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Autonomous Unmanned Aerial Vehicle

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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 retrieving the information about surrounding environment by flight path. 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 Pixhawk PX4 flight controller having an in-built microcontroller. It is interfaced with GPS and Inertial measurement sensor unit. The quadcopter flight path is generated with the help of mission planner software. The designed quadcopter can fly autonomously to cover the predefined path.

Keywords— GPS, Pixhawk PX4, Mission Planner, monitoring.

I. INTRODUCTION

Unmanned Aerial Vehicles (UAV), also known as drones, are becoming popular more and more. They provide humans with different applications. The UAV could be driven remotely, or be programmed using mission planner. These UAV or drones vary through the hardware configuration in the platform: Multi-Rotor, Fixed-Wing, Single-Rotor, and Fixed-Wing Hybrid. Quadcopter drone contains multiple motor which drives the platform, an advantage would be high-precision flight, quick throttle changes, and heavy-weight lifting capability as compared with other types of drones. In our project, to make the Quadcopter autonomous, we used Mission planner platform to program and utilized mission planner software to generate the flight plan of the quadcopter by using input values from GPS sensor. The components are assembled together and rigorous testing is done under different environment conditions to tune the flight controller for successful flight. An experimental drone capable of autonomous flight was developed by equipping the flight control and GPS sensor in the Drone. The GPS was calibrated by measuring the deviation between a position where the GPS sensor was set and the ones measured by the GPS. An experiment on autonomous flight control was performed, and the autonomous flight control of drone was evaluated by comparing planned flight routes of straight and L-shaped lines and routes where the drone actually flew. Consequently, the experimental drone could fly autonomously along the planned flight routes.

II. PROPOSED SYSYTEM

The Global Positioning System (GPS) is the core technology for unmanned aerial vehicle (UAV) localization. UAVs can be mounted and fly autonomously based on GPS without any pilot and can be utilized for observation and surveillance. UAVs are utilized for places such as high-rise facilities that are not easily accessible by people. Some studies have focused on identifying and keeping track of intruders with UAVs. In order for UAVs to autonomously monitor multiple points, flight paths need to be planned and generated. One approach is to plan flight paths based on points specified by pilots manually. Optimal UAV flight paths are planned by 3D simulations. Pilots can intuitively specify a small number of flight paths by using their own control without understanding any logic for generating multiple flight paths. Then, enhance flight paths are generated by collecting, utilizing, and analyzing the predefined flight paths. Such approaches are difficult to apply to generating complex paths because of the multiple paths, the cost of constructing 3D simulations, and pilot errors; thus, novel approaches are required.

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. 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.

E. 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.

F. 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 and sensors control.

G. 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

H. Pixhawk:

This flight controller is based on the rapidly evolving and refined Ardupilot mega or "APM", an open-source project from 3DR robotics. This amazing flight controller allows the user to turn any fixed-wing, rotary-wing, or multirotor vehicle (even boats and cars) into a fully autonomous vehicle; capable of performing a wide range of tasks even programmed GPS missions with waypoints with the optional GPS Module. It is a full autopilot capable of autonomous stabilization, way-point based navigation and support for two way telemetry with radio telemetry modules. It Supports 8 RC channels with 4 serial ports.

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 theoperation 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.

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

IV. WORKING

Pixhawk PX4 flight controller was one of the first and foremost decisions that was made when building this testbed. The Pixhawk also has a solid architecture for connecting with any of the other hardware components that were required; radio controller, GPS, etc. The Pixhawk turned out to be a perfect fit for the testbed in understanding how the system works. The flight controller is the medium between the UAV flying and inputs from the user's handheld transmitter. In the case of autonomous flight the flight controller communicates with a ground station (running on a laptop) and for this research Mission Planner was chosen. Another very similar program that could have been used is QGroundControl.

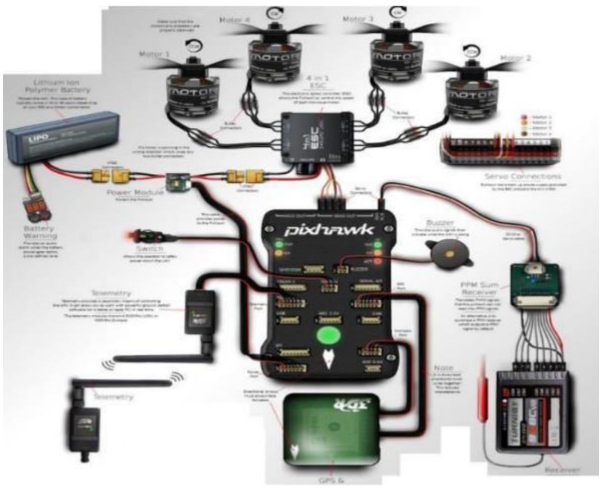

Fig 1. Design of our Proposed System

The PX4 already includes controllers in its flight stack for multirotor airframes.The flight stack itself is a collection of guidance, navigation, and control algorithms and estimators for attitude and positon for the autonomous flight being tested. Below is an example of the implementation of these blocks. Another great aspect of the PX4 is the fact that it already has simulation software for running the autopilot. This came in handy at many times when testing different applications without having to actually fly the UAV's. Fig. 1 represents the block diagram showing the working of our project. The working of our project starts with the transmitter and receiver section. The first step is to turn on the PX4 by Arm and Disarm in the controller. If Arm option is selected, then the Quadcopter is ready to work by turning on the PX4, 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 PX4 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 PX4 module sends signals to all the 4 ESCs to move the quadcopter in particular direction. 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.

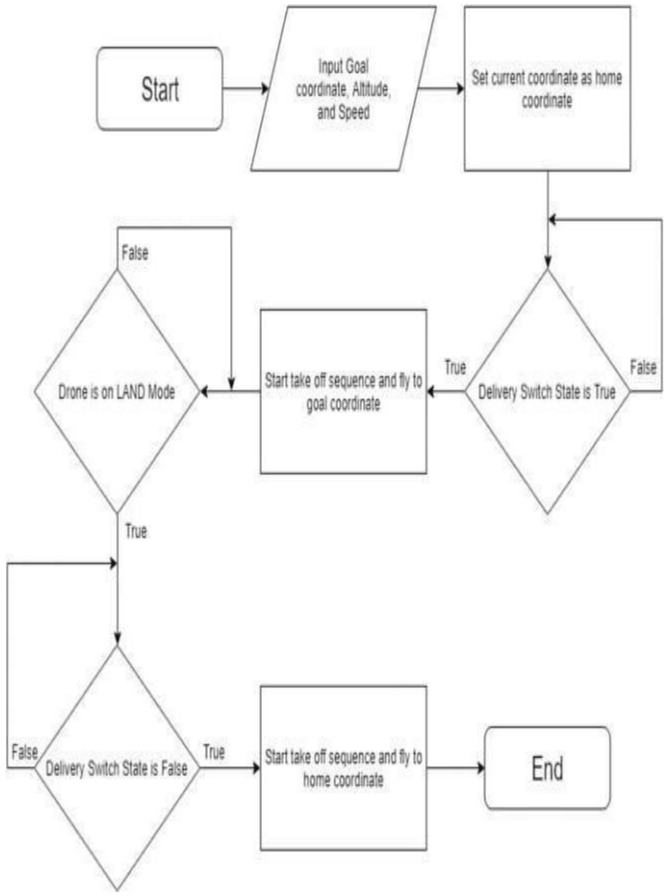

Fig 2.Ground Station to UAV Block Structure

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. 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.

IV. IMPLEMENTATION

Our system is composed of an PX4 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,

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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 PX4power module with a 6 position cable. The 5V routed to PX4 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 PX4board, 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 GPS module is connected to the PX4 board using old style GPS connection as well as a connection to feed it power from the PX4. Mission planner software serves as the ground station for our system, it is also used for first time setup of the PX4 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 PX4 itself should be connected to the 3dr telemetry port on the PX4 Reference. The streaming video is viewed using Alfred Home security application in the computer.

V. 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 Fig 3. Then the way point is plotted and the path is created using PX4 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.

Fig.3 Waypoint Creation in mission planner

Fig.4 Quadcopter using PX4 board

The complete setup of the quadcopter with all the components connected together can be moved accordingly towards the feed.

Fig.5 Quadcopter during test flight

VI. CONCLUSION

The Autonomous Unmanned Aerial vehicle is a great improvement over the manual system using case fields and paper. The computerization of the system has sped up the process. In the current system, it is used by various officials. The Micro Aerial Vehicle collects images and data and thus is found to be very reliable. Advantages of them are, It is efficient and reliable, Can explore places and terrain that were not previously explorable, Best for indoor use, Number of personnel required is considerably less, Relatively small to move through compact places. Future Enhancements of the proposed system is Autonomous Unmanned Micro Aerial Vehicle. Future work will consider the development of fully automated architecture, in which the MD computes coordinate and creates subareas. Providing such features enable the users to include more features into the system.

VIII. ACKNOWLEDGEMENT

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