DISA

PROJECT PROPOSAL

OBJECTIVE:

MONITORING AIR POLLUTION USING DRONES: CREATING A LOCAL 3D PROFILE OF AIR POLLUTANTS

Team details:

Deepak Kumar 2017PH10813

Gaurav Agrawal 2017ME20664

⊙ ABSTRACT

It is proven that air pollution changes abruptly even at relatively short distances, both horizontally and vertically. Air pollutants are especially difficult to monitor with conventional means of observation. This might, however, change with the usage of drones or *Unmanned Aerial Vehicles* (**UAVs**).

UAVs offers great potential for collecting air quality data with high spatial and temporal resolutions. Drones equipped with compact sensors can provide data at nearly any point in a three-dimensional axis. This interesting characteristic favour the reduction of sensor nodes used in every smart city or smart environment project, diminishing the total cost of the solution. Additionally, it permits the user to obtain local data for production monitoring, problem detection and local climate control.

A single UAV can cover a large area. They can help in creating a **3D** map of air pollutant concentration in a local area. They can be deployed frequently to record a more accurate state of air quality. The use of more than one UAV could offer simultaneous data at different locations and heights, giving the opportunity to investigate air quality at a bigger scale.

The data collected from these UAVs can then be used for various purposes, the major being informing the community about the quality of the air they breathe.

Through this project, we aim to design and make a *semi-autonomous* **QUADCOPTER** (can collect data from predefined waypoints and return to base without being required to control by a pilot) which will collect data from the air in both horizontal and vertical plane. With the help of this data, we will develop mechanisms to create a user-friendly 3D map of concentration of air pollutants in a local area.

⊙ INTRODUCTION

It is well-known that air pollution is affecting the lives of millions of people every second around the world. Hence it becomes the responsibility of every individual to contribute to reducing air pollution. However, it can't be achieved in a short duration and need efforts in a well-planned manner.

Therefore, monitoring of air pollutants in an area and sharing the analysed result with the community plays a significant role. It helps them not only in preparing themselves from the harmful effects of air pollution but also encourages them to take a step forward in reducing it.

Air pollutants known as particulate matter are a complex mixture of microscopic solids and liquid droplets with some particles—such as dust, dirt, soot or smoke—large enough or dark enough to be seen with the naked eye. Other particulates are so small they can only be detected using an electron microscope.

Before we move to actually investigating the pollutants present in air experimentally, we need to define the pollutants present in the air:

Chemical symbol	Substance	Characteristics
CO	Carbon Monoxide	Colourless, odourless gas
NO2	Nitrogen Dioxide	Highly reactive gas
O3	Ozone	Pale blue gas
SO2	Sulphur Dioxide	Colourless, irritating smell gas
PM2.5 and PM10	Particulate Matter	Inhalable particles
Pb	Lead	Metal Particles

Conventionally ground-based sensors have been used to monitor these pollutants in an area. With the availability of satellites, it has become a lot easier to monitor because a single satellite can cover a lot area.

Both these systems have worked well, but they also have their limitations. Sensors can be used only in limited numbers, and their vertical range is also very less. Also, it creates a lot of problem in collecting data from that much higher number of sensors. On the other hand, satellites can't monitor all type of pollutants, and also their resolution is not good enough.

That's where drones came into the picture. They are easy to use, don't cost much and are highly portable. Drones are specially considered for measuring and monitoring air pollution because of their mobility and convenient flying-movement. UAVs can monitor noise, traffic, light, wind, temperature, humidity, air quality and many other parameters.

⊙ DESIGN

For the project, we will require a lightweight UAV (Quadcopter) which will carry onboard sensors to collect data.
Firstly, we will be designing a frame which should be strong and lightweight with spaces for sensors.
Through ***CAD modelling*** **and** ***Simulation***, we can design a particular frame with required characteristics.

Manually operated drones (human in the loop) are controlled from a transmitter by the pilot. However, it might not work here (since we have to cover areas which might not be in the line of sight of the pilot) and so, we have to shift to autonomous control of the drone (software in the loop).

We will achieve this by mounting a flight controller and uploading a firmware to it which will enable the flight controller to instruct drone to go to pre-specified point locations automatically and perform the required task.
Now each sensor is made for one specific air pollutant. So, the drone will usually have more than one sensors and we need to suitably place the sensors on the frame such that the effect due to rotating propellers is negligible. We will also install an Arduino or a raspberry pi board on the frame for powering sensors and calibrating it.

⊙ WORKING

It is important for the UAV to integrate the data from all onboard sensors and tag the data with geolocation information in real time. Hence, a modular design is highly desired to build a UAV system that can be easily deployed and managed in field uses.

In the modular design, the system comprises five modules: the UAV, the ground station, the sensors, the data acquisition (DA)module, and the data fusion (DF)module. The UAV has a flight controller that directs the UAV to accomplish specific tasks according to a flight plan. The UAV will report its status to the ground station through its communication module. It will enable data from different sensors to be acquired digitally and then integrate it with the UAV's geo-location data, time data, and sensor data.

The UAV's flight controller provides the geo-location data to the data fusion module. The geo-location data often come from a GPS device to which the flight controller is connected. Since the GPS data carry time information, the flight controller provides time data as well. Furthermore, the flight controller can provide us UAV's altitude data, orientation, velocity, acceleration, and many more.

The sensors will record data in time-interval of fraction of seconds which will be calibrated with the GPS location. In this way, we can easily deduce data at a very accurate level and will be able to create a profile in one direction at a time. By combining data from all three directions, we will be able to create a 3D map. Generally, sensors display data in analogue form which we will convert into digital form using convertors.
The data collected can either be stored on drone and then later analysed or it can be simultaneous using the flight controller's wireless communication capabilities.

⊙ APPLICATIONS

- We can vertically and horizontally map pollutants without disturbing the atmosphere too much.
- Unmanned aerial vehicles can be used to take air quality samples in places where it would be hazardous to collect yourself, such as with really toxic chemicals.
- It will also work to address environmental disasters, when local communities and healthcare providers will want to rapidly know what might be in the air, how high contaminant levels are, and what to do to protect people's health. The drone can be deployed when crises are reported on the local air pollution emergency reporting phone line.
- Can be used to find source of contamination in environment when there is sudden increase in air pollution complaints in any area (example; here in Delhi each year during October-November there is a large increase in air pollution. It is found that the reason behind this is the burning of leftover parts of crops. The drone can find the field based on direction of gradient of air pollution.)
- The data collected by the drone can be made available to public so that they can avoid going to places where the level of pollution is dangerous else, they can wear a mask if necessary.
- The data can also be used by urban planners to plan things accordingly like making a residential apartment in an area where there is less polluted environment.
- When used as a swarm the system will be more efficient, collecting more data accurately and simultaneously.