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Predicting Mortality Rate using Gas Sensors

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Abstract: Air pollution occurs when large amount of certain harmful pollutants is released into the atmosphere that is dangerous to the health of humans and all other living beings on the planet. A large proportion of air pollutants comes from production and manufacturing in industries and vehicle emissions. Burning fossils for energy production releases harmful gases and chemicals in the atmosphere. This also raises the earth's temperature and ultimately results in global warming and greenhouse effect. However, certain pollutants such as smog, soot, sulfur, carbon monoxide are especially dangerous because they can easily penetrate through the lungs and then mix with the blood causing bronchitis, heart strokes or even death. Hence, there is an intense urgency to monitor the quality of air to prevent its harmful effects. People need to be aware of how and to what extent their lives are affected due to such hazardous emissions. This project proposes a system built using the Arduino microcontroller and gas sensors to analyze the concentration of several harmful gases present in the atmosphere and its correlation to the mortality rate of that particular area. The system is designed to sense the several toxic gases in the air and their respective concentration at any given moment and to develop a model that can predict the mortality rate based on previous records. The concentration of gases is taken in parts per million (PPM), and the mortality rate is calculated as the number of deaths per hundred thousand people. The data is analyzed, and predictions are made using a suitable machine learning predictive model trained according to the previous records of mortality rates of a particular area. The results are displayed on an interactive web interface designed using Django, which also shows the locations of hospitals nearest to the user and also has a chatbot implemented to assist the user.
Keywords: Internet of Things, Air pollution, Predictive modelling, Evaluation metrics, Mortality rate, Parts Per Million.

I. INTRODUCTION

One of the essential elements of life is air. Our atmosphere has certain vital gases such as oxygen, nitrogen, carbon dioxide and traces of other gases. There is a perfect balance of all the gases present in the atmosphere. It's of utmost importance to maintain the balance of concentration of gases in the atmosphere considering the survival of humans and other organisms. Humans need an atmosphere which is free from any harmful gases and contaminants. Air pollution is the introduction of harmful pollutants in the atmosphere in a quantity which can become grave harm for humans to survive. The air pollutants are measured in parts per million (PPM). There are primary pollutants which are released directly into the atmosphere mainly due to manufacturing and production in industries and burning of fossils to produce energy. Secondary pollutants are those which on reacting with primary pollutants releases harmful contaminants in the atmosphere. Certain air pollutants such as smog, ashes, sulfur, CO can impair visibility, they can penetrate the lungs and can cause or intensify bronchitis, can induce heart strokes and can even cause deaths. In fact, air pollution is solely responsible for the deaths of approximately 7 million people worldwide annually or around 1 in 8 premature deaths yearly. Almost 500,000 children below the age of 5 die every year from a respiratory infection linked to indoor/outdoor pollution and second-hand smoke [1]. Therefore, it becomes a paramount concern to monitor the increasing level of such contaminants in the atmosphere and to spread awareness about the harmful effects it has on human beings. Several researches have been conducted worldwide, and numerous models have been developed to monitor toxic gases such as Carbon Monoxide, Sulfur, LPG, Nitrogen Oxides, etc. Recent surveys and studies have reported that there is an association or link between the air pollution and the concentration of particulate matter in the air and the increasing daily mortality rates. Some population-based studies in metropolitan areas in the United States of America have also found such connections between air pollution and mortality rates. However, such surveys and reports have been criticized because they do not take into account other factors such as smoking or other risks [2]. However, the fact that the increasing population has an impact on the health conditions of human beings cannot be neglected either.

According to the statistics by Lancet, India has topped the list of countries with pollution-related deaths 2015, with nearly 2.5 million humans dying prematurely due to diseases related to water, air and other kinds of pollution [3]. According to The Lancet report, air pollution was the most significant contributor, linked to 6.5 million deaths in 2015, ahead of water pollution (1.8 million) and workplace-related pollution (0.8 Million) [3]. Some of the air pollutants are SO2, CO, CO2, NO, volatile organic compounds (VOCs), particulates, chlorofluorocarbons (CFCs), etc. [3].

Around the globe, governments are building smart cities to keep a constant check on such problems. Real-time monitoring of the quality of air requires the transfer of data continuously between remote devices over the internet and needs to be analyzed accordingly to keep a check on the rise of pollution. Hence, to achieve such an IoT based implementation of a system, proper sensing is required. The things in "Internet of things" would be sensors which can communicate with each other through Machine to machine (M2M) communication protocols which can be stored in several affected areas to access real-time data that can be transferred to a control system where the data can then be analyzed, and required actions can be taken accordingly. The proposed model consists of three broad components – sensors, a processing unit and cloud platform. The sensors such as MQ2, MQ135 collect data from the surroundings related to concentration of harmful gases in the atmosphere and send it to a processing unit which can be a remote computer which processes the required information and then sends the processed data to the cloud platform where further analysis can be done, and predictive analysis on the results can be helpful in framing the solution to the problem of air pollution hazards.

II. PROPOSED WORK

The model for air pollution monitoring and predicting mortality rate, predicts the mortality rate of a particular area using a dataset and values of toxic gases recorded from gas sensors (MQ2 and MQ135) and displays it in an interactive web interface built using Django. The library in the Arduino for LCD and MQ level gas sensors are loaded and a sketch containing the Arduino code is compiled and loaded in the Arduino. The Arduino board is connected to gas sensors such as MQ2 and MQ135 which measures concentration of gases such as Sulfur, Carbon monoxide, LPG, smoke level in PPM. The air quality is measured by MQ135 gas sensor in AQI. These sensors are connected to analog pins in Arduino. The LCD and potentiometers are connected to control the backlight of LCD. A buzzer is connected which goes on when AQI reaches a level more than 400. The LCD also displays the recorded values of gases. The data recorded is then sent to a python script using an API which contains the machine leaning model built using Random forest regressor**.** This particular model is best suitable for a dataset which contains large number of records (18,000 in this case). It gives the maximum ROC/AUC score when compared with other regressor models. The mortality rate is predicted based on the input features. Missing values are removed from the dataset and categorical variables are converted to dummy variables and then the model is trained. The predicted mortality rate is displayed on the web interface which also consists of interactive features such as a chatbot and a map which displays the nearest hospitals to the user. The user needs to register to the website before seeing the prediction. The Arduino serial plotter plots the graph based on the recorded values and the time on which these values are recorded. The graph between the predicted mortality rate and the gas concentration is also displayed in the web interface.

III. ARCHITECTURE

The model consists of various modules for different functionalities and has several hardware components as well. The architecture diagrams and the model workflows are discussed below.

A. Overview of the proposed system

Fig. 1 shows the abstraction of the proposed system in different layers. The users directly interact with the cloud to get relevant information about the system through an interactive interface.

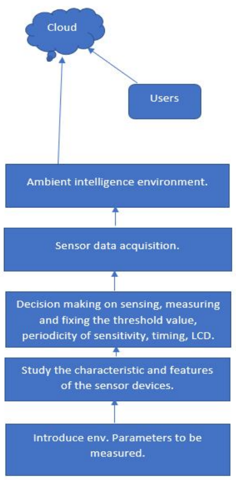

Fig. 1 Overview of the proposed system.

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B. Block diagram of the Proposed System

Fig. 2 represents the component or the block diagram of the proposed system. It depicts the connectivity between the principle components of the system.

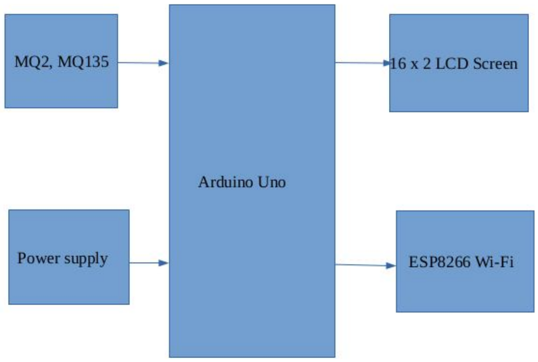

Fig. 2 Block diagram of the proposed system

C. Functionality of the proposed Model

Fig. 3 shows the flow of the proposed model. The entire workflow of the system right from loading the libraries and building the code to the interactive end-user experience has been mentioned in the flow diagram.

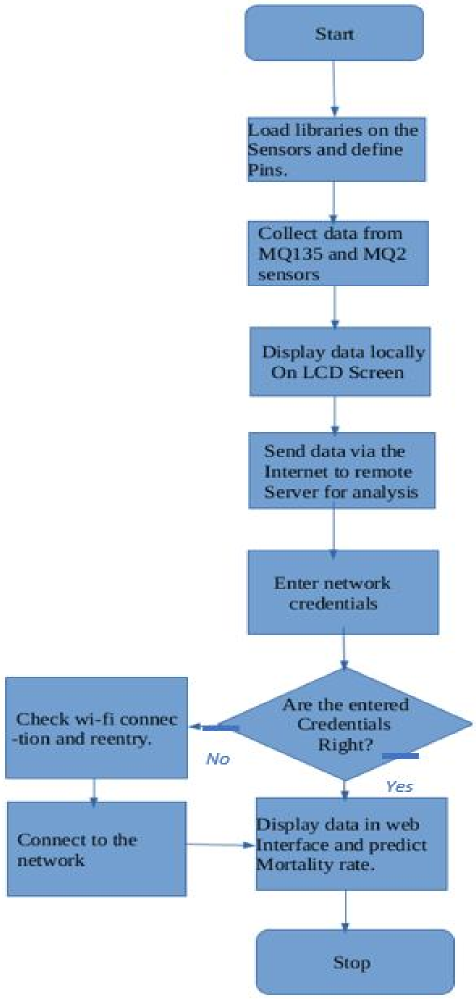

Fig. 3 Functional flow diagram of the proposed model

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IV. SYSTEM SETUP

This section contains the detailed description of the hardware and software components that were used in building the framework. It also contains the architectural diagram and the complete hardware setup of the model. The components were used to build the model are shown in table 1.

TABLE I
LIST OF HARDWARE COMPONENTS

Index	List of components		
	Name	Quantity	Model
1	Arduino Uno	1	ATMEGA
2	Gas Sensors	2	MQ2, MQ135
3	LCD	1	16x2
4	Jumper Wires	30	M2M, M2F, F2F
5	Bread Board	1	
6	Resistor	1	10K ohm

Fig. 4 shows the sketch diagram of the hardware components of the system.

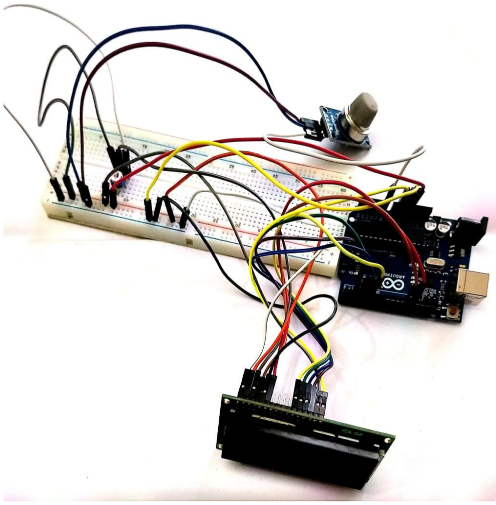

Fig. 4 Sketch diagram

V. RESULTS AND DISCUSSION

Table I shows the values were recorded by varying the concentration of the gases by changing the distances of the source of gases from the sensors for experimental purposes only.

TABLE III
DATA COLLECTED FROM THE SENSORS AND PREDICTED RATE

LPG (PPM)	CO (PPM)	SULPHUR (PPM)	MORTALITY RATE (PER 100,000)
0	0	0	0.000
8	9	9	2.732
12	18	11	3.625
15	17	18	5.003
12	12	7	2.989

After testing various regression model, the model with the best accuracy was the random forest model with an AUC-ROC Score of 87% approximately. The model was trained on a dataset from an official website of record maintenance. This dataset originally contained 10 columns with several redundant features. After thorough feature engineering and dimensionality reduction techniques including Principal component analysis (PCA), the set of parameters were reduced to 3 which where Carbon monoxide, Sulphur and LPG. The parameter to be predicted was the mortality rate. After training the model, the input data was collected from the sensor and their corresponding mortality rates were predicted which are mentioned in the Table II. The mortality rates were then displayed in an interactive web application built using Django framework which included functionalities such as chatbot and displaying locations of nearest hospitals on a map. The entire system model consisted of 3 main steps: Collection of data from the sensors, predicting mortality rate using predictive modeling, analyzing the predicted data.

Fig. 5 displays the LCD screen which displays the concentration of gases LPG, CO and S when a match stick is lit near the gas sensor.

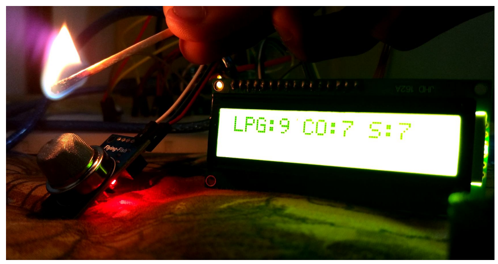

Fig. 5 LCD displaying concentration of gases.

Fig. 10 depicts the mortality rate corresponding to the readings in Fig. 9 in an interactive web interface.

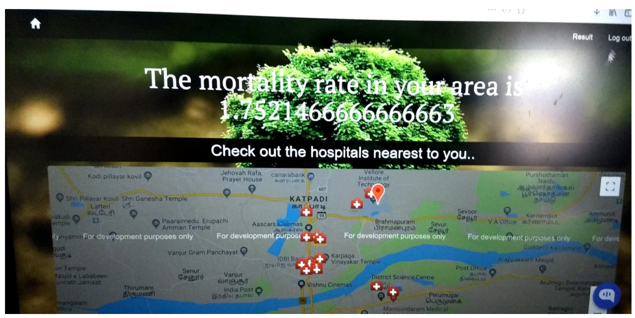

Fig. 10 Web interface displaying the mortality rate

Fig. 11 displays the graph in which the x axis contains the LPG concentration in PPM and the y axis contains the CO concentration in PPM. The points are the corresponding mortality rates. It is clear that, as the concentration of LPG and CO increases in the atmosphere, the mortality rates also increase.

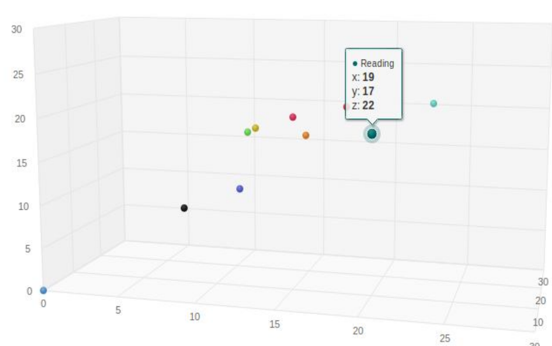

FIG. 11 3D SCATTER PLOT

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VI. CONCLUSIONS

The proposed system was designed and tested. The proposed system can measure the air quality of a particular area with the help of the hardware module fixed at certain locations. The proposed system collected real time pollution statistics using various sensors which monitored percentage of gases like LPG, Sulfur and carbon monoxide. Using these inputs, the algorithm predicted the mortality rate. Although there are a huge number of existing systems, the proposed system provides a unique feature by calculating the mortality rate and displaying it in an interactive web interface. The additional benefit of the proposed system is the web application which will help the common man understand and be aware of the pollution status of localities and the harsh mortality rates. This awareness can also lead to people making a contribution directly to reduce pollution levels.

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