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ORIGINAL CONTRIBUTION

A Precise Model of Insect Flight Vitality and Development of Unmanned Micro Aerial Vehicle

R. Anandan[1] · K. Kalaivani[1]

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Abstract In recent times, scores of innovations are taking place in the field of unmanned aerial vehicle (UAV) technology that includes continuous development of design of on-board processing, memory, storage, and communication capabilities. Since UAVs are now being used extensively in many areas of expertise that include commercial, military, civilian, agricultural, and environmental applications, it is very essential that these UAVs communicate efficiently. The communication may be of the UAV-to-UAV (U2U) type or it could be with the already existing prevalent networking infrastructures UAV-to-Infrastructure (U2I) type of communication. A new prototype is developed based on the insect flight dynamism. These insect wings are very thin membranous structure. They are subjected to many forces and follow aerodynamic flying and hovering. The current research trend on this subject is the simulation of insect wing structure and utilization to create a prototype for the development of unmanned micro air vehicles. In the present study, three flying insects such as dragon fly, cicada, and jewel beetle are selected and the wing aerodynamic parameters are analyzed by mathematical models. The comparative scanning of the data revealed that cicada wing structure is their aerodynamic characteristics may serve as a prototype. The results are discussed with relation to the base data for the flapping-wing system in micro air vehicle. In this paper, we have tried to put forward an approach that is capable of providing real-time positioning and tracking of a UAV. The approach has three parts: tracking device, backend server, and mobile app.

Keywords Unmanned aerial vehicle · Hovering · Cicada wing structure · Micro aerial vehicle

Introduction

The development of micro aerial vehicle or micro air vehicle (MAV) has dominated the interest of various researchers for a wider application from both civil and strategic groups. The MAV technologies are growing, and the data are available in plenty. The MAVs are nowadays designed with dimensions of less than 500 mm and have a fully autonomous operation for a limited duration, for a range of military and civil missions. These MAVs are predominant because its electronic supervision and detection sensor equipment are in a miniature model so that the full payload or mass falls into a small fraction of vehicle MAV’S of such small dimensions are deployed in real-time data acquisition capabilities, low radar cross section, low noise, and low production cost [1]. The design of such vehicles includes surveillance, detection, communications, and placement of unattended sensors. This surveillance includes day and night video and infrared image capture in urban areas and battlefields. Such data are useful in the location of opposition forces, hostage rescue, counter-drug operations, and sensing of biological agents, chemical compounds, and nuclear materials.

Depending on the type of lifting surface that is used to carry its weight, MAVs are broadly categorized into three different types, namely fixed wing, flapping wing, and rotatory wing. Each one has its own advantage. Fixed wing is used for long range and endurance, while the flapping

✉ R. Anandan
anandan.se@velsuniv.ac.in

1 Department of Computer Science and Engineering, Vels Institute of Science, Technology & Advanced Studies, Pallavaram, Tamil Nadu, India

wings are used for internal navigation and rotatory MAVs are used for short-range operations, but it can provide high-quality multidimensional images due to its hovering type. The small size, low weight, low flight velocity under high atmospheric wind is the greater challenge for the researchers. Limitations in the size and operation at low speeds result in flight at low Reynolds number where nonlinear effects are seen in aerodynamic parameters such as lift, drag, and pitching moment. The recent technology focuses on mainly these vehicles fully autonomous and enabling them to fly in cooperative swarm mode for a few mission applications.

The flapping-wing aerodynamics has gained more importance and greater interest in research because of its potential applications in micro UAV's. Biological systems, such as birds and insects, provide an interesting feature for flapping-wing MAV's because of its similar characteristics to aerodynamic principles like Reynolds number, unsteady aerodynamics, materials, stability, performance, and propulsion. Insect flight movement is fast, more vulnerable, and versatile [2, 3]. These flapping-wing MAVs can be used in a wide range of atmospheric conditions, such as gusty winds**.**

The membranous wings of flying insects are very thin structures. Often they are described as structures of an airfoil. Their thickness always is less than 100 µm**.** These wings are subjected to many forces. The high-frequency flapping motion requires various accelerations. This means that the aerodynamic force in the wing is greater than the weight of the body of insects they undergo continuous deformation during flying in the air as well as hovering at a particular spot. The various aerodynamic studies on different insects have been attempted by many research workers [4–6]. But still, the flying mechanism and the hovering mode of the insect wings by using the thin flapping wing are not fully understood. Many laboratories are carrying out a much more clear analysis of the structural mechanism. The recent trend is studying aerodynamism of insect wings on the basis of utilizing a similar phenomenon for the development of unmanned micro and mini air vehicle. The present study is an attempt to know comparative flying efficiency and hovering among three popular flying insects via dragonfly, cicada, and jewel beetle.

A wing moving in air experiences a fluid force; therefore, the wing structure and the fluid interactions are the important parameters to ascertain the flying efficiency. The mechanisms of hover for staying in the same spot in the air are achieved with rapid wing beating [7]. This ability is so complex the use of sideways stabilization as well as lift and drag forces are necessary to overcome the gravitational force. The lifting force is caused by the downstroke of the wings. The major governing principals for flying and hovering are due to the time interval for wingbeat ($\triangle t$), the frequency of the wingbeat (f), the energy produced at steady state (E), and the kinetic energy utilized (ke). In this present analysis, the above parameters are numerically obtained by using mathematical formulae suggested by earlier workers of a similar line. Further, the important parameters Reynolds number also be calculated to know the force flow on the wings. Reynolds number (Re) is a dimensional number used in fluid mechanics to indicate fluid flow in steady or turbulent states. The results are discussed in relation to the development of unmanned micro air vehicles.

Material and Methods

The fore wings of three hovering insects were the materials for these present investigations. These insects those known for hovering and easily available in our area were utilized. These insects are *plantalaflavescens* (dragonfly); it has a very light wing foil with highly reticulated veins. The insect flying speed is 4.7 miles/hour. The identification of the insect was done by referring the world catalog of odanata [8], *Dundubia* (cicada); it has a fine very thin elongated fore wings with reticulated venation. The speed of the insect is 45 miles\hour. The identification of the insect was done by referring by the world catalog of the cicadoidea [9, 10] and SternoseraBasalis (jewel beetle); it is a wood borer. The speed of the insect is 12.2 miles\hour.

The identification of the insect was done by the world catalog and bibliography of jewel beetle [11]. The dragonfly was collected on our university campus. Likewise, the cicada insect was collected during last year's monsoon from our campus. The jewel was collected from the Nilgiris. The fore wings of the above insect were dissected out, and the structure, pattern of the venation chord length, and the length of the wings were recorded [12] (Fig. 1). The selection of the above three insects was based on their fly speeds and hovering behavior.

The other required biological data of the insects under investigation such as the height of the insect, the weight of

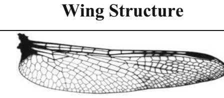
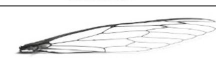
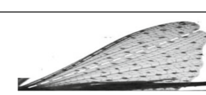
Name of the Insect	Wing Structure
Dragon Fly (*Plantalaflavescens*)	
Cicada (*Dundubia*)	
Jewel Beetle (*SternoseraBasalis*)	

Fig. 1 Wing structure of hovering insects under investigation

Table 1 Biological data of hovering insects under investigation

Name of the insect	Weight (gm)	Height (mm)	Wing length (cm)	Wing chord length (cm)	Wing speed	Wing beat (bits/sec)
Dragon fly	0.15	0.8	7.6	0.51	14.2 MPH	38
Cicada	1.9	1.1	3.4	1.3	16.8 mph	41
Jewel beetle	2.01	1.8	4.1	0.7	12.5 mph	58

the insect, wing speed, and wing beat were also noted (Table1).

The basic aerodynamic characteristics feature of the insects is time interval for wing beat, frequency, work don, energy, produced at steady state, power produced, kinetic energy, and Reynolds number. The above parameters were also calculated by using the observed biological data of the investigative insects. The various formulas for obtaining aerodynamic characteristics are given in Table 2. The formula and the numerical calculations were followed as per the previous workers [13–15].

Implementation of Mathematical Model

The studied parameters were implemented as follows:

ARM STM32 Microcontroller

ARM Microcontroller is best suited as the controller chip for the prototype [16, 17]. It uses 16/32 bit architecture and is less expensive. The circuit board contains these two essential things:

SRAM

It is used when making calculations.

Flash Memory

The flash memory is where the main code is stored. If the program is complex, it may take up quite a bit of space. Memory is useful when storing in-flight data such as GPS coordinates, flight plans, and automated camera movement. The code loaded to the flash memory remains on the chip even if it is a power cut.

Inertia Measurement Unit (IMU)

IMU contains an accelerometer and gyroscope [18]. The IMU also has a magnetometer. The uses of the three are described below,

Accelerometer

It measures linear acceleration in up to three axes (say, X, Y, Z). The units are normally in gravity, i.e., 9.8 m/sec^2 or 32 feet/sec^2 [19]. To line up the linear axes with the main axes of the UAV, we use an accelerometer.

Gyroscope

It measures the rate of angular change in up to three angular axes (say alpha, beta & gamma). The units are often in degrees per second. To line up the rotational axes with the main axes of UAV, we use the gyroscope.

Magnetometer

It is used to measure the earth's magnetic field and is used to determine the UAV's compass direction (with respect to magnetic north) [20].

GPS Chip

To determine the global positioning of the UAV, the GPS chip is mounted. The GPS chip talks with the orbiting satellite and sends the coordinates to the user or to be used for the navigation of the UAV [21].

Obstacle Sensor

Obstacle sensor which uses ultrasonic waves is used to detect and avoid the obstacle coming[22].

Piezoelectric Actuators

They are used to make the wings of the UAV flap. The wings of the UAV are connected to the piezoelectric actuators [23].

Power Source

The power provided to the UAV is by using a solar-powered cell fitted on the top of the prototype[24].

Table 2 The various formulas used for obtaining aerodynamic characteristics

Name of the characteristics	Formula
Time interval for beat/sec	$\Delta t = (2\ h/g)^{1/2}$
	where
	Δt is the time interval
	h, height of the insect
	g, gravity constant(980 cm/sec^2)
Period for total beat	$T = 2\ \Delta t$
	where
	Δt = time interval for beat
Frequency	$F = 1/T$
	Where
	T, period of total beat
Average force	AF = mxg
	Where
	m, mass; g, gravity constant (980 cm/sec^2)
Work done	$W = AF x D$
	where
	AF, average force; D, distance
Energy required at steady state	$E = mgh$
	where
	m, mass; g, gravity constant (980 cm/sec^2)
Angular velocity	$\varphi = 2(d/\Delta t)/l/2$
	where
	d, chord length; Δt, time interval; l, length of wing
Inertia	$I = ml^2/3$
Energy required at motion state (kinetic energy)	$KE = \frac{1}{2}(I \text{ x } \varphi^2)$
	Where
	I, inertia; φ angular velocity
Reynolds number for obtaining flow around air foils	$Re = Uc/v$
	Where
	U, flight speed; c, chord length
	V, Kinetic viscosity (constant = 1.460×10^{-5} m^2/s)

Wings

Wings are made using the biometric material, and the weight of the wing is made light.

Transceiver

Transceiver is used to send/receive the signals to/from the remote controller, respectively [25].

Small Camera

The camera will be placed on the downside of the UAV for the surveillance work. It will be connected to the brain chip and to the memory to function according to the person who is in charge of controlling the UAV.

Working Principle

The working of the prototype is described below:

- The wings are connected to the piezoelectric actuators which are connected to the main controller chip.
- The controller chip acts as the brain for the prototype. The signal from the remote is sent to the controller chip.
- The controller chip after receiving signal performs the computation and directs the signal to the other connected parts.

- When the user presses the start button in the remote controller, the signal is sent to the chip which sends the signal to the wings of the prototype, and the flapping of the wings starts. Due to the flapping, the prototype is lifted.
- To maintain the gravity, acceleration, and direction of the prototype, accelerometer, gyroscope, and magnetometer are used.
- When the prototype is flying and it encounters an obstacle, the obstacle sensor detects it and sends the signal to the controller chip. The controller chip sends the signal back to the wings.
- To move the prototype in the forward direction, the UAV is bent down from the nose part.

Methodology

The drone's main construct starts from its body shape where we will be using an elliptical-shaped body since it will provide much space in the middle due to the big bulge which should be enough to fit in all the bigger Arduino modules and at the ends of the body where it becomes smaller, tiny modules or weight adjustments can be added to help in flight.

- The elliptical body will have two halves. On the upper half, we shall fit two individual DC motor both on the right and left. The same applies to the lower half of the drone.
- In the middle, the main motherboard is fit in place with the help of a thin frame; the module used here will be ARM STM 32 Arduino development board. To this board, all other Arduino modules will be connected (camera module, bridge connector, transceiver)
- The DC motors that we have connected will all be connected to the bridge connecter Arduino module. This module helps in controlling the motor speed and rotation. The individual motors will be connected to the bridge connector. The DC motors will work in pairs; hence on the left, upper and the lower motor will be a pair, and on the right, it applies the same.
- The bridge connector will help in reducing and increasing the throttle of motor spin. We will use the motor speed for the drone's movement.

Bridge Connector Module

All the DC motors will be connected to this module and are supposed to be programmed in pairs as the left wings and the right wings. The left wing would contain 2 motors and the right wing would contain the other 2 motors; hence, setting them in pairs would enable a decent controlled elevation or directional movements.

Moving Left

Dropping a specific amount of throttle on the left-wing motors will drop the drone toward the left side enabling it to move toward the left.

Moving Right

Dropping the wing speed on the right wings motors will tilt the drone toward right, hence making it move toward the right.

Elevation/Demotion

When it comes to adjusting the altitudes of the drone, all the DC motors that were operated in pairs for directional movement will now throttle up and down together so the drone has the elevation and demotion just like a helicopter.

Circuitry Blueprint

As per Fig. 2, we will be using gears and motors to give the flapping mechanism which can also be called the ornithopter model. It is recommended to use a piezo actuator in order to reduce the drone size to the most minimal possible, and also the power consumption would not be as much as a motor would use. This should give us enough space to install any other essential parts that a drone would need. In case if motors are preferred for the flapping mechanism, it is always best to use vibration-reducing motor mounts to reduce the vibrations caused by the motors, since even the smaller vibration can cause a big impact on the flying motion of such a minimal scale drone.

The piezo actuator we will be using would be a rotary actuator that would flap the wings in about an angle of 60° and can flap as fast as we set the frequency for the oscillation.

Remote Control

To control this drone, the user can avail of an app that is specifically made for this drone to maneuver it as well as use all the functionalities that are provided within the drone-like the camera. The drone will have a Bluetooth/hotspot Arduino module inside it by which the drone will be connected to the phone. Now one limitation that we might come across might be the range, as long as the frequencies of our hotspot or Bluetooth go the farther the drone can travel. Hence, it would be a better idea to give

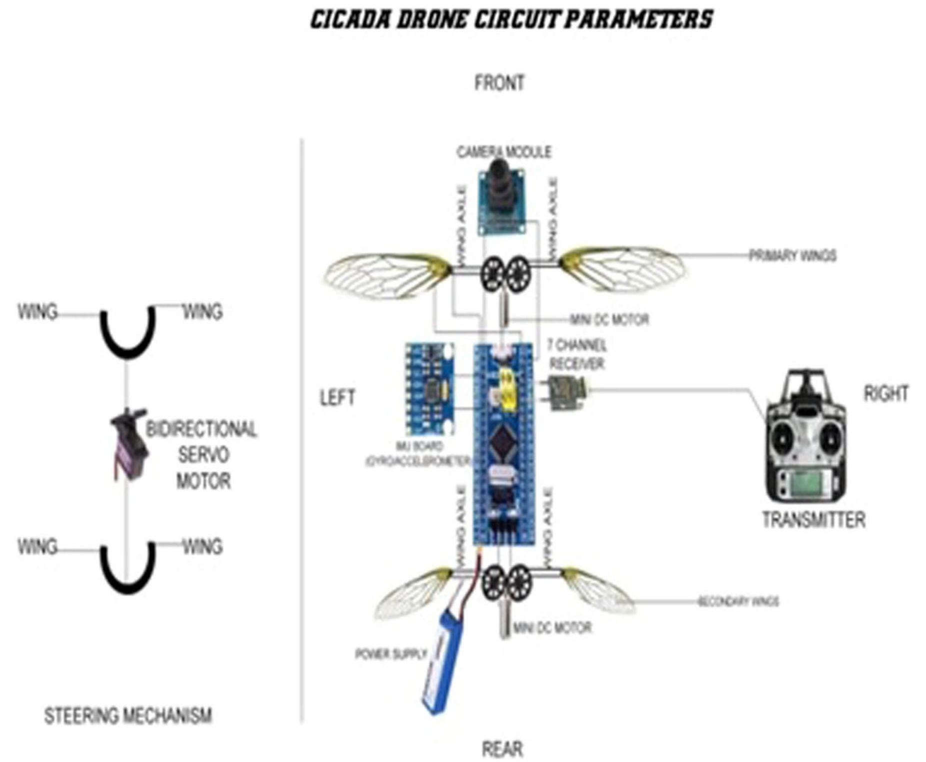


Fig. 2 Blueprint of MAV

the drone a peer to peer connection as we will also be looking at a live video stream of whatever the drone's camera captures. These live video feeds can either be given by continuous downloading between the two devices or by saving the clips to a backend server and then processing the video from there.

Uses of having a backend server would be that we will not have to add any micro SD card module into the drone's body which will also make it heavier. But it is important to have a higher bandwidth between the two peers so that there is not much latency when the video is streaming. It is obvious that a few fractions of seconds delay cannot be avoided as the video cannot be streaming in real time. One basic property to keep in mind would be.

Higher the FPS [frames per second] of the video = higher the bandwidth required, similarly lower the fps lower the bandwidth required.

Results and Discussion

Hovering behavior is presented among certain winged flying insects. When an insect stays at a particular spot in the air by doing continuously beating its wings rapidly, this ability is known as hovering. However, it is still very complex to know the exact wing beats to achieve hovering; the upbeat and downbeat forces cause the insect to oscillate and wings staying in the same position. The time interval Δt is to complete up and down strokes of the wing. The Δt is worked out for the three hovering insects under this study. The data for Δt are given in Table 3; from the data, it is evident that Δt for jewel beetle is 1.92×10^{-2} s the same value for cicada is 1.49×10^{-2} s and for dragonfly, it is 1.28×10^{-2} s. The above data are meant for a single wing. From this comparative data on Δt, it is inferred that the weight of the insect influences the time interval for wing beat. For example, dragonfly insect weight is 0.15 gm, where the time interval for wing beat is 1.28×10^{-2} s; the same time interval is increased to 1.92×10^{-2} s in the case of jewel beetle where the insect weight is observed as 2.01 gm. This would suggest that for efficient hovering against gravitational force body mass should be significantly reduced level.

The next important aerodynamic parameter is the frequency of the wing beat. In this category also, the mass of the organism affect the frequency of the wing beat. The less weighted dragonfly the recorded frequency of the fore wing is 39.06 Hz. On the other hand, the cicada has 1.9 gm weight but the wing frequency is lower than dragonfly. Similarly, in the case of jewel beetle whose weight is 2.01 gm, the frequency of wing is further reduced and recorded as 26.04 Hz. By holding the above information, one can suggest that the wingbeat frequency depends on the weight of insects. The wing frequency is one of the necessary characteristics for effective flying and hovering. This can be noticed in the insects of the cicada as well as

Table 3 Aerodynamic characteristics of hovering insects under investigation

Name of the insect	Time interval for wing beat (Δt)	Total time interval for 2 wings (T)	Frequency (F)	Work done (W)	Energy produced at steady state (E)	Power produced (P)	Kinetic energy (K)	Reynolds number (E)
Dragon fly	1.28×10^{-2} s	2.56×10^{-2} s	39.06 Hz	0.149×10^{-4} J	0.176×10^{-5} J	0.58×10^{-3} Watts	63 kw	2217.43
Cicada	1.49×10^{-2} s	2.99×10^{-2} s	33.37 Hz	0.484×10^{-4} J	2.048×10^{-5} J	1.61×10^{-3} Watts	373 kw	6687.21
Jewel beetle	1.92×10^{-2} s	3.84×10^{-2} s	26.04 Hz	0.345×10^{-4} J	3.545×10^{-5} J	3.59×10^{-3} Watts	200 kw	2679.18

dragonfly; however, for effective flying energy produced at the steady state and kinetic level is the most important feature. The deserving observation recorded in this present study; the insect cicada produced 2.048×10^{-5} J at a steady state which is an equivalent of 1.61×10^{-3} Watts. Further during hovering, 373 kw of kinetic energy is utilized. Therefore, it is presumed that among three insects cicada insects can hover longer duration, attain significant speed, and cover a longer distance. The interesting point in this discussion through the jewel beetle wing beat is 58 bits/sec; the speed of the insect is only 12.5 miles/hour.

From the foregoing results, it would be reasonable to suggest that for greater hovering and a longer stay in the air at a particular spot the wing structure of cicada is more suitable than the wings of other insects (Fig. 3).

To substantiate the above hypothesis, the wing structure of three insects was submitted for the calculation of Reynolds number. It is an important aerodynamic factor for a flexible flapping-wing system. The Reynolds number is normally to define the structure of the wing for the flying efficiency under unsteady conditions. It has been shown from many wings structural studies that Reynolds number increases during normal hovering mode [26]. It is also an indication for harmonic hovering kinematics [27]. The insect wings are very smaller in size and beat with greater speed. Therefore, the calculation of Reynolds number also is considered.

The Reynolds number for various insects has already been worked out by many earlier workers [28, 29]. Normally for an insect wing, the range is given with relation to the dimension of the wing and fluid in an air foil-based wing structure. The same was worked out for the above three insect wings, and the very data are given in Table 3. The Reynolds number varies with three different wing structures of this present study. Highest Reynolds number (Re: 6687.21) is noticed for the cicada wing structure. It is recalled at this juncture; the other parameters of hovering are also indicative for the structural suitability. Hence, cicada's forewing structure may be considered as a prototype model wing structure for micro air vehicles.

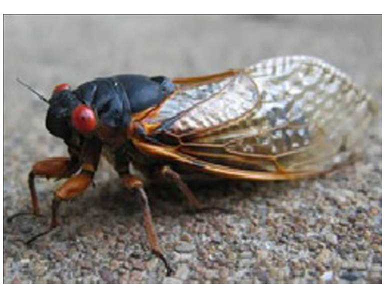


Fig. 3 Cicada

Construction of the Micro Aerial Vehicle

Consider all the possibilities of having a miniature flying object with the best stability in flight and control. The near resemblance for a MAV to real-world flying object would be replicating the dragonfly. Dragonflies are known for agile movements and faster twists and turn on air time. It also has the capability to hover in a particular place for a longer period of time. This hovering technique that the dragonflies use can be a vital add on to the MAV replication.

In general, the body of a dragonfly is completely linear with four wings attached to its sides and each of these wings is controlled by individual muscles within its body. The structure of the wing is shown in Fig. 4. Having such a body gives it the capability to fly in every possible direction in ease. Hence, implementing a dragonfly body gives us a multi-direction MAV; the only problem would be the

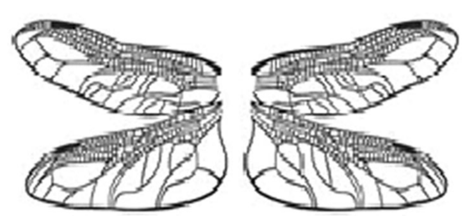


Fig. 4 Wing structure

weight management and the body parts alignment within the MAV.

The wingspan of a dragonfly is about 60 mm in general with a body length of around 50 mm, but in the case of a MAV, it is mandatory that the wingspan always stays bigger than the body length after stacking up all the required parts within the body.

Both the pair of wings need to be parallel in order to thrust ahead in flight, and they also need to be of the same length. The wings in our MAV need not have individually motorized wings since it will only complicate things for the one who will be maneuvering it. Hence, the wings will be separated into pairs, calling it the upper wings and the lower wings.

The body of the drone will be 3D printed based on our requirement with its wings being made of polycarbonate or polypropylene sheets as they are as thin as 0.5 mm and are sturdy to heavy conditions.

Wing Motors

Dragonflies tend to have two pairs of wings; hence, they need not flap as faster and harder as any other single winged insect or a bee. This decreases the pressure on the motor we would use and also retains the wing structure. Having lesser flaps of the wings would also cause a decrease in the vibration which would give a smoother flight mode for the MAV. The appropriate flapping mechanism that can be used for this MAV is the piezoelectric actuator.

A piezoelectric actuator works in electronic input where it is converted into vertically linear vibrations depending upon the frequency of current that is fed into the actuators. Hence, installing this in a MAV gives us control over its flapping speed and altitude control. Piezo actuators are also small in size; hence, attaching them in each for a pair of the wings should let it control the upper wings and the lower wings separately. The electric channeling to the piezo actuators will be in two different channels to provide two different frequencies when required.

Self-Balancing Mechanism

Balancing the drone in mid-air is a tough challenge for the one piloting the drone. Hence, a little help on that should help the pilot in order to maneuver it more efficiently. We can bring a self-balancing mechanism to the drone by using a simple Arduino chip "MPU-6050 IMU" as shown in Fig. 5. This chip connected to the mainboard automatically calibrates the axis on which the drone is moving with a fixed center point it tends to bring it to an alignment automatically without us having to do that.

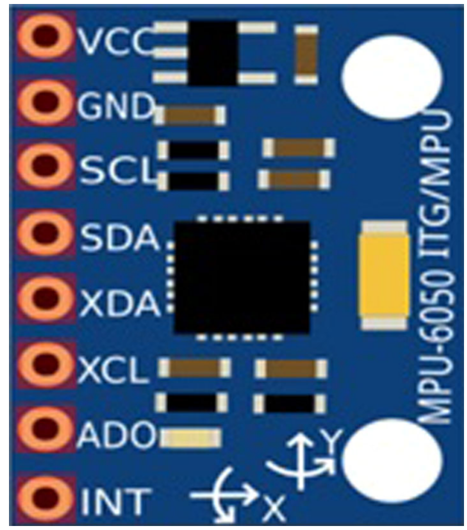


Fig. 5 Arduino chip "MPU-6050 IMU"

Arduino Implementation

The motherboard or the brain of this drone will be based on Arduino chips only. Since it has to be compact in size, the drone will be using an Arduino nano board (ATmega328) or also briefly known as a microcontroller as shown in Fig. 6. The Arduino boards have compatibility with a huge number of sensors that can help to make this drone easier. Its dimension is around 18 × 45 mm accordingly which our drone outer body will be evenly made in order to fit the parts in perfectly with just molds so that no soldering or gluing work has to be done. This microcontroller runs in 16 MHz clock speed which is more than enough to handle most of the sensors with ease and needs a power supply of around 712 V. Using Arduino boards lets us configure our project the way we want; hence, we can replace parts anytime the drone requires or even bring an update when required.

The battery unit will be added to the back of the body in order to bring a body balance and tap on to the drone's center of gravity to have a stable flight mode.

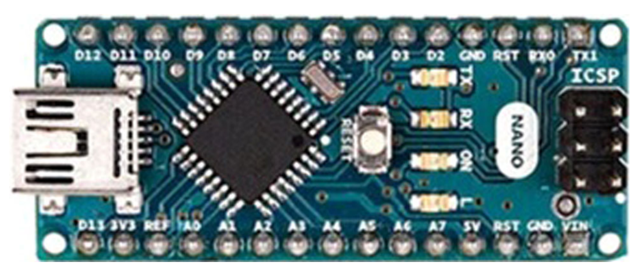


Fig. 6 Arduino nano board (ATmega328)

Arduino Camera

Arduino cameras are not usually known for quality, yet it can do the job of surveillance when programmed and tuned to the perfect balance. The main key factors that would affect a camera quality are the recording of the video and its frames per second (FPS), resolution, bitrate, and the color range. Having the highest color resolution, bitrate, FPS, and color scheme may help if it was to capture images, but since we need a camera that can both record and stream video live via the transceiver to our phone we will have to compromise on the quality and that is why most of the cameras we see are in monochromatic color. But being so we may not be able to see some important details; hence in this black eye camera, we will be implementing a new mechanism for the quality measures of the camera. It can be attempted to separate the color rendering part to the main UNO board to process it so the camera will have less workload on it, and hence, it can deal with the other factors like resolution, bitrate, etc. The Arduino module OV7670 has its own processing unit and some of the advantages of using OV7670 are:

- Auto white balance
- Automatic exposure
- Automatic gain control
- CMOS sensor

The CMOS sensors are based on photosensitive diodes that are connected to resistors in series. As a result, the photocurrent is continuously converted into an output voltage. Thus, no integration takes place and works on a simpler circuit. The relation between the output voltage and the light intensity is nonlinear. CMOS sensors are more susceptible to noise. Low-end cameras use CMOS technology as they consume little power, image noise suppression, and much more.

Just like any other Arduino module, even this one can be programmed by using the Arduino IDE like defining the bitrate, resolution, and much more. The black eye camera will also have an offline mode just in case the user is not connected to the Wi-Fi relay, the camera can be set in offline mode. The offline mode will have an SD card slot attached to the camera which in turn will have the camera in recording mode. Depending upon the storage size of the SD card size, the recording will be on process trying to fill the SD card. But with the Smartphone app, it is possible to control the time length of recording that has to be done.

Comparison with Previous MAV Model

There are drones already available in the market that can replicate dragonflies; hence, we have studied the existing drones and built this on top of all those models considering the flaws that previous models had and also keeping in mind about the little updates we can bring in with exchange and update in Arduino modules, this dragonfly version that we build on top of an integrated circuit built dragonfly, it can easily excel in every field of work.

Some of the comparison has been done with the working model and compared with the previous models.

In the mid-1990s, an exploration venture at Los Alamos National Laboratory hypothetically researched the plausibility of smaller-scale robots manufactured utilizing miniaturized scale lithographic strategies for military uses, for example, insight assembling and detecting or interruption of an assortment of ecological improvements (electrical, mechanical, and substance). Over the span of this examination, the theoretical structure of a rotating wing vehicle was investigated utilizing the littlest economically accessible electromagnetic engines (1.5 g in mass), with various airfoil edges, slender film batteries, and scaled-down camcorders, acoustic sensors, and interchanges chips. Four diverse airborne vehicle setups were likewise examined: fixed wing, revolving wing, small scale aircraft, and a latent and auto-rotated gadget dependent on a Samara seed. The theoretical rigid or steady wing had an absolute weight of 4 g, with 1 g of sensors and a sailing rate of 900 cm/s. The reasonable turning wing has a counter-pivoting rotor setup with a sensor weight of 1 g, a sailing rate of 200 cm/s, and a continuance of 5 min. The calculated miniaturized scale carrier had an all-out mass of 1.8 g, highlighted a practically straightforward film envelope loaded up with hydrogen, and had a sailing rate of 200 cm/s. The applied auto-turning gadget had an all-out mass of 0.3 g, with a wing zone of 1.5 cm $\times$ 5 cm. These were intended to persist high up for most extreme period conceivable subsequent to existence sent by a subtle parent vehicle.

In late 1992, the RAND Corporation led a technical forum for the Advanced Research Projects Agency on "Future Technology-Driven Revolutions in Military Operations." The numerous programs incorporated "fly on the divider," or scaled-down fly-sized vehicle conveying sensors, route, handling with correspondence capacities. The vehicle configuration included the capacity to travel around by flying, creeping, or jumping. The alternative model included the expansion of a "stinger" on the vehicle that was expected to incapacitate adversary frameworks. For a reasonable plan, a mass on the request for 1 g, with a size on the request for 1 cm, was chosen. The force essential for drifting and for the onward flight was assessed, utilizing energy hypothesis, to be $\sim$30 mW/g and $\sim$45 mW/g. In correlation, the floating force prerequisite with huge creepy crawlies varies from $\sim$9 to 19 mW/g, and for hummingbirds, $\sim$19 to 26 mW/g. In light of utilizing a 530 J slim film lithium polymer battery, this was determined to produce an expected drift time of 4.9 h and a flying time of 3.3 h, covering 80 km.

In the overdue of the 1990s, the Defense Advanced Research Projects Agency (DARPA) discharged sales for Micro Ariel Vehicles that could have a measurement no bigger than 15 cm, a mass of around 100 g (with a payload of 20 g), and a crucial of around 1 h.

All in all, it was seen that the fixed-wing MAVs beat the rotating wing MAVs regarding journey speed, range, and perseverance. Notwithstanding, the significant favorable position of the rotational wing MAVs is their float and low-speed ability, which is exceptionally valuable for observation inside or in restricted territories.

As of late, DARPA discharged particulars for the nano air vehicle (NAV) program. The objective of this program was to build up a vehicle much littler than the MAV determinations. The gross mass of the NAV was determined as 10 g, with a payload of 2 g. Designs that were chosen for level one of this program were a coaxial helicopter, a fluttering wing vehicle propelled by a hummingbird, a fluttering wing motivated by a cicada, and a solitary bladed rotational wing (ordinarily called a monocopter) enlivened by a Samara seed. The dimension, weight, and execution prerequisites of the NAV were planned to push the restrictions of streamlined features, impetus frameworks, and hardware. The vehicle dependent on the hummingbird was chosen for additional improvement in level two of the program. The last model was equipped for steady, controllable flight inside just as outside, with a locally available camera and a fuselage fairing that made it resemble a genuine hummingbird.

The Air Force Research Laboratory has likewise discharged a strategic plan that depicts completely independent mechanical flying creatures continuously 2015 and a completely self-governing automated bug by 2030. A few examination bunches are right now researching an assortment of issues identified with such vehicles, explicitly concentrating on fluttering wing optimal design, wing air versatility, blast reaction, strength, and control just as self-ruling flight. The comparison of the previously developed model with the existing model is shown in Table 4.

Conclusion

Bioinspiration and biomimetics structure a typical subject of a significant number of these small scales and nano air vehicles (alluded to as micro flyers), for two key reasons. The principal reason is the conviction that a micro flyer playing out a reconnaissance strategic stays undetected by resembling a genuine feathered creature or creepy-crawly and actually covering up on display. The subsequent explanation is that by the ethicalness of their size, micro flyers fall in a size system that is normally populated by huge bugs and little feathered creatures. It is accepted that by duplicating a few of the qualities of these common fliers, man-caused micro flyers can improve a few parts of their exhibition, for example, flight continuance, mobility, and blast resistance. Be that as it may, it is imperative to alert against aimlessly replicating organic frameworks without appropriately understanding their capacity. It is very enticing to reason that if a specific element exists on a fowl wing, and the flying creature flies well, at that point that element is basic for flight. A case of this thinking is to infer that quills on winged creatures, by prudence of their gainful streamlined properties, more likely than not advanced to empower flight. In any case, it is currently a generally acknowledged reality that flying creatures advanced from theropod dinosaurs, and quills developed for a few reasons before the precursors of winged creatures could fly. A portion of these reasons incorporates warm protection, water repellency, and hue to draw in a mate. Various fossils have affirmed that quills existed in non-avian dinosaurs. These early plumes mirror the phases of quill improvement anticipated by hypothetical thinking dependent on transformative formative science.

Nowadays, smaller-scale air vehicles have been utilized in geo route and in guard security reasons. Much examination is in progress to structure and create 300, 150, and 75 mm vehicle classes. The advancement of reasonable development in this field requires concentrates on air dynamisms of little fluttering wing frameworks. The flow pattern in wings is concentrating research on adaptable wings than the fixed ones. This significant basic innovation needs biomimetic standards. Basic and practical investigation of wings of creepy crawlies, flying creatures, and bats gives the best biomimetic models. The current paper bargains on the streamlined attributes of three creepy crawlies. Among the three bugs, cicada, which is known to be a lord of creepy crawlies, has a wing framework for viable floating noticeable all around. It is alluring to attempt considerably more examinations including PC recreation to comprehend the flying and floating system of this bug toward the path for the advancement of miniaturized scale air vehicles of tomorrow.

The framework can be utilized for checking the region or observation. The nearness of the camera will assist the controller with viewing the zone; discover anything, crisis circumstances, and numerous different exercises. It tends to be likewise conveyed in the guard framework as the automaton for controlling the cross-fringe exercises. Because of its little structure and fluttering instrument, it cannot be seen effectively or seen by people.

Table 4 Comparison between AEE F50, AeroVironment Nano Hummingbird, the imperial eagle, Weiyujie W-1 Sky Hawk, Festo Bionicopter vs Arduino Dragon fly

Specification	AEE F50	AeroVironment Nano Hummingbird	The imperial eagle	Weiyujie W-1 Sky Hawk	Bionicopter	Arduino Dragon Fly (this work)
Control unit	Remote	Remote	Remote	Remote	Smartphone or digital spectrum transmitter	Mobile application
Altitude coverage	4921.26 ft	NA	15,091.9 ft	14,763.8 ft	NA	500ft (Can be upgraded)
Max. velocity	22.0 m/s	4.91744 m/s	25.0342 m/s	22.2222 m/s	NA	35 m/s
Wing type	Multi rotor	Flapping wing	Fixed wing	Fixed wing	Flapping wing	Flapping wing
Flight time	40 min	11 min	NA	NA	NA	Day time
Weight	2000 g	19 g	2500 g	1200 g	175 g	500 g
Wing span	NA	160 mm	1600 mm	900 mm	630 mm	60 mm
Camera	16.00 mp	2 mp	NA	NA	NA	0.3 mp
Range	65,616.798 ft	3280 ft	49,212.6 ft	5314.9 ft	NA	500ft (Can be upgraded)
Energy source	Battery	Battery	Battery	Battery	2 LiPo cells	Solar cell

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