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UAV for Surveillance and Environmental Monitoring

Sajal Sharma*, Ankit Muley, Rajesh Singh, Anita Gehlot

CoES, University of Petroleum and Energy Studies, Dehradun - 248007, Uttarakhand, India;
sajal.sharma1@gmail.com, ankitmuley15@stu.upes.ac.in, rsingh@ddn.upes.ac.in, anita@ddn.upes.ac.in

Abstract

An unmanned aerial vehicle is an aircraft with its crew removed and replaced by a computer system and radio link. This paper describes the use of a multi-rotor unmanned aerial vehicle which includes a system for real time video transfer, temperature sensing and also a smoke detecting unit. The multi-rotor described in this paper is a quad-rotor, which is capable of flying autonomously and transmitting the collected data in real time along with a video feed. The control of multi-rotor is done using graphic user interface, video is received and recorded on a laptop and the data is displayed over another graphic user interface designed on lab-view software. This multi-rotor with the described set of sensory nodes helped in real time monitoring of environment. The use of these unmanned aerial vehicles can be extended to various other fields such as data collection, object delivery, surveillance, research etc.

Keywords: Autonomous, Central Node, Environmental Monitoring, GPS, Multi-Rotor, Real-time Video Surveillance, Sensor Nodes, Safety Inspection, Temperature Sensor, UAV

1. Introduction

This paper discusses various applications of UAV for industrial and civil applications other than recreational purposes. The drone described here is a multi-rotor and to be specific, quad-copter which is equipped with task specific sensor nodes[1]. Sensor nodes used contain temperature sensor and smoke detection sensor, which can be calibrated to detect flammable gases, or carbon dioxide level, or smoke level in the environment its flying in. Detecting such parameters can help in detecting fire and proper actions can be taken before the situation goes out of hand[2]. This quad-rotor also provides the user with a real time video feed which can be helpful in search and rescue operations, to save human lives during any disaster situation or any situation that requires this task[3]. With its autonomous flying capabilities and GPS availability, it provides a flying platform which is easy to use and operate[4]. Application of this drone is extended to wildlife monitoring where use of thermal cameras can help in monitoring wildlife activities during night and help in avoiding wildlife poaching[5]. The high definition camera feed to the central node data collection center helps in analyzing the data obtained and determining any structural failure that requires change or repair[6]. Graphic user interface provide a friendly flying capability to the drone which can be used on a computer platform or on a hand held device. The sensor node data is also represented in G.U.I. format, eliminating all the tedious raw data conversion and analysis[7].

2. Quadcopters for Surveillance and Environmental Monitoring

Choosing UAV platform for the task in hand is as important as actually performing the task. Different UAV platforms have their own pros and cons which when understood and used properly can give us a perfect application based embedded product. A quad-copter platform (Figure 1 part 3)

*Author for correspondence

has been developed in order to perform surveillance, environment monitoring, smoke detection in case of fire and for safety inspection. In order to make the task of the user easy, GUI (see Figure 2 part a and part b) based drone control along with a central node data transfer feature has been incorporated in the flying platform.

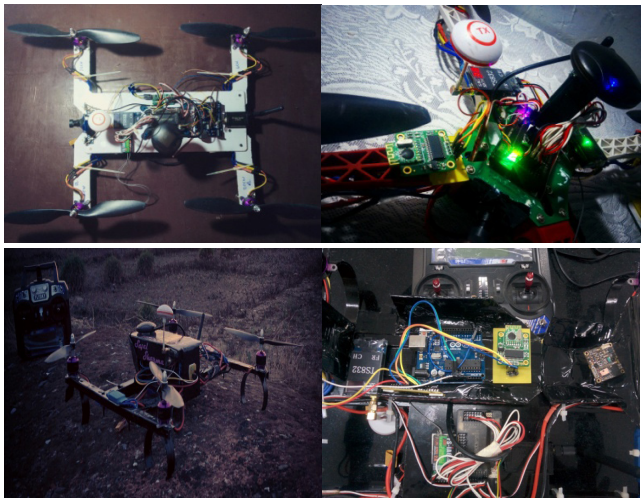

Figure 1. Designed UAV.

2.1 II-A. Quadcopter (General Components)

Quad-copter has a few main components to achieve flight, which are:

- Flight controller: It is an open source arduino board with magnetometer, accelerometer and barometer to provide itself with the necessary feedback values to sustain flight.
- Brushless direct current motors: These are three phase motors, that is, they require a three phase controlled power supply, which can vary the speed of each of the motor to keep the platform air borne.
- Electronic speed controller: This component is a current amplification circuit, which takes in power from a power source and provides it to the motors on the basis of signal received from the flight controller.
- Radio Transceiver: A radio transceiver module is a control module used by the user in order to manually control the quad-copter. This emits radio frequency PWM signals, which are then converted into input signals for electronic speed controllers.
- Lithium Polymer Batteries: LiPo batteries provide great energy density as compared to other battery power sources and have a high discharge rate, making them ideal to use in multi-rotor applications.

2.2 II-B. Payload Components

- Camera: A 2 mega pixel, 480 tvl camera is placed on board to be used as a real time video transfer module. This provides a live feed from the flight, making surveillance, safety inspections and other video based operations possible.
- Video telemetry: A video telemetry module transmits audio video data from UAV to the central data collection center. This can help in flying the drone manually even out of line of sight.
- Global positioning system: The use of GPS along with the flight controller makes this quad-copter an autonomous flying drone. It provides with the current location and heading of the drone and also helps in performing various tasks based on the location[8].
- Data telemetry R.F. module: All the flight data along with the data collected from onboard sensors is transmitted to the central data collection centre using R.F. transceiver for system monitoring.
- Sensors: The drone described contains temperature and smoke sensor, whose data is constantly monitored and transmitted using an open source microcontroller platform by arduino.

2.3 II-C. Results

- Graphic User Interface: Since the drone can fly in autonomous mode, there is an open source G.U.I. available to use this feature that works on both computers and hand-held devices. Using these G.U.I. GPS coordinates can be fed to the micro-controller giving drone a flight path and by adding specific tasks at particular coordinate, flight plan is created[9] (see Figure 2).

Figure 2. Graphic User Interface (Hand-held device (left), Laptop (right)).

- Central data collection node: All the data sent over by the sensors during flight is received and accumulated using a central node, which comprises of an arduino board with a transceiver module. Shown below is proteus simulation (see Figure 3) of the sensor node which also acts as a data transmitter and another node that acts as a receiver and analyzer (Figure 4).

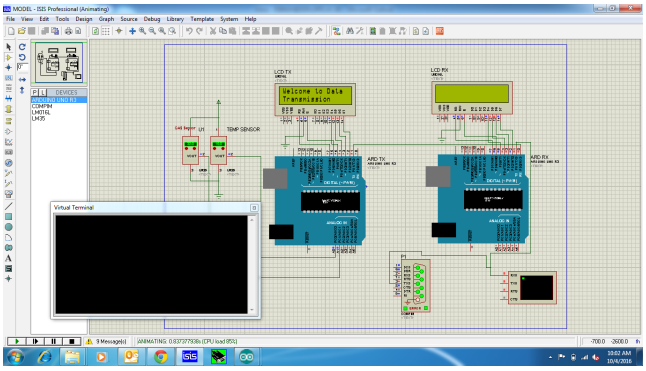

Figure 3. Proteus simulation for sensor node and transceiver module.

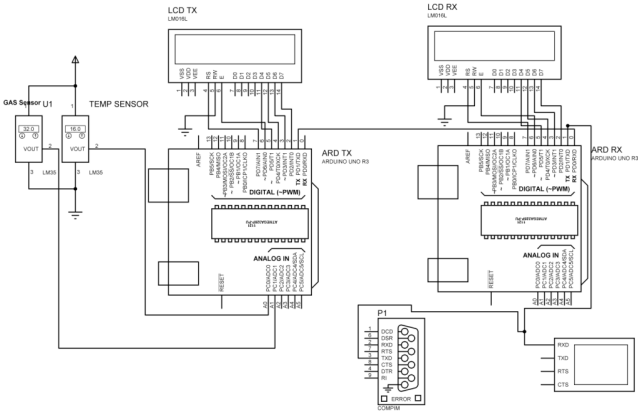

Figure 4. Circuit diagram for sensor node and transceiver module.

The sensor circuit in the figure is packaged and place on the drone itself, so that it can transmit the data it collected during its flight time.

- Video receiver: The video receiver used helps in viewing the real time flight video on a computer (Figure 5.) or LCD screen or even as a first person view using first person view glasses.

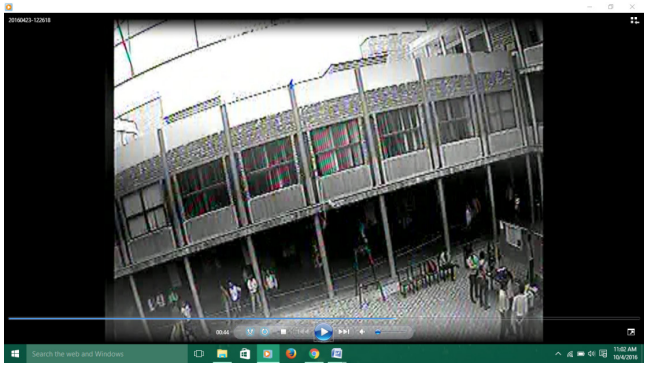

Figure 5. Screenshot of real-time video being transmitted from drone.

- Lab-view data logger: This is the graphic user interface for the central node (Figure 6.) that collects all the data. This application shows intensity of gas and the current temperature as being measured and transmitted to the receiver module. A comparison chart of temperature and smoke values with time is also prepared.

Figure 6. Lab-view data logger (graphic user interface).

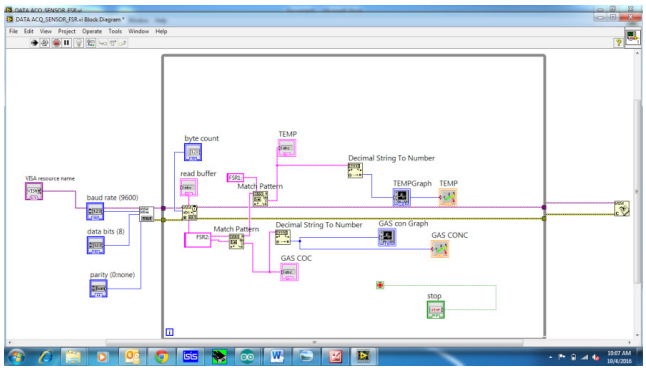

Figure 7. Lab-view, block diagram for graphic user interface.

3. Applications

Use of a flying platform is not limited to any specific field, but can be used for various purposes by incorporating the appropriate sensor nodes on it. Fields for using this quad-copter are:

- Surveillance: Having a person present and vigilant all the time for safeguarding or inspecting an area is not feasible because of the human body limitations, but can be easily done by a machine in a much faster and efficient manner. By adding a high definition camera capable of transmitting its audio-video feed in real time can solve this problem. A flying platform capable of high altitude flight can cover a large area in a comparatively small amount of time and provide an efficient and secure way of surveillance[10,13].
- Safety inspection: Monitoring water damns[11], transmission towers, boilers, radio transceiver towers, etc. can be a tedious task and not every part is easily accessible. This can also be done by analyzing feed from a high definition camera and checking for all the parts that are faulty and need replacement or repair. This reduces the amount of time required for the same process if done by humans.
- Environmental parameter monitoring: Sensor node package installed on the drone helps in capturing temperature and smoke data from the environment in which our drone is flying. To do so we can plan a flight around a particular area whose parameters are required[12].
- Search and rescue operations: Having a bird's eye view for search and rescue operations can save valuable time and even in some cases lives of the ones who are stranded. Searching for person lost or stuck in harsh terrains can be a tedious and time consuming task, which can be simplified by using aerial images of the desired area. Assessment of disaster struck areas for search and rescue is also a valuable feature from this drone.

4. Conclusion

All the features and uses discussed above proves the ability of UAV in providing efficient and cost effective solutions for many problems that require human labor and can also be dangerous. This flying platform with various task specific sensor nodes gives safety to human operator, a wider field of view, long range and less tiring alternative for hard work. Power consumption of the sensor nodes is very low and hence the effect on the flight time of the drone is minimal and all the factors such as endurance, video telemetry range, data telemetry range, payload capacity, etc can be modified by choosing an appropriate platform among fixed wing and many multi-rotor drones.

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