IoT-Based Air Quality and Sound Intensity Monitoring System using Raspberry Pi

Nanda M B, Madhura K, Chathurya K, Laxmi Tripathi

Abstract*: In day to day life, the increase in Air and Sound pollution has become a distressing problem. It has now become a vital issue that is to be considered. To overcome this problem, an IoT based system to monitor the pollution levels constantly has been proposed. Nowadays Internet of things (IoT) is one of the most widely used and researched technology to monitor the environmental changes. It gives an innovative approach where various devices can be connected together with the use of the internet. By interconnecting different objects located at different locations, we can collectively analyze the data at a single place. This feature is useful in data analytics. Raspberry Pi mini-computer is used to collect different data from different sensors and this data is monitored. In our proposed system we are using four different modules namely Air Quality Monitoring System, Sound Intensity Monitoring System, Cloud based Monitoring System, Notification system. These modules are integrated together to monitor the environmental changes. This system can be implemented in remote areas where the bulky equipment cannot be placed. Industrial areas where the pollution levels are high can be constantly monitored and precautionary measures can be implemented if the pollution is more.

Keywords*: IoT, Raspberry Pi, Air Quality Monitoring, Sound Intensity Monitoring, Cloud storage.

I. INTRODUCTION

IoT is a network of physical objects or the devices that are connected to each other. These devices have the ability to collect data and share it among themselves using Internet. The concept of IoT was originated back in the year 1982, when a coke machine present in a University was formulated to tell whether the coke is cold or not. But it became popular in 1999 when Kevin Ashton used RFID (Radio frequency Identification) to tag objects so that they can be managed easily. Embedded devices helped a lot in evolving the IoT. In this era of IoT, the devices collect the data and analyze the data. The economic growth rate of IoT is greater than 29.9% per year. Wireless Sensor Network (WSN) is group of spatially dispersed inexpensive sensors which are autonomous in nature and are used for monitoring and checking the physical or environmental conditions such as temperature, pressure etc. The data collected from these sensors are sorted and processed in central location present in the network. The sensors present in the network are taken as nodes. Over the past decade, there has been exponential increase in the number of the industries. This type of growth has caused some serious problems and damage to the environment. Pollution is a critical issue as it has direct effect on the health of the living beings present in that area [1]. Pollutants also cause acid rains and photochemical smog.

One of the most efficient ways to control pollution is periodically measuring the level of pollution in area using IoT [2]. This will help in analyzing the level of pollution and through this information, steps can be initiated to control the pollution. This in turn results in reducing the number of diseases and eventually providing better life for everyone. The development of several monitoring system has given a ray of hope. IoT plays a major role in development of these systems because of its versatility and cost-effectiveness. Keeping this in mind, a monitoring system has been proposed in this paper which monitors both air and sound pollution. This system overcomes the flaw of the previously proposed systems. The main component of this system is Raspberry Pi which is a portable Single Board Computer [3]. It consists of 64 bits, 1.5GHz ARM v7 Quad Core Processor that increases the efficiency of the computer. It acts as a gateway node for the WSN. The Raspberry Pi is connected to various sensors such as sound sensor (LM393), air quality sensor (MQ135) and temperature and humidity sensor (DHT11). All these sensors have their own advantages which make them suitable for the proposed system. The sensors are used to gather the required environmental data which is later sent collectively to the storage unit through the Raspberry Pi. An additional Wi-Fi module is built in the Raspberry Pi that helps in sending the processed data to a storage platform [4].

If the output data is more than the set threshold value, then notification is sent to the concerned authority so that they can take the necessary steps to reduce the pollution level. The output of the processed and analyzed data is stored and represented with the help of a cloud platform, ThingSpeak. It is an open platform that allows the aggregating, analyzing and visualizing of data present in the cloud with the help of MATLAB analytics.

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II. SENSORS AND MODULES USED

A. MQ-135 Air Quality Sensor

The air quality of the surrounding gives an overall information about the air pollution levels in the environment. The MQ135 gas sensor is mainly used to detect pollutants such as Carbon-di-oxide, oxides of nitrogen, Benzene, alcohol and smoke [5] [6]. The MQ-135 gas sensor has a wide detecting scope with fast response. It has high sensitivity and has a long life. This sensor gives an over-all air quality level which makes it an economical choice. It works at 5V voltage level and 40mA current supply. The MQ135 sensor has VCC, ground, Analog and digital output pins.

Fig. 1. MQ-135 Gas Sensor.

B. LM-393 Sound Sensor

The sound level in the environment is measured using the LM-393 sound sensor [7]. The sensor has a voltage comparator that can operate with a single power supply. The potentiometer is fixed to the module to set the sensitivity of the sound meter. This can be used to set the sensitivity according to the environment the system is placed. The voltage level should be between 3.3V to 5V for the sensor to work. The output can be measured in decibels using the analog pin of the module. LM393 sensor has VCC, ground, Analog and digital output pins.

Fig. 2. LM-393 Sound Sensor.

C. DHT11 Humidity and Temperature Sensor

The DHT11 sensor is used to detect the humidity and the temperature values in the environment the system is placed in. These values are important to know the accuracy of the MQ-135 sensor as the gas sensor does not give accurate measures in extremely high or low temperature and humidity regions. The sensor gives the output in the form of digital values.

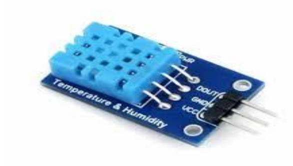

Fig. 3. DHT11 Humidity and Temperature sensor.

D. Raspberry Pi 4B

The Raspberry Pi 4B mini-computer is used in this project. The GPIO pins can be used to connect different sensors through which the data can be collected and sent to the cloud-based storage system. A Wi-Fi and Bluetooth connectivity are in-built feature in the Raspberry Pi module. There is a storage unit on the Raspberry Pi which stores the collected data temporarily. Later this data can be used for data analysis periodically.

Fig. 4. Raspberry Pi 4B module.

E. ESP8266 NodeMCU

ESP8266 NodeMCU is development kit that can be incorporated with the Raspberry Pi module. It has a small memory unit. This module is used to get the analog values from MQ135 and LM393 sensors.

Fig. 5. ESP8266 NodeMCU.

III. METHODOLOGY

The system implemented, is used to keep track of the air quality and sound intensity levels in the environment where the system is placed.

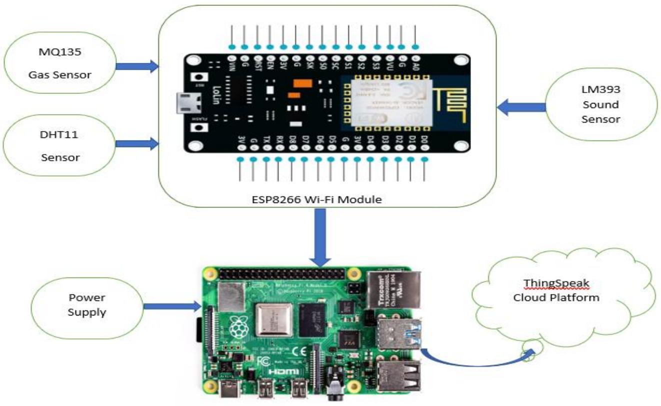

Fig. 6. System Architecture.

The architecture of the overall system is shown in the form of a block diagram in Figure 6. The proposed system has Air quality monitoring system. The air quality index value is a standard that is given by the government authorities. The air quality index can be measured in PPM or microgram/cubic meter [8]. This value is useful to analyze how polluted the area is. The air quality monitoring is carried out using MQ135 sensor. The sound intensity monitoring can be done with the help of LM393 sensor. The sound intensity should be around 45dB to 55dB in residential area. 55dB to 65db in commercial area. The industrial area should have the values less than 75dB. The cloud-based system is used to store the collected values and these values is used to plot the graphs. Threshold values are set in the storage unit. Notification module sends the notification to the authorized user when a value exceeds the threshold value. Figure 7 represents the proposed system and Figure 8 represents the data flow in the system.

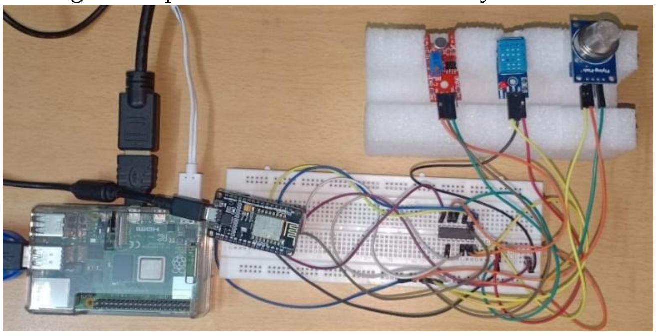

Fig. 7. Proposed system.

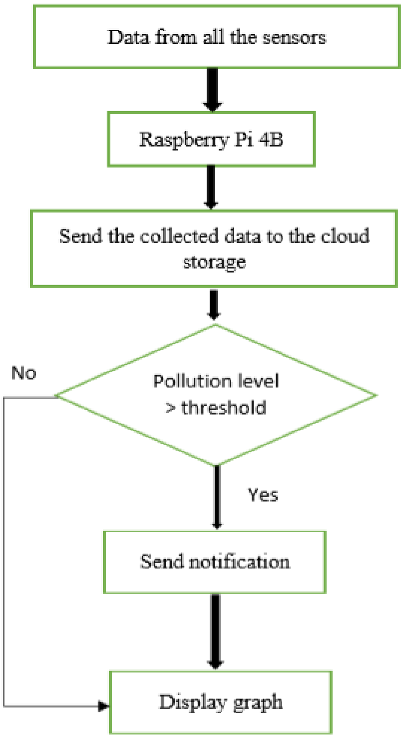

Fig. 8. Flow of data within the system.

The flow chart of the system shows how the data is sent from the sensors to the Raspberry Pi module and the to the cloud storage. From the stored data, notification is sent if the pollutants levels increase more than the threshold vales. The system collects the data from MQ135, LM393 and DHT11 sensors together. These values are collected by the Raspberry Pi module. The collected data is sent to the storage unit which is the ThingSpeak platform for the proposed system. The threshold values are checked for every value inserted into the storage unit. A notification is sent if the value exceeds the predefined standards.

IV. EXPERIMENTAL RESULTS

A. Air Quality Monitoring

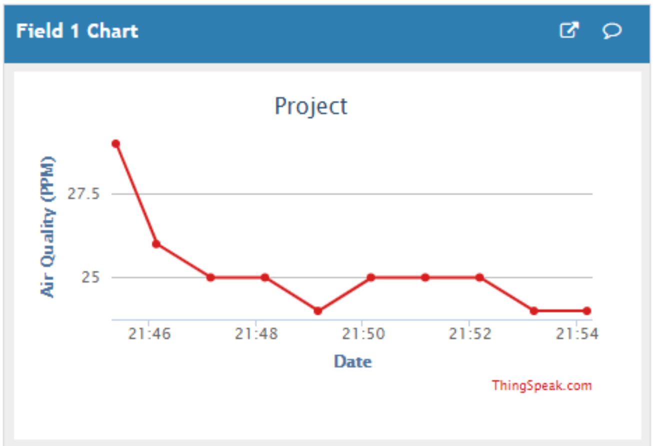

Fig. 9. Air quality graph.

The Figure 9 shows the plot of the graph for air quality level using MQ135. The level of pollutants is represented in the PPM units. When the sensor is exposed to smoke, benzene and other pollutants, the PPM value increases. The threshold values are stored in the cloud storage, which sends the notification when the value plotted in the graph is more than the value stored.

B. Humidity Monitoring

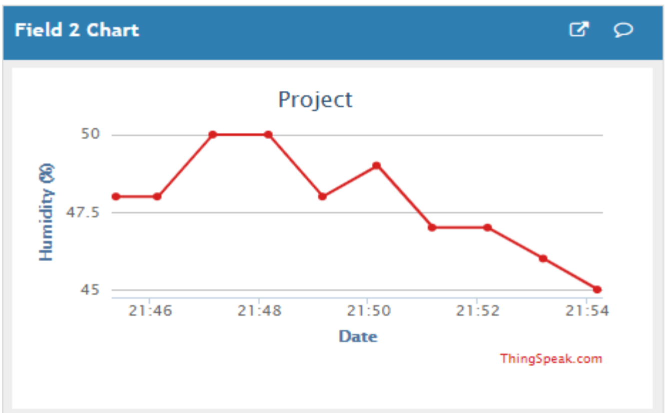

Fig. 10. Humidity level graph.

The Figure 10 shows the plot of the graph for humidity level in the environment using DHT11. The humidity value is given accurately with a tolerance of 1%. The humidity value is important to monitor as the MQ135 sensor works accurately when the humidity values is not extremely high or low.

C. Temperature Monitoring

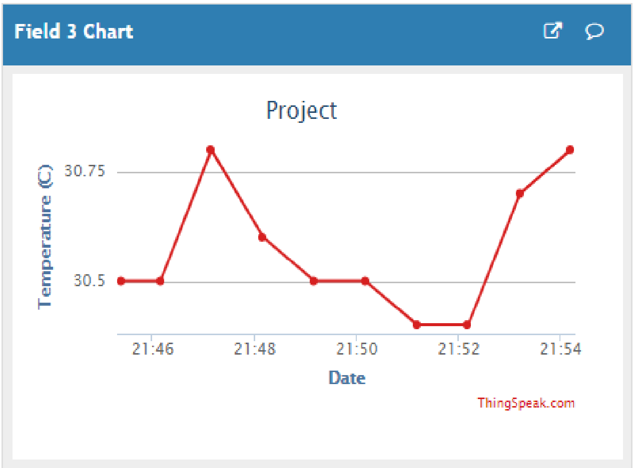

Fig. 11. Temperature level graph.

The Figure 11 shows the plot of the graph for temperature using DHT11 in Celsius scale. The Fahrenheit values can also be obtained by using the conversion formulas. The temperature values obtained from the sensor is approximately accurate with a very little tolerance. This makes it convenient to monitor the temperature changes in the area.

D. Sound Intensity Monitoring

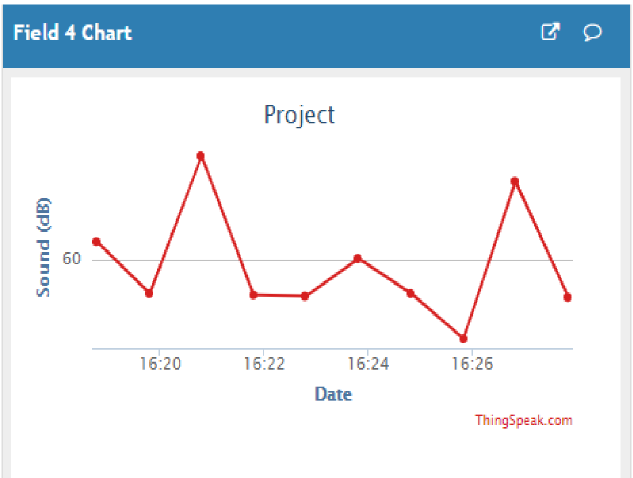

Fig. 12. Sound intensity level graph.

The Figure 12 shows the plot of the graph for sound intensity level. The sound levels are measured in decibels. The variation of the decibel level when the sensor is exposed to different intensities of sound is measured and plotted on the graph.

E. Location Monitoring

The Figure 13 shows the location of the system.

Fig. 13. Location of the system.

V. CONCLUSION

The IoT based applications used in the proposed system is a step taken to control the pollution in the environment by constant monitoring of the level of pollutants in the area. The use of the IoT techniques in the system provides an effective way to monitor and analyze the environmental fluctuations. Using the internet, remote sensing of the data is implemented [9] [10]. With the help of the notification system, the users get the information about pollutant levels in the area. As the data is connected to the cloud and monitored frequently, this system helps to analyze various patterns in the environment. Highly polluted areas such as industrial areas can make better use of this system by monitoring air and noise pollution levels in that area. The cloud platform stores the data which is an efficient way to store the vast data. This system is cost-efficient when compared with others, as it is including the monitoring of both air and noise pollutions in a single system.

FUTURE WORKS

In the future, the system can be extended by connecting different regions to a single cloud system and a collective monitoring can take place at a time [10]. Different sensors can be interconnected with the system to further reduce the pollution in the air. Air filters can be used in areas with high levels of air pollutions to reduce the level of pollution. A buzzer system can also be connected which rings the buzzer to alarm the people in that area.

REFERENCES

1. Giovanni B. Fioccola, Raffaele Sommese, Imma Tufano, Roberto Canonico and Giorgio Ventre, "Polluino: An Efficient Cloud-based Management of IoT Devices for Air Quality Monitoring", IEEE Conference paper, 2016.
2. Anwar Alshamsi, Younas Anwar, Maryam Almulla, Mouza Aldohoori, Nasser Hamad, Mohammed Awad, "Monitoring Pollution: Applying IoT to Create a Smart Environment", IEEE Conference paper, 2017.
3. Arnab Kumar Saha, Sachet Sircar, Priyasha Chatterjee, Souvik Dutta, Anwesha Mitra, Aishwarya Chatterjee, Soummyo Priyo Chattopadhyay, Himadri Nath Saha, "A Raspberry Pi Controlled Cloud Based Air and Sound Pollution Monitoring System with Temperature and Humidity Sensing", IEEE Conference paper, 2018.
4. Gagan Parmar, Sagar Lakhani, Manju K. Chattopadhyay, "An IoT Based Low Cost Air Pollution Monitoring System", IEEE Conference paper, 2017.

5. MingHua yang, SiJie Shao, XiaoYan Wang, "The monitoring system design of harmful gas inside special vehicle", IEEE Conference paper, 2012.
6. Kiruthika.R, A. Umamakeswari, "Low Cost Pollution Control and Air Quality Monitoring System using Raspberry Pi for Internet of Things", IEEE Conference paper, 2017.
7. Yung-Chung Tsao1, Bo-Rui Su2, Chin-Tan Lee2 and Chia-Chun Wu, "An Implementation of a Distributed Sound Sensing System to Visualize the Noise Pollution", IEEE Conference paper, 2017.
8. Xuan Zhao, Siming Zuo, Rami Ghannam, Qammer H. Abbasi and Hadi Heidari, "Design and Implementation of Portable Sensory System for Air Pollution Monitoring", IEEE Conference paper, 2018.
9. V.Sandeep, K.Lalith Gopal, S.Naveen, A.Amudhan, L. S. Kumar, "Globally Accessible Machine Automation Using Raspberry Pi" , IEEE Conference paper, 2015.
10. Md.Shaedul Islam, "An Intelligent System on Environment Quality Remote Monitoring and Cloud Data Logging Using Internet of Things (IoT)", IEEE Conference paper, 2018.

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