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Multicopters as IoT

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Abstract: Multicopters have been increasingly popular now a days, and its compact size and portability allows it to use for various applications. The autonomous multicopters capable of self-sustained flights on a fixed GPS guided route. The prime objective of this project is to treat it as an IoT (Internet of Things), where the quadcopter will be always connected to the Internet, and will be collecting and sharing data during flight. It can fly autonomously, or one can take control of it from anywhere in the world. It can also have inter-copter communication to work as a single unit and response to each other's status. All this can be achieved by adding very less budged over the price of an autonomous multicopter.

Keywords**:** *Quadcopter, Multicopter, Autonomous, Drones, UAV (Unmanned Aerial Vehicle), Autonomous Multicopter, Self-guided drone*

I. INTRODUCTION

Multicopters has founds its use in many applications, starting from security, package delivery, emergency response to surveillance. With the help of GPS and other navigation tools, autonomous flight can also be achieved. However, their usage are severely limited by the short battery life. Increasing the flight time can be achieved by either decreasing the weight, or increasing the capacity. Instead we propose a method, where multiple multi-copters act as a single unit, with constant communication between them to achieve uninterrupted flight mission.

II. LITERATURE REVIEW

This project is a combination of some existing individual system, and pushing the applications of multicopters in various fields, providing alternative solutions for some major limitations such as battery life, short range, and human interactions.

III. EXISTING SYSTEM

Existing quadcopter are either manually controlled, or autonomous which are guided by GPS on a fixed path. The major disadvantage of multicopters is the extremely short battery life, which is 10-15 minutes. The limited battery life is the main reason that currently make widespread development unfeasible, and cannot be used for long range. All present systems requires full or some human interaction, and is therefore not fully autonomous. Each individual multicopter is treated as solo, and has no communications among them.

IV. PROPOSED SYSTEM

Autonomous multicopters can fly on specific GPS guided path. But due to limitations of environment awareness, data transmission restrictions, limited battery range and lack of inter multicopters communications, the applications are limited. Multicopter's core controllers are already programmed to hover and balance in its position without any external adjustments. Another external layer with the help of GPS, barometer and ultrasonic sensor can be used over the existing controller to make it fly autonomously between GPS set points.

In our project we use another controller layer over this, where it uses a communication chip such as Wi-Fi module, or a GSM-network module which will allow connectivity with the internet. This will allow the quadcopter to communicate with the internet, and also communicate among multiple multicopters.

V. ARCHITECTURE

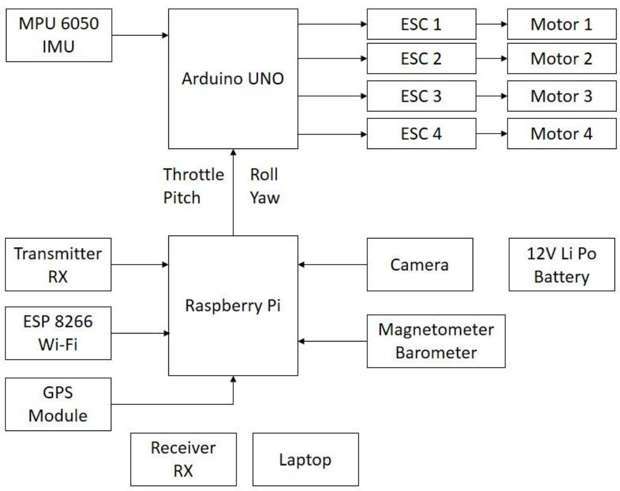

Figure 1: Component Diagram

VI. CORE BALANCING CONTROLLER

The Arduino Uno runs the main controller for balancing. It mainly takes input from the IMU and the high level controller. It continuously runs in a loop and does adjustments to individual motor to maintain a stable flight.

First it reads accelerometer and gyroscope values from the IMU. The accelerometer is accurate for a long term, but for short terms it is very noisy. On the other hand Gyroscope is free from noise, however it has a tendency to drift from the original value overtime. Therefore Kalman Filtering algorithm is used to fuse these two values, and estimate the actual orientation of the multicopter.

Once the current position and set points are calculated, a PID(proportional–integral–derivative controller) algorithm is used to calculate the individual motor values. Individual PID parameters are set to achieve a stable flight. This loop runs continuously at 300 Hz.

VII. AUTONOMOUS FLIGHT MODE

While the core balancing algorithm is taken care of the Arduino Uno, supported by the IMU MPU6050, the Raspberry Pi is responsible for the autonomous flight controller. It takes in input from the GPS, Wi-Fi module, Magnetometer and Barometer tocalculate the flight path based on the previously determined flight path using way-points.

A few separate program runs together to achieve this functionality.

Navigation: Depending upon current position coordinates, and the next way point, the route, heading, speed is calculated and the Arduino is instructed to head towards that direction.

Manual Communication: Manual control can be taken through a RC Transmitter or via Server, and passes this control inputs to the controller.

Obstacle: Ultrasonic sensors continuously monitors the distance from obstacles on all 6 sides, and warns the controller if the multicopter comes dangerously close to any object.

Server Communication: Regular data is uploaded and downloaded from the server, and takes in command which instructs the controller for any change.

Inter-Copter Communication: This communicates with other multicopters and sends and receives event information's.

Image Processing: The image captured by the camera is processes for navigation purpose or on-board processing

VIII. DOCKING SYSTEM

Docking System consists of detecting and tracing special shapes which are pre-defined for landing and charging. There are many pre-existing algorithms for image processing that are suitable for this task. We used Edge Detection algorithm to identify these shapes and guide the quadcopter while it lands.

The Docking System first extracts the GPS location of the charging stations, and navigates it to that location. Once reached it hovers about 10 meter high, from where it tries to identify the docking station. The camera takes images at regular intervals, which is then processed. Based on that, the controller is instructed to make minute adjustments as the multicopter descends. Once landed it goes to a sleep mode, while the quadcopter is charged. Once charged, it continues with the flight instructions.

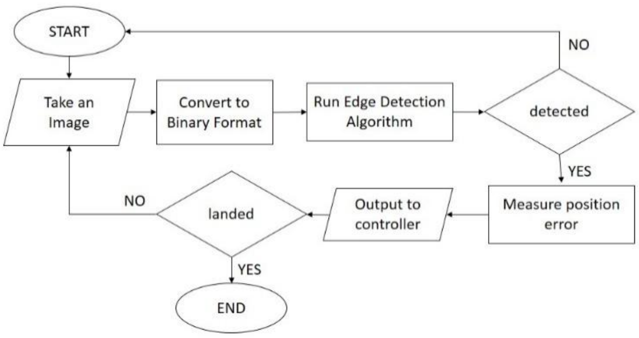

Figure 2: Logic Diagram of Autonomous Docking System

IX. INTER MULTICOPTER COMMUNICATION

Each quadcopter is equipped with a Wi-Fi module or a GSM module. Using this module they can send event instruction to each other through a common server or direct communication. For example, when I quadcopter on a mission is about to run out of battery, it can broadcast it coordinates to other drones, as "Help Me". The closest multi-copter who can take his place will accept the request, and reach the location. Then the previous one can hand over his mission details to the new drone, and go back to charging station. This facilitates un-interrupted functionality of the multi-copter.

X. COMPONENTS

Brushless Motor: These motors are similar to normal motors, without the brush on the shaft. Instead it has three coils inside, and a number of magnets forming the coil which is attached to the rotating shaft.

ESC: Electronic Speed Controller. Unlike normal motors, brushless motor has 3 phases thus it require special controller. It is capable of generating high frequency signals with controllable phases to control the speed of the motors precisely, as well as provide enough power for the motors.

Battery: Normal batteries is not enough to supply the huge power demands of the motors. Therefore special Li-Po batteries are used. 3300mAh, 3 Cell 11.4V, 30C, which is capable of delivering up to 100amps of power at a time.

IMU: MPU 6050, which has 6DOF (6 Degrees of Freedom, 3-axis Accelerometer, 3-axis Gyroscope) is used to continuously monitor the Multicopter's positions and angles. These angles are used to balance in air, and achieve a stable flight.

Core-Controller: Arduino Uno, it is programmed to take input from the IMU, and external controller and with the help of a PID algorithm decides the PWM (Pulse Width Modulation) input for each motors individually. This loop runs at over 250 times a seconds, responding to every small changes and adjusting accordingly.

RC Transmitter and Receiver: This telemetry used to manually control the quadcopter when required.

Wi-Fi Module: ESP 8266, is a very cheap widely used Wi-Fi module. This chip alone plays an important role in making the multicopter an IoT device.

GPS Module: This module gives a near to accurate latitude and longitude of the Multicopter's position, in a global level.

Magnetometer and Barometer: These sensors gives the compass alignment and altitude reading of the multicopter.

Camera: This is used for video recording, video surveillance, and image processing for visual guidance and automated landing capabilities.

Raspberry Pi 2 B: These takes care of the external controller of the autonomous quadcopter. It reads data from Wi-Fi module, GPS module, Magnetometer, Barometer, Camera and instruct the lower level controller to move accordingly. All IoT related communication, image processing, obstacle avoidance calculations are done here. This loop may run at a lower speed than the core controller.

Applications

In places where one need to implement video surveillance over a large area or building, autonomous multicopters with proper video recorder equipment can be used instead of many fixed cameras to cover the entire ground. Problem of limited battery life and short flight range can be solved by using multiple multicopters. Each copter can fly on its route, and automatically come to the docking station and set to charge itself. At the same time they can communicate between them and trigger an event where another copter with full charge can start its flight. These can be synchronized so that there will be at least one quadcopter in the air at a time. Anytime manual control of these multicopters can be taken and deviate from its normal course. Since these type of video surveillance is dynamic in nature, and not fixed, it is difficult to purposely avoid them, or to disable them physically, thus improving security.

Road traffic and accidents can be easily monitored through these multicopters. They can fly over its fixed path and with proper image processing to identify road conditions, and report back or update traffic status automatically. Traffic Controller can send these multicopters to any specific locations to get a visual of the problem and take necessary steps to resolve the issue.

When a person calls Emergency helpline, it takes some time for the emergency team to respond due to reach limitation, accessibility, or lack of personal nearby. In emergency each seconds counts, and is important. Once the emergency is logged, a multicopter can be assigned which can reach the coordinates much faster. In case of medical emergency, it can take live footage and send to the responders who can prepare themselves what to expect exactly at the locations. In case of crime, it can take visual footage of the crime, and inform the responding officers about the hostages and hostile situations.

XI. RESULTS

We achieved a stable autonomous flight, however the GPS navigation controller can be further improved for better control and path prediction. We managed to implement some basic inter-multicopter communication however it is yet to be tested in real life due to lack of multiple multicopters which was over our project budget. Docking System worked well, but failed in some cases where there was not enough light or due to external obstructions. The exact charging mechanism is beyond the scope of this project, which needs to be further enhanced to achieve stable and safe charging, since Li-Po Battery have a different charging mechanism.

CONCLUSION

This project is the first stepping stone that opens up a wide range of possibilities. It not only addresses the issue of limitations of multicopters, but also adds new features that involves limited or no human interactions or maintenance.

This project was mainly focused on the inter-multicopter communication, autonomous flight, and auto charging docking station. We did able to achieve the basic functionalities, however the concept can be further improved for better performance and more features.

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