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An IOT Enabled Air Quality Measurement

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Abstract

Objectives: To develop a portable, low cost and efficient pollution monitoring device. Embedded module can be placed on rooftop and display will show the ambient quality values. **Methods/Statistical Analysis**: We have adopted the method of data acquisition in real time using semiconductor sensors of MQ series. The sensor data is sampled with help of AVR microcontroller, processed with the program and the values are displayed on LCD. Power consumption is tried to keep low by using sleep mode of microcontroller. The processed data is uploaded on cloud platform and analysed for critical parameters. **Findings:** The data could be accessed by the user and even government authorities to monitor air quality in real time and take precautionary steps. This low cost & portable solution has semiconductor sensors interfaced with AVR microcontroller. It needs very low power & to make it work independently we can include solar energy to power it. The data taken is validated at different location and with the data of standard equipment setup at locations. **Application/ Improvements:** Device finds application in industries, educational institutes and public places. Adding more sensors for detection of other gases would improve monitoring of various gases in environment.

Keywords: Air Quality, Arduino, Gas Sensors, IOT, Low Power

1. Introduction

Recent advancements in human lifestyle resulted in contamination of air thus becoming bane for human survival. The World Health Organization considers an annual average of 10 micrograms per cubic meter to be safe. India's air-quality standards set the limit at 40 micrograms per cubic meter[1] (Greenstone et. al, 2015). India was ranked 155 out of 178 countries in Environmental Performance Index (API) and 13 of the world's 20 most-polluted cities[1] are all in India. A study in September 2014 suggests that excess pollution is reducing the life expectancy of 660 million Indians by 3.2 years, on average. Central pollution control board has been working on reducing the pollution level and ordained the methodology for monitoring the air quality index[2], but increase in the number of vehicles and huge number of industries in cities has led to the serious problem of air quality deterioration.

There are several traditional methods espoused for monitoring the emissions[3]:

1. Fossil fuel estimation and accounting raw material consumption,
2. CO2 flux measurement in air using IR radiation, and
3. Development of wireless sensor node and deployment of Wireless Sensor Networks based on the coverage area and scalability issues.

A WSN with 100 CO2 sensing nodes was proposed[4] in where collection tree strategy is as routing protocol and G-GSTWH algorithm is used for optimal node placement. Traditional Instruments available today to measure air quality of indoor and outdoor air pollution are bulky in size and expensive. Real Time Wireless Air Pollution Monitoring System is developed in the study but IOT has not been implemented[5].

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The current method used to measure air pollution in cities is to put an air pollution monitor somewhere in the city and assume that everyone is exposed to that level of air pollution. However, we know that there is large variability, with levels near roads being much higher than further away. People move around the city and by [tracking them] and giving them a small air pollution sensor, we can see what the air pollution levels are where they are. This gives data of particular point and does not cover a vast area.

In concurrent with India's PM Modi Swatch Bharat that focus upon the need of clean air and Digital India Campaign that largely aims at developing newest of its kind technology- Internet of Things, we the engineers of tomorrow, cognizant of our social responsibility have devised an innovative solution to curb the country and the environment from the menace of air pollution.Thus, Presenting "*My Enviro*-An IOT enabled air quality monitoring". It's portable, economical and affordable to even individuals.

The study's aim is to examine the interaction of pollutant mixtures and weather on health and health inequalities, now and in the context of future air quality and climate policies, through epidemiological studies based on the development, testing and application of multi-pollutant data that are disaggregated in time and space. It also examines the impact of selected air quality and climate policies on changes in the distributions of (multi-) pollutant concentrations and related health burdens, including exceedance patterns, and their relationship to weather extremes.

Thus, the major objectives of this project are:

1. To create a tool which will monitor the quality of air of our environment,
2. To analyse the content of different gases that are present in the air or area around us, and
3. To display the data obtained on the LCD.

2. Requirements Analysis

2.1 Hardware Requirements

The major requirements to achieve the objectives of a project include:-

1. A suitable microcontroller which is capable of access to the internet through internal configuration or by the use of external hardware.
2. Array of sensors for reading gaseous concentration in the environment.
3. A programming environment or IDE which would be used to:

   a. Interface sensors to the microcontroller,
   b. Enable web interface, and
   c. Interface auxiliary hardware like cooling system, voltage sensor, etc.

4. A housing/box for the entire system.

The microcontroller selected for the project is the Arduino Yun. It is a AtMega32 IC based microcontroller which has an on-board Wi-Fi and Ethernet shield, which enables it to easily connect to the web. The programming of the device is easy and versatile which allows the interfacing of the sensors and other hardware with the board readily.

The sensors have been chosen keeping in mind the industrial and domestic standards for levels of pollutants as well as the cost and operating conditions.

Auxiliary hardware includes cooling fan, voltage sensors, battery, etc.

The entire hardware is housed in a wooden box of handy dimensions making the project easily portable and storable.

2.2 Software Requirements

The requirement of software arises in the following cases:

1. To program the microcontroller,
2. To interface the device with the internet such as data logging and alerts, and
3. To analyze the data.

The programming of the device is done through two software stacks:

2.2.1 The Arduino IDE 1.6 or Above

This open source IDE integrated development environment is used to program the microcontroller and interface all the hardware to the main board. It is compatible with all windows based PCs and has minimal system requirements.

2.2.2 TEMBOO

This software stack is available exclusively on the web and is used to generate codes called CHOReOS based on the conditions required and the board specified, in order to achieve web connectivity and enhanced functionality.

The analysis of the data is done on Google Spreadsheets, which only requires a Gmail account to access. The alerts are generated through email via Gmail and Twitter.

3. Operational Feasibility

An operationally feasible system is one that will be used effectively after it has been developed. If users have difficulty with a new system, it will not produce the expected benefits. The proposed system is found to be operationally feasible because of the following reasons:

- It does not need a physical operator. All the functioning of the module is automated. The need of an operator only arises if one wishes to check the data being logged online,
- The system is low maintenance. The need for overhauling arises only when the network through which the device is connected to the web is changed, and
- It is flexible in nature. New sensors and features can be added by changing the underlying coding.

For proper calibration and accurate readings, the sensors need preheat of 30 hours.

The fabrication part of the project has the following features:

1. *3D printed ventilation grid*: For the proper circulation of the air in and out of the box, 3D printed mesh has been attached at each side of the box,
2. 3D printed logo or project emblem, and
3. *Acrylic sheet for top view*: The top view of the box has been kept transparent with usage of acrylic sheet. The complete circuitry can be seen from the top.

4. Results

4.1 Collecting and Processing Data from Sensors

Processing by microcontroller and display on LCD: The array of gas sensors is interfaced with the Yun, which processes the analog data collected and displays the output on the LCD screen as shown in Figure 1.

- The gas sensors read the concentration of the dedicated gases in the vicinity. Since the gas sensors used are semiconductor sensors, the output of the sensors is in analog Voltage (in Volts) or Current (in mA),
- The Arduino Yun performs analog to digital conversion and has a 12-bit resolution, thus enabling 4096 levels of digital data,
- The digital data is converted into parts per million (ppm) or (parts per billion) as per the algorithm used to design the code for the particular sensor, and
- The algorithm for each sensor is designed by studying the graphical trends present in the data sheets of each sensor. Flowchart of entire program can be referred if Figure 2.

Following these steps, the resolved outputs are displayed on the LCD screen which is interfaced with the Yun. The module was run after initial calibration of the sensors, which was done by preheating the array for 30 hours. The device was tested in the vicinity of the AKGEC college campus following which the data was obtained as shown in Table 1.

5. Retrieval of Data and Analysis of Data

During the initial stages of the streaming phase, some errors were faced during calibration and coding. Also,

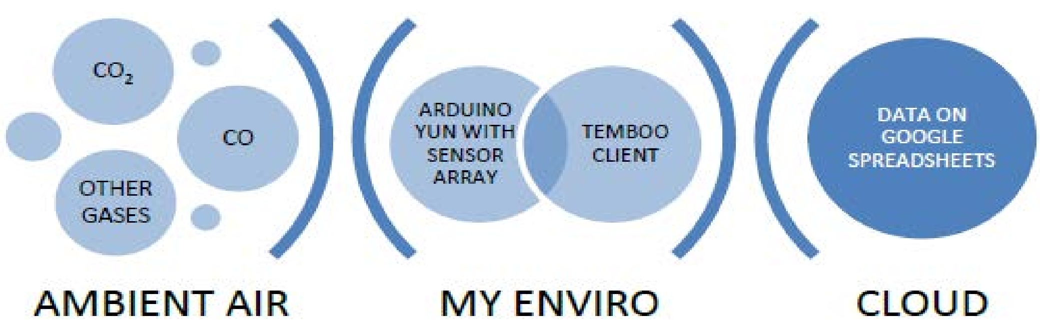

Figure 1. Flow diagram of the device.

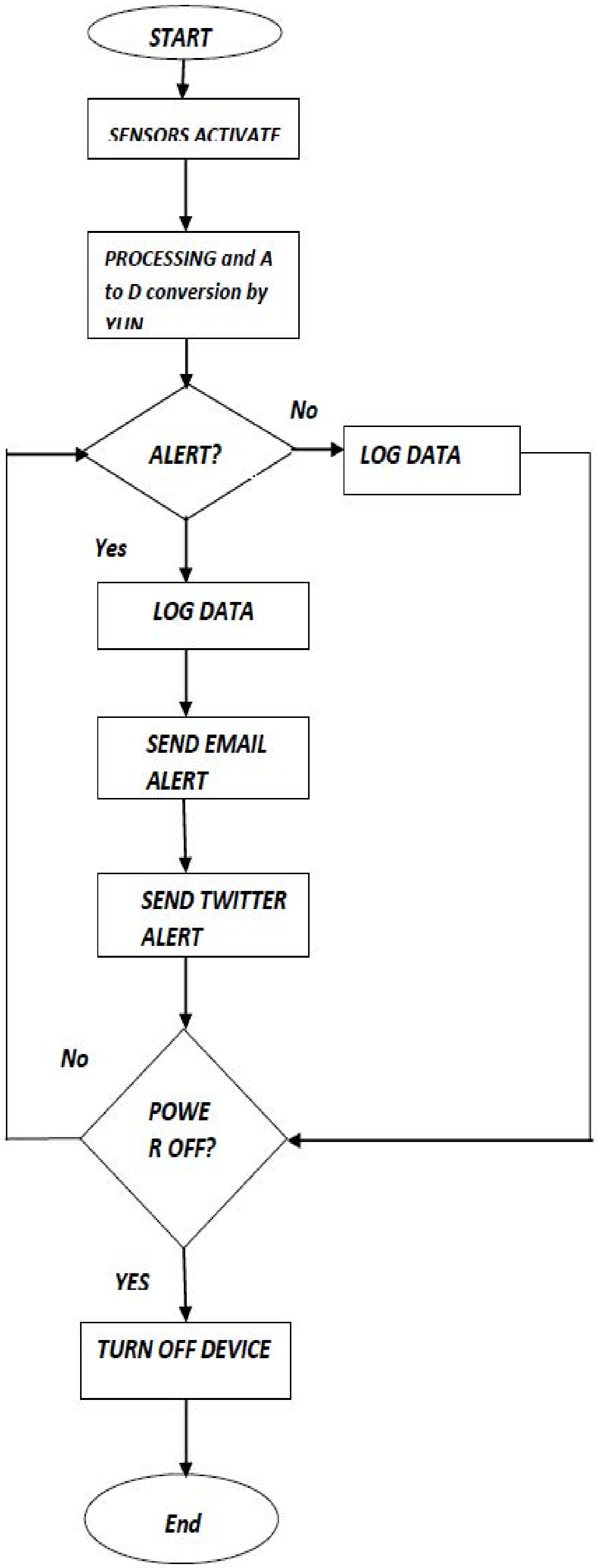

Figure 2. Flowchart of the program.

Table 1. AKGEC College vicinity tested

Pollutant	Concentration
CO	1.2 ppm
CO2	35 ppm
H2S	13 ppm
NH3	177 ppm
O2	20.5
General Air Quality	Good (as per Air Quality Index)

due to access time of the Wi-Fi connection, the streaming was hampered too. A test run of the project resulted in the data upload as shown in Figure 3 and results are obtained in form of graphs showing pattern of pollution level variation as shown in Figure 4.

6. Future Prospects

The major drawback of the project is that even if it is successfully able to log and display the data acquired by the sensors as well as generate alerts whenever predefined levels are crossed, it does not perform any function to mitigate or control the source of pollution (e.g. a particular machine such as a generator, household appliances, etc.)

Thus, the main scope of further improvements in the project is regarding the control of the sources of pollutants. Efforts are being made to design a relay mechanism using an Arduino Pro Mini microcontroller along with an ESP8266 Wi-Fi shield so as to connect to the central hub i.e. the Yun over the internet and relay talkback commands to particular machinery.

Another field where improvements can be done is in the microcontroller itself. Arduino Yun is a handy board which is easy to understand and program. It is very versatile in nature as well. But, as per the changing standards of data networking and communication and new standards for Internet of Things being developed rapidly, it will slowly become obsolete.

Last but not the least improvements can be made in the fabrication of the module itself. The PCB layout can be improved by using smaller and robust components as well as the housing can also be changed as per the internal components change. We are looking forward for integrating the entire project with NI dashboard and making the module solar-powered:

Stream : Sheet1

TIME	MQ7(CO)(ppm)	MQ135(AIR QUALITY)(%)	MQ136(H2S)(ppm)	OXYGEN(%)
2110hrs	35	20.9	13	20.5
2140hrs	35	20.9	12	20.5
2210hrs	35	20.9	13	20.5
2240hrs	38	20.3	12	21.2
2310hrs	36	20.3	13	21
2340hrs	38	19.9	12	20.7
0010hrs	37	20	14	20.3
0040hrs	38	19.9	15	20.2
0110hrs	40	19.5	14	20.2
0140hrs	38	19.9	13	20.1
0210hrs	0	0	0	0
0240hrs	0	0	0	0
0900hrs	0	0	0	0
0930hrs	35	20.9	13	20.5
1000hrs	35	20.9	13	20.5
1030hrs	34	20.9	13	20.5
1100hrs	32	21.1	12	21.4
1130hrs	30	21.5	11	21.5
1200hrs	32	21.1	12	20.4
1230hrs	30	21.5	11	20.4
1300hrs	31	20.3	12	20.3

Figure 3. Streaing data.

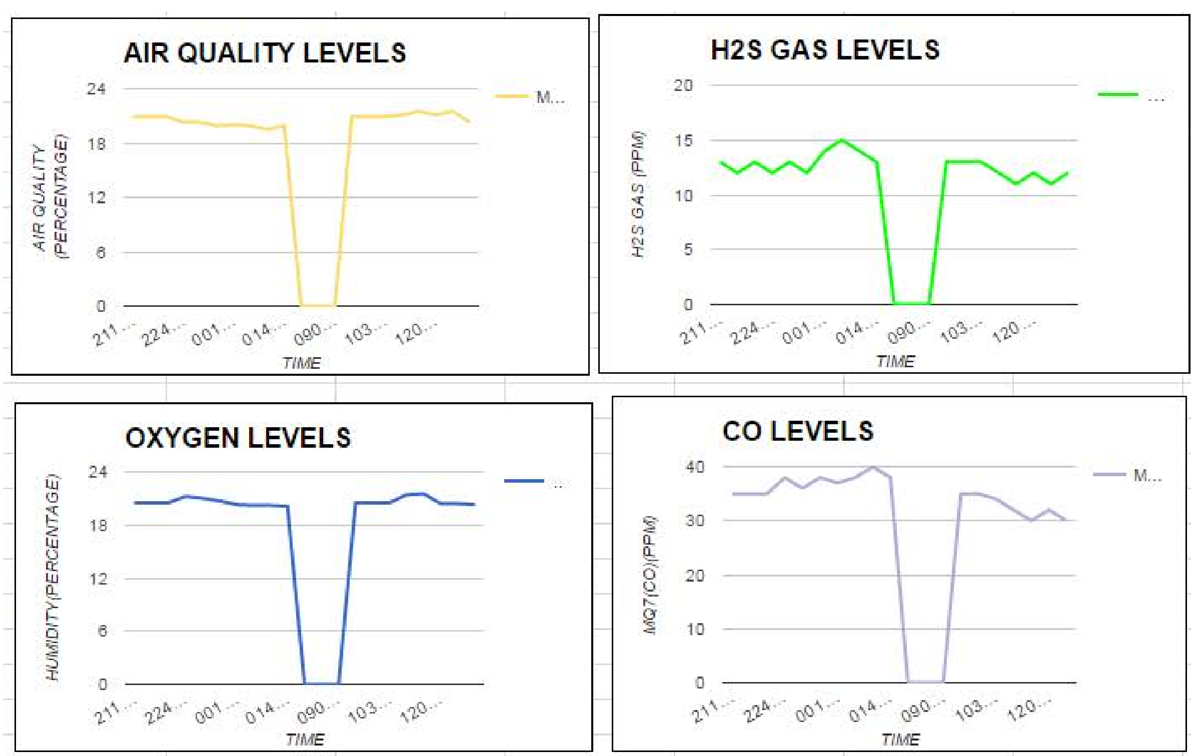

Figure 4. Graphs of output data.

- This module can be adopted by the Pollution Control Board to analyse as well as control pollution levels in the cities,
- A consumer utility product that can be housed in industries, homes, hospitals etc.,
- Portable in nature, and
- Power efficient.

Real-time analysis as well as previous pollution records can be analysed. We will generate a PHP based application using Laravel framework that will be interfaced with NI.

This will enable the user to have a quick review of the ambient quality of a particular region by simply accessing the smart phone.

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