IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⋈ Impact Factor 7.39 ⋈ Vol. 11, Issue 7, July 2022

DOI: 10.17148/IJARCCE.2022.11739

A BRIEF STUDY OF HEXACOPTER AND ITS PARAMETERS

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Abstract: Aeronautical observation is very effective way for the observation of various fields, and researches in recent years. In this paper the study of Hex copter and its different parameters are explained in detail. Firstly, a multicopters/Drones advantages are discussed. All the parameters of the drone like Throttle, Roll, Pitch and Yaw are discussed in detail in this paper.

Keywords: Roll-pitch-yaw control, hexacoper, matlab, solidworks, Trajectory control etc.

I. INTRODUCTION

In the traditional aeronautical observation, fixed cameras were installed on helicopters or hot air balloons to obtain observation. Even after it the helicopters were used for the observation. But in the areas where Humans cannot go, like narrow caves and disaster areas, it was impossible to perform observation. But now a day, an Unmanned Aerial Vehicle (UAV), also known as drone, is used for this type of observation and characterized by the absence of the human pilot on board. Its flight is controlled by navigator or pilot on the ground on board system, under the remote control. However, the flight operations of an UAV and its controlling are same as the rules and procedures followed by the aircraft with on board pilot and flight crew.

Due to its various advantages UAV is now used for military purposes and also for civil applications, such as in fire prevention and emergency response operations, for nonmilitary security, in pipelines surveillance, for remote sensing and research aims, and in all cases in which such systems may allow the execution of “dull, dirty and dangerous” missions, event its cost is lower than conventional aircraft and without losing life of individual. Other application areas of the UAV are aeronautics, computer science, mathematics, electronics, mechanics, automatic control, signal processing, etc. UAV is also able to travel various places where pilots cannot go or where there is high risk involved, for example in disaster areas after nuclear blasts, areas with unstable weather, volcanoes, etc. [15]

1.2 Multicopters/ Drones

Drones are defined by the U.S.'s Federal Aviation Administration as an Unmanned Aerial System (UAS). The term UAS covers a wide array of aircraft, from drones to your average hobby radio-controlled airplanes. Most multicopters are piloted in the line of sight (LOS), just as any radio-controlled airplane. This variety is not considered a drone. Technically, a drone both flies outside LOS and has the capability of autonomous flight (autopilot) [1]. A multicopter's primary function is for videography, cinematography, and photography whereas drones can be preferred in military or for spying purposes. Multicopters uses lift and torque as a working principle. In a traditional helicopter, the main rotor spins in one direction as to lift the weight and a tail rotor is used to put a constant pressure on the tail to keep the body stable. A multicopter uses counter-rotating propellers to keep the body stable while the propellers turn.
The axes of rotation used in muticopters are called pitch, yaw, and roll. Pitch is simply pointing the nose of the aircraft up or down. Yaw is turning the aircraft to the left or right. Roll is turning the aircraft such that the sides go up and down [1]. So in order to get lift of different types of muticopters, motor mechanism or propellers need in symmetry, Therefore most of the multicopters comes in even number of propellers or motors. In research, A quadcopter or rotor is the first type to be considered as multicopter. Quadrotor helicopters have become increasingly popular as unmanned aerial vehicle (UAV) platforms, used for Aeronautical observation like aerial photography, agricultural monitoring etc. These vehicles having 4 identical rotors in 2 pairs spinning in opposite directions, and having many advantages over standard helicopters in terms of safety and efficiency at small sizes.

Even several radio controlled toys are constructed based on quadrotor platforms or quad copter, and many research groups have begun constructing quadcopter UAVs as robotics research tools [5].
Nowadays, UAV with more than four rotors, i.e. hexacopter and octocopter, is developing, its advantage is to the possibility of managing one or more engine failures and also to increase the total payload. In UAV the advantages of

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more rotors appear in term of more power and more lift that is more time on the fly. However, it is against the production cost to the increasing of drone size and weight. So the hexacopter seems to be a good compromise and commonly used configuration of a hexacopter is treated. A hexacopter is a UAV whose six-rotors or pairs of counter-rotating fixed-pitch propellers are located on the vertices of a hexagon and are equidistant from the center. In order to characterize the aircraft dynamic behavior, the mathematical model of the hexacopter is need to be implemented first in simulation before making it in real considering all its external and internal influences [2].

1.3 Hexacopter Unmanned Aerial Vehicle

The hexacopter is the Unmanned Aerial Vehicle (UAV) which belongs to the family of multi rotors. The hexacopter model is a rigid body with a symmetrical structure. This Multi-rotor has six arms located from center towards the vertices of a hexagon. Each arm has a propeller in the end which driven by an electric motor. The controlling board and battery is mounted at the center of the virtual hexagon. As the model of hexacopter is symmetrical, the center of gravity of the hexacopter is at the center of the hexagon. Out the six propellers, a pair of three propellers spin in one direction and pair of other three propellers in opposite direction. The blades mounted on every propeller has a fixed pitch.

1.4 Basic Movements of hexacopter

The movements of the hexacopter is controlled by controlling the angular speed of the propellers [3]. All propellers produces a thrust individually by pushing the air downwards. All different upward thrusts are used to give motions to model, as the source of the thrust is outside the center of gravity. In addition with the upward thrust, reaction torque is also produces opposite to the rotation direction of the rotor. A pair of three rotors spinning in the same direction provides a resultant torque in one direction which is equal and in opposite direction of the pair of other three rotors, so over all torque is zero when they all are spinning at same angular speed.
The basic four movements of any flying objects are:

1. Throttle
2. Roll
3. Pitch
4. Yaw

The different angular speed of every propeller are mapped in a particular way to generate control signals for these basic movements. In other words the control signal of these basic movements collectively decides the angular speed of the particular rotor. The roll and pitch angle of the hexacopter results in the motion or movements along the ground which counts for the linear movement of the hexacopter. The little pitch angle to the hexacopter provide a forward or backward movement keep the total thrust same.

1.4.1 Throttle

The throttle is the main control of the hexacopter to provide the motion in vertical direction. The thrust generated by the propellers collectively results in all hexacopter maneuvers. All the blades have fixed pitch, so on the same angular speed they produce the thrust upwards which counter the force of gravity acting on the model. With increasing in angular speed, the thrust will also increase. The certain constant threshold thrust is required to compensate the total weight of the hexacopter. With further increase or decrease in angular speed will generate upwards or downwards motion in vertical direction.

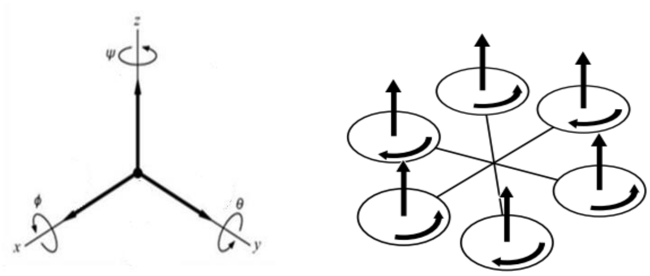

Figure 1.1 : Thrust is shown by arrows upwards. [8] [2]

1.4.2 Roll

The rotation of the hexacopter on X-axis as the center of rotation axis is called Roll. The angular speeds of the propellers are controlled separately. The thrust produced by the three of the right side propellers is increased and the thrust produced by the three of the left side propellers is decreased to generate the rolling effect. The increase in thrust is same as the decrease in the thrust so the total thrust of the hexacopter remains the same.

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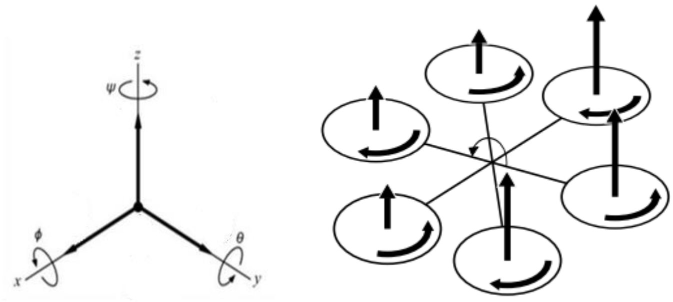

Figure 1.2: Right side thrust is increased and left side thrust is decreased to counter clockwise direction [8] [2].

1.4.3 Pitch

The rotation of the hexacopter on Y-axis as the center of rotation axis is called Pitch. As generating roll, pitch is also generated by changing the angular speeds of the propellers. The two propellers are on Y-axis so change in their thrust will not have any effect to generate pitch. The thrust of consecutive two propellers on one side of the Y-axis is increased and thrust of the other two is decreased by the same proportion. The change in the thrust of different part the hexacopter generate the pitch.

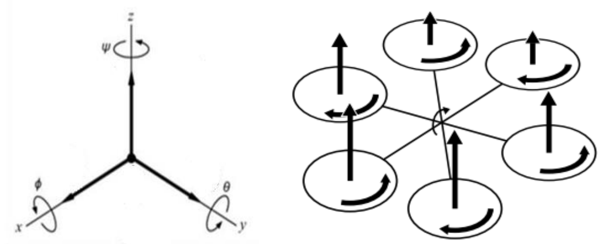

Figure 1.3: Two propellers generates more thrust while opposite two are generating less thrust to produce clockwise pitch [8] [2].

1.4.4 Yaw

The rotation of the hexacopter on Z-axis as the center of rotation axis is called Yaw. The z-axis is same as the vertical axis passing through the center of the virtual hexagon. In order to generate the clockwise rotation of the whole body, the thrust generated by propellers rotating clockwise will be increased and the thrust generated by propellers rotating in counter-clockwise will be decreased in the same proportion.

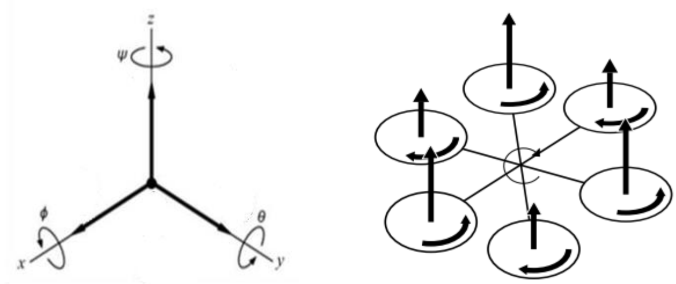

Figure 1.4: Thrust is increased and decreased for propellers rotating clockwise and counter-clockwise to produce Yaw [8] [2]

1.5 Body Fixed frame

The hexacopter model has 6-degree of freedom (DOF) and to track its motion a body fixed frame is required. The body fixed frame is the fixed frame with its origin at the hexacopter's center of gravity. The body fixed frame is compared with inertial frame to calculate the change of the basic movements (Throttle, Yaw, Pitch, Roll). The inertial frame is the frame with its origin on the surface of earth.

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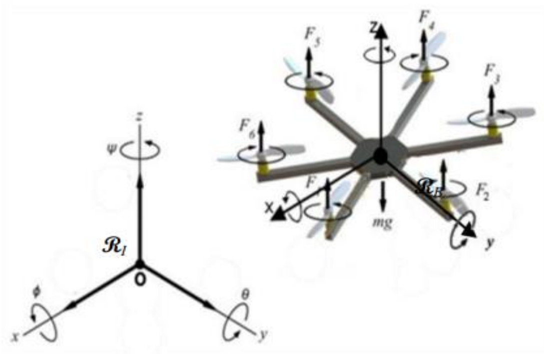

Figure 1.5: Inertial frame and hexacopter with body fixed frame [10]

II. CONCLUSION

In this paper a Complete study of Drone was done. Different parameters of the drone like throttle, Yaw , Pith and Roll was discussed in this paper. The advantages of the hex captor over quadcopter also discussed.

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