© June 2021| IJIRT | Volume 8 Issue 1 | ISSN: 2349-6002

Air Pollution Detection Using UAV

Adarsh Sudarsanan[1], Amalu S Panicker[2], Karthik J[3], Sachu Pradeep[4], Mohamed Samshad[5], Arun C[6], Praveen Raj R S[7]

[1,2,3,4]*Department of Electrical and Electronics, Mar Baselios College of Engineering and Technology, Kerala, India*

[5,6]*Research Assistant, ICFOSS, Thiruvananthapuram, Kerala, India*

[7]*Assistant Professor, Dept. Of EEE, Mar Baselios College of Engineering and Technology, Kerala, India*

***Abstract* - Due to the increase in the population there is an increase in the air pollution. The air pollution has a vast impact on the economy, environment and health of the people. The major pollutants are particulate matter, nitrogen dioxide, carbon dioxide, Sulphur dioxide, carbon monoxide, methane etc. These pollutants can be either manmade or naturally occurring. The current method of measuring air pollution is by using sensors fixed over building over an interval of distance. The disadvantage of this method is that each building will be using more power for its sensor part and also this method cannot be used in rural areas with fewer buildings. This problem is removed by using environmental drones or e drones for monitoring and analysis of air pollution.**

Drone is a very useful technology as it helps to reach places where humans can't reach. It is also known as unmanned Aerial vehicle (UAV). The main aim of this project is to develop an environmental drone for autonomous monitoring, analysis, and countering of air pollution. Various low-cost sensors are used to measure the humidity, temperature, pressure, wind speed, precipitation at different heights of a particular area. Air Quality Index (AQI) is measured by measuring the concentration of different pollutants in an area. These data from the drone is sent to the base station via wireless communication to the base station for AQI mapping. The threshold values of the pollutants have already been standardized.

***Index Terms* - AQI, UAV, Air Pollution, Mapping, QGIS.**

I.INTRODUCTION

Increasing urbanisation, thriving industrialisation, and related human activities are the main reason for increasing pollutants in the atmosphere, which leads to poor air quality. Around 50% of global population will reside in the urban areas by 2030. More than 80% of the urban population is adversely affected by polluted atmosphere as per the standards of WHO (2016). Air pollution has been among the top five global risk factors for mortality.

Air pollution levels in various Indian Cities including New Delhi are on the rise, emphasizing the need of AQI measurement and taking measures to reduce the pollution levels. Air pollution leads to death of around 2 million Indians every year. In the per capita emission of greenhouse, India is placed low, but considering the country as a whole, Indian stands third, right after China and US.

Many countries have standardized method for calculating air pollution. AQI [1] is one of the methods used by government agencies to depict the atmospheric pollution level. As AQI increase public health is at stake.

In India, National Air Quality Index (AQI) was launched in 2014. The Central Pollution Control Board (CPCB) along with State Pollution Control Boards is operating the National Air Monitoring Program. More than 350 measuring stations are located in over 240 cities pan India. There are namely six categories for depicting AQI Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. For measuring AQI 8 pollutants are considered PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb, out of which at least 3 pollutants including one of the PM value is mandatory to calculate AQI. Based on the measured concentration, different sub index values are calculated for each pollutant based on the health impact of the pollutants. The dominant value of the sub index is considered as the AQI.

The use of stationary sensors [2] for calculating AQI has many practical difficulties. Only AQI values for a particular region can be taken using stationary sensors.

Since it is fixed at a particular height, pollutant values at different height cannot be measured.

In this paper the proposed idea is to use an Unmanned Aerial Vehicle (UAV) [3] to measure the pollutant values at different regions. Since it is not a stationary system, values at different altitudes can be easily measured.

The organization of this document is as follows. In Section 2 (Methods and Material), the different components of the drone and sensing part are listed along with the methods. In Section 3 (Block Diagram and Working), detailed working and block diagram is explained. Discussed in Section 4 (Result) the end result of the proposed work. In section 5 (Conclusion), the final conclusion of the proposed work is mentioned.

II.MATERIALS AND METHOD

The Environmental drone is a drone which is designed to obtain the environmental data of the pollutants at a particular station or location. The E-drone has a base station at the location where environmental data is to be acquired. The drone has its own base station which corresponds to the geographical area where the AQI is to be calculated. The drone is equipped with all the necessary sensors which are used for the whole air quality assessment objective.

A. *Components*

1. Frame

The frame for the system needs to be durable and should have necessary space to carry all the required components during the whole process. It is built from quality glass fiber and polyamide nylon and has integrated PCB connections for direct soldering of ESCs. It weighs about 330 grams without any electronic parts in it.

2. Brushless DC Motors

Four A2212 brushless DC motors shown in Figure 1 were used to convert the battery electrical power to mechanical power to spin the propellers for system flight. Each motor was mounted on respective arms of the quadcopter considering its direction of rotation which is clockwise and anti-clockwise

Figure 1: BLDC Motor

3. Propellers

Four propellers which is a clockwise pair and an anticlockwise pair, 10 x 4.5 inches, were mounted on the four brushless motors. Proper care was taken to ensure that the propellers were securely fastened to the motors to prevent them from slipping off during the flight.

4.Electronic Speed Controllers (ESC)

Electronic Speed Controllers (ESC) are used for controlling the speed of electric motors. Four ESCs were connected to the four BLDC motors. The ESCs used were simonk 30A which were powered by LiPo batteries.

5.Battery

The drone as a whole were powered by Lithium Polymer battery of 3000 mAh. It has three cells and all of them must be charged sufficiently for safe operation of the drone. This provided a flight time of approximately 15 min and was sufficient to power for the drone to acquire environmental data at the test altitude height of 50 m.

6.Battery voltage checker

This is a important tool which must be used before operating the drone. It is used to check the voltage levels of the 3 cells of the battery before operating the drone. It has a buzzer which will go off if the battery level is below a predefined value.

7.Development board for drone

The development board used to program the Environmental drone is APM 2.8 (Arducopter) [4] as shown in Figure 2. It is a much-advanced development board which uses ATMEGA2560 processor and has built in 3 axis gyroscopes, accelerometer and a high precision barometer which can detect the height of its operation. As most of the sensors are embedded in the board itself, the overall complexity of the drone is reduced.

Figure 2: APM 2.8

8.Development board for sensors

For embedding the different sensors an Arduino Uno board with 14 digital i/o and 6 analog i/o pins were used. It uses an ATmega 328P processor.

9.Global Positioning System (GPS)

The Neo 7M GPS is used for getting the location of the environmental drones in latitude and longitude coordinates. It can be directly connected to APM 2.8 through provided ports and is shown in Figure 3.

Figure 3: Ublox Neo-7M GPS

10.LoRa

LoRa (long range) [5] is a proprietary low-power wide-place network modulation method. It is a low power long range communication method which we are incorporating in the drone for transferring the environmental data to the base station.

11.Air Pollution Sensors

The environmental drone uses gas sensors to collect environmental data at a particular height. Different sensors are used to collect the pollution concentration data of different pollutants. Figure 4 shows the pictures of the different gas sensors [7] used to take measurements of CO2, CO, NH3, SO2, PM, O3 and NO2 in the E-drone system. MQ-7, MQ-131 [7], MQ-137, GP2Y1010AU0F, MICS 2714 are used. These air pollution sensors are extremely sensitive and proper care must be taken in order to acquire the exact readings. Improvements will need to be made to shield the onboard air pollution sensors from the drone's electronic interference to ensure accurate AQHI measurements.

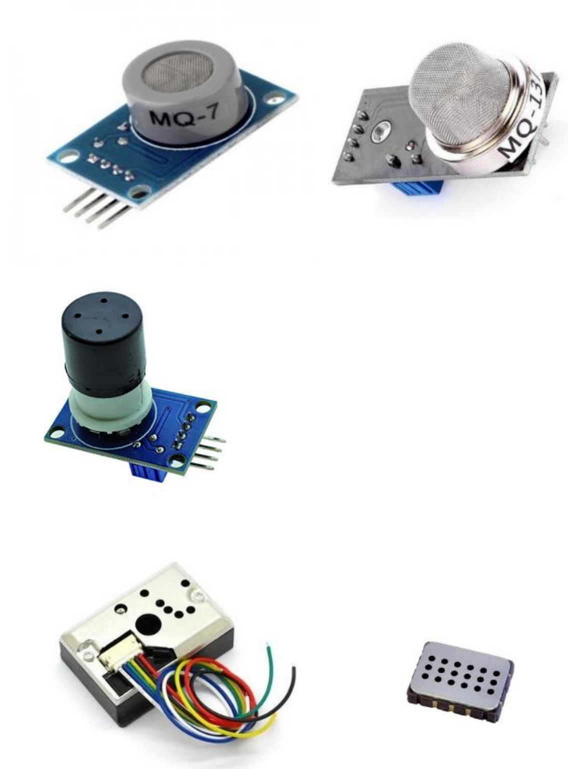


Figure 4: CO sensor, Ammonia Sensor, Ozone Sensor, PM Sensor, NO_2 Sensor

B. Method

1.AQI

AQI calculation is done using the formula provided by the Central Pollution Control Board (CPCB). Pollutant values at different time intervals are obtained and they are given appropriate sub index values based on their effect on human health. The dominant value of the sub index is considered as the AQI of the particular region

2.AQI Maps

The AQHI maps were generated using a global information system software known as QGIS [8][9].

The pollution concentration data collected by the drone is sent to the base station and on the base station

AQI is calculated. The map of the region to be environmentally monitored is divided in to sub regions according to the number of environmental drones available for the total operation. Once the AQI is calculated the software uses the data from the computer and using a scale based on the received values, plotted the AQI values of the various pollutants over the map. Different color codes are used for different AQI values. The color codes are as per the CPCB guidelines.

III.BLOCK DIAGRAM AND WORKING

A. Block Diagram

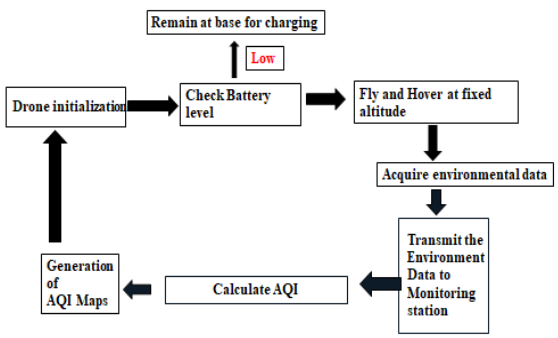


Figure 5: Block Diagram

B. Working

The drone can be operated on hourly basis. The drone checks its current battery charge level at the start of each hour to see if it has enough power to lift off. To start a flight in our example, each cell must have a minimum voltage of 3.6 V. The E-drone may be charged once it lands on the ground to preparation for its next trip.

If the battery level is above the predetermined threshold, power is supplied to the motors of the drone through the ESCs, causing the drone to lift up into the air.

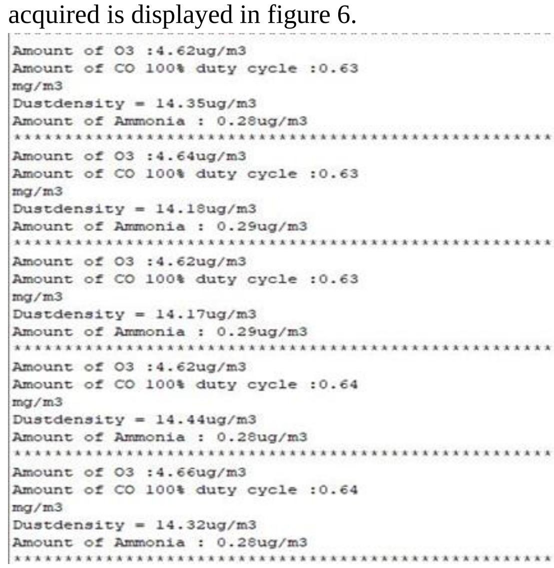
The drone flies up till it reaches the necessary height for collecting environmental data. When the drone reaches the required altitude, it is made to hovers there while environmental data is collected using the onboard sensors. Individual pollutant concentrations and geographical positioning data from various sensors comes under this.

The LoRa network is used to provide data from the O3, PM, NO2, CO2, SO2, CO, and NH3 pollutant sensors as a single data stream to the computer in the ground monitoring station. The Environmental drone system is a centralized system, with the measured environmental data collected by a computer at a ground monitoring station. Each Drone will be equipped with a GPS shield so the exact location at which the drone takes its measurement will be known. Multiple E-Drones can be used to obtain environmental data and AQI for different pollutants in different locations.

The calculations are done in the base station. The collected environmental data is used to calculate the Air Quality Index of that particular location. Similarly collected Air Quality Index of different locations is together used to make AQI mappings. For mapping AQI, QGIS software can be used. The AQI is plotted with respect to its geographical position in a shape file of the area where it was taken. Detailed environmental analysis (especially for air pollution) can then be conducted at the monitoring station using the generated AQI maps.

IV.RESULT

The UAV's as shown in figure 1, capacity to quantify the air contamination convergences of O3, CO, NH3, and PM 2.5 were tried and the example information acquired is displayed in figure 6.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Amount of O3 :4.62ug/m3
Amount of CO 100% duty cycle :0.63
mg/m3
Dustdensity = 14.35ug/m3
Amount of Ammonia : 0.28ug/m3
*******************************************************
Amount of O3 :4.64ug/m3
Amount of CO 100% duty cycle :0.63
mg/m3
Dustdensity = 14.18ug/m3
Amount of Ammonia : 0.29ug/m3
*******************************************************
Amount of O3 :4.62ug/m3
Amount of CO 100% duty cycle :0.63
mg/m3
Dustdensity = 14.17ug/m3
Amount of Ammonia : 0.29ug/m3
*******************************************************
Amount of O3 :4.62ug/m3
Amount of CO 100% duty cycle :0.64
mg/m3
Dustdensity = 14.44ug/m3
Amount of Ammonia : 0.28ug/m3
*******************************************************
Amount of O3 :4.66ug/m3
Amount of CO 100% duty cycle :0.64
mg/m3
Dustdensity = 14.32ug/m3
Amount of Ammonia : 0.28ug/m3
*******************************************************
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Figure 6: Pollutant values

The E-drone was operated at six distinct areas to create AQI maps. The AQI information gained from the 6 areas using three pollutant sensors and PM sensor as shown in the figure 2, are displayed in Table 2.

Location	Lat	Log	AQI
Aruvikara	8.556756	77.00215	48
Plamoodu	8.512457	76.94421	70
Attingal	8.710078	76.86969	90
Neyyar	8.526114	77.21415	28
Neyyattinkara	8.379882	77.10441	160
Palode	8.72354	77.04056	40

Table 1: AQI values at different locations

The sensor information gathered in particular areas are utilized to figure their individual AQI. These AQI values are superimposed on the given shapefile as for the given scope and longitude. The distinctive AQI ranges are likewise given diverse shading which makes it amazing to recognize and comprehend.

The AQI maps were produced utilizing QGIS programming. The AQI is plotted concerning its topographical situation in a shape document of the space where it was taken. Detailed natural examination (particularly for air contamination) would then be able to be led at the observing station utilizing the produced AQI maps. The product naturally gets the ecological information from the drones inside the predetermined locale and afterward produces AQI maps for each air pollutants. Human intercession isn't needed to create these guides as the environmental drones sends its information to the PC with the assistance of The LoRa network is utilized to give information from the O3, PM 2.5, CO, and NH3 pollution sensors as a solitary information stream to the PC in the ground checking station. Every drone will be outfitted with a GPS safeguard so the specific area at which the robot takes its estimation will be known. Numerous environmental drones can be utilized to get environmental information and AQI for various pollutants in various areas.

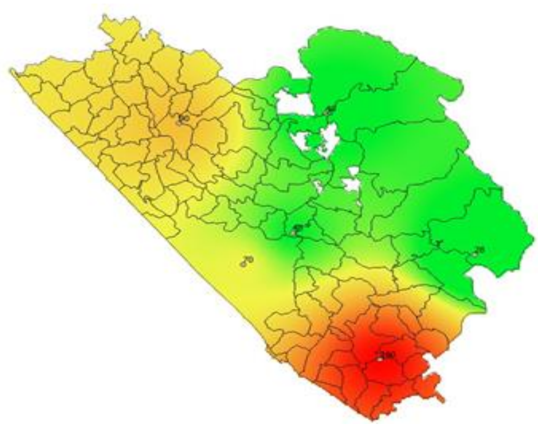

Figure 6: AQI mapping

V.CONCLUSION

E-drones offer another way to deal with huge scale air pollutant elimination that will actually automatically monitor and eliminate pollutants that are effectively in presence in the atmosphere. This tale approach includes the utilization of drones to independently screen the air quality at a particular area, distinguish the presence of any of these toxins, and carry out a appropriate decrease alternative at a particular elevation to guarantee these pollutants in the atmosphere are removed. The E-drone has been utilized to measure the contamination convergences of O3, CO, NH3, and PM 2.5. The finish of our test is that E- Drones can be utilized to perform mechanized flying contamination discovery and reduction, albeit further tests should be completed to improve the framework.

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