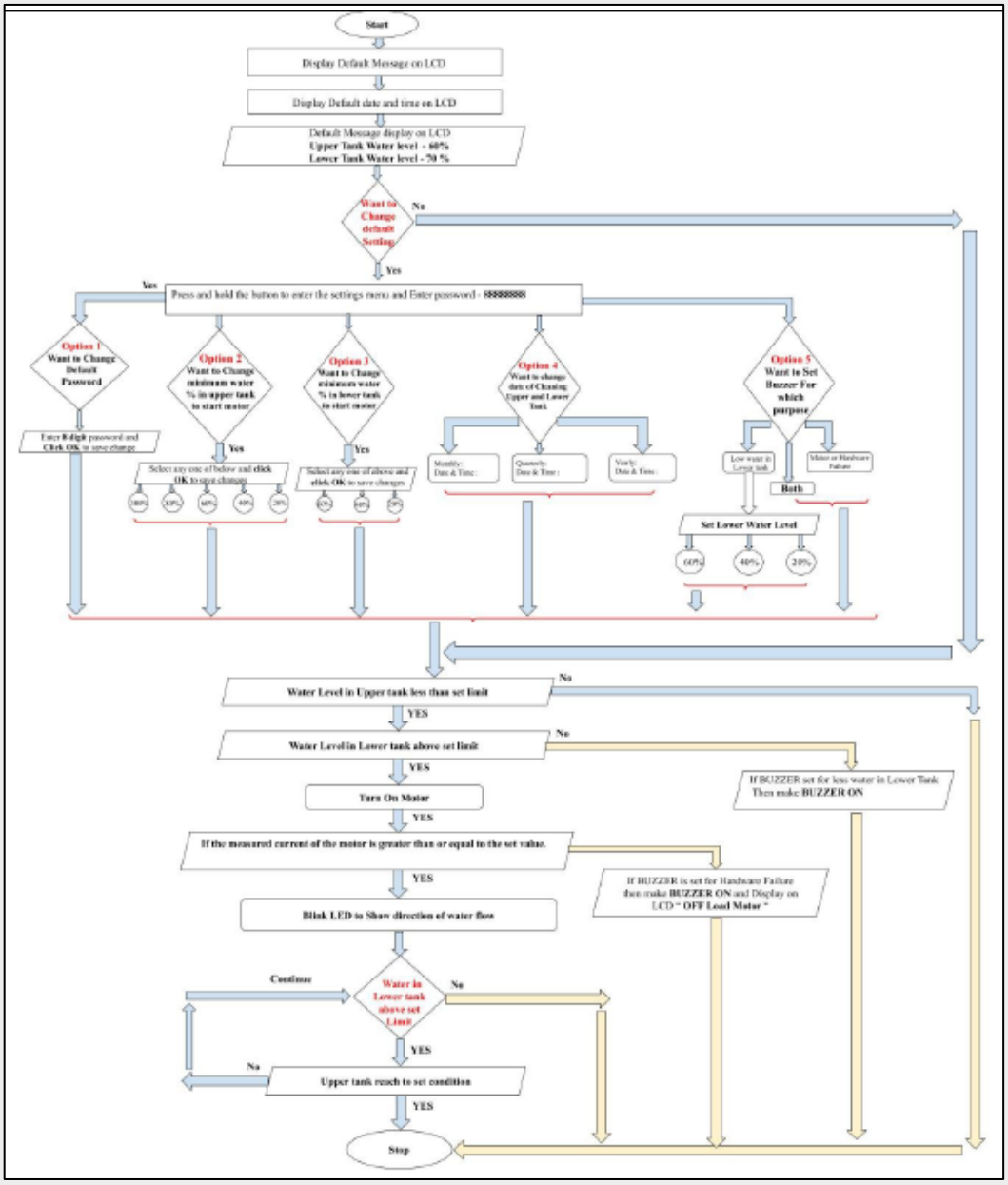


Figure 2. Flowchart of Proposed System

3. System Hardware

The hardware components used in proposed system *viz.,* STM32F103C6T6, Real Time Clock (RTC), Liquid Crystal Display (LCD), Current Transformer (CT).

3.1 *STM32F103C6T6:*

The STM32F103C6T6 is a microcontroller from STMicroelectronics, belonging to the STM32F1 series. It's based on the ARM Cortex-M3 core, designed for high-performance and low-power applications. The processor used is processor core is a 32-bit ARM Cortex-M3 processor core, operating at a clock speed of

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up to 72 MHz, providing fast computation and low interrupt latency. The memory has 32 KB of flash memory for code storage and 10 KB of SRAM, providing sufficient space for smaller embedded applications. The operating voltage range of 2.0V to 3.6V, making it compatible with low-power devices.

It includes up to 37 GPIOs (General Purpose Input/Output pins), which can be configured as digital inputs, outputs, or alternate functions, depending on the requirements. The STM32F103C6T6 has multiple timers: one 16-bit advanced timer (TIM1) and two 16-bit general-purpose timers (TIM2 and TIM3), making it ideal for applications like PWM control, input capture, and time-based events. In the packaging the STM32F103C6T6 comes in a 48-pin LQFP (Low-profile Quad Flat Package), which is compact and suitable for space-constrained designs[12].

3.2 *Real-Time Clock (RTC)*

A Real-Time Clock (RTC) is an essential component in electronic devices that keeps track of the current time and date, even when the main power supply is turned off. Here's some basic information about RTCs. The functionality RTCs maintain accurate time by using a crystal oscillator. They can keep time in hours, minutes, seconds, day, month, and year formats. The power source of RTCs often have a dedicated backup battery (like a coin cell) to maintain time when the main power is off. This ensures that they continue to function accurately during power outages[13].

3.3 *Liquid Crystal Display (LCD)*

The LCD is a flat-panel display technology commonly used in various devices, including televisions, computer monitors, and smartphones. LCDs operate by manipulating light through liquid crystals, which are substances that exhibit properties between liquids and solid crystals. LCDs consist of several layers, including a backlight, polarizers, and the liquid crystal layer. The backlight illuminates the display, while the polarizers filter the light. By applying voltage to the liquid crystals, the display can control the passage of light, creating images and text[14].

3.4 *Current Transformer (CT)*

A current transformer (CT) is an electrical device used to measure alternating current (AC) in power systems. It operates on the principle of electromagnetic induction, where the primary current flowing through a conductor induces a proportional current in the secondary winding. Current transformers are typically used in high-voltage applications to reduce the current to a manageable level for measurement and protection purposes. CTs are often employed in electrical metering, where they enable accurate monitoring of power consumption without directly connecting measuring instruments to high-voltage lines[15].

4. Result and Discussion:

The system operates using five sensors in the upper tank and five sensors in the lower tank, with their values

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set at 20%, 40%, 60%, 80%, and 100%. When the water level reaches any of these specified thresholds, the data is stored and continuously displayed on an LCD screen. Users have the option to select the desired water percentage levels for both tanks, which determines when the motor will activate.

The motor starts when the water level is equal to or less than the selected percentage. If the water level in both tanks falls below the specified thresholds, a buzzer is activated to alert users. Additionally, Real-Time Clock (RTC) logic is implemented to set a cleaning schedule for the tanks and display the current time continuously.

5. Conclusion:

The design and development of water level monitor and control and system is tested successfully. The system work done properly as per our methodology. After overall experimental setup completed then as water level increase in both tank it will update water percentage level on LCD and as condition set by user meet to actual condition it will turn on the motor. When there is low water in any tank as per settled by user it makes Buzzer on for emergency alert. From the overall work it is concluded that the proposed system not only enhances water conservation efforts but also contributes to improved operational efficiency in water management.

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Automatic Greenhouse Monitoring Using Arduino

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Abstract:

The "Greenhouse Monitoring and Controlling System Using Arduino" project aims to design a smart, automated system that optimizes greenhouse conditions for plant growth. This system utilizes an Arduino microcontroller as the core unit to monitor and control key environmental factor like temperature, humidity, soil moisture, and light intensity.

In this system, sensor for temperature, humidity (DHT11), soil moisture, and light (LDR) are interfaced with the Arduino to continuously collect real-time data. The Arduino processes the sensor readings and, based on predefined threshold values, controls actuator such as fans, water pumps, and artificial lighting to maintain optimal conditions. For example, if the temperature exceeds a set limit, the Arduino can automatically activate fans or cooling systems. Similarly, if soil moisture levels drop, the water pump is triggered to irrigate the plants.

The system can also integrate an LCD display to provide real-time feedback on the greenhouse's status, and data can be logged for analysis. By maintaining a balanced environment, the system supports better plant health and higher crop yields while minimizing manual intervention.

This project offer a cost-effective solution for small- to medium-scale greenhouse operations. It demonstrates the potential of automation in agriculture, reducing human effort and ensuring precision in maintaining optimal growing conditions. The system's modular design also allows for future upgrades, such as remote monitoring through GSM or IOT integration. Overall, the project contributes to sustainable agriculture by making greenhouse management more efficient and resource-conscious.

Keywords: Greenhouse cultivation, Smart system, Sensors, Microclimate, Automated process, Microcontroller.

Introduction

The Greenhouse Monitoring and Controlling System using the Arduino project is designed to automate and optimize the environmental conditions within a greenhouse, ensuring a conducive atmosphere for plant growth. Greenhouses are widely used in agriculture to grow plants in controlled environments, protecting them from external weather conditions and allowing for more consistent and efficient farming.

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However, maintaining optimal conditions such as temperature, humidity, soil moisture, and light is crucial for plant health and can be labour-intensive. Automation in greenhouse management addresses this challenge by continuously monitoring environmental parameter and making real-time adjustments. In this project, the Arduino microcontroller serves as the core platform due to its flexibility, affordability, and ease of use. Various sensor are integrated with the Arduino to gather data on key environmental factor. These sensor typically include temperature and humidity sensor like (DHT11), soil moisture sensor ,and light sensor (such as an LDR). These inputs provide real-time data, which the Arduino processes to assess the current state of the greenhouse. When any parameter deviates from the optimal range, the system automatically takes corrective actions. For instance, if the temperature rises above a certain threshold, cooling systems such as fans can be activated. If the soil moisture level is too low, an irrigation system is turned on to water the plants. Artificial lighting can also be controlled based on the light intensity detected within the greenhouse.

The project can also incorporate an LCD display to show real-time sensor readings, allowing for easy monitoring. Additionally, logging the environmental data for future analysis can help optimize plant growth patterns over time. The system's modularity allows for the addition of more advanced features such as remote monitoring and control through GSM or IoT integration, making it adaptable for future improvements.

This automated system significantly reduces human intervention, saving time and labour while maintaining precise control over environmental conditions. It is especially beneficial for small- to medium-scale greenhouses, providing a cost-effective and reliable solution for improving crop yields. The project not only demonstrates the advantages of automation in agriculture but also promotes sustainable farming by optimizing resource usage, such as water and energy. Overall, the Greenhouse Monitoring and Controlling System using Arduino is an efficient and scalable solution for modern greenhouse management, contributing to the advancement of agricultural technologies.

Proposed work

The proposed of greenhouse monitoring system using Arduino Uno aims to track essential environmental parameters such as temperature, humidity, soil moisture, and light intensity. The system integrates sensors (DHT11, soil moisture sensor, and LDR) with Arduino Uno to collect real-time data. The collected values will be displayed on a 16x2 LCD screen for easy monitoring. Based on preset thresholds, the system can trigger actuators like fans or water pumps via a relay module to maintain optimal greenhouse conditions. This automated approach enhances plant growth by ensuring a stable environment while reducing manual monitoring efforts, making it cost-effective and efficient.

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Methodology

System Design and Planning

Identify key environmental parameters to monitor (temperature, humidity, soil moisture, and light intensity) Select appropriate sensors and components compatible with Arduino Uno. Design the circuit diagram for sensor connections and actuator control.

Hardware Setup

Arduino Uno – Acts as the central controller.

DHT11 Sensor – Measures temperature and humidity.

Soil Moisture Sensor – Detects soil water content.

LDR (Light Dependent Resistor) – Monitors light intensity.

16x2 LCD Display with I2C Module – Displays real-time sensor readings.

Relay Module – Controls devices like fans, heaters, and water pumps.

Power Supply – Provides necessary voltage to the system.

Software Development

Arduino IDE is used for writing and uploading the program.

Include necessary libraries (DHT, LiquidCrystal) for sensor integration.

Implement code for reading sensor values and displaying them on the LCD.

Define threshold values to trigger actuators using conditional statements.

System Implementation

Assemble the components on a breadboard or PCB and ensure proper wiring.

Load the Arduino program and test sensor responses.

Integrate relays for automation based on threshold values.

Testing and Optimization

Verify the accuracy of sensor readings by comparing with standard measuring tools.

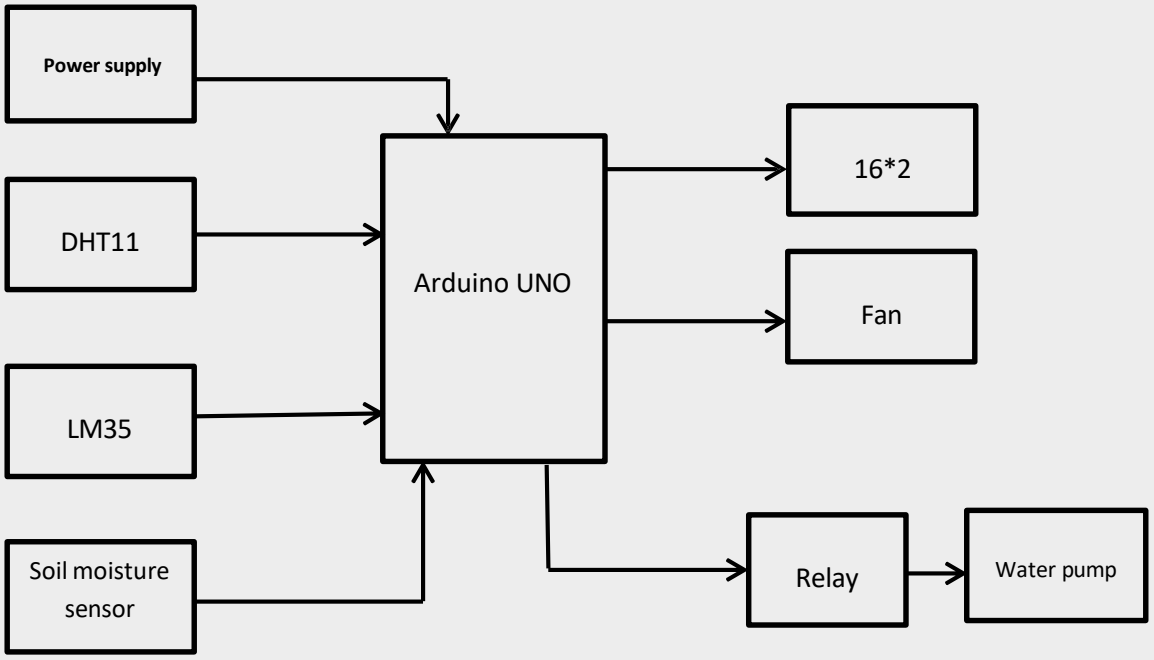
Test system response under different environmental conditions.

Adjust code parameters to improve efficiency and reliability.

This methodology ensures an efficient, real-time greenhouse monitoring system using only Arduino Uno.

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Block diagram



Conclusion:

The Greenhouse Monitoring and Controlling System using Arduino automates agricultural processes in controlled environments by integrating sensors and actuators with a microcontroller to monitor and adjust parameters like temperature, humidity, soil moisture, and light intensity. This system enhances productivity by reducing the need for manual labor and ensuring plants receive optimal growing conditions. It also promotes sustainability by optimizing water and energy use, helping to reduce waste and operational costs, which is vital in an era of resource scarcity. While the system offers significant advantages, such as efficiency and resource conservation, it has limitations. The processing power and memory of Arduino boards may not handle larger or more complex setups effectively. Additionally, the setup process requires technical expertise, and periodic maintenance is needed to ensure sensor accuracy.

In conclusion, the Arduino-based system is an innovative solution for modern farming, offering automated control, improved crop quality, and efficient resource management. As technology advances, future enhancements could overcome current limitations, playing a key role in sustainable agriculture and global food production.

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Advantages:

Real-time Monitoring: Tracks environmental parameters like temperature, humidity, and soil moisture to ensure optimal plant growth.

Automation: Automatically adjusts conditions like watering and ventilation, reducing the need for manual intervention.

Cost-Effective: Arduino Uno is affordable and widely accessible, making it a budget-friendly solution for greenhouse management.

Customization: Easily customizable to include additional sensors or control systems (e.g., automated irrigation, ventilation).

Sustainability: Helps conserve resources by precisely controlling water and energy consumption, reducing wastage.

Improved Crop Yield: By maintaining optimal environmental conditions, it can lead to better plant health and higher crop yields.

Future scope

Advanced Sensor Integration: Including light intensity, pH, and CO2 sensors for all-encompassing environmental control.

Sustainability: Using smart irrigation and solar power technologies to provide environmentally friendly, energy-efficient solutions.

Automated Systems: Increasing automation for climate management, pest control, and nutrient supply. IoT connectivity allows for more convenient remote monitoring and control using computers or smartphones

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Motion Detection Camera Using Raspberry Pi

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Abstract:
This research paper explores the design and implementation of a motion detection camera system built around the Raspberry Pi, a compact and cost-effective single-board computer. The system employs the Raspberry Pi, paired with a camera module and motion detection sensors, to monitor a designated area for movement and trigger specific actions, such as image capture, video recording, or sending notifications. Due to its modularity, scalability, and ease of integration with various technologies, the Raspberry Pi-based motion detection system can be widely applied in security, home automation, and surveillance sectors. The proposed system is cost-effective, energy-efficient, and customizable, making it an ideal solution for small- to medium-scale projects. This paper discusses the design, development, and testing of the system, detailing each component and the methodology used to ensure that the system functions reliably and efficiently under various environmental conditions.

Keywords:
Motion detection, Raspberry Pi, Surveillance, Security system, Image capture, Video recording, PIR sensor, Home automation, System design, IoT, Camera module.

Apparatus Used:
The motion detection system relies on several components to create a functioning and reliable setup. The key apparatus involved in the construction and operation of the system are:
Raspberry Pi Model 4: Serving as the central processing unit, the Raspberry Pi handles all the processing tasks, including motion detection, image capturing, and sending notifications. It also manages the communication between the connected peripherals, such as the camera and PIR sensor.
Pi Camera Module v2: A high-definition camera module connected to the Raspberry Pi, capable of capturing still images and videos upon detection of motion in its field of view.
PIR Motion Sensor: A Passive Infrared (PIR) sensor that detects motion by measuring changes in infrared radiation emitted by objects in its vicinity. The sensor is an essential part of the system, as it triggers the camera to capture images or videos when movement is detected.
MicroSD Card: The microSD card acts as storage for the Raspberry Pi's operating system, software, and recorded images or videos. It also stores the motion detection software, enabling the system to operate seamlessly.
Power Supply: The Raspberry Pi is powered by a standard 5V USB power adapter. A reliable power source is essential for continuous operation of the system.

LED Lights (Optional): For night-time motion detection or low-light environments, LED lights can be incorporated to ensure visibility. These lights are controlled by the Raspberry Pi and turn on when motion is detected.
Monitor/Display (Optional): During setup and testing, a monitor is used to display the output, observe the system's responses, and tweak settings. It is optional for ongoing system operation.

Introduction:
Motion detection systems have become an integral part of modern security systems, offering an affordable solution for surveillance and automation. These systems detect movement within a predefined area, triggering an action such as recording video, taking snapshots, or activating an alarm. Traditional motion detection systems are often costly, require professional installation, and may not be easily customized or expanded to meet specific needs.

With the advent of single-board computers like the Raspberry Pi, there has been a significant shift in how DIY projects, including motion detection systems, are designed and deployed. The Raspberry Pi is an affordable, versatile platform that allows hobbyists, engineers, and researchers to develop powerful systems without the need for expensive equipment. This paper explores how to build a motion detection camera system using the Raspberry Pi, aiming to provide a low-cost, scalable, and flexible solution for various real-world applications, such as home security, office monitoring, and even automation systems.

The primary objective of this project is to develop a motion detection system that can reliably detect movement, capture images or videos, and send notifications based on user-defined preferences. By leveraging the capabilities of the Raspberry Pi, this system can be customized to include additional sensors, integrate with cloud platforms for remote monitoring, and even use machine learning techniques for object recognition. This paper outlines the design process, the components selected, and the steps involved in building and testing the system, as well as the advantages and limitations of such an approach.

Proposed work :
The proposed work aims to design and develop a motion detection camera system that uses the Raspberry Pi as the central processing unit. The system will be capable of detecting motion within its range, activating the camera to capture images or videos, and notifying the user via email or SMS. The core components of the system include the Raspberry Pi, Pi Camera module, and a PIR motion sensor. Additionally, the system is designed to be cost-effective, easily scalable, and flexible enough to be adapted to various use cases, ranging from simple home security to more advanced surveillance setups.

To achieve the desired functionality, the system will need to detect motion accurately, trigger the camera at the right time, and store or send the captured media efficiently. The proposed system will also integrate the use of various software libraries and tools, such as Python programming, OpenCV for image processing, and email/SMS APIs for notifications. Furthermore, the system will be designed with an emphasis on low power consumption, making it suitable for long-term

use in remote locations or installations that are off the grid.

The proposed work also explores the potential for extending the motion detection system by adding features like remote monitoring, cloud storage, and integration with other smart home devices. The system will be designed with scalability in mind, enabling users to add more cameras, sensors, or enhance the functionality by integrating artificial intelligence for more advanced motion recognition.

Methodology :

System Design & Planning:

The design of the motion detection camera system follows a structured approach that involves several key steps: requirement analysis, component selection, system architecture design, and software development.

Requirement Analysis: The system needs to detect motion reliably in various environmental conditions, such as low light, varying temperatures, and potentially busy or dynamic areas. Therefore, the key requirements include accurate motion detection, real-time video capture, and efficient image/video storage. Additionally, the system should be capable of sending timely notifications to the user without overwhelming them with false positives. The power requirements are also considered, with a focus on ensuring the system can operate continuously for extended periods without failure.

Component Selection: To meet the design requirements, the Raspberry Pi Model 4 was selected due to its processing power, GPIO pins, and compatibility with a variety of sensors and modules. The Pi Camera Module v2 was chosen for its ease of integration with the Raspberry Pi and its ability to capture high-resolution images and videos. The PIR motion sensor, known for its reliability and affordability, was chosen to detect motion. Other components, such as the power supply and microSD card, were selected based on compatibility with the Raspberry Pi and the expected system workload.

System Architecture:

The architecture of the motion detection camera system includes multiple components working together to ensure smooth operation. The Raspberry Pi serves as the brain of the system, receiving input from the PIR sensor to determine when motion is detected. When motion is detected, the Raspberry Pi activates the Pi Camera module to capture an image or start recording a video. The images or videos are saved to the microSD card or sent to a cloud service if configured. In addition, the system sends notifications to the user through email or SMS, alerting them to the detected motion.

The system also includes a monitoring module, which provides real-time feedback on the camera's status, detected motion, and system performance. This is particularly useful during the testing phase and can be utilized for debugging and optimization purposes.

Implementation & Testing:

The implementation of the system involves programming the Raspberry Pi to interact with the PIR sensor and Pi Camera module. The system software is written in Python, using libraries like RPi.GPIO for GPIO control, OpenCV for video capturing, and smtplib for sending email notifications. Once the system is set up, field testing is performed in various environments to

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ensure that the motion detection system works efficiently under different lighting and weather conditions.

During testing, the system's performance is closely monitored to fine-tune its response time, motion detection sensitivity, and accuracy in capturing images/videos. Several test scenarios are conducted, including motion detection in low-light conditions, varied motion speeds, and different distances from the sensor.

Block Diagram:

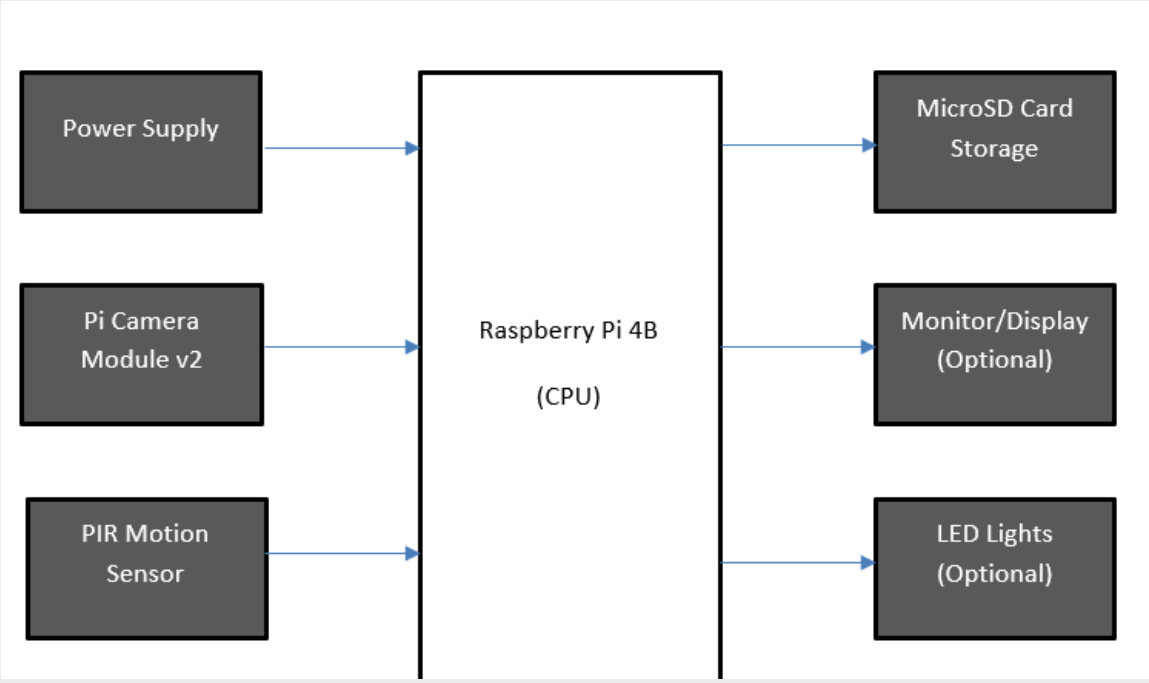


Fig : Block Diagram

Advantages:

The proposed motion detection camera system offers numerous advantages:

Cost-Effective: The use of the Raspberry Pi and commonly available sensors reduces the overall cost of the system, making it an affordable solution compared to traditional CCTV or surveillance systems.

Scalability: The modular nature of the system allows for easy scaling. Additional cameras or sensors can be added to cover larger areas or improve detection accuracy.

Flexibility: The system is highly customizable. Users can adjust the sensitivity of the PIR sensor, change the notification settings, or add features like cloud storage or remote monitoring.

Energy-Efficient: The Raspberry Pi is a low-power device, making the system ideal for long-term operation in energy-constrained environments.

Remote Access: Through IoT platforms or cloud-based services, users can remotely monitor and control the motion detection system from anywhere, providing increased convenience and functionality.

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Conclusion:

The motion detection camera system based on the Raspberry Pi is an efficient, scalable, and cost-effective solution for a variety of applications, including security, home automation, and surveillance. By leveraging the power of the Raspberry Pi, users can create a customizable system that meets their specific needs, whether it's for small-scale home security or larger, more complex monitoring tasks. The system's modularity ensures that it can be expanded or adapted to new technologies, and its open-source nature allows for further development and innovation. As IoT and smart home technologies continue to grow, the Raspberry Pi-based motion detection camera system represents a powerful tool for creating affordable, efficient, and reliable monitoring solutions.

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Perimetric contraction on n –gon and related fixed point results

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Abstract: This paper introduces a novel extension of the classical Banach Contraction Principle, focusing on "perimetric contractions" in n-gon. Unlike traditional contractions that deal with the distances between pairs of points, perimetric contractions are concerned with the contraction of the entire perimeter of an n-gon, considering the distances between consecutive points along the boundary. This new perspective enables the development of fixed-point results in higher-dimensional metric spaces. The core objective is to establish a fixed-point theorem for mappings that contract the perimeters of n-gon, providing a generalization of Banach's original theorem. The paper demonstrates that such mappings are continuous and presents conditions under which fixed points exist and are unique. Additionally, the relationships between perimetric contractions and conventional contraction mappings are examined, thus expanding the applicability of fixed-point theorems in more complex settings.

Mathematics Subject Classification: 47H10

Keywords: Fixed point theorems, Metric spaces, Perimetric contraction on n-gon.

1. Introduction:

S. Banach developed the Contraction Mapping Principle in his 1920 dissertation, which was later published in 1922 [1]. S. Banach was the first to formulate this result in an accurate abstract form appropriate for a variety of applications, even though the concept of successive approximations in a number of concrete situations (solution of differential and integral equations, approximation theory) had previously been presented in the works of P. L. Chebyshev, E. Picard, R. Caccioppoli, and others. One hundred years later, fixed-point theorems continue to pique the interest of mathematicians worldwide. This is supported by the large number of articles and monographs that have been written about fixed point theory and its applications in recent decades; for example, the monographs [2-4] for a survey on fixed point results.

Over time, there have been numerous generalizations of the Banach contraction principle. The authors [5] pointed out that metric extensions are typically verified against three classical fixed point theorems in addition to Banach's fixed point theorem. These are Caristi's theorem [8],

the extension of Banach's theorem to nonexpansive mappings [7], and Nadler's famous set-valued extension of Banach's theorem [6]. At the same time, there are at least two different kinds of generalizations of these theorems that may be distinguished: the first weakens the contractive character of the mapping, as seen in [9–18]; the second weakens the topology, as seen in [19–32].

Assume that X is a metric space. We prove the fixed point theorem for a new class of mappings, $T: X \to X$, in this work. These mappings can be generalized as mappings contracting perimeters of n gon. This work's main theorem proof is based on the concepts of the proof of Banach's classical theorem and generalized for perimetric contraction of triangles. However, the key distinction is that our mappings' definition is based on mapping n points of the space rather than three.

Additionally, we need the necessary condition that $T(Tx) \neq x$ for any $x \in X$such that $\neq x$, which stops the mapping T from having points with least period two [33]. A significant subclass of these mappings are the ordinary contraction mappings, from which we can quickly derive the classical Banach's theorem as a straightforward consequence. For a space X with $|X| = \aleph_0$, where $|X|$is the cardinality of the set X, an example of a mapping that contracts the perimeters of n-gon but is not a contraction mapping is built.

The core of this paper is to establish a fixed-point theorem for mappings that contract the perimeters of n-gon, thereby extending the established theory of Banach's contraction principle. This work addresses the properties of such mappings, investigates their uniqueness and existence of fixed points, and provides conditions under which these mappings exhibit interesting geometric behaviors. We will also explore the relationship between these perimetric contractions and ordinary contraction mappings, highlighting their connections and differences in the context of metric spaces. By introducing the perimetric contraction of n-gon, this paper contributes to the ongoing research in metric space theory, extending the applicability of fixed-point theorems to more complex and higher-dimensional structures.

2. Mapping contracting perimeters of n –gon

Definition 2.1. Let (X, d) be a metric space with $|X| \geq n$. We shall say that $T: X \to X$ is a *mapping contracting perimeters of n- gon* on X if there exists $\alpha \in [0,1)$ such that the inequality

$$d(Tx_1, Tx_2) + d(Tx_2, Tx_3) + \ldots + d(Tx_n, Tx_1) \leq \alpha \left(d(x_1, x_2) + d(x_2, x_3) + \ldots + d(x_n, x_1)\right) \quad (2.1)$$

Holds for all n pairwise distinct points $x_1, x_2, x_3, \ldots\ldots, x_n \in X$.

Remark 2.2. Note that the requirement for $x_1, x_2, x_3, \ldots, x_n \in X$ to be pairwise distinct is essential. One can see that otherwise this definition is equivalent to the definition of contraction mapping.

Proposition 2.3. *Mappings contracting perimeters of n- gon are continuous.*

Proof. Let (X, d)be a metric space with $|X| \geq n$, $T: X \to X$ be a mapping contracting perimeters of n –gon on X and let x_0 be an arbitrary .If x_0 is an isolated point of X, then it is clearly T is continuous at x_0. Therefore it remains to show that for any $\epsilon > 0$ there exist a $\delta > 0$ such that $d(Tx_0, Tx) < \epsilon$ for all $x \in X$ satisfying $d(x_0, x) < \delta$.

Let $\epsilon > 0$ be an arbitrary. Choose $\delta > 0$ be such that $0 < \delta < \frac{\epsilon}{(2n-2)\alpha}$

Since x_0 is a accumulation point of , there exist $x_1, x_2, x_3, \ldots, x_{n-2} \in X$ with $x_1 \neq x_2 \neq x_3 \neq . \neq x_{n-2} \neq x_0$ such that $d(x_0, x_1) < \delta, d(x_0, x_2) < \delta, d(x_0, x_3) < \delta, \ldots, d(x_0, x_{n-2}) < \delta$. Now , for all $x \in X$ with $x \neq x_0$ satisfying $d(x_0, x) < \delta$. we have

$$d(Tx_0, Tx) \leq d(Tx_0, Tx) + d(Tx, Tx_1) + d(Tx_1, Tx_2) + \ldots\ldots\ldots + d(Tx_{n-2}, Tx_0)$$

By using (2.1) and triangle inequality we have,

$$d(Tx_0, Tx) \leq \alpha\big(d(x_0, x) + d(x, x_1) + d(x_1, x_2) + \ldots\ldots\ldots + d(x_{n-2}, x_0)\big)$$

$$\begin{aligned} d(Tx_0, Tx) &\leq 2\alpha\big(d(x_0, x) + d(x_0, x_1) + d(x_0, x_2) + \ldots\ldots\ldots + d(x_0, x_{n-2})\big) \\ &\leq 2\alpha(\delta + \delta + \delta + \ldots\ldots\ldots + \delta) \\ &\leq 2\alpha(n-1)\delta \\ &\leq 2(n-1)\alpha\delta \\ &\leq (2n-2)\alpha\delta \\ &< \epsilon \end{aligned}$$

and hence the result follows.

□

Theorem2.4. *Let (X, d), $|X| \geq n$, be a complete metric space and let the mapping $T: X \to X$ satisfy the following to conditions:*

(i) $T^m(x) \neq x$ for all $x \in X$ with $m = 2,3,4, \ldots\ldots, n-1$ such that $T(x) \neq x$.

(ii) T is a mapping contracting perimeters of n-gon on X.

Then T has a fixed point. The number of fixed points is at most $n-1$.

Proof. Let $x_0 \in X$, $Tx_0 = x_1$, $Tx_1 = x_2$, $\ldots\ldots\ldots, Tx_n = x_{n+1}, \ldots\ldots\ldots$ Suppose that x_i is not a fixed point of the mapping T for every $i = 0,1,2, \ldots\ldots$ Let us show that all x_i are different. Since x_i is not fixed , then $x_i \neq x_{i+1} = Tx_i$.

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By condition (i) If m =2, then $T^2(x_i) = T(Tx_i) = T(x_{i+1}) = x_{i+2} \neq x_i$.

If m =3, then $T^3(x_i) = T(T^2x_i) = T(x_{i+2}) = x_{i+3} \neq x_i$.

……..

If m = n-1 , then $T^{n-1}(x_i) = T(T^{n-2}x_i)$

$= T(T(T^{n-3}x_i))$

$= T(T(T(T^{n-4}x_i)))$

……..

$= T(T\left(T\left(T\left(\ldots\ldots\ldots\ldots\ldots(T(x_i))\right)\right)\right)$ …(n-2 times of T)

$T^{n-1}(x_i) = x_{i+n-1} \neq x_i$.

Since x_i is not fixed point for all m $= 2,3,4,\ldots\ldots, n-1$ and by the supposition that x_{i+1} is not fixed point we have $x_{i+1} \neq x_{i+2} = Tx_{i+1}$.

By condition (i) If m $= 2$, then $T^2(x_{i+1}) = T(Tx_{i+1}) = T(x_{i+2}) = x_{i+3} \neq x_{i+1}$.

If m $= 3$, then $T^3(x_{i+1}) = T(T^2x_{i+1}) = T(x_{i+3}) = x_{i+4} \neq x_{i+1}$.

……..

If m $= n-1$, then $T^{n-1}(x_{i+1}) = x_{i+1+(n-1)} \neq x_{i+1}$.

Since x_{i+1} is not fixed point for all m $= 2,3,4,\ldots\ldots, n-1$. There fore $x_i, x_{i+1}, x_{i+2}, \ldots\ldots, x_{i+n-1}$ are pairwise distinct. Further ,set

$p_0 = d(x_0, x_1) + d(x_1, x_2) + d(x_2, x_3) + \ldots\ldots\ldots + d(x_{n-1}, x_0)$,

$p_1 = d(x_1, x_2) + d(x_2, x_3) + d(x_3, x_4) + \ldots\ldots\ldots + d(x_n, x_1)$,

$p_2 = d(x_2, x_3) + d(x_3, x_4) + d(x_4, x_5) + \ldots\ldots\ldots + d(x_{n+1}, x_2)$,

$p_3 = d(x_3, x_4) + d(x_4, x_5) + d(x_5, x_6) + \ldots\ldots\ldots + d(x_{n+2}, x_3)$,

…...

$p_n = d(x_n, x_{n+1}) + d(x_{n+1}, x_{n+2}) + d(x_{n+2}, x_{n+3}) + \ldots\ldots\ldots + d(x_{n+m-1}, x_n)$,

Since $x_i, x_{i+1}, x_{i+2}, \ldots\ldots, x_{i+n-1}$ are pairwise distinct by (2.1) we have $p_1 \leq \alpha\, p_0$, $p_2 \leq \alpha\, p_1, \ldots\ldots\ldots, p_n \leq \alpha\, p_{n-1}$ and $p_0 > p_1 > p_2 > \ldots\ldots > p_n > \ldots\ldots$ (2.2)

Suppose that $j \geq n$ is a minimal natural number such that $x_j = x_i$ for some i such that $0 \leq i < j-(n-1)$. Then $x_{j+1} = x_{i+1}, x_{j+2} = x_{i+2}, x_{j+3} = x_{i+3}, \ldots\ldots, x_{j+(n-1)} = x_{i+(n-1)}$. Hence $p_i = p_j$ which contradict to (2.2) .

Further , let us show that $\{x_n\}$ is a Cauchy sequence. It is clear that

$d(x_1, x_2) \leq p_0$,

$d(x_2, x_3) \leq p_1 \leq \alpha\, p_0$,

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$$d(x_3, x_4) \le p_2 \le \alpha\, p_1 \le \alpha^2\, p_0\,,$$

$$\ldots\ldots$$

$$d(x_n, x_{n+1}) \le p_{n-1} \le \alpha^{n-1}\, p_0\,,$$

$$d(x_{n+1}, x_{n+2}) \le p_n \le \alpha^n\, p_0\,,$$

By the triangle inequality,

$$d(x_n, x_{n+p}) \le d(x_n\,, x_{n+1}) + d(x_{n+1}\,, x_{n+2}) + d(x_{n+2}\,, x_{n+3}) + \ldots\ldots\ldots + d(x_{n+p-1}\,, x_{n+p})$$

$$\le \alpha^{n-1}\, p_0 + \alpha^n\, p_0 + \alpha^{n+1}\, p_0 + \ldots\ldots\ldots + \alpha^{n+p-2}\, p_0 = \alpha^{n-1}(1 + \alpha + \alpha^2 + \ldots + \alpha^{p-1})p_0 = \alpha^{n-1}\left(\frac{1-\alpha^p}{1-\alpha}\right)p_0.$$

Since by the supposition $0 \le \alpha < 1$, then $d(x_n, x_{n+p}) < \alpha^{n-1}\left(\frac{1}{1-\alpha}\right)p_0$. Hence $d(x_n, x_{n+p}) \to 0\ as\ n \to \infty$ for every > 0. Thus $\{x_n\}$ is a Cauchy sequence. By completeness of (X, d), this sequence has a limit $x^* \in X$.

Let us prove that $Tx^* = x^*$. By the triangle inequality and by inequality (2.1) we have

$$d(x^*, Tx^*) \le d(x^*\,, x_n) + d(x_n\,, Tx^*) = d(x^*\,, x_n) + d(Tx_{n-1}\,, Tx^*)$$

$$\le d(x^*\,, x_n) + d(x_n\,, x_{n+1}) + d(x_{n+1}\,, x_{n+2}) + \cdots + d(x_{n+i-2}\,, x^*)$$

where i $= 1,2,3, \ldots,$ n.

$$\le d(x^*\,, x_n) + \alpha\big(d(x_{n+1}\,, x^*) + d(x_{n+2}\,, x^*) + \cdots + d(x_{n+i-2}\,, x^*)\big)$$

Since all the terms in the previous sum tend to zero as $n \to \infty$, we obtain $d(x^*, Tx^*) = 0$.

Suppose that there exist at least n pairwise distinct fixed points $x_1, x_2, x_3, \ldots\ldots, x_n$. Then $Tx_1 = x_1$, $Tx_2 = x_2$, $Tx_3 = x_3$, $\ldots, Tx_n = x_n$, which contradicts to (2.1).

Remark 2.5. Suppose that under the supposition of the theorem the mapping T has a fixed point f_1 which is a limit of some iteration sequence x_0, $x_1 = Tx_0$, $x_2 = Tx_1$, ... such that $x_n \ne f_1$ for all $n = 1,2,3, \ldots$. Then f_1 is a unique fixed point. Indeed suppose that T has another fixed point $f_2, f_3, f_4, \ldots, f_{n-1}$ such that $f_2 \ne f_1$, $f_3 \ne f_2$, $f_4 \ne f_3, \ldots, f_{n-1} \ne f_1$.

It is clear that $x_n \ne f_2$, $x_n \ne f_3, \ldots, x_n \ne f_{n-1}$ for all $n = 1,2,3, \ldots$. Hence we have that the points $f_1, f_2, f_3, f_4, \ldots, f_{n-1}$ and x_n are n pairwise distinct for all $n = 1,2,3, \ldots$. Consider the ratio

$$R_n = \frac{d(Tf_1, Tf_2) + d(Tf_2, Tf_3) + \cdots + d(Tf_{n-1}, Tx_n) + d(Tx_n, Tf_1)}{d(f_1, f_2) + d(f_2, f_3) + \cdots + d(f_{n-1}, x_n) + d(x_n, f_1)}$$

$$= \frac{d(f_1, f_2) + d(f_2, f_3) + \cdots + d(f_{n-1}, x_{n+1}) + d(x_{n+1}, f_1)}{d(f_1, f_2) + d(f_2, f_3) + \cdots + d(f_{n-1}, x_n) + d(x_n, f_1)}$$

Taking into consideration that $d(f_2, f_3) \to 0, d(f_3, f_4) \to 0, \ldots, d(f_{n-1}, x_{n+1}) \to 0, d(f_{n-1}, x_n) \to 0$ and $d(x_{n+1}, f_1) \to d(f_1, f_2), d(x_n, f_1) \to d(f_1, f_2)$, we obtain

$R_n \to 1$ as $n \to \infty$ which contradicts to condition (2.1).

Example2.6. Let us construct an example of t he mapping T contracting perimeters of n-gon which has exactly n-1 fixed points. Let $X = \{x_1, x_2, x_3, \dots\dots, x_n\}$, $d(x_1, x_2) = d(x_2, x_3) = \cdots = d(x_n, x_1) = 1$ and let $T: X \to X$ be such that $Tx_1 = x_1$, $Tx_2 = x_2$, $Tx_3 = x_3$, …, $Tx_n = x_n$. One can easily see that conditions (i) and (ii) of Theorem 2.4 are fulfilled.

Example2.7. Let us show that condition (i) of Theorem 2.4 is necessary. Let $X = \{x_1, x_2, x_3, \dots\dots, x_n\}$, $d(x_1, x_2) = d(x_2, x_3) = \cdots = d(x_n, x_1) = 1$ and let $T: X \to X$ be such that $Tx_1 = x_2$, $Tx_2 = x_1$, $Tx_3 = x_4$, $Tx_4 = x_3$, …, $Tx_{n-1} = x_n$, $Tx_n = x_{n-1}$. One can easily see that condition (ii) of Theorem 2.4 is fulfilled but T does not have any fixed point.

Let (X, d) be a metric space. Then a mapping $T: X \to X$ is called a *contraction mapping* on X if there exist $\alpha \in [0,1)$ such that $d(Tx, Ty) \leq \alpha\,(d(x, y))$ (2.3) for all $x, y \in X$.

Corollary 2.8. ***(Banach fixed point theorem)*** *Let (X, d) be a nonempty complete metric space with a contraction mapping $: X \to X$. Then T admits a unique fixed point.*

Proof. For $|X| = 1, 2$ the proof is trivial. Let $|X| \geq n$. Suppose that there exist $x \in X$ such that $T^m x = x$ for $m = n$. Consequently $d(x, T^{n-1}x) = d(T^{n-1}x, x) = d(T^{n-1}x, T(T^{n-1}x)$ which contradicts to (2.3). Thus condition (i) of Theorem 2.4 holds. Let $x_1, x_2, x_3, \dots\dots, x_n \in X$ be pairwise distinct. By (2.3) we obtain $d(Tx_1, Tx_2) \leq \alpha\, d(x_1, x_2)$,

$$d(Tx_2, Tx_3) \leq \alpha\, d(x_2, x_3),$$

$$\dots.$$

$d(Tx_n, Tx_1) \leq \alpha\, d(x_n, x_1)$ which immediately implies condition (ii) of Theorem (2.4) .This completes the proof of existence of fixed point.

The uniqueness can be shown in a standard way.

Let (X, d) be a metric space and $x_1, x_2, x_3, \dots\dots, x_n \in X$. We shall say that the points $x_2, x_3, \dots\dots, x_{n-1}$ lies between x_1 and x_n in the metric space (X, d) if the extremal version of the triangle inequality

$d(x_1, x_n) = d(x_1, x_2) + d(x_2, x_n) + d(x_1, x_3) + d(x_3, x_n) + \cdots + d(x_1, x_{n-1}) + d(x_{n-1}, x_n)$ (2.4) holds. □

Example2.9. Let us construct an example of a mapping $T: X \to X$ contracting perimeters of n-gon that is not contraction mapping for a metric space X with $|X| = \aleph_0$. Let $X =$

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$\{x^*, x_1, x_2, x_3, \ldots..\}$ and let a be a positive real number. Define a metric d on X as follows:

$$d(x,y) = \begin{cases} \frac{a}{2^{\left\lfloor \frac{i}{n-1} \right\rfloor}}, & if\ x = x_i,\ y = x_{i+1}, i = 0,1,2,..... \\ \sum_{c=i}^{j-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}, & if\ x = x_i,\ y = x_j;\ i+1<j \\ 2(n-1)a - \sum_{c=0}^{i-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}, & if\ x = x_i,\ y = x^* \\ 0, & if\ x = y \end{cases}$$

where $\lfloor . \rfloor$ is the floor function. Then (X, d) is a complete metric space with a single limit point x^*.

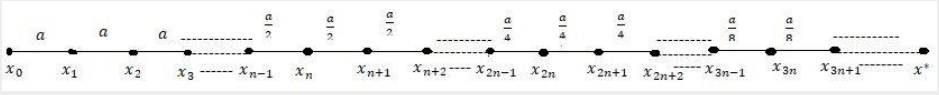


Figure 1: The points of the space (X, d) with consecutive distances between them.

Define a mapping $T: X \to X$ as $Tx_{i_m} = x_{i_m+1}$, for all i $= 0,1,2, \ldots \ldots$ and m $= 1,2, \ldots, n-1, Tx^* = x^*$.

Since $d\left(Tx_{(n-1)i_m}, Tx_{(n-1)i_m+1}\right) = d\left(x_{(n-1)i_m}, x_{(n-1)i_m+1}\right)$ for all $i_m = 0,1,2, \ldots$ and m $= 1,2, \ldots, n-1$, using (2.3) we see that T is not contraction mapping.

Let us show that inequality (2.1) holds for every n pairwise distinct points from the space X. Consider the points $x_{i_1}, x_{i_2}, x_{i_3}, \ldots, x_{i_{n-1}}, x^* \in X$ with $0 \le i_1 < i_2 < i_3 < \cdots < i_{n-1}$. Then we have

$$d(x_{i_1}, x_{i_2}) + d\left(x_{i_2}, x_{i_3}\right) + \ldots, + d\left(x_{i_{n-1}}, x^*\right) + d\left(x^*, x_{i_1}\right) = 2d\left(\left(x_{i_1}, x^*\right)\right.$$

$$= 4(n-1)a - 2\sum_{c=0}^{i_1-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}$$

and

$$d(Tx_{i_1}, Tx_{i_2}) + d\left(Tx_{i_2}, Tx_{i_3}\right) + \ldots, + d\left(Tx_{i_{n-1}}, Tx^*\right) + d\left(Tx^*, Tx_{i_1}\right)$$

$$= 2d\left(\left(Tx_{i_1}, Tx^*\right)\right. \quad = 2d\left(x_{i_1+1}, x^*\right) = 4(n-1)a - 2\sum_{c=0}^{i_1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}$$

Now ,we have,

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$$d(x_0, x_{i_m}) = \begin{cases} 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right), & if\ i_m = (n-1)p, \\ 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) - \frac{a}{2^{p-1}}, & if\ i_m = (n-1)p-1, \\ 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) - \frac{a}{2^{p-2}}, & if\ i_m = (n-1)p-2, \\ \vdots \\ \vdots \\ 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) - \frac{a}{2^{p-(n-2)}}, & if\ i_m = (n-1)p-(n-2). \end{cases}$$

where $p = 1,2,3, \ldots$ ---------- (2.5)

Consider the ratio,

$$R_{i_1} = \frac{d(Tx_{i_1}, Tx_{i_2}) + d(Tx_{i_2}, Tx_{i_3}) + \ \ldots + d(Tx_{i_{n-1}}, Tx^*) + \ d(Tx^*, Tx_{i_1})}{d(x_{i_1}, x_{i_2}) + d(x_{i_2}, x_{i_3}) + \ \ldots + d(x_{i_{n-1}}, x^*) + \ d(x^*, x_{i_1})}$$

$$= \frac{4(n-1)a - 2\sum_{c=0}^{i_1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}}{4(n-1)a - 2\sum_{c=0}^{i_1-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}}$$

$$R_{i_1} = \begin{cases} 1 - \frac{\frac{a}{2^p}}{2(n-1)a - 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right)}, & if\ i_1 = (n-1)p, \\ 1 - \frac{\frac{a}{2^{p-1}}}{2(n-1)a - 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) + \frac{a}{2^{p-1}}}, & if\ i_1 = (n-1)p-1 \\ 1 - \frac{\frac{a}{2^{p-1}}}{2(n-1)a - 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) + \frac{a}{2^{p-2}}}, & if\ i_1 = (n-1)p-2 \\ \vdots \\ 1 - \frac{\frac{a}{2^{p-1}}}{2(n-1)a - 2(n-1)a\left(1-\left(\frac{1}{2}\right)^p\right) + \frac{a}{2^{p-(n-2)}}}, & if\ i_1 = (n-1)p-(n-2) \end{cases}$$

$$R_{i_1} = \begin{cases} \frac{2n-3}{2n-2}, & if\ i_1 = (n-1)p, \\ \frac{n-1}{n}, & if\ i_1 = (n-1)p-1 \\ \frac{n}{n+1}, & if\ i_1 = (n-1)p-2 \\ \vdots \\ \frac{(n-2)+2^{n-3}}{(n-1)+2^{n-3}}, & if\ i_1 = (n-1)p-(n-2) \end{cases}$$

Now ,let us consider the points $x_{i_1}, x_{i_2}, x_{i_3}, \ldots, x_{i_n} \in X$ with $0 \le i_1 < i_2 < i_3 < \cdots < i_n$. Then, we have,

$$d(x_{i_1}, x_{i_2}) + d(x_{i_2}, x_{i_3}) + \ \ldots, + d(x_{i_n}, x_{i_1}) = \ 2d((x_{i_1}, x_{i_n})$$

$$= 2\sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}$$

and

$$d(Tx_{i_1}, Tx_{i_2}) + d(Tx_{i_2}, Tx_{i_3}) + \ldots, + d(Tx_{i_n}, Tx_{i_1}) = 2d((Tx_{i_1}, Tx_{i_n})$$
$$= 2d(x_{i_1+1}, x_{i_n+1})$$
$$= 2d(x_{i_1}, x_{i_n}) - 2\left[d(x_{i_1}, x_{i_1+1}) - d(x_{i_n}, x_{i_n+1})\right]$$
$$= 2\sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}} - 2\left(\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} - \frac{a}{2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor}}\right)$$

Consider the ratio,

$$R_{i_1, i_n} = \frac{d(Tx_{i_1}, Tx_{i_2}) + d(Tx_{i_2}, Tx_{i_3}) + \ldots + d(Tx_{i_n}, Tx_{i_1})}{d(x_{i_1}, x_{i_2}) + d(x_{i_2}, x_{i_3}) + \ldots + d(x_{i_n}, x_{i_1})}$$
$$= \frac{2\sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}} - 2\left(\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} - \frac{a}{2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor}}\right)}{2\sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}}$$
$$= 1 - \frac{\left(\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} - \frac{a}{2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor}}\right)}{\sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}}}$$

It is to be noted that $i_n \geq i_1 + (n-1)$. Therefore

$$\left\lfloor \frac{i_n}{n-1} \right\rfloor \geq \left\lfloor \frac{i_1}{n-1} \right\rfloor + 1$$
$$\Rightarrow \quad 2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor} \geq 2.2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}$$
$$\Rightarrow \quad \frac{1}{2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor}} \leq \frac{1}{2.2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}}$$
$$\Rightarrow \quad \frac{a}{2^{\left\lfloor \frac{i_n}{n-1} \right\rfloor}} \leq \frac{a}{2.2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} \quad \ldots\ldots\ldots\ldots (2.6)$$

Now from (2.5), we can write,

$$d(x_{i_m}, x^*) = \begin{cases} \frac{2(n-1)a}{2^p}, & if\ i_m = (n-1)p, \\ \frac{2(n-1)a}{2^p} + \frac{a}{2^{p-1}}, & if\ i_m = (n-1)p - 1, \\ \frac{2(n-1)a}{2^p} + \frac{a}{2^{p-2}}, & if\ i_m = (n-1)p - 2, \\ \vdots & \\ \frac{2(n-1)a}{2^p} + \frac{a}{2^{p-(n-2)}}, & if\ i_m = (n-1)p - (n-2). \end{cases} \quad \ldots\ldots\ldots (2.7)$$

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from above equation (2.7) we get

$$d(x_{i_m}, x^*) \leq 2(n-1)d(x_{i_m}, x_{i_m+1})$$

$$\Rightarrow\ d(x_{i_1}, x^*) \leq 2(n-1)d(x_{i_1}, x_{i_1+1})$$

$$\Rightarrow\ \ d(x_{i_1}, x_{i_n}) \leq d(x_{i_1}, x^*) \leq 2(n-1)d(x_{i_1}, x_{i_1+1})$$

$$\Rightarrow\ \ \sum_{c=i_1}^{i_n-1} \frac{a}{2^{\left\lfloor \frac{c}{n-1} \right\rfloor}} \leq 2(n-1)\frac{c}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} \ldots\ldots\ldots\ldots(2.8)$$

Consequently, from (2.6) and (2.8) we have

$$R_{i_1, i_n} = 1 - \frac{\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}} - \frac{1}{2}\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}}}{2(n-1)\frac{a}{2^{\left\lfloor \frac{i_1}{n-1} \right\rfloor}}} = \frac{4n-5}{4n-4}$$

Thus the inequality (2.1) holds for any n pairwise distinct points from X with

$$\alpha = \frac{4n-5}{4n-4} = \max = \left\{\frac{2n-3}{2n-2}, \frac{n-1}{n}, \frac{n}{n+1}, \ldots, \frac{(n-2)+2^{n-3}}{(n-1)+2^{n-3}}, \frac{4n-5}{4n-4}\right\}.$$

Therefore, T is a perimetric contraction on n- gon in X.

□

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Synthesis of Environmentally Friendly Nanocrystalline ZrO_2, Nb_2O_5 and $Nb_2Zr_6O_{17}$ Catalysts to Pyrazolone Derivatives Synthesis Via Knoevenagel Condensation.

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Abstract

Synthesis of nanocrystalline ZrO_2, Nb_2O_5 and $Nb_2Zr_6O_{17}$ were carried by using molten salt synthesis method. Highly pure oxide and NaCl were mixed into 1: 10 mole ratio using mortar and pestle. Further mixed powder was decomposed at 800, 840 and 860°C in furnace for 12 hr. diffuse reflectance spectra (DRS) was obtained after heating of each well-grounded powder materials to study the phase purity. At the end the fine ground powder was washed using distilled water to remove NaCl. Oven dried material at 120°C for 6 hr were used as environmental catalyst to synthesis of heterocyclic organic to Pyrrazolone derivative. After the reaction catalyst was recovered and oven dried to recycle to the synthesis. It shows that almost same yield of pyrrazolone material which is important to synthesis of antibacterial materials. XRD results are closely matched with TEM images with an average particle size in the range of 50–80 nm. All the catalyst synthesized were environmentally friendly. Our approach not only useful to organic synthesis but also to obtain the renewable energy.

Keywords:

Pyrazol-5(4H)-one, Chromones, nano oxide catalysts, Knoevenagel condensations

1. Introduction

The synthesis of environmentally friendly nanocrystalline metal oxides has increased considerable attention due to their potential applications in green chemistry, catalysis, and sustainable organic transformations. Among these, zirconium dioxide (ZrO_2), niobium pentoxide (Nb_2O_5), and their mixed oxide composites, such as $Nb_2Zr_6O_{17}$, have emerged as promising heterogeneous catalysts due to their high thermal stability, acidity, and tunable surface properties. These materials are particularly effective in catalytic organic transformations, including the synthesis of pyrazolone derivatives via the Knoevenagel condensation reaction.

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Pyrazolone derivatives are an important class of heterocyclic compounds with diverse applications in pharmaceuticals, agrochemicals, and materials science. The Knoevenagel condensation, a widely used method for C=C bond formation, provides an efficient and straightforward approach for synthesizing pyrazolones under mild and environmentally benign conditions. However, conventional catalysts used in this reaction often involve toxic reagents, harsh conditions, or non-recyclable homogeneous systems, leading to environmental concerns and limitations in catalyst recovery.

The development of nanocrystalline ZrO_2, Nb_2O_5, and $Nb_2Zr_6O_{17}$ catalysts offers a sustainable and efficient alternative for pyrazolone synthesis. These metal oxides exhibit strong Lewis and Brønsted acidity, high surface area, and excellent catalytic activity, making them ideal candidates for facilitating Knoevenagel condensation. Additionally, their heterogeneous nature allows for easy separation and reusability, reducing waste and enhancing process sustainability.

In this study, we report the synthesis and characterization of nanocrystalline ZrO_2, Nb_2O_5, and $Nb_2Zr_6O_{17}$ catalysts and their application in the synthesis of pyrazolone derivatives via Knoevenagel condensation. The influence of catalyst composition, morphology, and reaction conditions on product yield and selectivity is systematically investigated. Our findings highlight the potential of these eco-friendly nanocatalysts in green and sustainable organic synthesis.

Experimental Section

Synthesis of Nanocrystalline Catalysts via Molten Salt Synthesis (MSS)

Molten Salt Synthesis (MSS) is an effective method for obtaining nanocrystalline materials with high purity, controlled morphology, and enhanced catalytic properties. The process involves the dissolution of precursors in a molten salt medium, which facilitates homogeneous nucleation and crystal growth.

2.1 Synthesis of ZrO_2 Nanoparticles

Zirconium oxychloride ($ZrOCl_2 \cdot 8H_2O$) was mixed with an equimolar ratio of NaCl-KCl salt mixture in a 1:4 weight ratio (precursor:salt) was taken in mortal pastel. The mixture was heated in a crucible at 700°C for 4 hours in a muffle furnace under air atmosphere. After cooling, the solidified mass was washed thoroughly with hot deionized water to remove residual salts. The obtained powder was dried at 100°C for 6 hours and further calcined at 500°C for 3 hours to obtain pure nanocrystalline ZrO_2.

2.2 Synthesis of Nb_2O_5 Nanoparticles

Niobium pentachloride ($NbCl_5$) was dissolved in an equimolar NaCl-KCl salt mixture in a 1:4

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weight ratio was taken in mortal pastel and make it homogenous. The mixture was heated at 750°C for 5 hours in a furnace. The cooled product was washed with hot deionized water to remove the molten salt medium, followed by drying at 100°C. The dried sample was calcined at 500°C for 4 hours to obtain nanocrystalline Nb_2O_5.

2.3 Synthesis of $Nb_2Zr_6O_{17}$ Nanocomposite

Zirconium oxychloride ($ZrOCl_2 \cdot 8H_2O$) and niobium pentachloride ($NbCl_5$) were mixed in a molar ratio of 6:2 in deionized water and stirred for 2 hours. Ammonium hydroxide (NH_4OH) was added dropwise until the pH reached ~9, leading to the formation of a precipitate. The precipitate was filtered, washed, and dried at 120°C for 6 hours. The dried precursor was ground with NaCl-KCl salt mixture in a 1:4 weight ratio and heated at 800°C for 5 hours in a furnace. The product was cooled, washed with deionized water to remove salts, dried at 100°C, and further calcined at 600°C for 4 hours to obtain nanocrystalline $Nb_2Zr_6O_{17}$.

3. Characterization of Catalysts

The synthesized nanocrystalline catalysts were characterized using various analytical techniques:

- X-ray Diffraction (XRD): To determine the crystalline phase and purity.
- Fourier Transform Infrared Spectroscopy (FTIR): To analyze functional groups and chemical bonding.
- Scanning Electron Microscopy (SEM): To study surface morphology and particle distribution.
- Transmission Electron Microscopy (TEM): To determine nanoscale structural features.
- Brunauer–Emmett–Teller (BET) Analysis: To measure surface area and porosity.

4. Catalytic application for Knoevenagel Condensation for Pyrazolone Synthesis

A mixture of aldehyde (1 mmol), pyrazolone (1 mmol), was taken 25 ml round bottom flask and 10 ml ethanol was added in it. The synthesized nanocatalyst (10 mol% with respect to the reactants) was added to the reaction mixture. The reaction was carried out under reflux at 80°C with continuous stirring for 2–4 hours. The progress of the reaction was monitored by thin-layer chromatography (TLC). After completion, the reaction mixture was cooled to room temperature. The solid product was filtered, washed with cold ethanol, and recrystallized to obtain pure pyrazolone derivatives. The solid catalyst was separated by filtration, washed with ethanol, dried at 100°C, and reused in subsequent reaction cycles.

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SCHEME-1

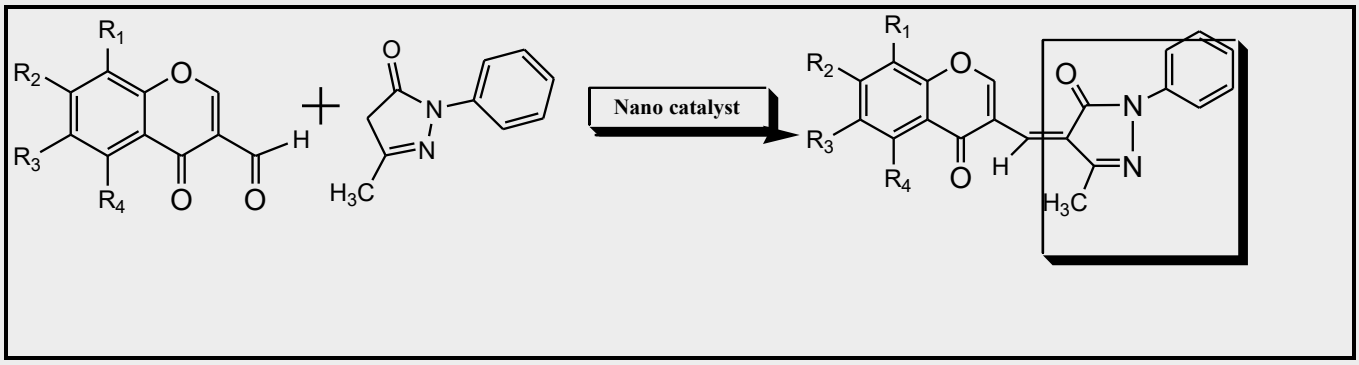


Table:1 Time and yield data of recently synthesized compounds using nono catalysts ZrO_2, Nb_2O_5 and $Nb_2Zr_6O_{17}$

Compound	R1	R2	R2	R4	ZrO_2,		Nb_2O_5		$Nb_2Zr_6O_{17}$	
					Time	% Yield	Time	%Yield	Time	%Yield
1	H	Cl	H	Cl	60 min	62	45 min	70	10 min	95
2	H	CH_3	Cl	H	70 min	52	70 min	65	15 min	90
3	H	H	Cl	H	65 min	60	60 min	67	15 min	92
4	CH_3	H	CH_3	H	90 min	54	90 min	60	25 min	85
5	H	CH_3	H	H	82 min	55	65 min	65	12 min	87

Catalyst Reusability Study

The recovered catalysts were tested for their recyclability in multiple reaction cycles. After each cycle, the catalyst was washed, dried, and reused under identical reaction conditions. The efficiency and product yield were evaluated to assess catalyst stability and performance over consecutive runs.

Conclusion

The molten salt synthesis (MSS) method successfully produced nanocrystalline ZrO_2, Nb_2O_5, and $Nb_2Zr_6O_{17}$ catalysts with high purity, controlled morphology, and excellent catalytic performance. The catalysts were effectively used in the Knoevenagel condensation reaction, demonstrating their potential as environmentally friendly and reusable materials for sustainable

organic synthesis.

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Artificial Intelligence: Grasping Today and Tomorrow

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Abstract

Artificial Intelligence (AI) is changing how we engage with technology by allowing machines to learn, adapt, and make decisions. This paper examines the definition, operation, and future of artificial intelligence. It talks about deep learning, machine learning, and applications in fields like automation, healthcare, and finance. . It also highlights ethical concerns, including bias and job loss. The final section of the paper examines upcoming developments in AI and how society may get ready for these developments.

1. Introduction

Artificial Intelligence (AI) is a field within computer science dedicated to building machines that can emulate human intelligence. These AI-driven systems handle huge volumes of data, recognize patterns, and make decisions, boosting efficiency in many industries. Although AI has been in development for years, recent breakthroughs in computing power and data access have made it more influential than ever.

2. How AI Works

AI systems rely on algorithms, which are basically a series of instructions aiding computers in problem-solving. There are three main categories of AI:

1) Narrow AI – Specializes in specific tasks such as voice assistants like Siri and Alexa, recommendation systems(Netflix, YouTube),spam filters in emails.
2) General AI – This AI can understand, learn and apply intelligence across various tasks like a human.
3) Super AI – A theoretical stage where AI exceeds human intelligence. It could have independent thoughts, emotions and consciousness.

- **Machine Learning (ML)**

Machine Learning (ML) is a type of Artificial Intelligence (AI) that enables computers to learn from data and make predictions or decisions without explicit programming.

- **Deep Learning (DL)**

Deep learning is a subset of machine learning that uses artificial neural networks to model

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and solve complex problems. It is inspired by the structure and function of the human brain, consisting of multiple layers of interconnected nodes (neurons).

3. Applications of AI

AI is making waves across nearly every industry, boosting both efficiency and precision. Here are some significant applications:

1) Healthcare: AI aids in diagnosing illnesses, developing medications, and assisting in robotic surgeries.
2) Finance: Financial institutions use AI for fraud prevention, risk assessment, and automated trading.
3) Retail: AI enhances shopping experiences and streamlines supply chains.
4) Autonomous Vehicles: AI allows self-driving cars to navigate safely.
5) Cybersecurity: AI for phishing detection, threat intelligence, and automated security alerts.

4. Ethical and Social Concerns

While AI brings numerous advantages, it also raises ethical questions:

1) Bias in AI: AI systems might reflect the biases present in their training data.
2) Job Loss: Automation could eliminate certain jobs, demanding adaptability from the workforce.
3) Privacy Concerns: AI's dependence on large datasets raises issues related to data security.
4) Decision Transparency: Many AI models are intricate and hard to explain.

5. The Future of AI

We can expect significant advancements in AI in the years to come. Key trends include:

1) AI in Education: Customized learning experiences are likely to gain traction.
2) AI for Creativity: AI could lend a hand in writing, music, and art creation.
3) Ethical AI Development: There's an increasing focus on regulations aimed at ensuring responsible AI usage.
4) General AI Research: Researchers are pursuing AI that can think similar to humans.

6. Conclusion

AI stands as a powerful force shaping our future. While it offers many benefits, it also poses challenges that need to be addressed. By promoting ethical AI development and preparing for changes in the workforce, we can unlock AI's full potential for a brighter future.

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IOT Based Mining Helmet For Coal Miners

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Abstract:

The "IoT-Based Mining Helmet for Coal Miners" project aims to enhance the safety and well-being of coal miners by developing a smart helmet equipped with advanced sensors and IoT technology. This helmet integrates an ESP32 microcontroller with MQ2, MQ7, and MQ135 gas sensors, a DHT11 temperature and humidity sensor, and an LCD display. The MQ2, MQ7, and MQ135 sensors monitor hazardous gases such as methane, carbon monoxide, and other toxic fumes, ensuring real-time detection of dangerous atmospheric conditions in underground mines. The DHT11 sensor provides continuous measurement of temperature and humidity to prevent heat-related illnesses.

The ESP32 microcontroller serves as the processing unit, collecting data from the sensors and transmitting it wirelessly to a central monitoring system via Wi-Fi. The onboard LCD display offers miners immediate visual feedback on environmental conditions, while alerts and warnings are generated when unsafe thresholds are breached. This system not only improves situational awareness for miners but also enables remote monitoring for safety personnel, allowing timely interventions in emergencies. By combining sensor technology, real-time data transmission, and IoT integration, this smart mining helmet presents a proactive solution to enhance occupational safety, reduce accidents, and safeguard miners' health.

Introduction

Coal mining is one of the most hazardous occupations, with miners constantly exposed to a range of environmental dangers, including toxic gases, high temperatures, and poor ventilation. Traditional safety measures, while effective to some extent, often lack real-time monitoring and prompt alert systems, limiting their ability to prevent accidents and health risks. The dynamic and unpredictable nature of underground mining environments necessitates advanced technological solutions to enhance safety standards and reduce life-threatening incidents.

The advent of the Internet of Things (IoT) has opened new avenues for developing intelligent and connected safety devices. This research presents an innovative IoT-based smart mining helmet designed specifically for coal miners. The proposed helmet integrates an ESP32 microcontroller with a suite of sensors, including the

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MQ2, MQ7, and MQ135 gas sensors for detecting methane, carbon monoxide, and other harmful gases, along with a DHT11 sensor for monitoring temperature and humidity levels. An LCD display is incorporated to provide miners with immediate feedback on environmental conditions, while wireless data transmission enables real-time monitoring by safety personnel at a central station.

By offering early detection of hazardous conditions and facilitating rapid emergency responses, this smart helmet aims to significantly improve safety protocols in the mining industry. The proposed system not only enhances individual miner safety but also contributes to broader occupational health management, showcasing the potential of IoT in transforming traditional safety practices.

Proposed work:

This research proposes the development of an IoT-based smart mining helmet using an ESP32 microcontroller integrated with MQ2, MQ7, and MQ135 gas sensors, a DHT11 temperature and humidity sensor, and an LCD display. The system will provide real-time monitoring of hazardous gases and environmental conditions, transmitting data wirelessly to a central monitoring unit to enhance safety measures and enable prompt emergency responses in coal mining operations.

Methodology:

The proposed IoT-based smart mining helmet system is designed to provide real-time monitoring of hazardous conditions in coal mines through an integrated network of sensors and wireless communication technology. The methodology for this research involves a systematic approach, including hardware setup, sensor integration, data acquisition, processing, and wireless communication, as detailed below:

Hardware Components:

The system employs an ESP32 microcontroller as the primary processing unit due to its low power consumption, built-in Wi-Fi, and Bluetooth capabilities. The helmet is equipped with three gas sensors—MQ2, MQ7, and MQ135—to detect methane, carbon monoxide, and other toxic gases, respectively. A DHT11 sensor is incorporated to measure ambient temperature and humidity. An LCD display provides immediate feedback to miners regarding environmental conditions.

Sensor Integration and Calibration:

The gas sensors (MQ2, MQ7, and MQ135) are calibrated to predefined safety thresholds according to industrial standards. The DHT11 sensor is configured to maintain accuracy in temperature and humidity readings. Each sensor is interfaced with the ESP32 microcontroller using analog and digital pins, ensuring seamless data **flow.Data Acquisition and Processing**:

The microcontroller continuously collects data from all sensors at regular intervals. The sensor readings are

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processed using onboard algorithms to filter noise and improve accuracy. The ESP32 compares sensor data against safety thresholds. If dangerous gas concentrations or extreme temperature and humidity levels are detected, an alert is generated.

Alert Mechanism:

Upon detection of unsafe conditions, the helmet triggers an audible and visual alert for the miner using a buzzer and the LCD display. The display shows real-time sensor values and warning messages. The buzzer is activated in critical situations, prompting immediate action.

Wireless Communication and Remote Monitoring:

The ESP32 microcontroller transmits sensor data wirelessly to a central monitoring system through Wi-Fi. This data is logged and displayed on a graphical interface for safety personnel. The remote monitoring system can trigger evacuation protocols and emergency responses if necessary.

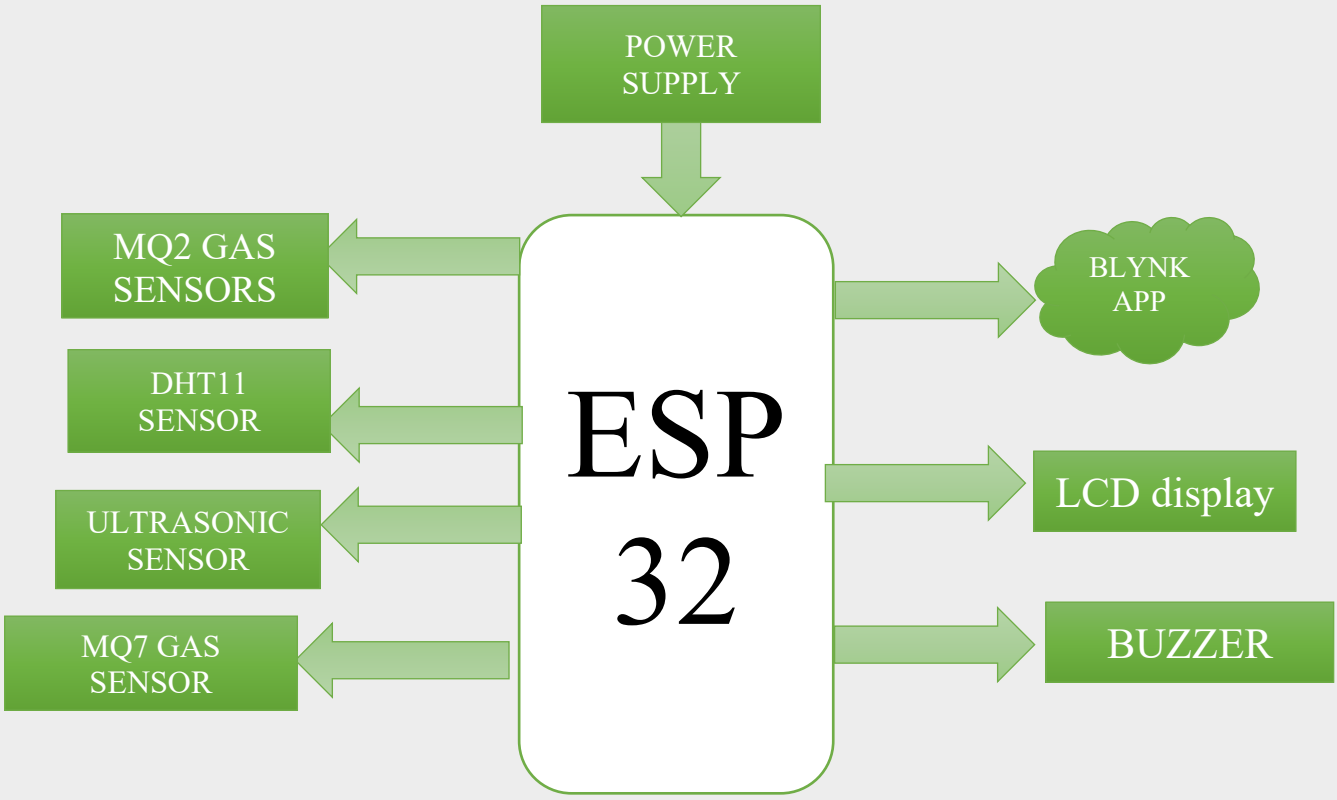
Power Management:

A rechargeable battery powers the helmet. To enhance operational efficiency, a low-power mode is implemented during periods of stability, extending battery life.

Testing and Validation:

The system will undergo rigorous testing in controlled environments to validate sensor accuracy and reliability. Field tests will be conducted in mining settings to evaluate performance under real-world conditions.This methodological framework ensures that the smart helmet is capable of delivering robust, real-time safety monitoring and contributes to proactive risk management in coal mining oper.

Block diagram



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Advantages:

The proposed IoT-based smart mining helmet offers several advantages, significantly enhancing safety and operational efficiency in coal mining environments. It provides real-time monitoring of hazardous gases and environmental conditions, ensuring early detection of dangers such as toxic gas leaks and extreme temperatures. The system's wireless data transmission capability enables remote monitoring by safety personnel, facilitating prompt emergency responses and effective risk management. The helmet's compact and portable design ensures miner comfort and mobility while maintaining safety standards. By utilizing cost-effective components such as the ESP32 microcontroller and readily available sensors, the solution is economically viable for large-scale implementation. Overall, this smart helmet promotes proactive safety measures, reduces the risk of accidents, and contributes to improved occupational health management in the mining industry.

Future scope

The IoT-based smart mining helmet presents numerous opportunities for future enhancement and broader applications. Future work could integrate advanced sensors, such as optical particle counters for dust detection, to provide a more comprehensive assessment of air quality. The inclusion of GPS modules would enable precise location tracking of miners, improving rescue operations during emergencies. Machine learning algorithms could be incorporated to predict hazardous conditions by analyzing historical sensor data trends. Additionally, integrating the system with wearable health monitoring devices could provide real-time insights into miners' physical health, further enhancing safety protocols. Expanding the wireless communication module to support advanced networks like LoRa or 5G would enable seamless data transmission over larger mining areas. The helmet's application could also be extended to other hazardous industries, such as construction, oil and gas, and chemical manufacturing, demonstrating its versatility and potential for widespread adoption.

Conclusion:

This research introduces a smart mining helmet leveraging IoT technology to enhance safety in coal mining operations. By integrating an ESP32 microcontroller with gas sensors (MQ2, MQ7, MQ135), a DHT11 temperature and humidity sensor, and an LCD display, the proposed system offers real-time monitoring of hazardous gases and environmental conditions. The helmet's ability to provide immediate alerts to miners and enable remote monitoring by safety personnel contributes to proactive safety management and reduces the risk of accidents. The proposed solution is not only cost-effective but also scalable, demonstrating significant potential for improving occupational safety standards in

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the mining industry. With future enhancements, this smart helmet could become a vital safety tool across various hazardous work environments, showcasing the transformative impact of IoT in industrial safety applications.

Refrences:

Google scholar

Old videos of related project

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Automatic Grass Cutting Using Arduino

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Abstract

This project presents the design and development of an autonomous grass cutting machine using Arduino. The machine utilizes a combination of sensors, actuators, and Arduino microcontrollers to navigate and cut grass automatically. The system integrates ultrasonic sensors for obstacle detection, GPS for navigation, and a cutting mechanism using a DC motor. The Arduino microcontroller processes sensor data and controls the machine's movement and cutting actions. The machine is designed to optimize cutting efficiency, reduce manual labor, and promote lawn maintenance. This project demonstrates the potential of Arduino-based automation in gardening and lawn care applications.

Keywords: Autonomous systems, Arduino, Grass cutting machine, Lawn maintenance, Automation, Robotics.

Introduction

The increasing demand for efficient lawn maintenance solutions has led to the development of autonomous grass cutting machines. These machines offer improved cutting efficiency, reduced manual labor, and enhanced lawn aesthetics. This project aims to design and develop an autonomous grass cutting machine using Arduino, a popular microcontroller platform. In recent years, the demand for automated solutions in everyday tasks has significantly increased, particularly in gardening and lawn maintenance. Traditional lawn care can be time-consuming and labor-intensive, requiring regular mowing to keep grass at an optimal height and maintain an aesthetically pleasing appearance. With advancements in technology, especially in robotics and microcontrollers, it is now possible to automate these tasks, offering convenience and efficiency. The objective of this project is to design and develop an automatic grass cutting system using an Arduino Uno. This robotic mower is intended to autonomously navigate a designated area, detect obstacles, and effectively cut grass while minimizing the need for human intervention.

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By utilizing sensors for navigation and a motorized cutting blade, the system aims to provide an effective solution for homeowners and landscapers alike.This report outlines the design, hardware components, working principles, and potential applications of the automatic grass cutting system, highlighting its advantages and areas for future improvement. The successful implementation of this project not only demonstrates the capabilities of microcontroller technology but also paves the way for further innovations in automated gardening solutions.

Methodology

Chassis Setup: The robot's chassis is constructed to hold all components securely. The chassis should include mounts for motors and blades, as well as space for the Arduino and sensors. **Motor Control:** Two DC motors are used to drive the wheels, and one or two additional motors control the cutting blades. Motor drivers (e.g., L298N) interface the DC motors with the Arduino, providing control over speed and direction. **Obstacle Avoidance and Navigation: Ultrasonic Sensors**: These sensors detect obstacles in the robot's path. When an obstacle is detected, the Arduino adjusts the movement of the robot (e.g., by reversing or turning).**Boundary Detection**: Limit switches or predefined boundary lines (such as a perimeter wire) are used to define the mowing area. The robot turns around when it reaches these boundaries.

Compass or IR Sensors: To ensure that the robot covers the entire area without repetition, a compass or IR sensors can help the robot maintain orientation.**Cutting Mechanism**: A motorized blade system is placed beneath the chassis, and the blade motor is controlled by the Arduino to start/stop cutting. It is essential to ensure that the blades are safe and covered while the robot is operating.**Power Supply**: A rechargeable battery powers both the Arduino and motors. A solar panel can be added for recharging if desired.

Working Process: Start-Up: When the system is powered on, the Arduino runs an initialization sequence to check motor functionality, sensor calibration, and boundary detection. **Autonomous Navigation**: The ultrasonic sensors continuously scan for obstacles in the robot's path. If an obstacle is detected, the robot changes its direction (turns or reverses).The robot moves in a random pattern or a pre-defined path (such as a spiral or grid pattern) until the area is fully covered. If the robot detects the boundary (either through the boundary sensors or limit switches), it turns to stay within the designated mowing area.

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Grass Cutting: The blade motor operates based on the proximity of grass (as the robot moves). The Arduino continuously sends signals to the motor to power the blade during movement, ensuring that it cuts grass in the robot's path. When the robot finishes mowing an area, it either returns to its starting point or turns off the cutting mechanism.

Recharging (Optional):The robot can be equipped with an automatic return-to-base feature. Once the battery is low, the robot returns to a charging station for recharging, which can be done using a wireless charging module or a docking station.

Challenges and Considerations: **Battery Life**: The robot must operate efficiently to minimize battery consumption while mowing large areas.

Navigation Precision: For larger or more complex areas, GPS or advanced mapping software may be required to create more accurate paths.

Safety: The system must ensure that it can stop the cutting blades in case of any obstruction, such as a person or animal.

Weather Resistance: The system must be waterproof and resistant to outdoor conditions, especially the electrical components.

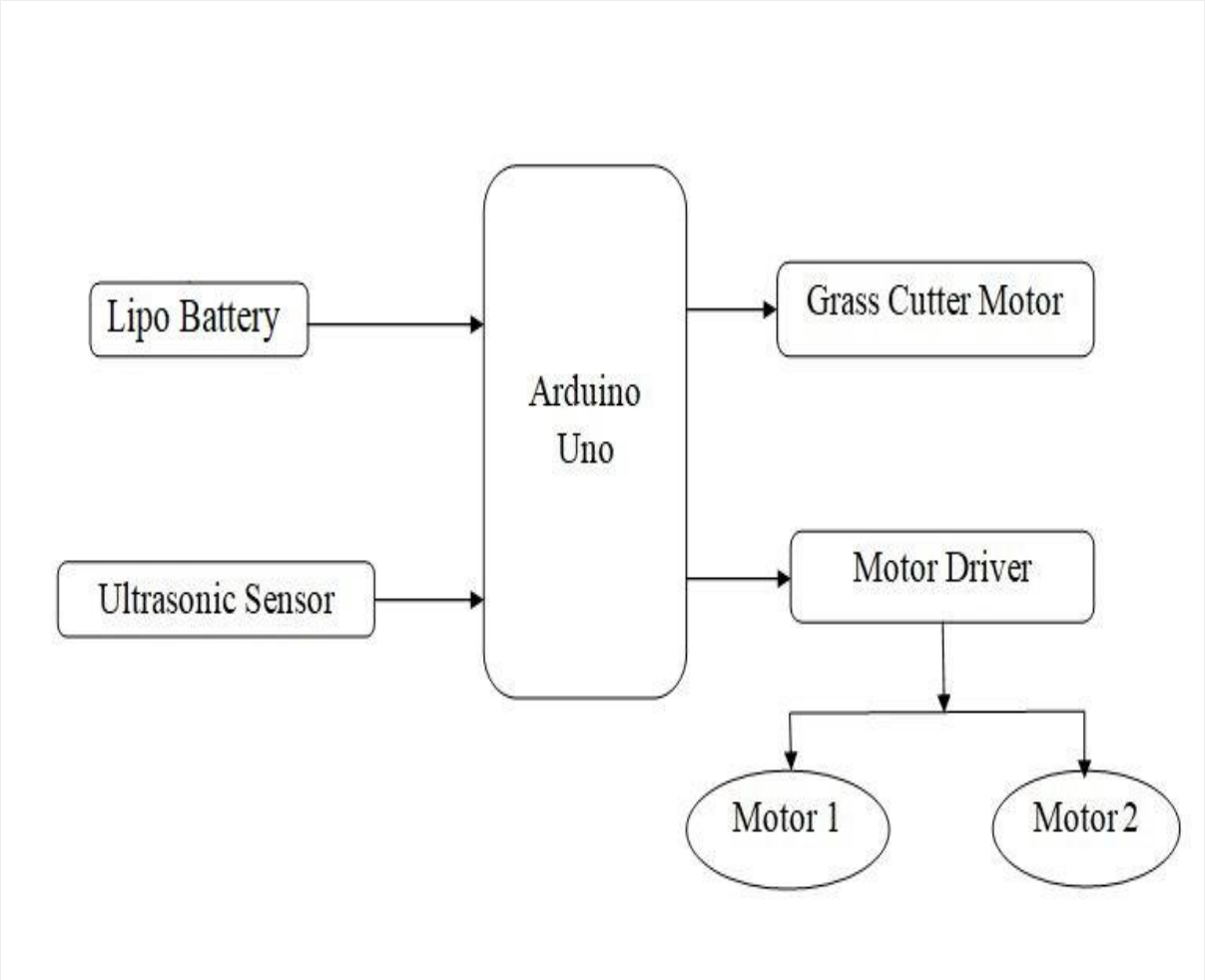
Possible Enhancements: **Remote Control**: Using a Bluetooth or Wi-Fi module, you can add a Smartphone app or web interface to control and monitor the robot.

GPS Navigation: For large lawns, using GPS modules can help in creating a grid-based or path-following movement pattern.

Solar Charging: A solar panel can be integrated to recharge the robot when it's idle, reducing the need for human intervention.

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Block Diagram



Conclusion

The automatic grass cutting system using Arduino Uno represents a significant advancement in lawn care technology, combining automation, efficiency, and convenience. This project demonstrates how robotics and microcontroller technology can simplify everyday tasks, allowing users to maintain their lawns with minimal effort. savings, consistent performance, and environmental friendliness make this solution appealing for homeowners and commercial landscapers alike.

While the system has its limitations, such as initial costs and terrain Through the integration of sensors, motor drivers, and control algorithms, the system can navigate its environment, detect obstacles, and effectively cut grass. The benefits of labor restrictions, the ongoing developments in technology and the increasing demand for automated solutions suggest a bright future for robotic mowers. Future enhancements, including improved navigation, smart connectivity, and

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adaptive learning, hold the potential to elevate these systems to new heights, making them even more efficient and user-friendly. In conclusion, the automatic grass cutting system not only showcases the possibilities of current technology but also paves the way for future innovations in landscaping and gardening. As these technologies evolve, they will likely play an essential role in the maintenance of green spaces, contributing to a more sustainable and automated future in care lawn.

Advantages

Labor Savings Reduces the need for manual mowing, allowing homeowners and landscapers to save time and effort. This is especially beneficial for individuals with large lawns or those unable to mow due to physical constraints.

Consistency and Precision Provides consistent cutting height and coverage, ensuring a well-maintained lawn. The system can operate on a schedule, resulting in evenly trimmed grass without missed spots.

Efficiency Operates autonomously, allowing for continuous mowing while the user engages in other activities. This efficiency can lead to better lawn health, as regular cutting promotes growth and prevents overgrowth.

Obstacle Detection Equipped with sensors to detect obstacles, the mower can navigate around furniture, trees, and other obstacles without human intervention, minimizing the risk of damage to both the mower and surroundings.

Eco-Friendly Many robotic mowers use electric power, which reduces carbon emissions compared to gas-powered mowers. This makes them a more environmentally friendly option for lawn care.

Cost-Effective Over Time Although the initial investment in a robotic mower may be higher than a traditional mower, the reduction in labor costs and maintenance over time can lead to savings.

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Future Work

Advanced Navigation Systems GPS Integration: Incorporating GPS technology can enable precise mapping and navigation, allowing the mower to cover larger areas efficiently and return to a charging station autonomously. **SLAM Technology**: Implementing Simultaneous Localization and Mapping (SLAM) can improve obstacle detection and path planning, allowing the mower to navigate complex terrains more effectively.

Improved Sensor Technology LIDAR Sensors: Using LIDAR (Light Detection and Ranging) can enhance obstacle detection accuracy and improve navigation capabilities, especially in dense or complex environments. **Multiple Sensors**: Incorporating additional sensors (e.g., infrared, cameras) can provide better environmental awareness and help the mower avoid obstacles more effectively.

Smart Connectivity Mobile App Control: Developing a mobile application for remote monitoring and control can enhance user interaction, allowing users to set schedules, receive alerts, and adjust settings from their smartphones. **IoT Integration**: Connecting the mower to the Internet of Things (IoT) can enable real-time data sharing, allowing for remote diagnostics, updates, and integration with smart home systems.

Enhanced Battery Technology Solar Power Integration: Incorporating solar panels could allow for self-charging capabilities, reducing downtime and dependency on traditional power sources. **Longer Battery Life**: Future designs can focus on using higher-capacity batteries or improved energy management systems to increase operational time.

Machine Learning and AI Adaptive Learning: Implementing machine learning algorithms can enable the mower to learn from its environment over time, optimizing its cutting paths and improving efficiency. **Data Analytics**: Using AI to analyze lawn conditions can help customize mowing strategies based on grass type, growth rate, and weather patterns.

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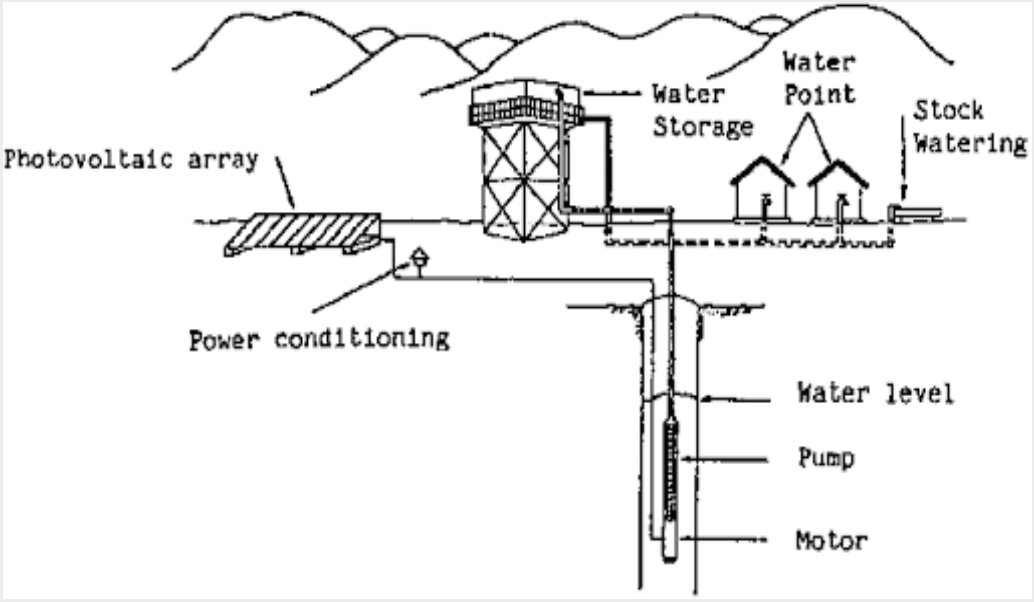
Development and Automated Solar Power with Water pump of using tracker in agriculture

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Abstract:
Agricultural technology is changing rapidly. Farm machinery, Farm building and production facilities are constantly being improved. Agricultural applications suitable for photovoltaic (PV) solutions are numerous. These applications are a mix of individual installations and systems installed by utility companies when they have found that a PV solution is the best solution for remote agricultural need such as water pumping for crops or livestock. A solar powered water pumping system is made up of two basic components. These are PV panels and pumps. The smallest element of a PV panel is the solar cell. Each solar cell has two or more specially prepared layers of semiconductor material that produce direct current (DC) electricity when exposed to light. This DC current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines, or stored in batteries for later use by the pump. The aim of this article is to explain how solar powered water pumping system works and what the differences with the other energy sources are.
.**Keywords**: Solar Panel, Watere Level Sensor, Battery Storage, LDR Sensor, Water Pump, etc.

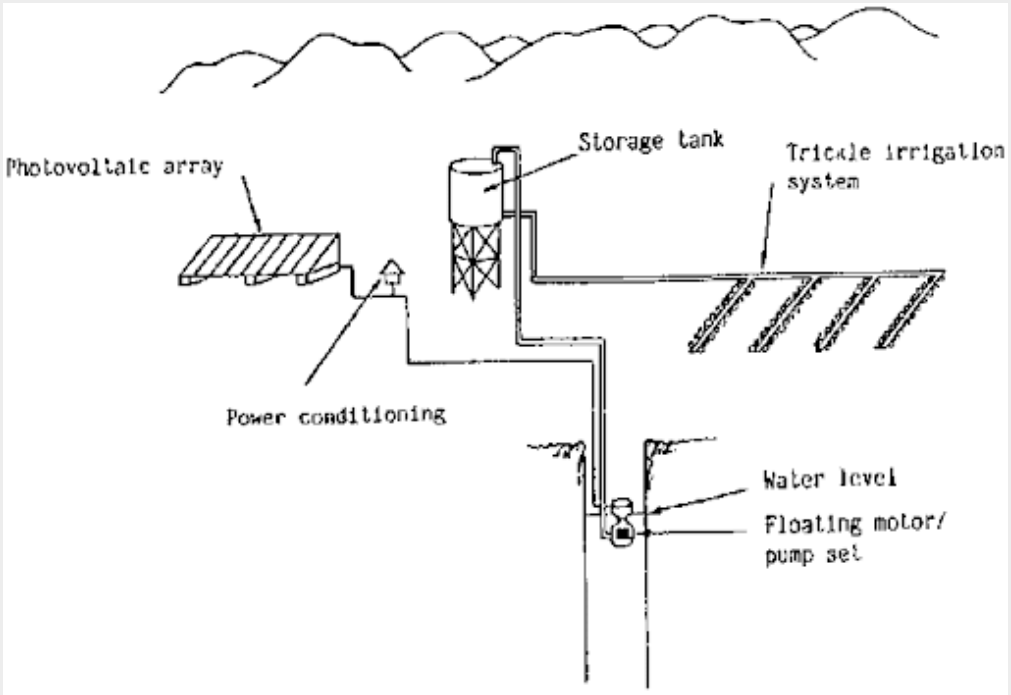
Introduction Energy is a key ingredient for the overall development of an economy. India has been endowed with abundant renewable solar energy resource. India is large country and the rate of electrification has not kept pace with the expanding population, urbanization and industrialization and has resulted in the increasing deficit between demand and supply of electricity. This has not only resulted in under electrification but also put heavy pressure on the governments to keep pace with demand for electricity. People not served by the power grid have to rely on fossil fuels like kerosene and diesel for the poor people in rural areas.

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(Figure 1: solar Water pumping system)

Wherever the rural areas have been brought under power grid the erratic and unreliable power Supply has not helped the farmers and the need for an uninterrupted power supply especially during the critical farming period has been a major area of concern. India receives a solar energy equivalent of 5,000 trillion KWh/year with a daily average solar energy incidence of 4-7 KWh/m2. This is considerably more than the total energy consumption of the country. Further, most parts of the country experience 250-300 sunny days in a year, which makes solar energy a viable option in these areas. Decentralized renewable energy system, which relies on locally available resources, could provide the solution to the rural energy problem, particularly in remote areas where grid extension is not a viable proposition.



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(Figure 2: Solar Irrigation System)

Solar energy, with its virtually infinite potential and free availability represents a nonpolluting and inexhaustible energy source which can be developed to meet the energy need of mankind in a major way. The high cost, fast depleting tested kits are available to retrofit the most pole most pole mounting applications.

Proposed work

The proposed work focuses on developing an automated solar-powered water pumping system with a solar tracker to enhance agricultural irrigation efficiency. The system integrates a solar panel with a dual-axis or single-axis tracking mechanism to maximize sunlight absorption, ensuring optimal energy generation throughout the day. A microcontroller-based automation unit controls the water pump operation based on real-time data from soil moisture sensors, temperature sensors, and water level detectors. This automation ensures precise irrigation, reducing water wastage and energy consumption. The use of renewable solar energy minimizes dependence on conventional power sources, making the system environmentally friendly and cost-effective for farmers. By implementing this solution, agricultural productivity can be improved while promoting sustainable and efficient water resource management**.**

Methodology

System Design & Planning

Requirement Analysis: Determine power requirements based on land size, crop type, and water demand.

Component Selection: Choose solar panels, tracking mechanism, water pump, microcontroller, and sensors.

Solar Power System with Tracking

Solar Panel Installation: Mount photovoltaic panels on a tracking system to follow the sun's movement.

Tracking Mechanism: Implement a single-axis or dual-axis solar tracker using:

Light Dependent Resistors (LDRs) for detecting sunlight intensity.

Servo or stepper motors for panel movement.

A microcontroller (Arduino, Raspberry Pi, or PIC) to control tracking.

Water Pumping System

Pump Selection: Use a DC or AC submersible pump based on water source depth and flow rate requirements.

Solar Inverter (if needed): Converts DC power from solar panels to AC for an AC pump.

Automation & Control System

Microcontroller-Based Automation: Controls pump operation based on sensor inputs.

Sensors Used:

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Soil Moisture Sensor: Monitors soil water levels to trigger irrigation.

Temperature & Humidity Sensor: Adjusts irrigation timing based on weather conditions.

Water Level Sensor: Ensures the water source or storage tank has sufficient water before pumping.

Relay Module: Turns the pump ON/OFF based on sensor readings.

User Interface (Optional): Implement a mobile app or IoT-based remote monitoring for real-time control.

Implementation & Testing

System Integration: Connect all components and ensure proper communication between sensors, controllers, and actuators.

Field Testing: Deploy the system in an agricultural field and monitor performance over different weather conditions.

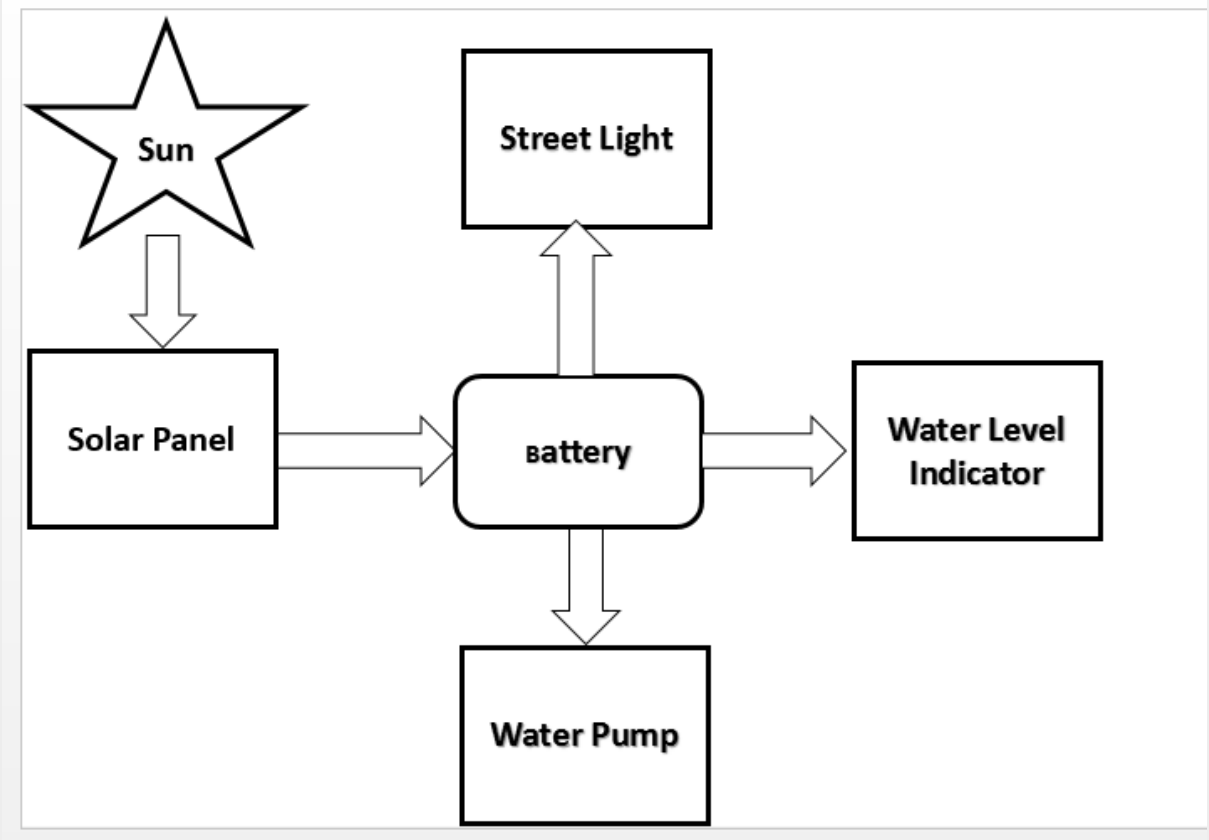
Optimization: Fine-tune parameters for efficient energy use and water management.

Maintenance & Scalability

Periodic Maintenance: Check solar panels, sensors, and pumps for efficiency.

System Scalability: Upgrade with additional solar panels, larger pumps, or advanced AI-based irrigation algorithms for improved performance.

Block Diagram



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Conclusion:

The development of an automated solar-powered water pump with a solar tracking system offers a sustainable and efficient solution for modern agriculture. By harnessing renewable energy, this system reduces the dependency on fossil fuels and traditional electricity sources, making it an environmentally friendly choice for rural and off-grid farming areas. The integration of automation and real-time monitoring enhances the precision of water usage, ensuring crops receive the optimal amount of water based on their needs. This not only conserves water but also increases crop yield and farm productivity, especially in regions facing water scarcity. The solar tracking technology maximizes energy efficiency by ensuring that the solar panels capture the most sunlight throughout the day, improving overall system performance. This innovative system holds great potential to transform agricultural practices, especially in remote, off-grid areas, by providing reliable, cost-effective, and sustainable irrigation solutions. As agriculture continues to face challenges due to climate change and limited resources, the widespread adoption of such technologies will play a crucial role in ensuring food security, promoting sustainable farming, and supporting rural development

Advantages:

Increased Energy Efficiency – The solar tracker maximizes sunlight absorption, improving energy generation by 25-40% compared to fixed panels.

Cost Savings – Eliminates electricity or fuel costs, making irrigation more affordable for farmers.

Water Conservation – Automated sensors regulate water usage, reducing wastage and optimizing irrigation.

Eco-Friendly & Sustainable – Uses renewable solar energy, cutting down carbon emissions and promoting sustainable farming.

Higher Crop Productivity – Ensures consistent irrigation, leading to better crop growth, higher yields, and improved farm income.

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