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DESIGN OF UNMANNED AERIAL VEHICLE USING SINGLE ROTOR

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ABSTRACT

A Drone is a flying air vehicle also known as unmanned aerial vehicle (UAV) that does not carry human operator, use aerodynamic force to provide vehicle lift can fly autonomously or be piloted remotely, can be expandable or recoverable, and can carry a lethal or nonlethal payload. The user can operate the drone through Bluetooth RC Controller android software. Arduino Nano is the controller is used in this work to control the operation of UAV. Bluetooth module HC-05 is used to interface the control signal given by user and the controller. The main purpose of this work is to build a vertically mounted single copter with a maximum payload economically and low space occupying in the air.Conventional copters endure of many disadvantages such as weight, cost and restriction in aerodynamic structure and displacement in Centre of gravity.

KEYWORDS:UAV, VTOL, Monocopter, Robots.

I. INTRODUCTION

In recent years, there are numerous researchers taking efforts which are directed towards flying of inventive system. These systems are generally named as flying robots (or) Drone (or) Unmanned Aerial Vehicle (UAV). Drones are more suitable where humans could not survive the extreme environment because of its automaticity, repetitiveness, tirelessness and robustness. It may operate with various degrees of autonomy: either under remote controlled by a human operator or fully autonomously by on-board computers.

The most common propulsion system of an UAV consists of power source, Electronic Speed controller (ESC), DC brushless electric motor, and a propeller. The flight controller sends a pulse width module signal (PWM) signal to the ESC which then processes and performs the commutation of the DC motor [1],[2]. UAVs are generally classified on the basis of number of rotors, size and their ability of locomotion. This project is development of vertical take-off landing (VTOL) drone that reduces the number of rotors into single rotor and reduces the cost when compared to bicopter, tricopter,quadcopter etc [3].

Currently, UAVs are used basically for monitoringpower transmission line, disaster relief, wildlife, gas and oil pipelines, weather reconnaissance, pollution and environmental monitoring, port and off-shore line security, land mine, forest fire detection and even in civil applications[4]-[7]. However, the advantages of UAVs in comparison with manned aircraft monitoring and their intrinsic safety (e.g., no risk for the pilot in dangerous remote missions), low weight, and cost effectiveness; moreover large amount of data can be collected by various sensors and cameras, and several other monitoring applications can be implemented.

A Monocopter is also known as gyrocopter is a rotorcraft that uses a single rotating blade. The concept is similar to the whirling helicopter seeds that fall from some trees [8]. The name gyrocopter is sometimes applied to monocopter in which the entire aircraft rotates about its centre of mass as it flies (Swirl Effect).When a rotor slices over the body of the drone, it sends ripples of pressure across the surface that creates large downward force which in turn reduces the total thrust provided by the BLDC motor. This is the major problem in vertically mounted single copter (VMSC). This issue is nullified by selecting high rated BLDC motor.

GLMAV consists of two sections namely: Ballistic launcher and Micro air vehicle (MAV). The Ballistic launcher launches the air vehicle to the location to be tracked as well as surveyed and fly independently with the help of coaxial rotors. Optical sensor is used to detect the desired coverage area (100m-500m). The air vehicle sends the observed details such as position and image of a person or object to the ground station. Ground station is associated with transmission system sends the control signal provided by control laws to the air vehicle through wireless Zigbee connection [9].

Medical delivery drones (Zipline) take flight in east Africa. Zipline has been saving lives in Rwanda since October 2016 with drones that deliver blood. Zipline's autonomous fixed wing drones now form an integral part of Rwanda's medical-supply infrastructure, transporting blood products from a central distribution centred to hospitals across the country. Using GPS navigation (and in coordination with Rwandan air traffic control), the drone heads for its target. When the Zip reaches its destination, typically within an hour of the initial request, the doctor gets a whatsapp message to come outside, and the Zip drops the blood pack in a padded container with its own little parachute. The Zip then heads back home for an arresting-hook-assisted landing onto a soft mat, and it's ready to fly again after a quick battery swap [10].

The problem of user demand based UAV assignment over geographical areas subject to high traffic demands. A neutral based cost function approach is formulated in which UAVs are matched to a particular geographical area. It is shown that leveraging multiple UAVs not only provides long range connectivity but also better load balancing and traffic offload. This proposed approach yield significant improvements in terms of better spectral efficiency and reduced delays compared to a ground based network baseline without UAVs [11].

Novel tilt tri-rotor unmanned aerial vehicle which combines the vertical flight capability of a helicopter and forward flight performance of an airplane is proposed. The nonlinear dynamic model of tilt tri-rotor UAV is given by the equations of Newton-Euler. An accurate mathematical model is obtained based on the Newton-Euler dynamic equations as well as parameter identification. In transition mode, both aerodynamic and thrust forces act on the aircraft body are very complex. To solve the problem of attitude control, a novel control allocation is developed. The transition corridor is important for hover-to-cruise flight, it is acquired by balancing flight conditions. The main contribution of this work lies in the proposed novel strategy for the control of the UAV's attitude in transition mode and rest of the paper deals withmathematical model and designing controller [12].

From the literature survey, it is observed that most of the researchers used multi rotors in all their UAVs which lead to high initial cost. Since more than one motor is used, Multi-rotors (3, 4, 6, 8 – number ofmotors) have a limited flying time because most of the drone's energy isspent onfighting gravity and stabilizing in the air and small payload capabilities. Most of the UAVs used wings in their structures to achieve vertical take-off landing (VTOL) which is an additional load to the UAV. Multi-rotors endure of many disadvantages such as weight, cost and restriction in aerodynamic structure and displacement in Centre of gravity. The objective of our work is to provide a vertically mounted single copter shortly called as UAV with low initial cost and low space occupying in the air. To introduce a new form of copter i.e. using a single rotor and new methodology to control the direction using servo motors. To design a cuboid shaped structure with minute holes to avoid the usage of extended wings to nullify swirl effect.

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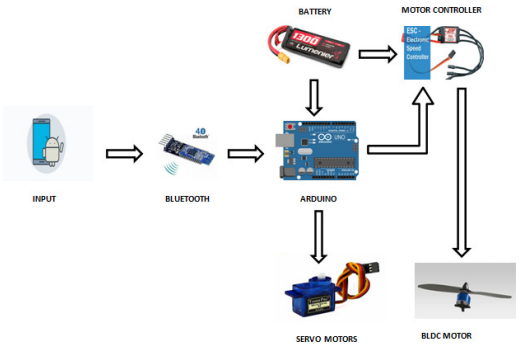
II.SINGLE ROTOR UNMANNED AERIAL VECHICLE

Initially, the userinterface to control the speed and direction of the copter is done by an Android application BLUETOOTH RC CONTROLLER through HC-05 Bluetooth Module. Then comes the controller,The Controller we used here is Arduino (Nano) because of its light weight and its ease of Programming and low Power Consumption (5V). The Arduino controls both the direction and speed of the copter by transmitting PWM(Pulse width modulation) signals to the Servo and Brushless motor. The need of two Servos is because a Servo can rotate upto only 180 degrees. To Control the speed of the Brushless motor, 40 amps Electronic Speed Controller is used. The Speed Controller sends the PWM signals in an alternate manner so that the coils of the Brushless motor are energized accordingly. The Brushless motor is powered by 2200 mAhlipo battery. To attain desired thrust, a suitable Propeller is used. A 10" diameter and 4.5" pitch Propeller is used here. The Maximum load of the motor is about 1500 grams.Figure 1 shows the methodology of overall work



. Fig:1 Methodology of this work

II. INNER DESIGN AND COMPONENT PLACEMENT

The vertical design of drone looks like segmental structure, where the total structure divided by two plates, one holding Servo motors fixed on that plate, and other plate having Arduino and Bluetooth module fixed on it.The main consideration in vertical design is center of gravity, in order to maintain it by using placing the battery that neutralize the effect of weight acting on all sides, in order to wiring components from top to bottom, and one to another, the inner plate is readily holed for wiring purposes. All the plates are fixed tightly by using screws on all sides, the inner two plates inside the structure that holds the components are look like trays, that placed within the hole of two outer plates, that support the plates, After placing all the components and wiring flexibly, then proceed the structure by putting holes on all over the outer plates for air flow. For safety landing and avoid damage placing a sponge ball or any support at the bottom of the drone. Fig 2 shows the structural design and component placement.

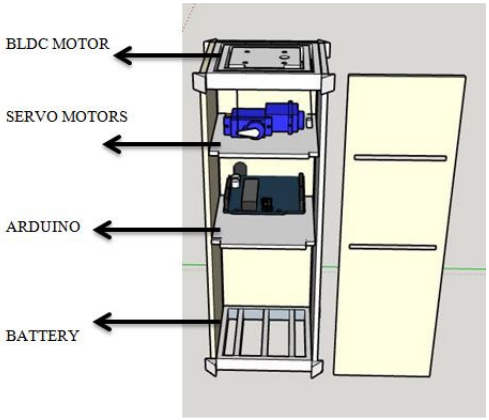


Fig 2 Inner design and component placement

III. SOFTWARES

SKETCHUP

Sketchup, formerly Google Sketchup, is a 3D modelling computer program for a wide range of drawing applications such as architectural, interior design, landscape architecture, civil and mechanical engineering, film and video game design. It is available as a web-based application.

ARDUINO

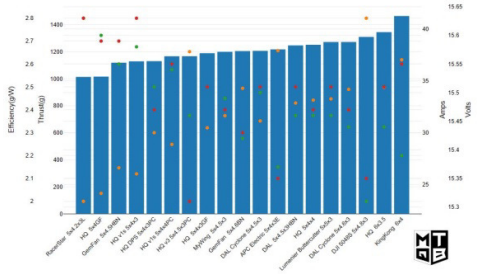
Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or breadboards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++.

AUTOCADD

AutoCAD is a tool used to reconstruct the 3D model into 2D model for each and every sheets for further proceeding in laser cutting. (Simply convert sketchup file format to AutoCAD DXF (Drawing Exchange Format).

IV. MOTOR TEST RESULT

EMAX II RS2306 (2400KV) RACE EDITION:



From that results, we achieved the thrust of 1.5kg by 40 amps,14.8v and tri propeller.

1s(1 cell)=3.4v

4s(4 cell)=14.8v

The speed of the motor can be determined by multiplying the voltage delivered by each cell of the Lithium polymer battery and the kilovolt (KV) generated by motor.

For example,

In 2400 KV motor,

1V = 2400 RPM (Revolution Per Minute)

For 4s battery

14.8 V = 14.8*2400 = 35,520 RPM

To increase the flight time, more capacity battery like 2200mAh is chosen. LIPO batteries can be found in packs of everything from a single cell (3.7V) to over 10 cells (37V).The cells are usually connected in series, making the voltage higher but giving the same amount of amp-hours.

The calculation follows this simple rule:

Maxsource = Discharge rate * Capacity

For example take a battery of capacity 4000 mAh with discharge rate of 20 C mentioned. With this battery source a maximum of 20 C * 4000 mAh = 80A is discharged. In the RC LIPO battery world it is called "C Rating". Remember the battery should never be discharged BELOW 80 % of its capacity.

V. CONCLUSION

The core intention of the project is to perform all basic operations of multicopters with less cost and size , so we chose single copter, which reduces 1/4th cost of quadcopter. Basically drone used to reduce human efforts in photography field,carrying loads etc.This project will clearly demonstrate the goal of proving that small scale UAV's are useful across broad range of applications. Some of application only be legal and remaining are having proper permission from government officials,without permission, it's illegal.After 2018 Dec, In India, officials made legal for using drone for any application.
Some of impacts that single copter is bring out are:

- Increases the passion towards photography sectors.
- Monitoring over hazardous areas,(reduces human risks)
- If this monocopter is made successfully, due to cheap rate, all basic applications of drone are performed by students, photographers...etc.

REFERENCE

[1] O.Solomon and P. Famouri, "Dynamic performance of a permanent magnet brushless DC motor for UAV electric propulsion system – part I," in Proc. 32nd Annu. Conf. IEEE Ind. Electron., Paris, France, 2006, pp. 1400-1405.

[2] J. Gieras et al., Axial Flux Permanent Magnet Brushless Machines. NY, USA: Springer-Verlag, 2008.

[3] Adhi, "Unmanned Aerial Vehicles", International Journal of Engineering and Techniques, Volume 3 Issue 5, Sep-Oct 2015.

[4] Hector and Ona, "Analysis of Inverted Rotors in Multirotor Aerial Vehicle with VTOL", IEEE Transactions on Vehicular Technology, VOL. 67, NO. 6, June 2018.

[5] Alex, Erion and Donald, "Reactive Motion Planning for Unmanned Aerial Surveillance of Risk-Sensitive Areas", IEEE Transactions on Automation Science and Engineering, VOL. 12, NO. 3, July 2015.

[6] Richard, Dominik and Alexis, "Design of a Passive Vertical takeoff and Landing Acquatic UAV", IEEE Robotics and Automation, VOL. 2, NO. 2, April 2017.

[7] Lorenzo, Eric, Felix and Christian, "Autonomous Takeoff and Flight of a Tethered Aircraft for Airbone wind energy", IEEE Transactions on Control System Technology, VOL. 26, NO. 1, January 2018.

[8] Manas, Muthu and Anitha, "ORBOT – An Efficient and Intelligent Monocopter", IEEE International Conference on Circuits and Systems (ICCS 2017).

[9] Gnemmi, Chngey, Meder and Berner, " Conception and Manufacturing of a Projectile-Drone Hybrid Ssytem", IEEE Transactions on Mechatronics, VOL. 22, NO. 2, April 2017.

[10] Mckibillo, "Medical Delivery Drones Take Flight in East Africa", SECTRUM.IEEE.ORG, January 2018.

[11] Vishal, Mehdi,and Rajesh, "UAV-Assisted Heterogenous Networks for Capacity Enhancement", 1089-7798, IEEE, 2015.

[12] Daibing, Li Yu and Jiyanf, "Transition Flight Modelling and Control of a Novel Tilt Tri-Rotor UAV", Information and Automation 2017 IEEE International Conference, pp. 983-988.