RESEARCH PAPER

Smart Air Quality and Health Advisory Using IoT and ML

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ABSTRACT

Air pollution is a significant environmental and population health issue because of the rapid urbanization and industrialization. The quality of air should be regularly monitored and the health warnings should be timely to ensure that the harmful pollutants do not harm the health of people to an extent. A smart air quality monitoring system is being developed that integrates IoT, ML to enable real-time health and environmental analysis. It works based on an ESP32-based sensing unit and various environmental sensors to detect such parameters as temperature, moisture, gas levels, those of particulate matter (PM2.5) and the level of ozone. The data is transmitted through a serial communication connection and processed in a Python based environment in such a way that they could be analysed and displayed in real time. Graphical dashboard The sensor readings, predicted air quality level and health warnings accompany the sensor readings are displayed in a GUI-based graphical dashboard at all times. The system is based on evidence-based classification logic that separates air quality into such categories as good, moderate, unhealthy, and hazardous. This allows the system to provide suggestions to people that are relevant to their scenario. Combined with smart data processing, IoT sensors can be used to track the environment at all times, to make a correct evaluation of the pollutants and to receive proactive health recommendations. The model can assist individuals to be more conscious of the risks of air pollution at an earlier stage and also enhance environmental management and population in the industrial and urban regions.

Keywords: Internet of Things (IoT), Air Quality Monitoring, Environmental Sensing, PM2.5 Detection, Ozone Monitoring, Smart Health Advisory, Real-Time Data Analytics.

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I. Introduction

Pollution of air has become one of the most significant environmental issues in the planet environment, which negatively affects the health of people and the state of nature. The pollutants that are harmful in the air have been highly concentrated due to rapid urbanization, growth of industries, automobile emissions, and increased use of energy. Some of the worst pollution include carbon monoxide, sulfur dioxide, nitrogen oxides, ground-level ozone and PM2.5 and PM10. By the time it comes, they can cause serious lung diseases, heart problems, less lung functioning, and even death in case you are exposed to such pollutants over a long period. Children, the elderly, pregnant women, and individuals that already have illnesses are particularly susceptible to poor air quality[1]. Air pollution harms the environment through acid rain, reduced crop yield, damage to ecology, and climate change besides damaging the health of people. This is why the air quality should be monitored accurately and continuously to be aware of the situation on the environment and make the pollution control methods effective. Nevertheless, the conventional air quality monitoring system is difficult to install and maintain and cannot deliver fine-grained and localized and real-time environmental data at large scales due to their high construction and maintenance costs. Due to this issue, we require better technology to develop environmental tracking systems which are continuous, distributed out and cheap.

The recent advancement in technology enabled the development of smart systems to monitor the environment that consume sensing technologies, as well as advanced data analytics. One of the most significant innovations in this sphere is the IoT. It has transformed the way the environment is monitored by linking the sensing devices which are capable of collecting and transmitting real-time data with regard to the environment. Through the IoT technology, environmental sensors are able to communicate with one another using wireless networks and cloud computing platforms, thus the conditions in the environment can be tracked at all times. With the help of inexpensive sensors which are constructed using microcontrollers and connection modules, IoT-based sensing platforms have the capability to monitor numerous environmental parameters, including the quantity of the amount of particulate matter in the air, the concentrations of gases, the temperature, the humidity, and the pressure of the air[2]. These sensing nodes can be installed in the cities, industrial areas, residential neighborhoods, or traffic routes to get perpetual environmental data. With the reality that IoT systems are dispersed, solutions that track can be developed that will facilitate the coverage of large regions, but at low costs at the same time. Moreover, IoT systems can be used to collect, store, and transmit data automatically. This implies that much tracking does not need to be done manually thus it will make environmental management more efficient .

The IoT sensors of air quality and other devices can also gather and transmit data in real time, hence digital platforms can be utilized immediately to interpret and distribute environmental information. Real-time monitoring enables government agencies, the environmental groups and even the towns to be aware immediately of the level of pollution hence they respond promptly in cases where there are dangerous environmental conditions. IoT sensors may transmit information to main cloud servers, at which it may be stored, processed and visualized with the help of web-based dashboards and data analytics applications. Individuals using these platforms are able to view the trends in pollution, monitor the developments in the environment and receive notifications as soon as the amount of pollutants are above the amount that is believed to be safe. IoT monitoring systems may be tied to mobile apps and web sites also, in order that individuals and groups can access air quality information in an easy manner. This accessibility has made people be more conscious of the environment and makes them make wise decisions on outdoor activities, transportation, and other health considerations during periods when there are bad air quality [3].

The smart environmental monitoring systems can be improved with ML and artificial intelligence (AI) techniques, which enable the systems to analyze data and predict it in intelligent ways. Since IoT sensors provide much information regarding the surrounding, it requires sophisticated analytical tools to uncover the patterns of pollution and valuable insights. ML algorithms can be able to identify complex relationships in the past and present environmental data that may not be readily identifiable using conventional statistical procedures. High-quality environmental data can be used to predict the quality of air in a situation and identify pollution sources and even approximate the health risks that could arise due to exposure to pollutants using ML models. There are numerous algorithm types that have been employed to sort and predict environmental data including decision trees, support vectors machines, neural networks and ensemble learning techniques. These models trace and train the previous environmental information and continue to improve in future prediction as more information arrives [4]. This renders air quality tracking systems more valid and beneficial.

Integrating environmental sensing technology with big data analytics is possible to process a lot of environmental data in a short time and enable a deeper analysis of pollution. The environmental monitoring systems capable of conducting analyses can scan the patterns of pollution in various locations and various times. This assists the researchers and legislators in determining the causes of air pollution. These emerging ideas can be used to make specific environmental legislation, traffic management strategies, and measures of pollution.
Combining IoT sensing, cloud computing and ML can also be used to develop smart environmental platforms capable of providing an individual with a customized estimation of their exposure to pollution. These systems can scan the location of an individual, activities that one is undertaking and environment to determine the level of exposure to pollution and how individuals can remain healthy. This assists the public health activities in reducing the health risks arising due to pollution [5].

ML-related frameworks through sustained research of environmental factors have proved to be quite promising in forecasting the air quality level and identifying potential health hazards within the environment. Predictive models can examine time-gathered data on the environment to make guesses on the level of pollution to come in the future and provide an early warning when the air quality may be deteriorating. The predictions can be valuable in planning cities, transportation management and preparation of health care emergencies. The smart environmental monitoring systems can also be linked with the eHealth platforms which rely on the real-time environmental variables to give health related recommendations. An example is individuals with condition of the lung such as asthma or chronic obstructive pulmonary disease who can receive alerts about the need to spend less time outside when the pollution is too high. These health advice systems are proactive and thus aid in the betterment of the health of the people and the reduction of the ill impacts of the pollution [6].

Environmental health mapping systems to forecast the future occurrence of health issues are the new studies that have been underway. These applications are based on real-time air quality data and geographic analysis and ML algorithms to visualize the distribution of pollution throughout cities. Such systems help in locating regions that are highly polluted, tracking the movement of pollutants, and helping certain strategies to conserve the environment. Moreover, with the help of smart environmental systems based on IoT sensing and ML, the digital monitoring systems can also offer personalized pollution monitoring as well as real-time notifications and health risk forecasting. With these tools, people can save the environment and be more conscious of it as people will have access to correct data regarding the air quality [7].

Smart sensor technologies are also applicable to make smart environmental decision-support systems together with advanced analytics. These tools can be utilized by policymakers, environmental groups, and healthcare groups to assist them in developing data-driven strategies that can help protect the health of the population and minimize pollution. Predictive analytics and an environment under continuous observation can enable the decision-makers to make good policies regarding pollution control and control the industrial emissions. The primary aim of this study is to develop a smart system of air quality monitoring and health recommendations that integrates environmental sensing with the use of IoT and ML. Such a framework will enable real-time tracking of pollution, categorization of air quality conditions, and development of health warnings depending on environmental parameters that have been detected [8].

II. Related Work

Increasingly new research in environmental monitoring has been aimed at integrating artificial intelligence with realtime sensing technology in order to have a clearer view of air quality and improve awareness of public health. Smart tracking systems are based on automated sensing networks and predictive analytics that ensure the constant monitoring of the level of pollution and provide early alerts about a potential risk to their health. These systems involve both the gathering of information about the surrounding and analyzing it with the assistance of AI to aid in the continuous monitoring and datadriven decision-making. These frameworks can provide people and groups with more precise data on pollution and timely recommendations by using a combination of smart analytics and sensing devices. This integration enhances the management of the environment health by ensuring ease in how both the officials and the people can respond in the intelligent manner in instances where harmful conditions of pollution are detected. That is why real-time environmental sensing and smart data processing have become significant to improve the air quality control and extend the term of the environment [9].

Managing air pollution in city centres has also been assisted by big data which is designed with the ability to handle great volumes of environmental data. The new sophisticated environmental data systems have the ability to collect, store and process extremely large volumes of data which originate with sensors, monitoring stations and other systems that look after the environment. Through these platforms, data are easily shared among researchers, policymakers, and environmental groups to monitor the level of pollution on a large scale. With the help of big data technologies, such systems introduce the possibility to consider long-term pollution patterns, discover pollution hotspots, and develop particular methods of pollution reduction. Through these models, governments and urban planners can also create environmental policies that are working and that can make the cities more sustainable. The development of environmental tracking network and the big data analytics simplifies the management of the smart cities, as it allows people to make decisions informed by data about how to eliminate pollution and save the environment [10].

Another significant innovation in terms of environmental monitoring is to use IoT technologies and ML algorithms to assist in the prediction of the quality of air at any moment in time. IoT sensors continuously measure something on the environment such as the level of particulate matter, gases, temperature, and humidity. These sensors transmit the information they receive to central processing systems. ML models there analyse the information to identify patterns in pollution and predict the way the air will be in the future. Learned predictive models over environmental data sets are able to identify trends in the quantities of pollutants and better predict when a pollution incident might occur. These types of forecasting tools allow to discover unsafe environmental conditions in time and make efforts to safeguard individuals against pollution. Timely tips and suggestions are also used in real-time forecasting to raise the level of awareness among people, which assists in people staying safe during periods when the air quality is poor [11].

Indoor air pollution monitoring systems have also become the subject of intensive recent research, as well as outdoor air pollution monitoring systems. Increasingly, there is the use of sophisticated artificial intelligence to generate smart predictive models that analyze the state of the indoor environment and identify variables that influence the quality of the air indoors. These systems rely on the information provided by environmental sensors to determine the level of pollution in an area and recommend the improvements that can be done to improve the indoor environment. Forecasting models are able to identify sources of pollution such as poor ventilation, domestic emissions or other environmental pollutants and determine how they may impact the health of people. Automation of analysis and decision-making makes these smart monitoring systems useful in maintaining a healthier indoor environment and increasing awareness of the dangers of indoor air pollution. Such work demonstrates that artificial intelligence is able to assist in managing the indoor environments and contribute to the improvement of the population health [12].

Air quality forecasting systems may be improved by incorporating multisource data fusion methods into them in order to be more accurate and reliable. This is one more significant sphere of study. Increasingly, environmental monitoring devices integrate information of several various sources including environmental sensors, weather forecasts, satellite images, geographical information and the like. A combination of this various types of data makes ML models determine the interrelation of environmental variables and patterns of pollution in intricate ways. By integrating various data, the environment can be studied in a more comprehensive manner and it becomes easier to have the predictive models predicting the pollution levels in an accurate manner. Such systems are also able to consider the climate as well as the health risks associated with exposures to the pollutants simultaneously. When they process the results of data provided by numerous sources through sophisticated analytics, environmental monitoring systems may be able to conduct more accurate forecasts and assist the approaches of the public health management in improving its functionality [13].

The development of inexpensive environmental monitoring devices has also become a significant place of research which seeks to make the air quality monitoring technologies more accessible. Conventional surveillance locations can prove to be costly and difficult to locate hence unable to provide all the information regarding the environment. In order to overcome this issue, scientists have developed cost-efficient monitoring tools which utilize wireless communication and a series of sensors collaborating with each other. Such systems have numerous sensors which are capable of measuring numerous things about the environment simultaneously such as the quantity of dust, temperature, humidity and gases in the air. The multi-sensor arrangements enhance the precision of surveillance and enable to perform an entire examination of the environment. It is easier to transmit information over a distance using wireless technologies and maintain a watch over objects, which means that these systems can be introduced both in large cities and in the countryside. These tracking systems are not very expensive and can be expanded and this makes it easy to create more environmental monitoring systems and provide more people with information regarding the air quality [14].

In the recent past, academics have also investigated personalized environmental health frameworks which deploy IoT-based sensing devices and ML algorithms in providing individual users with information about the pollution that is unique to them. Such smart systems peer into the surroundings and data regarding the individual, such as their location, activities and hours they have been exposed to in the vicinity. Environmental data+predictive analytics can be used to determine the level of pollution exposure and make health recommendations based on that knowledge. Such concepts may involve advising the people to spend less time outside when there is a lot of pollution or practicing safety measures to reduce the health risk. Therefore, custom environmental monitoring systems are highly significant to raise awareness of people concerning the environmental concerns and provide them with the data they require to make sound decisions regarding their health and daily habits. Such a integration of IoT and ML indicates that it is feasible to create environmental tracking systems, which are both superb and user-centered [15].

A study of how to govern urban air quality has also been done in the framework of stakeholder-driven frameworks that emphasize collaboration among government agencies, researchers, and environmental groups. The primary objective of such governance models is to develop successful data management ecosystems capable of managing big environmental data and ensure monitoring procedures of pollution are transparent and responsible. These structures contribute to making more productive decisions concerning the environment and enhancing the strategies of pollution control in smart city infrastructures as people can share data and conduct research together. Good governance models also support the integration of technologies that are used to track the environment with policy planning and urban management projects. Governments, through joint environmental data ecosystems, are able to devise better means of minimizing pollution and make cities that are increasingly growing more environmentally friendly [16].

ML approaches have been extensively used in predicting the AQI, as well as estimating the amount of pollution in cities. Having the environmental datasets to construct the predictive models, one can correctly classify the quality of the air and visualize the dynamics of pollution as time goes by. With the assistance of these models, smart systems of monitoring the environment can be made, predicting the level of pollution and determining the health risks that are associated with them. Examples of ML-based methods are regression models, decision trees and neural networks, which are extremely effective at attempting large environmental datasets and making correct predictions on air quality. ML is increasingly being applied in monitoring air quality as researchers strive to develop improved prediction models that can address the increasing challenges posed by the urban air pollution. Such intelligent surveillance is quite significant to keep the well being of the people in the urban areas and assist in long term environmental control [17].

III. Methodology

By using IoT sensors together with the analysis of data using ML, we develop an intelligent system of air quality control and health guidance. That enables the environment to be monitored and health advice proactively taken. The system employs a microcontroller-powered sensing device with a number of environmental detectors to receive real-time data concerning the temperature, humidity, gas concentration, the concentration of particulate matter (PM2.5), and the concentration of the ozone. This is because these environmental factors are continuously recorded and communicated to a processing environment where they are to be studied and made sense of. The sensing design allows gathering real-time information concerning the environment, thus it becomes simpler to locate and monitor pollutants in diverse environments [18].

The hardware layer of the proposed framework constitutes a small unit of a microcontroller which is mounted with air quality monitors which are able to measure various environmental variables. The sensors are particulate matter and gas monitoring modules that are utilized in order to provide an eye on the aspects of pollution which significantly impact the health of people. The microprocessor controls the work of the sensor, gathers the readings at the specified intervals and prepares the data to be transmitted. A communication module, such as Wi-Fi or wireless networking is employed to send the data received to a CPU or cloud platform so that it can be researched further. This form of communication among one another ensures that the monitoring of the environment is proper and continuous even in distant locations.

A data processing module is intended to receive sensor data and perform preparation functions such as parsing, filtering and normalizing sensor data. These measures are used in eliminating noise, invalid reading, and variations in sensor values in order to have the study correct. Once the preprocessing phase is completed, the data is then sent to an analysis tool based on ML. It also has classification logic which is data-driven which can be used to examine the environmental factors and subdivide the air quality levels according to the trends of pollutant concentration. Such figures could represent various air quality levels such as good, moderate, unhealthy or dangerous. This allows us to know the nature of the environment.

One can make the process of environmental data interpretation and pollution even more reliable and accurate with the help of intelligent optimization methods and the predictive modeling strategies. Both the past and real-time environmental data allow finding patterns and trends in the levels of air pollution through ML algorithms. According to the current knowledge, predictive models have the ability to make guesses about how the air quality will be in the future. It assists individuals and cities prepare against potential risks to the environment. Through these techniques, the surveillance system will be able to locate potential sources of pollution and make individuals more conscious of the environment and take preventive health measures [19].

A graphical user interface is utilized to create a real time visualization dashboard displaying the environmental parameters, the condition of the air quality, and health warnings accompanied by them. The system allows individuals to monitor the environment at any given time and be informed of the potential health threats involved in being exposed to pollution. The visual features, such as charts, indicators, and alerts, make people perceive information about air quality quickly and accurately. Health suggestions can also be based on the levels of pollution. To give an example, in the event of excessively high pollution, users can be advised to spend less time outdoors or use masks covering their faces. The combination of IoT based sensors, smart data analysis and real time visualization forms an entire system of air quality monitoring and health predictions[20]

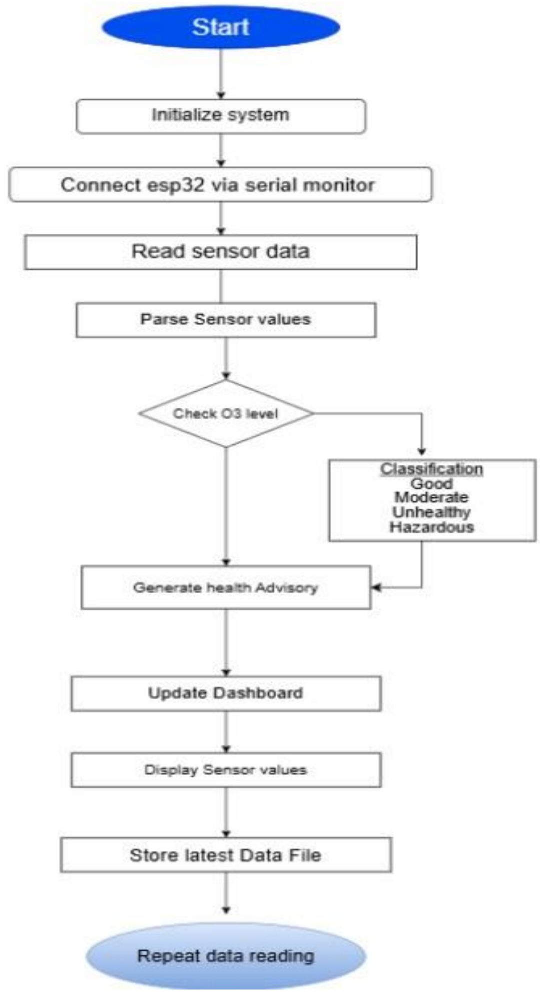


Fig. 1 System Flowchart

Fig. 1 is a flow chart which illustrates the operation of an environmental tracking system. The system reads and interprets sensor values of O3, temperature, humidity, gas, and PM 2.5 (mkg/m 3) upon startup and connection to an ESP32 via serial port COM8. Then it classifies the quality of the air into categories depending on the quantity of ozone among other environmental factors. *A) System Design and Architecture:*

The system (Fig. 2) is designed in such a way that it includes the IoT sensors connected to a system that will enhance the processing and data presentation of the received data to ensure that the air quality can be constantly monitored and health warnings given. The architecture consists of the sensing layer, the data processing layer and the human interface layer. Environmental sensors connected to an ESP32 microcontroller and included in the sensing layer are measuring real-time information about the atmosphere such as the level of particulate matter, ozone, gases, temperature, and humidity. Being the central controller, the ESP32 receives the sensor values and transmits the data to a processing environment through a serial communication interface.

The sensor readings are received by the data processing layer which provides some basic processing on the received data stream such as parsing, validating and formatting. This level ensures that the environmental data is arranged according to order in that it can be analyzed and interpreted further. When the data are processed, they are relayed to the monitoring and classification module which tests the state of the environment.

The user interface layer gives a graphical screen, which display the existing environmental data in a manner that is easy to interpret. According to processed information, the dashboard will constantly display the most recent sensor results, air quality condition and health warnings. The stratified system design ensures that the device components, data processing algorithms, and the graphical interface are able to communicate with one another with relative ease. This allows the environment to be monitored and the users of the system to interact with it in a reliable manner.

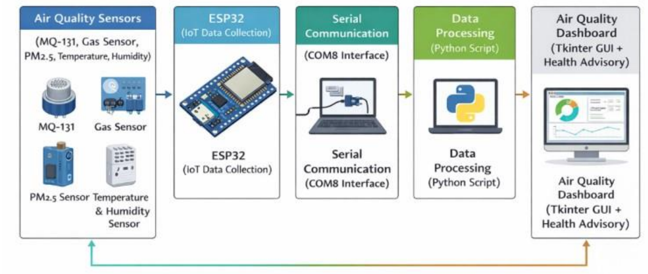


Fig. 2 System Architecture

B) IoT-Based Environmental Data Acquisition:

To collect environmental data, an IoT-based sensing device (Fig. 3) constantly collects data related to the weather. The sensing unit is developed with several environmental sensors, and an ESP32 microprocessor that gathers information and transmits data to other devices. None of the sensors examine the same aspect of the environment, such as the quantity of particulate matter, ozone, gases, temperature, and humidity. These parameters are extremely crucial to quantify air pollution and the calculation of the world.

Regularly, the ESP32 microcontroller gathers the analog or the digital outputs of the sensors and converts them into formatted data values. Readings are then placed in a comma separated data stream and the measured factors are put there. The data are then sent to a computer system which is then connected so that the data can be processed and further analyzed.

The monitoring device is able to capture what is happening in the environment with time due to the fact that it provides information at all times. This real-time sensing will help the system to identify rapid increases in the level of pollutants and respond to them. With the use of low cost environmental sensors and an IoT communication platform the monitoring system is able to collect environmental information fast and cheaply and at the same time the setup and running costs remain minimal.

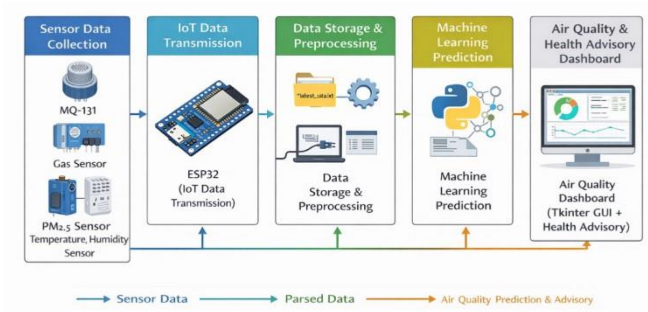


Fig. 3 IoT Data Processing

C) Data Processing and Air Quality Classification:

The data concerning the environment is received in the sensing module and transmitted to the data processing module to be interpreted and comprehended. The processing system is used to process the incoming serial data stream using data parsing techniques to isolate the various sensor parameters. To give the correct measurements of the surroundings, each parameter will be converted into a number and compared with that number.

The processed data is examined with classification arguments to determine the present situation of air quality and air pollution level. The classification module classifies the environmental conditions into groups, such as good, moderate, unhealthy and dangerous based on the known quantities of pollution. It is these categories that make the system able to understand the world in a manner that is meaningful and easy to comprehend by users.

The data processing also ensures that sensor readings are continuously being updated and this allows the monitoring system to provide an almost real-time estimate of the air quality. Classification mechanism is another important element of transforming the raw sensor reading into valuable categories to air quality. The system has the ability to monitor the environment effectively and alert people on the level of pollution at the correct time through turning the environmental data into air quality measures that can be comprehended.

D) Real-Time Monitoring Dashboard and Health Advisory Generation:

Users interlink with the system at the monitoring dashboard. It displays the data concerning the surroundings and the quality of air visually. A graphical user interface is created using a software structure that allows sensor readings and system prediction to be viewed in real time. The processing data always gets displayed on the dashboard automatically updating the information on the dashboard at specified times.

The quantity of environmental factors such as the quantity of particulate matter, ozone, gases, temperature and humidity are seen in a transparent manner on the screen. The dashboard displays the classified air quality condition with varying amount of pollution indicated by various color in addition to displaying the raw sensor values. The visual aids are beneficial in enabling users to acquire the prevailing situation of the surrounding within a short period of time.

This system emits health warnings depending on the type of air quality it identifies to inform the users of potential health hazards. Some of the things that people are advised to do through the warning messages include spending less time outside, wearing masks to safeguard themselves or staying indoors when the pollution levels are high. The ability to monitor on a real-time basis and generate advisories automatically makes users more conscious and enables them take measures to ensure they are not exposed to pollution. This interactive visualization tool makes the environmental monitoring system easier to use in general and enables the people to make smart decisions.

IV. Experimental Results

Smart air quality tracking and health advisory system is effective in interpreting the pollution concentration and documenting environmental parameters, which has been experimented to be effective. The sensor data of the IoT sensor unit was examined to determine the cleanliness of the air and make recommendations. Performance evaluation examines sensor measurements, air quality classification and variations in environmental parameters to determine the capabilities of the system in terms of tracking performance. The effectiveness of the proposed monitoring system was tested by real-time sensor data of the IoT sensing module.

TABLE I ENVIRONMENTAL SENSOR READINGS COLLECTED FROM IOT MONITORING SYSTEM

S.No	**$PM_{2.5}$ (µg/m³)**	**O_3 (ppb)**	**Gas Level (Ω)**	**Temperature (°C)**	**Humidity (%)**
1	32	45	210	27	62
2	40	58	230	28	60
3	52	72	260	29	59
4	85	110	310	30	57
5	120	160	380	31	55

Table I presents the real-time data of environmental sensors, including PM 2.5, ozone, gas, temperature, and humidity.

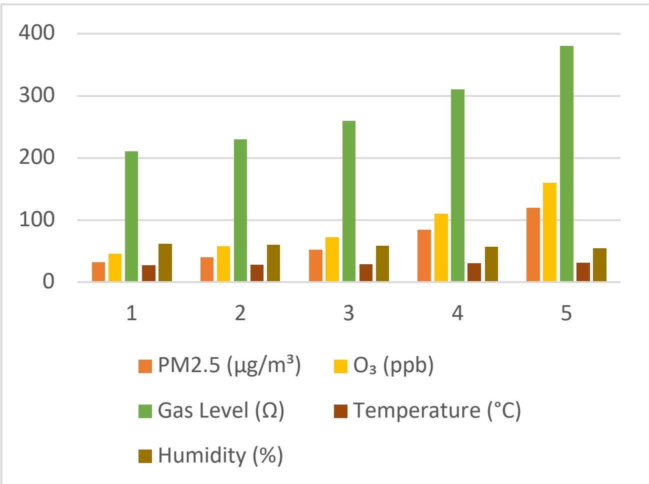


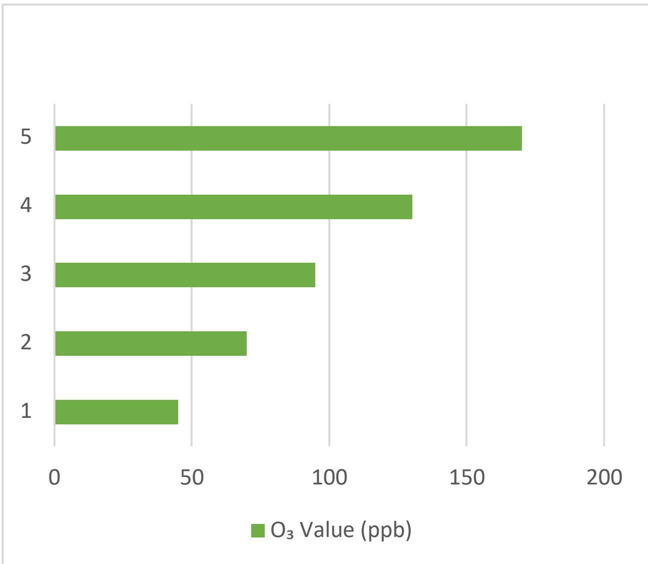
Fig. 4 Comparative Sensor Data Analysis

Figure 4 illustrates a bar graph indicating the variations in the quantity of PM2.5 (µg/m 3), O3, gas, temperature and humidity across five data points.

TABLE II AIR QUALITY CLASSIFICATION AND HEALTH ADVISORY OUTPUT

S.No	**O_3 Value (ppb)**	**Air Quality Status**	**Health Advisory**
1	45	Good	Safe outdoor activities
2	70	Moderate	Sensitive people limit exposure
3	95	Moderate	Avoid long outdoor exposure
4	130	Unhealthy	Stay indoors recommended
5	170	Hazardous	Avoid outdoor activities

Table II shows how the air quality was rated according to the quantity of ozone and the types of pollution that are defined as not healthy to humans. It also displays the health warnings associated with every amount of pollution.



O_3 Value (ppb)

Fig. 5 Ozone Concentration Levels (ppb)

Fig. 5 indicates that there was an increase in concentration of ozone (O3) as the readings were done over five successive readings recorded in parts per billion.

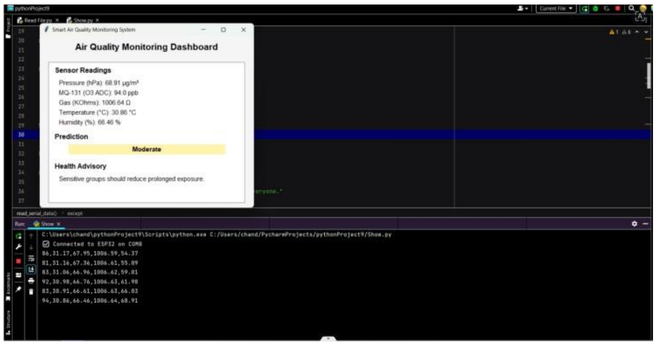


Fig. 6 Air Quality Monitoring Dashboard GUI

Fig. 6 demonstrates Python Tkinter interface which provides real-time sensor data, prediction of air quality of a certain type, which is the middle of a range of values, is moderate and a special health warning.

V. Conclusion

Developing a smart air quality system that integrates IoT sensors with data analysis tools and can deliver real-time health recommendations and environmental monitoring has been proven to be successful. The sensing unit based on the ESP32 continuously gathers the values of the environmental parameters like temperature, humidity, amount of gases, amount of the particulate matter (PM2.5), and the concentration of the ozone. The primary layer that gathers information is the sensing unit, which ensures that the environment is faithfully and continuously observed at various locations. The collected data is analyzed and presented in an easily accessible Python-based interface which visually depicts the data in a dynamic dashboard to display real-time sensor data, the current status of air quality, and any health warnings emitted.

Using the applied logics on classification, the system is able to classify air quality conditions into multiple categories including good, moderate, unhealthy and hazardous. This enables users to learn within a short time the risks associated with their health and the environmental conditions. By aggregating the environmental information into simple and easy to understand data all the people, even the non-experts can have access to the data. It is also easier to use and the graphical design presents the data in a manner that is easy to understand. This allows you to acquire knowledge fast and make prudent decisions. Using the real-time visual representation tools such as charts, status indicator, and warning message, users could observe trends in pollution and take direct action against the occurrence of dangerous air conditions.

The developed system is effective to gather the environmental data periodically and provide helpful information regarding the exposure to air pollution. These types of intelligent monitoring solutions are beneficial because they can support the field of social health, increase awareness of the environment, and lay the foundation of further applications of smart cities and environmental monitors.

In the future it can be improved and concentrate on how to predict the quality of air and analyzing the trends of pollution using more accurate ML and DL models. The complex environmental patterns can be estimated using sophisticated predictive models such as neural network, ensemble learning techniques and time series prediction algorithms, which can provide more accurate forecasts on air quality.By making such types of improvements, people and the government can make preventative measures prior to the pollution levels reaching the harmful levels.

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