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IOT AND CLOUD BASED REAL TIME OUTDOOR AND INDOOR AIR QUALITY HEALTH MONITORING FOR ASTHMA PATIENTS WITH ALERTS

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Abstract

Air pollution has been a global challenge for environment protection. A lot of people suffer from asthma due to air pollution and it becomes extremely difficult for a person when experiencing an asthma attack. The effective way of treating bronchial asthma is to first avoid it. It affects the lungs and the inflammation is to be detected in the early stage. So monitoring the environment and doing precautionary measures will avoid the intermittent asthma. But for persistent asthma type immedicate medical attention is required. So this paper presents an IoT based proposed system which measures the quality of air using the sensors. Along with measuring the air our proposed design measures the temperature and senses any unusual flame or fire in our environment. Raspberry pi microcontroller is used here. The measured data is sent to cloud server for further monitoring. This IoT based air quality monitoring system for asthma patients is designed and the measured parameters are sent to the caretaker.

Keywords:

IOT, Gas Sensor, Embedded, Pollution Detection, Air Quality, Cloud

1. INTRODUCTION

Bronchial asthma is found in people who live in industrial areas. This chronic disease needs medical attention immediately. Nearly 20percent of the children are affected by bronchial asthma. Pollution in the environment leads to destructive issues to both living and non-living organisms. The Pollution may exist in form of noise, heat, light, soil and water [11]. The Pollution may create allergic and nonallergic problems. The environment parameters should be monitored. The pollution produced in large amount by coastal oil rigs or refineries , nuclear power plants and hazardous chemical gas and electronic wastes. The Air pollution in the environment may leads to cough, wheezing, heart attack etc. It leads to heart and lungs failures. The Air pollution may affect both environment and organisms existing in it [12]. The Internet of Things (IOT) is technology which has dynamic global network infrastructure. This Technology can be interfaced with sensors. The Sensor monitors and sends the data to Cloud via network connections. So that environment can be protected various cases such as weather, floods, endangered species protection, military survey etc. The Sensors monitors entire changes in the environment and updates it to the cloud. IOT applications are authorized for both public and private services. The IOT applications can provide solution to pollution. The Pollution rate level can be obtained from the sensors interfaced with IOT technology. So that measures to reduce the pollution can be analyzed and it reduced to desired level. IOT based applications with Raspberry Pi are utilized in smart cities [13]. This Raspberry Pi based pollution monitoring system can be used to monitor the real-time pollution levels in any area. The Raspberry pi air pollution monitoring system with IOT can be designed at low cost. This Monitoring system can be completely automated without any human intervention. The Government adapts to this type monitoring system with defined policies. The Size of the monitoring system will be more compact by utilizing Raspberry Pi board [14]. More environmental sensors can be interfaced with the system in order to analyze and monitor data about pollution rates at desired intervals. The work addressed in this paper helps to avoid the risk of chronic obstructive pulmonary disease (COPD) by developing a raspberry pi-based hardware software real time system to detect the pollutants like O3, CO, NO2, SO2, PM10, and PM2.5. The ARM1176JZF-S 700 MHz processor board runs on python and all detection and diagnosis blocks are implemented.

2. LITERATURE SURVEY

The author [1] analyzed the air pollution parameter with Raspberry-Pi. The Analysis is mainly done over co and no2, temperature etc. The Results are updated on Thing speak platform. It is described indoor air quality issues and the Experiment was carried with Raspberry Pi and air quality sensors. The Air quality sensors utilized are sulfur dioxide (SO2), carbon monoxide (CO), Ozone (O3) etc [2]. S. Chen et al 2014 [3] used Internet of Things (IoT), which plays vital role in products measurement and control units which helps to solved the user's application. B.C. Kavitha et al (2018) implemented IOT based air pollution monitoring system. This System has utilized CO2, Butane and LPG sensors. These Sensor records the data existing in the environment [4]. We use IOT to measure the air pollution and also measuring the ultilization by using several metrics like PM 2.5, carbon monoxide, temperature, humidity levels are monitored and recorded. The Recorded parameters are updated to IBM Bluemix Cloud [5]. Korunoski et al (2019) [6] air pollution are monitored spatial resolution with IOT. The Experiment was conducted at skopje city. The Results of this reveals that IoT data spatial resolutions are superior in nature. G. Spandana et al (2018) [7] implemented ESP8266 and GPS to transfer the data measured by air quality sensors. This Experiment was based on IOT application. This Experiment describes the pollution ranges existing in the environment. Somdeep Acharyya et al (2017) [8] measured the indoor air pollution. The CO2, CO, dust parameters existing in the indoor are measured. This System has utilized required sensors for measurement each parameter exiting in the indoor. Ali AbaasAboodee Al-Zaheiree et al (2020) [9] initially framed an IOT application to measure the quality of air and the Sensors such as MQ2, MQ7, etc are utilized was monitoring and measuring purpose. Each Parameters measured will be displayed at LCD and IOT platform. Poonam Pal et al (2017) [10] designed an IOT based air pollution monitoring system. The quality of air was measured with sensors such as smoke, alcohol and NH3. The

parameters will be displayed at LCD and IOT platform as well. Several works have emerged in recent times and works were carried out in Integrated circuits. The very large integrated circuit design are efficient, consumes low power and can be customized.

2.1 IMPORTANCE OF AIR QUALITY MONITORING

Air pollution due to major air pollutants at higher concentrations leads to respiration risk like asthma or chronic obstructive pulmonary disease (COPD). The harmful gases like sulfur dioxide (SO2), particulate matter (PM), ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), and Lead (Pb) affect and irritate the airways when short term or long-term exposure happens. The COPD exacerbation risk due to pollutants are chronic. The lung tissue and air pathway may be affected due to the dust if any. The Indian Medical Association has taken steps and requested the government to increase air quality measuring station around the nation. Central Pollution Control Board (CPCB) has produced reports where 122 cities have higher level of pollution about 225 µg/m3 against the normal range of 60µg/m3. Since the air pollution leads to diseases like cardiocerebral vascular disease, ischemia heart disease and lung cancer, air quality measurement becomes important.

2.2 ROLE OF AIR QUALITY IN ASTHMA

The pollutant exposure will lead to asthma and if it happens early in infant life its chronic. NO2 increases the occurrence of asthma in childrens. The industry and traffic-related air pollution exposure will damage lung function and the need for inhalers will affect the regular activities. The lunch cancer is a common problem on people in cities due to PM and nitric oxide. The pollution in long term PM causes adenocarcinomas lung cancer. The other issues are common are cough/phlegm production and irritation. In industry areas, people suffer from acute upper respiratory tract infections and lower respiratory tract infections. These diseases depends on the concentration level and time of exposure.

3. PROPOSED METHODOLOGY

High pollution in air creates adverse respiratory health effects in asthma patients such as increased wheezing and chest tightness, High exposure to high polluted areas may also cause cancer. In this paper, air pollution monitoring system is designed for monitoring both outdoor and indoor air pollution with the view of health monitoring for asthma patients. This is accomplished with the help of international air quality standard. Air Quality Index (AQI) is measured, and it is compared with the international standard. The pollutants level is measured using the sensors and analyzed using the microcontroller unit. CO2, NO2, CO are affecting in most cases and the industry emissions contribute to these pollutants. The sensor data are calibrated to check where the level is higher than the government nominations. The microcontroller unit and IoT sends the data to the processing system. The AQI is calculated, and the values are categorized into dangerous or not if it is more than 101. For AQI values in the range 51-100 is a problem for Asthma patients. Hence an alert can be given for asthma patients regarding the AQI through a mail to move to safe places if environment worsens.

3.1 PROPOSED HARDWARE

The Raspberry pi 3B+ used here for the design of air quality monitoring system. Various sensors such as MQ-135, DHT-11 and flame sensor are interfaced with Raspberry pi with the help of ADC converter. Data from the sensors are collected and for a particular place and are sent to cloud server. The parameters of air quality are measured using MQ-135. In addition to this DHT-11 and flame sensor are used for measuring temperature, humidity and flame respectively. The Sensors field parameters are analyzed with Python programming. The Measured parameters are updated to the cloud server. The Proposed air quality monitoring system consumes low power, gives high accuracy, compact and portable in nature. It can be carried anywhere for monitoring the quality of air for ensuring save livelihood for asthma patients.

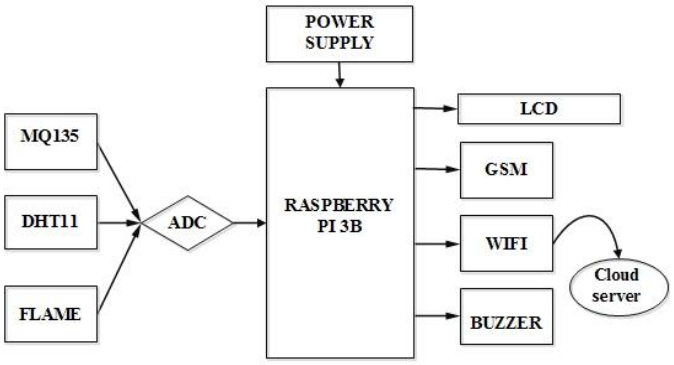
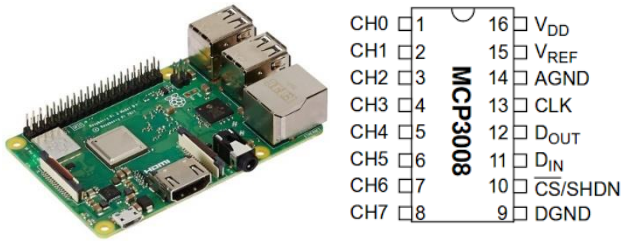


Fig.1. Block diagram of proposed design

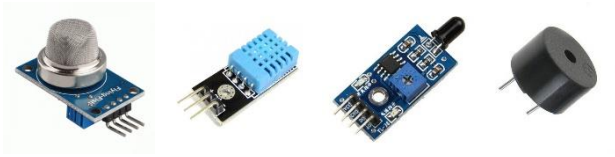
Controller unit: The controller unit has the Raspberry Pi 3 B+ has quad core processor. In this version Raspberry pi supports Ethernet and USB ports in Fig.2. Raspberry Pi 3B+ microcontroller supports peripheral devices. The Raspberry Pi supports. The Raspberry pi does not have of analog pins. To manage that MCP3008 ADC is used here for converting analog signals to digital signals. This MCP3008 ADC has 8 channels hence 8 sensors can be connected to it effectively.



(a) (b)

Fig.2. (a) Raspberry pi module (b) ADC converter

Sensing Unit: The sensing unit consists of three different types of sensors namely MQ-135 for measuring air quality of the environment, DHT11 for measuring temperature and humidity of the environment and flame sensor for sensing flame in the surrounding. The sensors used here are analog sensors and it is interfaced with raspberry pi through MCP3008 ADC converter.



(a) (b) (c) (d)

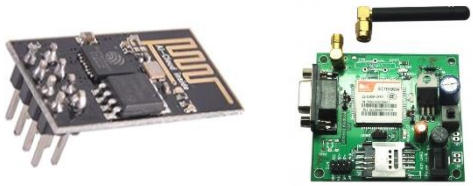
Fig.3.(a) MQ135 sensor, (b) DHT11 sensor, (c)Flame sensor (d) Buzzer

The MQ135 is a type of gas sensor used to measure the presence of harmful gases of atmosphere such as NH3, NOx, Alcohol, Benzene, CO2 Fig.3(a). In our proposed work analog format of sensor is used. The temperature and humidity are measured using the digital temperature and humidity sensor The DHT11 sensor is shown in Fig.3(b). Temperature and Humidity is given in the Table.1. The other sensors used for monitoring are the flame-sensor, buzzer, and ESP8266 Wifi Module and GSM SIM900 Module. For monitoring Thingspeak Cloud Server is used in the initial prototype. But the classification is undergone in the python platform.

Table.1. Rating of Temperature and Humidity in DHT11

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90 % RH 0-50ºC	± 5% RH	± 2º C	1	4 Pin Single Row

The alert message about the AQI to the required authority through a message and mail is sent.



(a) (b)

Fig.4.(a) Wifi module (b) GSM module

Fig.5. Thingspeak Prototype

3.2 WORKING

The sensor unit collects data from the surroundings. These data are sent to Raspberry pi through ADC module for analog to digital conversion. The raspberry pi processes the data and take decision accordingly by comparing it to the threshold value. The collected values are displayed in LCD module. The sensor values are also sent to thingspeak if the raspberry pi relates to wifi signal. Thus, data obtained send to thingspeak sensor are efficiently stored in it along with time information. This module provides visualization of the collected data and can alert the user through an email in case of emergency. The data can be viewed from anywhere with the help of channel information. The AQI is calculated and compared with the database. AQI categories were shown in Table.2.

Table.2. AQI category of India

AQI Category
Good (0-5)
Satisfactory (51-100)
Moderate (101-200)
Poor (201-300)
Very poor (301-400)
Severe

4. RESULTS

(a) (b)

Fig.6. Proposed model (a) Experimental setup (b) Output window

(a) (b) (c)

Fig.7. Thingspeak output, (a) plot for air quality, (a) plot for temperature, (a) plot for flame

Table.3. Measured Parameters

Date and Time	Air Quality	Temperature	Flame	Emergency
2021-07-30 07:25:11 UTC	54.34742	76.73509	0	0
2021-07-30 07:50:23 UTC	57.64454	128.5435	0	0
2021-07-30 08:00:06 UTC	59.91941	126.58846	0	0
2021-07-30 11:06:18 UTC	20.8502	83.57771	0	0
2021-07-30 11:10:13 UTC	13.76448	80.64516	0	0
2021-07-30 11:18:15 UTC	16.73751	87.97654	0	0

The AQI category is shown in Fig.8-13.

ID	Location	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
28016		24	15	27	12	0	18	31.07.2021 15:52:17
28015		1	16	27	38	0	10	31.07.2021 15:52:17
28013		21	7	2	42	0	6	31.07.2021 15:52:17
28013		30	19	25	46	0	8	31.07.2021 15:52:16
28006		3	3	9	16	0	31	31.07.2021 15:52:16
26002		45	25	7	45	0	36	31.07.2021 15:52:15
28012		19	27	5	11	0	16	31.07.2021 15:52:15

Fig.8. Pollution level AQI =0-50

The Fig.8 shows good air quality index with the range of 0 to 50. The individual AQI of pollutants are given.

ID	Location	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
54804	office	69	53	78	89	1	72	31.07.2021 16:52:06
54808	office	97	48	63	63	1	46	31.07.2021 16:52:06
54806	office	92	51	77	63	1	73	31.07.2021 16:52:05
54807	office	76	47	79	92	1	62	31.07.2021 16:52:05
54805	office	91	33	42	66	1	51	31.07.2021 16:52:05
54798	office	83	37	75	62	1	62	31.07.2021 16:52:04
54799	office	90	34	54	83	1	83	31.07.2021 16:52:04

Fig.9. AQI level with pollutants ranging 51-100

The Fig.9 gives the satisfactory range for different pollutants.

ID	Location	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
63705	office	196	62	139	157	6	123	31.07.2021 14:52:16
63703	office	215	78	114	115	5	274	31.07.2021 14:52:16
63704	office	159	82	177	100	6	167	31.07.2021 14:52:16
63706	office	247	82	123	120	2	245	31.07.2021 14:52:15
63692	office	229	67	153	145	8	165	31.07.2021 14:52:15
63701	office	134	77	162	153	9	118	31.07.2021 14:52:14
63694	office	145	83	94	167	4	96	31.07.2021 14:52:14

Fig.10. Moderate pollutant level AQI= 101-200

The Fig.10-Fig.13 shows the pollutants moderate level, poor level, very poor and severe level of pollutants.

ID	Location	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
64501	office	328	110	237	178	12	499	31.07.2021 16:42:15
64503	office	276	101	219	175	16	409	31.07.2021 16:42:15
64500	office	318	108	201	197	10	504	31.07.2021 16:42:14
64502	office	326	109	273	198	16	588	31.07.2021 16:42:14
64499	office	254	105	217	206	11	611	31.07.2021 16:42:13
64498	office	296	102	235	185	16	725	31.07.2021 16:42:13
64497	office	325	105	236	168	15	765	31.07.2021 16:42:13

Fig.11. Poor polluted area AQI.

ID	Location	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
67108	office	390	233	381	452	31	1051	31.07.2021 16.49.18
67111	office	386	180	283	671	29	1563	31.07.2021 16.49.18
67107	office	398	215	380	334	28	1505	31.07.2021 16.49.18
67109	office	369	187	295	228	27	977	31.07.2021 16.49.18
67110	office	365	154	382	380	23	1499	31.07.2021 16.49.18
67105	office	368	230	301	275	32	1090	31.07.2021 16.49.17
67106	office	362	196	285	318	25	1031	31.07.2021 16.49.17

Fig.12. Very poor pollutant level AQI= 301-400

ID	PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	Time Stamp
69224	492	330	430	766	42	1839	31-07-2021 16.52.41
69223	472	339	403	993	37	1662	31-07-2021 16.52.41
69218	467	369	485	837	34	1836	31-07-2021 16.52.40
69214	427	260	436	890	43	1999	31-07-2021 16.52.40
69220	412	266	435	863	47	1723	31-07-2021 16.52.40
69216	483	385	417	752	48	1907	31-07-2021 16.52.39
69222	431	297	457	992	48	1786	31-07-2021 16.52.39

Fig.13. Severe polluted area AQI=401-500

The hardware was used to get the reading of the gas level. According to certain observation are made. Some of the cities under investigation was Hyderabad, Karur, Tirupur and coonoor. The device was tested in these locations which are having industries or high traffic. When Hyderabad was known for traffic, Karur is surrounded by cement factory, paper mill and sugar factory. Tirupur is known for textile while Coonoor for tea factories. This paper focuses on the hardware design so the investigation and questionaries of the real time data will be presented in the next manuscript. Few studies are presented below. For comparison data of Lanzhou, china was used for correlation. The report show that our work correlates with the results taken at Lanzhou, china. Lanzhou is chosen due to its industrial nature and huge population as per the literature by Yueling et al (2020).

The study of the air pollution impacts on children shown that an AQI value of greater than 200 is dangerous to their health. bronchitis and upper respiratory tract infection are common among children living in envirоinment or nearby industries which have high level of pollutant emission. Pneumonia causes due to NO2 and SO2 was studied. From the analysis the work found that during cold season the problem in respiratory tracts increases due to the pollutant.

5. CONCLUSION AND FUTURE WORK

The quality of air we breathe is an important parameter which decides our wellbeing. In case of asthma patients, the quality of air is the indicator of their life. Therefore, it is crucial to measure the quality of air we breathe and take necessary action if the air quality standards are not meet. In this paper an air quality monitoring system based on IoT is designed to measure the quality of air specifically for asthma patients. In addition to this the temperature of our environment and unwanted flame or fire is detected. All the parameters are successfully measured using raspberry pi module with the help of respective sensors and the measured parameter are sent to thingspeak cloud server using Wifi. The measured values are compared with calibrated values and if the measured values are greater than the calibrated value,

then an indication to the required authority and the lives of asthma patients can be saved.

In future machine learning approaches are to be used in the detection, diagnosis, and treatment of asthma due to pollutants.

REFERENCES

[1] B. Sivasankari, S. Dharini and R. Haripriya, "IoT based Indoor Air Pollution Monitoring using Raspberry Pi", *International Journal of Innovation Engineering and Technology*, Vol. 9, pp. 16-21, 2017.

[2] H. Zhang and V. Ganesan, "Low Cost, Multi-Pollutant Sensing System using Raspberry Pi for Indoor Air Quality Monitoring", *Sustainability*, Vol. 13, No. 1, pp. 370-385, 2021.

[3] S. Chen, H. Xu, D. Liu, B. Hu and H. Wang, "A Vision of IoT: Applications, Challenges, and Opportunities with China Perspective", *IEEE Internet of Things Journal*, Vol. 1, No. 4, pp. 349-359, 2014.

[4] B.C. Kavitha, Deepa Jose and R. Vallikannu, "IoT based Pollution Monitoring System using Raspberry – Pi", *International Journal of Pure and Applied Mathematics*, Vol. 118, No. 24, pp. 1-9, 2018.

[5] S. Kumar and A. Jasuja, "Air Quality Monitoring System based on IoT using Raspberry Pi", *Proceedings of International Conference on Computing, Communication and Automation*, pp. 1341-1346, 2017.

[6] Mladen Korunoski and Kire Trivodaliev, "Internet of Things Solution for Intelligent Air Pollution Prediction and Visualization", *Proceedings of International Conference on Computing and Communication*, pp. 1-6. 2019.

[7] G Spandana and R. Shanmughasundram, "Design and Development of Air Pollution Monitoring System for Smart Cities", *Proceedings of International Conference on Intelligent Computing and Control Systems*, pp. 1-5, 2018.

[8] Somdeep Acharyya, Sayan Hazra, Atanu Pal and Nabarun Sengupta, "Indoor Air Quality Management using Raspberry Pi and Graphlab", *International Journal of Engineering Research and Technology*, Vol. 6, No. 9, pp. 29-36, 2017.

[9] Ali Abaas Aboodee, Al-Zaheiree, Yasir Ahmed Taha AL-Zubaidi, S.S. Gaikwad and R.K. Kamat, "Advanced Air Pollution Detection using IoT and Raspberry Pi", *International Journal of Recent Technology and Engineering*, Vol. 8, No. 5, pp. 1-14, 2020.

[10] Poonam Pal, Ritik Gupta, Sanjana Tiwari and Ashutosh Sharma, "IoT Based Air Pollution Monitoring System using Arduino", *International Research Journal of Engineering and Technology*, Vol. 4, No. 10, pp. 1-8, 2017.

[11] V. Sujatha, S. Ravindrakumar, D. Sasikala, V.M. Senthil Kumar, N.V. Kousik and Jayasri Subramaniam, "CMOS based Driver Tree Design for Microprocessor Clock Distribution units in Biomedical Image Processing Circuits", *ICTACT Journal on Microelectronics*, Vol. 7, No. 1, pp. 1080-1084, 2021.

[12] J.G. Wagner and A.C. Rohr, "PM2.5-Induced Cardiovascular Dysregulation in Rats is Associated with Elemental Carbon and Temperature-Resolved Carbon Subfractions", *Particle and Fibre Toxicology*, Vol. 11, pp. 1-25,2014.

[13] X. Dai and X. Zhang, "Monte Carlo Simulation to Control Indoor Pollutants from Indoor and Outdoor Sources for Residential Buildings in Tianjin, China", *Building and Environment*, Vol. 165, pp. 1-16, 2019.

[14] S.H. Hwang and W.M. Park, "Indoor Air Concentrations of Carbon Dioxide, Nitrogen Dioxide, and Ozone in Multiple Healthcare Facilities", *Environmental Geochemistry and Health*, Vol. 42, pp. 1487-1496, 2020.