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DESIGN AND DEVELOPMENT OF QUADCOPTER WITH PAINT SPRAY MECHANISM

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Abstract - *The research includes the design and development of a Quadcopter which will be equip with paint spray mechanism to do specific marking at precise position on ground. This quadcopter can be used for marking building layout on ground to save time, cost and labours. The course of action is started by doing an estimation of the quadcopter weight. The approx weight is then accustomed to find out what type of major components will be chosen, such as motors, propellers, and other electrical components. Selection of component is completed with contemplation of weight, strength, and cost. After a conceptual design and materials are gathered, all components are accumulated in a frame to test the performance of the quadcopter. The quadcopter completely focused more on functionality of the quadcopter with the contemplation of further studies and development.*

Key Words*: *Design of Quadcopter, Dynamics, motion, paint spray, precision marking

1. INTRODUCTION

A quadcopter is an aircraft heavier than air, capable of vertical take-off and landing, which is propelled by four motors, positioned in the same plane, parallel to the ground. Unlike standard helicopters, a quadcopter uses fixed-pitch blades in its rotors and its motion through the air is achieved by varying the relative speed of each propeller. The first quadcopter was the Omnichen 2, invented in 1920 by Etienne Omnichen. This vehicle made 1000 successful flights and flew a recorded distance of 360 meters. Then the convert a wings model a quadcopter designed by Dr. George E. Bothezat, appeared in 1956.[6] Nowadays there is an incredible evolution in 21st century in quadcopters. To introduce more robust controller and modeling, techniques, Universities, students and researchers are working continuously, so that they can provide detailed and accurate representations of real-life quadrotors. The research includes the design and development of a Quadcopter which will be equip with paint spray mechanism to do specific marking at precise position on ground. The quadcopter is useful for in many situations. In the future scope of quadcopter this might be helpful in other management activity like aerial survey, security petroling 3D building modeling, safty inspection tools and many more others. Practically, quadcopter is being used for object detection through image processing in border security of the nation [4].

2. LITERATURE REVIEW

A. S. Vempati et. Al. (2014), in this research designing and constructing a light-weight quadrotor has developed with enhanced on-board computational control and a various functions. They brief described the functionality of various hardware components used in the fabrication process.[1]

Parag Parihar et.al. (2016), this paper explained the selection of components of quadcopter, the analysis is done with conception of the thrust. This paper gives the detailed process i.e testing the previous model, doing calculation, designing the quadcopter to the purchasing components and assembling those. And here the final product is ready.[4]

Dr. Pran Kanai Saha (2019), They focused on designing the Roll $Troll$(s), pitch $Tpitch$(s) and yaw $Tpitch$(s) angle control system design and simulation of the designed control system. In addition, they were going to integrate android mobile device, GPS and 3G communication technologies to gather real time audio visual geo location information[3]

Vibha Kishor and Ms. Swati Singh (2017), Design and develop a quadcopter using Arduino Uno board instead of pre programmed KK flight Controller board. Quadcopter mounted with camera and GPS tracker could be used for surveillance of wide areas such as forest and coast guard applications etc.[6]

Anudeep M et. Al. (2014), in this paper design and development of quadcopter has been done and some modification in the design of quadcopter frame is also performed to sustain load for that static analysis is done on frame. In the result small deformation happen but which is also within the limit.[2]

Omkar Tatale et. Al. (2018), The design, construction and testing procedure of quadcopter. Design is based on the approximate payload carry by quadcopter and weight of individual components which gives corresponding electronic components selection.[5]

2.1 Working principal

Quadcopter machine works at the principle of air lifting phenomena with excessive pressure. The propellers pressure the air in downward with excessive pressure because of which an uplift pressure is created and as a end result motion response regulation is carried out at the entire device, whilst this uplift force dominates the earth's gravitational pressure, the whole device start flying within the air. But there's a trouble with the rotation of propellers.

If we rotate the propellers in clock clever course then because of this rotation, a torque could be implemented over the complete gadget in one route .And similarly if we rotate the propellers in anti-clock wise direction then also a torque might be produced over the complete machine and the entire machine will start rotating anticlockwise. to triumph over this trouble we rotate two propellers in clockwise direction and ultimate two propellers in anticlockwise course. This phenomenon produces torque in contrary route and that they get balanced and the system stays strong at the same time as flying.

Two fundamental phenomena are used for movement of quadcopter, thrust and torque. Quadcopter uses its 4 propellers attached to a motor which creates thrust and help quadcopter to raise excessive. motion of quadcopter are described primarily based on the enter values (x, y, z, θ, ϕ, ψ) given to it. Out of 4 motor attached with propellers, two motors rotate in clockwise (CW) route at the same time as other in counter clockwise (CCW) direction. movement of quadcopter is consequently managed specially via three moves. those moves are labeled as

1 Yaw Rotation (ψ)

Yaw is defined as motion of quadcopter either to left or right and it is controlled by way of throttle stick of transmitter. Yaw decides the route of quadcopter.

2 Pitch Rotation (θ)

Pitch is defined as the complete motion of quadcopter either in forward course or in backward route. It's additionally managed by using throttle of receiver. moving the throttle in ahead path moves quadcopter in forward direction while transferring throttle backward movements quadcopter in backward direction [2].

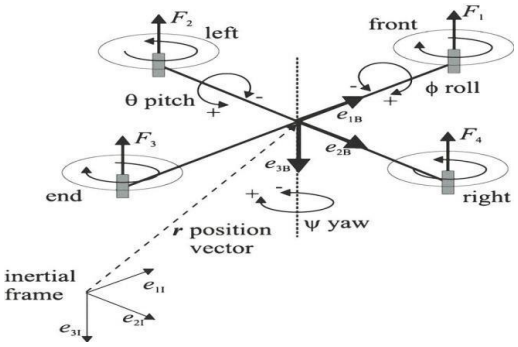

Fig- 1 Yaw, Pitch & Roll rotation

3 Roll Rotation (ϕ)

The movement approximately the longitudinal axis of quadcopter is called roll motion. Left or proper motion of throttle stick is observed via quadcopter, it actions in in the direction of right when throttle move to right and actions to left whilst throttle stick moves in left course. This parameter hence makes quadcopter to fly in left or right direction. [2].

Take-off and touchdown motion mechanism

Take-off is movement of Quadcopter that carry up from ground to hover role and landing function is versa of take-off role. Take-off (landing) motion is manipulate by means of increasing (decreasing) velocity of four rotors simultaneously because of this converting the vertical motion.

Ahead and backward motion

Forward (backward) motion is control via increasing (lowering) velocity of rear (the front) rotor. Lowering (increasing) rear (the front) rotor pace simultaneously will affect the pitch perspective of the Quadcopter.

Left and proper movement

For left and right motion, it may manage by means of converting the yaw attitude of Quadcopter. Yaw attitude can control via growing (lowering) counter-clockwise rotors speed whilst decreasing (growing) clockwise rotor speed.

Hovering or static role

The hovering or static role of Quadcopter is performed via two pairs of rotors are rotating in clockwise and counter-clockwise respectively with equal speed. with the aid of two rotors rotating in clockwise and counter-clockwise function, the overall sum of reaction torque is zero and this allowed Quadcopter in hovering position.

3. METHODOLOGY

The signals may be transmitted from Transmitter and it'll be received by the Receiver inside the drone. From the receiver the signal goes to the Flight controller where the signal might be processed with accelerometer and gyroscope sensors. The processed signal may be despatched to the ESC, which permits the unique quantity of present day to the motor based at the signal it receives. The propellers are mechanically coupled to the automobiles so that they rotate and produce thrust. The FPV digicam takes current supply from the flight controller and it records the video, the video signals might be processed by means of the transmitter and it is going to be received by the receiver in ground. The pump takes modern deliver from the Li-Po battery and pressurizes the liquid from the garage tank then the pressurized liquid flows through the pipeline and enters the nozzle then gets sprayed. The flow price of the pump may be controlled by way of varying the enter current which can be managed from the transmitter.

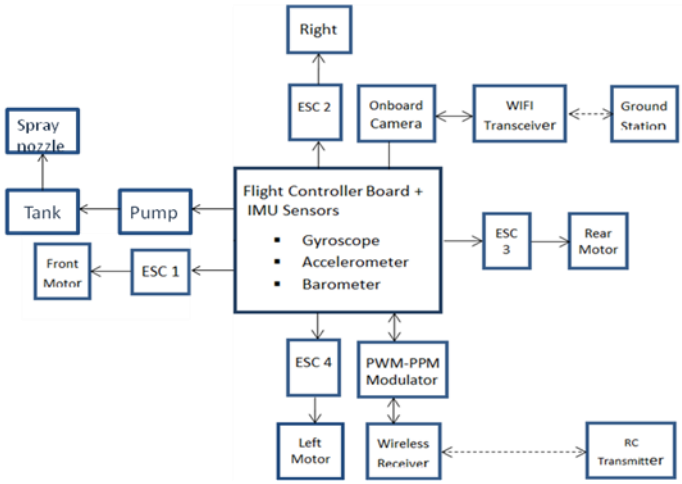

Fig- 2 Block diagram for quadcopter

3.1 Components Used

Propellers

A propeller of size 1045 is used here to build quadcopter. The propellers are used in the quadcopter to develop lifting pressure through high spin of the propellers. The purchased propellers gives 4.5 in pitch in one rotation.

Fig- 3 1045 Propellers

Electronic Speed Controller (ESC)

The commands are given in the form of PWM signals, which are accepted by individual ESC of the motor and output the appropriate motor speed accordingly. ESC convert 2 phase battery current to the 3 phase power and also regulates the speed of brushless motor by taking the signal from the control board. The ESC rating is higher than motor Amp, so

ESC Rating = (1.2 to 1.5) X max. Ampere rating of motor

Fig- 4 ESC 40 Ampere

Battery

Lithium Polymer (LIPO) rechargeable batteries are used for quadcopters because they have high specific energy and light in weight.

Max. Current withdraw by motors = no. of motors X max. Current withdraw by single motor

Fig- 5 LiPo 3s Battery 5200Mah

Motors

The brushless DC motors are generally used for manufacturing the drone. The RPM of the motor can be controlled by varying the input current. This motor MOTOR KV1800 and P1045 propeller produces a maximum thrust of 1500 grams.

Fig- 6 BL Motor 1800kv

Power Distribution Board

The power distribution board is commonly used in the drone manufacturing for transferring the power taken from battery to the ESC's.

Fig- 7 Power Distribution Board

Flight Controller

The flight controller used to control operations and also it presents Auto altitude hold function. The accelerometer and gyroscope sensor in the Flight controller process the signals from the receiver and gives the output to the ESC. It can measure flying altitude, attitude and therefore can be used for autopilot/automatic control.

Fig- 8 Pixhawk V2.4.8 FCB

GPS

The GPS in the quadcopter is used for navigation to the waypoints plotted on preplanned path on map. The configuration in flight control board into the drone remote control navigational software. This GPS allows drone to fly on specific path to cover each waypoints in list and it also can be configured for return to home command.

Fig- 9 M8N GPS inbuilt Compass

Radio Transmitter and Receiver

The Transmitter and receiver used are FlySky CT6B 2.4Ghz 6CH and FS-R6B respectively. This combination provides a range of about 1000 meters. This Transmitter and receiver provide upto 6 channel options.

Fig-10 Fly sky i6 2.4 6CH Transmitter and FS-i6 Receiver

3DR Telemetry

Telemetry Radios can (optionally) be used to provide a wireless MAVLink connection between a ground control station like mission planner and a vehicle running pixhawk flight control board. This makes it possible to tune parameters while a vehicle is in flight, inspect telemetry in real-time, change a mission on the fly, etc.

Fig-11 3DR Telemetry

Pump and Nozzle

Here to pump the liquid paint from the tank we have used 12 volt DC pump with controlled discharge of 1 lit/min. and to mark center precisely gas nozzle is connected to the outlet.

Fig- 12 R385 Diaphragm based Pump **Fig-13** Spray Nozzle

Quadcopter Frame

The design of quadcopter frame is also one of the important factors in designing the quadcopter. The 'X' Quadcopter frame is mostly used because of its more stability and for the light weight component we have chosen 650 mm diagonal quadcopter frame of carbon fibre material.

Fig-14 650 mm CF Quadcopter frame

Table 1. Built up Weight of quadcopter

Sr.no.	Component	Specification	Weight(gm)
1	Propeller	10x4.5"	40
2	BL Motor	1800 kv	400
3	Battery	3S, 5200MAH	360
4	ESC	40A	136
5	Power Distribution		8

	Board		
6	Flight Control Board	Pixhawk V2.4.8	40
7	GPS Module	M8N inbuilt Compass	33
8	3DR Telemetry-Air Module	Range 2.5km, frequency 433 MHz	30
9	Remote Control Receiver	6 Channels	20
10	R385 Pump with Air nozzle	DC 6-12V maximum flow rate of up to 1 – 3L/min	36
11	Motor Driver with SG90 Servo motor		30
12	Water Tank 1 litter + 0.9 lit paint	Plastic Tank of 1 Litter	1000
13	Quadcopter Frame	650mm Carbon Fibre quadcopter Frame	620
	Total Weight		2753 (Approx.)

4. CALCULATIONS

After selecting parts for building a drone, the mass can be approximated equal to 1 kg i.e. 1000 gm. Therefore, weight of a drone is

W = m * g = 2.753*9.81

= 27.00 N.

A. Lift

To overcome the weight of 28.25 N and take off, the lift force should be greater than weight. As quadcopter has 4 arms, this force can be divided into 4 parts. Therefore, the lift required for each arm is,

L = 27/4 = 6.75 N

At this amount of force, the UAV will hover. To accelerate the drone and increase its altitude, this lift force must be greater than 6.75 N. so let's consider lift of 8 N for the structural analysis.

B. Motor calculations:

To take off the UAV, the thrust should overcome the weight. when thrust is equal to weight, the UAV just hover and land. When, Thrust = 2 * mass = 2 * 2.753

= 5.50kg. or 5500 g.

The force will twice the hover thrust and can accelerates upwards. Therefore, the motor should be selected which provides the thrust of minimum 5500 g.

4.1 Thrust Calculation

Thrust developed at 100% RPM can be three times larger than the total weight of the drone so that the drone has better maneuverability and the drone can climb higher altitudes with higher rate of climb.

Thrust produced by one propeller with one motor= 1500 grams

Total thrust produced = 4 x 1500 = 6000 grams

Thrust to weight Ratio = Thrust produced / total weight of drone

= 6000 / 2753

= 2.18 : 1

Fig-15 Assembled Quadcopter with Paint Disperssion Mechanism

5. CONCLUSION

In this research we have illustrate a design of a quadcopter incorporate with paint spraying mechanism for building layout marking in construction industry. This method of layout marking in construction fields reduces the number of labours, time, cost and the risk involved to the personnel involved in layout marking process. This quadcopter can also be used in spraying disinfectant liquids over buildings, water bodies and highly populated areas.

6. FUTURE SCOPE

If quadcopter equip with camera will also perform other management task such as Security Monitoring, Site Management, and Visual Inspections. Weight lifting capacity of the quadcopter can be increased by increasing the number of motors or by increasing the propeller size or by increasing the rpm of the motor. Increased weight lifting capability will allow us to carry more pesticide in the tank. Flight time can be increased by increasing the battery capacity. But the problem is that when battery capacity increases the weight of the battery will also increase. Under the current COVID19 Pandemic situation, it can be used to sanitize large hotspots areas without actually going there in person.

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