Design and fabrication of flapping wing flying robot

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1. INTRODUCTION

An ornithopter is may be manned or an unmanned aircraft flying machine [1]. It consists the flapping mechanism, reciprocating or oscillating motion instead of the rotary motion used in airplanes and helicopter. It simulates the flapping-wing flight that found in the nature. The word ornithopter combines bird and wing and it doesn’t need to have feathers though.

It is different from the helicopter and airplanes because it uses the reciprocating motion of a bird’s wing instead of the rotating propeller which provides both lift and thrust and this machine is driven by rotating foils.

All the lift does not have to be provided by the flat wings of the ornithopter. The body and tail also provide a large share of the overall lift in real birds.

Two types of ornithopters are available [2]. Modelled by winding up a rubber band the simplest versions are. This ornithopters are the easiest to build and fly inside. The rubber-bands are useful in order to see who can get the longest flight time for a school contest. The formation and flight of these ornithopters is an excellent way for children to get acquainted with science and the teamwork. This is the recommended point of departure for adults. To supply all the lift to the ornithopter the wing of this ornithopter is not enough only. Even in real birds, the tail and body provide a significant portion of the total lift.

There are two types of ornithopter.
1.) By winding up a rubber band.
2.) By using the coreless DC motor and with using a gear mechanism.

The ornithopter which is made using the rubber band which is least expensive to build, and it can be flown indoors only. in this ornithopter the rubber band provides power to the ornithopter to fly it. It can fly for the longest flight time. this ornithopter is generally made by the kids to learn about the science and how to work as a team. It is also recommended starting point for the adults.

Another type of ornithopter which is powered by an electric motor. The electric motor that we are going to use in this project is the coreless DC motor which has a capacity to fly the ornithopter without any damage it or failed it. The range of this ornithopter is varies from the 10 cm wingspan which is also called the “mini air vehicle”
which is the size of an eagle. This type of ornithopter is capable to carry payloads such as cameras and can controlled by the radio frequency.

2. REVIEW OF LITERATURE
From the past few years, the flapping wings mechanism called ornithopter has been very much applied in micro aerial vehicles (MAV’s). These micro sized birds and insects have ability to move in stealth. Thus, these vehicles have increased the problems in controlling and dynamics in air flight.

Russell Louis Tedrake, has developed a large scale ornithopter named phoenix [3] which weighs about 400 grams and is designed to study the control of flapping wing flight and research on control. The design is used to optimize payload capacity, crash survivability, and field repair abilities.

Another design of an autonomous flight is a 13-gram MAV [4] is done by a clap and fling mechanism. In which 1 gram constitutes the electronic parts with a microcontroller, visual sensors, tele communication electronics, and driving motors. The flight control of ornithopter can fly toward a target using onboard sensing and computational resources only. In that ornithopter there is dead-reckoning algorithm which is used to recover from the temporary loss of the target which can occur with a visual sensor with a narrow field of view.

3. OBJECTIVES
To determine the design of the ornithopter test environment, our team collaborated a set of goals were established that the group expected the device to accomplish.

1. Design and build a mechanism capable of measuring wing strokes at a speed of 7 Hz.
2. Test platform to check the flight of the ornithopter.
3. Understanding the effect of shape of the wing on flight.

4. MATERIAL RESEARCH AND METHODOLOGY
Choosing the right motor and battery are both very much essential for building a successful ornithopter and to optimize its efficiency.

4.1 Electric Motors
The electric motor and battery are used in many radiocontrolled ornithopters. In an ornithopter, there are several types of electric motors. The selection of the motor type depends on the requirements of the design.

The motor used for this venture is the brushed motor due to its various advantages from the other motors. The indoor and micro-sized ornithopter coreless engines are fantastic. Such motors are much cheaper than any other motors. These triggers the vibration of pagers and mobile phones.

Coreless motors have major advantages of extremely low inertia, low mechanical time and high efficiency. The low weight, due to the ironless heart, allows faster acceleration and deceleration than any other form of dc engine. The iron core in which other big advantages were extracted.

In nut-shell

Advantages
- DC motor can reach an efficiency rate of 15%.
- High acceleration and deceleration rates and good controllability
- Design is very compact and small.
- Operation is very smooth.
- Lighter than cored dc motors
- Low electricity consumption and good battery life.
- Noise is very less.
4.2 Gears

Due to their low friction, spur gears as shown are the best choice for ornithopters. Using worm gears should be avoided. They may be tempting because they require a significant reduction in gear in a single stage, but the frictional losses are extremely high! For broad or controlled ornithopters, a chain drive could be suggested. The chain drive provides weight reduction by spreading the load into more of the gear teeth, and it is almost as effective as spur gears.

Here, limited supply of sufficient gears made building electric ornithopters difficult for a long time. Gears from industrial suppliers such as Stock Drive Products are issued for larger ornithopters. In these larger sizes, suitable cluster gears are not available, and usually the pinion gears do not conform to the same size as the larger gears. The solution is to fit a shaft made from "pinion wire" with the wide spur gear. The solution for a large reduction ratio is simple and lightweight.

Gearbox can require one, two, or three phases and our gear reduction is 6, depending on the maximum reduction you need. A single stage gearbox is the simplest to construct, but it does not provide required reduction. Several steps contribute to the sophistication of the transmission system and allow you, without excessively large gears, to achieve greater reduction ratios. The average gear ratio can be measured comfortably. It’s just the outcome of each point. The maximum reduction will be, for example, 4 to 1 and 6 to 1 for a second stage so 4 x6= 24 to 1.

The ornithopters style "microair aircraft" have lightweight, quick-shooting wings and heavy wing loads, to better meet the size requirements and withstand the storm. The gear ratio of these ornithopters to a coreless motor may be 24:1.
4.3 Ornithopter Flapping Mechanisms

The goal of the flapping process is to transform the rotor action of the engine into the flapping wing's collective activity. The system must be lightweight and symmetric. The symmetric wing motion must also be given for the ornithopter to fly straight [5].

The motion for wing flapping is provided by four bar mechanism. There is an engine powered revolving crank shaft. The binding rods drive the wings up and down as the square travels along.

![Flapping Mechanism](image1)

The Outboard Wing Hinge is the device we have used. This divides the two wing hinges here so that the joining rods move between the hinges of the roof. The flap is symmetrical because the angle between the retaining rods is low. To help the outboard wing hinges, a more complex body structure is required.

4.4 Ornithopter Wing Design

The rigid framework is based on the front of the wing in the ornithopter. [6] With flies, birds and almost all bugs it’s the same. Behind the strong wing spar, the membrane part of the wing is more elastic and lags passively below. It will also come to life as the wing grows and descends when the wing descends, like in figure below. They apply to the twist of the legs, an integral gesture of fluttering wings which is as significant as the fluttering movement.

![Basic parts of ornithopter wings](image2)

This enables the wing to tilt at a certain angle if the plane rotates. Because of the loop, the wing rotation is in the upward direction, which is regarded as the upward and lower direction as the wing cross sections are shown.
4.5 Ornithopter Stability and Control

In the back of the ornithopter there is a horizontal stabilizer. A down force is provided by the tail to keep the nose up, and the tail which is incidence or angle relative to the wing is more than the airplane. This angle is generally about 5 degrees. But sometimes it may be less or more depending on where the centre of gravity is located and other parts of the ornithopter design.

There is slight difference between the two wings which can cause the ornithopter to turn left or right. If the spars of the wing are made up of wood, then their weight will naturally alternate. We can also use the carbon rods for the wings or the tension of the wing membrane. If the ornithopter wants to take a required turn to one side which can be corrected by adding weight to the wingtip on the outer side of the turn. Because of the inertia the added weight acts to suppress the flapping motion of the weighted wing when the flapping amplitude of the unweighted wing is increases. There is a difference in the thrust which results to the difference in the travel that will compensate for an unexpected pull to one side.

Steering is done by the tail and this steering is used for the turning softening of the ornithopter. But this is less successful and more difficult to made like a real bird. For effective the ornithopter steering there is a simple elevator system which is more effective. The tail of most of the bird is like a flat, triangular. This tail is swing out to the left and right sides so that there is a rolling moment on the ornithopter because of the downward force which is acting on the wing surface of the ornithopter.

The tail of the ornithopter may rotates about its long axis. In this moment, the force which is acting downward is redirected in such a way that it provides yaw control. In RC ornithopter. the tail rotates about an oblique axis which describing the two motion here and that motion is combined.

5. FABRICATION

5.1 Specifications & Calculation

Required flaps = 7 per second
Gear Reduction Ratio = 1/24
Number of rotations (n)= 7*24*60 = 10080rpm = 10000 rpm
Voltage (V)= 3.7V
Current Supply (I) = 0.1A
Power Input = V*1 = 3.7*0.1 = 0.37W = 370 mAh
Angular Velocity (w) = 2*3.14*n/60 = 3.14*2*10000/60 = 1046.66 rad/s
Efficiency of the motor (E) = 15%
E = Power Output/Power Input
Power Output = Torque (T)* Angular Velocity (w)
E= (T*w)/(V*I)
T=(E*V*I)/w = (0.15*3.7*0.1)/1046.66 = 5.3*10^-5 Nm
Power Output = T*w = 0.02*1046.66 = 0.05 W = 55.5mAh
With this, we are getting around 7 flaps/Sec which is enough for the flight of the ornithopter.

5.2 Fabrication Steps

- Firstly, the frame or the structure for supporting the ornithopter is made.
- Mechanism for flapping of wings is made using four bar chain
• Using offset link, power is transferred from motor to four bar chain.
• Wing and tail profile is made from membrane and connected to the structure

6. RESULT AND DISCUSSION
Micro Aerial vehicle is a new technology in which a variety operation can be done by using this technology like point to point communication, image capturing from high altitude, for surveillance in the border or many places where terror attack is more.

The lifting capacity of the flapping wing mechanism is more than the fixed wing mechanism and it can increase the lifting load without increases its speed.

It generates enough lift.
It can be used for the army purpose.
It is light in weight.
It can be controlled by using the remote.

Bibliography


