CYBORGS

Gokul Karthik Sai Vamshi, Sahil Sunil Hinge

Gokul Karthik Sai Vamshi, India

Sahil Sunil Hinge, India

ABSTRACT

Technological advancements have converted wars fought from sticks and stones to modern nuclear weapons. In the coming future, war will not only be fought between humans but robots will also be playing a significant role in turning the tables of war.

WHAT ARE CYBORGS?

Cyborgs are animals that have been augmented with machines, with electronic equipment like chips, electrodes to enable us to have control over them.

IMPORTANCE IN DEFENSE

Cyborg is not a fictional character or a new concept but an *existential reality*, where countries like the United States, Russia and even China have made phenomenal progress in ***enhancing*** the ability of certain animals and insects. The Indian defense organization DRDO is working on a mouse where they are implanting ***electrodes*** in its brain and mounting a wireless micro stimulator on its posterior, with the advancements in it, we can remotely control these animals from a computer and use them as a surveillance system in situations like ***terrorist attacks***, ***sniffing landmines***, ***search and rescue*** operations.

CYBORG MICE

In this paper, we will be using the concepts of ***optogenetics*** and modern technology to control animal behavior.

OPTOGENETICS

A method of controlling neural activities using light and genetic engineering, in this field, scientists have found a protein called opsin in algae that uses light to move towards it, similarly ***channelrhodopsin-2*** is an opsin which gets activated to blue light and can be implanted in the brain of animals through genetic coding. With this, we can implant fiber optic threads through surgery to target neurons responsible for certain action potentials, which can be activated by turning on and off a blue light to trigger the desired actions and controls.

Keywords: Optogenetics, Spying, Defence, National Security, Triggered Response

CYBORG MICE

A team of korean researchers of KAIST korean advanced institute of science and technology augmented a mouse with a head gear having optical cables of about 500 nm.
The optical cables were surgically implanted on the mouse in certain regions of the brain that is responsible for locomotion.

EXPERIMENTAL PROCEDURE

The mouse which has a augmented headgear was placed in phase and its MPA-VGPA circuit was monitored to tack the neural activity during the experiment
By sending a signal to the head gear the light could be switched on and off, hence causing a mouse to scamper straight ahead. By applying it in a head mounted object control with timely photostimulation of MPA-VGPA circuit, the circuit induced action only occurred when the target was detected within the **binocular[1]** collar visual field and with the combination of a photo stimulator and movement of a suspended object, we could control the direction of the mouse.

OPTOGENITICS

The brain is an incredibly dense and weird computer made out of hundreds and billions of individual cells called neurons which communicate with each other through electrical and chemical signals. When a neuron is activated with chemical signal it sends an electrical pulse which forms a chain of such electrochemical signals

Each neuron has its specific role and if we could figure out the specific function of that individual neuron then we can cure diseases such as *parkinsons* and *schizophrenia.*

Now with the advancements in science we can now control neurons by activating them with specific lights. This is possible because of microorganisms from ponds called *chlamydomonas*. Chlamydomonas is an organism which needs light for photosynthesis. It locomots to the light using special organelles called an *eyespot[2]*. The eyespot contains a light sensitive protein called channelrhodopsin which responds to blue light by moving towards the positively charged ions across the eyespot membrane causing the voltage of the eyespot to change. It is observed that if we take a piece of this DNA that encodes with that of the ***channelrhodopsin protein*** then we can target the favored neurons according to our will using the blue light through the optic cable. Now the neurons can be activated using the blue light without affecting the surrounding neurons and only work their way on the target neurons.

We can also silence the neurons with the help of halorhodopsin which are sensitive to orange light and counteract the effect of that of the channelrhodopsin
By combining the tools mentioned we can control the mouse's brain using the light.

ROBOTS OR CYBORGS

The invention of wheel and fire was a significant leap for the people of the stone age. When the nuclear arms race between the Soviet Union and the USA had begun, the spy's of the Soviet Union and the United States were up to their every nook and cranny to get the secrets of each other's nuclear secrets. The top officials took their security very seriously as the threat of assasination of top government officials was at its peak and so was the infiltration of spies into enemy borders to gather information. This was the time when ***information*** became more important than ever, giving rise to the ***age of information***. Satellites, drones, robots are now things of the past, these are the expected ways of spying, can be easily detected and need a lot of complex programming and heavy hardware to function, ***Cyborgs*** leads the future.

Figure 1: Description of the image.
a.)Rat b.)PCB Image c.)PCB Image

The PCB is shown with the footprint of their components. The PCB will be mounted on the back of the mouse, the onboard sensors will allow the user to control the rat and help them change the direction of the rat.
The onboard GPS(Global Positioning System) gives information on the routes the rats travel and the MPU(Gyroscope Sensor) will give the orientation of the rat's direction. We have a camera on board which helps send the visual data and a microphone with a transmitter whose frequency can be set to will and the transmitted audio can be received by a transceiver working in the same frequency range.
All of the onboard electronics weigh less than 56 grams with an error of +- 3 grams, the battery of 17 grams included. Detailed specifications of all the used electronics is given on page number .

Steering the mouse

The ***MIDAS*** system is used to control the direction in which the mouse is moving. The direction can be controlled remotely using a controller that connects wirelessly to the PCB mounted on the posterior of the mouse.(The image of the mouse mounted with the motor and attached to the target object is given in figure 2).
To test this theory the scientist used a maze filled with 7 obstacles for the mouse to travel through and solve it. They used *3* methods of control for the mouse's direction.(The image of the maze and the results using different control methodologies are given in figure 3).

1. **Only object controlled**
   In this method a servo motor or a motor with encoder is used to control the angle of an object hanging from the motor which is so adjusted to be in the viewing field of the mouse. The mouse then follows the object.
   By controlling rotation of the motor we can achieve a change in direction of the mouse. But this way of control is not very reliable, as the experimental results show that the mouse followed a longer path than necessary to complete the maze and overcome the obstacles.

2. **Only led controlled**
   In this method, optical fibers are implanted in the brain of the mouse. The optical fibers are attached to blue led's on the PCB. These leds can be remotely controlled i.e can be turned on and off. The optical fibers are implanted in the brain of the mouse in certain regions where the channelrhodopsin can be activated. The implantation of the optic fiber is in the peripheral region of the brain of the mouse, which controls the locomotion of the mouse giving the scientist control of the mouse's direction.
   But this method of controlling the mouse using leds only proves to be less effective when done experimentally. So the scientist switched to a combination of both of these.

3. **Both led and object controlled**
   The scientist, by observation, saw that the previous two models had some drawbacks of their own. In the previous trial they could not get the desired results as the mouse was not following the results accurately and taking a longer path than expected to complete the maze, in fact in many of the trials the mouse could not overcome the obstacles at all.
   Using both the light controlled channelrhodopsin and the object hanging the scientist could control the mouse as desired and got the exact expected results.
   The mouse completed the circuit in the least time with minimum number of distractions or deviations and responded to the produced *stimuli[13]* with incredible accuracy.

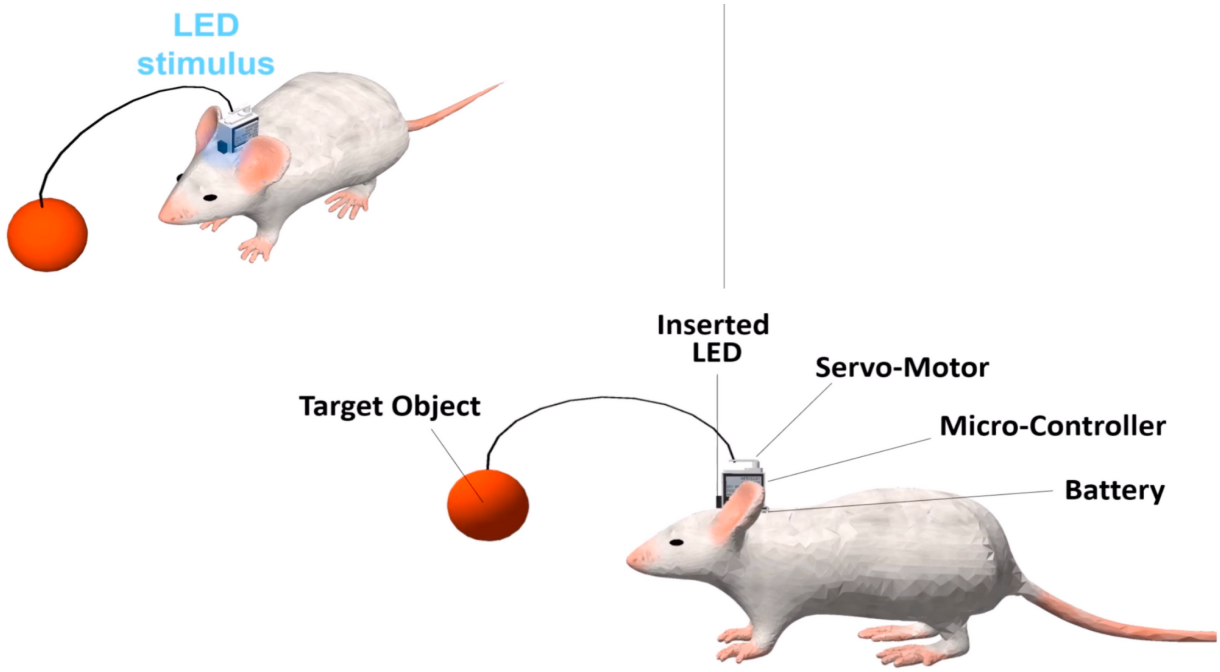

Figure 2: the image shows a mouse mounted with a servo motor for object angle change, an led, a battery for electricity and a microcontroller for controlling the angle of the servo motor and the turning on and off of the led.

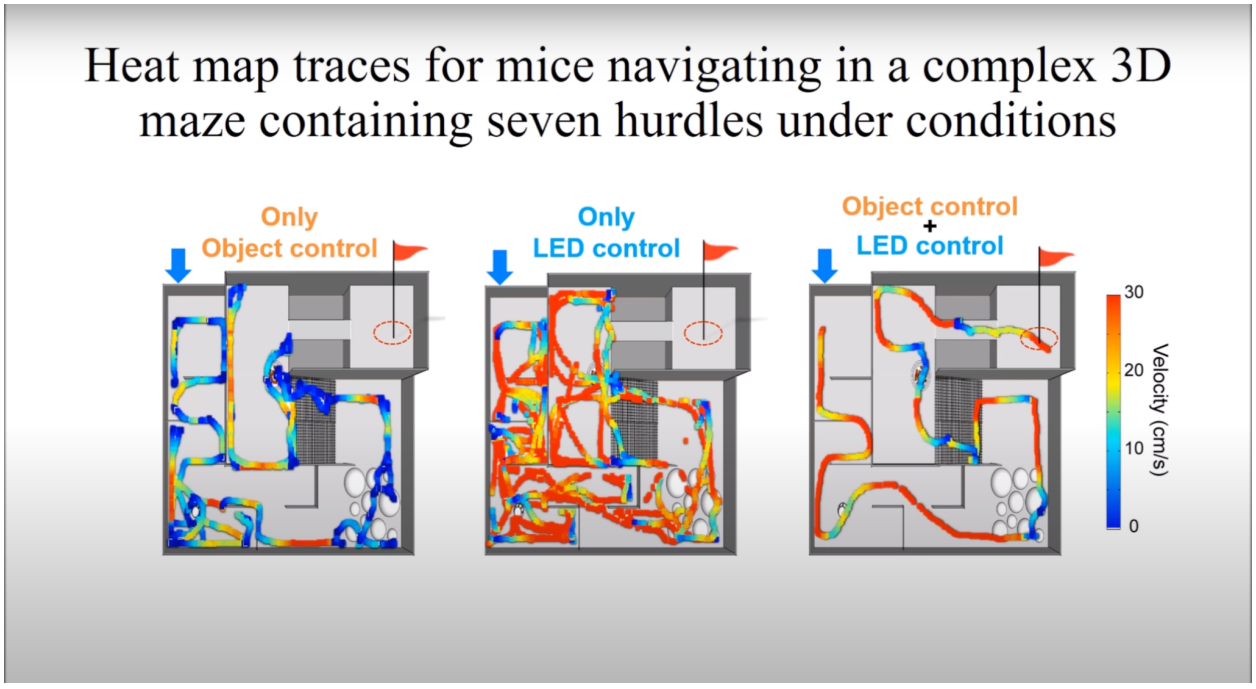

Figure 3: this is the image of the path taken by the mouse to solve the maze using different control methods as labeled above.

ELECTRONICS AND TECHNOLOGY INVOLVED

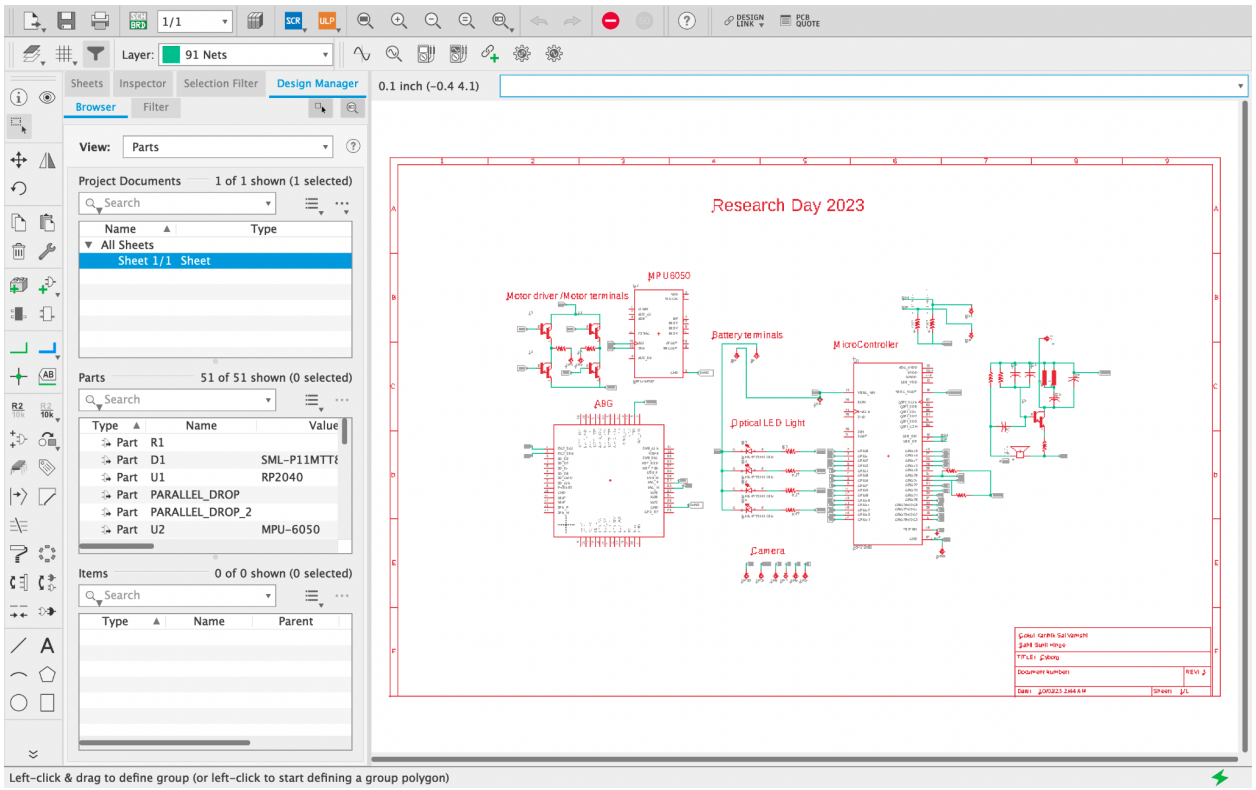

*Figure 4: The following is the schematic of the PCB(Printed Circuit Board) used on the cyborg mouse. The schematic is made on **Eagle Cad** Software by **Autodesk** company pvt.ltd on a students educational account license. Note : the following schematic is not to scale.*

The following are the technical specifications of the circuit board :

1.) The board features a **RP2040** microcontroller which was made by the ***Raspberry pi foundation*** for Raspberry Pi Pico.
2.) The RP2040 is an extremely powerful microcontroller, capable of performing 2 tasks simultaneously without the use of interrupts. Each pin of the microcontroller can give a maximum output of 150mA of current making it a versatile tool.
3.) We can further enhance the capabilities of the RP2040 using some complimentary capacitors, resistors and mosfets according to the given datasheet.
4.) The RP2040 has been chosen because it supports a wide range of input voltage levels, i.e 3.1 to 5.5 volts and can even perform well under changing input voltage situations which can occur as the *lithium polymer[3]* battery discharges.
5.) It features an *IMU[4] (Inertial Measuring Unit)* made by ***adafruit*** foundation which helps in orientational sensing of the *Cyborg rat*.

6.) The board also consists of an A9G module for GPS and large distance communications.
7.) The board comes with its own *H-Bridge* motor driver made out of 4 darlington pair transistors which help the motor control its speed and direction according to the user requirement.
8.) The board has 4 Blue LED's for controlling the cyborg rat's brain using optical fiber glass. The LED's have *0402* as their package so we can easily connect optical ray tubes to them to be implanted into the *Cyborg rat's* brain.
9.) The circuit has a MIC that can record and send data in the form of amplified modulated waves which can be decoded and the information be obtained at the receiver end. The *A9G* module helps in the smooth transfer of data without any significant errors, to minimize any unwanted wave signals we have a high capacitance capacitor as the lower bypass filter for high and medium range frequency modulation.
10.) The board has a ***camera*** for video transmission. The camera is a ***2****k resolution* camera with 4X zoom. The camera using the transmitter on the PCB can send live data from its location to the intended area.
11.) The transmitter range is limited by the length of the antenna it is equipped with.
12.) The components used on the board are all SMD*[5] (Surface mount devices/technology) that can be soldered on the board using the stencil given by the manufacturer and some solder paste. The solder paste can be heated using a *hot plate* or a *heat gun.*
13.) SMD components are used because they are more efficient than the *through hole components[5]*. They occupy less space on the board and are lighter than the through hole components. They are more efficient in power transmission and the response time of a surface mount is magnitudes times faster than that of the through hole device.
14.) The *traces[6]* of the board are so given to handle any spike in current and any voltage overshoot.

Other specifications :

1.) The onboard electronics are powered by a lithium ion battery of 750mAh. This means that the board (if working on peak ability) will be powered for 4-5 hours and on a practical use the charge can last up to 7-10 hours.
2.) The circuit is minimized into a space of 22.84mm X 22.78mm, i.e in an area of 520.29mm square.
3.) The weight of the empty board is 8.6 grams and the weight including the electronic components, sensors and the modules sums up to 23 grams. This brings the total weight to 31.6.
4.) The weight of the battery is around 20 grams, so the total weight is about 51.6 grams.
5.) The copper density of the build is set to be around *2 oz* / square feet, for the polygon copper poring.

6.) The board can be programmed using the DP[7] and DN[8] line pads. We can use circuit python, micro python or pandas as the goto python library or use C/C++ for coding the board according to our requirements.

7.) The programming of the RP2040 can be done directly without the use of series termination resistors as they are inbuilt into the PCB[9].

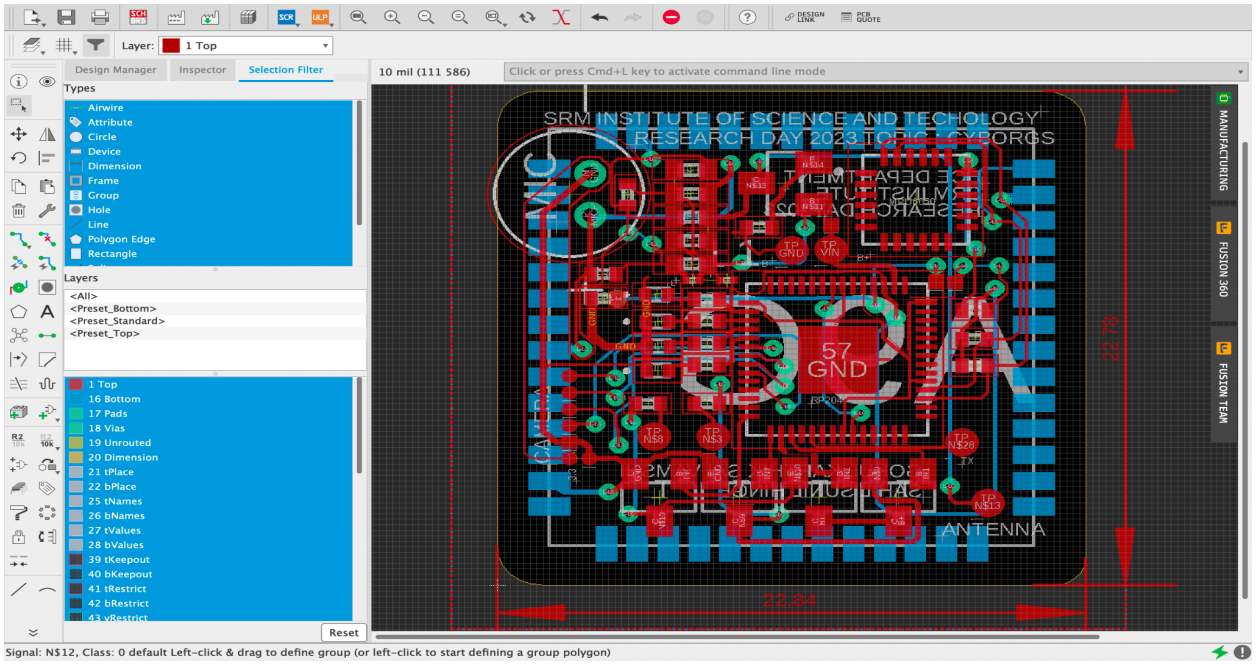

Figure 5: This is the board file of the PCB. It is a 2 layer board with all the components being SMD(Surface mount device) and the corners are curved in order to maintain safe installation without any risk of chipping/hurting the ***Cyborg rat.*** *The board is made with the help of the software* ***Eagle Cad[11]*** *made by* ***Autodesk*** *company pvt.ltd. This is a student account using an educational license.*

Conclusion

In this paper we are trying to make an effort in understanding deeply about the cyborgs and how we can improve their capabilities with the existing technology .

We are also trying to improvise and work on a more efficient way of controlling cyborgs through principles of optogenetics and research based on the MIDAS system which is more power efficient, comparatively higher accuracy and less threatening for the animal.

With more research in this sector we can create a cyborg of different animals combining their natural capabilities and controlling them efficiently hence bridging the gap between India and other countries in this sector.

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https://www.makerfabs.com/desfile/files/a9g_product_specification.pdf

LED and CAPACITOR PACKAGE - 0402 Datasheet Link :
https://www.alldatasheet.com/view.jsp?Searchword=0402%20pdf&gclid=CjwKCAiA0JKfBhBIEiwAPhZXD0ZwzyxkM5MCUbIVJYOruVO0_ECMNGH2AakJmWkG21VkKhT4a_Ia0BoCVNoQAvD_BwE

Darlington Pair Transistor :
https://www.ti.com/lit/ds/slrs023e/slrs023e.pdf?ts=1675968045762&ref_url=https%253A%252F%252Fwww.google.com%252F

Figure 1 : google :
https://www.google.com/search?q=cyborg+rat&rlz=1C5CHFA_enIN971IN971&source=lnms&tbm=isch&sa=X&ved=2ahUKEwix0ebu2I79AhU44DgGHXMmDdQQ_AUoAXoECAEQAw&biw=1440&bih=735&dpr=2

Figure 2, Figure 3: https://youtu.be/qgo9iSO4yBc

Figure 4, Figure 5 : PCB designed by us.

Autodesk Eagle(PCB design Software used) :
https://www.autodesk.in/products?mktvar002=5019031|SEM|11381098541|111085713053|kwd-15326526&utm_source=GGL&utm_medium=SEM&utm_campaign=GGL_DEC_Autodesk_APAC_IN_eComm_SEM_BR_New_EX_0000_5019031_PureBrand&utm_id=5019031&utm_term=kwd-15326526&mkwid=s|pcrid|595091379051|pkw|autodesk|pmt|e|pdv|c|slid||pgrid|111085713053|ptaid|kwd-15326526|pid|&utm_medium=cpc&utm_source=google&utm_campaign=&utm_term=autodesk&utm_content=s|pcrid|595091379051|pkw|autodesk|pmt|e|pdv|c|slid||pgrid|111085713053|ptaid|kwd-15326526|&gclid=CjwKCAiAlp2fBhBPEiwA2Q10DxjPd9MOeVefvQpXQ4xiC6Z538pHrnTz64kPdjTLt_J1g_MK9qgknBoCEOkQAvD_BwE&ef_id=YvK6dAAFOd8yEgAK:20230212001109:s

Terminologies

[1] Binocular : it is a type of vision possessed by animals that have both the eyes in the same direction to perceive a three dimensional signal.

[2] Eyespot : The eyespot organelle of the green alga Chlamydomonas allows the cell to phototax toward (or away) from light to maximize the light intensity for photosynthesis and minimize photo-damage.

[3] Lithium polymer : Lithium polymer batteries are rechargeable batteries that are a mixture of lithium ion and a gel/polymer type of mixture. They are also called lipo batteries.

[4] IMU : IMU refers to an inertial measurement unit, a type of sensor that can measure the orientational effect of the body using the MEMS(Micro mechanical-electrical system) system. This sensor can help us with the orientation of the body with the acceleration value of the body and with the magnetometeric reading of the surrounding area.

[5] SMD & through hole components : SMD refers to surface mount devices or surface mount technology. This refers to the package of a particular component, whether the component has leads that penetrate through the surface, or is called through hole.

[7] DP, [8] DN : DP DP signifies the data positive and the data negative terminals of the USB connector which are used for programming the arm cortex based silicon microcontroller.

[9] PCB : Printed circuit board (PCB) is an electronic circuit board composed of copper layers cut with a CNC machine. The traces cut act as wires connecting different components.

[11] Traces : Traces are connections made in a PCB using the process of etching, in which the copper layer is cut and placed on an insulating fiber glass material commonly referred as *FR4* material.

[13] Stimuli : An external event or occurrence that triggers an internal notion to occur.

***Note** : All the measurements given, applied with a tolerance value of +/- 3% and an error in measurement of +/- 5%.*