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"Design & Development Analysis of Quadcopter"

Parag Parihar[1], Priyanshu Bhawsar[2], Piyush Hargod[3]

Final Year Department of Mechanical Engineering

Mandsaur Institute of Technology, Mandsaur (M.P.)

Abstract: UAVs are widely used in military operations as well as industries nowadays because of their reliability, cost effectiveness and multi-functionality. Stage, research have been made on quadcopter by worldwide researchers. Thispaper describes the study of the each components of the Quadcopter and analysis of the Quadcopter's assembly with concept of the thrust.This means going through the process of researching previous models, performing calculations, purchasing individual parts, testing those parts, designing the final product. Experimental results show the improvements of the stability of Quadcopter. Our news and features will cover developments in quadcopter technologies, innovative uses for quadcopter and how quadcopter use will impact society.

Keywords: Quadcopter, balancing, drone, multi-rotor

I. Introduction

Drone stands for Dynamic Remotely Operated Navigation Equipment. A Drone, also called a Quadcopter, is a multirotor helicopter that is lifted and propelled by four rotors. Most of helicopters, Quadcopters use two sets of identical fixed pitched propellers; two clockwise (CW) and two counter-clockwise (CCW). These use variation of RPM to control lift and torque. Control of vehicle motion is achieved by altering the rotation rate of one or more rotor discs, thereby changing its torque load and thrust/lift characteristics by using a microcontroller. A Quadcopter is a helicopter with four rotors, so it's also known as quadrotor. Because of its unique design comparing to traditional helicopters, it allows a more stable platform, making Quadcopters ideal for tasks such as surveillance and aerial photography. And it is also getting very popular in UAV research in recent years.

Quadcopter, also called unmanned aerial vehicles (UAVs), have no human pilot onboard, and instead are either controlled by a person on the ground or autonomously via a computer program. These stealth craft are becoming increasingly popular, not just for war and military purposes, but also for everything from wildlife and atmospheric research to disaster relief and sports photography. Drones are becoming the eyes and ears of scientists by surveying the ground for archaeological sites, signs of illegal hunting and crop damage, and even zipping inside hurricanes to study the wild storms.You can even rent a personal drone to soar above the horizon and snap a photo or video. Our news and features will cover developments in drone technologies, innovative uses for drones and how drone use will impact society.

Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of revolving narrow-chord airfoils. Unlike most helicopters, Quadcopters generally use symmetrically pitched blades; these can be adjusted as a group, a property known as 'collective', but not individually based upon the blade's position in the rotor disc, which is called 'cyclic' (see helicopter). Control of vehicle motion is achieved by altering the pitch and/or rotation rate of one or more rotor discs, thereby changing its torque load and thrust/lift characteristics.

To plan and build a Quadcopter there is a lot of terms you need to understand. To give you a better understanding of what a Quadcopter contains I will now go through some of the parts it contains.

II. Literature

Review Stage Many research have been made on quadrotor by worldwide researchers.

The website of abc NEWS posted an article by Rheana Murray on 8th August 2014,headlined, "How Drones will Replace Humans in the Workplace" to which Mary Cummings, a drones expert who teaches at MIT and Duke University says, "Maybe if you are a cargo pilot for FedEx or UPS, drones will augment the delivery world and one could argue that they would be much more environmentally friendly since they could take cars off the road for last mile delivery and help reduce congestion." She further adds, "Jobs like delivery for which cargo planes are used currently and crop dusting should be turned over to drones immediately. Crop dusting is the most dangerous job in general aviation with a high accident rate. Drones can not only do that job better, but much safer. This will happen in the next 10 to 20 years. Ultimately, drones will create more jobs than they replace, they will save lives, and they will give us capabilities we only dream about – like everyone owning our own flying cars."

In a website known as www.farmingdrones.com, an article headlined "Farming Takes Flight Drones save IL Farmers Time and Money was posted. It explains how drones are used in agriculture to give a crystal clear view of their fields. Dennis Bowman, a crop sciences educator with the University of Illinois Extension, is using two drones to take aerial snapshots of crops in the research plots on the university's South Farms. He says,"It offers a quick and easy way to check on the plants" progress and determine if they need more attention. It does allow the opportunity to get an overall survey of the area and make a better use of your time, rather than just walking out blindly into a field of corn that's taller than your head, and hoping that you stumble across any of the problem areas that might be out there. People think about drones and a lot of times, the negative connotations come to mind, privacy issues and those kinds of things. But in the agricultural community, we are out in the middle of nowhere most of the time,flying them over fields of crops". He further says that the agriculture industry is expected to be one of the largest markets for drone usage.

The practical use of a quad copter was cited in New Zealand to examine the front of the Roman Catholic Cathedral in Christ church that was damaged in the 22 February, 2011 earthquake.

III. METHODOLOGY

3.1 PRINCIPLE OF QUADCOPTER

Quadcopter is a device with an intense mixture of Electronics, Mechanical and mainly on the principle of Aviation.

As stated it Sir Cayley to maintain a plane in flight, These 4 principal forces operating the plane in flight are schematized on the figure below.

Two of these forces are generated by the relative movement of the air compared to the plane. The first one is the lift. This force is directed upwards and is acting perpendicular to the displacement of the plane. It is thanks to this force that the plane is maintained in the air. The second is the drag. It is exerted in the direction opposed to the displacement of the plane. It is due to the breaking action of the air on the plane and is opposed to the advance of the plane. The lift and the drag are called aerodynamic forces because they are resulting from the action of the air due to the displacement of the airplane.

The force due to gravity, the weight of the plane, is opposed to the lift. The balance of the lift and the weight leads to the fact that the plane is maintained at constant altitude. To ensure that the plane continues to move forward, it is necessary to provide a force that compensates for the force called drag. This force is called the thrust. The thrust is generated by the system of propulsion of the planes, the engines. In the case ofthe flight at cruising speed, the role of the engine is thus to compensate for the force of drag, but not to make the plane climb. On the other hand, at the time of takeoff, the engine power will be used to bring the plane to the altitude of flight.

To keep the plane in flight at constant altitude, a force of lift must balance the force due to gravity (weight of the plane).

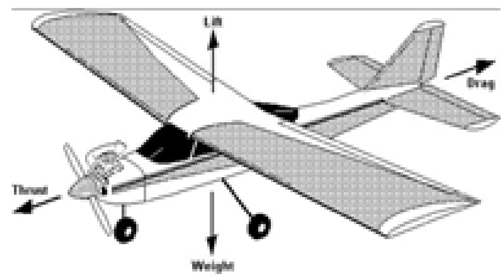

FIG: Forces acting on a flying plan

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3.2 CONSTRUCTION

Quadrotor consisting of a main body having four arms centrally connected to each other and four DC brushless motor attached to each free end of arm. Quadrotor consists of four rotor/propeller attached to each motor shaft. Four rotors with fixed angles represent fixed pitch to generate equivalent force at each end to lift the body and payload. All DC brushless motors are attached to electronic speed controller to control speed of each individual motor. Four electronic speed controllers connected with each other by parallel connection in to power distribution board. A battery is used as power source. The rotation of propeller is controlled by remote controller (RC).

3.3 THEORY

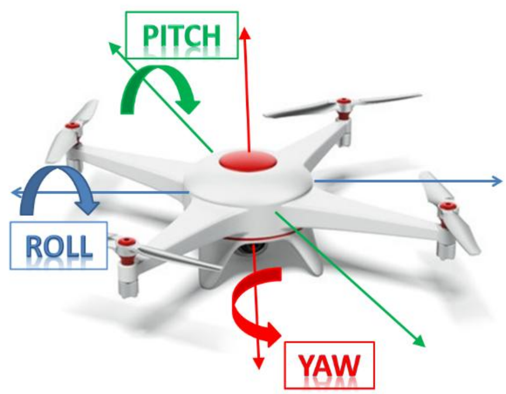
All DC brushless motor attached by parallel connection with other motors. Power distributed to power distribution board from battery. Further the power distributes equally to four electronic speed controllers and then goes in to each DC brushless motors. Accelerometers will measure the angle of Quadrotor in terms of X, Y and Z axis and accordingly adjust the RPM of each motor in order to self stabilize by it-self. The stability is provided by setting the direction of rotation clockwise of one set of opposite motors and counter-clockwise of other set of motors which nullifies the net moment and gyroscopic effects.

3.4 Quadcopter Movement Mechanism

Quadcopter can described as a small vehicle with four propellers attached to rotor located at the cross frame. This aim for fixed pitch rotors are used to control the vehicle motion. The speeds of these four rotors are independent. By independent, pitch, roll and yaw attitude of the vehicle can be control easily. Pitch, roll and yaw attitude off Quadcopter are shown in Figure

Yaw Motion (ψ): Rotation around the vertical axis is called Yaw.The Rudder controls Yaw (Left and Right).

Pitch Motion (ɵ): Rotation around the side-to-side axis is called Pitch i.e. Moving Upside and Downside about horizontal axis. The Elevator controls the Pitch.



Roll Motion (Φ): Rotation around the front-to-back axis is called **Roll** i.e. Tilting about the axis.The Ailerons controls Roll axis (Left and Right).

Take-off and landing motion mechanism

Take-off is movement of Quadcopter that lift up from ground to hover position andlanding position is versa of take-off position. Take-off (landing) motion is control byincreasing (decreasing) speed of four rotors simultaneously which means changing thevertical motion.

Forward and backward motion

Forward (backward) motion is control by increasing (decreasing) speed of rear (front)rotor. Decreasing (increasing) rear (front) rotor speed simultaneously will affect thepitch angle of the Quadcopter.

Left and right motion

For left and right motion, it can control by changing the yaw angle of Quadcopter. Yaw angle can control by increasing (decreasing) counter-clockwise rotors speed whiledecreasing (increasing) clockwise rotor speed.

Hovering or static position

The hovering or static position of Quadcopter is done by two pairs of rotors are rotatingin clockwise and counter-clockwise respectively with same speed. By two rotorsrotating in clockwise and counter-clockwise position, the total sum of reaction torque iszero and this allowed Quadcopter in hovering position.

3.5 COMPONENTS

Flight Controller

The flight control board is the 'brain' of the Quadcopter. It houses the sensors such as gyroscopes and accelerometers that determine how fast each of the Quadcopter's motors spin. Flight control boards range from simple to highly complex. This Flight controller KK 2.1.5 is the latest one and program is pre-installed in it.

The flight control board is regarded as the "brain" of the Quadcopter. Flight control boards range from simple to highly complex.

DC Brushless Motor: This is a high power motor with excellent efficiency. Motors are rated by kilovolts, and the higher the kV rating, the faster the motor spins at a constant voltage. The purpose of motors is to spin the propellers. Brushless DC motors provide the necessary thrust to propel the craft. We use 1000 KV motors.

Propellers

We are using two types of propeller Pushers and Pullers:

Pushers: Pushers give thrust when they are rotated in clockwise direction.

Pullers: Pullers give thrust when they are rotated in anti-clockwise direction.

The propellers come in different diameters and pitches (tilting effect). The larger diameter and pitch is, the more thrust the propeller can generate. It also requires more power to drive it, but it will be able to lift more weight. When using high RPM (Revolutions per minute) motors, the smaller or mid-sized propellers.

When using low RPM motors the larger propellers can be used asthere could be trouble with the small ones not being able to lift the Quadcopter atlow speed. The size of propellers given as 10*4.5.

Electronic Speed Controller (ESC): The electronic speed controller controls the speed of the motor or tells the motors how fast to spin at a given time. For a quadcopter, 4 ESCs are needed, one connected to each motor. The ESCs are then connected directly to the battery through either a wiring harness or power distribution board.

Electronic Speed Controller (ESC) is an electronic circuit to vary the speed, direction and possible to act as a dynamic brake, of abrushless Motor. The maximum current flowing in the ESC is in between the range 30-40 ampere.

Battery (LiPo): Lithium polymer batteries (LiPo) are most popular for powering remote control aircraft due to its light weight, energy density, longer run times and ability to be recharged. We selected zippy 4000mah, 11.1 V, 3 cell, 20 C battery.

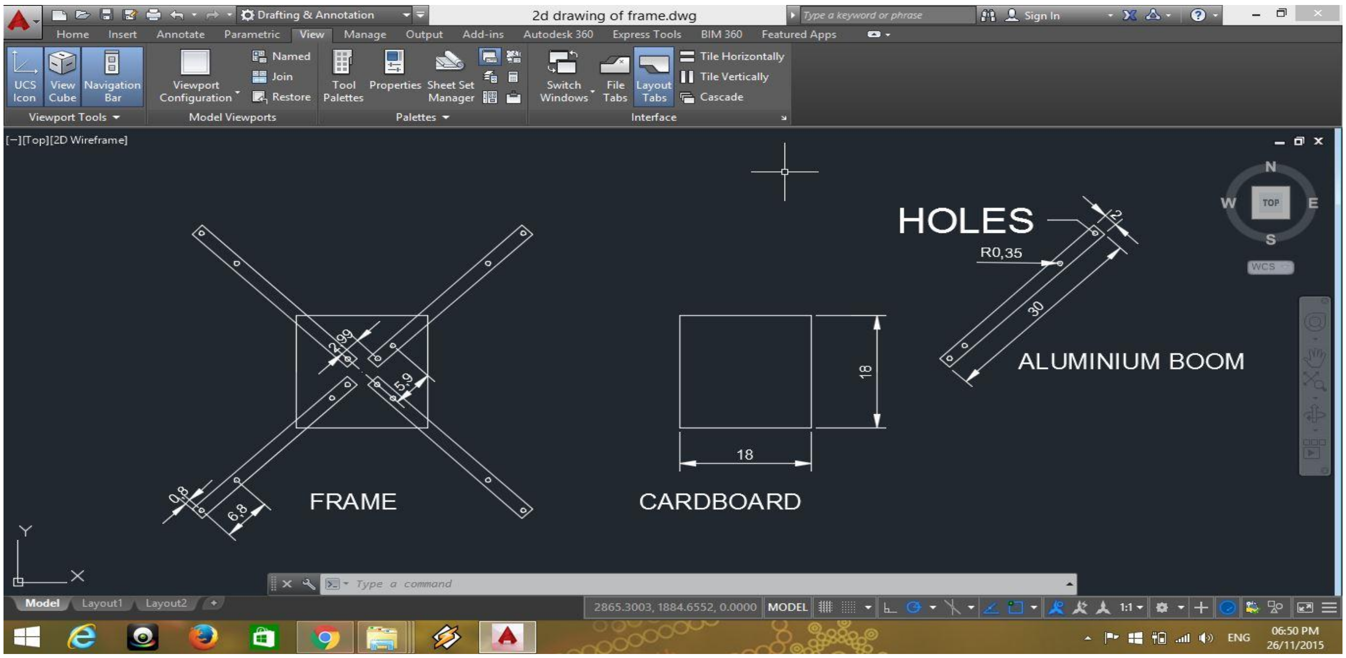
Transmitter & Receiver

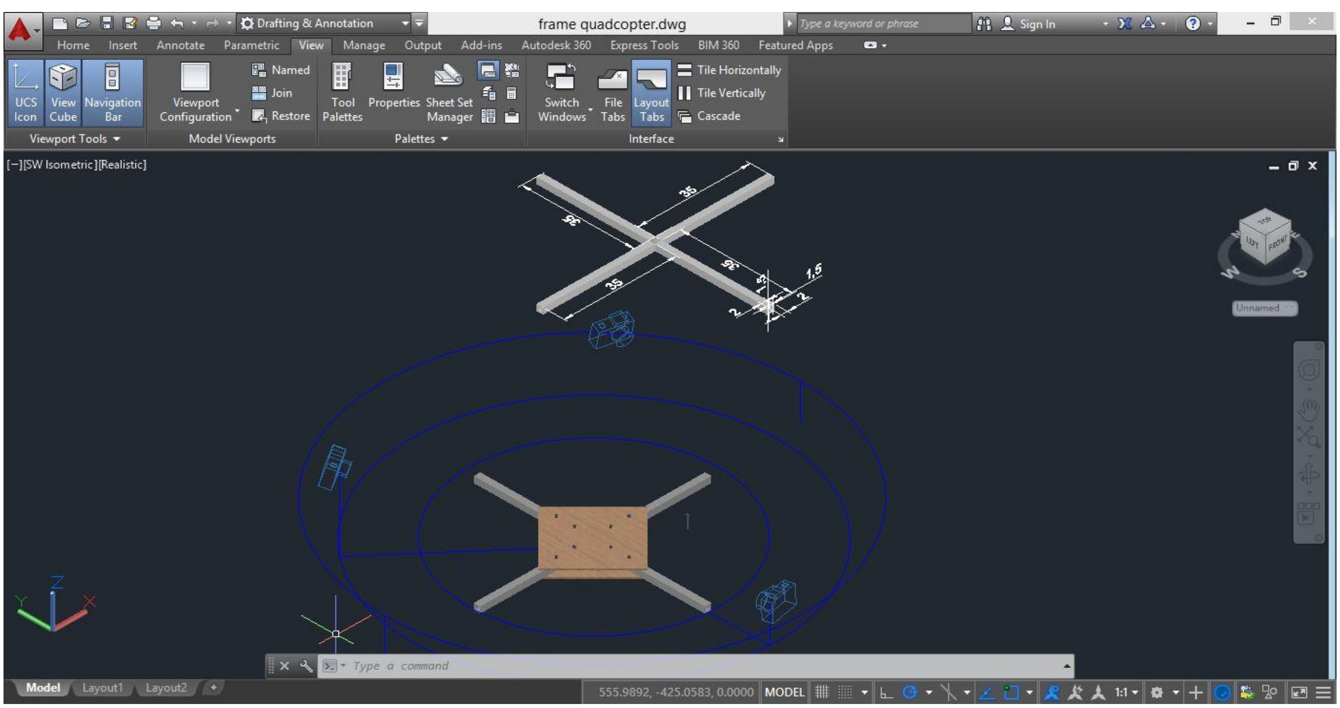
This transmitter can be used on any of your planes and with a LCD display screen you can now program the radio at the field and no more to carry your laptop to the field to change any setting. The RCB6i has all the features and more than any high end radio but at a fraction of cost.

Some of the unique features of this radio are

- Interchangeable from mode 1 to mode 2 with the use of a Slider at the back of the radio
- Remote range test (you don't have to walk a kilometre to find out the range of your receiver)
- Variable transmission power (for indoor and outdoor)

3.6 FRAME DESIGN AND CONSTRUCTION





3.7 Introduction of Data Recorded

Cutting and filing the hollow aluminium rods(Booms). Balancing the Parts of Quadcopter Frame: Balanced the four aluminum rods and landing gears, its sizes and most important of all about is the weight of this aluminium rods we have balanced it and kept all 4 rods weight 68 gm.

- Length of rod = 20 cm each
- Length of landing gears = 9.3 cm each

Assembling the Frame after balancing its parts

Specifications:-
Cardboard
Size = 10.5cm×10.5cm
Thickness = 0.5cm

Aluminium Boomseach
Size = 10cm×2cm
Weight = 17gm each
Thickness = 0.1cm

Aluminium Boom hole from outside corner
1st hole = 0.8cm in each
2nd hole = 6.8cm in each

Aluminim + Cardboard hole from center of inside aluminium end
1st hole = 2.99cm in each
2nd hole = 5.99cm in each

IV. RESULT & ANALYSIS

How to select Esc (Electronic Speed Controller)

According to battery Specification = 4000mah
For the proper selection of Esc we must know the capacity of battery in mah and how much it's C rating. C rating means maximum safe charging
Since in our specification, theC rating is 20C
Therefore, 20C = 20 * 4 = 80 A
So its maximum safe current flow is 80 A. If current flow in Esc is more than 80 A then motor will be blasted.
So we analysis that the Esc should be less than 80 ampere and we select our Esc is 30 – 40 A.

How to select frame size

For selecting the size of frame, it is necessary that the size of the propeller should be known.
Propeller size is given by the formula,

$$= n \times m$$

Where,
n = Diameter of propeller in inches
m = Pitch of propeller in inch
i.e. Pitch is how many moves in one rotation

Since our propeller size is 10×4.5, so the diameter is 10 i.e. radius is 5
According to the formula given as,
X = 2.R (radius of Propeller)

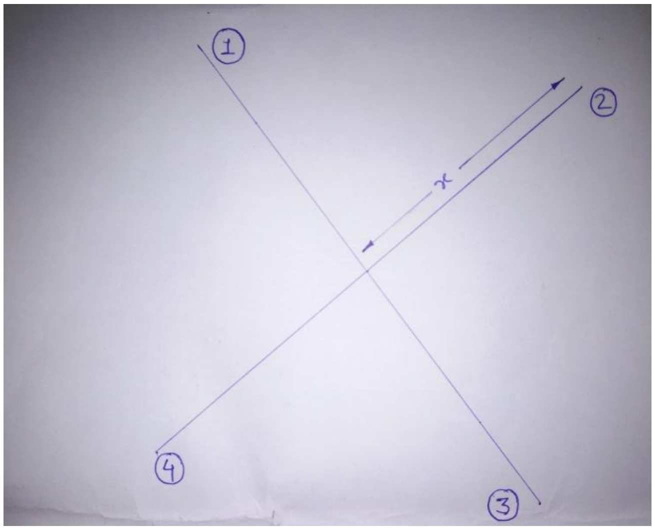


Figure 3.1 Size selection of frame

X = 2×5 = 10 cm
So we have selected the total length of rod 2×10=20cm as we have discussed above.

How to Calculate Thrust to weight ratio

Required Thrust per motor = 1200/4 =300 g

(Total Thrust on Quadcopter) = 1200 g

Total weight of the body i.e. Quadcopter=700 g

The condition for lifting i.e. fly of Quadcopter is that the ratio of total thrust of the body to the total weight of the body should be minimum 1.5,

As according to our calculation,

Total Thrust/ Total weight = 1200/700 = 1.7

It is right from our analysis result that it is ready to fly the Quadcopter.

V. CONCLUSION

Quadcopter will soon take on be an imperative existence in the coming future. They will be seen taking up larger roles for a variety of jobs including business in the immediate future They could become a part of our daily lives, from smallest details like delivering groceries to changing the way farmers manage their crops to revolutionizing private security, or maybe even aerial advertising.

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