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Autonomous Quadcopter for Surveillance and Monitoring

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Abstract— **The quadcopter system is an extremely maneuverable and versatile platform for many applications especially surveillance and aerial photography which can be used to monitor and survey important areas as well as areas which are normally very difficult to access or dangerous locations. The main objective of this paper is to create an autonomous quadcopter for surveillance through camera and to search and retrieve the information about surrounding environment. This drone can be used for agriculture, military applications, disaster relief. The autonomous quadcopter we have designed is capable of self-controlled flight. Our design utilizes an Arducopter Version 2.8 flight controller having an in-built microcontroller. It is interfaced with GPS and Inertial measyrement sensor unit. The quadcopter flight path is generated with the help of mission planner software. During flight, the video obtained from the mobile camera is viewed using the Alfred Home Security Surveillance app. The designed quadcopter can fly autonomously to cover the predefined path and send the video signals which can be viewed with the app.**

Index Terms—**GPS, Arducopter, Mission Planner, Camera interfacing, Surveillance and monitoring.**

I. INTRODUCTION

Surveillance is the monitoring of behaviour, activities, or other changing information for the purpose of influencing, managing, directing, or protecting people. This can include observation from a distance by means of electronic equipment. It can also include simple relatively low-technology methods such as human intelligence agents. Surveillance cameras are video cameras used for the purpose of observing an area. They are often connected to a recording device or IP network, and may be watched by a security guard or law enforcement officer. With cheaper production techniques, surveillance cameras are simple and inexpensive enough to be used in security and monitoring systems. Aerial surveillance is the gathering of surveillance, usually visual imagery or video, from an airborne vehicle such as an unmanned aerial vehicle, helicopter, or spy plane. The surveillance aircraft must be robust [5], [6], and able to fly avoiding obstacles.

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In our project, to make the Quadcopter autonomous, we used Arducopter platform to program and utilized mission planner software to generate the flight plan of the quadcopter by using input values from GPS and sensors. An Inertial Measurement Unit (IMU) sensor which provides values regarding angles and angular velocities of quad copter frame is utilized to obtain flight characteristics. The components are assembled together and rigorous testing is done under different environment conditions to tune the flight controller for successful flight.

II. LITERATURE STUDY

Sandeeep Khajure, Vaibhav Surwade, Vivek Badak, [1], proposed a design process by using metal rod for the quadcopter frame and in that design there is a possibility of increased vibration. Due to the vibration the quadcopter often gets imbalanced, hence we have designed our quadcopter by using the thick plastic material. It may reduce the weight and as well as vibration in the body of the copter. The quadcopter used the open source software in the work done by Nuryono Nuryono S. Widodo et al. [3] to reduce cost. They have discussed using open source software for 3D modelling of ground surface. In the work done by Sravan Kumar N et al. [2], a manually controlled quadcopter using the RC transmitter and receiver is discussed. In this design, the quadcopter is to be controlled manually and the flight controller parameters are obtained in trial and error method.

According to the work by Moulesh Kumar et al. [4], for the navigating process they used Raspberry Pi 2. But Raspberry Pi board is not designed for real-time quadcopter control. Hence it is found to be more difficulty to navigate with this design. Anurag Singh Rajpoot et al. [7] designed quadcopter with arduino UNO board as the controller. But arduino board is not suitable for real time control of quadcopter. Hence the quadcopter requires tuned PID parameters. Also the flight characteristics of quadcopter is not good. In the work of Wael R. Abdulmajeed et al. [8] they used apm 2.6 controller which leads the quadcopter using onboard sensors. But it is not having the inbuilt compass required for navigation. Also it is designed as a manually controlled quadcopter. Here we have used arducopter APM 2.8 quadcopter, the latest version of APM series which has many sensors onboard. We also designed as an autonomous quadcopter.

III. Component Specification

A. Hardware

The components which are used in our system are described in detail with their working and operation as follows

A. Brushless Motor**:**

Brushless Motors are a bit similar to normal DC motors in the way that coils and magnets are used to drive the shaft. These motors do not have a brush on the shaft which takes care of switching the power direction in the coils, and so it is called as brushless motors. Instead, the brushless motors have three coils on the inner of the motor, which is fixed to the mounting. For a small scale quadcopter, the DC Brushless motor we have used is of 1000 KV rating. It can operate at 7.4-14.8 volts.

B. ESC:

The brushless motors are multi-phased, normally 3 phases, so direct supply of DC power will not turn the motors on. That is where the Electronic Speed Controllers(ESC) comes into play. The ESC generating three high frequency signals with different but controllable phases continually to keep the motor turning. The ESC is also able to source a lot of current as the motors can draw a lot of power.

C. Propellers**:**

On each of the brushless motors, there is mounted a propeller. The 4 propellers are actually not identical in rotation. The motor torque and the law of physics will make the Quadcopter spin around itself if all the propellers were rotating the same way, without any chance of stabilizing it. The larger diameter and pitch the more thrust the propeller can generate. It also requires more power to drive it, but it will be able to lift more weight.

D. Camera Connection**:**

The implementation of Surveillance is done by mobile camera. This camera has a pixel of 16mp.An app is interfaced with the pc and the mobile camera to retrieve the video.

E. Battery**:**

The power source for the whole device is the battery. The recommended battery is LiPo (Lithium Polymer) battery because of it is light weighted nature.

F. GPS**:**

To navigate the position of the quadcopter. It is also used to fly the quadcopter as autonomous. By using GPS only we can create the waypoint (predefined path) to fly the quadcopter autonomously.it contains a 2meter range of accuracy at all 360 degrees.

G. Ardupilot**:**

This ardupilot is used to control the flight movement. Flight movement is controlled by using the mission planner software. It also includes the accelerometer, gyro meter. microcontroller acts as the brain of the quad-copter, it's responsible for all actions a quad can perform from take-off and landing to autonomous flight as well as camera and sensors control.

H. Power Module**:**

The power module is used to supply the voltage from battery to APM (flight controller board) and motors through ESC. Without this module we cannot operate the Ardupilot

B. Software

The main purpose of using the software is to make the quadcopter as autonomous.

A. Mission planner software**:**

Mission planner is the software which plays a vital role in the operation of the quadcopter this software is mainly used to create waypoints which will direct the quadcopter through predefined path. Interfacing the RC transmitter and receiver we can able to control the quadcopter manually. But with the help of GPS and utilizing mission planner software, we make the quadcopter as autonomous one.

B. Features of mission planner**:**

In the mission planner software, the following operations can be done.

1. With current point and click way point entry using google maps, autopilot can be controlled.
2. It has full ground station support for monitoring missions and sending in flight commands.
3. It checks the sensor output and test the autopilot performance.
4. It can download mission log files and analyze them.
5. APM setting can be configured depending on the kind of frame configuration that is being used.
6. It has user friendly interface with loads of useful functions.
7. It loads firmware onto APM, configures in different ways to use the APM chip from different aerial and ground vehicles.

IV. Working

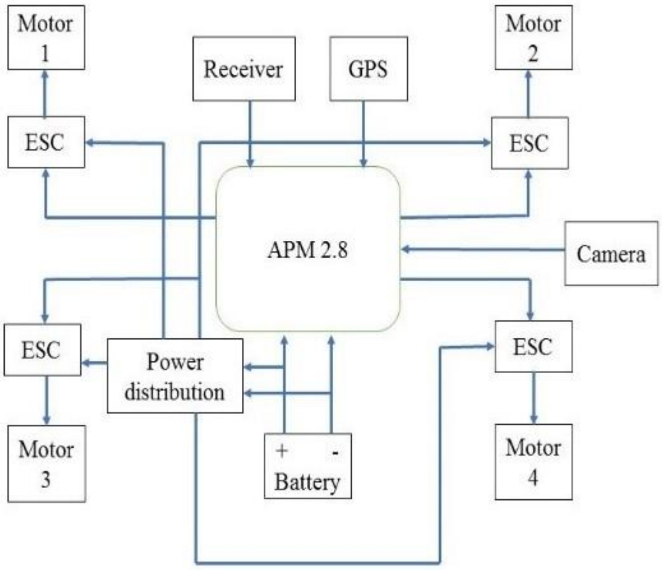
Fig. 1 represents the block diagram showing the working of our project. The working of our project starts with the transmitter-receiver section. The first step is to turn on the APM 2.8 by Arm and Disarm in the controller. If Arm option is selected, then the Quadcopter is ready to work by turning on the APM 2.8, and if Disarm is selected, then the whole circuit goes off. The same transmitter-receiver module can be to control the quadcopter manually.

Once this gets over, the GPS retrieves the current location of the quadcopter, and by using the 'Mission Planner' software the predefined path is set by using way points. Then the APM 2.8 subtracts the location of current point (taken from the GPS) from the waypoint which is given by the

Mission Planner software.

After this step is done, according to the result, the quadcopter is made to move in desired direction with the help of Electronic Speed Control (ESC). The ESC is an interfacing device to control the speed of the motor by the inputs given by the controller. Based on the output of the subtracted position, the APM 2.8 module sends signals to all the 4 ESCs to move the quadcopter in particular direction.

Fig.1 Block Diagram



Due to this, every motor has to carry ¼ of the weight of Quadcopter as opposed to Helicopter where the single motor carries the whole weight. Hence building a quadcopter with live control as well as autopilot capabilities that is versatile enough requires to tackle several problems. Then fitting the quad with a mobile camera that can be controlled from the ground station is done. We have used the motor as brushless motor, because they can achieve high torque. The aircraft must have an adequate payload capability as well as stabilization and localization capability. Alongside with the aircraft, there is a need for a camera that able to performs the image acquisition process at the right place and time.

The movement of the quadcopter is controlled via 4 motors. Suppose if the quadcopter wants to move forward then the motor on the backward should rotate in a higher RPM than the front motors. This way the movement of the quadcopter is controlled. The surveillance process takes place with the help of mobile, which is placed in the quadcopter itself. Then a Personal Computer at the ground station is connected with the mobile in the quadcopter wirelessly. With the help of "Alfred home security app", the video can be viewed from the ground station PC itself

V. Implementation

Our system is composed of an APM 2.8 board that is used as the controller for the quad, it senses data from the onboard gyros, altimeter, accelerometer, etc and makes the calculations necessary to change the outputs going into the ESCs, effectively controlling the speed of the motors to keep the quad stabilized. The system is powered by a 3-cell Li-Po battery which is connected to a power distribution cable that is used to feed power to the ESCs and also route 5V of power to the APM's power module with a 6 position cable. The 5V routed to APM are sufficient to run it along with all the on board sensors as well as the external GPS/compass module. Each ESC is connected to one of the motors through 3 bullet connectors, they act as a 3 phase power source for the motors and control the speed, direction of rotation and also can act as a dynamic brake for the motors.

The inputs of those ESCs are connected to the output pins on the APM 2.8 board, to pins 1, 2, 3 and 4, the purpose is to control the speed of each motor, so we can effectively perform all 4 possible quad movements which are roll, yaw, pitch and accelerate along the common orientation. The external Ublox NEO-7 GPS module is connected to the APM board using old style GPS connection as well as a connection to feed it power from the APM. Mission planner software serves as the ground station for our system, it is also used for first time setup of the APM board, to load firmware and also used for our system's configuration.

Mission planner is the ground station software in charge of autopilot, where we can set way points for our quad to carry out its mission. Mission Planner allows the usage of regular pc gaming joysticks as input which is what we plan to use for our system dynamic control. The RF transceiver connected to the APM itself should be connected to the 3dr telemetry port on the APM Reference. The video captured using the mobile camera attached with the quadcopter. The streaming video is viewed using Alfred Home security application in the computer.

VI. Results and Discussion

The GPS module first retrieves the current location of the quadcopter in the google map using mission planner software. The output of the GPS module is shown in below Fig.2.

Fig.2 GPS Location in mission planner

Fig.3 Waypoint Creation in mission planner

Then the way point is plotted and the path is created using APM 2.8 in the same google map itself. This is shown in Fig.3. The map gets changed once the quadcopter is in motion, and the new waypoint is taken into account and the path is calculated. Mobile camera is used for surveillance purpose. The Alfred Home Security app that is installed in the mobile and the laptop is configured in such a way that it can be controlled at any distance.

Fig.4 Surveillance Output in Camera

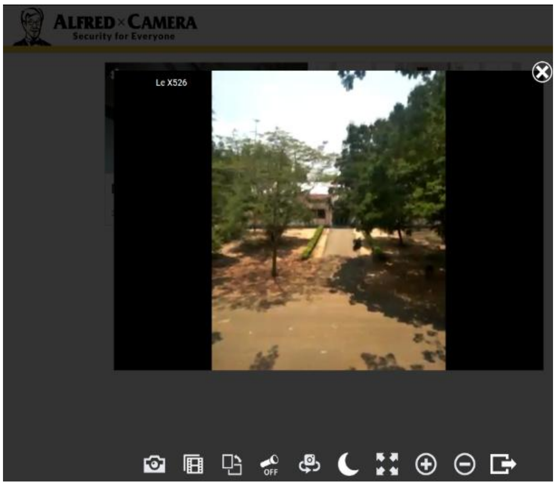


Fig.5 Surveillance Output in PC

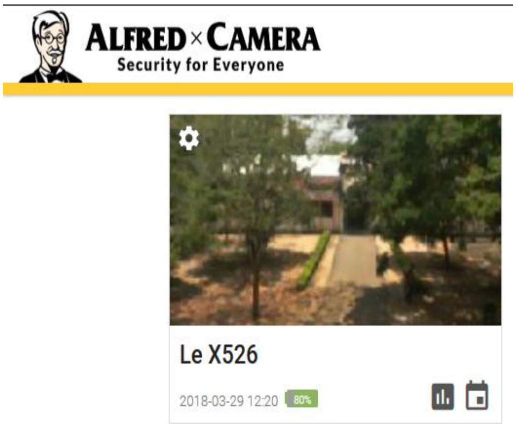


Fig.6 Surveillance Output

Fig.7 Quadcopter using APM 2.8 board

Fig.8 Quadcopter during test flight

Gmail sign-in is updated for authentication purpose in the Alfred application. The phone camera is used to capture the real time video and transfer it to the computer. Fig.4 shows the surveillance output in camera view, Fig.5 and Fig. 6 shows the personal computer view in the surveillance output. The complete setup of the quadcopter with all the components connected together can be viewed in Fig.7. The quadcopter is then test run and checked for the operation. The test flight of the quadcopter is shown in Fig.8. The quadcopter has completed its test flight successfully and the camera output is successfully viewed in the computer.

VII. Conclusion

As per the design specifications, we assembled and tested the autonomous quadcopter for surveillance and monitoring. By connecting GPS, we created the waypoints to fly the quadcopter autonomously. By using this quadcopter, we can save the people in disaster reliefs. The camera connection has been done by using Alfred Home Security Surveillance App. Thus, surveillance functionality is monitored under human supervision, henceforth being beneficial towards military applications. It can also be utilized for aerial photography of any geographic region. It is easy to maneuver, thereby providing flexibility in its movement. It can be used to provide surveillance at night through the usage of infrared cameras. The system can further be enhanced for future prospects. The GPS data logger on the quadcopter stores its current latitude, longitude, and altitude in a comma separated value file format and can be used for mapping purposes. Thus the project helped in surveillance and monitoring of different locations and terrains.

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