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Design and Fabrication of a Gesture Controlled Drone

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Abstract - *UAVs (Unmanned Aerial Vehicles) or drones can be defined as powered aerial vehicle that does not carry any human operator, use a thrust force to provide vehicle lift and can fly autonomously or with a remote control. There is relatively much growth in the use of UAVs in the field of geographical surveying, photography, surveillance, agriculture, hazard mitigation, search and rescue operations, etc. making it an interesting field of research in today's digital world. Remote control of a drone is difficult for operators having less technical knowledge which may take a long time for the operator to gain control over the drone. Use of gestures over remote control is a unique method of gaining control over the drone, which makes it easy for an operator with less or no technical knowledge to gain control over the drone within few minutes. Gesture control of a drone has been implemented by various researchers and these methods are highly expensive as well as they are affected by various parameters like wavelength of light, unbalanced forces on accelerometers, bulky apparatus etc. We propose a method of gaining gesture control by combining some of the methods used by previous researchers and using an alternative for some of the sensors which helps us rectify the problems faced by earlier researchers as well as helps us to cut down the expenses for the project by a notable amount.*

Key Words: Unmanned Aerial Vehicle, drones, thrust, gesture, remote control.

1. INTRODUCTION

There is relatively much growth in the use of UAVs in the field of geographical surveying, photography, surveillance, agriculture, hazard mitigation, search and rescue operations, etc making it an interesting field of research in today's digital world. There are two types of drones based on their shape and size: fixed wing and multi rotor. Multi rotor drones are compact in size, provide good stability and are very sturdy in collisions as compared to fixed wing drones, thus providing an upper hand to multi rotor drones for operations in uncharted areas.

Remote control of a drone is difficult for operators having less technical knowledge which may take a long time for the operator to gain control over the drone. Use of gestures over remote control is a unique method of gaining control over the drone, which makes it easy for an operator with less or no technical knowledge to gain control over the drone within few minutes. Gesture control of a drone has been implemented by various researchers which includes gesture control of a drone using image processing, using leap motion controller, using Microsoft Kinect motion sensor, using a combination of accelerometers and gyroscopes, etc. The above used methods are highly expensive as well as they are affected by various parameters like wavelength of light, unbalanced forces on accelerometers, bulky apparatus etc. There are various drones in the market, some of which apply the concept of gesture control. We propose a method of gaining gesture control by combining some of the methods used by previous researchers and using an alternative for some of the sensors which helps us rectify the problems faced by earlier researchers as well as helps us to cut down the expenses for the project by a notable amount.

2. OBJECTIVE OF THE PROJECT

The main objective of our project is to gain gesture control of a drone, to minimize the learning curve for an operator and manufacture the drone at an affordable price to increase the use of drones in the field of geographical surveying, surveillance, agriculture, photography, etc.

To achieve this objective, following steps must be taken:

1. To study various research papers to know the work done on Gesture Control of Drone and Drone Dynamics.

2. To collect data and organize it in a way to extract required information.

3. To calculate optimum value of payload and lift required.

4. To establish a feasible connection between the hand controller and the quadcopter through the communication base.

5. To select sensors, motors, batteries and micro-controllers based on market survey.

3. PHYSICS OF A QUADCOPTER

A drone works on the principle of vertical lift. As the propellers start to rotate, a downward thrust and the drone hovers. For landing of the drone, the same principle applies but instead of downward thrust, an upward thrust is applied.

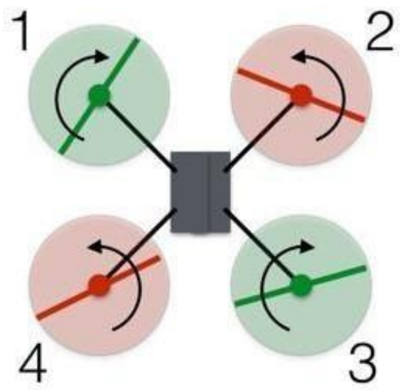


Fig. 1 Rotation of Motor

For turning (rotating), the red rotors are rotation counter-clockwise and the green ones are rotating clockwise. With the two sets of rotors rotating in opposite direction, the angular momentum is zero. Therefore, to rotate the drone, decrease the angular velocity of rotor 1 such that the angular momentum is unbalanced. So, the drone rotates in clockwise direction. But, decreasing the angular momentum decreases the thrust. Therefore, when the angular velocity of rotors 1 and 3 is reduced, that of rotors 2 and 4 is increased. [7]

As there is no difference in moving forward and backward (since the drone is symmetrical), in order to fly a thrust component is required. Increasing the angular momentum of the rear rotors will tilt the drone in forward direction. Now a slight increase in thrust for all rotors will produce a net thrust component to balance the weight along with a forward motion component. [7]

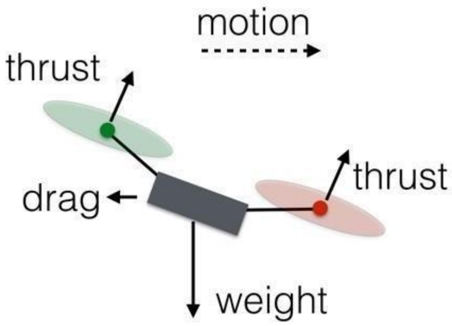


Fig. 3 Fundamental Forces on Quadcopter

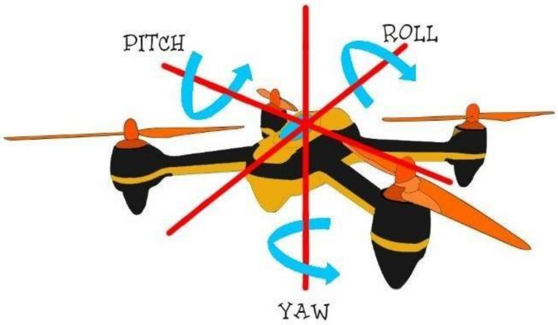


Fig. 4 Drone Dynamics

4. THRUST CALCULATIONS

Weight of Frame= 800 gm (Estimated) Weight of Components = 700 gm (Approx.) Total Weight = 1500 gm

Assuming weight = 2000 gm

2[Weight of Drone] + [Total Weight * 0.2]/No. Of Motors (Standard Formula)

= 2[2000] + [2 * 2000 * 0.2]/4

= 4000 + 800/4

= 4800/4

= 1200 gm per motor.[9]

Selected motor is A2212/13 KV 1400 BLDC thrust = 1265 g

5. COMPONENTS

5.1 HAND CONTROLLER

The main function of the controller is to transmit gesture signals to the communication base. It comprises of a motion sensor, microcontroller and a RC transmitter.

a. Motion Sensor

The function of the motion sensor is to collect gesture data and transmit it to the communication base using 433MHz transmitter. The motion sensor used in our project is "MPU-9250 9DOF motion sensor". It consists of 3-axis accelerometers, 3-axis gyroscope and 3-axis magnetometer. The motion sensor sends the gesture signals to the microcontroller.[2]

b. Microcontroller

The function of the microcontroller is to store data and manipulate it when required. The microcontroller that we are using in our project is "LILYPAD USB plus". The main advantage of using this microcontroller is that it consumes less power and gives higher output when compared to other microcontrollers like raspberry-pi. The microcontroller sends radio signals using a 433MHz transmitter to the communication base.[5]

5.2 COMMUNICATION BASE

The communication base consists of a 433MHz receiver, microcontroller, 2.4GHz radio- transmitter. The microcontroller that we have used in the communication base is "ARDUINO UNO". It receives the radio signals transmitted by the hand controller using 433MHz receiver module. These radio signals are further transmitted to the quadcopter using a 2.4GHz radio transmitter which is "AIDENPEN NRF24L01".

5.3 QUADCOPTER

The basic ideology behind our project is design, fabrication and testing of a gesture- controlled quadcopter. The quadcopter consists of body, BLDC motor, electronic speed controller, Lipo-battery, Flight controller, 2.4GHz receiver and ultrasonic sensors.

a. Body:

The body is of 'Stretch X' design as this structure is the most dynamically stable.[8] We get reduced air disturbance and improved cornering performance. Stretch X frames are more precise on pitch and more sensitive on roll axis. The trade-off is that the weight is slightly more. We'll be using PLA as our primary material. The design is made up of 4 main parts: the lower base (1), the upper base (1), the lower arm (4) and the upper arms (4).

b. BLDC Motor:

The motors used should provide enough thrust so as to fulfil the conditions of Hovering and flight.

c. Electronic Speed Controller:

The main function of this unit is to vary the current going to the motor. The motors od the drone rotate at different speeds to move through space.

d. LIPO Battery:

A lithium polymer battery is used as an energy source for the motors and flight controllers.

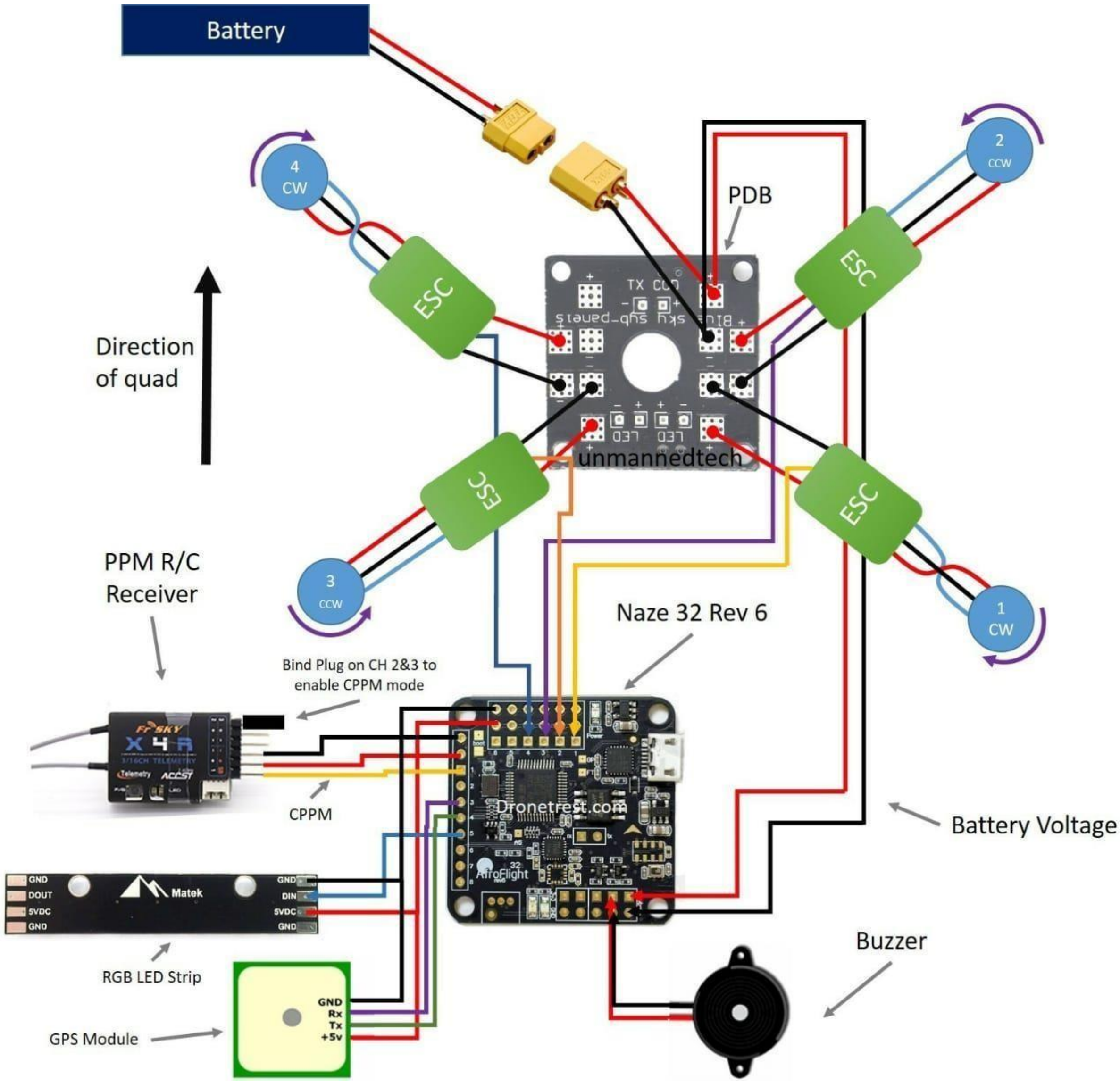


Fig. 5 Circuit Diagram

6. METHODOLOGY AND WORKING

Early researchers have been able to gain gesture control over a quadcopter within a range of 10-22 meters from the controller. This range is too low when compared to other commercial quadcopters which can fly within a range of 100-800 meters from the controller. Thus, to achieve a higher range we propose a method in which by the use of a communication base we will be able to achieve a range within 60-80 meters.

Another issue with early attempts has been the altitude of the drone which has been within a range of 6-12 meters. We propose a method to improve this range to 18-20 meters by the use of a motion sensor which helps the drone to know its exact postion with reference to the controller.

There have been no attempts to avoid collision of the quadcopter with any obstacle which has been successfully covered in our project by mounting pairs of ultrasonic and proximity sensors.

The cost of previously completed efforts has been within a range of Rs.20000-64000 which is not at all within an affordable range for commercial sector. We have successfully cut down these costs to Rs.9000 which lies within the budget of a commercial consumer.

The sensors on the hand controller like accelerometers sense the Gestures and send this information to the 33mhz receiver on the communication base. The communication base in turn encodes this into Radio Frequency.

The encoded radio frequency (rf) of gesture signal is sent to the quadcopter by the 433mhz transmitter and on receiving the signal the 433mhz receiver sends the signal to the decoder which decodes the signal from rf to digital signal. This digital signal is then converted by the memory of Naze 32 rev 6 controller through programming that is fed into the controller.

The controller then orders to change the Electronic Speed Controllers to change the speed at which particular motors are rotating to do the required or necessary action. For Example, making a Right Turn, Increasing Speed, etc.

The sensors on the Quadcopter are also connected to the Controller. They feed their input and relate information about the surroundings to the controller. For example, if there is a wall in near proximity to the left arms, the quadcopter is close to the ground, etc.

Thus, through both these inputs, the Controller controls the Quadcopter.

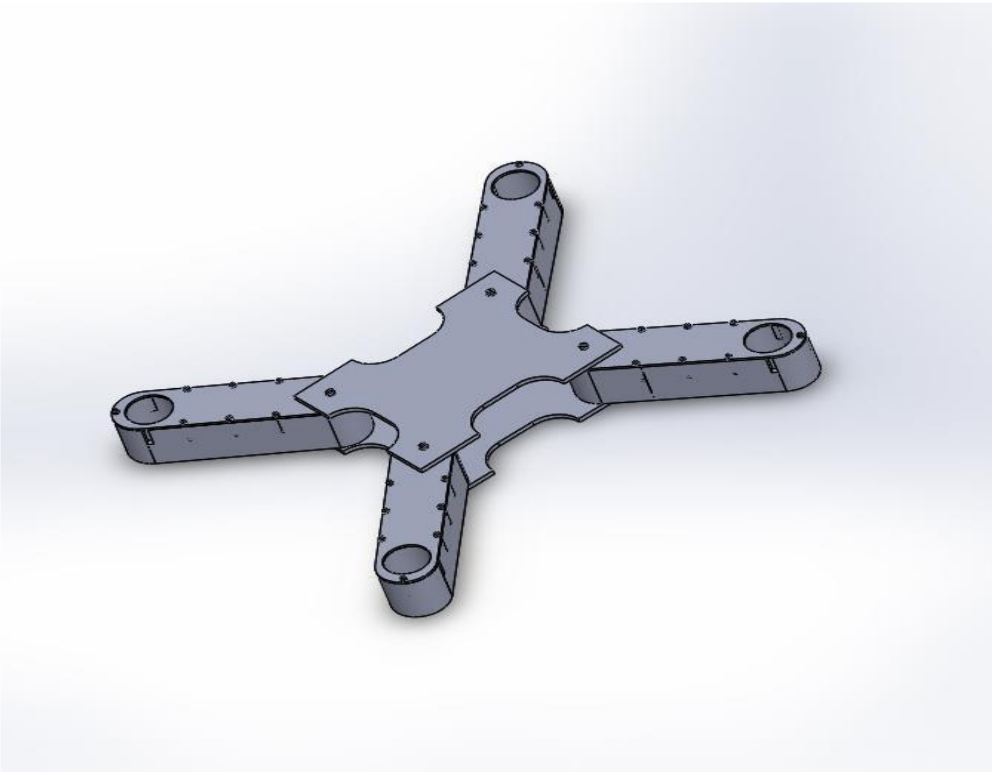


Fig. 6 Quadcopter Body Design

7. ANALYSIS AND RESULT

7.1 ANALYSIS OF ARM:

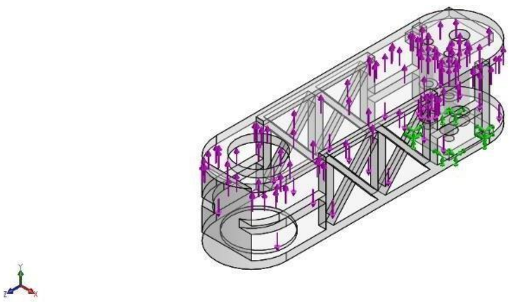


Fig. 7 Wire Frame of Drone Arm

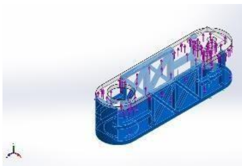
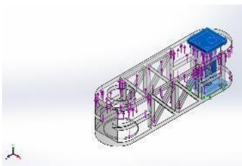
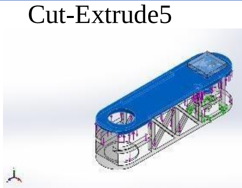
Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Boss-Extrude13 	Solid Body	Mass:0.0801121 kg Volume:6.73211e-05 m^3 Density:1190 kg/m^3 Weight:0.785098 N	C:\Users\user.DESKT OP-6AHM9PI\Downloads \LowerArm3.SLDPRT Jan 21 11:00:02 2020
Boss-Extrude6 	Solid Body	Mass:0.0177197 kg Volume:1.48905e-05 m^3 Density:1190 kg/m^3 Weight:0.173653 N	C:\Users\user.DESKT OP-6AHM9PI\Desktop\ A dvait BE\Part1.SLDPRT Jan 21 11:41:40 2020
Cut-Extrude5 	Solid Body	Mass:0.0439012 kg Volume:3.68918e-05 m^3 Density:1190 kg/m^3 Weight:0.430232 N	C:\Users\user.DESKT OP-6AHM9PI\Downloads \UpperArm3.SLDPRT Jan 21 11:00:01 2020

Table 1 Model Information

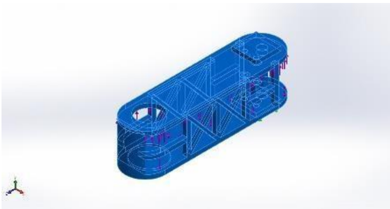
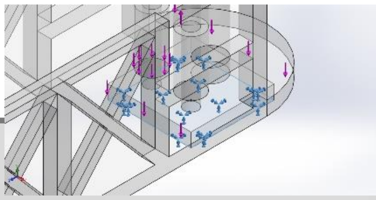
Model Reference	Properties		Components
	Name:	**PC High Viscosity**	**Solid Body 1(Boss-Extrude13)(LowerArm3-1), Solid Body 1(Boss- Extrude6)(Part1-2), Solid Body 1(Cut-Extrude5)(UpperArm3-1)**
	Model type:	**Linear Elastic Isotropic**	
	Default failure criterion:	**Unknown**	
	Tensile strength:	**6.27e+07 N/m^2**	
	Elastic modulus:	**2.32e+09 N/m^2**	
	Poisson's ratio:	**0.3912**	
	Mass density:	**1190 kg/m^3**	
	Shear modulus:	**8.291e+08 N/m^2**	
Curve Data: N/A			

Table 2 Material Properties

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** **1 face(s)** **Type:** **Fixed Geometry**

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**-0.000165805**	**-9.30809**	**-0.000351608**	**9.30809**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

Load name	Load Image	Load Details
Force-1		**Entities:** **1 face(s)** **Type:** **Apply normal force Value:** **11.76 N**

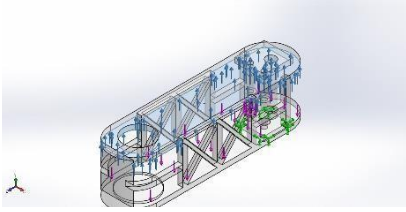
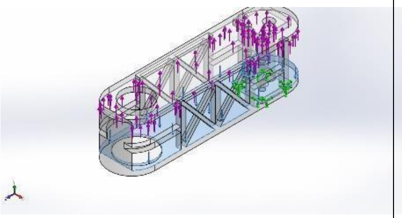
		
Force-2		**Entities:** **1 face(s)**

Table 3 Loads and Fixtures

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	5.22049 mm
Tolerance	0.261024 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

Mesh information – Details

Total Nodes	19763
Total Elements	10549
Maximum Aspect Ratio	13.946
% of elements with Aspect Ratio < 3	87.8
% of elements with Aspect Ratio > 10	0.171
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:05
Computer name:	

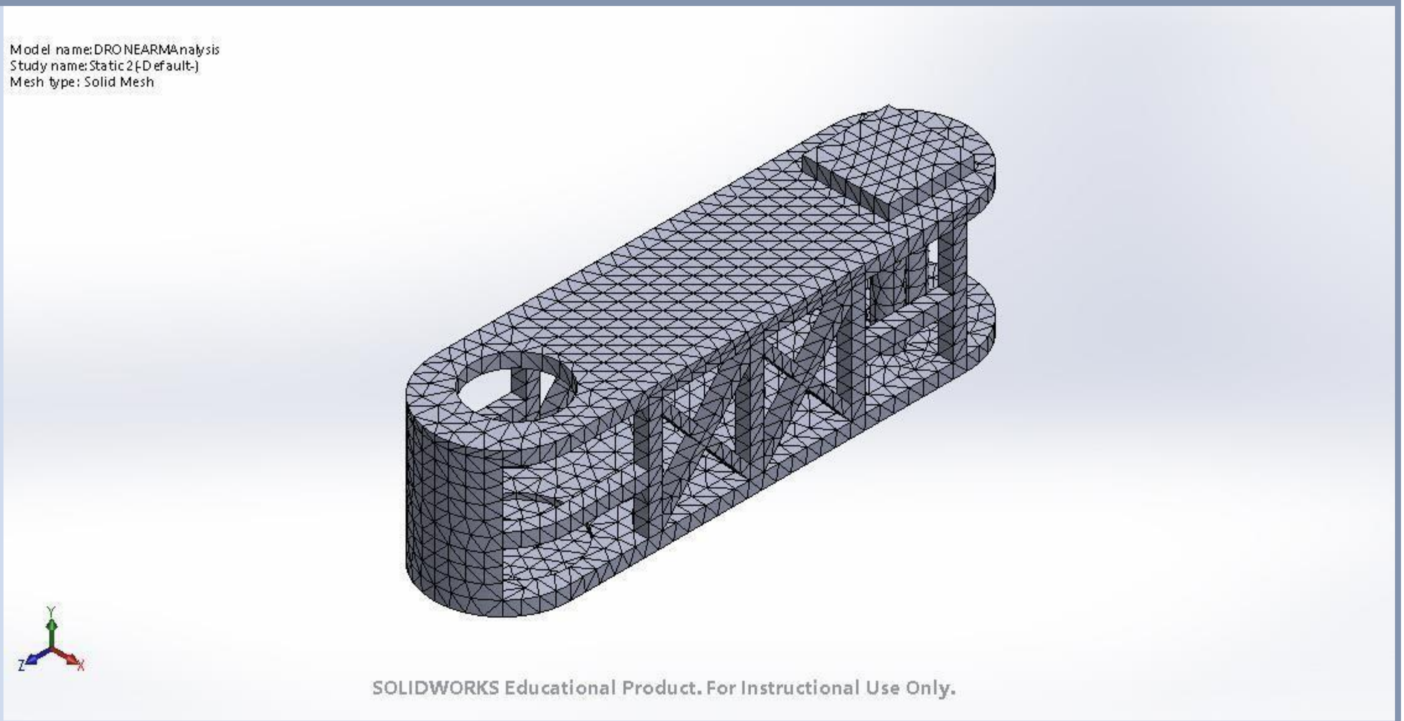


Table 4 Mesh Information

7.2 STUDY RESULTS

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.757e+02 N/m^2 Node: 17215	7.431e+05 N/m^2 Node: 7793

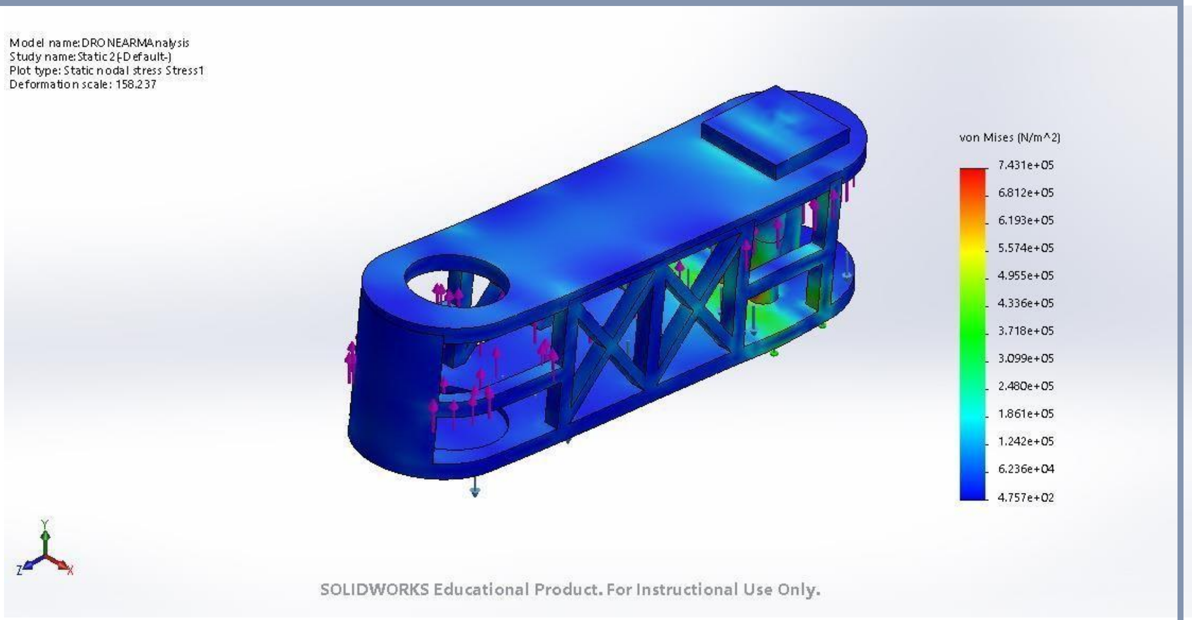


Fig. 8 Static Stress Analysis

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 12202	1.216e-01 mm Node: 14809

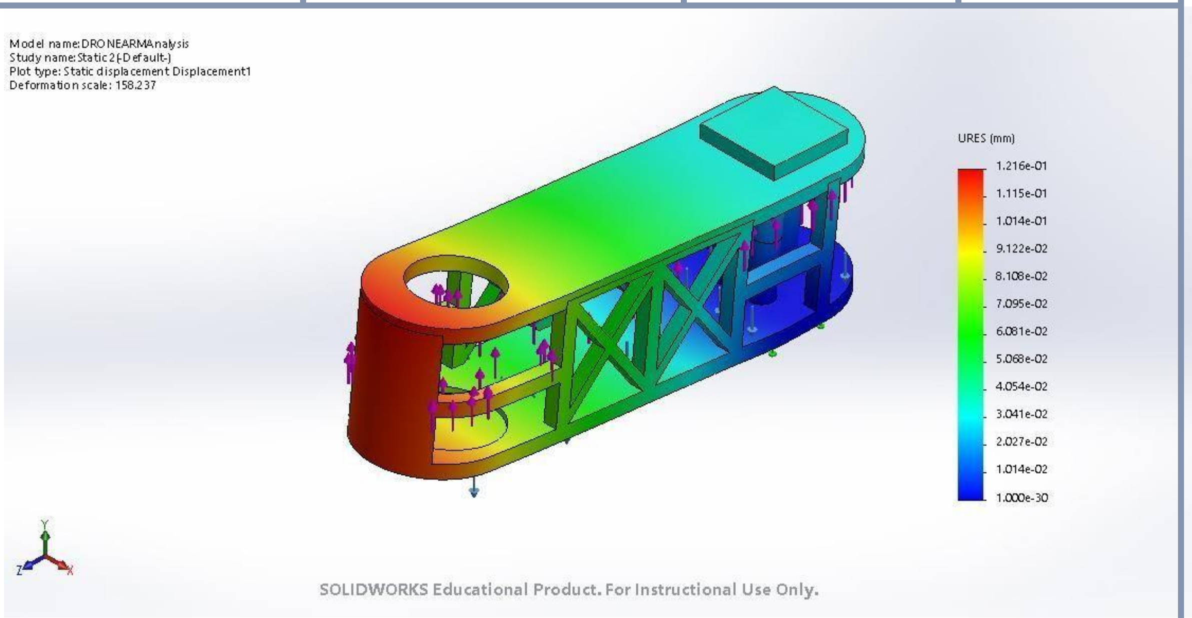


Fig. 9 Static Displacement Analysis

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.141e-07 Element: 4487	2.537e-04 Element: 3451

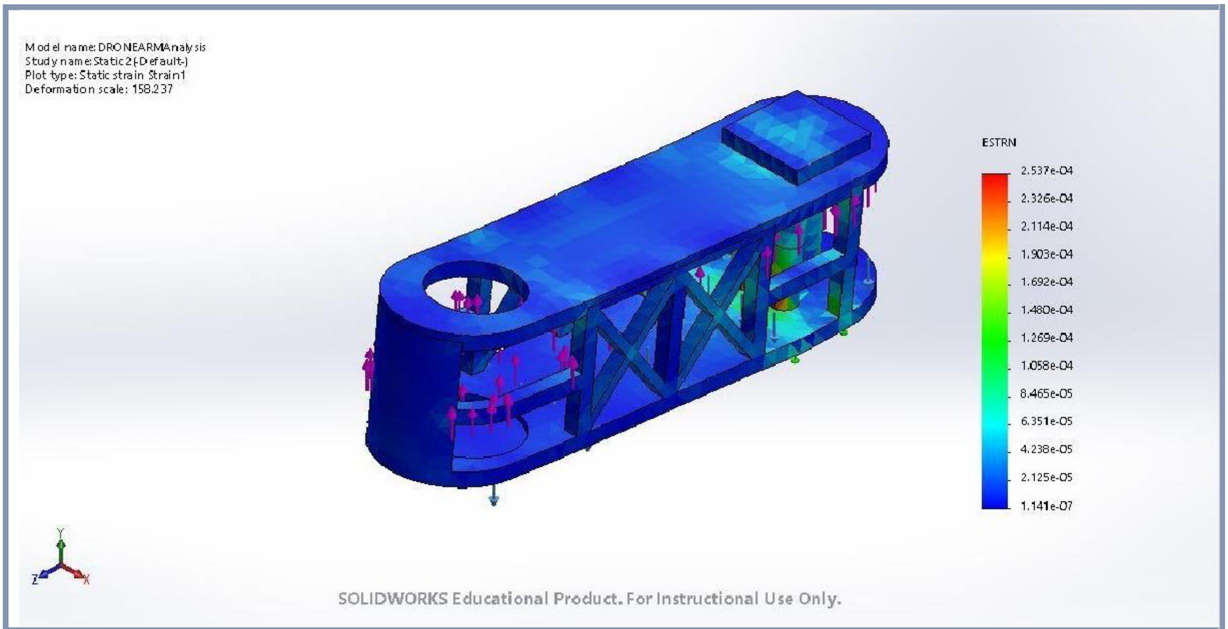
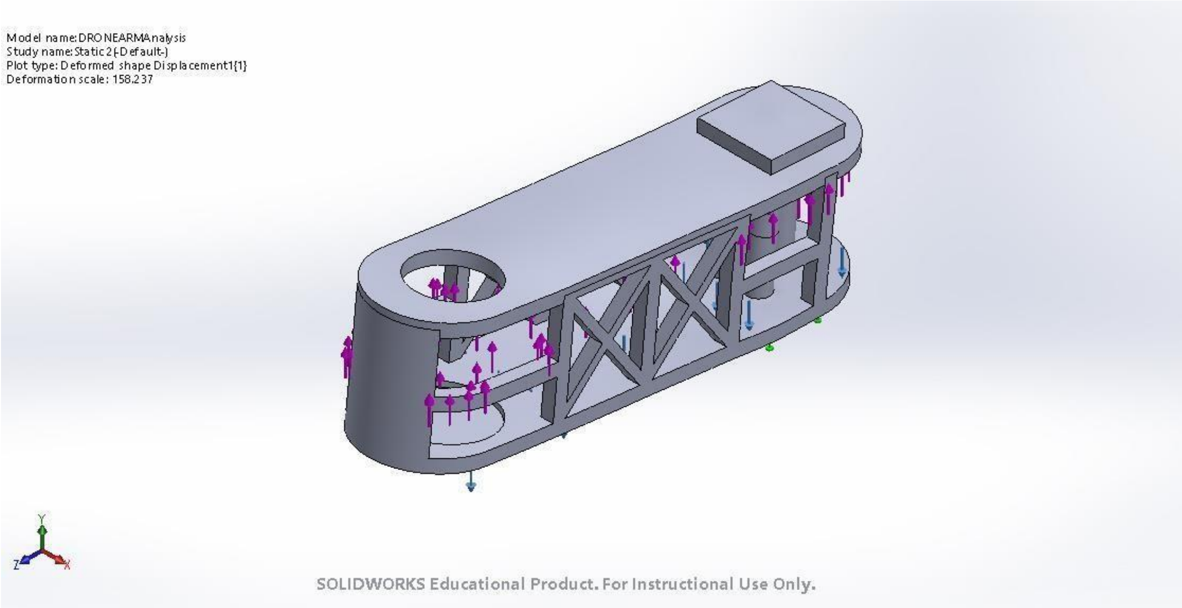


Fig. 10 Static Strain Analysis

Name	Type
Displacement1{1}	Deformed shape



DRONEARMAnalysis-Static 2-Displacement-Displacement1{1}

Fig. 11 Deformed Model

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