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Airsense - Air Quality Monitoring

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Abstract*: This paper basically aims to measure the indoor air quality by making use of two prominent sensors namely the DHT11 sensor which is used to measure the temperature and humidity and the MQ135 sensor which is used to detect harmful gases in the air such as Ammonia, CO2, CO, Nitrogen oxides, alcohol, smoke. The sensor allows us to determine the values of various gases in the house and classify it as good, bad, poor or toxic. This allows us to be alert and take necessary course of action to make the household a better and safer place to reside. This setup uses an Arduino uno as the microprocessor to perform necessary calculations. The data is then captured to the host system serially and is used for data visualization in Realtime using python and its various libraries.

Keywords: IOT, MQ135, DHT11, Realtime Indoor Air Quality Monitoring, Arduino UNO, Python

I. INTRODUCTION

IOT stands for internet of things. It can be described as a link or network of physical devices or objects that are combined or embedded using sensors, software and other technologies. The sole purpose of an IOT project is to collect and transfer the collected data so that this data can create or be used to create a useful insight. The data is collected and exchanged over various devices connected across the network. These devices can range from common household objects to complex devices or tools. IOT has made our life lot easier. It allows us to connect almost all electronic household items together such that everything can be controlled by from a single point even by using our own voice and virtual assistant. IOT is the link which joins the physical and digital world. It bridges the real/physical world to the digital world.

Our environment is degrading day by day. The advancement in technology and infrastructure is definitely helping us grow but also is leaving a black mark over the environment we reside in. The increased industries, pollution is degrading the air around us. The air quality depends upon the levels of various harmful gases present in the air. These gases are often the result of emissions from industries or factories.

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Continuous exposure to such poor-quality air can lead to many lung disorders and in turn can cause fatal diseases. It's necessary that we care about the air we breathe and the environment we reside in. Many studies have showed that regular exposure to poor air quality causes over 2.5 million premature deaths, out of which over 1.5 million deaths are the results of poor indoor air quality.

This project aims to provide us the measure and quality of the air inside our home by calculating the presence of various harmful gases and their levels in the air. Temperature and humidity sensors are also added in order to calculate room temperature and humidity level which in turn gives us the air quality. The results obtained from these sensors is displayed as output in an understandable manner using an LCD display panel. Using it we can view the real-time results and know how good the air quality inside our home is along with the temperature and humidity of the air inside our house. In order to take actions to neutralize the air pollution and improve quality of air, it's necessary that we have an affective mechanism to detect and measure the quality of air around us. We can go through measures to improve air quality once we fetch data regarding air quality using this system. Detection is therefore an important step for a goal oriented towards better quality air around us. The increasing population and urbanization demand more utilities and technologies to be introduced and used in regular basis. Increasing population leads to clearance of forests and natural habitats that actually act as an air filter for our environment. Loosing such natural air filters leads to uncontrollable levels of toxic and harmful gases in the air. Increased use of motor vehicles has shown drastic increase in emissions of pollutants into the air. According to studies, the six most common air pollutants are carbon monoxide, sulfur oxides, nitrogen oxides, lead, particulate matter and ground level ozone. These pollutants are often referred to as criteria pollutants and are significant in analyzing and deciding the quality of air around us. The emissions from vehicles include gases like carbon monoxide, carbon dioxide and nitrogen oxides that cause air pollution. If we talk about the methodologies applied as of now to measure air quality, we come across several heavy equipment and machineries which require space and cost. These need to be maintained regularly to ensure proper and accurate working. The cost efficiency is low as initial expenses are obviously high and apart from those expenses are incurred to maintain the system regularly. The equipment used in such case are fixed at certain locations to gather data collected from the equipment which is run through software to obtain insights on the raw data. Since deploying once such equipment comes out to be expensive, deploying such mechanisms in a widespread manner in several locations seems to be a lot more costly.

Regular maintenance of them is another great challenge that comes in between the efficiency of the system not only by the cost but also by the results produced. Irregular and improper maintenance can affect the equipment and the data which comes out, these could lead to inaccuracy and further can lead to calculation errors in the software using such data. Thus, making the final output unreliable and inefficient. Another thing we must consider is that availability of real-time data. It would be better if we are able to monitor the real-time air quality, this allows us to lookup on any changes happening the air and quickly responding if the air quality proves to be not at all suitable. This helps by increasing our speed of reacting and thus allows us to take necessary measures and actions in a much faster way.

This project is limited to the accuracy of data collected by the sensors. The project works within the confined limits of the data collected by the sensors. Since this project works mostly using sensors, it's important to check if the sensors are in good shape and work completely fine and error free. A slight disfunction or issue in the sensor can completely affect the whole system as the data collected will be wrong and the calculations performed to output the air quality will get affected and our final result will be wrong or inefficient which cannot be used properly as it will be considered unreliable. It's also important the code for Arduino is very well implemented and the results are correctly calculated based on the data collected by the sensors. The connections should be correct and should be properly joined.

The prime objective of this project is to develop a system using Arduino UNO which allows real-time monitoring of indoor air quality. The various sensors used in the system allows us to measure levels of gases in the air and helps us to calculate the humidity as well as temperature of the air. It also allows us to know about the air quality, whether the air quality is good or bad. The output is shown in the display. This output is fetched and a real-time graph is drawn using python and various graph plotting libraries such as matplotlib. The real-time graphs allow us to read and monitor the indoor air quality and lets us know even small rise or degradation of air.

This project enables us to develop a much smaller and more transportable, or in other words a portable air quality monitoring system that can be used within our homes to monitor the air quality within our house. It adds up as an extra utility which allows us to ensure a safe environment within our house and allows us to be aware and alert. Being small, and portable, it's easy to be located anywhere in the house and as it uses cost efficient components, the overall cost is comparatively low and it provides good accuracy and reduces maintenance needs of the device, thus making it not only cost efficient but also operationally easy and efficient.

II. LITERATURE SURVEY

[1][5][6][7][8][9] "Real Time System Monitoring and Analysis-Based Internet of Things (IoT) Technology in Measuring Outdoor Air Quality" - Yuda Irawan, Refni Wahyuni, Muhardi, Hendry Fonda. Published in the year in 2021 in Pekanbaru, Indonesia.

The paper shows a simple approach for developing an air quality monitoring system using a DHT11 and MQ135 sensors along with an Arduino Uno which is further connected to a raspberry pi. The DHT11 sensor is used to measure the Temperature and Humidity, while the MQ135 sensor is used to measure the air quality. The MQ135 sensing element will find the degree of CO, CO2, NH3, NOx, Alcohol, smoke etc.

The collected data is then sent to a web server and is used to output the real-time values to the end user once the user logs in with his/credentials. This approach is bit more expensive as two IOT devices i.e., Arduino UNO and Raspberry pi are used. This project specifically has been designed to sense and measure outdoor air quality and provide results as feedbacks to the user at real-time when users login using their own credentials. This ensures only authorized entry to such sensitive data.

[2] "Development of an Internet of Things solution to monitor and analyse indoor air quality" - Dylan Wall, Paul McCullagh, Ian Cleland, Raymond Bond. Published in the year in 2021 in United Kingdom.

In this paper a BME680 air quality sensor, ESP32 microcontroller unit, Raspberry Pi server and Web server is used to develop an indoor air quality analyzing and monitoring system. The BME680 sensor is 4 in one sensor that can sense or detect humidity, temperature, pressure and gas. The ESP32 module is used to wirelessly transmit the data to Raspberry Pi. The data collected is initially stored in a local storage like an SD card. The data is then processed using server-side software implemented by Raspberry Pi. After the processing of data, the sensor sends it to an external MySQL database. This data is used by a web application to provide insights in the form of a dashboard which shows the output information in a GUI format.

[3] "Low Cost, Multi-Pollutant Sensing System Using Raspberry Pi for Indoor Air Quality Monitoring" - He Zhang, Ravi Srinivasan and Vikram Ganesan. Published in the year in 2021 in Gainesville, FL 32603, USA.

This paper gives us an idea to build a low cost multi pollutant sensing system using Raspberry Pi 3B Plus module. Along with the microcontroller, it uses a DHT22 sensor which allows us to measure humidity and temperature levels. There is another sensor namely the SDS 011 sensor which measures particulate matter in the range of 0.3 and 10 µm in diameter using a laser scattering technique. It also has a SPEC-DGS-NO2 968-043 sensor which is a low-power IoT integrated gas sensor that measures NO` levels. The SPEC-DGS-SO2-968-038 sensor was also used, this is a high-performance IoT integrated gas sensor similar to SPEC-DGS-NO2 968-043 which is used to detect and measure SO2 levels. Then we have a SPEC-DGS-CO 968-034 sensor, which is a light weight sensor that has an ability to measure CO levels. The raspberry pi along with all these sensors perform measurement task and are efficient in producing the result in a few seconds. These measurements processed and are exported as a CSV file which can be further used for data analysis and data visualization.

III. METHODOLOGY

This project uses Arduino UNO microcontroller. Several sensors like Temperature and humidity sensor, air quality sensor was connected along with the Arduino board. These sensors allow us to measure humidity, temperature and concentration of various gases in the air. These measured data are then analyzed and is displayed using the LED display. The data is further received by the python program to plot a real-time graph using the real-time values obtained from the Arduino. The graphs can be plot using libraries like matplotlib which is an efficient data visualization library in python. The system is then checked in various environment to ensure accuracy and proper working of the sensors and the results calculated and provided by the Arduino to the python program for further real-time plotting of graph.

The connections of the various components to the Arduino board can be denoted using a schematic diagram. The fig.1 shows how the various components are connected to the Arduino board. The DHT11 sensor and MQ135 sensor are the two main components. These are sensors to measure Temperature and humidity, and air quality respectively. We also have an OLED display to show the real-time results.[4]

The project mostly works within the Arduino and serially sends the data to the host for real-time plotting of graph. Initially the MQ135 sensor and DHT11 sensor collects the reading and send it to the Arduino uno board. These values are then displayed to the OLED screen. Along with that, the MQ135 sensor data is sent to the host computer using the serial or com port. Once the host system receives the values, a python script along with graph plotting libraries like matplotlib is used to plot the graph in real-time. The graph shows the varying air quality values, and we can see changes if any harmful emissions are detected in the air.

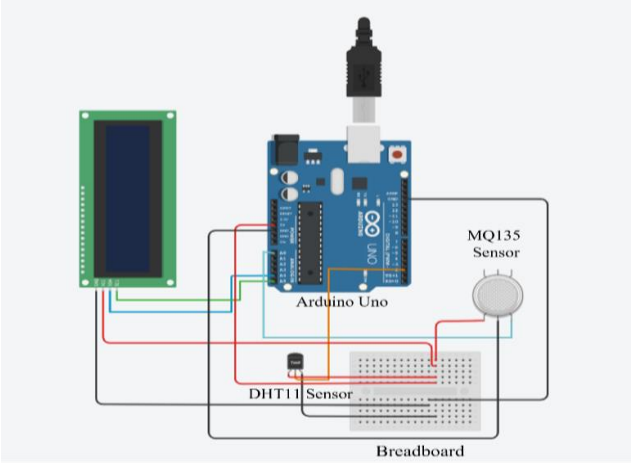

Fig. 1. Schematic Diagram of Airsense

The air quality is measured by the MQ135 sensor. It is measured in the form of ppm (parts per million) values. The MQ135 sensor can measure the ppm values from a range of 10 to 1000 ppm. The MQ135 sensor gives out output values based on ppm values of all the gases it can detect, this gives an output of an index in the range of 0 to 1000. The Table.1 shows the various levels of concern and the corresponding index values.

Table 1. Air Quality Index Range

Level of Concern	Values of Index(ppm)
Good	0 - 50
Moderate	51 -100
Poor	101 -150
Unhealthy	151 - 200
Toxic	201 - 300
Hazardous	301 and Higher

The range 0-50 is good, the air quality is satisfactory and safe to inhale, and poses little to no risk. The range 51–100 signifies moderate air quality. It's an acceptable range however it may cause discomfort to some people who are sensitive to air pollution. Then comes the range 101-150 which signifies that the air is poor. Though the general population may not experience severe effects, sensitive people may find it difficult and might experience discomfort. The range 151-200 signifies Unhealthy. In this range the general public may experience health issues and people who are more sensitive may experience even more serious health issues. The range 201 – 300 signifies Toxic air quality. It denotes serious health alert. It signifies that everyone may experience severe health issues. The range 301 and higher is consider to be hazardous which is really severe and effects the people severely. It causes serious health repercussions and may be fatal depending upon the people being affected. Such air quality needs to be neutralized and people in that locality must be evacuated and treated immediately.

IV. CONCLUSION

The air around often controls what our health condition may lead up to. Since humans and other living organisms highly rely on essential components like oxygen within air, its highly necessary that we inhale gases or components which does not interfere with our daily essential metabolic activities. The air we breathe is so important in the terms of keeping how healthy we remain. The increased number of certain pollutants or harmful gases or components may cause severe lung disorders, breathing ailments, severe diseases and many other issues which may eventually lead to major health issues or may even lead to death of an individual. It is high time that we take air quality as an important aspect of our households and our surroundings and keep our efforts to reduce pollution along reducing release of other possible harmful elements to the air. We usually spend most of our time in our households with our loved ones and we sometimes neglect several breathing discomforts or ailments which are seen within households as we perceive our households as the safest environment, we can spend time. Since we spend a lot of time in our households, its important that we ensure that the air quality is maintained good and all possible pollutants or harmful components are got rid of. It is not possible for us to maintain a good quality of air and eradicate pollutants or harmful components from indoor air or air within our households unless we know whether it is safe or not. Without proper equipment to measure the air quality, its not possible to take actions to neutralize the harmful nature of poor air quality. To this purpose, Airsense comes into the picture. It helps us to monitor and know the real-time air quality values of the air within our households, so that we know when we have to act to make the air around us better for us to breathe and prosper.

Airsense provides one of the most cost-efficient way to measure and monitor he indoor air quality and display the results in the OLED as well as in a graphical form in real-time so that you can observe the real-time change in the air quality and see even the slightest of the changes. Being cost efficient makes it more accessible to people and since it's affordable, it's more likely to be adopted by most of the financial groups. Our health is in our hand and we need to ensure that we keep track of all factors that affects it. Air we breathe being one of the most significant factors that maintains our health, it needs to be ensured that we breathe good air and that our household remains safe as we have always seen it as.

DECLARATION STATEMENT

Authors are required to include a declaration of accountability in the article, counting review-type articles, that stipulates the involvement of each author. The level of detail differs; Some subjects yield articles that consist of isolated efforts that are easily voiced in detail, while other areas function as group efforts at all stages. It should be after the conclusion and before the references.

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Authors Contributions	All authors have equal participation in this article.

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Ms. Neenu Kuriakose joined the Department of Computer Science, St. Albert's College (Autonomous) in July, 2021 with four years of experience in Software Industry and teaching undergraduate courses in Computer Science. She did her Bachelor's Degree in Computer Application from Rajagiri College(MG University) in 2014, Masters from UC College Aluva in 2017 and M.Phil from Amrita University in 2021.She is currently pursuing PhD. Her areas of interest include Internet of Things (IoT), Machine Learning, Computer Security and Block-chain Technology. She has published 10+ papers in professional journals. She holds two patents, entitled as "Block-chain enabled intelligent IoT architecture with AI "and "Intelligent IoT based smart irrigation system using cloud computing". She earned an Indian book of record in 2nd August 2021. She is an active national mentor of Yuva IncubatED team. Ms.Neenu received Best Research scholar award from novel research academy(2021) and Indo-Asia Best Researcher award in Computer Security era(2021).She currently conducts the Department Certificate Program in Internet of Things (IoT) . She also actively participates in continued learning through conferences and professional research.

Ms. Sangeetha J working as an Assistant Professor and Assistant Controller of Examination, Department of Computer Science in St. Albert's College (Autonomous) having over a decade of experience in academics and industry. She joined the Albertian family in 2011. She has done her M.Phil in Computer Science and pursuing her Ph.D. She has specialized in Data Mining and has extensive knowledge in the full life-cycle of software development process including requirement gathering, design, coding, testing and debugging. She has designed various software applications for various agencies including financial enterprises and educational consultancies. She has published papers in many national and international publications. She presented papers in various national and international seminars/conferences. Her area of research is data mining.