Quadcopter Unmanned Aerial Vehicle (UAV) Pick and Drop

Jiger Jain
jiger13@gmail.com

Manoj More
manoj.m.more@gmail.com

***Abstract*—Helicopter design has been the center of attention since the beginning of the 20th century. First full-scale four rotor helicopter (quadrotor) was built by Debothezat in 1921 [1].Other examples are Breguet Richet helicopter, Oemnichen helicopter, Convertawings Model A and Curtis Wright VZ-7.[2], [3] In the recent years the world has seen a astonishing ascendance of non tripulated vehicles, and among these is the quadrotors, aircrafts or quadcopters. These types of aircraft have been of particular interest due to its easy maneuverability in closed and open spaces and somewhat simplified dynamics. Quadcopters are the next form of helicopters having more dynamic stability than helicopters. Hence its miniatures are adapted as Unmanned Aerial Vehicles (UAV).[4] This paper is the study of using neural networks and fuzzy logic for PID control of quadcopter which is to be used for pick and drop service for any food, packaging or newspaper industries.[5]**

I. INTRODUCTION

The foremost objective of this project is to make a device which can serve as product for many small scale as well as large scale industries for the enhancement in their services and fulfill needs of customers.[6]

Quadcopters are 6 degree of freedom unmanned aerial vehicles (UAVs) which generally use 4 rotary blades for propulsion. Compared to other UAVs, quadcopters have the advantage of increased stability while hovering (in comparison to controlled helicopters) and maneuverability in close quarters or tight turns. [7] Drone services and their implementations have been around the corners of world from past couple of years. Their ease of access, traffic free roaming, fast and time saving features are some highlights of this technologies. Looking at the current emerging technologies and delivery services offered by vivid companies, their statistics and rate of delivery are of great concern. In order to cope up with the current market scenario we can make use of above mentioned technologies for the benefit of society and business models. Unmanned air vehicles (UAVs) are increasingly being used in areas where manned aircraft are too dangerous, costly or difficult to deploy. In addition to well publicized military applications they can be used in many civilian areas such as search and rescue, monitoring of forest fires, traffic congestion monitoring, aerial surveys, sensing of airborne pollutants, railway track inspection, police and security surveillance.[8] Our solution aims at merging drone technologies to provide quick delivery services, to banner various entertainment products and to make students learn the available aerial drone technology.

II. QUADCOPTER MOTION STUDY

A. Statics

In order to develop a safety procedure to avoid collision with objects, the dynamics of the Quadcopter must be analyzed. It is important when the system detects an object to give a series of outputs that will make the vehicle to avoid it without creating unsteady flying dynamics. Usually, Quadcopters collide in the direction of motion because of the difficulty of maneuverability. For this reason, only that type of analysis will be developed in this document. To start the Quadcopter analysis, the static study is pertinent in order to understand how the forces and moments of inertia cancel each other. The sum of the forces in the vertical direction must be equal to zero. This means that the thrust created by all the helices must equal the weight of the vehicle in order for it to remain stationary in the direction of gravity. Figure 2 is a drawing of a Quadcopter as seen from the front plane. As shown, Figure 2 only has two helices for easiness of visualization.[9]

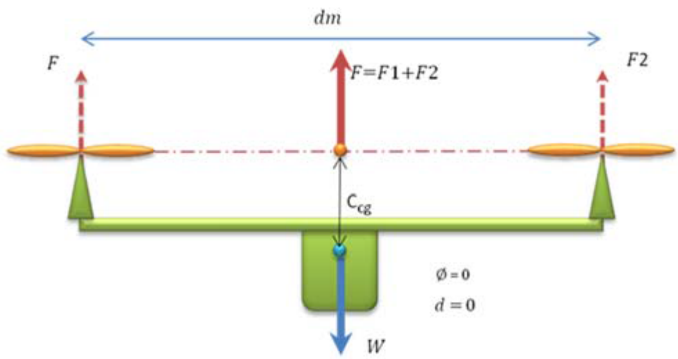

Fig. 1. Quadcopter Static Equilibrium

B. Dynamics

Next, it follows to analyze the moment created by the spinning helices. As known, every spinning object has a rotational moment of inertia. For this reason, in order to cancel the torque created by changing the velocities of the helices, it is needed for two pairs of helices to rotate in a different direction. This can be appreciated by Figure 2. Making all the helices rotate in the same speed will create static equilibrium. On the other hand, by increasing the velocity of the helices in the x axis and decreasing the velocities of the y axis will create torque by the axis of the center of gravity. This will make the Quadcopter to rotate. This can be done in a way that the sum of the forces is equal to the weight of the vehicle in order to not change in elevation.

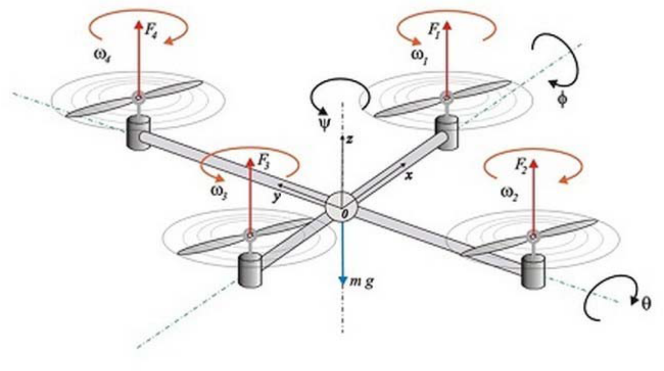

Fig. 2. Direction of Forces and Velocities

Now that static analysis is explained, it follows to make the dynamic study. Usually, there are two flying dynamics that Quadcopters use. The + and the X configuration this two configurations can be appreciated in Figure 3. The flying characteristics between the two are different, but the principle is the same. On the + configuration and using Figure 5 as a reference, by increasing the thrust in the left and reducing it on the right will create a moment about the green axis. This moment will make the vehicle to tilt to the right at an

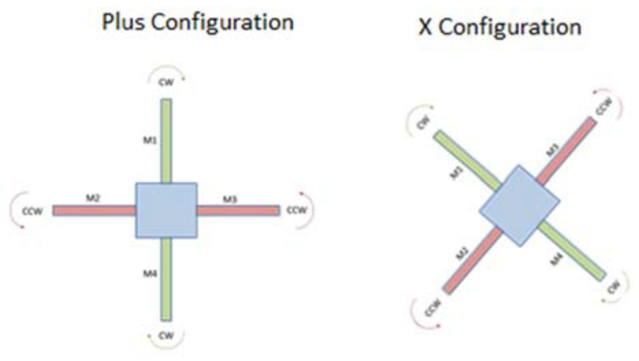

Fig. 3. ”X” vs. ”+” configuration

angle making the thrust to be on that same direction. This thrust will then have components in the vertical and horizontal plane, making the Quadcopter to move to the right but not to increase in elevation. Figure 4 is a graphical representation of this principle. However, the difference in thrust force must be by the same amount in order to balance the vertical loading as well as the moments of inertia in the helices so the device does not spin about the center of gravity. This flying configuration will be used if the obstacle is predominantly closer to a blade, as shown in Figure 6.

For the X configuration flying dynamics, the rotation of the vehicle is not predominantly in a specific axis. Instead, it is at a 45 degree angle. Referring again to Figure 6, in order for the Quadcopter to move to the right, both helices of the left side must create a higher but equal thrust force.

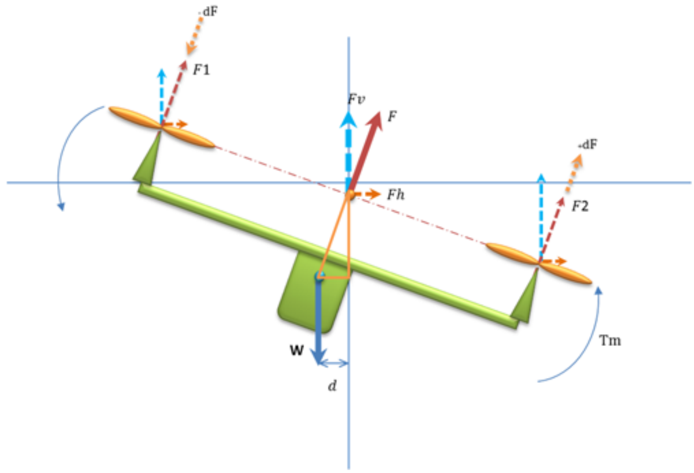

Fig. 4. Forward Motion

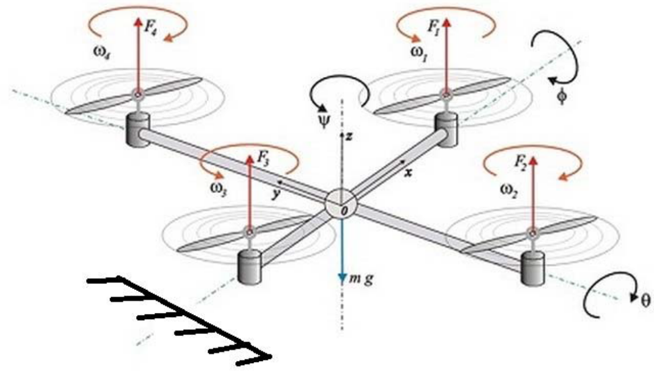

Fig. 5. ”+” configuration obstacle

The helices on the right on the other hand, must reduce the force so the vertical components are equal to the weight of the device. This create force component to the right making the device to move. Since both pairs decrease and increase by the same amount, the torque about the direction of gravity is zero. This configuration will be adopted if the obstacle is close to a complete side of the Quadcopter. As shown in Figure 7.

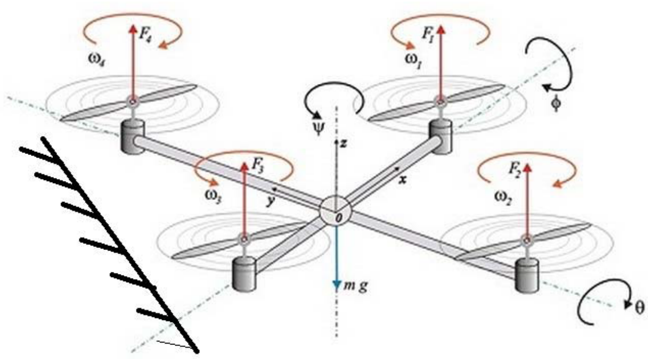

Fig. 6. ”X” configuration obstacle.

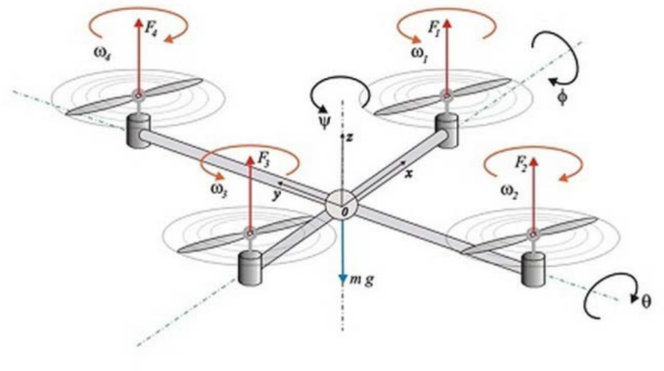

Fig. 7. Mathematical Model

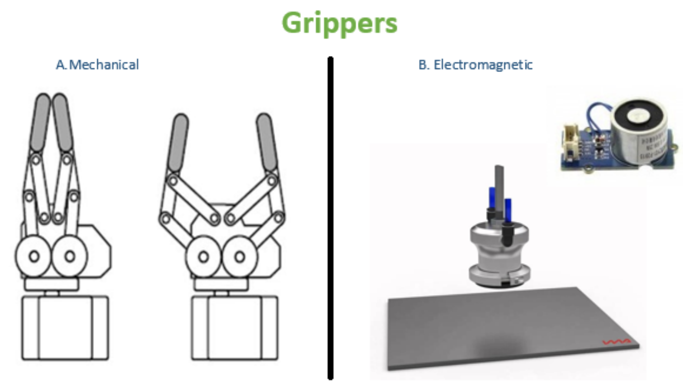

Fig. 8. Grippers

III. Methodology Adapted

The PID control method is an algorithm used in the stabilization of a signal input, which may be used in the application of a quadcopter to stabilize the quadcopter according to a certain reading, such as its altitude.[10] Using this method, a desired speed or position is set in the programming of the quadcopter. Sensors are used to measure the actual speed or distance and an error e is calculated.

$$(1a) \quad e_i = (v_{desired}) - (v_{measured})_i$$

$$(1b) \quad e_i = (x_{desired}) - (x_{measured})_i$$

The motor response u(k) is then altered according to three parameters P,I, and D which can be set constants or be variable for rapid response and stability.[10]

$$(2) \quad u(k) = K_p e(k) + K_I \sum_{i=0}^{k} e(i) + K_D(e(k) - e(k-1))$$

The Kp term modulates the signal according to the error in measurement, while the KI term relates to the sum of recent errors and Kd corresponds to the rate at which the magnitude of the error has changed. The purpose of this method is to have a diminishing and minimum error within a certain time. The time and precision in which the quadcopter stabilizes depends on the initial values given the PID terms.[11]

A. Gripping mechanisms used

We have used two methods to facilitate our gripping mechanism First is by using mechanical gripper and second is using electromagnet. The working of mechanical gripper involves servo movement which turns mechanical energy into gripping mechanism. Whereas electromagnet uses electromagnetic principle to become a magnet and use it to grab the required object.

B. Software Implementation and computation

We used MPU6050[12] IMU sensor which gives six degree of freedom[8].It has inbuilt accelerometer and gyroscope.[13], [14] By using this we were capable of flying the quadcopter perfectly. Using the raw data of this sensor (Figure 9) we calibrated the stable position as can be seen in the figure 10. This made us capable of setting the initial value. Thus stabilize our quadcopter so that in can hover properly in air.[15], [16] The look-up table for different readings have been made and analyzed in order to get our Proportional, Integral and Differential gain values used in code.[8]

IV. Results

Following table gives an idea regarding gyroscope initial state value and its offsets.[14] These values are used to make the stabilization calculations and set the Proportional, Integral and derivative gain values.

State	Gx	Gy	Gz
Initial State	46.07	49.95	-39.90
Offset	-46.07	-49.95	+39.90
After Calibration	0	0	0

Table 1 : Offset calculation

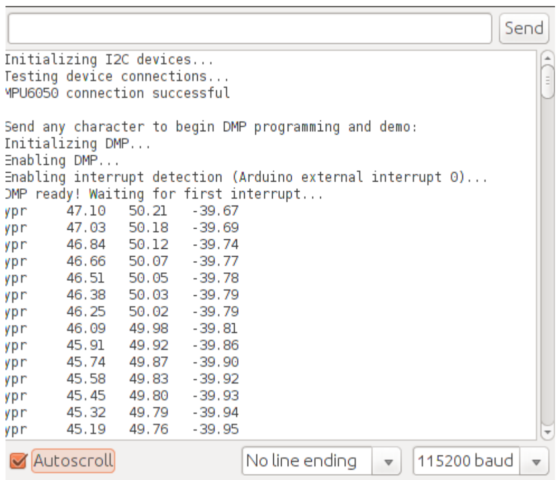

Fig. 9. Raw data

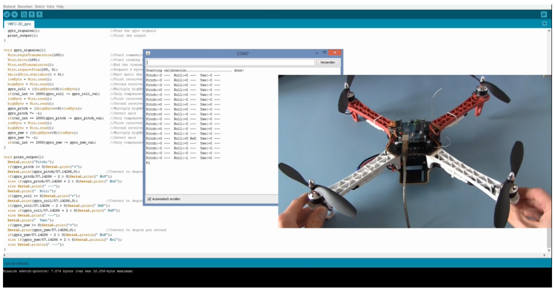

Fig. 10. Stabilization

V. Components Used

Parts	Quantities
Propellers	4
BLDC motors	4
ESCs	4
KK microcontroller board	1
Battery (Li-po)	1
Charger	1
Transmitter(75 MHz/ 2.4GHz) 4/6/8 channels	1
Receiver(75 MHz/ 2.4GHz)	1

Table 2: List of Major Components[17]

VI. Conclusion

The project is an manual drive device which is been used for delivery services and can be used for surveillance too. The gate of opportunities is wide open in this scope and the limit to number of applications is sky.

VII. Future Scope

The project concentrates on delivery of services and to reach a new level we can implement automation of drone and maintain a database of customers and their locations, by using google navigation system and GPS device we can have full proof delivery service.[18]

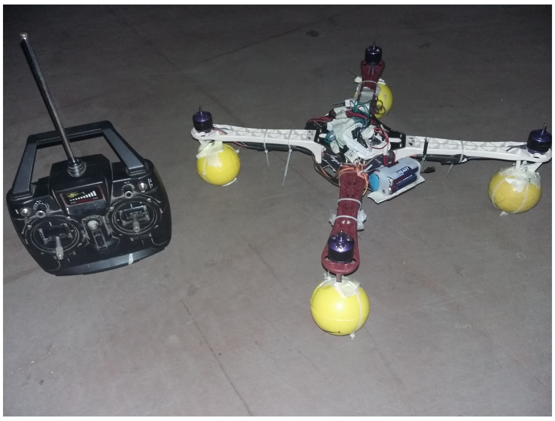

Fig. 11. Project appearance

VIII. Acknowledgment

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