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IoT Based Ornithopter

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***Abstract*: In recent years the subject of flying vehicle propelled by flapping wings, also known as ornithopter, has been an area of interest because of its application to micro aerial vehicles (MAVs). These miniature vehicles seek to mimic small birds and insects to achieve never before seen agility in flight. This renewed interest has raised a host of new problems in vehicle dynamics and control to explore. Ornithopters are robotic flight vehicles that employ flapping wings to generate lift and thrust forces. In order to better study the control of flapping wing flight we are developing an ornithopter model which will be capable of carrying a wireless camera. This report elaborates the essential aspects for the development of ornithopter and also describes mechanism of operation and the various applications of our ornithopter model. Our ornithopter model has a wing-span of 1.15m with a constant flapping frequency of 3Hz. The design for the same model is done with the objective of achieving the maximum lift and minimum drag possible which are the most important aspects considering the flight of the ornithopter. The complete design of the ornithopter model is done in solid work. The Ornithopter model is developed by keeping the aspects of gear reduction, aspect ratio, importance of tail, centre of mass, power requirements in consideration. At last, the design was analysed using CFD in Ansys fluent in order to get the results of lift and drag force at various angle of attack and flow velocities.**

***Keywords*: Bird drone, Flapping mechanism, Ornithopter aerofoil, Lift.**

1. Introduction

An ornithopter is an aircraft that flies by flapping its wings. Designers seek to imitate the flapping-wing flight of birds, bats, and insects. Though machines may differ in form, they're usually built on an equivalent scale as these flying creatures. examines the history of ornithopters and their design, and investigates developments and future trends of this uniquely inspired aircraft [1]. Since the earliest recorded history, humans have shared a nearly universal desire for the freedom of flight. Though science eventually shifted its focus to balloons, and then to fixed-wing flight, as a means of sustaining flight, the freedom and effortless grace of birds is as captivating now as it ever was [2]. From the earliest days of man's dreams of launching himself skyward to today's advanced designs, flapping-wing craft, known generally as ornithopters, have held a constant place in the quest to achieve the flowing elegance of flight so easily mastered by nature's own aeronaut [3].

Traditional ornithopters use a complete membrane wing which flaps its wing with a single degree of freedom and examines that the feasibility of using various techniques for fabricating light weight flapping wing mechanisms for subsequent use in bird mimicking micro aerial vehicles [4]. Studied an ornithopter prototype that mimics the flapping motion of bird flight is developed, and the lift and thrust generation characteristics of different wing designs are evaluated.

2. Mechanism of Wings and Tail

A. Calculation for Power Requirement

1) The total length wing loading

Time taken to travel from one destination to another destination.

Battery capacity= 2200 mAh

Battery discharge= 97.46%

All up weight= 280 gm

Time= battery capacity x battery discharge/all up weight

= 2200 mAh x 97.46%/280 gm

=30 min

Drone flight time= 30 min

If 100% battery discharge then drone flight time will be 30.8 min.

Wing loading = body mass/wing area

= 0.28 kg/0.0144 m^2

= 19.44 kg/m^2

Distance travel= w= ekt

Where kt denoted torque

Speed of ornithopter when battery discharge in 30 min and it travel 1 km is 3.3×10^{-2} km/min.

And for 10 km it will be 0.33 km/min.

Distance= speed x time

Therefore, distance travelled by ornithopter in 30 min at speed of 0.033 is 0.99 km.

2) Motor power

The BLDC motor has a maximum speed of 3000 rpm at 11.1v with 36.66 watts and 3.3 A. So, the BLDC motor power would be 103.99 w.

B. Tail Design

The tail section of the ornithopter is liable for both of the controllable degree of freedom apart from the power to throttle

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the drive motor. The tail is set up with one servo directly connected to the tail at an angle and another further up the body which rocks it via a linkage. With the tail at an angle to the rudder servo it allows the servo to held into the zero-angle position with reference to the ornithopter body and while the tail stays near the trimmed position for horizontal flight. Two servos are mounted on body frame to move rudders attached to the tail, which are used to change the direction and pitch of ornithopter.

3. Ornithopter Power System

A. Servo Motor

Servo motors are DC motors that allow for precise control of the angular position. They are DC motors whose speed is slowly lowered by the gears. The servo motors usually have a revolution cut off from 90 to 180. A few servomotors also have a revolution cut off of 360 or more. It is used to control the motion of the tail.

Fig. 1. Servo motor

B. BLDC Motor

A brushless DC electric motor (BLDC motor or BL motor), also known as electronically commutated motor (ECM or EC motor) and synchronous DC motors, are synchronous motors powered by direct current (DC) electricity via an inverter or switching power supply which produces electricity in the form of alternating current (AC) to drive each phase of the motor via a closed loop controller. The controller provides pulses of current to the motor winding that control the speed and torque of the motor. It is used to create flapping mechanism.

Fig. 2. BLDC motor

C. Electronic Speed Control

An electronic speed control or ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio-controlled models. Full size electric vehicles also have systems to control the speed of their drive motors. It is used to control the speed of BLDC motor on the command of slider potentiometer.

Fig. 3. Electronic speed controller

D. Lithium Polymer Battery

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li poly, lithium-poly and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte. These batteries provide higher specific energy than other lithium battery types and are used in applications where weight is a critical feature, like mobile devices and radio-controlled aircraft.

Fig. 4. Lithium polymer battery

E. Ripstop Nylon

Ripstop Nylon is used for making the wings and the tail part of the ornithopter. It is used because it’s lighter in weight and it’s water repellent.

Fig. 5. Ripstop nylon

F. Camera

ESP32 CAM WiFi Module Bluetooth with OV2640 Camera Module 2MP for face recognition.

Fig. 6. ESP 32 camera

G. *Transmitter and Receiver*

The Transmitter is an electronic device that uses radio signals to transmit commands wireless via a set radio frequency over to the Radio Receiver, which is connected to an aircraft or multi-rotor being remotely controlled.

Fig. 7. Transmitter and Receiver

4. Block Diagram and Working

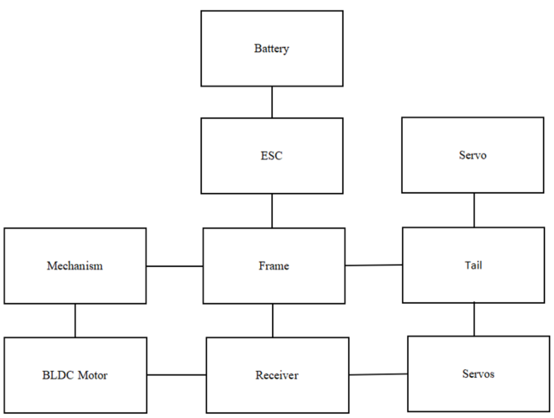

Fig. 8. Block diagram

The most critical part of the ornithopter is the drive mechanism that converts the electric power from the battery to the flapping motion of the wings. This system is the most complex to design and fabricate because it must withstand very large forces that reverses direction several times a second while at the same time it needs to be extremely light and durable. Because of the loads, it must be made from durable material which makes it beneficial to perform careful analysis and trim as much weight as possible. The drive system can be further broken down into four sections, the electric motor, a gear reduction stage, a linkage to convert the high torque rotation into a reciprocating motion and the connection to the wing spars. The gear box design is done in solid work and these gears were assembled on two base plates for supporting them.

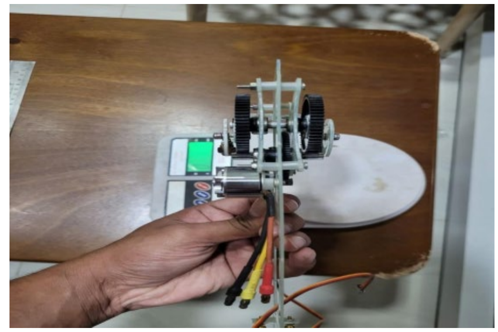

Fig. 9. Gear mechanism

Ornithopter wings can be flexible or rigid. The rigid wing design is much more complicated. Each cross section of the rigid wing has a real aviation wing profile. For wings of ornithopter we used carbon fiber rods to support the wings. We have done the making of wings with the help of carbon fiber rods.

Fig. 10. Wing

Then we construct the tail with the help of balsa wood which will be used to direct the path of ornithopter. After that connect the wings and tail to the body of ornithopter where tail would be connected to servo motor. Then we connected the transmitter and receiver with the ornithopter for establishing the connection between the ornithopter receiver to the transmitter. The binding of the transmitter and receiver should be done. After the binding of the transmitter and the receiver set the maximum speed of the BLDC motor by keeping the throttle at the maximum and for setting the lowest speed of ornithopter we should keep the throttle at the lowest. The BLDC motors set at channel 3 and servo motors are set at channel 1 and 2. After establishing all the connection of the ornithopter provide signal to it with the help of transmitter.

5. Result and Discussion

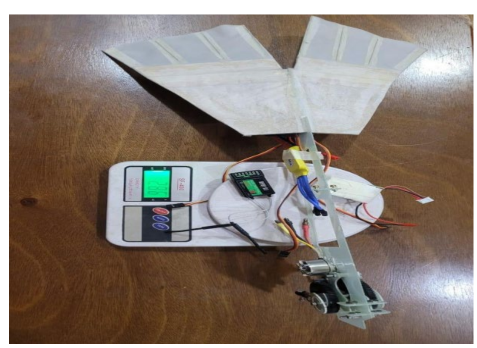

Fig. 11. Gear mechanism with tail

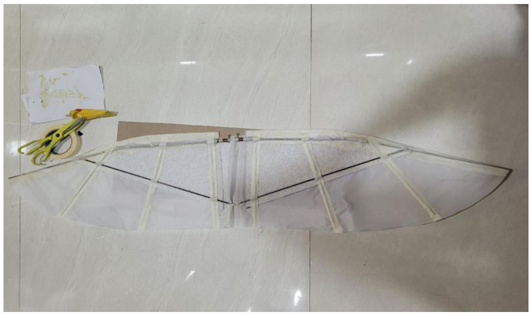

Fig. 12. Wing

Fig. 13. Tail

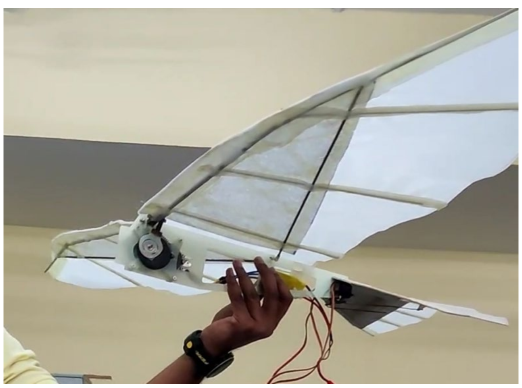

Fig. 14. Ornithopter

Ornithopters are aircraft that use flapping wings to generate lift and propulsion, mimicking the flight of birds. There has been a lot of research and development in the field of ornithopter design over the years, with various designs and prototypes being tested.

One of the main advantages of ornithopters over traditional fixed-wing aircraft is their potential for more efficient flight. Ornithopters are able to generate lift with a flapping motion, which can be more energy-efficient than the constant forward thrust needed by a conventional aircraft. Additionally, the flapping motion can provide a degree of stability that is difficult to achieve with traditional aircraft designs.

However, ornithopters also present a number of challenges in terms of their design and operation. One of the main challenges is the complexity of the flapping motion, which requires precise control of wing movement and timing. This can be difficult to achieve in practice, and has been a major obstacle to the development of practical ornithopter designs.

Another challenge is the issue of weight. Ornithopters require a significant amount of power to generate lift and propulsion, and this power must be supplied by an on-board power source. This can result in a heavy and cumbersome design, which can limit the performance and practicality of the aircraft.

Despite these challenges, there have been a number of successful ornithopter designs and prototypes developed over the years. These include small-scale models for hobbyists and researchers, as well as larger designs for potential commercial and military applications. With continued research and development, it is possible that ornithopters could one day become a viable alternative to traditional aircraft designs, offering a more efficient and versatile mode of flight.

6. Conclusion

The ornithopter can be designed from ground up with the needs of research in mind. All components can be designed to be as lightweight and high performance as possible to maximize payload capacity and are intended to fail in predictable and field repairable ways. In addition to this, all parts of ornithopter are simple and inexpensive to fabricate and assemble. With the newer innovations and researches in technology, we can make them as per requirements. In this paper, various mechanical aspects that define the designing of ornithopter has studied. The study is mainly focused on a wing and gearbox design. Other things like motor, battery, ESC, servo motors, controller and receiver are just part of selection based on payload capacity and compatibility with mechanical components.

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