CONTROL AND NAVIGATION OF AERIAL DRONE IN HARSH ENVIRONMENT USING APM

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This report is submitted in partial fulfillment of the requirements for the Bachelor of Electronic and Computer Engineering Major in Telecommunication

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
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2016

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DEDICATION

To my beloved parents and brother, thank you for your endless love and support,
without them,
I would be aimless
To my lecturers and friends, guidance and knowledge were
shared and discuss together
till a sleepless night
Thank you

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In the end, Worth it.

ABSTRACT

There are two types of lightning which are the cloud to ground and cloud to cloud. Currently, studies in cloud to cloud are based from image taken from ground. The idea is to build a device which can capture lightning image from a closer distance to better understand the characteristic of cloud to cloud lightning. This study can be a breakthrough in learning the behavior of the lightning and in future harness the lightning power for unlimited source of energy. The approach of this study is to build an aerial drone which could fly as close as possible, to the desired lightning that will be studied. The project covers the building of the aerial drone which will be responsible to carry an image capturing system that would be cover by another researcher. It is important to build an aerial drone which is capable of flying at a distance while maintaining the stability during flight time. This project starts from the building of its hardware which cover the body frame, propulsion system, power managing system, and communication system. Then, the control system for the aerial drone is coded using an Arduino based software which provide the needed stability and control by manipulating the sensors and radio control. Both hardware and software where tested in a series of experiment to study the aerial drone behavior during flight time. After the experiment, a clear conclusion can be made based on the results we obtain from the experiments.

ABSTRAK

Terdapat dua jenis kilat iaitu awan ke permukaan bumi dan awan ke awan. Untuk ketika ini, penyelidikan berkenaan dengan kilat awan ke awan hanya berdasarkan gambar yang ditangkap daripada daratan. Sebuah alat yang boleh mengambil gambar kilat dari jarak yang lebih dekat telah diketengahkan untuk lebih memahami ciri-ciri kilat awan ke awan. Penyelidikan ini boleh menjadi satu anjakkan dalam pemahaman ciri-ciri kilat dan seterusnya menyerap tenaga kilat sebagai salah satu sumber tenaga di dunia. Tujuan penyelidikan ini adalah dengan membina sebuah pengangkutan udara yang boleh terbang sedekat yang mungkin ke kilat yang ingin dikaji. Projek ini meliputi pembinaan pengankutan udara yang bertanggungjawab untuk membawa sistem pengambilan gambar. Ianya amat penting untuk membina sebuah pengankutan udara yang berupaya untuk terbang pada jarak yang dekat sambil mengekalkan kestabilikan semasa terbang. Projek ini merangkumi pembinaan perkakasan termasuk struktur badan pengankutan udara, sistem pendorongan, sistem tenaga, dan sistem komunikasi. Sistem pengawalan pengankutan udara ini kemudian dikodkan menggunakan applikasi berasaskan Arduino untuk mencapai kestabilan dan pengawalan dengan menggunakan alat pengesan dan pengawalan radio. Perkakasan dan aplikasi akan diuji dengan beberapa ujikaji untuk memahami tingkah laku pengankutan udara sewaktu penerbangan. Selepas ujikaji dilakukan, konklusi dapat dibuat berdasarkan maklumat yang diperoleh daripada ujikaji.

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CHAPTER 1

INTRODUCTION

Throughout the report, there are five chapters that would explain in detail about the project. In this chapter, it will briefly explain the overall project which consist of the project introduction, problem statement, objectives, scope of work and expected outcome. Project introduction will explain the main concept of project. Problem statement and objectives are based on the purpose of the study while the scope of work will help as an outline toward the completion of the project.

1.1 PROJECT INTRODUCTION

Generally, there are two types of lightning, Cloud to Ground (CG) and Cloud to Cloud (IC). Presently, capturing the images of lighting has been done on the ground and in fix position. The idea is to construct an aerial drone that could fly with stability and control to a determined location which then capture images of lightning with an optical device. The proposed project will be executed by a team of students as it has several parts that need to be tackled. Those parts include the stability and control system, images capturing system, radio communication system, and battery management system. This project will cover in the development of the control system for the aerial drone. During flight time of an aerial drone, it may experience external source of disturbance such as strong winds. A control system mainly consists of a flight controller and several sensors are required to ensure stability. Control is done by transmission of signals to the aerial drone via a command centre on the ground. A transmitter and receiver will be included in the control system.

1.2 PROBLEM STATEMENT

In a harsh environment, strong wind is one of the main disturbances that will affect the stability of an aerial drone. To obtain stability in aerial drone, designing is required to produce a good control. The design of the control system will determine how stable the aerial drone fly when the environment is harsh.

1.3 OBJECTIVES

The objectives are set to ensure the project are at the right path and reached the desired outcome of:

- To design and build an aerial drone.
- To design an aerial drone control system that can archive stability and control during flight.
- To provide guidance and navigation to aerial drone.

1.4 SCOPE OF WORK

Designing and building of an aerial drone consists of body frame, propulsion system, power management system and main processor. Flight control and navigation requires the use of sensors and control using software that will be uploaded in the main processor. Only strong winds will be covered in the harsh flying environment for this project.

1.5 EXPECTED OUTCOME

The outcome of this project is the construction of a prototype with a control system on board. The cost of the project may be high as materials and components are expensive. The application of the project is to capture lightning images while furthering the lightning studies. This project may be a breakthrough in unlimited renewable lightning energy harvesting which could be beneficial to humankind.

CHAPTER 2

LITRITURE REVIEW

2.0 INTRODUCTION

In this chapter, previous studies where studied to give a better overview of the project. With this information, better decision on which method to use, which materials to use and any useful information to approach the objectives can be made.

2.1 REVIEW ON THE HARDWARE OF THE AERIAL DRONE (FRAME TYPE)

Basically, there are several types of frame for aerial drone. Studies have been made for Tricopter, Quadcopter, Hexacopter and Y6 aerial drone body frame. Each frame type has their advantage and disadvantage which will be discussed further in this chapter.

2.1.1 TRICOPTER

Tricopter aerial drone is accompanied by three arms, where each of the arms is connected to a motor. The head of the aerial drone which points forwards is usually between two of the tricopter arms. Usually, the angles between the arms are 120 degrees, depending on the builder preference. Movement of the aerial drone is controlled by the rear motor, as it is able to rotate by a normal servo motor. The movement involves the reaction to stability sensor and changing of yaw angle.

The advantages of tricopter frame body include; a new way of designing as it flies closely like an airplane of forward direction and motion. The overall cost of building a tricopter is lowest among other frame type as it uses less component and hardware. The disadvantages of tricopter frame body include; Complex control as it uses a RC servo motor to control the direction of aerial drone. Most of the flight controller does not support this configuration as it is more to a DIY approach frame type.

2.1.2 QUADCOPTER

Quadcopter aerial drone is accompanied by four arms, where each arm is connected with one motor. There are two basic configuration of quadcopter which are the “X” configuration (forward position between two arms) and ”+” configuration (forward configuration along an arm). Quadcopter is one of the basic frame type that would be used by aerial drone user or developer which allows easier configuration.

Advantages of quadcopter frame body include; widely used by users and developer as it is the easiest construction and a versatile design. The aerial drone arms are symmetric to each other where allows easier control and provide better stability. It is compatible to most of flight controller in the market as it is easy to configure.

Disadvantages of quadcopter frame body includes; if there is a failure in the flight system, it does not have any redundancy protocol, which means if any of the motor or propeller fails to operate, the craft is likely to crash.

2.1.3 Hexacopter

Hexacopter frame type is accompanied by six arms to its body, where each arm relates to one motor. The head or front of the craft is like quadcopter where it can be either between two arms or along an arm of the aerial drone.

The advantages of hexacopter include; it is an improvement of quadcopter frame where it includes two extra arms. With the additional arms, the hexacopter increased its thrust thus can carry more payloads at the aerial drone. It can also

include an emergency backup system where if any system fails, the copter can be landed safely rather than crash to the ground. Almost all the flight controller in the market support this configuration based on its advantages. Disadvantages of hexacopter include; the additional arms mean an increment in overall cost as well as total weight and size. Additional batteries also needed to power up the extra motors which then increase the overall payload.

2.1.4 Y6

Y6 design is another way to configure hexacopter which have 6 motors but with only 3 arms. The motors are set at both side of the arm while the propellers are mounted at the underside to produce the downward thrust.

Advantages of Y6 frame types include; with the reduction of support arms, the total weight of the aerial drone is reduced, thus the total payload the craft can lift increased. Y6 configuration eliminates gyro effect using a rotating propeller. It can also be equipped with emergency protocol if there is any fail in the system, the craft will likely land safely rather than crash. Disadvantages of Y6 frame type includes; the increment of number of motors increase the total cost. The additional motors also meaning that more power is needed to have the same flight time as a quadcopter. Not all the flight controller in the market supports this configuration.

2.2 Motors

The motors used for the aerial drone can greatly affect the total payload and the flight time of the craft. Once a motor is chosen based on the specification needed, all of the arms need to use the same kind of motor. Each motor will have a slight

difference in speed even when it is made by the same brand and model or even from the same production line. The error will be eliminated by the flight controller during the flight time

There are two types of motor that can be used to equip to the aerial drone. Brushed motors case has fixed magnets around the outer layer of the casing where coil spin inside them. Compared to brush less motor, the coils are the one who is fixed to the outer layer or inner layer of the casing while the magnet will be the one spinning. Brush less motor is considered a better choice as it has been extensively used by user or developer in helicopters, airplanes or even boats and cars.

Another aspect that needs to be consider is the KV of the motor. KV is the number of revolution per minute (rpm) for constant rotation of a motor given when 1V of voltage is applied with no load attached at the motor. The rpm will be reduced once the motor is attached with a propeller.

2.3 Propeller

Propeller is the component which attached to the motor. The propeller used in aerial drone is like the RC airplane rather than the helicopter blades. This is due to size of the helicopter blade which is not suitable to a multi rotor aerial drone. The number of blades does not mean more thrust to the aerial drone. A smaller in diameter of propeller will produce a smaller inertia which means it would be easier to speed up or slow down; suitable to be use in acrobatic flight type. Propeller is design into two different kinds; a clockwise (CW) rotation and counter clockwise (CCW) rotation. It is important to know which motor attached to which type of propeller as it will provide a downward thrust to the aerial drone.

Another matter to consider is the balancing of the propeller. Most cheap propeller is not well balanced as it can be simply tested with putting the propeller on

a tip of a pencil. It is a good practice to make sure the propeller is well balance before attaching them to the motors. If anything can happen is that the propeller will have vibration that can cause an unbalanced to the aerial drone which can cause the aerial drone to crash. One way to reduce the unbalanced propeller is to shave of the heavier side of the propeller.

2.4 Electronic Speed Control ESC

In the propulsion system, a component that controls the motor is called an electronic speed control (ESC). This component is responsible to vary the speed of the motor given by the input from radio control. It is attached to each of the motor; between motor and the power distribution board. The input signal is then connected to the flight controller which then controls the motor.

2.5 Flight Controller Sensors

2.5.1 Accelerometer

In the X, Y and Z axes, accelerometers measure its linear acceleration with units of gravity (g) which is 9.81 meters per second per second. When the accelerometer read the data, the output can be integrated two times two give a position of the aerial drone. With the reading of data is based on gravity, the downward position of the aerial drone can be determined; this helps in the stability process during the flight time. The accelerometer sensor need to be mounted linear to the axes of the aerial drone to ensure a stable flight. Accelerometer gives a correct and stable reading but it is too sensitive to the vibration of the aerial drone. Relying on only accelerometer can cause the aerial drone to crash.