UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF UNMANNED AERIAL VEHICLE (PORTABLE VERSION)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Industrial Automation & Robotics) (Hons.)

by

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Dedicated to all my loved ones.

ABSTRAK

Tujuan kajian ini dijalankan adalah bagi menghasilkan sebuah pesawat tanpa pemandu (UAV) mudah alih. Peranti kawalan jauh yang digunakan bagi tujuan penerbangan di udara yang tidak mempunyai pemandu di dalamnya dinamakan sebagai pesawat tanpa pemandu (UAV). Pesawat tanpa pemandu ini mempunyai pelbagai rupa dan bentuk termasuklah model H, model Y, model X8 dan lain-lain. Model X mudah alih adalah model yang akan dibincangkan di dalam kertas ini. UAV model X mempunyai empat rotor sebagai sifatnya dan mempunyai empat motor dimana setiap satunya berada pada tangan. Rotor-rotor ini terletak 90 darjah dari satu sama lain. Quadcopter (UAV yang mempunyai empat rotor) kebiasaannya menggunakan dua pasang kipas yang sama dimana sepasang kipas arah putaran lawan jam serta sepasang kipas arah putaran jam. Pergerakan UAV ini dikira sebaik menerima arahan dari pengawal dan bertindak seiring dengannya. Kiraan ini dilakukan didalam program itu sendiri, dimana nilai untuk diubah boleh diubah secara manual bagi memenuhi citarasa pengguna. Rekabentuk UAV ini dihasilkan dengan merujuk rekabentuk-rekabentuk terdahulu yang telah dihasilkan oleh pencipta-pencipta lain atau syarikat-syarikat lain dengan tujuan mencapai tujuan mudah alih.

ABSTRACT

The objective of this research is to design and fabricate an Unmanned Aerial Vehicle (Portable Version). A device which is used or intended for flight in the air that has no on-board pilot is called Unmanned Aerial Vehicles (UAVs). UAVs include many devices such as H model based, Y model based, X8 model based etc. An X based model (portable version) is proposed in this paper. An X model based UAV inhibits a four rotors characteristic and has four motors in which each one is designated on each arm. The rotors are in 90 degrees apart from each other, where the front is in between the two front motors. Quadcopters generally use two pairs of identical fixed pitched propellers in which two clockwise (CW) and two counterclockwise (CCW). The movement or heading of the UAV is calculated upon receiving command from its controllers and reacts accordingly. The calculation is performed within the coding, where the value for tuning can be adjusted manually to suit one's preference. The design of the UAV is made with reference to previously made designs from other inventors or companies with the need to achieve portability.

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LIST OF ABBREVIATIONS

UAV	-	Unmanned Aerial Vehicle
CW	-	Clockwise
CCW	-	Counterclockwise
PID	-	Proportional, Integral and Derivative
RC	-	Radio Control
ADC	-	Analog-to-digital
DSC	-	Digital Signal Controller
ICD2	-	InCircuit Debugger/Programmer 2
IDE	-	Integrated Development Environment
DC	-	Direct Current
APM	-	Ardupilot Mega
ESC	-	Electronic Speed Controller

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will provide the introduction for this project. Essentially, it begins the foundation of the project in the background, review about this project stated in project overview, some issue proclamation of this project that is in the problem statement, explanation about description of prototype, the objective of this project, the project scopes are to ensure the project can be run smoothly and finally report outline for development of the unmanned aerial vehicle (UAV) portable version.

1.1 Background

An unmanned aerial vehicle (UAV), commonly known as a drone is an aircraft without a human pilot aboard. The overall working of flight of drones may operate with various degrees of autonomy, either under remote control by a human operator or fully or intermittently autonomously, by onboard computers. The change of the capacities of the current flying vehicles requires commitments from various orders including aeronautics, electronics, signal processing, automatic control, software engineering, sensors, etc. One of the present patterns in drones is the improvement of little flying machines fit for performing hover while forward flight (Salazar-Cruz & Lozano 2005).

Unmanned Aerial Vehicle (X model based) is a UAV which has four rotors and consist of motor for each associated arm. The rotor situated at a 90 degree between each other, where the front is in between two front rotors. Quadcopters generally use two pairs of identical fixed pitched propellers in which two clockwise (CW) and two counterclockwise (CCW). These uses independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor, it is possible to precisely generate a desired total thrust to locate for the center of thrust both laterally and longitudinally and to create a desired total torque, or turning force. By using APM Flight Control as the microcontroller, we can control the rotor speed as it controls the drone's angle. The APM can also control the roll, pitch and yaw of the drone with the help of accelerometer, gyroscope and magnetometer built in APM to sense and perform some calculations that are programmed by using Arduino for the control algorithm to stabilize the drone.

1.2 Problem Statement

The aim is to create an unmanned aerial vehicle (UAV) portable version. Making a portable version UAV is the primary objective. Stabilizing the orientation of the drone is also important in order to control the position of the drone, while explicitly taking the limits of the control signals into account.

Figure 1.1: Example stability calibration.

Optimizing energy consumption of Small Aerial Vehicles is one of several problems that remain to be unsolved in the domain of UAVs. In a recent work, a novel X based model UAV was introduced that was able, when possible, to roll on the ground thanks to a tilting propeller and caster wheels. Most of the drones would possess battery problems. The normal flight time for a drone is around 20-30 min in which that would be the longest time the drone can reach in this recent time.

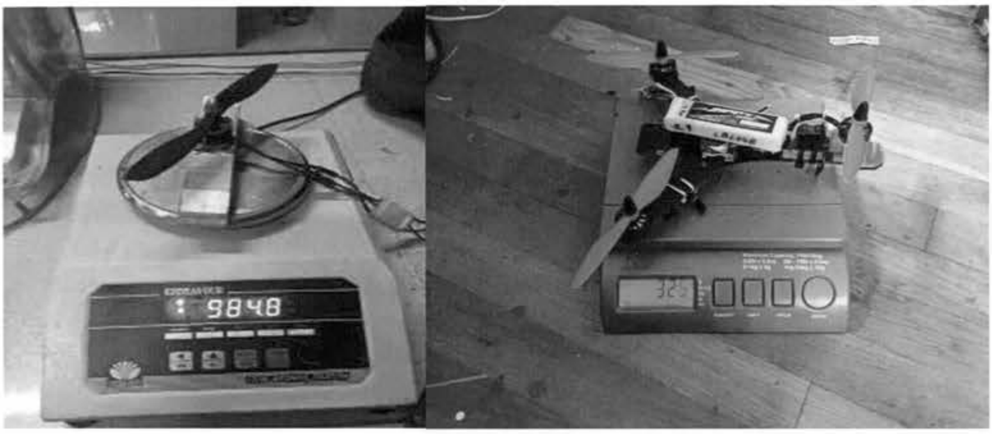

Figure 1.2: Example of load estimation.

There are many factors that should be considered. The main theme revolves around the total amount of work done by the motors to get the craft up. Less amount of motors equal less power and thrust. The existing motors must hence, work harder. Generally, it's needed a good thrust to weight ratio for maximum flight times. For the larger rotor is capable of carry heavier payloads. So, the type of motor is also one of the factors that also need to be considered whether brushes or brushless, the rating of the motor, etc. Knowing the weight of the rotor is the thing that needed to known. When building, or planning your next drone build knowing the exact weight can be difficult. However, some refine the weight estimation needed to be establish.

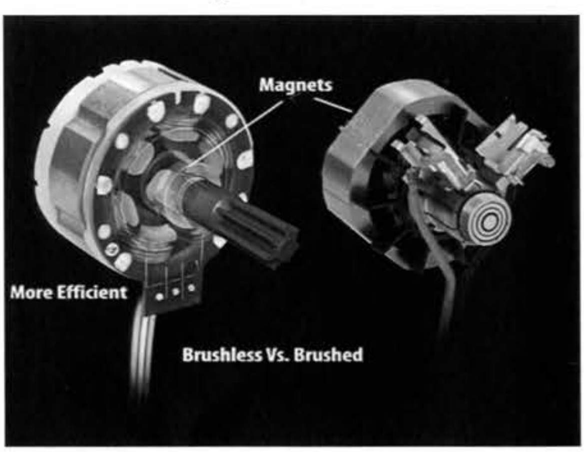

Figure 1.3: Brushless or brushed motor.

Different type of frame also effects the overall output results and configurations. The type of frame going to be used needs to be considered as that gives some restrictions on the maximum motor or propeller size. Most frames that can be buy will also give some recommendations as to what motors should be use to give an idea of what to look for. And also some additional accessories like landing gear, prop guard, etc need to be considerate under payload.

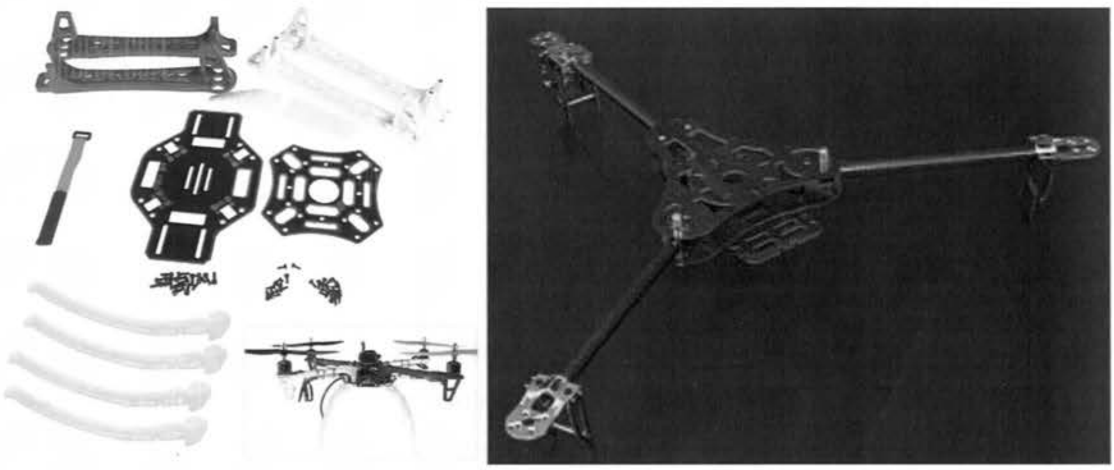

Figure 1.4: Example of body frame.

1.3 Description of prototype

a) PID tuning
   i. Tuning UAV using PID control system only for fly indoor estimation.
b) Body frame
   i. Detachable 3D-printed frame.
   ii. X based shape model.
c) Type of rotor
   i. 2 Clockwise Brushless Motor.
   ii. 2 Counter-clockwise Brushless Motor.
   iii. 9443 Propeller.

d) Microcontroller
   i. APM2.8 Flight Control.
e) Safety
   i. There are some regulation to fly the UAV that's need to be referred in Civil Aviation Regulation (Chambers 2016) for safety of civil and equipment which is UAV.

1.4 Objectives of Research

In this paper, twelve degrees of freedom unmanned aerial vehicle (UAV) portable version, X based is proposed, in which the translational dynamics is expressed in the UAV body frame and is depicted by air velocity, angle of attack and sideslip angle. The present work highlights construction and testing aspects of a X model based UAV. Unlike a helicopter that rises on a single column of air, the X model based UAV rises on four columns of air making it more stable. System is made stable by using gyroscopes, which measure the orientations of the UAV in three directions such as roll (X – axis), pitch (Y – axis), and yaw (Z – axis). As the system is equipped with the closed loop mechanism, the feedback controller provides a necessary feedback to the gyros in order to bring the system back to stability. An onboard flight controller is used to stabilize the UAV against turbulent orientations on its four arms. The objective of this project is:

a) Designing X based model UAV for low cost but great stability.
b) Using PID control for tuning the stability.
c) Designing the portable frame using 3D – printer or suitable material.
d) Brushless type motor with propeller that can support payload efficiency.

1.5 Scope of Research

A couple of rules are proposed to guarantee that the project will accomplish the goals by narrowing the requirements for this project. These are the scopes covered in this project: Using Arduino programming to convey RC controller to the APM flight controller. The scope of this study is:

a) Design portable X based model UAV using 4 rotors for low cost but high performance.

b) Brushless motor and 9443 Propeller for light type of payload.

c) Designing a suitable control system to operate the UAV that is PID controller.

d) Configure the UAV specialize to fly indoor.

e) Design manned & unmanned flight instruction.

f) 3D - printer frame based body frame.

1.6 Thesis Outline

The structure and layout of the thesis are as follow:

Chapter 1 – Introduction: This part briefly clarifies about the introduction which covers the goals, scopes of the project and the issue proclamations

Chapter 2 – Literature Review: This chapter describes about compare of drone or unmanned aerial vehicle (UAV) that done by others and what to do and what not to of drone.

Chapter 3 – Methodology: This part clarifies about the methodology of this project, which describe details about the technique utilized for developing up this project and furthermore approach taken so as to finish the project.

Chapter 4 – Project Development: In this part explain about the hardware parts, frame design and software that will be highlighted for the unmanned aerial vehicle (UAV) portable version X based model.

Chapter 5 – Expectation Result: This part will consider about the desire output result of the development of the unmanned aerial vehicle (UAV) portable version X based model.

Chapter 6 – Conclusion and Recommendations: This part will close about the whole project and future desires that should be possible for the future project.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the review of other UAV researcher project is covered in order to understand and obtain the information on the technology available and the methodologies that they used for their project on the same topic.

2.1 Three rotor Configuration UAV

There are many design of three rotor configurations of UAV and one of the designs is Y model based.

2.1.1 Overview of three rotor UAV

Three rotor UAV or Tricopter is as the name implies, possess only three rotors on its frame or body. Unmanned Aerial Vehicle (Y model based) is a UAV which has three arms, each connected to one motor. The front of the UAV tends to be between two of the arms (Y3). The angle between the arms can vary, but tends to be 120 degrees. Unlike a helicopter that rises on a single column of air, the Y model based UAV rises on 3 columns of air making it more stable. This also due to the factor that these Tricopter have six degrees of freedom and are equipped with gyroscope, magnetometer and accelerometer. The aforementioned three sensors before measures the orientations of the UAV in three directions namely roll (X axis), pitch (Y axis) and yaw (Z axis).

Figure 2.1: A model of Three rotor UAV or Tricopter.

2.1.2 Flight Control of three rotor UAV

The Tricopter motion in flight is similar to any other aircraft, in which the orientation and flight control is a product of roll, pitch, and yaw. The control strategy is the same as any tradition helicopter. Control strategies of Tricopter are shown in figure below. Figure 2.2 shows the roll control that by varying the rotor speeds of the forward two rotors will generate a roll. By decreasing rotor speed 1 the Tricopter will roll to the left and rotor speed 2 roll to the right.

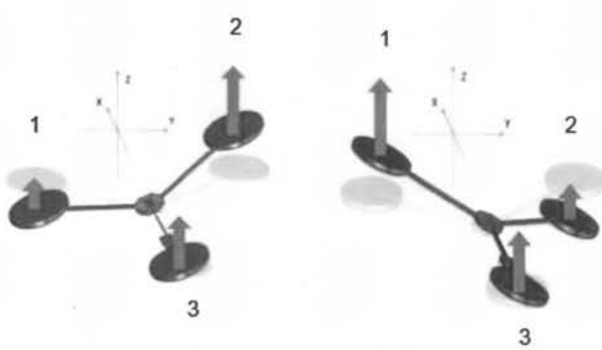

Figure 2.2: Roll control.

Figure 2.3 shows the pitch control. Varying the rotor speeds from front and aft rotors will generate a pitch. By decreasing rotor speed 1 and 2 and increasing rotor speed 3 the tricopter will pitch down and sustain forward flight. By increasing rotor speed 1 and 2 and decreasing rotor speed 3 the tricopter will pitch up and fly backwards.

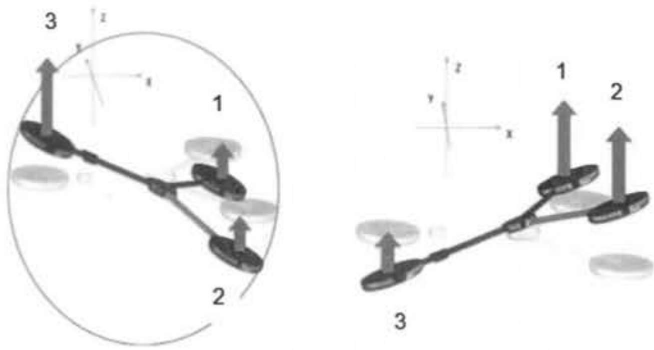

Figure 2.3: Pitch control.

Figure 2.4 shows the yaw control in which the yaw is controlled by varying the angle of rotor 3 to vector the thrust to product a torque moment which will yaw the tricopter left or right. In order to maintain lift the rotor speed increases while the thrust angle changes. Figure 2.4 shows the tricopter yawing right.

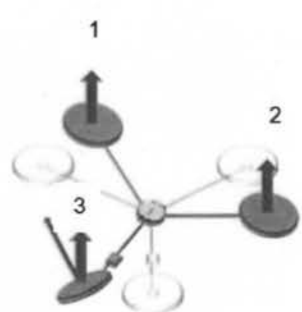

Figure 2.4: Yaw control.

2.2 Four rotor configuration UAV

Four rotor configurations UAV is very popular among the researcher. In this subtopic, the four-rotor configuration UAV is developed by degree student of Universiti Teknologi Malaysia (UTM).