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THOMSON REUTERS

[Ratra* *et al.*, 6(5): May, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN AND DEVELOPMENT OF QUADCOPTER FROM SCRATCH

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DOI: 10.5281/zenodo.573511

ABSTRACT

Quad copter can achieve vertical flight in a stable manner and can be used to monitor or collect data in a region such as loading mass. The project goal was to design the semi-autonomous Quad copter to minimize the cost and develop it from the scratch. This means going through the process of researching previous models, performing calculations, purchasing individual parts, testing those parts, designing the final product .In this we initially decided how big we want the quad copter and then we made necessary calculation based on the previous research work to calculate the size of propeller ,capacity of motor .In this project a simple approach is being used to design and develop quad copter using a flight controller (KK flight controller board). The input for the controller board is through a receiver mounted on the quad copter which takes input from the user using a transmitter. In the project we have used 2.4 GHz transmitter due to the fact that it is a free frequency and data loss at this frequency is minimum. Flight controller board in response to it controls the speed of the brushless dc motor using an electronic speed controller.

INTRODUCTION

A quadrotor is a helicopter (quadcopter) which has four rotors spaced equally from the centre of mass, usually arranged at the corner of a square body. Quadcopter are classified as rotorcrafts, as opposed to the fixed wing aircraft because their lift is generated by set of vertically oriented rotors. The quadcopter platform is built with integration of electronic and mechanical system.Quadrotors symmetrical design allows for easier control of the overall stability of the aircraft .In this we use “X” configuration of the frame so the controlling ,maneuverability of the quadcopter is much easier .Quadcopter consist of four rotors of same pitch propellers :two in clockwise and two in counterclockwise.

Quadcopter consist of six degree of freedom (three translational and three rotational) and only four independent inputs (rotor speeds), so quadcopter are seriously underactuated. In order to achieve six degree of freedom rotational and translational motions are coupled. Since these aerial vehicles have very less friction in their motion so there is requirement of some damping in order to stop moving and be stable which is achieved by using PID controller. (1)

The basic concepts of flight mechanism are as follows:

[1] Yaw (turning left and right) is controlled by turning up the speed of regular rotating motor and taking away the power from counter rotating motor , by this no extra lift will be produced by the motor ,but since the torque from one motor is less and one is more which will make quadcopter rotate
[2] Roll (tilting left and right) is controlled by increasing speed on one motor and lowering that of opposite one
[3] Pitching (moving the nose up and down) ,it is done in the same way as roll but using the another set of motor

To roll or pitch, one rotor’s thrust is decreased and the opposite rotor is increased by the same amount resulting in the tilting of the one rotor due to which the force acting on the copter is split into two parts horizontal and vertical.

Resultant of the splitting there are two actions: Firstly, there is small decrease in the altitude of the rotor due to small vertical component causing the quadcopter to fall, in order to compensate thrust from each rotor must be

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increased to compensate from the height. Secondly, quadcopter will begin to travel opposite the direction of newly created horizontal component.

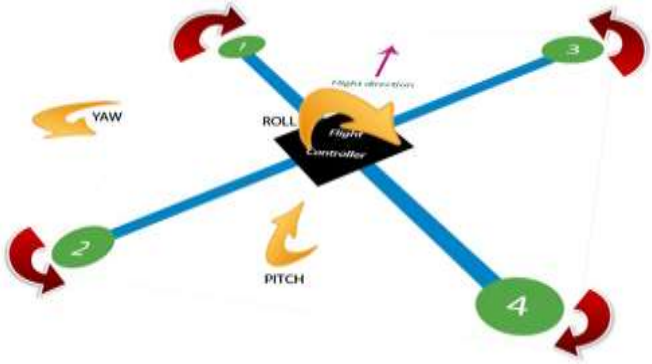

Figure: Mechanism of Quadcopter

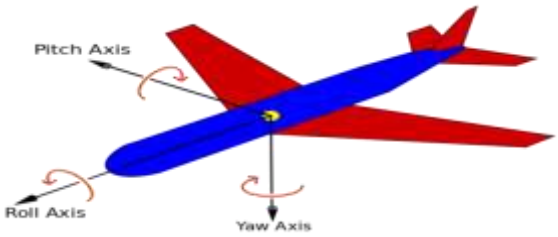

Fig: Notation for movement in 3D [4]

The components of Quadcopter are hollow aluminum pipes, wood, **AX-2306N-1300** brushless motor, Turnigy Plush 30A Electronic Speed Controller, Flight controller KK v2.0 board, propeller 8x4, 2.4GHz receiver, Sponge balls and transmitter and 3-cell 2200mAh 25C LiPo Battery.

II.PID Configuration

In order to control the Quadcopter we use PID control due to their simplicity and ease of implementation .They also omit the steady state error often experienced by PD controller. The given experiment uses KK v2.0 controller in order to stabilize and controlling the quadcopter. The input for the quad is being received by the receiver and from the user via transmitter. The receiver is further connected to the flight controller board in order to perform the required action and also stabilize the quad copter. (2)

LAYOUT

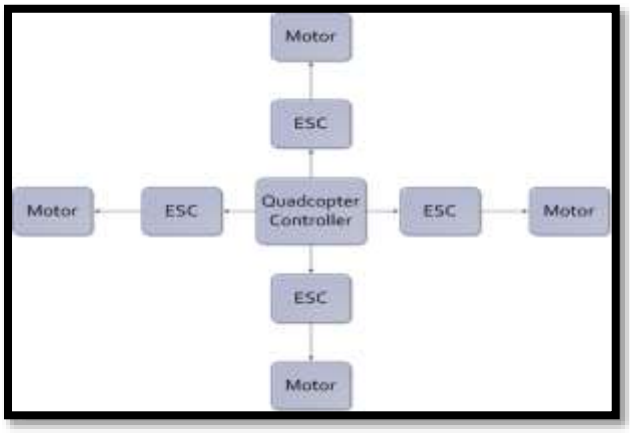

Figure: Basic Layout

In the quadcopter flight is controlled by the flight controller (KK controller board) by altering the speed of the brushless dc motor, in order to achieve the action for lifting and the turning mechanism, these ESC (input side)

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are directly connected from the battery and is also connected to the flight controller and (at output) are connected to the brushless dc motor. Sponge balls are connected to the base of each arm of the quadcopter for shock absorbing purpose.

DESIGN METHODOLOGY

SENSOR SELECTION

Attitude determination systems normally consist of gyroscopes, accelerometers and magnetometers, whereat a device, containing gyroscopes and accelerometers, is commonly called Inertial Measurement Unit (IMU). A gyroscope is a device used primarily for navigation and measurement of angular velocit.3-axis gyroscopes are often implemented with a 3-axis accelerometer to provide a full 6 degree-of-freedom (DOF) motion tracking system. Gyroscopes have evolved from mechanical-inertial spinning devices consisting of rotors, axles, and gimbals to various incarnations of electronic and optical devices.

BRUSHLESS DC MOTOR

Brushless motors have more torque per weight, more efficiency, reduced noise factor, reliability, longer life span, more power and overall reduction of electromagnetic interface.

PROPELLERS

Propellers transducers the rotary motion to aerodynamic lift forces. Two pair of counter rotating propellers make the aerodynamic torque is zero. We will be using 8 inch diameter with a pitch of 4.8 inch/revolution.

Electronic speed control (ESC)

An ESC controls the brushless motor by converting the supplied DC from the battery into three phased AC. ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake**.**

Battery (Li-Po)

Lithium polymer batteries (Li-Po) are increasingly popular for powering remote control aircraft; due to light weight, energy density, longer run times and the ability to be recharged.

Microcontroller selection

In order to gather information from the sensors, interpret the data and send the appropriate control signals to the actuators a microcontroller is needed. Searching for the right controller to be interfaced with other components, we came across Arduino Uno which is a user friendly microcontroller board.

Lippo alarm:

A Lippo alarm is an audible and visual alarm that plugs in to your battery to provide a voltage warning when in flight. This is necessary to know when to land your craft prior to engine failure due to low batteries. (3)

V. Calculations

Weight of motor =4*40gm=160 gm
Weight of Li-Po battery 3 cell =120 gm
Weight of controller (1 board) =14.5 gm
Weight of 4 ESC =64 gm
Weight of Sponge Ball =60 gm
Weight of Frame =200 gm
Total weight =618.5 gm + Weight for additional props =1050 gm
Total thrust required from motor =1050*2 =2100 gm
Thrust to be produced by each motor =2100/4 =525 gm
Voltage from battery =3.7*2 =11.1 V
Voltage to controller =5 V
We used plastic propeller of size 8*4
For which motor is used of size 80 W and speed 9800 rpm.

ESCs

Since Input to motor = 10 A
So ESCs required will be
Input =5V, 2A
Output =10A

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So we used ESCs of 10 A .

Frame

Radius of propeller =4 inch =4*2.54 =101.6 mm
For both propeller =101.6*2 =203.2 mm
Size of board required (Diagonal) =57 mm
Total length =203.2+57=260.2 mm
Consideration for additional props
Total arm length =520 mm (end to end) (4)

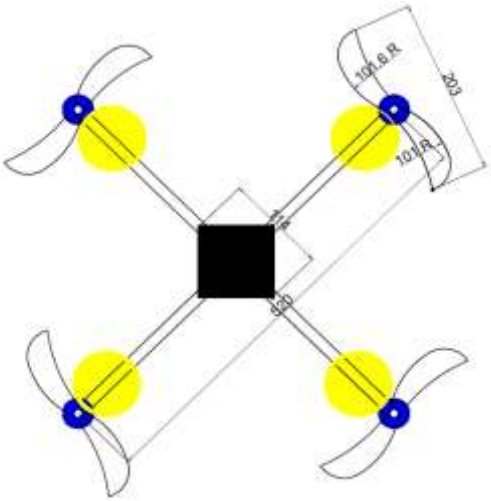

Figure:CAD

Figure:Final Model

APPLICATION

Science and research

They help scientists a lot in research works to observe different occurrences in nature or a particular environment from the sky

Search and rescue

Drones are very useful in searching and rescuing operations. Recently, due to extreme flooding in Texas, Drone use for search and rescue received a great deal of media attention as quad copters were used to search for flood victims.

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Surveillance

A drone allows recording and monitoring from the sky, and therefore, they are suitable to monitor public events, protests or any suspicious happening without being hard heard and seen. A great tool for police and the armed forces where it is difficult to monitor the terrain/

Unmanned cargo system

Drone also serves in delivering of lightweight packages and bundles of all sorts just like in the case of pizza hut in USA. This way, you can have a safe, environmentally friendly and fast transport of goods by air. (5)

CONCLUSION

We started with the use of PID controller and frame made up from the hollow aluminium hollow pipes, we experience difficulty in balancing of the frame and adjusting the gains of the controller. On other hand the benefit of the homemade frame is that it is more durable, tougher and can withstand crash unlike traditional plastic frames. Addition to this

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Ratra, M., & Jain, N. (2017). DESIGN AND DEVELOPMENT OF QUADCOPTER FROM SCRATCH. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(5), 457-461. doi:10.5281/zenodo.573511