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# Smart Embedded Framework of Real- Time Pollution Monitoring and Alert System

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***Abstract*—The sustainability and progress of humanity depend on a clean, pollution-free environment, which is essential for good health and hygiene. Huge indoor auditorium does not have proper ventilation for air flow so when the auditorium is crowded the carbon di-oxide is emitted and it stays there for many days this may be a chance to spreading of COVID-19 and other infectious diseases. Without proper ventilation virus may present in the indoor auditorium. In the proposed system, emissions are detected by air, noise, and dust sensors. If the signal limit is exceeded, a warning is given to the authorities via an Android application and WiFi, and data is stored in cloud networks. In this active system, CO2 sensor, noise sensor, dust sensor, Microcontroller and an exhaust fan are used. This ESP-32 based system is developed in Arduino Integrated Development Environment (Aurdino IDE) to monitor air, dust and noise pollution in an indoor auditorium to prevent unwanted health problems related to noise and dust. More importantly, using IoT Android Application is developed in Embedded C, which continuously records the variation in levels of 3 parameters mentioned above in cloud and display in Android screen. Also, it sends an alert message to the users if the level of parameters exceeds the minimum and maximum threshold values with more accuracy and sensitivity. Accuracy and sensitivity of this products are noted which is very high for various input values.**

***Keywords—IoT, sensors, pollution, Arduino IDE***

## I. INTRODUCTION

The sustainability of humanity and the progress of any nation depend on a clean, pollution- and hazard-free environment, which is essential for good health and hygiene. Any kind of pollution has a negative impact on population quality and has a direct impact on peoples' health in one way or another. Therefore, monitoring becomes crucial to ensure that the populace of any country may live a healthy life. Environment monitoring (EM) entails managing disasters effectively, reducing pollution, and successfully tackling problems brought on by unfavorable environmental circumstances. For a healthy future, it is crucial to assess the air quality and sound level and keep them under control [1-4]. Huge indoor auditorium does not have proper ventilation for air flow so when the auditorium is crowded, the carbon di-oxide is emitted and it stays there for many days this may be a chance to spreading of COVID-19 and other infectious diseases. Without proper ventilation virus may present in the indoor auditorium for many days [5].

The presence of toxic compounds in the atmosphere will have detrimental effects on human health, necessitating special caution. The model measures the noise intensity continually and accounts for it to the internet host via IoT. Due to Internet connection, the verified data can be accessed from far-off regions. This monitoring model's structure is based on the interactions or associations between distributed sensing units and a useful data processing mechanism. Here, we develop an air quality, dust and sound pollution surveillance system that enables us to monitor and assess real-time air purity as well as sound contamination in an indoor stadium using the Internet of Things. It would be ideal to enter the stadium while being inspected and watched. In order to solve the pollution issue, we are creating a framework that will allow us to recognize the rising problem of noise and the existence of hazardous substances in the region. The model continuously feeds information to the microcontroller by using an air sensor and a dB sensor to detect harmful pollutants in the ambient.

## II. RELATED WORKS

Concerning air pollution and its consequences on people's wellbeing, this century has seen a lot of worry. Towns and urban centers, wherein authorities have working toward lessen their consequences, but where its repercussions are most noticeable. While numerous alternatives have previously been suggested, residents still complain about poor circumstances in the regions where people inhabit. In order to help administrations, manage metropolitan contamination, the [6] study suggests a method that combines user comments and observations with actual data from specialized mobile Sensing devices that are constantly repositioned by state officials to confirm the stated circumstances of particular locations. The method of [6] is depicted in Fig.1.

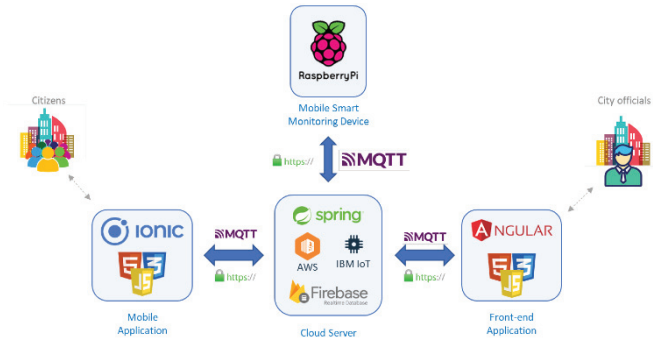


Fig. 1. Framework in [6].

Making use of ML [6-7], smart apps detect the pollution levels and record vehicular traffic on major routes. To assist the gathering of user comments and display acquired information to both organizations and consumers, the design allows a smartphone app and a site. The system design has indeed been developed and tested as solid evidence on a moderate campus. The program's viability and efficacy have been proven by its operational and performance testing, which have also made it possible to define certain knowledge gained and continued prospects as shown in Fig.2.

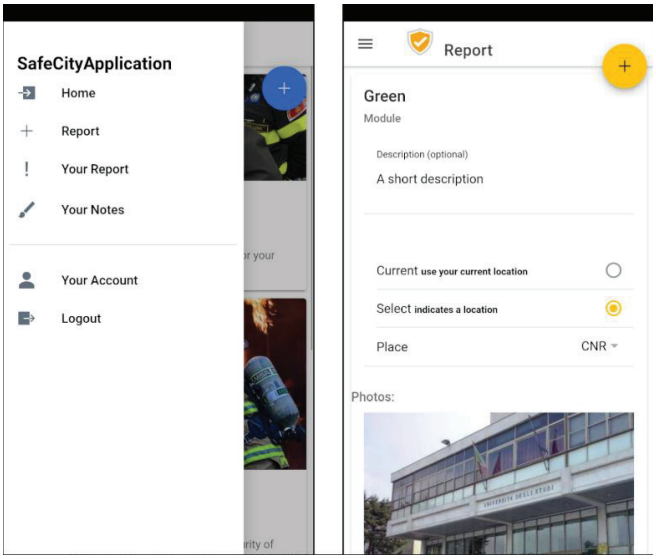


Fig. 2. Application menu in [6].

The sensor layer, core network, and data tier are the multiple sections that were established in [9]. Zigbee and Wi-Fi are utilized by each of the tiers for communication, however any other device with a comparable function could also be employed. Based on the edge-computing process, the whole volume of work is regulated and spread over these three levels [8-9]. The surveillance system in its entirety is built on the sensor surface. The primary duty with this tier would be to detect the vehicle emissions. The primary elements of such a level are the detecting units, that can be spread around a large region.

Mobile cloud features are made up the IoT gateways. Their job would be to talk to the additional two tiers. Upon completing any required analysis, this unit collects information from the whole sensor and transfers it to the web application [9]. This scheme is depicted in Fig.3.

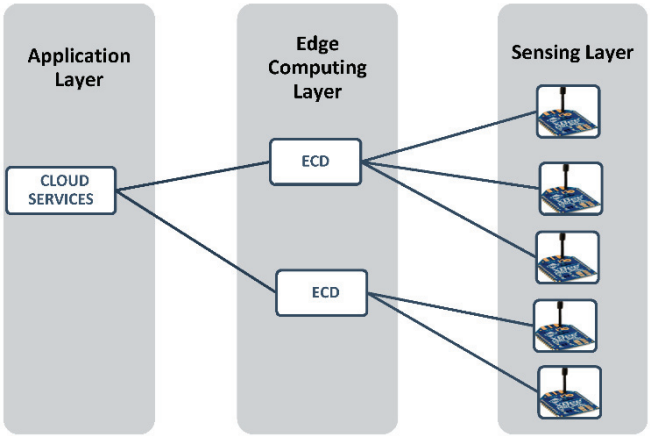


Fig. 3. Working steps of [9].

The observation that its smog detectors function well enough in stationary reference frame supports the network model's intention for stationary sensors. A number of studies in various settings were carried out to support the accuracy of the air quality surveillance system. By relating the environmental quality propensity towards other comparable data, some astounding discoveries were found.

To promote awareness, useful facts was produced first from enormous amount of data and disseminated to people locally. This provides a great option for tracking homes, businesses, and congested areas, but for commercial surveillance, the current models must be updated for increased precision. Endpoints are flexible and make it simple to upgrade in response to customer needs.

To track the index of air quality number from every place using long-range telecommunication and Internet connectivity, this work proposes a node and way station IoT architecture. Implementation mechanism of the customized equipment, such as the mobile nodes and bridge, is performed in order to realize the structured process. Network bridging powers the network device to reduce duplicate data [10-11]. The references of worldwide harmful gases differ, to mass transit being among them (i.e., exhaust emissions encompass intermodal transport, lorries, flatlands, and railways, point sources involve oilfields, hydroelectric dams, industrial plants, and processing equipment. While still mobility (automobiles) somehow doesn't contribute the majority of pollutants globally, it is a major issue in majorly contaminated in large cities. Rush hour in big cities causes significant amounts of air pollutants, that have an impact on people's well-being both directly and indirectly. The atmosphere is contaminated by a variety of elements, including some that are man-made and many which results from natural events. Additionally, pollution prevention plays a critical part in tackling the challenges of sustaining the environment for something like a decent society and planet.

Researchers have grown more worried over pollution levels over the recent years. Polluted air through manmade and biogenic, particularly in cities and commercial places, does have a considerable negative impact on humans. Examining the sources of contamination and eliminating it need regular review of the pollution levels. In this [15], the findings suggest a brand-new driverless multi-rotor airborne system that could be employed to track the air purity in big cities in quick time. This detecting system has a minimal

price and can cover large regions with better spatial precision, way up to the top ordinary structures [12-15].

Like a result among its effects on people's lifestyles and wellbeing, contamination is now a key contributor to an increase in death and mortality. One such result is a result of the industrialization, that increased the demand for power and the wasteful use of fossil fuels in attempt to meet it. As a result, major programs has given individuals the opportunity to proactively assess levels of various gas chemicals which present threats to human health as people grew more conscious of the harm that pollutants posed on human wellbeing.

Automatic tiny unmanned drones have become a possibility as a result of recent advancements in a variety of technical domains involving densely packed grid storage, incorporated tiny electromagnetic motors, or even other micro electromechanical system (MEMS) technology [16-20]. Despite the existence of several aerial vehicle, both powered and non-motorized, including such balloons and gliders, as well as miniature solitary blade helicopters, every model contains significant flaws that prevent it from being used with confidence for satellite data.

In several scientific domains requiring observation or object tracking on surface, the water, or in dangerous situations, UAVs are highly proficient of sophisticated independent operations. Scientists have centered their efforts of late on using Drones to detect pollution levels. [19] suggested air quality tracking model that offers information on the behavior of pollutants at various heights. They created an affordable method for measuring contamination that could be used to create perfectly alright thermal depictions for particular spots and monitor contamination in large areas as well as at altitudes (far above typical structures).

They tested the method in several parts of a major metropolitan area throughout particular periods, so also produced physical parameters with perfectly alright thermal which show the pollution levels in selected places depending on multiple heights. Researchers discovered that certain places require continuous air monitoring to identify if smog exceed the threshold for maintaining human life. Scientific investigations can enhance the suggested Aircraft pollutant metric system to more accurately predict the distribution of air pollutants in a 3-D region.

For many years, water debris has posed a major health problem. Streams are the major source of marine pollution. Coastal trash is indeed a term for the rubbish that often goes underwater from the sea. Various organizations identify that keep an eye on beach rubbish, typically with the assistance of people. While they only serve specific regions, permanent sampling sites also can seek data on waste. Additionally, such detection strategy is unable to immediately offer comprehensive waste data [21-23].

In [23], researchers developed a method for authentic surveillance and detection of ocean rubbish. The results of the studies demonstrate that it proposed scheme is capable of detecting beachfront garbage, performing data processing, and transmitting garbage information to a distant station. There was good integration between the electronic controller, online streaming servers, web access, Mongo repository, and Kafka adapter. With both the suggested UAV waste surveillance system, the researchers hope to provide to the conservation of nature globally. The method for detecting UAV rubbish is made for swarms of Drones. In the hereafter, it will be possible to build numerous Drones to check rubbish along specific regions' coastlines.

## III. PROPOSED SYSTEM

This paper suggests surveillance of the carbon di-oxide, dust and noise produced in indoor auditorium through an IOT-based system to track a region's Air Quality and Noise Intensity as shown in Fig.4.

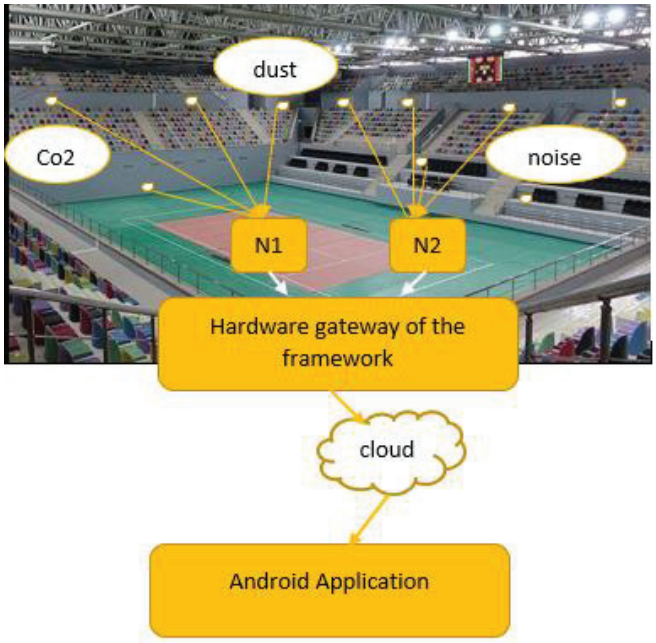


Fig. 4. Indoor stadium pollution control framework

Sensors are distributed at different locations in the stadium and their outputs are given to the node MCUs and updated to the cloud in real time. The four elements that make up the suggested system are the Air Quality Monitoring, Noise Detection, Cloud-data storage and Notifying system.First, the existence of the air pollutants is taken into account for Air Quality detection. The noise level is then measured using dB sensor. The ESP-32's built-in WiFi module ensure the data acquisition process, achieving the goal of periodic information analysis through the Cloud-data storage. If any sensor output exceeds the predetermined value Notifying system alerts the user. An android app called 'Indoor_app' is developed for mobile notifications.

In our active system CO2 sensor, noise sensor, dust sensor, ESP-32, 16X2 LCD and an exhaust fan are used. The ESP32 is a potent 32-bit microcontroller that has Bluetooth, integrated Wi-Fi, and a Transmission Control Protocol/Internet Protocol stack for connecting to the internet as shown in Fig.4. The CO2 sensor measures the carbon di-oxide level in auditorium and noise sensor is used to measure the noise in dB if both sensor values are more than threshold value it alerts the user by displaying alert message and it automatically runs the exhaust fan to until the CO2 comes to normal level. The dust sensor used to sense the dust particles present in indoor places where the samples are taken to prevent the particles move around humans.

When the CO2 level is higher than threshold buzzer and exhaust fan is switched on using relay. Audio sensor detects the sound frequency when the sound is higher than threshold buzzer will be turned high. Dust sensor takes multiple samples in a period of time and throws output. All these sensor values were updated in cloud. It assists in continuously transferring data into storage while sensing a variety of characteristics. Using IoT Android Application is developed in Embedded C, which continuously records the variation in levels of 3 parameters mentioned above and display in Android screen. It sends a warning message to the users if the level of parameters exceeds the minimum and maximum threshold values with more accuracy and sensitivity. Accuracy and sensitivity of this products are noted which is very high for various input values. The general operation of the system is shown in Fig. 5. In order to control and examine the clean air and noise pollution in real-time in a specific field using IOT, we design controlling models. In order to analyze the presence of harmful pollutants, the models use specific sensor such as carbon dioxide, ammonia, carbon monoxide sensors, continuously assessing the noise intensity, and alert accordingly. The sensors are communicating with ESP-32 and Arduino, which process the information and update it in the cloud and display the values on Android application. The framework allows real-time monitoring, control, and verification of the unhealthy gases, dust and noise levels. In order to avert any significant side-effects, instantaneous monitoring ensures warning message is popped up on the LCD panel and also on mobile phones by utilizing IoT as shown in Fig.5.

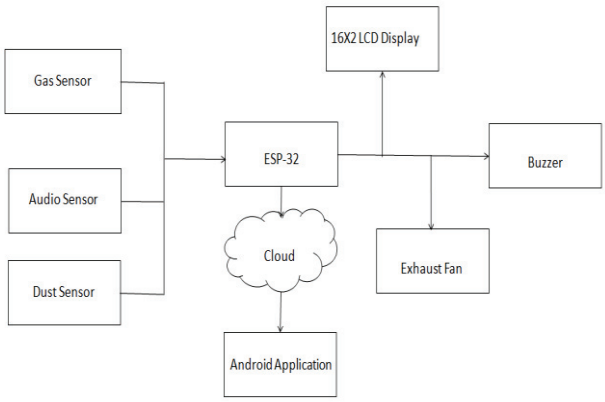


Fig. 5. Block Diagram of Proposed system

## IV. RESULTS

We employ ESP-32, a 16X2 LCD, a CO2 sensor, a noise sensor, a dust sensor, and an exhaust fan in our system. The gas sensor used is MQ6.The sensing element is encased behind a steel exoskeleton that makes up the gas sensor module. When current passes through the sensing element, the gases near to it converted into ions and these ions are absorbed by the sensing element. This alters the sensing element's resistance, which changes the amount of current that flows out of it. Microphone along with LM393 is used as the audio detector. When sound is detected using a microphone and supplied into the LM393, the intensity of the noise is determined in dB. The LM393 has an internal potentiometer that may be used to change the noise threshold. A compact six-pin analogue output optical dust sensor called GP2Y1014AU0F is made to detect airborne dust particles. It operates on the idea of laser scattering and is particularly good at picking up tiny particles like smoke from cigarettes. A phototransistor and an infrared emitting diode constitute this sensor as depicted in Fig.6.

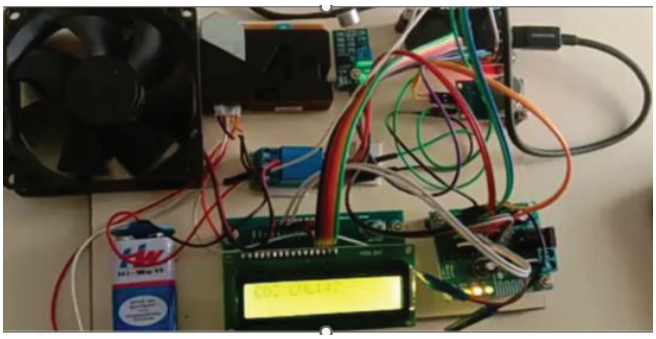

Fig. 6. Concept implementation

Embedded C programming is done in Aurdino IDE for ESP-32 and firebase application is developed for Android. IoT technology is utilized in this system to monitor and assess the degree of noise, dust and air pollution. With the help of this model, we can monitor, manage, and evaluate the intensity of many airborne pollutants as well as high-intensity noise that may result in atmospheric radiation. In order to avert any significant side-effects, instantaneous monitoring enables us to take immediate actions based on warning messages popped up on the LCD panel and on mobile phones with the help of IoT. Fig. 7 shows the Android output screen.

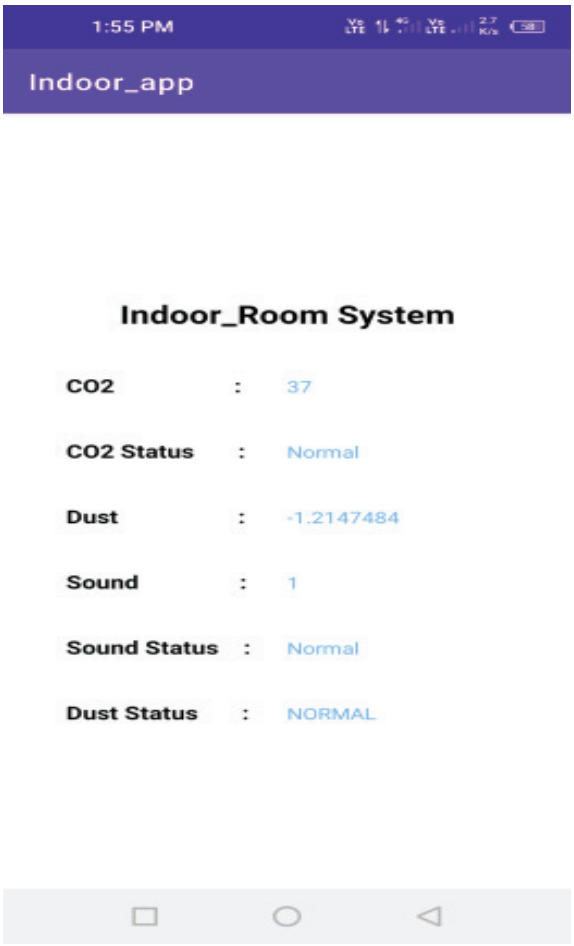


Fig. 7. Output Screen of smart embedded framework

The technology of remote monitoring has a wide range of applications that reduce the cost of wiring, including new methods of data study, process supervising and following up, of various factors. These IoT systems include numerous capabilities that can be quickly integrated into a device to enable IoT functionality. Real-time device progress reports can be created with the use of IoT technology. With the help of the Web of Things innovation, information from sensors can now be sent over the internet by connecting them to the existing framework. We are actively developing a model that can assess the erratic nature of characteristics such as air, noise and dust.

## V. CONCLUSION

This regulating system can be installed in a number of locations across the downtown or in other areas such as hospitals, motorways, school campuses, homes, plazas, and shopping malls The sensor continuously assesses the level of air, dust and noise contamination and outputs. The biggest expanding significance of this device is that the output is shown through a standard mobile application that works on all Android devices in both digital and analogue form. The information will be provided through a device that makes a beep noise, and if the air and noise pollution numerical increased from a pre-determined value, with the help of the user's cell phone GPS polluted region can be identified and remedial measures can be taken. Using this system, it is possible to regulate the level of pollution using the 'indoor_app' application in mobile devices. The Internet of Things approach has been demonstrated in practice for controlling particular criteria. Additionally, it sent data and sensor values to the clouds. This information may easily be distributed to many operators and would be valuable for a follow-up inspection. Once secure, this instinctive device is capable of tracking the pollution level indefinitely and evaluating the collected information. It is based on cutting-edge technology, is cost-effective in contrast to other technologies, and may be rooted and planted anywhere. Through a cellphone application, the outcome of this contamination regulating system is made available. The components that are being used here have a long lifespan, are accessible, manageable, affordable, and, of course, are environment friendly. The circuit connections are simple and it will have an ocular turnout and performance in real time.

## VI. FUTURE SCOPE

The system can be implemented in Exam Hall and can be used in hospital places like intensive care unit to find even minimum amount of dust, CO2 and noise level in this closed environment. It can be used to prevent spread of air-borne diseases in the closed surroundings as this product detect the harmful gas level high or low in value. The system can be modified into a home pollution monitoring system as well. Sensors are to be placed near windows or air inlets and automation could be given using decision making Artificial algorithms, such that upon high levels of dust windows must be shut and air purifier turns on. High level CO2 or temperature rise can trigger Air conditioner or exhaust fan during night time. With enhanced 5G communication devices the framework can be materialized for smart cities as well. As number of vehicles and structures increases and more trees cut down pollution tends to skies up. The affordable pollution monitoring and controlling framework turns to be a necessity to keep the quality of air and hence the sustainability of planet.

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