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COMPUTER ENGINEERING DEPARTMENT

CENG 407

Innovative System Design and Development I

UNMANNED AERIAL VEHICLE

(UAV)

LITERATURE REVIEW

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Abstract

This paper presents an embedded hardware/software architecture specially designed to be applied on quadcopter Unmanned Aerial Vehicles (UAV). Many types of UAVs exist nowadays to fulfill military or civil purposes. The class of quadcopter UAVs is mostly being used in commercial scenarios. They have limited power and very low computing power. UAVs are automatically piloted by an embedded system called "Flight Control System" and they are commercially available however, none of them provides support for the actual task that the UAV should perform. Users have to configure and write codes according to their UAV's task.

1. Introduction

1.1. The Term “UAV”

An Unmanned Aerial Vehicle (UAV) is an expression that identifies an aircraft that can fly without a pilot. Its combination of airframe and a computer system which combines sensors, GPS, cameras, servos, and CPUs this combined structure has to pilot quadcopter with no human intervention. Another common definition is that of an aircraft that is capable of flying in an autonomous way.

1.2. Common Usage

Drones are being used in many different fields. The most common usage of drones are commercial aerial surveillance, remote sensing (geological surveying), commercial and motion picture filmmaking, mineral exploration, disaster relief, construction, and lastly recreational use.

2. Understanding of UAV

2.1. Mechanical Understanding of UAV

There are different types of multi-rotor UAV according to their motor and arm numbers. First of them is the tri-rotor Y3 configuration. This type is the smallest one in the family. Since it has three motors and three is an odd number, control of the yaw movement (rotating in the axis of multi-rotor) is made by a different motor at the tail of the configuration like a single-rotor helicopter. This situation makes the control scheme of the tri-copter UAV. Secondly, the most common type of multi-rotor is quad copter X4 configuration. The problem in the tri-copter doesn’t occur here because motor number is even, and angular momentum can be controlled by rotating two motors CW and the rest CCW. There are more types like hexa-copter, octa-copter, quad copter X8 configuration, etc. These types have 6 or 8 motors, and they are used to carry more weight. The quad-copter design is selected because it is the optimum configuration as a multi-rotor UAV for TEKOFEST competition purposes.

Mechanical need of this project can be categorized as Mechanical Design of UAV, Mechanical Analysis, Thrust-Weight Optimization and Manufacturing. Mechanical Design of UAV means that the aerial vehicle needs to be designed as manufacturable, strong enough to overcome stress and shock in flight, light enough to be flyable, being able to do mission objectives like carrying a payload or dropping it. With and after design process, CAE analysis must be done properly. Analysis gives ideas about design in the process and also last design can be controlled by analysis at the end. General analysis needed are strength and fluid analysis. Moreover, thrust-weight optimization is a significant case. If quad copter is light, it has high maneuverability but low stability and carrying capacity. On the other hand, heavier quad copter can carry more load and resist wind better, but it can not move fast and needs more battery capacity and stronger motors. So, the optimum point should be found between thrust and weight. At the end, manufacturing is done. Kinds of methods can be used in manufacturing chassis, arms, landing gears and other mechanical components of quadcopter. These methods are additive manufacturing, machining, etc. They should be chose wisely to consider cost and functionality.

2.2. Electrical Understanding of UAV

UAVs or in more general terms a 'drone' is a great example of a multi-discipline project. UAVs could be many different types. In our situation, a multi-rotor quadcopter will be used.

A multi-rotor quadcopter consists of many electronic and electrical parts.

First of all, a motor which causes it to fly, take-off, landing, and many more maneuver the drone. For our drone, a **Brushless DC Motor** or **BLDC** will be used. Brushless DC motors are high-efficiency motors compared to brushed motors. This is because it has no brush attached to the outer rotor like brushed DC motors. The spinning of the motor is done by only the permanent magnets mounted to the outer rotor. After we fed up the motor in three phases it will be spinning on its axis. The spinning speed is denoted by the **KV** value. This value is referred to as the constant velocity of the motor. KV can be calculated by the following formula

$$K_v = \frac{\omega_{rpm}}{V_p \times 0.95} \qquad \textit{Eq. 1}$$

Where V_p is the peak voltage

KV value can be easily expressed as RPM that a motor turns when 1 Volt is applied with no load.

$$K_v = \frac{RPM}{V_{applied}} \qquad \textit{Eq. 2}$$

In our drone 1000 KV motor will be used. So that, revelations per minute will be **11.100** when the 11.1 V is applied. Since the drone has four arms on its body it will need the same number of arms. Propellers will be attached to motors.

Another electronic part is **ESC** which is the abbreviation of **Electronic Speed Controller**. This piece will be supplying the voltage to the motors through itself. Four ESC will be used and each will be supplying every individual motor.

The need for energy will be provided by another component which is the **Battery**. In general, drone batteries are Li-Po Batteries. Typical rechargeable batteries have four main parts inside. A positive electrode, a negative electrode, separator, and electrolyte. Compared to the other rechargeable batteries, Lithium Polymer batteries have only one difference that is a polymer separator instead of a liquid separator. In Li-Po batteries

These 3 electronic pieces will be combined in a different component that is maybe the most significant part of all, the **Flight Controller**. The flight Controller or FC is the brain of the drone. It is the circuit that involves many other parts in itself. Sensors, accelerometer, etc. FC is regulating, directing currents to power all parts of the drone. So, the direction of the drone will be adjusted or the camera will be on and the GPS module will be active and so will the other parts. Because drones will be autonomous a computer must be used for machine learning algorithms. A Raspberry Pi module will be used along with the FC to achieve machine learning algorithms. Thus, the drone will fully identify and process its surroundings.

A **Power Module** will be soldered to the FC in order to feed ESCs and motors. By this, our design will be neat and organized. This module will be soldered to the Power **Distribution Board**.

2.3. Software Understanding of UAV

The flight computer is the brain of the UAV, a computer system designed to collect aerodynamic information through a set of sensors (accelerometers, gyros, magnetometers, pressure sensors, GPS, cameras) to automatically direct the flight. All of these sensors are called payloads. These sensors gather information that can be processed on-board or transmitted to a base station for faster computation. We will handle our information on-board with a CPU.

That CPU is called a mission/payload controller and controls the operation of sensors. We will use the CPU for image processing.

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. Our drone will extract information according to its task and change its routine to fulfill that task.

We will use C/C++ in Raspberry Pi and Python(OpenCV) for image processing.

3. Conclusion

While preparing this report electrical, mechanical and software approaches of UAV were researched. The necessary parts were confirmed and researched.

4. Part List

Thrust System Parts:

A2212 / 1000KV Brushless DC Motor (x4)

DJI 1045 Propeller (x2 CCW & x2 CW)

Power Supply and Distribution Parts:

11.1V 5200mAH 3S 25C Li-Po Battery

30A Electronic Speed Control Unit (x4)

F18057/8 Power Distribution Unit

Power Module (Battery / Flight Controller Connection)

Command and Control Parts:

Raspberry Pi 3

Emlid Navio 2

Communication Parts:

10 Channel RC Transmitter and Receiver

Xbee 3 Pro (x2)

XBee Explorer USB

Xbee Adapter

2.4GHz Half Wave Antenna (x2)

720p 60fps Video Recording or Higher Ability Camera

Chassis:

F450 (450mm)

The chassis will be designed originally. F450 chassis will be used as reference and improved as needed.

Other Necessary Parts:

Battery Protector Cover

Battery Charger

Filament for 3D Printing

Soldering Set

Multimeter

Cutting Mat

All other mechanical assembling parts like screws, bolts, screw drivers, etc.

5. Refences

- https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/
- https://ardupilot.org/
- https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
- https://rotordronepro.com/
- https://www.getfpv.com/learn/fpv-essentials/