Chapter 2
IoT-Based Smart Air Quality Control System: Prevention to COVID-19

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2.1 Introduction

An extensive research demonstrates that polluted air has adverse impact on health. The poor air quality has always been a major concern for both health officials and the public. According to a report from the World Health Organization, around 3.7 million people died due to exposure to polluted air [1]. The short-term or/and long-term exposure to air pollution causes high mortality and increases the chances of other diseases including the COVID-19. As per the report, exposure to polluted air contaminated with traffic pollutants over 24 h, increases the hospitalizations regarding cardiovascular and respiratory issues [2]. The latest news report shows that a person exposed to such high pollution loses 7 years of his life on average [3]. The poor air quality in the Indo-Gangetic plains causes a reduction in life span of an average person by 7 years. As per World Health Organization (WHO) standard, 20 micrograms per cubic meter is acceptable concentration of particulate matter in air. The air quality in Indo-Gangetic plains does not meet the standard [3]. Health emergency has been declared by concerned authorities in few regions. The records clearly indicate that the maximum number of COVID-19 patients were from the highly polluted areas. The conditions of patients in polluted area were more severe than from that from the less polluted areas. The mortality rate is two times higher than that of less polluted regions [4].

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2.1.1 Motivation

The pollutants from atmosphere enter the indoor arena and become about 1000 times prone to get transmitted to the lungs and cause respiratory diseases and COVID-19 [5]. Air quality control is essential to prevent the spread of disease – COVID-19. Constant monitoring of indoor air helps to control the air quality and to ensure the reduced exposure of humans to the contaminated air, IoT-based smart devices and air purifiers are needed to be developed and used.

2.1.2 Contribution

This study brings the attention to environmental issues beyond the scope of the human eye and contributes to prevent spread of COVID-19 disease. The smart unit is designed using a microprocessor and sensors to detect the presence of particulate matter-carbon monoxide (CO) and carbon dioxide (CO_2) in the air and their concentrations. GSM module is also embedded to wirelessly send an alert message to the user. It stores the collected data on a cloud to monitor and control the quality of air. The accuracy of proposed smart unit is verified for the purpose of monitoring the air quality and the storing the data on cloud for applications.

The accuracy of proposed smart unit is verified for the purpose of monitoring the air quality and the storing the data on cloud for applications. It is effective to prevent the spread of COVID-19.

In this way, the entire work contributes to develop a smart device to check the air quality to control it effectively and hence to prevent the spread of coronavirus.

2.1.3 Organization

This chapter is organized in following sections. Section 2.2 discusses the related work. The proposed model with working is given under Sect. 2.3. Section 2.4 reports the results and analysis. The work is concluded in Sect. 2.5 with references to future work.

2.2 Related Work

This section brings a short discussion about the literature contributing for air quality control using IoT. In recent years, Internet of Things (IoT) and cloud computing are being deployed to develop the real-time monitoring devices for air quality control. The studies [6–14] are dedicated to monitor the air quality of indoor systems. They have integrated new emerging technologies to monitor the air quality. These studies are dedicated to collect real-time data using IoT-based smart devices. They have not integrated the wireless sensor network to transmit data on remote locations.

The idea of this work is to fill this gap between the emerging technology and existing smart air sensors. This chapter provides a platform to integrate the features of cloud computing with the benefits of IoT. This work launches a smart device to monitor and control the indoor air quality precisely and to upload the data collected in real time to a cloud server.

The agenda is to prevent the spread of COVID-19 by constant monitoring of air quality and to issue alert messages to the people. It is shown that high agglomeration of air pollutants facilitates the spread of the virus [15]. The poor quality of air results in high mortality rate due to COVID-19 [16, 17]. Hence, if the quality of air is constantly monitored and the low-quality alerts are issued to human, then the spread of COVID-19 can be prevented effectively. The study [18] shows that the target messaging to alert people about poor air quality brings behavioural change in people. They become alert and avoid excessive exposure to contaminated air.

2.3 Proposed Model

The proposed model is shown in Fig. 2.1. It has basically two parts – (1) sensing part and the web server. The sensing part is comprised of a set of sensors. The sensors are installed to sense the quantity of corresponding content of air and to control the quality. The sensor data collected by sensing part is sent to the web server part. It is achieved with LTE module which connects the sensing part and web server part. The target is to judge the air quality and analyse the data to alert the people. Web server is connected to cloud server to store the data on cloud server and apply machine learning to detect dangerous patterns of poor air quality. The cloud computing integration to the web server allows speedy analysis and fast accessibility. The web server processes a large amount of data, to support air quality control system. Users can access the web server via browsers to see the status of air pollution level manually.

For implementation, Amazon Web Services (AWS) is used for cloud storage. A GSM module is also integrated to automatically alert the users via SMS in case the quality of air crosses the threshold values.

The entire setup is built on IoT architecture (shown in Fig. 2.2) and its three layers: (i) layer to take readings from the environment, perception layer; (ii) a layer to provide connectivity between the input layer and processing layer, a network layer; and (iii) the processing and output layer, presentation layer [19].

The idea is to gather the environmental factors via sensors and store to analyse the gathered data on cloud. From the uploaded data, the degree of quality of air is judged, and then the targeted messages are broadcast to the registered users. The flowchart of proposed system is shown in Fig. 2.3.

The main components of the system are [21] described as follows:

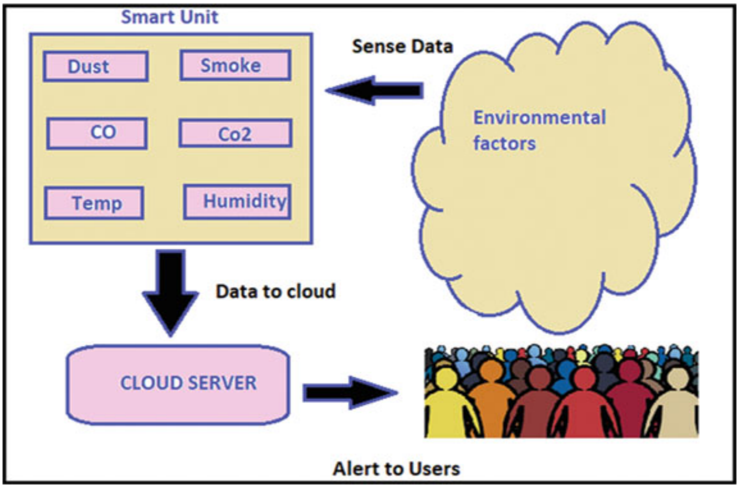

Fig. 2.1 Model of proposed system

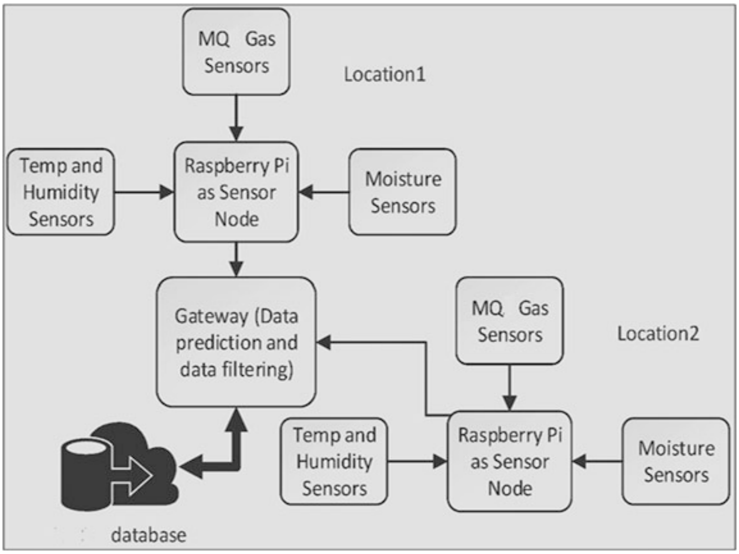

Fig. 2.2 IoT architecture

(a) *Raspberry Pi*

In the proposed model, the environment is being sensed via sensors, but the sensors cannot work autonomously; they need some processor. This processing unit controls, directs and helps the sensors to handle the data. In this proposed model, Raspberry Pi is being used. Raspberry Pi is a small computer and it has a built-in Wi-Fi module and multifunctionalities.

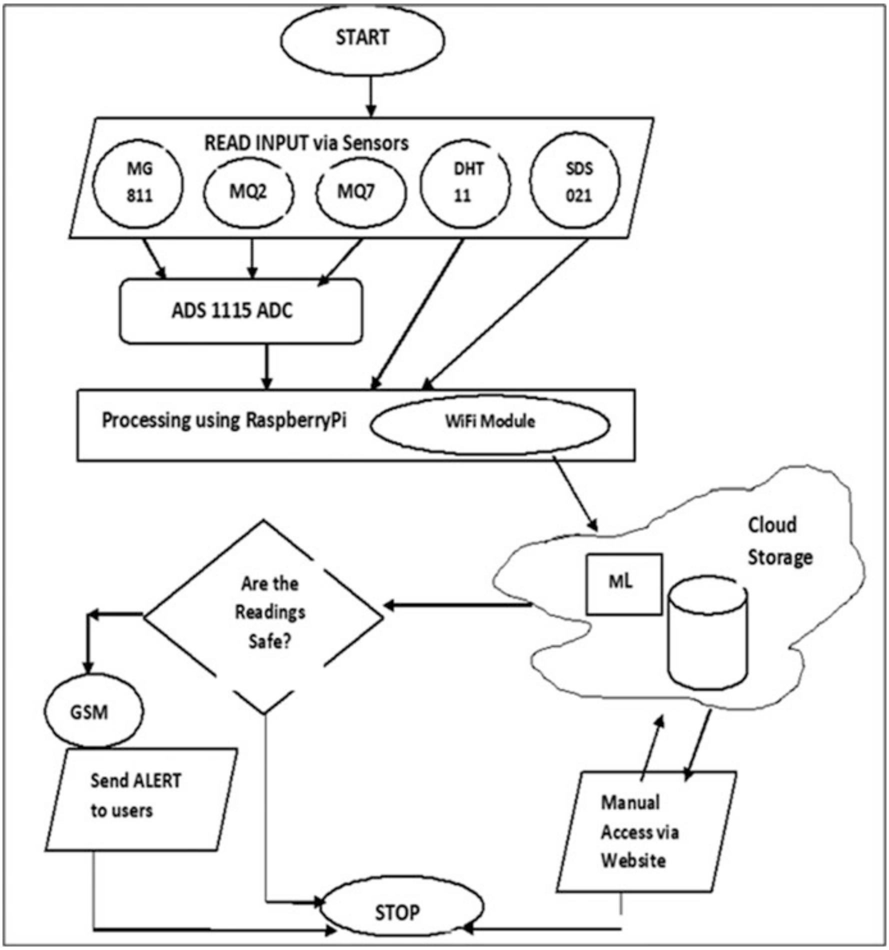

Fig. 2.3 Flowchart of proposed model

(b) *Sensors*

Sensors are devices which allow smart system to interact with the external environment. It allows to access the environmental factors and sense the data. In this proposed system, the MQ-2 sensor is used to detect smoke. Sensor MQ-7 is installed to detect carbon monoxide (CO). Sensor MG811 is assembled to detect carbon dioxide ($CO2$). Another sensor DHT11, to take readings of live temperature and to read the humidity of air in the ambiance, has been installed. To measure the PPM levels of PM 2.5 and PM 10 particulate matters, SDS021 sensor has been used along with other sensors.

(c) *Analog-to-digital converter*

ADS1115 ADC is used to connect MQ-2, MQ-7 and MG811 gas sensors to Raspberry Pi. It converts analog signals from the above sensors into digital signals and provides the digital output to Raspberry Pi for processing. The outputs of the sensors, SDS021 and DHT11, are digital.

(d) *Web service*

This research allows to access the real-time data to its authentic users via website. It is achieved through a cloud platform.

(e) GSM module

To alert the registered users about the poor air quality, GSM module is embedded. If the air quality does meet the WHO guidelines, then an alert SMS is broadcasted to the users automatically.

2.4 Results and Discussion

The device is installed, and readings are recorded to analyse the pattern of harmful levels of poor air quality. The standards state [20] that the content of pollutant in air is tolerable with concentration as mentioned – CO (ppm) $\leq$10; CO_2 (ppm) $\leq$1000; VOCs (μg/m3) $\leq$ 400. Figure 2.4 shows the constant readings of CO. Figure 2.5 shows the readings for CO_2.

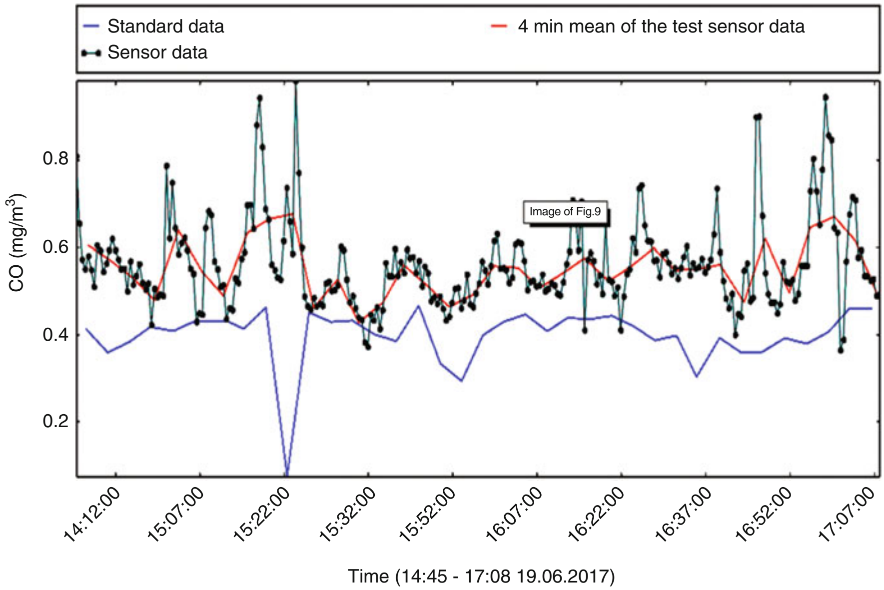

Fig. 2.4 Glimpse of data collected through sensor-CO

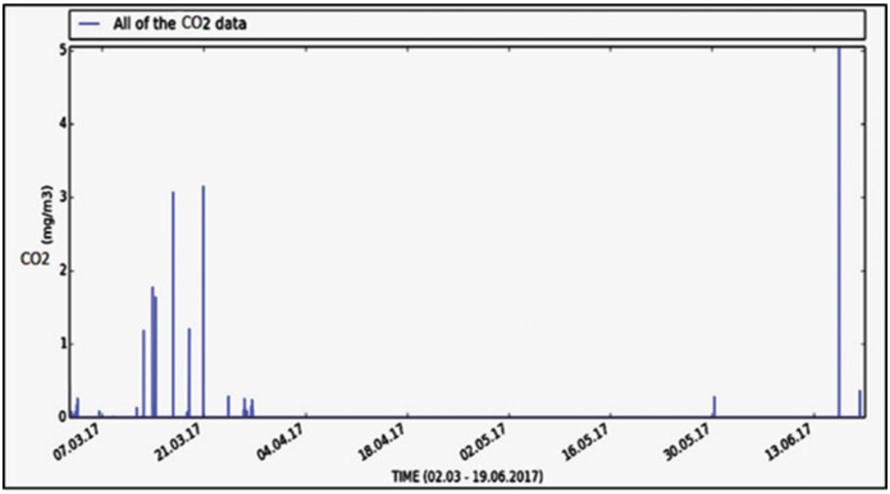

Fig. 2.5 Analysis of data collected through sensor-CO_2

In this way, the data can be seen live, and it gets uploaded on cloud server in parallel. On the cloud, data is continuously being monitored and analysed for crossing the threshold levels. If the concentration level crosses the threshold, then GSM module automatically triggers an SMS on the registered number of the user. In this way, the users are sent alert automatically and manually can be assessed through interface.

The experimental work shows that the sensor-based smart unit works well to detect the poor quality of air in the surroundings. The proposed model alerts the user in case their surroundings are contaminated, and hence they can avoid exposure to the contaminated air. Hence, the spread of COVID-19 is prevented effectively.

2.5 Conclusion and Future Scope

The study is dedicated to alert the human if the quality of air is poor in their ambiance. The agenda is to prevent the spread of COVID-19. As it is scientifically proven that the coronavirus spreads faster and easily if the air is polluted. Hence, this work is a short attempt in this direction and works with good accuracy. In future, it can be extended to a broad range of sensors and wider range of applications.

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