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Autopilot Eco Plane to Reduce Air Pollution

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***Abstract* - This research paper explores the concept of an autonomous drone, "Eco plane" as a potential solution to reduce air pollution caused by commercial aviation. This drone will be equipped with an air quality detector to identify areas with high pollution levels. It will fly over these areas while carrying a chemical solution to purify the air. Image processing techniques will be employed to detect and avoid obstacles, optimizing the plane's purifying capabilities. Real-time data on air quality and pollution levels will be collected and displayed on a mobile app dashboard, aiding in the monitoring of daily air purification progress. The collected data will also be analyzed to develop algorithms that predict the lifespan of individuals residing in polluted areas and determine when the environment becomes uninhabitable. Furthermore, this research will employ machine learning techniques to identify pollutants, providing valuable insights to policymakers for effective pollution reduction strategies.**

Keywords: air pollution, source identification, machine learning, real-time and drone.

I. INTRODUCTION

Air pollution is a pressing global issue with far-reaching consequences for human health, the environment, and overall well-being. The release of pollutants into the atmosphere, particularly from industrial activities, transportation, and energy production, has led to the degradation of air quality in many regions around the world. The adverse effects of air pollution are numerous and significant, affecting both the natural environment and the human population.

[1] One of the most alarming effects of air pollution is its detrimental impact on human health. Exposure to polluted air has been linked to a wide range of respiratory diseases, including asthma, Chronic Obstructive Pulmonary Disease (COPD), and lung cancer. Fine particulate matter (PM2.5) and harmful gases such as nitrogen dioxide (NO2) and Sulfur Dioxide (SO2) can penetrate deep into the lungs, causing inflammation, reduced lung function, and increased vulnerability to respiratory infections. Additionally, air pollution has been associated with cardiovascular diseases, cognitive impairment, and adverse pregnancy outcomes.

II. BACKGROUND ANDLITERATURE SURVEY

Many kinds of research have been conducted previously regarding air pollution, automation drones and air purifying.

We can use machine learning techniques to identify the air pollution sources. These models can evaluate enormous amounts of data and find patterns that are hidden by conventional methods. The use of machine learning algorithms to pinpoint the sources of air pollution has been investigated through several types of research. For instance, research in China that employed a Random Forest model to pinpoint the causes of PM2.5 pollution discovered that transportation, industry, and biomass burning were the main contributors. Convolutional neural networks (CNNs) were utilized in another investigation to identify the causes of air pollution, and it was discovered that vehicles and industrial emissions were the main culprits.[2]

Similar IOT machine learning research has been conducted by Saima Zafar, Ghosia Miraj, Raja Baloch, Danish Murtaza, and Khadija Arshad from the Department of Electrical Engineering at the National University of Computer and Emerging Sciences Lahore, Pakistan. It is an environmental monitoring device that keeps track of the humidity and temperature of the immediate area in real-time. Wi-Fi is used to transmit the sensor data to the cloud. Then, in the Android app designed for the end user who can view the surroundings at the location where the hardware is put, those data are made into graphs in both real-time data and graphical analyses. This system is a fantastic illustration of how to construct an IoT application using machine learning [3].

Autonomous drones were the subject of research by Azade Fotouhi, Ming Ding, and Mahbub Hassan from the University of New South Wales' School of Computer Science and Engineering. Here, theory has been used to examine drone maneuverability in order to clarify the trade-off between drone flying speed and turning agility. The performance of practical

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maneuverability is then examined by simulating and flying a commercial drone with an Android app. Some real-world maneuverability requirements for situations where the drone must frequently change directions are revealed [4].

III. METHODOLOGY

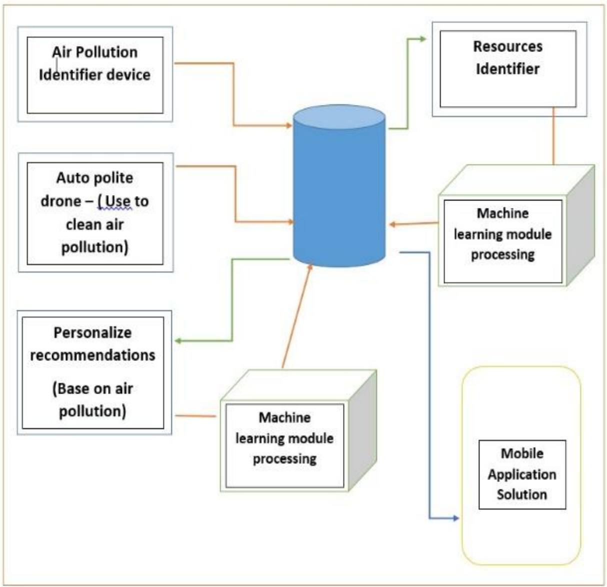

Figure 1: Overall process

a) Identification of sources of air pollution

In this component, we've focused to identify the accurate source of pollution and impact level with different sources and monitor the pollution via mobile app.

Here, three types of air pollution resources were identified. They are Mobile Sources, Stationary Sources, and Area Sources. Mobile sources encompass various forms of transportation, including automobiles, buses, aircraft, trucks, and trains. On the other hand, stationary sources comprise power plants, oil refineries, industrial facilities, and factories that remain fixed in one location. Lastly, area sources encompass locations such as agricultural areas, urban centers, and households with wood-burning fireplaces.

b) Detect and measure the polluted air

The design and development of an air quality monitoring machine will be carried out through this component.It will be designed using an Arduino Uno board, which is a type of microcontroller board and widely used for electronic prototyping. The machine will incorporate MQ gas sensors that are sensitive to various air pollutants such as carbon monoxide, nitrogen dioxide, and ozone. The sensors will be connected to the Arduino board and programmed to collect data on air quality. The design process will involve a thorough analysis of the available sensors, selecting the most appropriate sensors, and designing the circuitry to connect them to the Arduino board. After the circuit is designed, a PCB layout will be created, and the board will be assembled.

Before deploying the air quality monitoring machine, the sensors will be calibrated to ensure that they provide accurate and reliable data. The calibration process will involve exposing the sensors to known concentrations of air pollutants and measuring the response of the sensors. The calibration data will be used to develop a calibration curve that can be used to convert sensor readings into concentrations of air pollutants. The calibration will be performed in a controlled environment where the concentration of pollutants can be precisely controlled. The process will involve exposing the sensors to different concentrations of pollutants and measuring their response. The calibration data will be analyzed, and a calibration curve will be generated to map the sensor readings to pollutant concentrations.

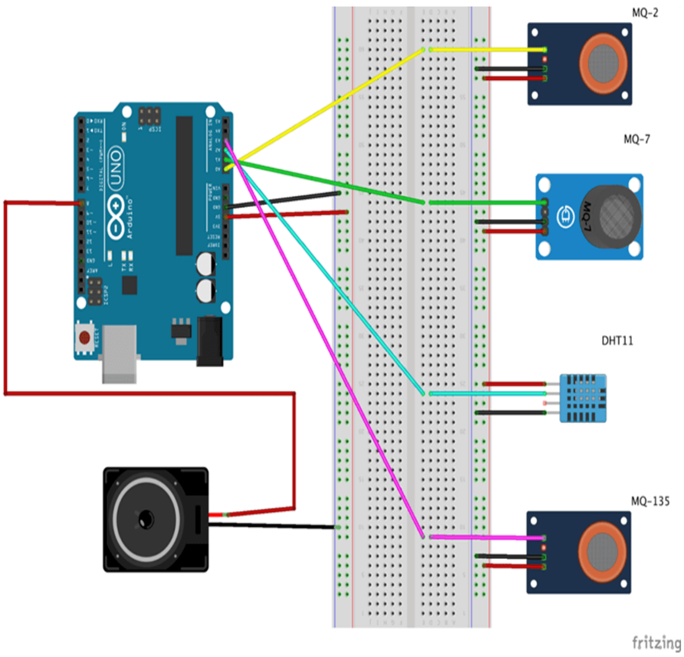

Figure 2: Air quality monitoring system structure

The next step is to integrate a Wi-Fi module called ESP32 into the air quality monitoring machine. The Wi-Fi module will be used to transfer the data collected by the sensors to a mobile app. This will enable users to monitor air quality in real-time from their smartphones. The Wi-Fi module will be connected to the Arduino board and programmed to send the sensor data to a server using the HTTP protocol. The server will store the data and make it accessible to the mobile app. The integration process will involve configuring the Wi-Fi module and programming the Arduino board to communicate with the server.

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c) Auto-pilot air purifying system

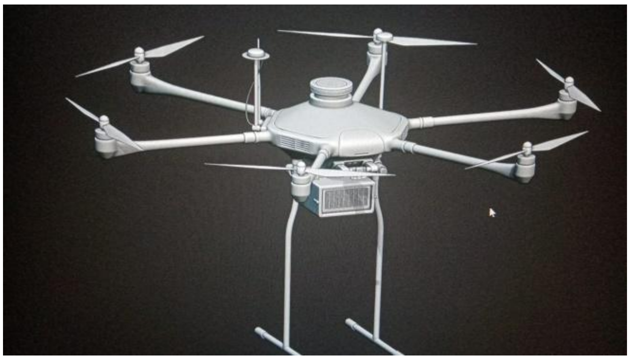

Figure 3: Eco plane

The design and development of the autopilot drone also known as the “eco plane” is involved in the first stage of this component. The drone would fly over polluted areas while carrying a chemical solution that can purify the air. Image processing techniques will be used to identify and avoid obstacles and adjust the direction of the plane to optimize its purifying capabilities.

Due to high-cost issues, a 3D model prototype of the autopilot eco plane is developed using Computer-Aided Design (CAD) software, rather than a real drone and the plane's performance under different weather conditions will be evaluated using simulation software.

Once the prototype is developed, the autopilot eco plane will be tested in a controlled environment to assess its performance in detecting areas with high levels of air pollution and purifying the air. The plane's efficiency, accuracy, and effectiveness in purifying the air in the targeted area will be evaluated by the team.

In the final stage, the autopilot eco plane will be tested in a real-world setting to evaluate its performance under different weather conditions and in various environments. Data on the plane's ability to navigate safely and avoid obstacles, purify the air effectively, and operate efficiently will be collected by the team.

A fully functional autopilot eco plane that can purify the air in polluted urban areas with minimal human interaction, contributing to the sustainability of the environment, will be the final product.

d) User-personalized recommendation system for air pollution

The major purpose of this component is to implement a system that delivers alerts and suggestions for users based on air quality data. Here we were able to identify the health level of the air according to the particulate matter in the air.

Figure 4: Air Quality Index (AQI) ranges

Air quality can be categorized by utilizing AQI cutoff values established by the EPA or other organizations. For instance, the classification of air quality as good is determined when AQI values range from 0 to 50. If the AQI falls between 51 and 100, it is considered moderate. In the range of 101 to 150, it is categorized as unhealthy for sensitive populations, and if it falls between 151 and 200, it is deemed unhealthy. If the AQI ranges from 201 to 300, it is characterized as extremely unfavorable, while values exceeding three hundred are classified as harmful. Conditional statements or rules can be employed to assign the appropriate air quality category based on the obtained AQI result.

The user can be provided with a notification that provides details about the air quality in their current location. On Android, the Notification Manager API can be utilized to send a notification. A notice can be generated and sent to the user's device, containing a title and message that describe the air quality condition of their present location. Additionally, the notification may include a link to an app that offers recommendations and other information regarding air quality.

Recommendations can be given to the user based on the AQI level. The advice can be formulated using conditional statements or rules, considering the AQI level. If the air quality is deemed harmful, the user can be advised to stay indoors or utilize an air purifier. For instance, if the air quality is moderate, the user may be suggested to limit outdoor activities or wear a mask. Furthermore, more general recommendations such as drinking more water, quitting smoking, and reducing driving can also be provided.[4]

After evaluating the state of a location using machine learning techniques, the recommendations to be made can be determined. Users who desire personalized recommendations based on their health situation can provide personal information such as age, gender, and occupation.

IV. TEST RESULTS

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The conducted tests in this project aimed to evaluate the performance and effectiveness of the developed IoT-based air quality monitoring and prediction system. The tests were designed to assess the accuracy of the prediction models, the reliability of the collected air quality data, and the overall functionality of the system.

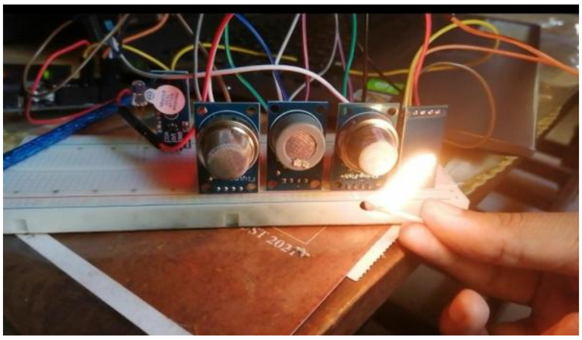

Figure 5: Testing the air quality

Table 1: Test results

AQI level	160 ppm
Temperature	45.53°C
Humidity	59.60%

The test results demonstrated that the employed algorithms effectively captured the complex relationships between the input variables and air quality measurements. Low error metrics, such as mean squared error (MSE) and root mean squared error (RMSE), showed that the models were highly accurate at forecasting air quality levels. These measures shed light on how well the anticipated values correspond to the actual air quality data.

The type of pollution sources and the corresponding sub-areas considered have been listed in Table 2 and Table 3. Based on the analysis, a considerable number of pollutants were identified within the category of Mobile Sources. To assess the pollution status of the area, an index was computed by determining the percentage levels of specific gases.

Table 2: Percentage levels in each type of sources

Sources	Pollutants	Percentage Level
Mobile sources	Nitrogen Oxides (NO_x)	35% - 47%
Stationary sources	Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), Carbon Monoxide (CO)	75% - 90% 19% - 25% 15% - 20%
Area sources	Carbon Monoxide (CO) Nitrogen Oxides (NO_x)	15% - 24% 12%- 17%

Table 3: Sub areas in main sources

Mobile sources	Stationary sources	Area sources
On-road vehicles include: • Motorcycles. • Passenger cars and trucks; and • Commercial trucks and buses Nonroad vehicles and engines include: • Aircraft. • Heavy equipment. • Locomotives. • Marine vessels	• Factories • refineries • boilers • power plants	• gas stations • dry cleaners • print shops. • autobody shops • furniture manufactures, • home sources (wood stoves, pesticides, etc.)

The testing process of a drone involves several crucial steps to ensure its functionality, safety, and compliance with regulations. These steps include verifying the compatibility of the flight controller with motors and sensors, testing the reliability of the components under various stress conditions, and ensuring the stability of the assembled drone during hover and maneuvers. Calibration of sensors and validation of their accuracy are also conducted to provide precise readings for flight control algorithms. The software development phase focuses on testing autopilot functionality, including basic commands and navigation algorithms for waypoint traversal and obstacle avoidance. Physical safety is addressed through the evaluation of propeller guard effectiveness and compliance with safe operating distances. Finally, privacy and legal compliance are verified by adhering to local drone regulations and respecting privacy guidelines. By following these steps, a safe, reliable, and compliant drone can be developed for a wide range of applications.

The Air Pollution Alert System underwent extensive testing to evaluate its performance in providing real-time information and personalized recommendations for managing air pollution. [6] Three machine learning algorithms, namely Decision Tree, K-Neighbors Classifier, and Logistic Regression, were trained to develop a predictive model for generating accurate recommendations. While the Decision Tree and K-Neighbors Classification models achieved impressive accuracies of 85% each and successfully provided tailored recommendations, the Logistic Regression model exhibited limitations, with an accuracy of only 66%. It failed

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to deliver reliable recommendations in this context, highlighting the challenges in accurately predicting personalized responses to air pollution based on the given dataset. Despite the failure of the Logistic Regression model, efforts were made to analyze the factors contributing to its suboptimal performance. For example, further investigation revealed that the model struggled to accurately account for certain individual factors, such as the impact of pre-existing health conditions on susceptibility to air pollution. This limitation served as an important lesson for the future refinement of the research component, highlighting the need for more robust feature engineering and potentially exploring alternative machine learning algorithms to improve the system's performance. Overall, while the research component showcased successes with the Decision Tree and K-Neighbors Classification models, the experience served as a reminder of the challenges and ongoing refinement required in developing accurate and personalized air pollution recommendations.

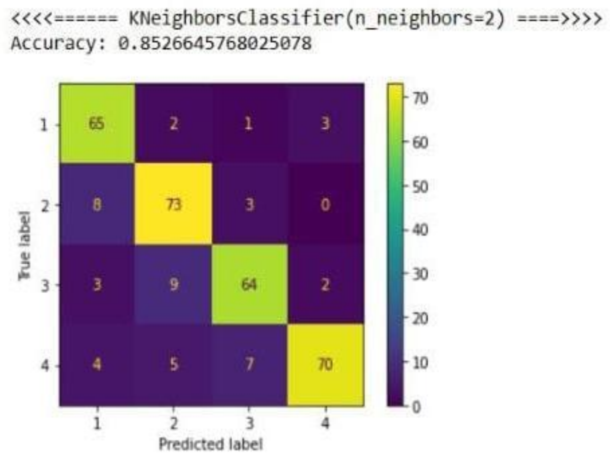

Figure 6: K-Neighbors classifier

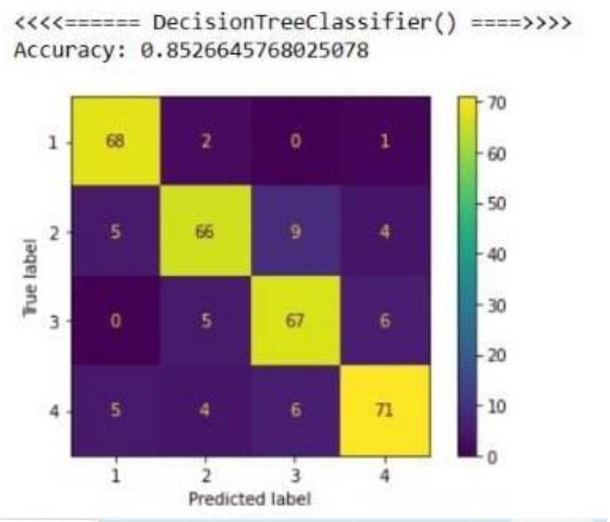

Figure 7: Decision tree

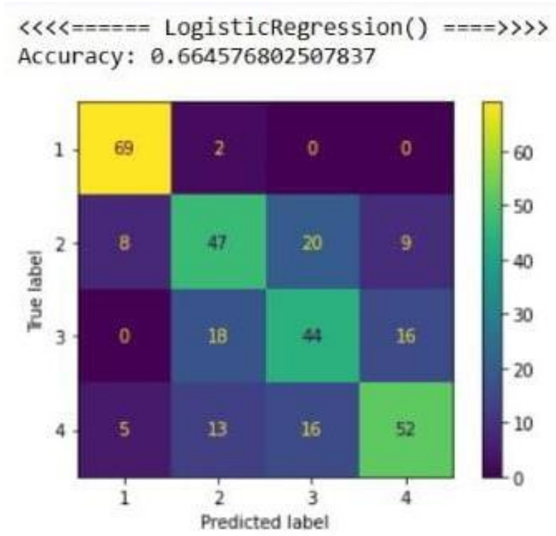

Figure 8: Logistic Regression

V. CONCLUSION AND FUTURE WORK

This research paper has presented a holistic and innovative approach to addressing air pollution, emphasizing the importance of IoT-based systems, machine learning algorithms, and proactive air purification techniques. The findings contribute to the ongoing efforts to mitigate the adverse effects of air pollution, promoting healthier and more sustainable urban environments.

Furthermore, the research project introduced the concept of an autonomous drone for air purification, enhancing the system's capabilities and providing a proactive approach to tackling pollution hotspots. By integrating the air quality monitoring system with the drone, users could identify polluted areas and initiate purification processes remotely. The mobile app provided a comprehensive view of the purification procedure, allowing users to track the drone's progress and receive notifications upon completion.

It is important to acknowledge that this research has certain limitations. The performance of the system may vary depending on factors such as the quality and coverage of the air quality data, the deployment of the IoT devices, and the scalability of the drone-based air purification. Additionally, addressing regulatory and safety considerations, as well as public acceptance, are crucial steps for the successful implementation of such a system in real-world scenarios.

As future work, it is recommended to conduct further studies to optimize the drone's purification efficiency, address regulatory frameworks, and evaluate the long-term impacts of chemical dispersal. Additionally, expanding the system's coverage and integrating it with the existing urban infrastructure could provide a comprehensive and scalable solution to tackle air pollution on a larger scale.

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