Automatic Dust Reduction System: An IoT Intervention for Air quality

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***Abstract*—Air quality is of great importance due to its direct impact on the environment, human health, and quality of life. It could be affected negatively by the presence of dust particles in the atmosphere. Thus, it is vital to purify air from dust and mitigate its impact on air quality. In this regard, dust sensors play a vital role in monitoring and measuring airborne dust particles. They utilize various techniques, such as optical scattering, to detect and quantify the concentration of dust in the air. Microcontrollers are powerful and versatile devices, which have been widely used in many Internet of Things (IoT) applications. They process the collected data from sensors and react accordingly by controlling the operation of IoT devices. Accordingly, the primary goal of this paper is to develop a model for reducing the amount of dust and other particulates in the air to improve its quality. In addition to the microcontroller, which controls the overall operation of the proposed model, two other main components are utilized: a sensor and a sprinkler. The results of the model have shown that it can successfully reduce the dust concentration and suppress the dust intensity to less than 0.1%. The result concluded that the proposed model achieved its primary goals by integrating sensors and sprinkler into an intelligent dust removal model.**

***Keywords*—Dust Suppression; dust elimination; digital dust sensor; humidifier; dust intensity**

I. INTRODUCTION

Because oxygen is supplied to our lungs, blood, and other organs through the air we breathe, it crucial for it to be as pure as possible to ensure a healthy life for humans. A vital component of environmental health is air quality. One of the biggest environmental hazards to human health is air pollution. As of 2019, 99% of people on Earth reside in places where air quality standards set by the World Health Organization (WHO) were not achieved. Each year, the poor air quality results in millions of deaths. Globally, ambient (outdoor) air quality is thought to have contributed to 4.2 million preventable deaths in 2019 [1, 10]. Surprisingly, multiple WHO's studies reveal that indoor air quality is five to ten times worse than outside air quality, especially in urban regions. The environment and human health are seriously threatened by air pollution, which is brought on by a variety of pollutants, including dust particles in the atmosphere [1, 3].

Poor air quality has a negative impact on the quality of life for individuals. Air pollutants have the potential to cause irritation. Many studies have demonstrated the link between specific air pollutants and lung cancer as well as respiratory ailments. The quality of the air both indoors and outdoors is vital. Common outdoor air contaminants include particulate matter, allergens, and ground-level ozone. Common indoor air contaminants include mold, radon, secondhand smoke, and dust [8].

Dust particles in the air are one of the main causes of air pollution [7] that could cause serious health hazards to humans. These particles can come from natural processes including wind erosion, vehicles emissions, construction sites, and industrial activity. High dust exposure can cause allergies, respiratory disorders, and other health concerns [4]. The issue with airborne dust is caused by the presence of rock dust in the atmosphere. Pneumonia is a potentially dangerous occupational lung illness that can be brought on by this dust. Statistics show that there are about 500 new cases of pneumonia detected yearly, which suggests that more work needs to be done to treat lung cancer and pneumonia [9].

In semi-arid environment, sandstorms frequently occur, especially in the summer. These sandstorms, which occur when strong winds swirl sand about and propel it into the air, may make it difficult for people to see far, and they also make driving more dangerous. The difficulty for drivers to spot other vehicles is a hazardous consequence, which raises the chances of accidents. Furthermore, breathing in dust might be harmful when traveling or working in factories that produce construction waste [2, 11, and 12].

In order to establish a sustainable ecosystem, it is essential to develop a model aimed at reducing the concentration of dust in the atmosphere. To lessen the severity of the dust and enhance the quality of the air, this study suggests a prototype that can be used to detect and reduce dust in the atmosphere. Thus, the goal of the paper is to create a dust removal system that employs intelligent control and hardware components to effectively minimize airborne dust particles.

Dust sensors greatly aid the monitoring and measurement of airborne dust particles. They use various techniques, such as optical scattering, to identify and measure the amount of dust in the atmosphere. Real-time data from these sensors makes it possible to evaluate the quality of the air and identify any possible health hazards. Therefore, the proposed model uses a dust sensor to continuously monitor dust levels in the air and start the necessary dust removal activities [5].

ESP32 microcontrollers are powerful and adaptable microcontrollers, which have been extensively utilized in Internet of Things (IoT) applications. Wi-Fi and Bluetooth are only two of the many communication capabilities provided by these controllers. They also have the processing capacity to manage sensor data and operate auxiliary devices. As the central nervous system of the dust removal system, the ESP32 microcontroller facilitates data processing, communication among hardware elements, and decision-making based on gathered sensor data. Existing methods of dust removal typically involve passive techniques such as air filters and ventilation systems [13]. While these methods can provide some level of dust reduction, they often have limitations in terms of efficiency, scalability, and real-time monitoring. Thus, the proposed model aims to overcome these limitations by developing an active and responsive system that can detect elevated dust levels and initiate immediate dust suppression measures [6, 8].

The remaining of this paper is organized as follows. Section II discusses the related work, Section III illustrates the methodology. Section IV presents the dust mitigation prototype. Section V presents experimental setup of the proposed model and results. Section VI presents the discussion and conclusion.

II. Related Work

According to the Energy Progress Report published in 2022 by the International Energy Agency (IEA), International Renewable Energy Agency (IRENA), World Bank, and World Health Organization (WHO), the United Nations Sustainable Development Goals (SDGs), which include improving air quality, are largely dependent on sustainable energy solutions [1]. The report evaluates the state of the world's efforts to achieve SDG 7, which is to guarantee that everyone has access to modern, affordable, dependable, and sustainable energy by 2030. It assesses advancements in energy efficiency, renewable energy, and the availability of clean cooking fuels and electricity. The proposed dust reduction system, which uses information technology to reduce air pollution, is in line with these objectives. The report offers a comprehensive discussion about the need to design creative solutions for monitoring air and reducing air pollution.

An annual report on the primary technical and natural dangers associated with hard coal mining has been made available [14], with a focus on the industry's need for efficient dust control. This report lists several coal mining dust emission sources, such as loading, blasting, drilling, and transportation. It also covers a number of dust control techniques used in the sector, including ventilation, water spraying, and the application of personal protection equipment. It is crucial to continuously monitor and control dust levels in order to lower the hazards related to dust exposure.

Controlling dust concentration in a hard coal mine processing plant's workplace was the subject of another investigation, which found that the spraying system, called New Environmentally Friendly and Efficient Pulverization Technology for Underground Mining (NEPTUN), significantly decreased dust levels [3]. The researchers measured the dust concentration before and after installing the NEPTUN system at various workstations using a dual-channel laser dust monitor. The results of the investigation showed that the processing plant's dust concentrations were considerably lower because of the NEPTUN spraying system, which suppresses dust using high-pressure water spraying. The results also showed that larger nozzle diameters and higher water pressure enhanced the system's efficiency.

A comprehensive review of many types of sensors, their operational mechanisms, and their uses in a variety of industries, including biomedical engineering, automotive systems, and environmental monitoring, was provided in [15]. The study covered the most recent developments in sensor technology, including wireless sensor networks and the IoT, which make it possible to gather and interpret vast amounts of sensor data for sophisticated applications. Furthermore, an overview of the several kinds of sensors—physical, chemical, and biological—as well as their uses in a range of industries, including agriculture, health care, and environmental monitoring, were given [16]. This study underlined how crucial it is to choose the right sensors for a given application based on factors like sensitivity, specificity, and operating principles. This discussion of the different sensor technologies provided insightful information that was useful for the creation and incorporation of sensors in the proposed dust reduction system.

The authors in [17] described multisensory data fusion and filtering for vehicle's safety systems, which provide insightful information for the integration of several sensors in the suggested dust reduction system. They presented a number of data fusion methods that may be used to integrate and merge data from many sensors in order to enhance system performance, including Bayesian networks, particle filtering, and Kalman filtering. Furthermore, it emphasized the significance of sensor fusion in vehicles' applications, including autonomous vehicles and driver assistance systems, where it is necessary to integrate data from several sensors to produce precise and trustworthy information for decision-making. The study underlined how important it is to take sensor fusion techniques into account when developing the suggested dust reduction system since it is likely to need information from several sensors in order to monitor and regulate the dust levels.

The use of big data and IoT technology in air quality monitoring was examined in [18], which offered insightful information for the suggested dust reduction system. The authors suggested an IoT-based air quality monitoring system that gathered data in real time from air quality sensors placed around different areas. Big data analytics techniques were used to process the gathered data in order to find trends, patterns, and anomalies and produce insights that decision-makers could use. The adoption of IoT and big data technologies in air quality monitoring presents a number of potentials and problems, including data security, privacy, and system scalability, all of which were covered in this study. The study emphasized how IoT and big data technologies might provide continuous, real-time monitoring of air quality, which could be essential for the successful installation of the suggested dust reduction system.

An automated cleaning method for removing dust from solar PV modules was demonstrated in study [19]. They discovered that automated cleaning solutions can enhance the performance of solar panels and are more effective and efficient than hand cleaning. The proposed model's dust removal component may benefit from the knowledge gained from this investigation.

In study [20], a smart dry fog technology for controlling fugitive dust emissions was introduced. The system is composed of a dry fog generator, a control unit, and a network of sensors. A thorough analysis of dust suppression systems was given in [21], which also assessed in applying this technology in different industries as well as their limitations and effectiveness. The efficiency of several dust suppression techniques, including ventilation, chemical treatment, and water spraying, in reducing dust emissions from various sources was covered by the authors. They also emphasized the significance of taking into account the unique properties of dust particles, such as their size, shape, and moisture content, when choosing the best dust suppression methods. The paper stressed on the importance of continuously monitoring and controlling dust levels in order to guarantee efficient dust control. A further study put forth a framework for incorporating sensors into an IoT platform [22]. A methodical approach to sensor integration—which encompasses sensor selection, data collection, processing, fusion, and visualization—was put forth by the authors. The framework highlighted the factors that should be taken into account when choosing the right sensors for a certain application type. These factors include cost, accuracy, and dependability. The authors also covered the opportunities and difficulties of integrating sensors into IoT platforms, including system scalability, data security, and privacy [23]. In conclusion, previous studies have shown that there is still room to develop novel approaches with even higher precision than those used previously in order to reduce or suppress dust particles in the ambient air.

III. METHODOLOGY

The proposed prototype for dust reduction includes five key components which are, the dust sensor, ESP32 microcontroller, sprinkler controlled by a spray module, TFT screen, and water level sensor. These components work together in a coordinated manner to achieve the goal of dust removal.

The dust sensor is responsible for detecting and measuring the concentration of dust particles in the air. It uses a digital dust particle sensor that can identify air dust aerosols greater than 0.8 μm in diameter. The sensor continuously monitors the ambient air and provides real-time data on the dust concentration. The ESP32 microcontroller acts as the central control unit of the system. It receives data from the dust sensor and processes it to determine if the dust concentration exceeds a predefined threshold. When the threshold is exceeded, the microcontroller triggers the spray module to initiate the dust suppression process. The spray module is designed to release a fine mist or water spray into the air to effectively reduce the dust concentration. It is comprised of a pump, nozzles, and a plumbing system that distributes the water evenly. The microcontroller controls the activation of the spray module based on the inputs received from the dust sensor. The TFT (Thin Film Transistor) screen, with its 3.5-inch display, serves as the user interface of the system. It provides real-time visual feedback to users, displaying the current dust concentration level, water tank level, and other relevant information. The TFT screen enhances user interaction and allows for monitoring and control of the system's operation. To ensure proper functioning of the system, a water level sensor is integrated to monitor the water tank level. It accurately measures the water level and provides feedback to the microcontroller. This allows the system to optimize water usage and prevent interruptions in the dust removal process.

By integrating and coordinating the functions of the above discussed components: dust sensor, ESP32 microcontroller, spray module, TFT screen, and water level sensor, the proposed prototype creates an intelligent and responsive dust removal system. The cooperative functioning of these components ensures efficient and effective dust suppression, leading to improved air quality and a healthier environment.

A. *Proposed Model Architecture*

The software system architecture encompasses the design and structure of the software system components that enable the coordination and functionality of the hardware tools. It involves the implementation of various software modules and their interactions to achieve real-time dust monitoring, automatic dust suppression, and user interface capabilities. The components contribute to the overall software architecture are:-

- Firmware for ESP32:- The ESP32 microcontroller requires firmware that serves as the foundation of the system. This firmware includes the necessary drivers and libraries to interface with the hardware components, such as the dust sensor, water level sensor, TFT screen, and spray module. It also manages communication between the different components of the system using protocols, such as Wi-Fi and Bluetooth, to facilitate data exchange and connectivity.
- Dust Monitoring and Control: The software architecture incorporates two modules for dust monitoring and control. The dust monitoring module reads the data from the dust sensor in real-time and processes it to determine the current dust concentration. Based on predefined thresholds, the control module initiates actions to activate the spray module for dust suppression. These modules work together to continuously monitor the air quality and respond accordingly.
- User Interface: The user interface module provides a visual representation of the system's status and enables user interaction. It utilizes the TFT screen to display real-time information, including the dust concentration level and water tank level. The user interface module allows users to monitor the system, adjust settings, and view historical data. It provides a user-friendly and intuitive interface to enhance user experience and system control.

- Data Storage and Analysis: This module captures and stores relevant data, such as dust concentration readings, system status, and user settings. It enables historical data analysis, trend identification, and performance evaluation of the dust removal system.
- Communication and Connectivity: The software architecture system includes modules for communication and connectivity. These modules enable the system to transmit and receive data from external sources, such as remote monitoring systems or control interfaces. Communication protocols like Wi-Fi or Bluetooth are utilized to establish connections and exchange information with other devices or systems. This enables remote monitoring, control, and integration with larger networks or cloud-based platforms.

The software architecture of the system ensures the seamless integration of the various software components with the hardware tools. It enables real-time monitoring, automatic control, user interaction, data storage, and connectivity functionalities. Through a well-designed software architecture, the dust removal system can effectively detect elevated dust levels, initiate appropriate actions for dust suppression, provide visual feedback to users, and facilitate data analysis for system optimization and performance evaluation.

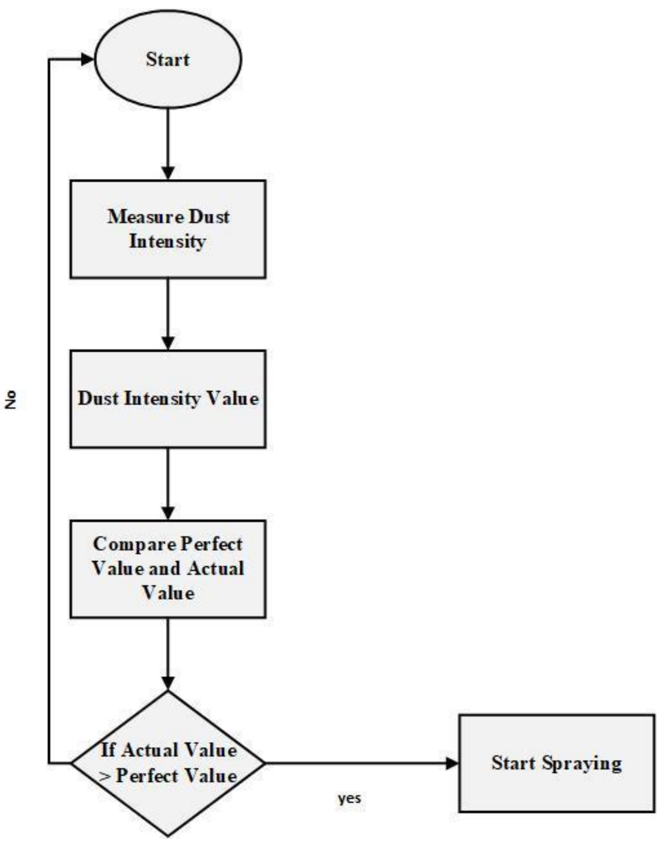

Fig. 1. Flowchart of the proposed system mechanism.

The flowchart in Fig. 1 represents a simplified process for an automatic dust reduction system. The purpose of this system is to measure the dust intensity in the environment and determine if it is necessary to start spraying to reduce the dust levels. The steps of this dust reduction system are as following:-

1) Start: The process begins by initializing the automatic dust reduction system.

2) Measure dust intensity: The system measures the current dust intensity in the environment using dust sensors.

3) Dust intensity value: The measured dust intensity value is obtained from the sensors.

4) Compare threshold value and actual value: The system compares the actual dust intensity value with a predefined (acceptable) value. This value represents the maximum of dust intensity level in the environment, where below this value no dust suppression action is needed. The system checks if the actual dust intensity is greater than the threshold value. If the actual value is greater than the threshold value, it indicates that the dust levels in the environment are too high and require intervention to mitigate the dust. If the actual value is less than the threshold value, the system returns to the "Measure dust intensity" step, and continue monitoring the dust levels in the environment.

5) Start spraying: If the actual dust intensity value is higher than the threshold value, the system initiates the spraying process to reduce dust levels in the environment. After spraying, the system returns to the "Measure dust intensity" step to reassess the dust levels and determine if additional spraying is necessary.

IV. Dust Mitigation Prototype

In the proposed system, the ESP32 microcontroller serves as the central control unit, managing the TFT display, dust sensor, water level sensor, and spray module. The system is powered by a Li-ion battery, which is charged using a charger. A voltage booster is connected between the battery and the ESP32 to ensure a stable voltage supply for the microcontroller and its connected components. Fig. 2 illustrate the different components of the system and the connections between these components.

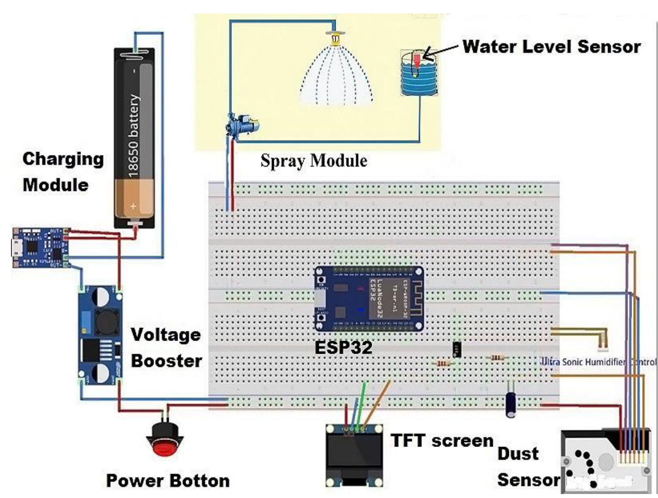

Fig. 2. Prototype components and connections.

In the followings, the role of each component is described:

- Charger Module and Li-ion battery: The charger provides power to the Li-ion battery, ensuring it remains charged and ready to supply energy to the system. The battery's role is to store energy and provide a stable power source for the entire system.

- Voltage booster: Connected between the Li-ion battery and the ESP32, the voltage booster steps up the battery's voltage to a suitable level for the microcontroller and its connected components. This ensures consistent performance and helps prevent under-voltage issues.

- ESP32 microcontroller: The ESP32 serves as the brain of the system, controlling and processing data from the sensors, managing the spray module, and displaying information on the TFT screen. It receives power from the voltage booster and communicates with each component through defined pin connections.

- TFT display: The TFT display is connected to the ESP32 and displays dust and water level readings, as well as warning messages when needed. It provides a user-friendly interface for monitoring the system's status.

- Dust sensor: The dust sensor is connected to the ESP32 through an analog input pin (A0). It detects dust levels in the environment and sends the readings to the microcontroller for processing. If the dust level exceeds the predefined threshold, the ESP32 activates the spray module.

- Water level sensor: The water level sensor is connected to the ESP32 through another analog input pin (A1). It measures the water level in the water tank used for the spray module. If the water level falls below a certain threshold, the ESP32 displays a warning message on the TFT screen.

- Spray module: Controlled by a servo motor connected to the ESP32, the spray module is responsible for releasing water to reduce dust levels when needed. The servo motor opens and closes the spray module based on commands from the ESP32.

The proposed dust reduction system is a cohesive unit that combines various sensors and components under the control of the ESP32 microcontroller. The system monitors dust and water levels, activating the spray module when necessary to mitigate dust levels, and alerts the user if the water level is low. The Li-ion battery supplies power, while the charger and voltage booster ensure stable and consistent performance (see Fig. 3).

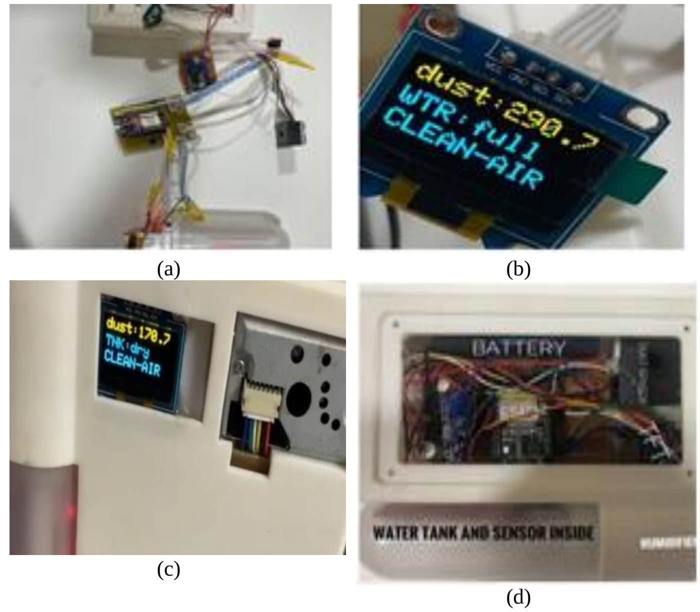

Fig. 3. Prototype connections actual figure. (a) Prototype connections. (b) IoT-based water quality monitoring system, monitors dust and water levels. (c) Water sensor, alerts the user if the water level is low. (d) Li-ion battery supplies power.

V. EXPERIMENTAL SETUP AND RESULTS

This section presents the test setup of the proposed prototype for dust mitigation. It includes the test setup, evaluation experiments, and the obtained results. The testing phase involved a comprehensive evaluation of the dust removal system to assess its functionality, performance, and effectiveness in reducing dust levels in the air. The testing phase aimed to validate the system's capabilities and ensure its reliable operation in real-world scenarios. The test was done in a controlled environment designed by the researcher. The system was implemented in a Plexiglass acrylic box measuring 15cm x 7cm x 20cm to simulate a controlled environment as seen in Fig. 4. Plexiglass acrylic is a transparent, lightweight, and durable material, making it suitable for creating a test chamber. The testing phase aimed to validate the system's capabilities and ensure its reliable operation in real-world scenarios. A controlled test environment was created, simulating different dust concentrations within the Plexiglass acrylic box. The test chamber was prepared with a calibrated dust source to generate consistent dust levels for evaluation. The system was calibrated and configured to establish baseline measurements and define the threshold for dust concentration. This calibration ensured accurate detection and appropriate response to elevated dust levels. Different evaluation setups were examined to test the proposed prototype:

Fig. 4. Plexiglass acrylic box.

1) Evaluation No. 1: Evaluation Objective: Verification of the Activation and Efficiency of the Spray Module in Response to elevated dust levels. This Evaluation Procedure is as following:

- Initialize the Dust Reduction System.
- Set the initial dust concentration to 350 micrograms/m3.

Anticipated Outcome: The TFT display should accurately reflect the concentration of dust present in the immediate environment. With the initial concentration set at 350 micrograms/m3, the ESP32 microcontrollers expected to initiate the spray module, thus mitigating dust levels as shown in Table I.

TABLE I. THE PARAMETER OF EVALUATION NO. 1

parameter	values
The initial dust concentration	350 micrograms/m3
The final dust concentration	150 micrograms/m3
time	10 minutes

Documented Result: The TFT display displayed the correct initial dust concentration of 350 micrograms/m3. As anticipated, the ESP32microcontroller successfully initiated the spray module.

Evaluation status is successful, and the spray module effectively reduced the dust concentration from 350 micrograms/m3 to approximately 175 micrograms/m3 within a span of 10 minutes, which demonstrates a significant decrease of approximately 50% in dust levels.

2) Evaluation No. 2: Evaluation Objective: Examination of the Water Level Monitoring Mechanism and Warning Functionality Based on the Moisture Indicator. This Evaluation Procedure is as following:

- Initiate the Dust Reduction System.
- Deliberately allow the water reservoir to dry up, causing a change in the moisture indicator status from "moist" to "dry."

Anticipated Outcome: The TFT display should present the accurate status of the water level in the reservoir by displaying either "moist" or "dry." In the event that the water level descends to the "dry" status, a warning message "Low Water Level!" should be distinctly exhibited on the TFT display.

Documented Result: The TFT display successfully indicated the change in moisture status from "moist" to "dry." As soon as the moisture indicator switched to "dry," the ESP32 microcontroller successfully triggered the "Low Water Level!" warning message. The status of the evaluation is successful.

3) Evaluation No. 3: Evaluation Objective: Performance Analysis of the Dust Reduction System under Optimal Operational Conditions. The evaluation procedure is as shown:-

- Initiate the Dust Reduction System with the initial dust concentration set at 350 micrograms/m3 and the water level indicated as "moist."
- Monitor the system's performance in reducing dust levels.

Anticipated Outcome: The TFT display should correctly indicate both the dust concentration and the moisture status. With the initial dust concentration set at 350 micrograms/m3, the spray module should be initiated by the ESP32 microcontroller and effectively reduce dust levels.

Documented Result: The TFT display accurately demonstrated the dust concentration and moisture status. With the initial dust concentration set at 350 micrograms/m3, the spray module was successfully initiated by the ESP32 microcontroller, thereby reducing the dust levels. The status of the evaluation is successful.

The evaluation on effectiveness shows that the system exhibited high effectiveness as it reduced the dust concentration from 350 micrograms/m3 to around 175 micrograms/m3 within a 10-minute duration. This signifies a notable decrease of approximately 50% in dust concentration levels. Therefore, the system proves to be highly efficient in maintaining optimal dust levels in the environment.

The main difference between Evaluation No.1 and Evaluation No.3 lies in the specific objectives and conditions under which the Dust Reduction System is evaluated. Evaluation No. 1 concentrated on the system's response to elevated dust levels and Evaluation No. 3 emphasized the overall performance under optimal conditions, including moisture status monitoring.

4) Evaluation No. 4: Evaluation Objective: Assess the Dust Reduction System's Performance in a Larger Test Environment (4m x 4m). Set up the Dust Reduction System in a controlled test environment designed by the researcher, a 4m x 4m room, simulating a larger workspace.

- Initiate the Dust Reduction System with the initial dust concentration set at 350 micrograms/m3 and the water level indicated as "moist."

- Monitor the system's performance in reducing dust levels in the larger test environment.

Anticipated Outcome: The TFT display should correctly indicate both the dust concentration and the moisture status. With the initial dust concentration set at 350 micrograms/m3, the spray module should be initiated by the ESP32 microcontroller and effectively reduce dust levels.

Documented Result: The TFT display accurately demonstrated the dust concentration and moisture status in the larger test environment. With the initial dust concentration set at 350 micrograms/m3, the spray module was initiated by the ESP32 microcontroller. However, the dust reduction performance was not as effective in the larger room compared to the smaller test environment.

The status of the evaluation is partially successful. Some technical issues were encountered during the test, which include uneven spray distribution and reduced spray coverage. These issues were attributed to the larger room size, which affected the spray module's ability to efficiently reduce dust levels throughout the entire space. Regarding the evaluation of the system's effectiveness in reducing the dust levels, the system has reduced the dust concentration from 350 micrograms/m3 to approximately 225 micrograms/m3 within a span of 10 minutes, which demonstrates a decrease of about 36% in dust levels.

In comparison to the previous evaluations conducted in the smaller test environment, the effectiveness of the system in the larger test environment was lower. This highlights the need for further optimization and adaptation of the system for larger spaces to achieve more efficient dust reduction. To enhance the system's effectiveness in larger environments, further research and development should focus on improving the spray module's coverage and distribution capabilities. This could involve modifying the nozzle design, optimizing the spray pressure, and incorporating additional spray units to ensure more uniform dust reduction throughout the entire space.

VI. Discussion

The proposed prototype for dust mitigation incorporated five components, which are a digital dust sensor, an ESP32 microcontroller, a water spray module, a TFT display, and a water level sensor to create a responsive and intelligent dust reduction system. The dust sensor monitored dust levels continuously, while the spray module suppressed dust when dust concentrations exceeded a pre-specified threshold. Together, all the system components have been utilized to reduce the environmental dust load.

The performance evaluation revealed that the combined dust sensor and sprinkler module system successfully reduced dust levels. In about 10 minutes, the system reduced dust intensity by up to 50% in a controlled test environment. This indicates that the proposed model achieved its objective of reducing airborne dust concentrations by integrating digital technologies.

The TFT screen displayed real-time dust levels and water tank measurements, allowing for system status monitoring. The warning feature alerted users when water levels were low, ensuring operation reliability. Thus, the screen provided visual feedback on the performance of the system and served as an effective user interface.

While the system performed well in a small test box, its effectiveness was reduced when operating the prototype in a larger room due to spray distribution and coverage issues. This demonstrates the need for further design optimization of the spray module in order to increase the effectiveness of dust control in spacious areas.

VII. Conclusion

In conclusion, the Automatic Dust Reduction System achieved its primary goals by integrating sensors and actuators into an intelligent dust removal model. The prototype successfully reduced the dust concentration in a small area. Nevertheless, for large-scale dust control, spray coverage and distribution must be optimized. Overall, the project demonstrates the feasibility of combining innovative technologies to develop an IoT intervention for enhancing air quality. With the appropriate modifications and enhancements, the proposed dust removal system could be implemented on a larger scale to assist in mitigating the serious threats posed by dust pollution. Future work for the dust reduction system involves several key areas of improvement and expansion. Additionally, enhancing the efficiency of the spray module is crucial. This can be achieved by optimizing the nozzle designed spray pressure, adding more spray nozzles to ensure adequate dust suppression, and implementing an adaptive spraying system that adjusts spray patterns based on room size and dust levels.

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