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Fire Alarm System Through Smoke Detection

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ABSTRACT- A reliable fire alarm system (FAS) is crucial for timely reporting and responding to fires. While existing techniques can predict undesirable outcomes, they lack guidance on when and how workers should intervene to minimize the associated costs. Recent advancements in sensors, microelectronics, and information technology have significantly improved fire detection technologies. However, the prevalence of synthetic materials in modern homes has increased the danger of fire-related injuries and deaths due to the release of toxic fumes and gases, including carbon monoxide. This highlights the need for ongoing analysis and development of fire detection techniques to ensure the safety of occupants.

KEYWORDS- Fire Alarm System, Smoke, Fire Safety, Synthetic Materials

I. INTRODUCTION

Fire is a dangerous threat for the safety of residents. Therefore, a form of fire disaster prevention is needed for residents by designing a fire early warning system. In our project, we have done data pre-processing using smote for sampling, min-max for normalization, outlier's detection, correlation matrix. The algorithms used in our project is random forest, decision trees and K-Nearest Neighbour.

The systematics of this paper is as follow. The first part discusses about motivation. Background, problem identification, purpose, and method are exposed in this section. The second part discusses about related works, previous research and papers that are related to the current research are discussed. The third part discusses about system design, the hardware specification and the algorithm of each classifier are exposed in this part. The fourth part discusses about evaluation, the comparison of each classifier are exposed in this part. The Fifth part discusses about conclusion, important findings are highlighted in this part. Future work are also discussed in the fifth chapter.

II. RELATED WORKS

This section goes through some recent works related to fire alarm system.

As per the study of this paper [1], the research introduces a novel two-stage fire detection approach utilizing video processing. In the initial stage, a combination of color and dynamic features is employed to identify real flames, while the motion orientation determines the fire region. The subsequent stage involves dividing the fire regions into spatio-temporal blocks and extracting correlation features that capture both spatial and temporal characteristics. These features are utilized to train and evaluate an SVM classifier. Remarkably, the method demonstrates accurate detection of general flames in the first stage, making it suitable for initial flame detection and sample selection in machine learning. Experimental results showcase its superior performance compared to existing methods in terms of true positive rate, false positive rate, and missing rate when tested on fire videos.

In this paper [2], the author developed and evaluated an alarm verification system using real industry data, combining stream processing, batch processing, and machine learning. The system achieved over 90% accuracy in classifying alarms at a streaming rate of 30K alarms per second. They also explored integrating unstructured data to improve classification accuracy and shared valuable lessons learned for researchers and practitioners building similar systems.

In this study [3], they focused on improving safety in smart homes by integrating gas leakage and fire systems using cost-effective, energy-efficient devices and M2M communication protocols. They proposed a dataflow system that collects valuable information and sends it to a central point in the M2M home network. Through experiments with our prototype system and various sensors, we applied supervised machine learning techniques to identify unexpected events and predict the level of danger. Additionally, their system can send timely notifications to alert relevant individuals and take appropriate actions.

This research [4] explores the utilization of acoustic sensors for early fire detection, aiming to enhance the reliability of existing fire detection methods by incorporating the acoustic signals generated during fire events. The study demonstrates that the acoustic vibrations produced by heated materials can be employed to train a machine learning algorithm for fire detection. The results indicate that the proposed machine learning approach successfully identifies fire events based on the measured acoustic signals. However, the performance of the convolutional neural network varies depending on the specific material exposed to the heat. It should be noted that this method serves as a proof-of-concept, and further investigation is required to examine factors such as different acoustic environments and materials, and potential techniques like transfer learning, domain adaptation, and data augmentation.

This research [5] findings indicate that the Naïve Bayes classification method demonstrates the highest performance among the tested algorithms for improving the detection rate of the smart fire alarm system prototype. With an accuracy of 100%, Naïve Bayes outperformed the decision tree (99.5%) and kNN (90%) due to limitations in rule complexity and varying data distances, respectively. The SVM method yielded the poorest results, suggesting that the linear hyperplane approach may not be suitable for data classification. Future work could involve implementing online learning for real-time operation of the Fire Alarm System while dynamically selecting the optimal classifier.

In this paper [6], author presents the design of an Internet of Things (IoT) fire alarm system that effectively alerts both the owner and the fire station during emergencies. The research focuses on distinguishing between different states of the surrounding environment, including sleep, passive, and active states, by utilizing a decision tree algorithm. By employing this approach, a cost-effective IoT system is developed, offering an ideal fire safety solution for residential areas and hospitals.

Researchers [7] have expanded the application of machine learning to predict fires in a specific scenario where multiple fires break out rapidly. Although this may seem implausible, it has become a grim reality in certain parts of the western United States due to the dry and hot conditions exacerbated by climate change. These circumstances pose significant fire risks and often lead to extensive destruction. Therefore, timely fire prediction is of paramount importance to enable swift action. Conventional fire monitoring approaches often struggle to detect fires in real-time, highlighting the need to address this critical issue. Numerous innovative approaches have been proposed to anticipate and predict forest fires, with a growing emphasis on integrating machine learning to enhance detection and prediction capabilities. Machine learning models offer advantages such as pooling operations, extracting detailed features, and leveraging substantial information, resulting in effective fire prediction outcomes. Furthermore, these models hold practical value in planning fire prevention and management strategies.

The utilization [8] of wireless sensor networks and machine learning in the proposed forest fire detection system has proven to be highly effective, offering improved accuracy in fire detection. The system ensures optimal performance by conducting analysis at both the sensor node and the base station, resulting in faster and more precise outcomes. A threshold ratio is implemented within the sensor node to adapt to various weather conditions and environments. This system can be deployed in any part of the forest, even without pre-existing network connectivity, as it relies on a dedicated built-in network infrastructure. With primary power supplied by rechargeable batteries and secondary solar power, the system can operate independently for extended periods. During real-life trials conducted in tropical forest sites, the integrated communication infrastructure of the proposed system exhibited faster response times, alerting relevant authorities promptly compared to existing systems.

This study [9] explores the application of wireless sensor networks and machine learning methods for detecting overheating and fire hazards within buildings. A wireless sensor network was deployed to gather temperature data from specific locations of interest. A novel machine learning algorithm was developed to intelligently analyze the collected data, taking into account information from individual sensors as well as their correlations. Through this algorithm, normal patterns were identified using training data, and hazards were detected by measuring the deviation of new observations from these established patterns. The proposed approach is fully automated, eliminating the need for human intervention. Experimental tests using real-world sensor data validated the effectiveness of the machine learning algorithm, demonstrating its potential in accurately detecting hazards.

This paper [10] presents a novel approach for flame alarm systems called New Feature Extraction and Description. The method involves extracting fire candidates in stable positions using a Chroma-intensity map, and utilizing the Brownian Correlation Descriptor as a discriminative feature vector. This descriptor incorporates dynamic dependence measures based on multiple adjacent frames to classify fire and fire-like objects. The proposed method demonstrates superior performance with a low false positive ratio compared to recent algorithms evaluated on the dataset. However, it should be noted that our approach has a higher computational complexity due to the utilization of additional frames.

III. METHODOLOGY

A. Data Collection

While selecting the data we made sure that our data should include all the attributes needed to get as precise result as possible.

B. Our data includes the following attributes-

Temperature[C], Humidity [%], TVOC[ppb], eCO2[ppm], Raw H2, Raw Ethanol, Pressure[hPa], PM1.0, PM2.5, NC0.5, NC1.0, NC2.5 and CNT.

C. Data Preprocessing

- DATA SELECTION- We used the heatmap method to select the data of interest. A heat map plots these coefficients to visualize the strength of correlation between variables. It helps you find the best features for your machine learning modeling. A heat map converts the correlation matrix to a color code.
- OUTLIER DETECTION- Outlier Detection is a key stage in numerous information mining undertakings. The motivation behind the outlier detection technique here is to recognize the boundaries impacted by the anomaly device out of thousands of boundaries. There are a few ways to deal with identifying exceptions. Boxplots were utilized for the information. Boxplots, otherwise called bristle plots, are made to show an outline of a bunch of information values with properties like least, first quartile, middle, third quartile, and most extreme.

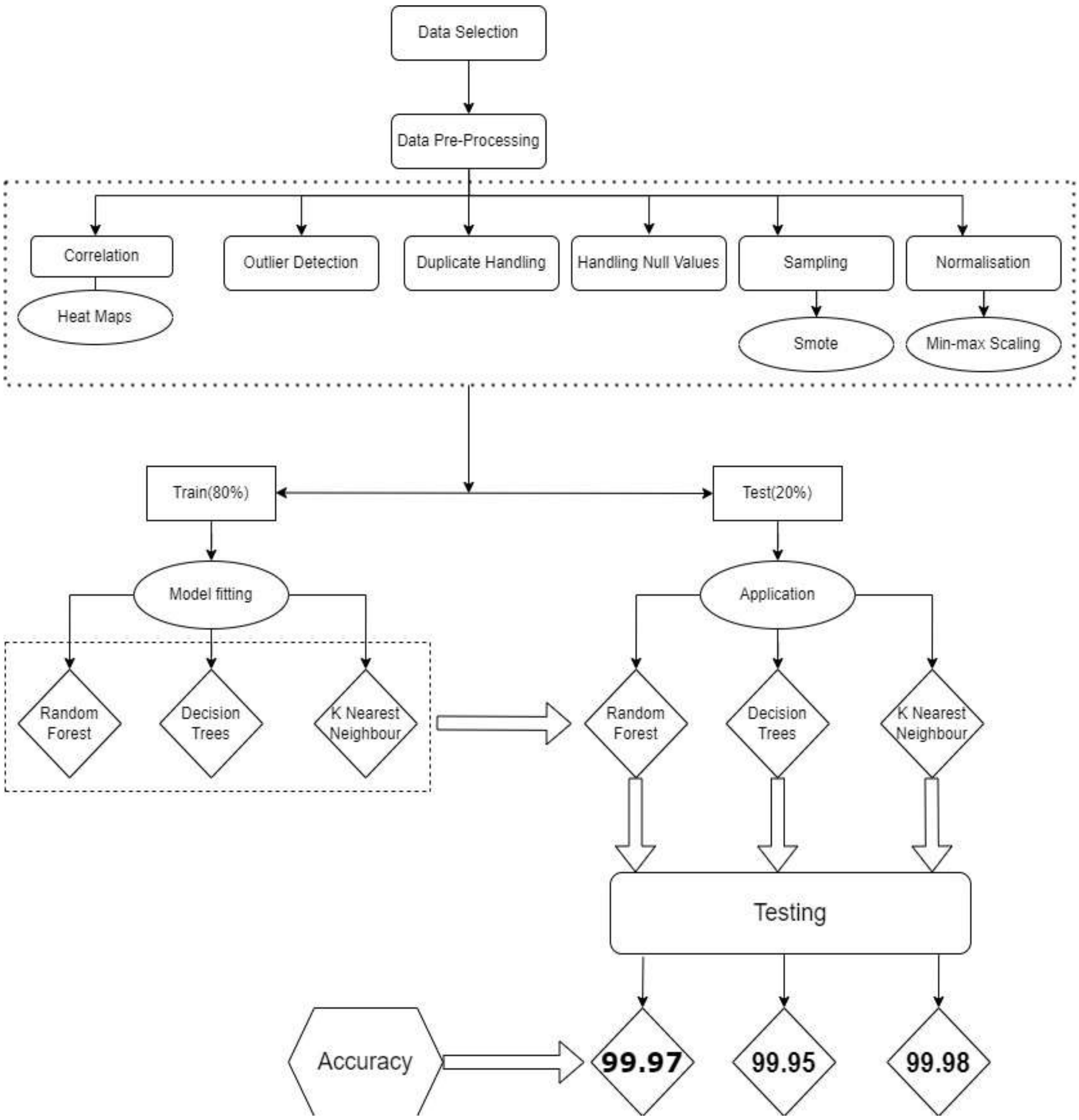

Figure 1: Methodology

- DUPLICATE HANDLING- We utilized Pandas built in technique drop duplicates () to drop copy columns. Naturally, this strategy returns another Data Frame with copy columns eliminated. We can set the contention in place=True to eliminate copies from the first Data Frame.
- HANDLING NULL VALUES- We utilized drone () for dealing with invalid qualities. The drone () capability is utilized to eliminate missing qualities. Decide whether lines or segments which contain missing qualities are eliminated. 0, or 'index': Drop columns which contain missing qualities. 1, or 'columns': Drop sections which contain missing worth.
- SAMPLING-For this we utilized the destroyed strategy for Destroyed (Engineered Minority Oversampling Method) is one of the most normally utilized oversampling procedures to tackle unevenness issues. The point is to adjust the class conveyance by copying and haphazardly expanding the minority class models. SMOTE orchestrates new minority examples between existing minority occasions.
- NORMALISATION- For standardization of the information we utilized min-max scaling. MIN-MAX SCALER change highlights by scaling each element to a given reach. This assessor scales and deciphers each element separately to such an extent that it is in the given reach on the preparation set, for example somewhere in the range of nothing and one.

D. Now, after that, we bifurcated our data into training and testing data. Using 80% of data for training and 20% of data for testing.

E. While training the data, we implemented 3 different models.

- RANDOM FOREST- Random Forest is a powerful and versatile supervised machine learning algorithm that grows and combines multiple decision trees to create a "forest". It can be used for both classification and regression problems in R and Python. A random forest algorithm consists of a collection of decision trees, where each tree in the ensemble consists of a sample of data drawn from the training set using permutations called bootstrap samples.
- DECISION TREES- A decision tree is like a flowchart where each inner node represents a test of a feature (such as whether a coin is flipped heads or tails) and each leaf node represents a class label (the decision

made after all features have been computed) and a branch. structure. Represents the combination of features that lead to these class designations.

- K-NEAREST NEIGHBOUR- The k-nearest neighbor's algorithm, also known as KNN or k-NN, is a non-parametric, supervised learning classifier, which uses proximity to make classifications or predictions about the grouping of an individual data point.

F. While testing the data, we applied the above 3 medals to the rest 20% data.

IV. NOVELTY

For this project, we have read more than 10 research papers and in all of them the most used method was image sensing and processing (a deep learning model) while we used supervised learning models like Decision trees, KNN and Random Forest (this being the algorithm as far as we have researched used nowhere for fire alarms and smoke detection). All of our project works textually without use of any kind of images. Our project reduces the complexity in solving the project.

V. RESULTS

When we implemented the 3 models to the testing data, the below table 1 shows the accuracy given by them.

Table 1: accuracy Results

ALGORITHM	ACCURACY
Decision trees	99.98%
Random Forest	99.97%
KNN	99.95%

The below table 2 shows the precision and recall.

Table 2: Evaluation Metrics

	precision	recall	f1-score
0	1.00	1.00	1.00
1	1.00	1.00	1.00
accuracy			1.00
macro avg	1.00	1.00	1.00
weighted avg	1.00	1.00	1.00

VI. CONCLUSION

In this paper, we have contributed by working with purely textual data, but as far as we've seen, all advances in fire alarms have been done with image data through image capture. Our project contributes to the achievement of SDG #3 "Health and well-being". Fire hazards are one of the most well-known disasters and our project helps prevent them in a more efficient way. We proposed an effective data flow system for collecting useful information at the central point of the project. From the dataset, we applied a supervised machine learning process to multiple algorithms to observe out-of-pattern events and predict levels of hazard risk. After applying the algorithms, the following table shows the accuracy achieved-

In future, we will collect more additional data and apply other machine learning algorithms to improve the accurate of the model to reduce the false positive. We have also the trend toward real-time analysis using cloud services

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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