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UNMANNED AERIAL VEHICLE (UAV) QUADCOPTER
with facial recognition

Engineering

Udai Rathore	BE(E&TC), Dr. D.Y. Patil School of Engineering, Pune, Maharashtra, India.
Aaquib Shaikh	BE(E&TC), Dr. D.Y. Patil School of Engineering, Pune, Maharashtra, India.
Vijay Khape	BE(E&TC), Dr. D.Y. Patil School of Engineering, Pune, Maharashtra, India.
Chandan Kumar Choubey	E&TC, Dr. D. Y. Patil School of Engineering, Pune, Maharashtra, India.

ABSTRACT

The military use of unmanned aerial vehicles (UAVs) has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. The larger UAVs also provide a reliable long duration, cost effective, platform for reconnaissance as well as weapons. They have grown to become an indispensable tool for the military. The question we posed for our project was whether small UAVs also had utility in military and commercial/industrial applications. We postulated that smaller UAVs can serve more tactical operations such as searching a village or a building for enemy positions. Smaller UAVs, on the order of a couple feet to a meter in size, should be able to handle military tactical operations as well as the emerging commercial and industrial applications and our project is attempting to validate this assumption.

KEYWORDS:

I. INTRODUCTION
While improving the mechanics, aerodynamics, and reliably of multi-copter is an active research area, the basics of quad-copter design is a solved problem. Instead of building in a quad-copter, the focus of this project was to explore what could be done with an autonomous quadcopter.

We selected the Quadcopter design because of its maneuverability, stability, and large payload capacity. The UAV that we are building is a prototype unit that could be used for commercial use but is not rugged or robust enough for military use. Although we will meet the goal of producing a small UAV that could perform useful missions in both military and commercial arenas, time and funding constraints forced us to design a UAV to meet our functional requirements but not to meet harsh environmental conditions such as those encountered during military missions. However, our UAV design certainly could be re-implemented with newer and more robust technology which would allow it to be used for military functions.

The Quadcopter configuration UAV will be capable of being remotely controlled to fly specific pre-determined missions. Such missions might include inspection of a difficult to reach location, rapid deployment video from the location of a fictitious campus incident, or surveillance video from a pre-planned route around campus. A scenario requiring autonomous flight would be a search and rescue situation where a building has collapsed and the survivors need to be found by detecting their faces and/or upper bodies.

II. RELATED WORK
The Problem Statement of this project is to design an Unmanned Aerial Vehicle capable of detecting human faces via image processing and maneuvering accordingly. This could take on a various number of applications, for example facial detection, facial recognition, surveillance, rescue missions from inaccessible and remote locations. This could also have applications in the Police department or military domain in identifying marked personnel.

A. Objectives
While defining the objectives of the project total cost, areas of application and versatility of the UAV were focused on the most. After a lot of considerations following were the decided objectives of the project:

1. To build a completely stable UAV capable of hovering in a fixed location despite interference.
2. To build a UAV capable of autonomous flight.
3. To build a UAV which can fly to a specified location based on GPS.
4. To build a UAV which is capable of live video streaming as well as being able to record video/images for later use.
5. To build a UAV with digital image processing capabilities to detect human faces and store the frame with the face highlighted in it.

III. SYSTEM DESCRIPTION
Following figure 3.1 and 3.2 shows the basic block diagram of the system that is to be implemented and the block diagram of the quadcopter itself:
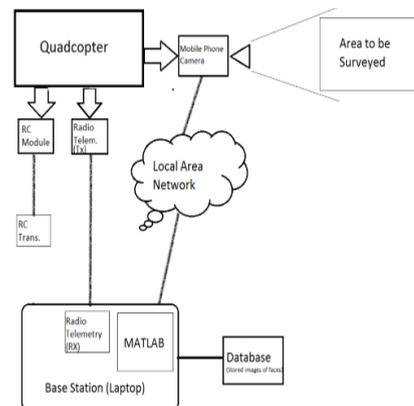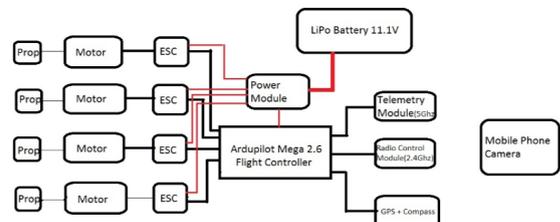

Figure 1 Block Diagram of system

Figure 2 Block Diagram of quadcopter

A. Flow of System
- The quadcopter is to be controller using the ArudCopter ArduPilot Mega 2.6, an autopilot board that handles that stabilized flight, integrates the local sensors such as GPS, sonar and battery monitoring as well as radio communication.

- The quadcopter's flight is controlled using a ground station computer over a 915 MHz communication link using a radio, which will be chosen based on its compatibly with the APM 2.6. The quadcopter is controlled using a command prompt interface by the program MissionPlanner, which initiates a MAVLink communication link to the quadcopter over the radio. The MissionPlanner software was chosen because of its ease of use.
- This ground station computer can change the mode of the quadcopter to be flown under manual control using a RC controller and by setting the flight mode of the quadcopter to Stabilize. It can also switch to any one of the enabled flight mode from the terminal, such as Return-to-Launch, Position Hold, Altitude Hold, Land, etc.
- An Android smartphone is placed on the bottom of the quadcopter and the video feed of the phone is accessible at the phone's local Wi-Fi IP address using a free app called IP webcam. This camera system was chosen because it is very easy to interface with, is supported by MATLAB and would likely work with any smartphone running a similar application. The quadcopter is able to recognize the human face using a custom MATLAB code that is written by us. This module uses the MATLAB program to search for a face in the given frame captured from the video. This program will also store the frames in which faces were detected in a specified location on the Base Station. If a human face is detected in the any part of the video, a box will be marked around the face to show that face is detected and facial tracking has begun, while also simultaneously a picture of the frame will be captured and stored on the hard disk of the Base Station which can later be used for facial recognition purposes or to identify who all are present in the area of surveillance.

B. Circuit Diagram
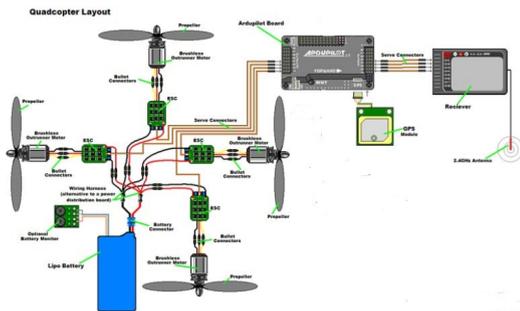
Figure 3 Circuit Diagram

C. Hardware Methodology
For the hardware methodology of this project was completed using the circuit diagram described in chapter 3. That circuit diagram was used as a blueprint to execute the design of the quadcopter.

The first step for us was to assemble the frame of the quadcopter.

The second step we took was to solder gold plated bullet connectors onto the motors and esc's. Once that was done we placed all 4 ESC's and all 4 motors on the frame as shown in figure 5. The ESC calibration was done at a later stage once the ArduCopter Mega 2.6 flight controller was installed onto the frame.

The third step taken by us was to install the RC receiver and radio telemetry module onto the quadcopter. The RC receiver had to first be bound to the transmitter.

The fourth step taken by us was to fit the APM 2.6 flight controller board to the frame. The GPS + external compass that came with the APM 2.6 was also mounted along with the board and necessary connections to the GPS + compass, telemetry module and receiver module were made.

Next, we setup the wiring for the quadcopter. This involved first mounting on the Lithium-Polymer battery onto the base of the quadcopter. The power from the LiPo battery is first fed into the APM 2.6 power module which powers the APM 2.6 flight controller and also sends on the power to the power distribution board which powers the rest of the quadcopter.
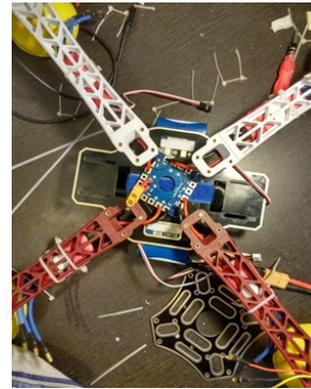
Figure 4 Completed Power distribution board on quadcopter frame

After the fourth step we were ready for our first test flight. Images of the first test flight are shown below. The first test flight was a success with the copter maintaining absolutely stable flight in stabilize mode.

The fifth and final step in the hardware methodology was to mount our smartphone onto the drone. This was done by first taking apart a used selfie stick which was acquired cost free from a donor. The head of the selfie stick was mounted atop the quadcopter in order to act as a camera gimbal for the phone. The smartphone with IPwebcam application installed on it was then mounted onto the quadcopter. This completed the quadcopter and hence we executed the initial design that we had made for the quadcopter.

D. Software Methodology
The facial detection and tracking in our project is carried out on MATLAB R2017a software running on a laptop with windows installed on it. This laptop acts as the base station for the drone when it is out in the field. The drone can be controlled via a RC remote control or via telemetry signals sent from the base station to the drone. Using these telemetry signals the drone can operate in one of many modes (Altitude hold, Stabilize, position hold) including autonomous mode. In autonomous mode a predefined flight path can be followed by the drone completely on its own and without any human intervention at all. This is accomplished by using the mission planner software.

1. Mission planner software running auto mode:
In Auto mode, the copter will follow a pre-programmed mission script stored in the autopilot which is made up of navigation commands (i.e. waypoints) and "do" commands (i.e. commands that do not affect the location of the copter including triggering a camera shutter). [21]

2. MATLAB R2017a running facial detection and tracking program:
The algorithm used for facial detection and tracking employed in the program is given by the flowchart below:
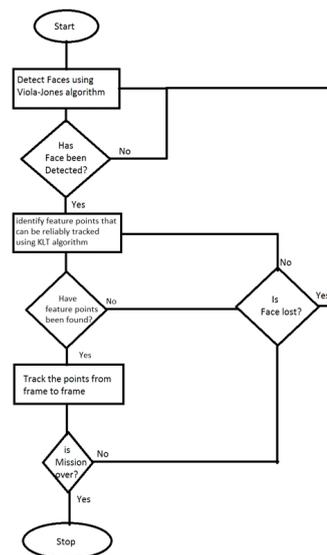
Figure 5 Flowchart of algorithm used

IV. RESULTS

After implementation of the design mentioned above it was observed that the desired objectives of the drone which we had kept in mind while designing it have been achieved.

The first objective of our drone was to build a drone capable of hovering in a fixed location despite interference which was achieved. The drone is capable of hovering in a fixed location using the position hold command in the ArduCopter interface. The drone can also hold a specific altitude while being able to adjust the pitch, yaw and roll.

The second objective was to build a drone capable to autonomous flight. This was objective was also achieved successfully by our drone. A mission or flight path can be pre-programmed using Mission Planner software. Once flight path is established and drone is in auto mode autonomous flight can be engaged. The third objective being related to this was also achieved.

The fourth and fifth objective being related were also achieved together. The fifth objective being the important one was to build a UAV with digital image processing capabilities to detect human faces and store the frame with the face highlighted in it. This was achieved in its entirety. A face which is present anywhere in the frame of the video is detected and highlighted by a yellow box. As soon as the detection occurs a screenshot of the frame is taken and stored in the hard disk of the drone for later use.

A. Hardware Results

In view of the various objectives an image of the drone and images of drone during stable flight are shown below. These images prove that the first 3 objectives of hovering, autonomous flight and guided flight have been accomplished.

The images shown below were taken during a demonstration performed in front of our project mentor and a group of students of our campus.

Figure 6 Images of drone sustaining stable flight while detecting faces in a crowd

B. Software Results

Result of facial detection and tracking program running on base station using MATLAB R2017a:

As can be seen from figure's 9, 10 and 11 the software written successfully detects faces, highlights it using a yellow box and stores the detected face to the hard disk of the base station. Even in a big crowd the drone is able to differentiate between faces and capture all the faces in a crowd.

Figure 7 Detected Images stored on the base station

Figure 8 Detected Images stored on the base station

Figure 9 Detected Images stored on the base station

We observed that an error does occur in the facial detection algorithm. If the face is only partially visible (either hidden behind an object or facing another side) then the drone is unable to detect the face. This is also true for very dark areas or very bright areas of the screen. Although the core of these errors lies within the algorithm of the code written, these errors can also be reduced with the help of a better camera. We used a mobile phone in place of a proper camera in order to save money. A dedicated camera with better resolution can be used to minimize these errors. Another way to minimize the errors is to use a dedicated video link for transmission and reception instead of the LAN method we were using. There were a lot of latency issues while using the IPwebcam and LAN methodology for video broadcasting that we were using. These latency issues also lead onto the errors occurring in the facial detection.

V. CONCLUSION AND FUTURE SCOPE

UAV's are an upcoming market in today's world. With the rate of development of automation in every field, automation for UAV's is also not too far off. Although the first step of automation, an autonomous UAV has already been created, our efforts in this project are to step it up a notch.

A truly autonomous vehicle is one which does not require any form of human intervention at all. As of now there are autonomous quadcopters which can fly to waypoints and navigate themselves, but in the case of discovering the location of humans in the area of surveillance still required human intervention. This was the main motto of our project, for a drone to be able to recognize faces in its path and store those images using digital image processing.

This motto of ours was achieved as can be seen in the sections above. Although we had reached the goal we intended to reach, we realized along the way that there is a lot of room for improvement in the drone. Not only improvement as far as the hardware is concerned but also with the facial detection algorithm that was deployed. There is immense room for improvement in this drone.

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