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# DEEP ANALYSIS AND MONITORING OF AIR QUALITY USING INTERNET OFTHINGS (IOT) UNDER SDG 3.9

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**Abstract:**

In this world there is five elements of nature (air, water, land, etc.) and in that one of the major needsis air. From the past pandemic time (covid spreading time) air plays a vital role of the spreading to the disease through air. Also, Air pollution is recognized as a pressing sustainability concern and is directly mentioned in two SDG targets: SDG 3.9 (substantial reduction of health impacts from hazardous substances) and SDG 11.6 (reduction of adverse impacts of cities on people). So thus, thequality of air should me maintain properly to avoid this form of disease spreading and the pollution caused. Also, the harmful gases like Carbon dioxide (Co2), carbon monoxide (CO), smoke, nitrogenoxide etc... are affecting the quality of air. To monitor these harmful gases/pollutants, the Internet ofThings (IoT) gives a wonderful solution through sensors (either fixed/moveable). This monitoring system, measures the quality of air and predict the upcoming issues. This system uses MQ7, MQ2, LM35 or DHT11 sensor and Arduino microcontroller board for monitoring Air Quality as it detects most harmful gases and can measure their amount accurately in the first phase of project. Then predicting the air quality using machine learning algorithm with this real time data.

**Keywords:** Air quality, IoT (Internet of Things), Machine Learning.

## I. Introduction:

Air pollution is considered as the prime concernof the industrial age, that affect human health and environment. Due to population growth and development of the industries and transportationfacilities the emission of various chemicals and gases started to increase drastically which has ledto air pollution. In September 2015, 193 countries, developing and developed countries alike, adopted the Sustainable Development Goals (SDG), known officially as the 2030 Agenda for Sustainable Development (UN, 2015). The most important reason for concern over the worsening air pollution in the country is,its effect on the health of individuals. Many casestudies and news reveal the tragedy behind the leakage of gases from the industries. When exposure to particulate matter for a long time canlead to respiratory and cardiovascular diseases such as asthma, bronchitis, COPD, lung cancer and heart attack. This proposed system of Environmental Air Quality Monitoring and Prediction is used to monitor, analyze, predict the real-time data. The location may categories into three area like Indoor, Outdoor and Traffic areas.The main air pollutants according to WHO (World Health Organization) are carbon monoxide, nitrogen dioxide, ozone, Sulphur dioxide and particulate matters. To overcome theeffect of air pollution, it must be identified and monitored. The conventional method of monitoring air pollution is by constructing fixedstations at fixed locations or mobile sensors,which can be difficult and at times costly to construct for monitoring air quality over a large geographical area. That the sensors can transmitthe collected data. The collected data of air qualitycan be stored by usingcloud service for knowingthe real-time status. Finally, the collected past dataset helps in figuring out the prediction whichlater helps to find the preventive measures.

## II. Related work:

[1] The system focuses on modeling the air quality pattern in each region by adopting both fixed and moving IoT sensors, which are placedon vehicles patrolling around the region. With our approach, a full spectrum of how air quality varies in nearby regions can be analyzed. It demonstrates the feasibility of our approach in effectively measuring and predicting air quality using different machine learning algorithms withreal world data. This evaluation shows a promising result for effective air quality monitoring and prediction for a smart city application. [2] Environmental monitoringsystem built on the combination of physical andcommunication redundancies. By colocation of similar sensor motes to monitor the same parameters, increasing the time to failure for each module via energy management, andincorporating an effective IoT-enableddependable control algorithm, the low-cost wireless sensor network can significantly improve the monitoring quality in terms of availability. [3] The IoT sensors are used for collecting the data and make it as a dataset then machine learning classification Algorithm, KNN(k-nearest neighbors) algorithm is used for predicting the accuracy. [4] During pandemic and non-pharmaceutical interventions oflockdown and confinement implemented citywide, regionally or nationally are affecting virus transmission, people’s travel patterns, and air quality. Many studies have been conducted topredict the diffusion of the COVID-19 disease, assess the impacts of the pandemic on human mobility and on air quality, and assess the impacts of lockdown measures on viral spread with a range of Machine Learning (ML) techniques. [5] Excessive exposure to ambient (outdoor) air pollution may greatly increase the incidences of respiratory and cardiovascular diseases. Accurate reports of the spatial- temporal distribution characteristics of daily PM2.5 exposure can effectively prevent and reduce the harm caused to humans. Based on the daily average concentration data of PM2.5 in Beijing in May 2014 and the spatial temporal kriging theory, the optimal fitting model andcompared the spatial temporal predictionaccuracy of PM2.5 using the method andordinary kriging (OK) method. [6] It provides scientific guidance to the end-users for effectively deploying low-cost sensors for monitoring air pollution and people's exposure, while ensuring reasonable data quality. To review the performance characteristics of several low cost particle and gas monitoring sensors andprovide recommendations to end-users for making proper sensor selection by summarizingthe capabilities and limitations of such sensors.

[7] The framework capable of accurately forecasting future sales in the retail industry andclassifying the product portfolio according to the expected level of forecasting reliability. By evaluating its performance in a real- world use case scenario, the proposed framework demonstrated capabilities of generating reasonably accurate monthly and quarterly salesforecasts.

## III. Proposed work:

Deep analysis and monitoring of air quality usingInternet of Things (IoT) under SDG 3.9 system uses a wide variety of sensor and microcontrollerto monitor the quality of air in both indoor and outdoor environment. The model monitors different air pollutants gases in the air using DHT-11, MQ-7 & MQ-2 Sensors, Arduino Nano, Node MCU (8266). It monitors the qualityof air by measuring carbon-monoxide (CO), Temperature and humidity, smoke (pm2.5), CO2 (Carbon dioxide). The sensed data is storedin Blynk cloud which can be viewed in Mobile application anytime while connected. The data isalso stored in local storage in Excel to make analysis and prediction.

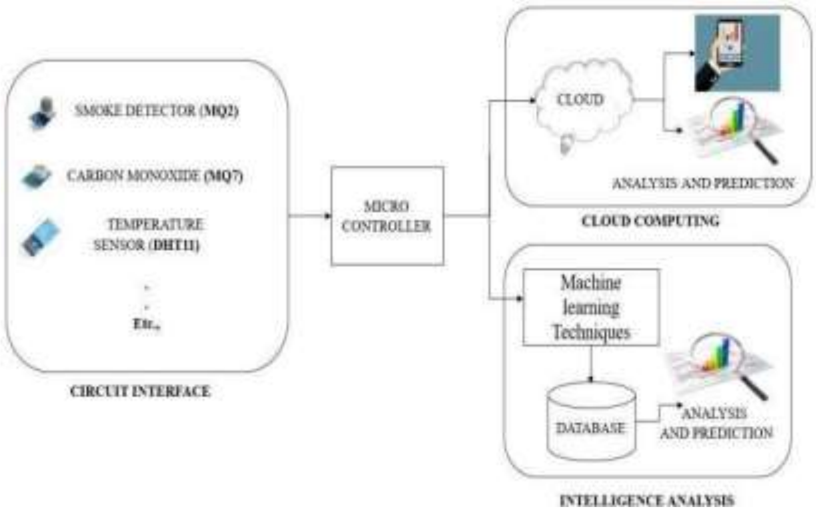


Figure 1: Architecture diagram for air quality monitoringand analysis system

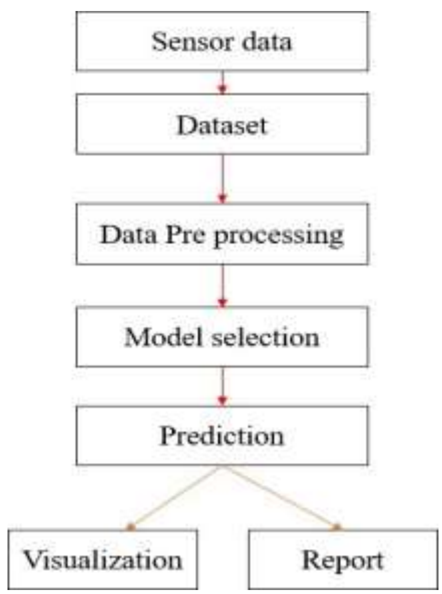


Figure 2: Work flow of machine learning algorithm

The sensors are interfaced with the Microcontrollers, and it relates to the network tostore the sensed values in the cloud and in the local storage. The DHT11 sensor is used to sense Temperature and Humidity, MQ-2 and MQ-7 sensor is used to monitor the quality of air by breaking down into various air pollutants. The Node MCU and Arduino Nano are used as Microcontrollers. Blynk Cloud is used to store the sensed values and it can be viewed in the mobile application as well as web application. An add-in is used to store the sensed values locally in MS Excel. After that the stored valuescan be converted into the csv (comma separatedvalues) then make the prediction using machinelearning algorithm.

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## IV. Module Description:

"Deep analysis and monitoring of air quality using Internet of Things (IoT) under SDG 3.9",consists of three modules to measure accurate real-time air quality and make analysis with thesensed data.

- ✓ Circuit Interfacing
- ✓ Cloud Computing
- ✓ Intelligence Analysis

### 4.1 Circuit Interfacing:

The DHT11 Sensor connected with ESP8266 Wi-Fi Module, MQ2 and MQ7 Sensor is connected with Arduino Nano. Then the surroundings can be monitored by the sensors and collecting the gases in the air with the use ofsensors. For Power supply connect theMicrocontroller with system.

### 4.2 Cloud Computing:

Create an account in Blynk cloud environment. Organize the output screen with suitable widgets. Specify the virtual pins for input and output. Write the suitable code in Arduino IDE to connect, store and visualize the data in cloudenvironment. The Real time data stored is sensed from DHT11 sensor connected with the ESP8266 Wi-Fi Module.


Figure 3: mobile application for Blynk

The Blynk cloud provides both web applicationand mobile application. It visualizes the sensed data through gauge meter and time-line graphs. The focus of the Blynk platform is to provide user-friendly interface for the end-users. Thesensed values are stored in cloud platform in which the stored data are retrieved as .csv file extensions for further analysis and prediction.

### 4.3 Intelligence Analysis:

In intelligence Analysis the collected real-time data can be used as input dataset and the csv fileis feed into to process for the prediction. This system uses machine learning algorithm (long short-term memory) LSTM algorithm is implemented for the prediction of air quality with the data of temperature, humidity, carbon monoxide (co), Methane (CH3), smoke and LPG gases for analysis.

## V. Methodology:

The proposed system offers "Deep analysis andmonitoring of air quality using Internet of Things (IoT) under SDG 3.9". It is composed of three Modules such as Circuit Interfacing, Cloud computing, Intelligence Analysis. The Micro controller relates to both Analog and Digital sensors like Temperature and humidity sensor (DHT11), MQ-2 and MQ-7 in Circuit Interfacing. Both Analog and Digital sensors areconnected to the Microcontroller. The System isintegrated for power supply. MQ-2 and MQ-7 sensor related to Arduino nano to store the data as locally in MS-Excel. DHT11 sensor relates to ESP8266 Wi-Fi module for storing sensing the sensed values in the Blynk cloud. Simultaneously all the data are collected and visualized in cloud environment along with timeseries storage. The Machine learning is used to identify the prediction. One of the regressions isused to predict a continuous dependent variablefrom a few independent variables. Experimentalsetups deployed to measure both the indoor andoutdoor environment for extension ofperformance improvement and the entire result is examined using LSTM (Long Short-TermMemory) algorithm.

### 5.1 The Mathematics Behind Long Short-Term Memory

When using the Long Short-Term Memory Algorithm to solve regression problems, you areusing the mean squared error (MSE) to how yourdata branches from each node.

This formula calculates the distance of each node from the predicted actual value, helping todecide

$$MSE = \frac{1}{N} \sum_{i=1}^{N} (fi - yi)^2$$

Where $N$ is the number of data points,
$fi$ is the value returned by the model and
$yi$ is the actual value for data point $i$.

which branch is the better decision for your prediction. Here, *yi* is the value of the datapoint you are testing at a certain node and *fi* is the value returned by the model data points.

## VI. Implementation:

In this section, we first describe the design and implementation of IoT sensor device deployed in our research. Our deployment and data collection are performed in indoor and outdoor environment. Next, we explain the preliminary processing of the acquired raw data and describehow we store and transmit the collected and cleaned data. Then, we further present the user interface to check the collected data for ouranalysis. Figure 3.1 describes the overall architecture of our proposed system.

### 6.1 IoT sensor instrument design:

We assembled two types of sensing devicesfrom off-the shelf parts, one for gases monitoring and the other type for temperature and humidity. In total, we developed five IoT sensor devices. The subsystems of the air qualitymonitoring modules are presented in Fig. 3, andthe functions of the sensors are described as following:

✓ **Temperature and humidity sensor:** We have a single sensor that can measure both temperature and humidity. The humiditysensor provides an accuracy of 2%, whereasthe temperature sensor has an accuracy of 0.5 ◦C. They have measurement ranges of 0 ∼ 100% and −40 ∼ 80◦C, respectively. Fig. 4 represents DHT11 sensors setup.

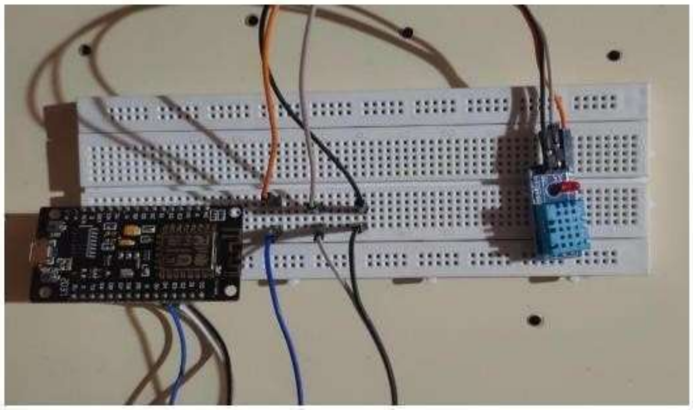

Figure 4: DHT11 Setup

✓ **Carbon monoxide sensor:** Our carbon monoxide sensor can measure CO within a range of 0 ∼ 10000ppm, with an accuracy of 5ppm (0 ∼ 2000ppm), 10ppm (2000 ∼5000ppm), and 20ppm (5000 ∼ 10000ppm).Note that since in a natural scenario, the proportion of CO is around 0.03%, this level of accuracy is sufficient for our purpose. Fig. 5 represents MQ2 and MQ7sensors setup.

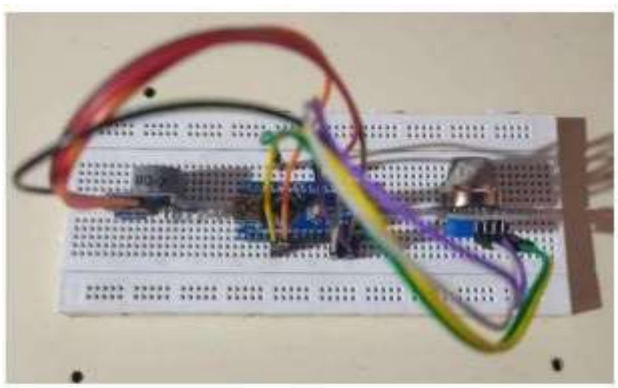

Figure 5: MQ2 and MQ7 Setup

✓ **Arduino nano:** This implements the protocol for sending data over thenetwork.

✓ **NODE MCU ESP8266 Wi-Fi module:**The real time temperature and humidity levels is collected and displayed in aBlynk application.

## VII. Experimental setup & result discussion:

The result discussion of this project is summarized and the connection setup arepresented under the following major headings: Snapshots of System. In this project, The Parts Per Million (PPM) measurement of air quality, which represents the mass of contaminants per unit volume of air, is sensed by the MQ-2 and MQ-7 Sensors when it is linked to an Arduino Nano. The Arduino IDE includes a text editor for creating code, a text console, and a set of menus that connect it to the hardware of the Arduino platform for uploading program. The ESP8266 Wi-Fi Module is connected to the DHT11 Sensor to measure temperature and humidity, and the function of the ESP8266 is tosend the sensed values to a cloud environment. Blynk Cloud is an IoT platform for cloud-baseddata storage, and widgets can be used in web andmobile applications to display detected values. The Temperature and Humidity Values as well as the Timeline graph for each parameter are displayed in this Blynk Application. Hence the collected real time data can be used as input forthe model prediction in machine learning(LSTM) algorithm. Fig. 6 - 12 shows the visualization of real time data and model prediction for air quality.

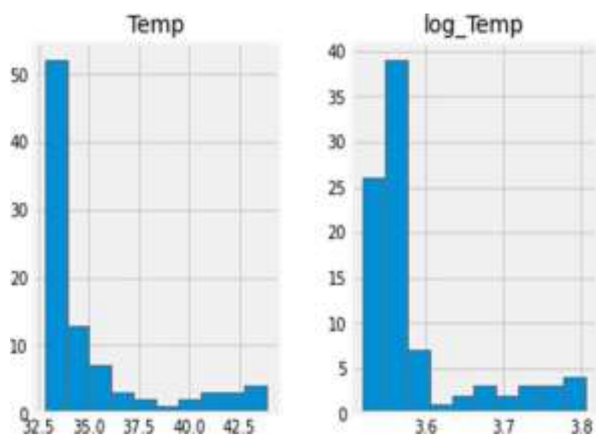


Figure 6: Histogram of Temperature

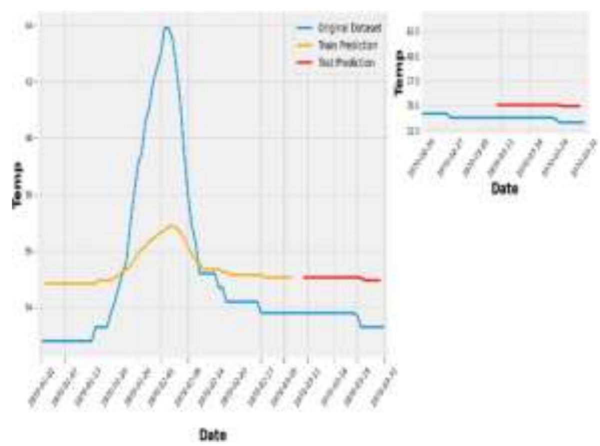


Figure 7: Model prediction of Temperature

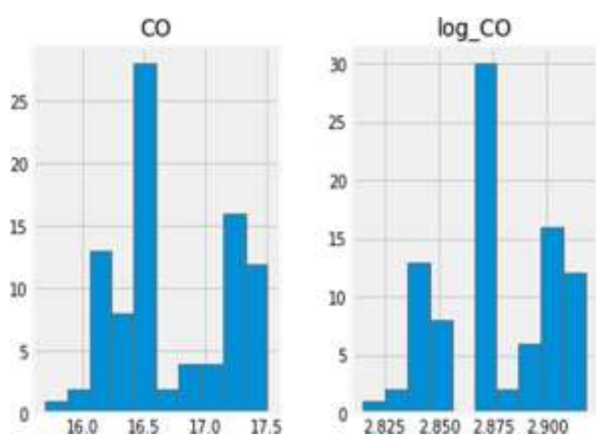


Figure 8: Histogram of CO (Carbon monoxide)

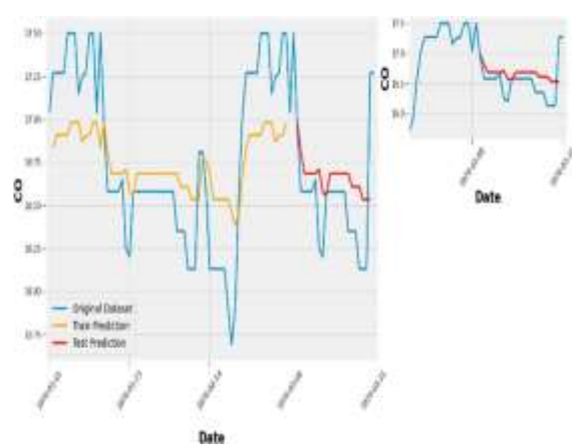


Figure 9: Model prediction of CO (Carbon monoxide)

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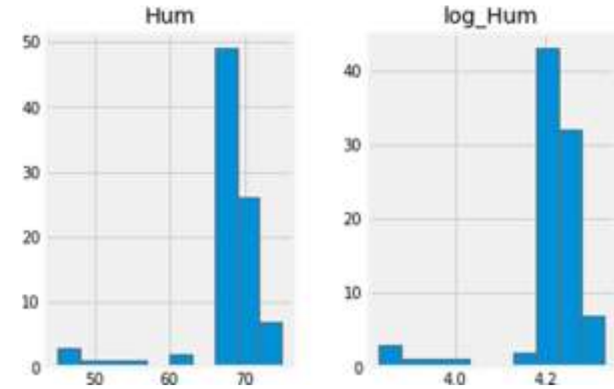


Figure 10: Histogram of Humidity

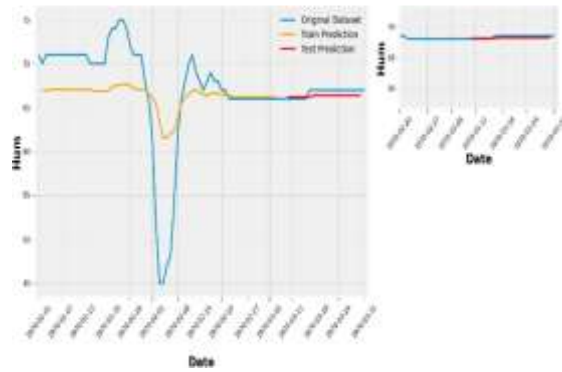


Figure 11: Model prediction of Humidity

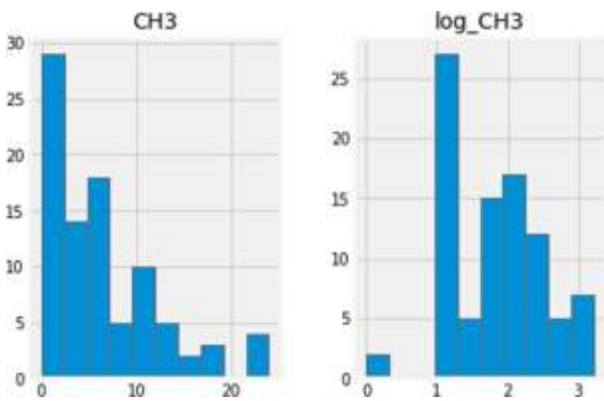


Figure 12: Histogram of CH3 (Methane)

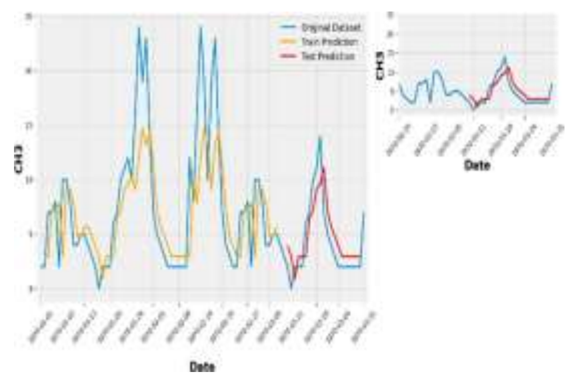


Figure 13: Model prediction of CH3 (Methane)

## VIII. Conclusion:

In this paper, we explored a new way to predictimmediate air quality around people, by combining sensors. Our experimental results show that our proposed hybrid distributed fixedand IoT sensor system is effective in predictingair quality around the people. The predicted air quality data from our system can be served in various scenarios, such as controlling the airpollution to have a better future and avoiding themain harmful disease cause for living organismsfrom these air contaminations in both indoor andoutdoor activities.

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