

# A small unmanned flapping airvehicle “Ornithopter”

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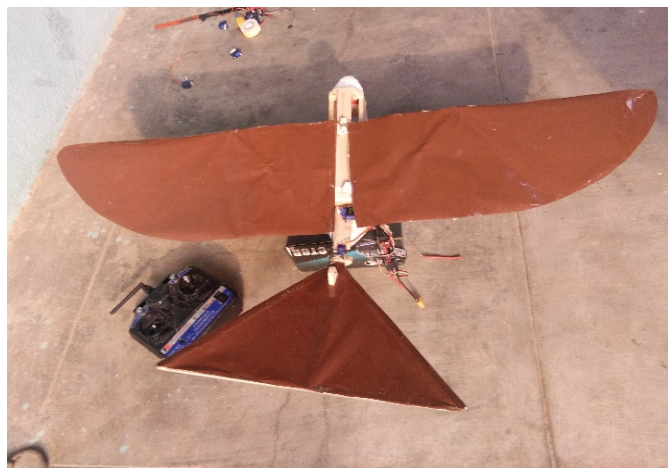
**Abstract**—The analysis of the flight of insects, birds and ornithopters is difficult because there is limited aerodynamic theory applicable for the large amplitude unsteady wing motions. Furthermore, the complex wing shapes and wing motions encountered in insect and bird flight entails complex aerodynamic interactions. A systematic theoretical and experimental study has been pursued by the senior author for the past several years to gain a better understanding of the aerodynamic, dynamic and mechanical problems of flapping wing flight. The primary intent has been to establish a strong technical base necessary for the development of the ornithopter as an alternative to the helicopter. The helicopter is best suited for hovering flight and suffers greatly reduced efficiency as forward speed is increased. On the other hand, the ornithopter can achieve hovering flight, albeit with much more mechanical complexity, but promises high efficiency in forward flight. The method of attack for this study of the ornithopter has been to depart gradually from the conventional aircraft configuration so that the large body of knowledge accumulated in the development of the airplane could be applied to the study of the ornithopter. In this paper the results of the aerodynamic studies are presented because of their applicability to the modeling of insect and bird flight.

**Index term**—Introduction; idea of the model; science behind the model; about the design; construction procedure; basic parts (gear box, flapping mechanism; wing; tail part), gear arrangements; planning; material used; problem faced; applications; future plans; references

## Introduction

An Ornithopter is an aircraft heavier than air, that flies like a bird by flapping its wings. The special feature lies in the wings that do not only generate lift but also thrust. And the gears which will regulate and convert the rotatory motion of the motor into linear harmonics. An Ornithopter is a body flying by the means of wings. It imitates the motion of birds. Unlike rc plane, the wings of ornithopter have flapping or oscillatory motion. The wings provide both lift and thrust. The tail of the ornithopter resemble elevator and rudder of rc plane. Flapping wing, Small Un-manned Air Vehicles (SUAVs) also known as ornithopters can revolutionize the civilian marketplace.

An ornithopter (from Greek ornithos "bird" and pteron "wing") is an aircraft that flies by flapping its wings. The Sanskrit epic Ramayana describes an ornithopter, the Pushpaka Vimana. In 1485, Leonardo da Vinci began to study the flight of birds. The first ornithopters capable of flight were constructed in France. From 1884 on, Lawrence Hargrave built scores of ornithopters powered by rubber bands, springs, steam, or compressed air.



## Idea of the model

In plane as we know that wings are fixed but in the case of birds, as we all know, they flap their wings in order to fly.

During our last project “R.C. PLANE”, we came across the idea of this ornithopter and finally we decided to construct one of our own. In our earlier project, we had referred some videos for inspiration and from the motion of ‘birds’. With the help of the teachers, we tried to mimic the flapping mechanism of birds.

## Science behind the model

### Gear box

The frequency of flapping doesn't match with the frequency of motor. Also the torque provided by the motor is not enough for flapping. Hence a gear box is needed which decreases the rpm of the motor and simultaneously increases the torque.

## Flapping mechanism

The shaft of the output gear performs a circular motion whose vertical velocity is harnessed by a vertical rod into the oscillatory motion of the wings.

- The motor drives a rotating crank.
- The crank has a connecting rod attached to it, and the other end of the connecting rod is attached to the wing.
- As the crank goes around, the connecting rod pushes the wing up & down
- A torque link was fixed to the output shaft. GI was used as the vertical connector and clamped to the arms of the wing using clevis.

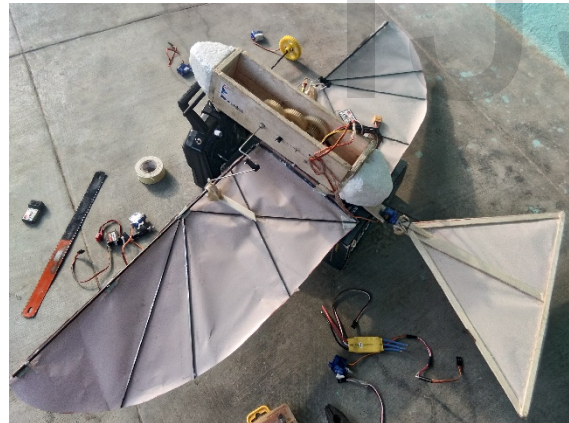
## Purpose of flapping mechanisms

- The purpose of the flapping mechanism is to convert and regulate the rotatory motion of the motor into the reciprocating motion of flapping wings.
- The mechanism is lightweight and fairly simple, provides a fairly symmetrical wing motion so that the ornithopter flies straight.

## ABOUT THE DESIGN

- Gear ratio 17.03:1
- Flapping frequency 4-6 hz
- Wing span 104 cm
- Max cord length 25 cm
- Weight 460 gm
- Cambered wings made of polythene
- Inverted t shaped tail

### CONSTRUCTIONPROCEDURE



Basic parts

Our ornithopter would closely resemble a bird . It would have mainly three parts namely

### **Main body**



### **Bird Wing**

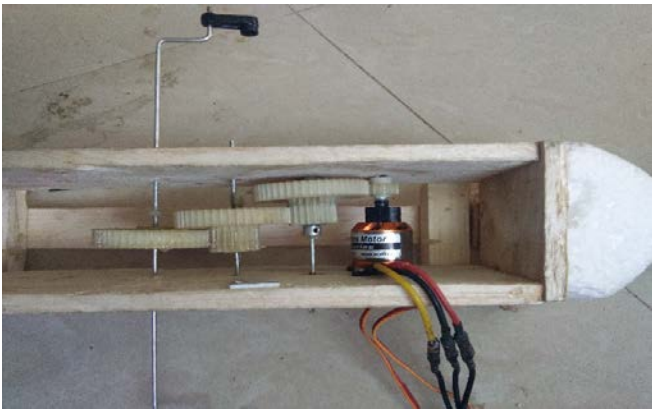


### **Bird tail**



### **Gear box**

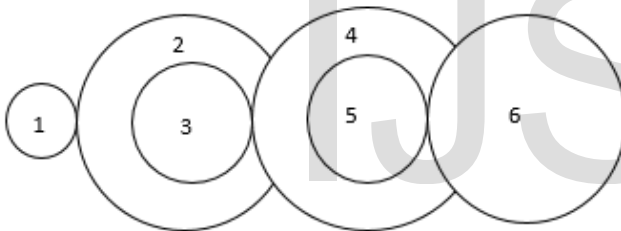
Four gears in series were attached to the plastic coated balsa. At one end, the pinion gear was fixed to the motor and two bigger double head gear with bearing were attached to the body using iron rod as axle. The output shaft was fixed to the final gear. The system was made rigid by attaching two blocks of Styrofoam on either end.



#### Gear arrangement

No of teeth in each gear

Gear 1=18 teeth      Gear 2=50 teeth      Gear 3=20teeth  
Gear 4=50 teeth      Gear 5= 20teeth      Gear 6=49teeth



For our gear arrangement it is –

$$\text{Gear ratio} = (t_2/t_1) * (t_4/t_3) * (t_6/t_5)$$

$$\text{Gear ratio} = (50/18) * (50/20) * (49/20) = 17.01:1$$

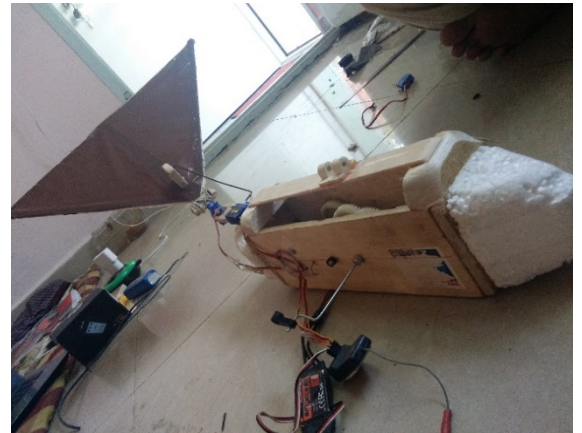
#### Wing

Carbon fiber sticks with horns attached were used as main arms of the wings. Polythene was used as the wing material and kite sticks were used to form the main skeleton of the wing which provided cambered structure to the wing.



#### Tail

We used actual bird tail made of decortion foil and carbon fiber syicks with rudder and elevator as the control surfaces as ornithopter's tail.



#### Planning

We will use gears used in photocopy machine. We are trying to arrange gears from a photocopy shop. Mostly all other components are provided by our club.

#### We would be completing our project in three phase

- Building a gearbox (to reduce rpm of motor).
- Attaching wings and other electrical components to the main body.
- Designing and attaching tail to the main body.
- We have planned to keep the weight of our ornithopter around 450 g.

#### Material used

- Transmitter and receiver
- Motor controller
- Brushless motor
- Lipo battery
- Gears
- Servo motor
- Galvanised iron rod
- Carbon fibre rod
- Balsa wood
- Transparent polythene
- Icecream sticks
- Gums and tape

#### Problems faced

- Unavailability of desired gears
- Fixing the gear to output shaft
  - mechanism to harness the vertical velocity of rotating torque link
- Unavailability of light weight components
- Overall strengthening and weight reduction of the model

#### Applications

Applications for ornithopters include but are not limited to:

- Recreational Vehicles
- Research Platforms
- Border Patrol
- Atmospheric Data Collection
- As a spy in bird's camouflage



SUAVs that can currently perform these application require a lot of man power, training and expense. Ornithopters provide a low cost, rugged, and easy to fly alternative which makes them suitable for enthusiasts, hobbyists and researchers.

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#### Future plans

- Improving gear ratio
- Strengthening main body
- Weight reduction

#### References

You tube links.....

- <https://youtu.be/vNHnb2Is61A>
- <https://youtu.be/poX2Hg9gae0>
- <https://youtu.be/hZC3ORawE8k>

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