Air Quality Monitoring using Drone

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***Abstract*—In recent years, the focus on environmental pollution has increased. The need arose to monitor air quality not only in town but also in remote and inaccessible areas. The solution proposed in this article is a low-cost remote monitoring system of dangerous areas based on drones. On the one hand, an operator positions the drone where measurements need to be taken. On the other hand there is a central station that performs the storing of the measurements, processes the data and sends them to the web application. A monitoring system based on LoRa (Long Range), a low-power wireless technology covering long distances, was mounted on the drone. The sensors have been chosen to be reliable while keeping low-cost. The microcontroller used for system management is APM 2.8 flight controller. Communication to the central station is via the MQTT protocol. This system allows the monitoring of air quality showing accurate and real time results on the web application For this, a Wi-Fi module, namely ESP8266 has been used. At a later stage of the project, a GPS module would be attached which would give the coordinates of the place to where the drone is travelling.**

***Keyword*—APM 2.8 Flight controller, node mcu esp8266**

I. Introduction

In recent years, the use of unmanned aerial vehicles (UAVs), commonly known as drones, has been a hot area of research. Drones' flexibility, mobility, and low cost make them suitable for a wide range of uses, even by private persons. Keeping abreast of the most recent scientific articles is critical given the technology's ever-increasing importance. The main focus of this article will be environmental monitoring efforts in order to gain a better understanding of a specific topic. People are becoming more conscious of the difficulties surrounding air pollution: present monitoring systems are unable to meet all of the needs of modern cities, and UAVs are useful tools in this context. This document tries to collect and discuss concerns surrounding the use of drones for environmental monitoring.

II. Objective

The aim of our work is to build a system that will help environmental researchers and other parties interested in the monitoring of air quality. Additionally, it should provide researchers with the necessary tools to visualize and analyse the gathered data via user-friendly interfaces.
The system will gather and transmit real-time air quality data and provide live streaming to the control center.

The objective of this study is to develop a "quadcopter" drone equipped with air quality sensors that will enable it to collect data and transmit the collected data, as well as to provide an easy and user-friendly platform to observe and visualize all the collected measurements.
In this paper, we propose the new mobile smart sensing technology in the form of a drone for real-time air pollution monitoring

The Drone will be controlled by an Apm 2.8 flight controller which will be program flexible according to the user. The flight will be made stable with the accumulation of various sensors like the gyroscope, accelerometer, magnetometer. Additionally, a Air quality Sensor unit would be attached to it which will take data and process it to the mobile application via wifi connection. The Drone would be controlled by radio controller unit.

III. Literature Survey

A. *Air pollution*

Air pollution is very difficult to assess. Since pollution is mostly caused by human activity, it makes more sense to assess it solely in metropolitan areas. The following are six common contaminants that are consistently examined and analysed:

Chemical symbol	***Substance***	***Characteristics***
CO	Carbon Monoxide	Colorless, odorless gas
NO_2	Nitrogen Dioxide	Highly reactive gas
O_3	Ozone	Pale blue gas
SO_2	Sulfur Dioxide	Colorless, irritating smell gas
$PM_{2.5}$ and PM_{10}	Particulate Matter	Inhalable particles
Pb	Lead	Metal particles

Sensor technology has advanced dramatically in recent years. It became available to people through low-cost sensors, not just to public environmental organizations.

B. *Low-cost sensors*

The Environmental Protection Agency is abbreviated as EPA[1] (of United States). The Air Sensor Guidebook[2] provides all of the information that novices (or even professionals) need to know before diving into the complicated realm of air quality and low-cost sensors.

The spatial and temporal resolution of conventional air pollution monitoring techniques is poor. Due to the low spatial resolution, only a few measurement components with limited coverage are deployed. The high cost of the equipment is to responsible. Because of the low temporal resolution, data analysis and distribution are delayed. This is owing to the difficulty and expense of the precision necessary. Traditional air pollution monitoring techniques are best used for background monitoring of the environment. Low-cost sensors can be distributed more widely with excellent spatial and temporal resolution but sacrificing the majority of their accuracy. They can be a useful tool for determining personal air pollution exposure. Their data should be scrutinised because they are strongly influenced by a variety of circumstances, including temperature, humidity, wind, and the presence of other gases in the atmosphere

The data collected by low-cost sensors is usually made public over the internet. Only low-cost sensors can be put on drones due to their light weight; the aforementioned influencing variables, particularly wind generated by the rotors, could bring even more inaccuracy. Recent Developments

The authors of [4] propose a Wireless Sensor Network for monitoring air pollution in three dimensions (us- ing only a single drone). The authors developed two approaches with similar algorithms to meet this problem. Sequential Monitoring Scheme, in which pollution data is collected in a rigid order, and Dynamic Monitoring Scheme, in which data is collected less frequently depending on the stability of a sub-area.

C. *Wireless Sensor Networks (WSN)*

The goal of a Wireless Sensor Network (WSN) is to gather, analyse, store, and publish environmental data. A WSN can be classified into three categories:

SSN (Static Sensor Network); Vehicle Sensor Network (VSN); Community Sensor Network (CSN) (VSN).

These networks could use both traditional and low-cost sensors. Sensor type has nothing to do with network type.

1) *Improving WSNs with drones*

:Wireless Sensor Networks are now confronting several unique challenges: switching behaviour; ease of maintenance; lack of 3-dimensional sampling

Current detecting devices are difficult to programme remotely. Drones can be altered at any time, depending on the situation.

Static, move unexpectedly, or have a priority transit task are the three types of Wireless Sensor Networks now available. Drones could be employed expressly for environmental tasks, and they can be easily shifted to keep sites safe.

D. Drone systems

Given the poor computational power of UAVs, the inaccuracy of GPS, and the general wireless connectivity, coordinating data collection and movements is rather difficult. problems. A survey of communication challenges related to drone networks can be found in ref [5].

The energy constraint has a significant influence on extended trips and is a significant barrier to drone adoption. Drones have outstanding mobility and data collection capabilities, but they cannot always rely on returning to the base to provide their data. To increase efficiency, acceptable communication protocols and algorithms must be implemented. Drone networks aren't necessarily synonymous with swarms: communications could be exchanged with base stations, antennas, any type of UAV (not part of the swarm), and a variety of other devices. Control systems for drones can be centralised or decentralised, but they always use ad hoc networks. This is due to the fact that UAVs are different from traditional network devices, as well as wifi's inherent flaws (such as signal collision).

E. *Drone monitoring and sensing*

Among the most valuable are drone monitoring and sensing capabilities. The target nodes can be reached quickly by taking advantage of their mobility and flying ability. Many agencies are taking advantage of drone monitoring because of its versatility. UAVs can monitor noise, traffic, light, wind, temperature, humidity, air quality, and a variety of other parameters in urban environments, which is the environment chosen for this work. They'll need specific sensors to accomplish this. While some of them may be simple to move (small weight and size, low cost, flexible maintenance schedule), many others (particularly those related to air quality) may not be. The progress of drone monitoring will always be closely linked to the progress of drone networks and swarms. Due to its restricted coverage, energy autonomy, and sensor choices, a single UAV's performance is severely limited. Swarms can cover an entire area while also coordinating the optimum routes to each sensor node. It's significantly easier and more versatile to equip numerous drones with different sensors than it is to have one drone perform everything on its own. Due to their hovering ability, quadcopters are the preferred platform [6][7][8][9] for monitoring and sensing.

The influence of wind caused by rotor movement has proven to be a difficulty for air quality sensors. Researchers in [10] looked into this problem by looking at the physical structure of the quadcopter and determining the ideal sensor placements. Unfortunately, because the geometry of each UAV model is so different, this analysis must be carried out for each one. If the wind is too strong on all sides of the drone, it will be necessary to construct an extension (up to 20cm) that will stick out. The proper balancing is then required.

IV. System Development

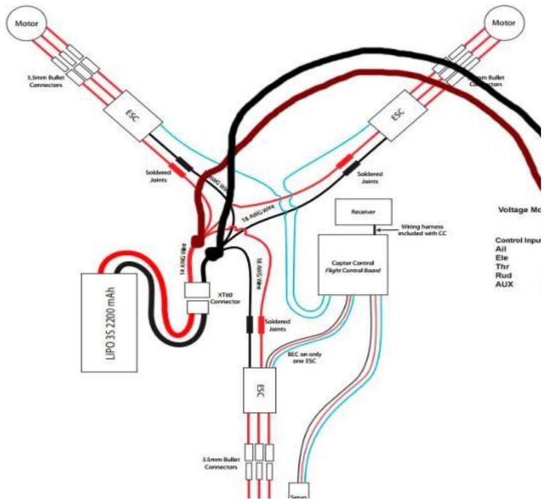

Fig.1 Block diagram

Above figure shows the block diagram of Tricopter Drone control using APM 2.8 Flight controller. .Here, in the block diagram all sensors are interfaced with Esp8266 used as the server client concept to send some data over a Wi-Fi network. Here we have used firebase cloud server to send some data over the network by generating an IP address and the client is being used here to receive those data which is being sent. BLDC make the quadcopter to fly and the calibration is done by the ESC's (Electronic Speed Controller). A pressure, temperature and humidity sensors are attached which gives the readings of a particular place. A magnetometer is also attached to the quadcopter, which indicates the direction in which it is facing. A server-client paradigm is used to send these readings from the quadcopter to the base station. A Wi-Fi module, the ESP8266, was used for this. The quadcopter has a camera mounted on it enabling live transmission of the location where the quadcopter is flying..

A.. Tricopter

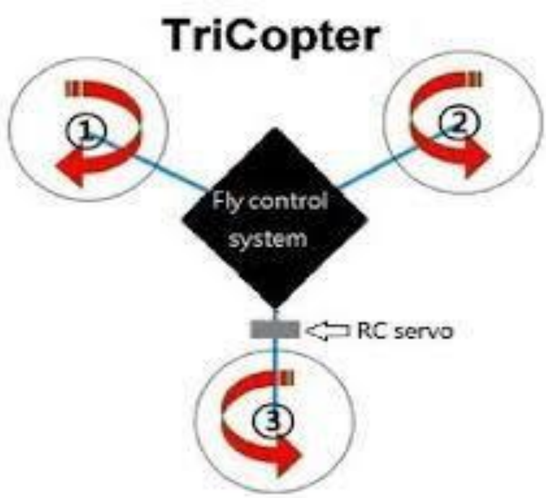

Fig.2 Tricopter

Tricopter works on the principle of high-pressure air lifting phenomena. The propellers force high-pressure air downward, resulting in an uplift force and the application of the action response law to the entire system. [2] When the uplift force exceeds the gravitational force of the earth, the entire system begins to fly. However, there is an issue with propeller spinning. If we rotate the propellers clockwise, a torque will be imparted in one direction to the entire system. Similarly, if we rotate the propellers counter clockwise, a torque is produced throughout the system, and the entire system begins to revolve counter clockwise.

B.. Arduino Mega

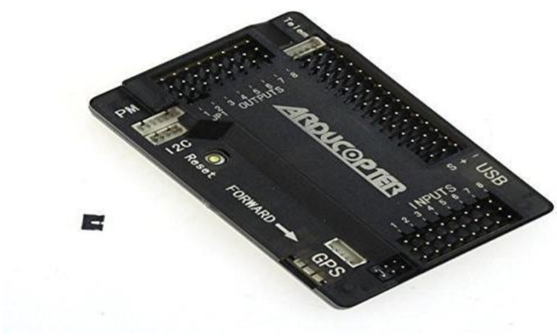

Fig.3 APM 2.8 FLIGHT CONTROLLER

A three-axis gyro, accelerometer, and magnetometer, as well as a high-performance barometer and an integrated 4 MB data flash chip for automatic data logging, are all included in the apm 2.8 flight controller.
The apm flight controller includes full data logging, graphing, and Google Earth mapping facilities for comprehensive post-mission analysis. The data transceivers on the apm 2.8 flight controller enable real-time telemetry and control between your ground station computer and the apm. It also contains a built-in compass and an i2c port for connecting an external compass.

C. Node MCU ESP8266 (Wi-Fi module)

Fig.10 Nodemcu esp8266

Espressif's ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry. With the complete and self-contained Wi-Fi networking capabilities. ESP8266EX can perform either as a standalone application

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or as the slave to a host MCU. WhenESP8266EX hosts the application, it promptly boots up from the flash.[13] The integrated highspeed cache helps to increase the system performance and optimize the system memory.

D. Client-Server Concept

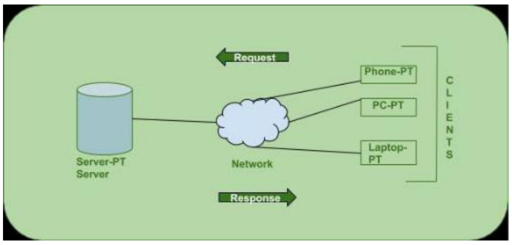

Fig.11 Client-server model

Client: When we talk about a client, we're talking about a person or an organisation who uses a service from a service provider (Servers).

service. Similarly in the digital world a Client is a computer (Host) i.e. capable of receiving information or using a particular service from the service providers (Servers).

Servers: Similarly, when we talk the word Servers, It mean a person or medium that serves something. Similarly in this digital world a Server is a remote computer which provides information (data) or access to particular services.

E. Project Description

Fig.2 Project model

Firstly, we have studied the associated works related to the Air quality monitoring using Drone developments over the last few decades. Then we have compiled the reviews of the individual papers and made a single literature review out of the individual papers. Next, we have bought the individual components of the Tricopter and sensor units. After that we have done the interfacing of individual sensors with the nodemcu, then we have assembled all the sensors together to achieve interfacing with drone and also to calibrate it. Next, we have used the ESP8266 MOD as the server client concept to send some data over a Wi-Fi network. Here we have used server to send some data over the network by generating an IP address and the client is being used here to receive those data which is being sent. For this we have done the interfacing of all the sensors individually with the ESP8266 MOD and later we have combined all the sensors together to achieve interfacing with this Wi-Fi module. Next, we have made all the required connections of nodemcu with different sensors to make the drone fly. A pressure, temperature and humidity sensors are attached which gives the readings of a particular place. Also, there is a magnetometer attached which indicates the direction of the Tricopter to where it is facing. These readings are being sent from the quadcopter to a base station using a server-client concept. For this, a Wi-Fi module, namely ESP8266 has been used. Moreover, we have calibrated the flight controller program on Flight controller microprocessor platform and the controlling of the drone is achieved through transmitter

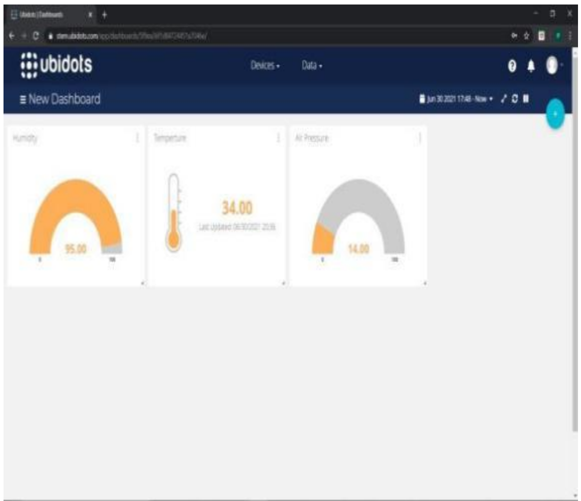

Fig.13 Readings of DHT11 and HX710b sensors

V. Conclusion

An overview of the latest Drone technologies was carried out to evaluate their usefulness as air pollution monitoring systems. Wireless Sensor Network and low-cost sensors were discussed with specific reference to environmental monitoring. Finally, this project was presented by outlining its key features, introducing the future plans, goals and its challenges. This preliminary analysis points toward interesting potential uses of light drones for 3D environmental monitoring

VI. Future Scope

In this project, we have developed a Tricopter using nodemcu esp8266, which give readings in terms of temperature, pressure and humidity and Camera for a live transmission of the location to where the quadcopter is flying. The Tricopter at present is being manually controlled using a remote-controlled transmitter. But in future, an autonomous control can be incorporated using a pre-designed algorithm. Additionally, the coordinates of the remote location can be obtained by attaching a GPS module in the quadcopter. Also, at later stage quadcopter will be used in remote package delivering as well as in search & rescue operations. The quadcopter will be controlled by voice commands of the user or by simple hand gestures.

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