Design of Dual Copter for Surveillance Applications

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Abstract. In this paper, an innovative design model of autonomous aerial vehicle is designed and fabricated with dual rotor setup. Nowadays, innovative unmanned aerial vehicles (UAVs) are widely required for surveillance, monitoring, data collection, reconnaissance and generally in places where humans face hazardous. In this model and design of UAVs, aero dynamic principles are adopted through reasonable design considerations and assumptions. Most of the researchers and academicians are currently pursuing research on AVs with various structures, wing designs, fabrication methods, controllers and materials to increase the efficiency as well as for various applications. In this proposed work, an effort is made to design and fabricate the dual copter with wide moving ranges for surveillance applications in military intelligence system. This proposed design will be suited for all environmental conditions to collect the data as well as monitoring the system. Dual copter chassis are fabricated using 3D printer after the validation and analysis the proposed design using Solidworks CAD tool. The chassis are fabricated with the provision of space where the required sensors, actuators and controllers can be assembled. Lithium polymer batteries are employed to achieve the better performance for copter. The fabricated setup is integrated with radio frequency controller to achieve the flight control through RF transmitter. Hence the performance of the fabricated device is validated and analyzed through various performance measures of dual copter.

Keywords: Brushless motor, PWM (Pulse Width Modulation), Radio Frequency Controller, Servo Motor

1. Introduction

A quadcopter, also known as quadrotor helicopter or quadrotor which are operated and controlled by four rotors. Quadcopters are commonly made up with two pairs of fixed propellers one is clockwise and another one is anticlockwise (ACW) \cite{1}. The desired total thrust can be attained by the regulation of rotor speed and also the rotor can be located in both lateral and longitudinal directions in the space by controlling rotor speed with various range. The desired torque and turning force can be achieved by rotor controller based on the applications \cite{2}. The control issues due to the induced torque can be avoided through counter rotor rotations where the comparatively short blades are required which is simpler to construct \cite{3}. This kind of air vehicles are considered as the first victorious vehicle among various model which have vertical take-off landing (VTOL) provisions \cite{4}. Two decades ago before 2000s, the electronics advancements endorsed the manufacturing of inexpensive low-weight air vehicles with global positioning systems, cameras, apropriate controllers, acclerometers \cite{5}. A Quadcopter with four self-governing rotors requires swash plate mechanism which will lightening the...
quadcopter for flying [6]. The swash plate mechanism was required to allow the helicopter in order to achieve the required degrees of freedom (DOF), in the meantime the control can be obtained by incorporating two more rotors [7]. The development of quadcopter are stabilized in recent days by controlling the four self-governing rotors without integration of electrical devices which are tedious and impossible [8]. Quadcopter control is basically a tedious one and intersect more problems while operating for different environmental conditions [9]. The quadcopters are opereated with six DOF (three linear movements and three rotational movements) and self-governed inputs of four i.e. speed of rotor and the performance achieved by coupled motion of rotational and translational [10]. Because of complicated aerodynamic effects, the results may be highly nonlinear [11]. Quadcopter has own damping system to prevent the little friction or motion with the provision to stop moving and remain stable which is not achievable in ground vehicles [12]. This results in the quadcopters emerging with flexible configuration which becomes very popular for small aerial vehicles. Its minimum size and maneuverability, provides the provision for quadcopters in any environments. Figure. 1. shows the design of quadcopter used for surveillance purposes. In the recent research environments, quadcopters have received more attention among the researchers to achieve the various innovation techniques of rotors for different applications [13]. The controller design requires more consciousness while selecting the quadcopters based on the required applications [11]. There are some uncertainties in the quadcopters such as degradation of actuators, environment disturbances and improper time delays in communication [14]. The above disturbances are amplified in the proposed design if it lost the its control in unbalanced situation [15]. Hence an effort is proposed to overcome the above mentioned drawback and this concept will functionalize the quadcopter movement in easier as well as achievable [16].

However, earlier forms of prototypes grieved from poor performance, and later the same type of premodeled design highly demands too much pilot interaction i.e. workload due to the unsatisfied augmented stability as well as limited ability of controller. [17]. These innovations have modern microprocessors that offer more electronic integration at minimum cost which are completely autonomous control [18]. These advantages made the quadcopters feasible for commercial, military, and even hobbyist purposes [19].

The advantages of the proposed dual copter are

- Increase the flying time
- Increase the efficiency of the copter

Figure. 1. Quad Copter

To overcome the drawbacks in the quadcopter it has been planned to design and fabricate the dual copter for surveillance applications in the military intelligence system and to implement the sound design and model with uniqueness in all aspects for uninhibited missions, fast and high
operations of dual copter. Also will validate and optimize the proposed design using CAE tools to ensure the well-designed model of the dual copter.

2. Proposed System
The proposed work will favor to terrestrial as well as aerial moving ranges for surveillance applications in the military intelligence system with best design of system. The proposed work will find the better accomplishment in the surveillance system with wide range and high load carrying capacity. The novelty of the work is the dual copter covers wide range of distance and high load carrying capacity compare to other drones currently exhibits. The propeller is designed in the enclosed manner except the top and bottom by the way air never leaks on sideward hence a cumulative amount of thrust is produced in this system it paves to higher energy efficiency. The centre of gravity and centre of pressure is aligned perfectly it ensure that the system is aerodynamically stable for manoeuvre and control. This proposed design will be suited for all environmental conditions. The advantages of the proposed model are

- Easily maneuver
- Reduce the usage of propeller blade number
- Enclosed cylindrical-shaped frame
- Increasing flying time

3. Methodology and Design
The details of stages involve for the development of dual copter was shown in the Figure. 2. The design is the most important stage for any product. In this work, the design and analysis of model were performed using solid works software. Initially the part drawings has to be completed with the specified dimension as shown in Figure. 3. (a), (b) & (c) which represents front view, top view and side view of the dual copter design respectively. The reason for choosing solid works over AutoCAD is the fact that the ease with working in the former one. The dimensions in the Figure, are mentioned in mm.

![Figure. 2. Methodology](image-url)
Since the project require the outer frame with less weight ratio, the design is ensured to achieve the smooth functioning of flying by using the simulation package. It plays a major role at the time of lifting the dual copter and the motor should be fixed in a correct position to prevent the error happening in the propeller blades.

**Figure. 3 (a) Front View of Dual Copter model**

**Figure. 3 (b) Top View of Dual Copter model**

**Figure. 3 (c) Side View of Dual Copter model**

**Figure.3. Solid Model of Dual Copter**
The radio controller has been selected with proper range of control to actuate the rotor as required for the betterment of flying and landing. The discharge rate of battery should be maintained to make the proper functioning as well as operating the copter [20]. Technical success of the system relies upon the work expected from the mechanical and electrical section. The fabrication of the project contains validated mechanical structure and electrical connections. The integration of the motor and other electronic components was made with the mechanical frame for execution of the proposed model. Then the model can be tested physically to verify the working efficiency.

4. Electrical Section

Transmitter transmits the radio frequency signals which will be received by the receiver at the rate of different inputs. The received signals will transfers to both the motors in the form of PWM (Pulse Width Modulation) signals to control the rotors [21]. But the brushless motor has three different poles which are actuated by PWM signals when it tends to rotate [22]. The three poles are activated with alternating signals to control the speed of brushless motor for performing the actions. Normally servo motor is actuated by the interpret of direct PWM signal. Both servo and brushless motor are controlled by the PWM signals. There are two servo motors are implemented for pitch, roll, yaw motion controls, this motions are achieved by air flippers which is attached to the shaft of servo motors [23]. Angular position of the servo motor is attained by the respective PWM input signals, for example 0.5 PWM to servo is 90°, 1 PWM to servo is 180°. And these PWM signals of brushless and servo motors are directly controlled by our radio control joystick. The electrical section of the project is modelled as shown in Figure 4.

![Figure 4](image)

Figure 4 Electrical Section of the model

5. Mechanical Section

The frame is constructed by additive manufacturing method with printing material called ABS (Acrylonitrile butadiene styrene). Normally ABS and Nylon is preferred for this kind of application. ABS is best suited for the frame because of its high strength and less weight-density ratio. 3D printer named CUBEPRO is used to fabricate the mechanical frame. The additive layer thickness was adopted as 200µm. Honey-comb structure is preferred for its strength and reliability. This frame tends to withstand load, sudden shocks and vibrations of motor occurs at the time of fly. Frame can be easily fabricated because of the availability of ABS material as plenty in the market and economically beneficial. Frame is in cylindrical shape and concentrated air flow produced by the two propellers which are thrusts downward by the way the drone lift upwards vertically. This airflow passes through flippers of the servo motor. The air is diverted by the flippers to attain the pitch, roll, yaw motions. The prototype of the fabricated model has been shown in the Figure 6.
6. Experimentation
The experimentation was carried out with the required specifications which has been disseminated as follows. The assembly of the mechanical and electrical section was made to make the intelligent dual copter and analyzed the performance of the model. The Figure. 5 shows the block diagram of the working layout. In this work, two sections were fabricated and connected to achieve the conduction. The model is the excitation of dynamics and longitudinal motion as well as lateral motion.

Brushless Motor:
\[ \text{Thrust (kg)} = \left( (2.83 \times 10^{-12}) \times (\text{RPM}^2) \times (\text{DIA}^3) \times \left( \left( (\text{AIR DENSITY}) \times 23.936 \right) \div 29.92 \right) \times \text{CF} \right) \div 2.2 \]

\[ \text{Thrust} = 600 \text{ g} \]

Where,
- \( \text{RPM} \) is mentioned in kV, it is multiplied with battery voltage,
- \( \text{DIA} \), diameter for the total length of propellers,
- \( \text{AIR DENSITY} \) can be calculated separately,
- \( \text{CF} \) changes based on prop type but should just be “1” for the calculations.
- \( \text{RPM} = (\text{Motor KV Racing} \times \text{Battery Voltage}) \)
- \( \text{Speed} = 10000 \text{ RPM} \)

Battery:
- \( \text{Voltage} = 11 \text{ (V)} \)
- \( \text{Energy} = \text{Voltage} \times \text{current} \times \text{time} = 24200 \text{ (J)} \)

Servo Motor:
- \( \text{Rotation} = 180 \text{ degree} \)
- \( \text{Torque} = 1.8 \text{ kgcm} \)

Electromagnetic waves is used in the process for controlling the dual copter with various level. Transmitter emits the signal and the receiver absorbs the signal in the form of PWD signals at the rate of 2.4 GHz. Then these signals are transferred to brushless and servo motors to control the up and down movement of the dual copter. Servo motor is attached with a RADAR to change the movement of left and right positions in the dual copter [19]. The radio frequency controller has the control range of 500m. It can be varied with the configuration of channel in the transmitter. Position of motor in the respective place must be accurate during the fly time [24]. The function of the dual copter is validated with various actions to accomplish the goal. The fabricated model with all components is represented in the Figure. 6.
7. Conclusion and Future Scope

Thus the design and fabrication of prototype of dual copter was successfully developed with intelligence system. The developed system shows that high bandwidth of control, wide range and high load carrying capacity with adaption of any environmental conditions. Thus, the greater accuracy and control over the process has been achieved through this design. The model of the proposed design are validated and optimized using CAE tools to ensure the well-designed dual copter.

The advancement of this model plays vital role in both aerial and terrestrial. GPS autonomous tracking and obstacle avoiding UAV with accurate PID controls can be implemented in future with the developed model [25]. It can be used to program the controller using Arduino board to perform the system integration. Then, synchronize the Zig bee module with mobile phone in the fabricated system to implement the IOT concepts.

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