e-Yantra Robotics Competition - 2017

Theme Analysis and Implementation - Spotter Snake

SS#3763

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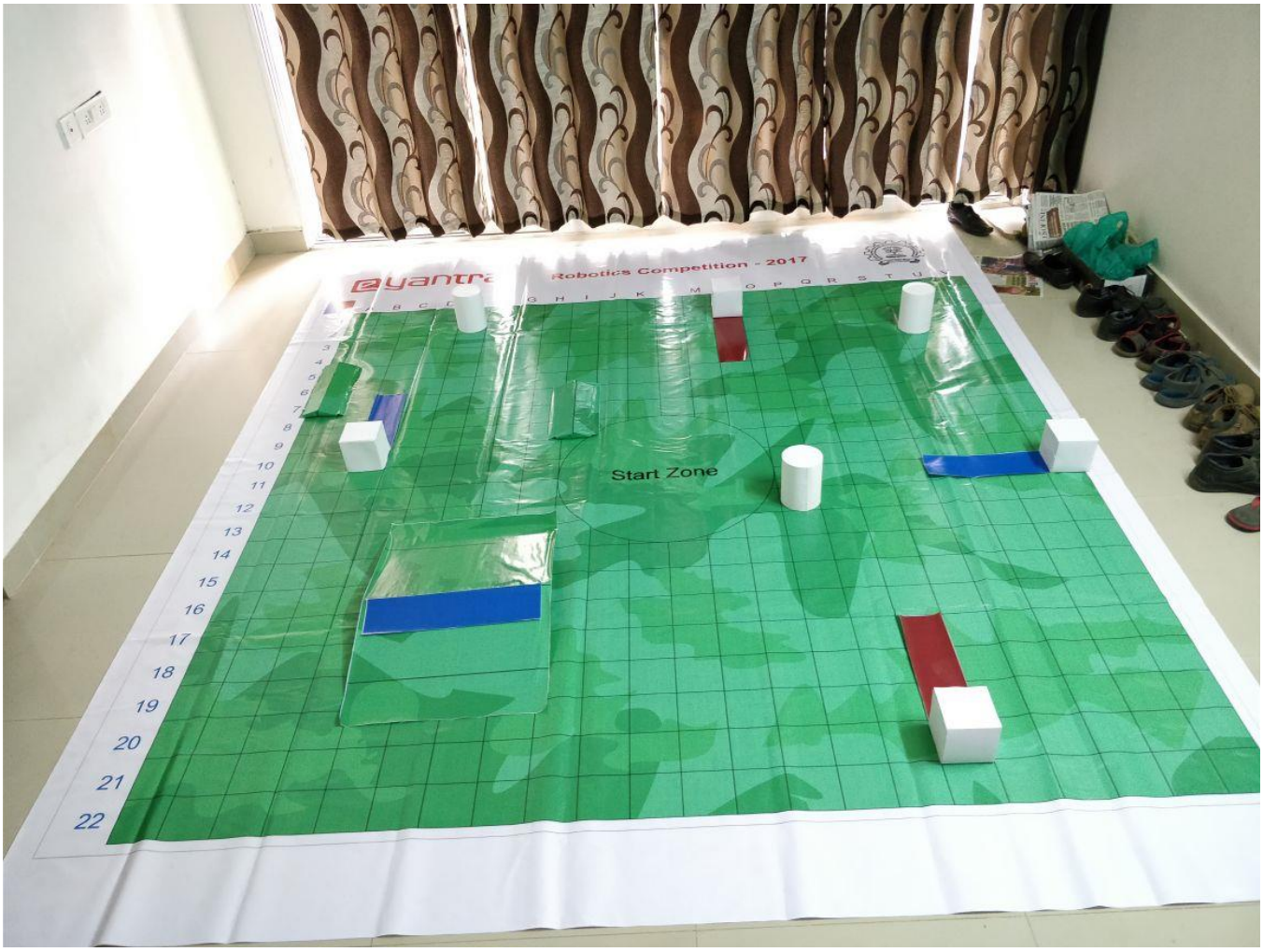
Preparing the Arena

Q1. Prepare the Arena for Spotter Snake and insert the image of arena here. (5)



Rules and Scoring

Q2. Spotter Snake theme consists of the following formula for scoring as in Section 7 of Rulebook:

Total Score = (600 - T) + (CR*300) + (RD*100) - (FD*50) - (P*30) - (RP*100) + B + CB

What will be your strategy to earn maximum points in a run? (5)

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Explain the various terms of scoring formula. Explain best and worst case scenarios. Support answer with scores for various scenarios.

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The scoring pattern contains all the elements required for a perfect and unbiased judgement.

1) (600-T): It has the element of the time, taking the swiftness of robot in account. The term T refers to the time taken by the spotter snake to complete the task. Less the time, More this term will fetch us marks.
2) CR (Successful crossing of ramp) : 300 points would be awarded to our team for crossing the ramps in the given arena successfully. The maximum value of the term would depend on the number of ramps given in the arena. Points will not be awarded again if we cross the same ramp again.
3) RD (Correct Rodent Detection): 100 points would be awarded for correct detection of rodent. Correct detection means the RGB LED should turn to the color of the rodent which the bot is detecting and the buzzer should beep 2 times with the interval of one second. This should be completely autonomous.
4) B (Bonus) : 100 points are awarded when the team's bot executes a perfect run which means detecting all the rodents successfully, crossing all the ramps and avoiding all the penalties.
5) CB (Creativity bonus) : This is out of 400 points which is awarded according to the discretion of the judges according to the different types of gait that the bot would perform and the functionality of head.

There are also different types of penalties :

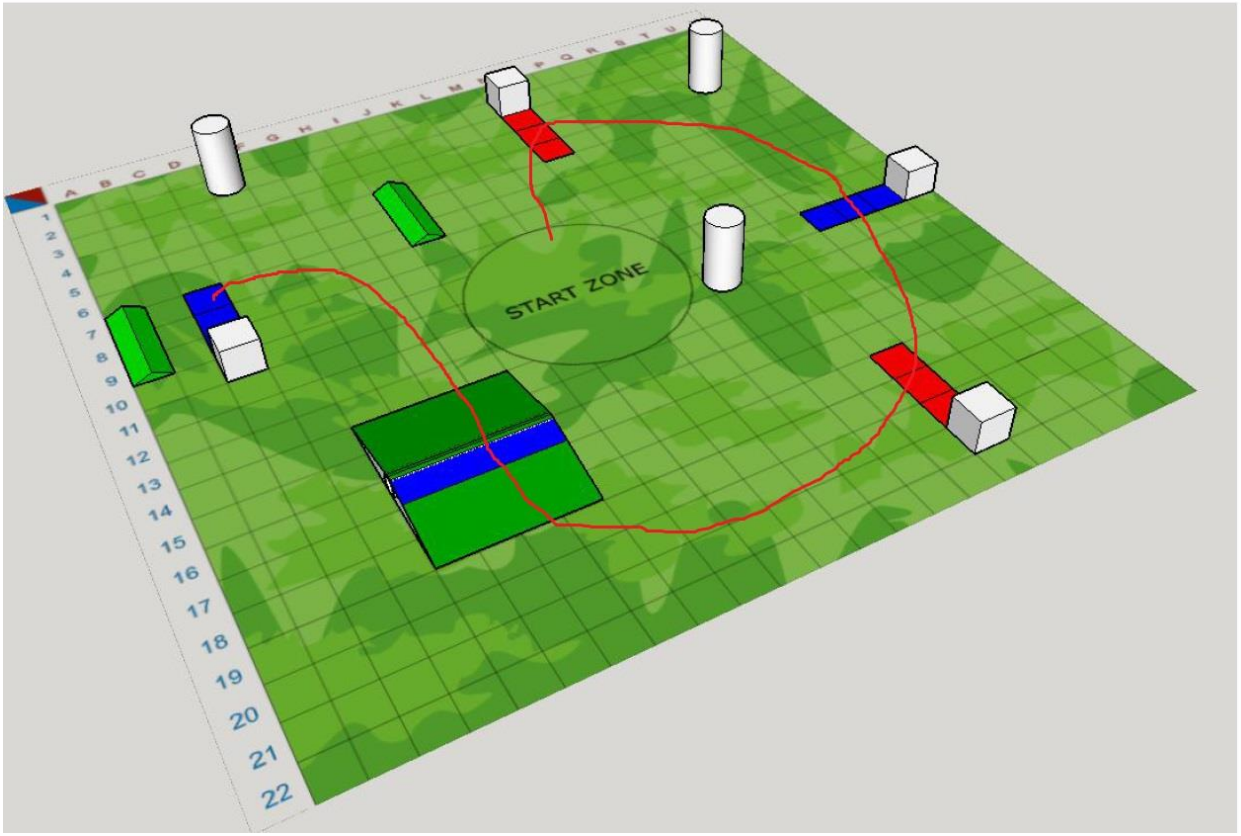
1) P (Penalty) : There would be a loss of 30 points every time when our spotter snake dashes into the obstacles (silos) , collides with a rodent head or more than one bracket goes outside the arena.

2) RP (Reposition Penalty): The repositioning of spotter snake in the start zone would cost the team 100 points each time. Repositioning can be done maximum 3 times. It can be done voluntarily by team during the run on will be imposed on them if the entire snake goes outside the arena or if found damaging the arena. Repositioning will be done by a team member accompanying the controller of the snake.

3) FD (False detection of rodent) :The team would bear this penalty of 50 points each time when the rodent is detected falsely means that either it is detected at a place where there is no rodent or it detects a rodent and flashes the LED of different color than rodent.

The various scenarios that could happen while traversing the arena are as follows :

1) **<u>Scenario 1 (Best case scenario)</u>**

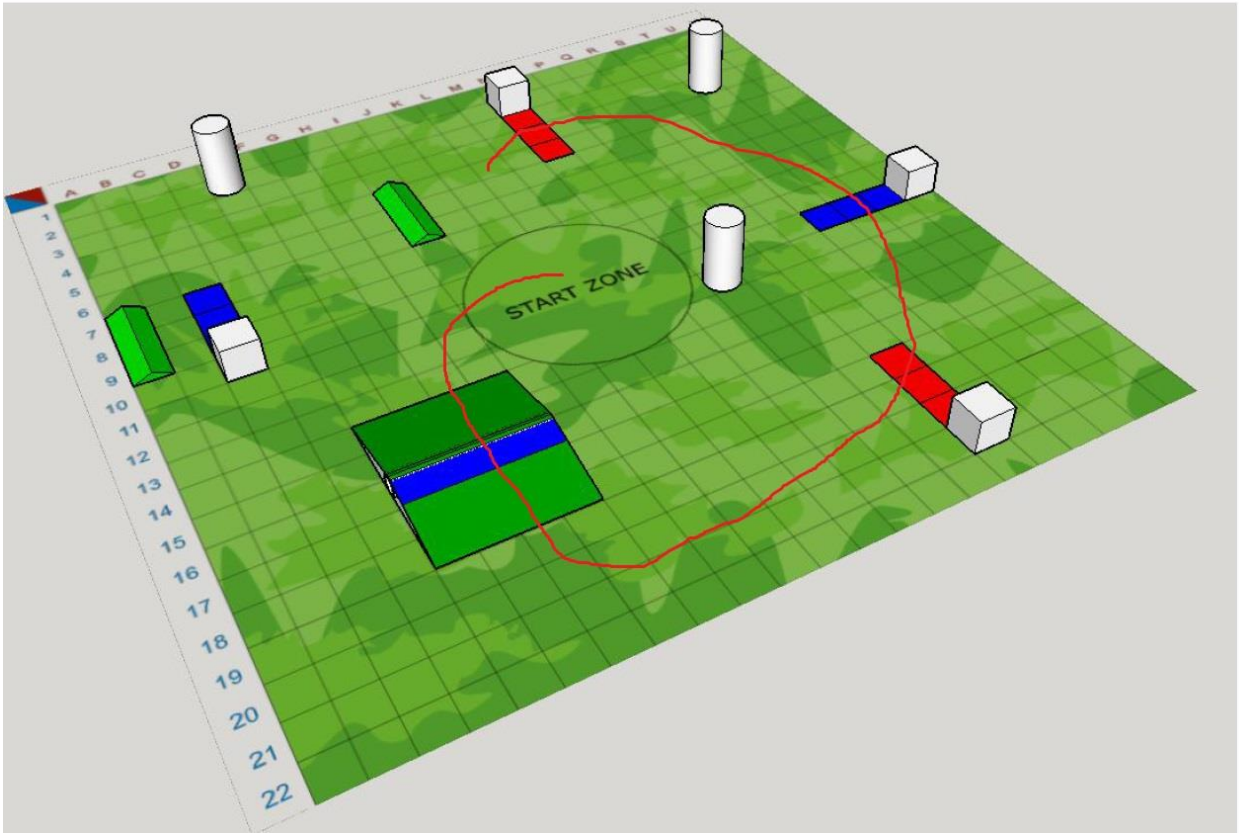


We ,as the controller of spotter snake, would make it transverse on the path depicted in the above figure with red. In this after starting from the start zone, the snake would detect the 3 rodents while taking a large right turn. After this it is going to climb the ramp and detect the blue rodent. After crossing the ramp the snake is directed towards the last blue rodent and stopped there. The spotter snake in this run doesn't incur any penalty, successfully detects all the rodents and crosses the ramp completely. Hence executing a perfect run.

Score for Scenario 1 (Best case) : We have taken a arbitrary value of T as 350 seconds, the time that snake takes to transverse the arena. We have also taken a CB as 200 points.

So total score = (600-350) +1*300 + 5*100 – 0*50-0*30-0*100 + 100 + 200 = 1350 points

2) **Scenario 2**

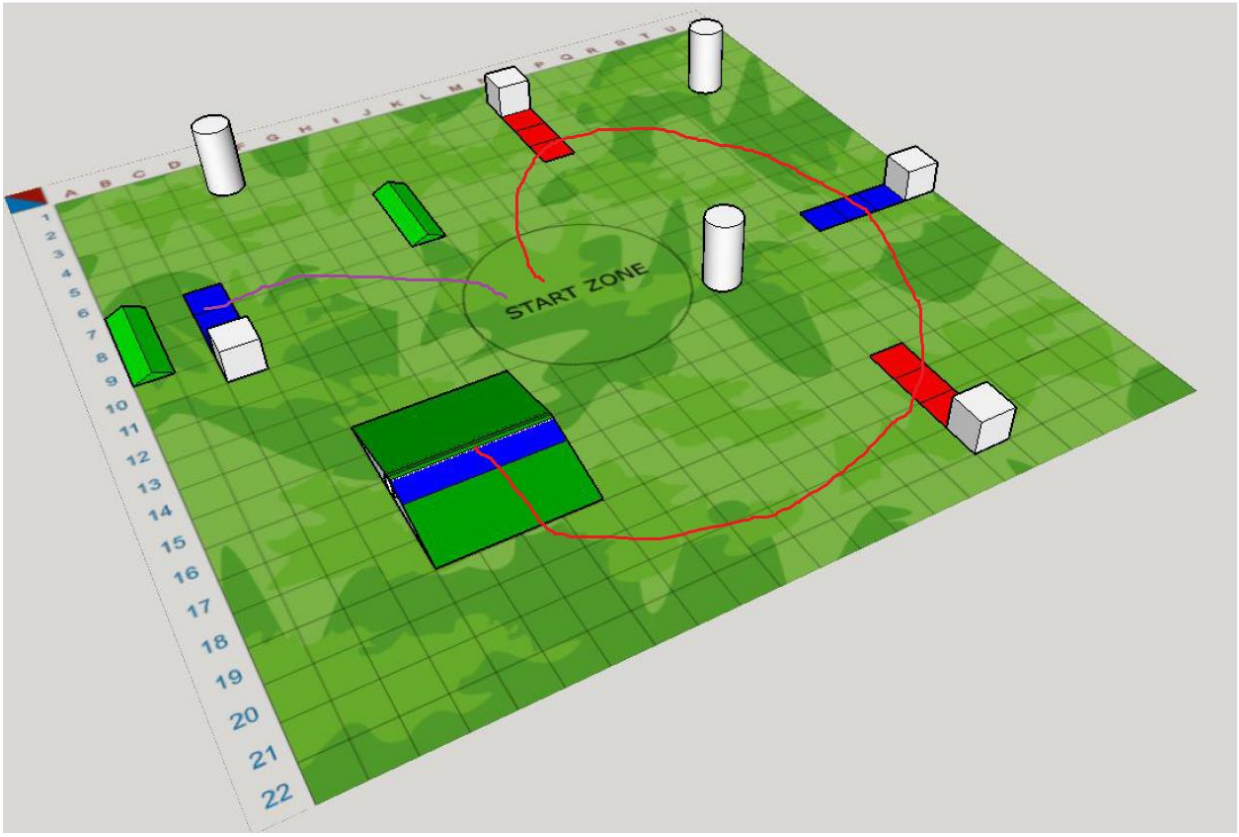


For traversing this arena we could also devise a strategy. If we are taking the above path, first crossing the ramp and also simultaneously detecting rodent, then taking a large left turn and detecting the 3 rodents. Now as we can see the 4th rodent (C10) is far from our current position, we are purposefully stopping the spotter snake here as this would save our time by sacrificing detection of one rodent. This strategy could be applied in other configurations also when there is a feeling that more time would be consumed for detecting one rodent.

Score for Scenario 2 : We have taken arbitrary value of T as 200 seconds. And CB arbitrarily as 200.

So total score = (600-200) +1*300 + 4*100 – 0*50-0*30-0*100 + 200 = 1300 points

3) **Scenario 3**

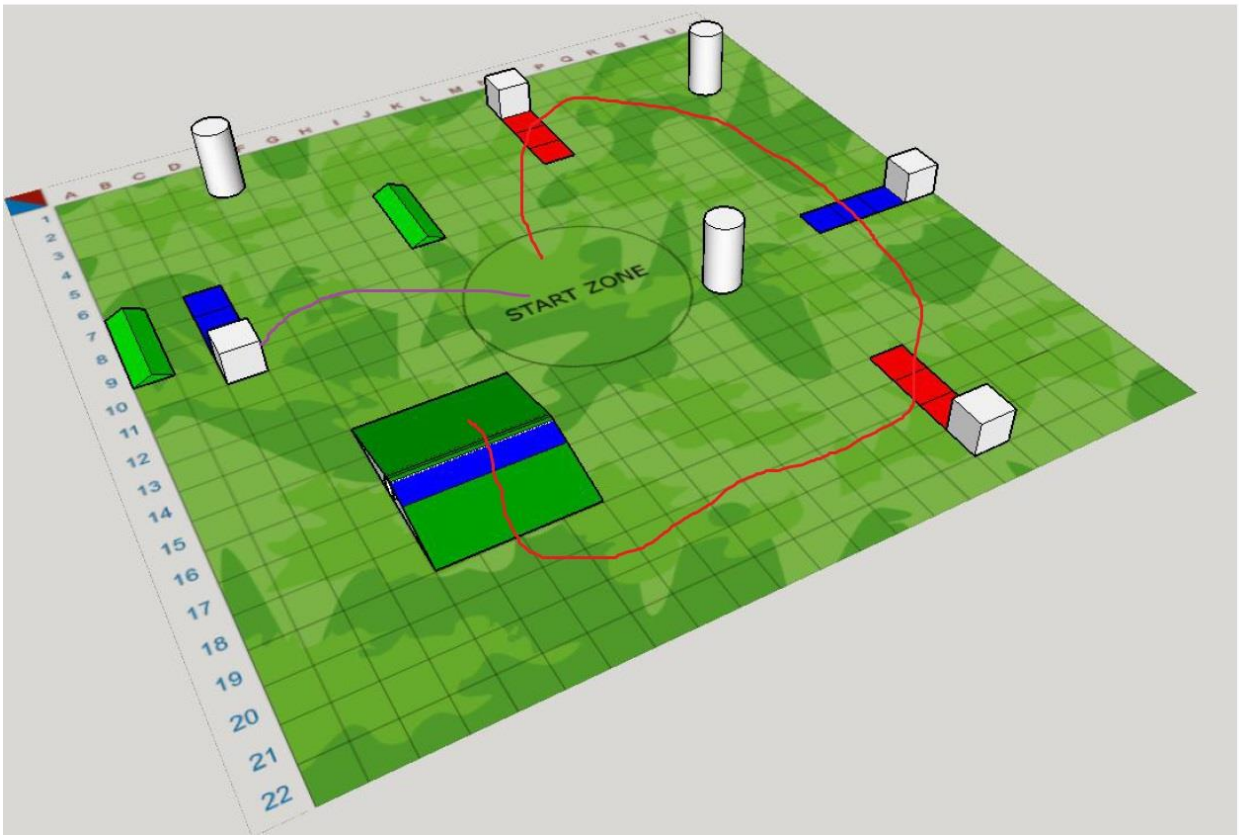


In this scenario while traversing the path selected in Scenario 1 (path in red) the snake gets stuck on the Ramp , so we are forced to Re- position the snake in the start zone thus taking a Re-position penalty. After Re-position we will detect the 4th rodent (C10) by following the purple path.

Score for scenario 3 : We have taken arbitrary value of T as 500 seconds. And CB arbitrarily as 200.

So total score = (600-500) + 5*100 – 0*50-0*30-1*100 + 200 = 700 points

4) **Scenario 4 (Worst case)**



For our worst case scenario we have considered that the snake takes each type of penalty once while traversing the arena. In this while following the path selected in Scenario 1, our bot detects the first rodent (at N2, north ,red) falsely thus costing us 50 points there . After that it gets stuck on the ramp forcing us to reposition it. After repositioning it in the start zone when we direct our snake towards the 4th rodent(at C10, south, blue) then it collides with the head of the rodent for which a penalty of 50 points is incurred.

Score for Scenario 4 (worst case) : We have taken arbitrary value of T as 550 seconds. And CB arbitrarily as 200.

So total score = (600-550) + 3*100 – 1*50-1*30-1*100 + 200 = 370 points

Spotter Snake Design

Q4. Designing and Constructing Spotter Snake in itself is a huge challenge. One of it is to distribute the weights (battery and circuitry) equally for stabilizing the snake robot. How would you distribute these weights in your snake robot? What were the various challenges you faced while designing the physical structure of the snake robot in Fusion 360. (5 + 5)

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Explain various parts of the snake robot and support your answer with pros and cons of your design.

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Ans : Balancing and distributing the weight of the battery and circuitry was indeed a challenge for us. Various considerations were taken to balance and stabilize the snake bot :

1) Li-Po Battery is attached in the tail part of the snake robot , because if it was attached in the middle then it would have a possibility of toppling the adjacent brackets with itself while performing the motion. In our case the head and first bracket are attached through a pin joint which combined together is counterbalancing the weight of the Li-Po at the tail.

2) The components are soldered on the perf board which is firmly attached to their respective brackets (head and tail) with nuts and bolts.

3) In the bracket where Servo motor is mounted , the wheels are attached at the center of gravity of the bracket which was found by trial and error basis.

4) Crossing of ramp posed a different challenge so while crossing the ramp, the weight of head and first bracket prevents the slipping of the snake at the slope because of weight of the Li-Po battery on the tail.

5) Li-Po battery and other circuits are not placed together. They are placed at the farthest point available (head and tail) so that the motion of the snake is not governed by concentration of weights.

6) Li-Po battery has been placed on the base of the tail rather than at the top, making it closer to the ground thus increasing stability.

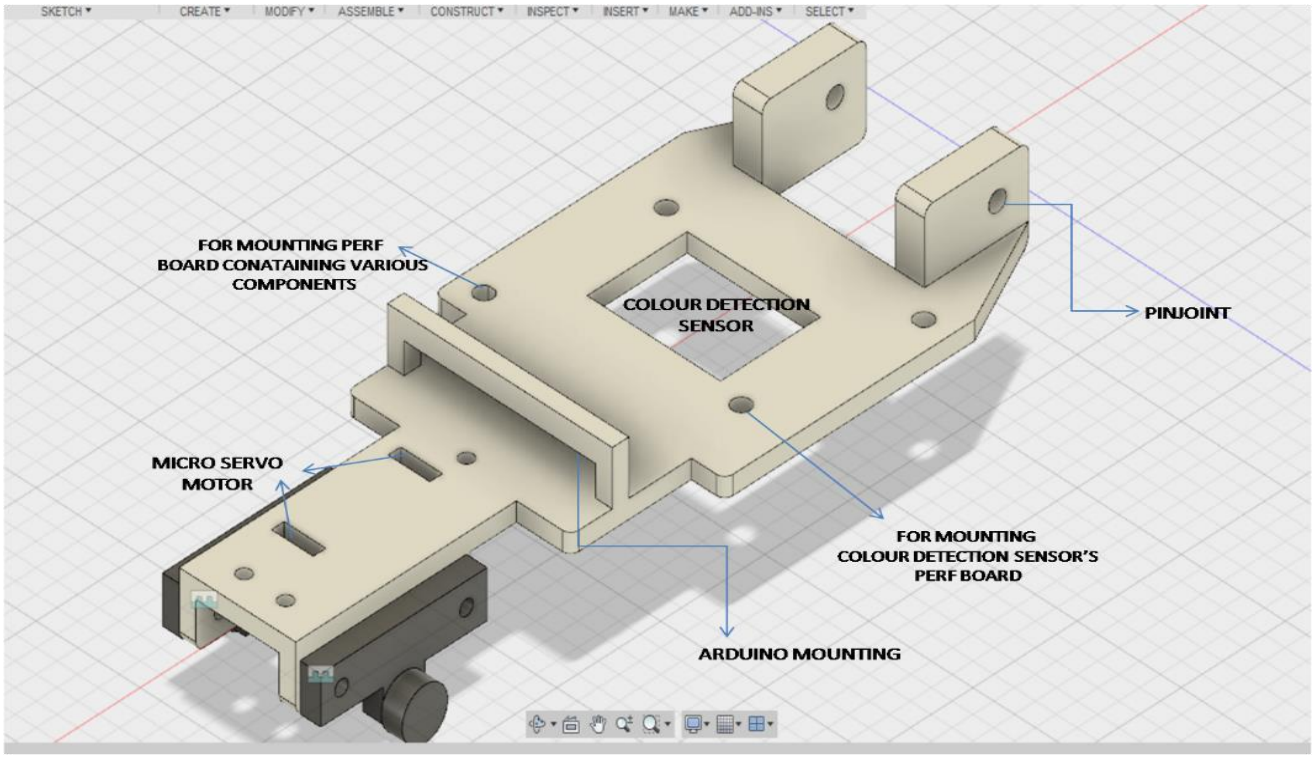
7) It is made sure while designing that the wheels are in one common file giving us a symmetric and stable motion.

Designing the spotter snake required a lot of brain storming due to many challenges faced as a lot of parameters were considered.

Different challenges are :

1) All the servo motors had to be placed at the same level for serpentine motion.
2) Trade off between swiftness and the different gaits (serpentine, caterpillar, sidewinding) the spotter snake would do , inclusion of wheels or not so that, a optimum combination is possible.
3) Placement of wheels was also a challenge as we had to see that they are in one line and it doesn't interfere with the other components, and gives the best motion.
4) Attaching adjacent brackets in such a way that they don't interfere with each other while performing the serpentine motion and also not placing them far away as increasing the distance would mean the Servo motor would have to exert more torque.
5) Constraint of 400cc was to be kept in mind every time while designing each bracket and elimination of unnecessary volume.
6) Wires going from the Servo motor to the Arduino at back shouldn't pose a hindrance to the serpentine motion.
7) Making all the electronic components accessible (especially Arduino Nano and Li-Po) and rigidly attaching them to brackets
8) Designing head and the tail in such a way that they are easily compatible while joining to the main body without making any major changes to the design of the main brackets.
9) Crossing of a ramp and if needed crossing the hurdle required a lot of brainstorming as the whole snake bot is rigid so adding another degree of freedom in that direction was a herculean task.
10) Doing a market survey of different types of wheels and their mounting and changing the design according it.
11) Placement of color detection sensor at optimum height for swift detection of rodent.

Various part of our snake bot are :



1) Head (Type 1 bracket)

Micro servo motor is mounted with the cable tie to the bracket. It facilitates our opening and closing the of cover which we have made like the mouth of snake. The colour detection sensor is soldered to the perf board and is mounted with the bracket on 2 bolts and the height is adjusted with the help of nuts which are placed at the bottom and top of the perf board. The height of the color sensor would be calibrated for best detection of rodent. The front two holes are used to mount a structure on which LED lights and buzzer will be installed.

Pros:

1) Mounting of Arduino Nano is such that it is accessible and rigid with the bracket.
2) The snake would open and close mouth (made from PVC sheet) with the help of micro servo which could fetch marks for creativity.
3) The level of the color sensor can be changed for best possible detection.

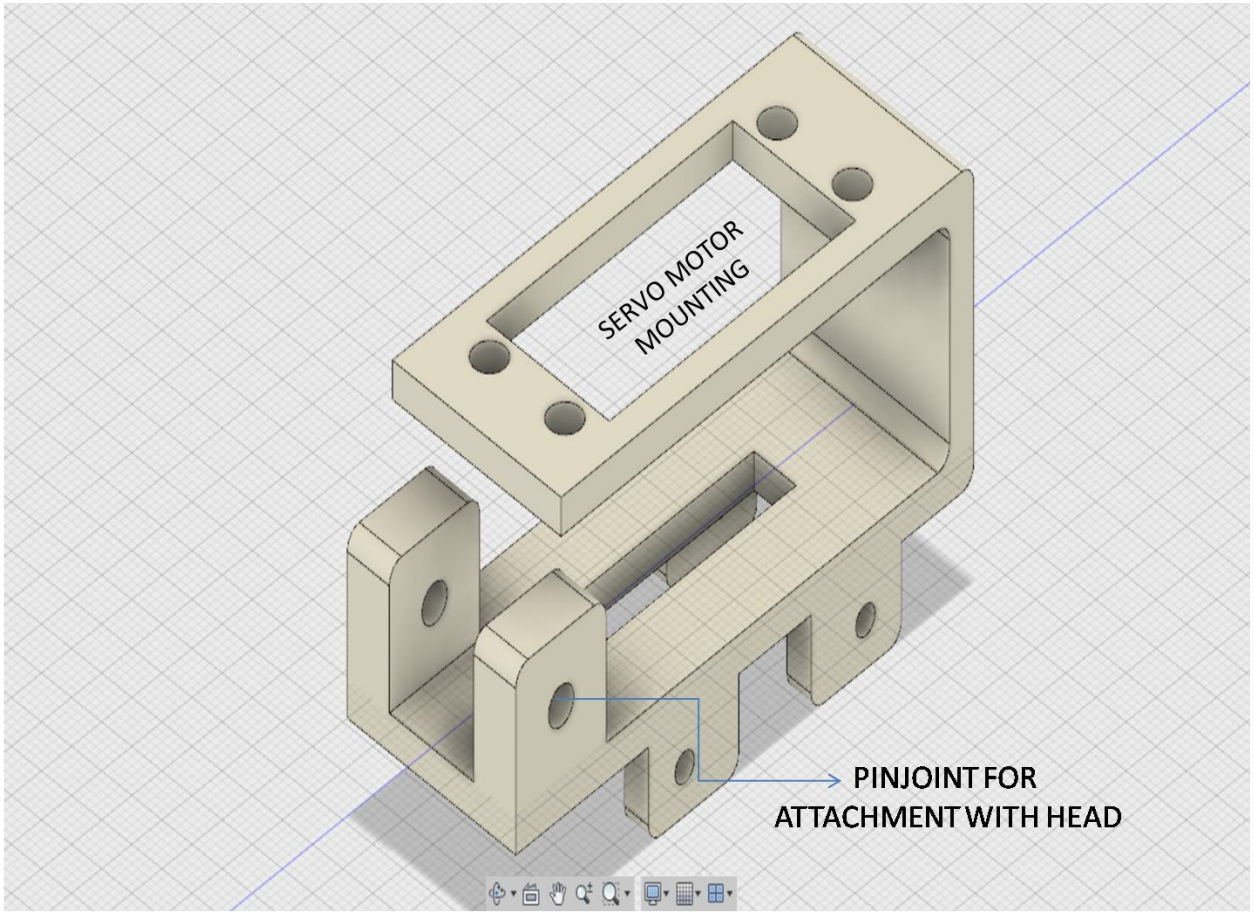
4) The perf board containing the other electronic components is mounted above the color detection sensor thus optimizing space consumption.
5) The provision of pin joint in the head allows it to go up and down with respect to the ground thus making it beneficial while crossing of ramp and hurdle.

Cons:

1) The length of the head is more with respect to the other brackets

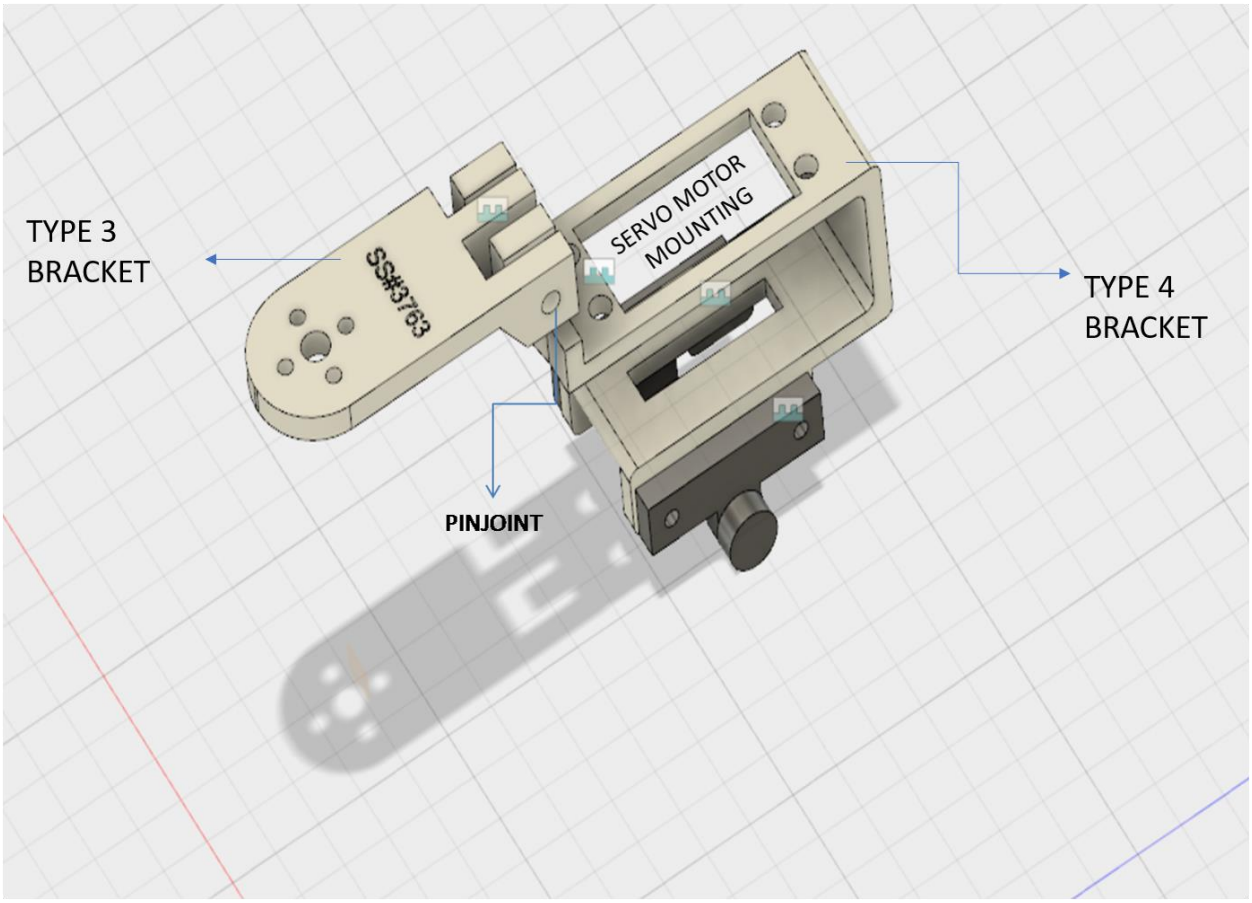
2) Long length of head would probably be a hindrance in sharp maneuvering.

2) First bracket (Type 2 bracket)



This is the first bracket after head , designed for joining head to the rest of the body.

3) <u>Main body bracket (Type 3 and Type 4 bracket)</u>

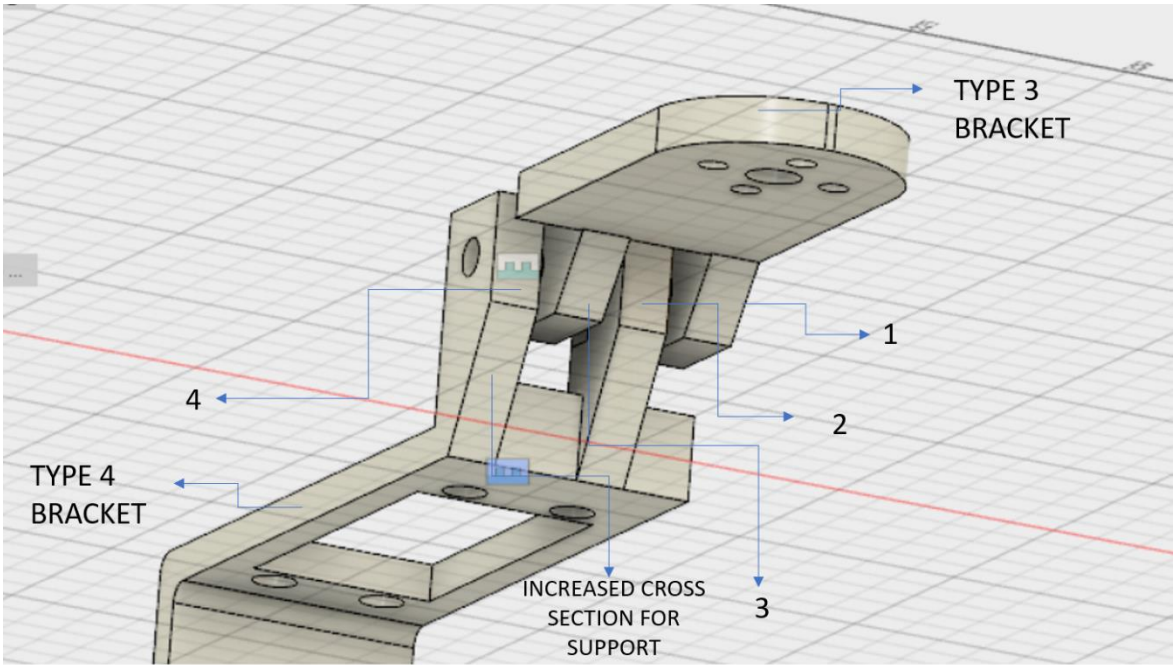


There will 9 such brackets in the whole spotter snake. These brackets would have the servo motors mounted on them , performing the serpentine gait. This is made of two parts :
Part 1 : Type 3 bracket would be joined to the servo motor ahead of it.
Part 2 : Type 4 bracket would house the servo motor and would be attached to
Part 1 through a pin joint created with a bolt and lock nut.

Pros :

1) Slot has been made at the bottom of the bracket for optimisation of the given volume. The unnecessary volume has been reduced by not adding material to the side of the bracket.

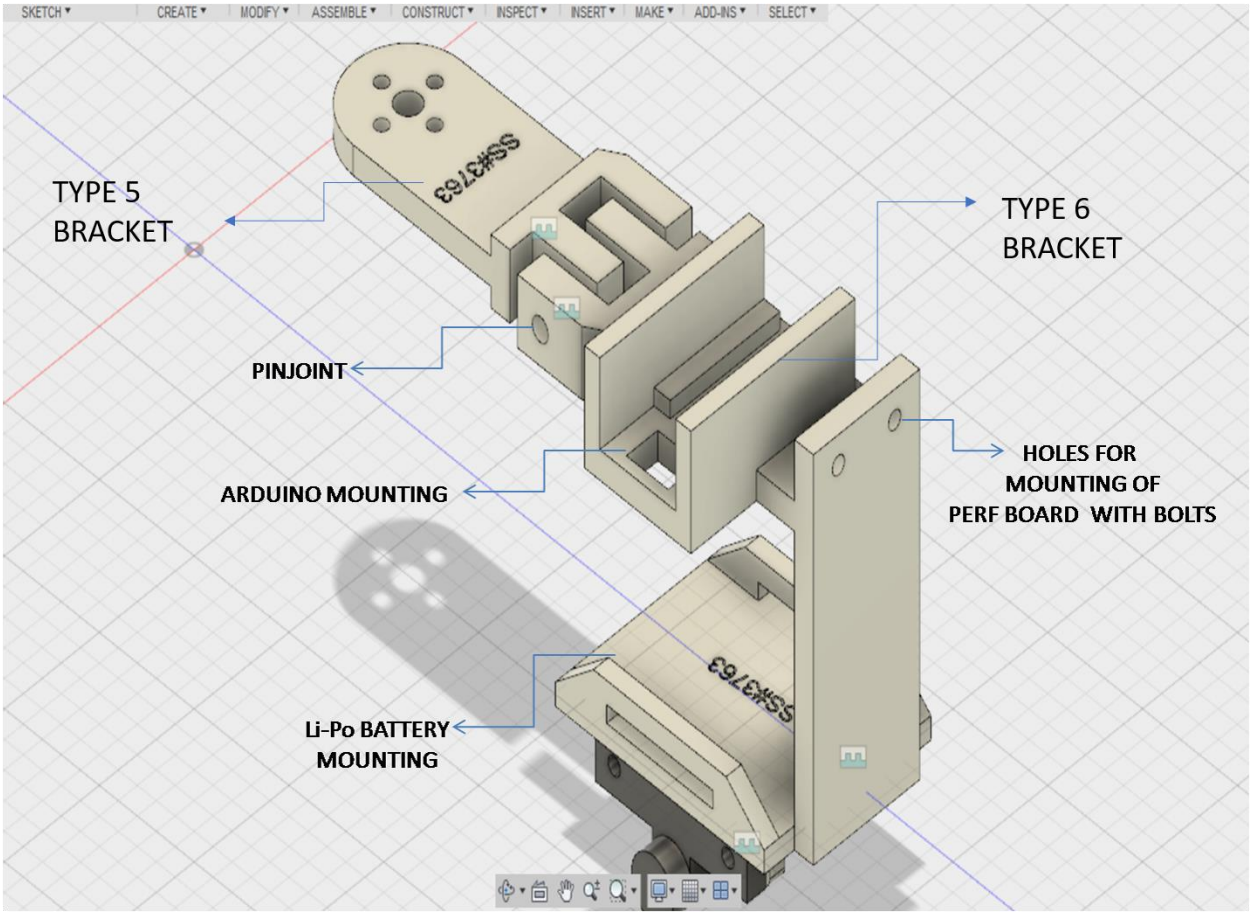
2) Enough distance has been given between the adjacent brackets so that they can rotate without any interference in the serpentine motion.
3) In order to provide another degree of freedom which would be beneficial to us while crossing the ramp or hurdle (if required) we have added a pin joint. The combination used during design of pin joint is such that 1 and 3 supports are attached to Type 3 bracket and the other supports 2 and 4 are attached to the Type 4 bracket, giving an alternate arrangement of supports which delocalises the stress induced in the pin joint while doing serpentine gait. The supports for pin joint of Type 4 bracket are attached to it through a triangle like structure providing it increased cross section and reducing the induced stress.



Cons :

1) Wheels attached to the brackets may not be rough enough to provide traction.
2) The design of bracket is such that Actuated Caterpillar Gait is not possible in our spotter snake robot.

4)<u>Tail (Type 5 and Type 6 bracket)</u>



The tail part of our snake has been designed to house the Li-Po Battery through Velcro straps, Arduino Nano which would have code for running the servo motors for executing the serpentine gait and the perf board containing the remaining electronic components soldered to it. The pin joint is also given in between Type 5 and Type 6 facilitating easy movement on hurdle and ramp.

Pros :

1) The thickness of the whole tail is more than the rest of brackets as more strength was needed because of the heavy Li-Po mounted on it and it would have the maximum motion as compared to the other brackets.
2) The Li-Po battery is mounted on it using Velcro straps making it removable. The space on the side of the brackets, make the Li-Po accessible. Moreover, using Velcro rather than a mount made of Nylon 66 reduced volume.

3) The housing for Arduino Nano is made such that all the pins are accessible for easy connections and USB is also accessible for re-programming the Arduino Nano.
4) The perf board is mounted vertically on the back side of the tail with the help of the bolts. The orientation of the perf board optimises the space given to us and also doesn't increase the height of the tail.

Cons :

1) The tail being heavy, would make the snake transverse a little slowly while performing reverse serpentine motion.

Spotter Snake Control

Q5. For controlling snake robot wirelessly, you have to design a joystick. How are you going to design the joystick? Explain the hardware and software used for construction of joystick. (10)

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List the various components of the wireless joystick. List various inputs and outputs of the joystick. Explain working of the code for joystick using flowchart/block diagram.

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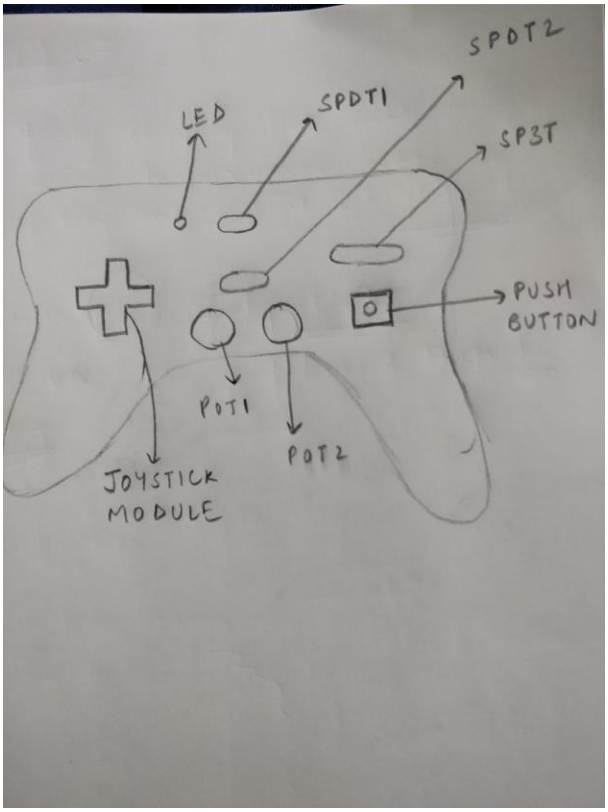
Answer :

List of components used in the wireless remote are:

1. Arduino Nano
2. Two potentiometers
3. Two Single Pole Double throw switch
4. One Single Pole Three throw switch
5. NRF24L01
6. Joystick module
7. One push Button switch
8. 1 micro farad capacitor
9. One LED

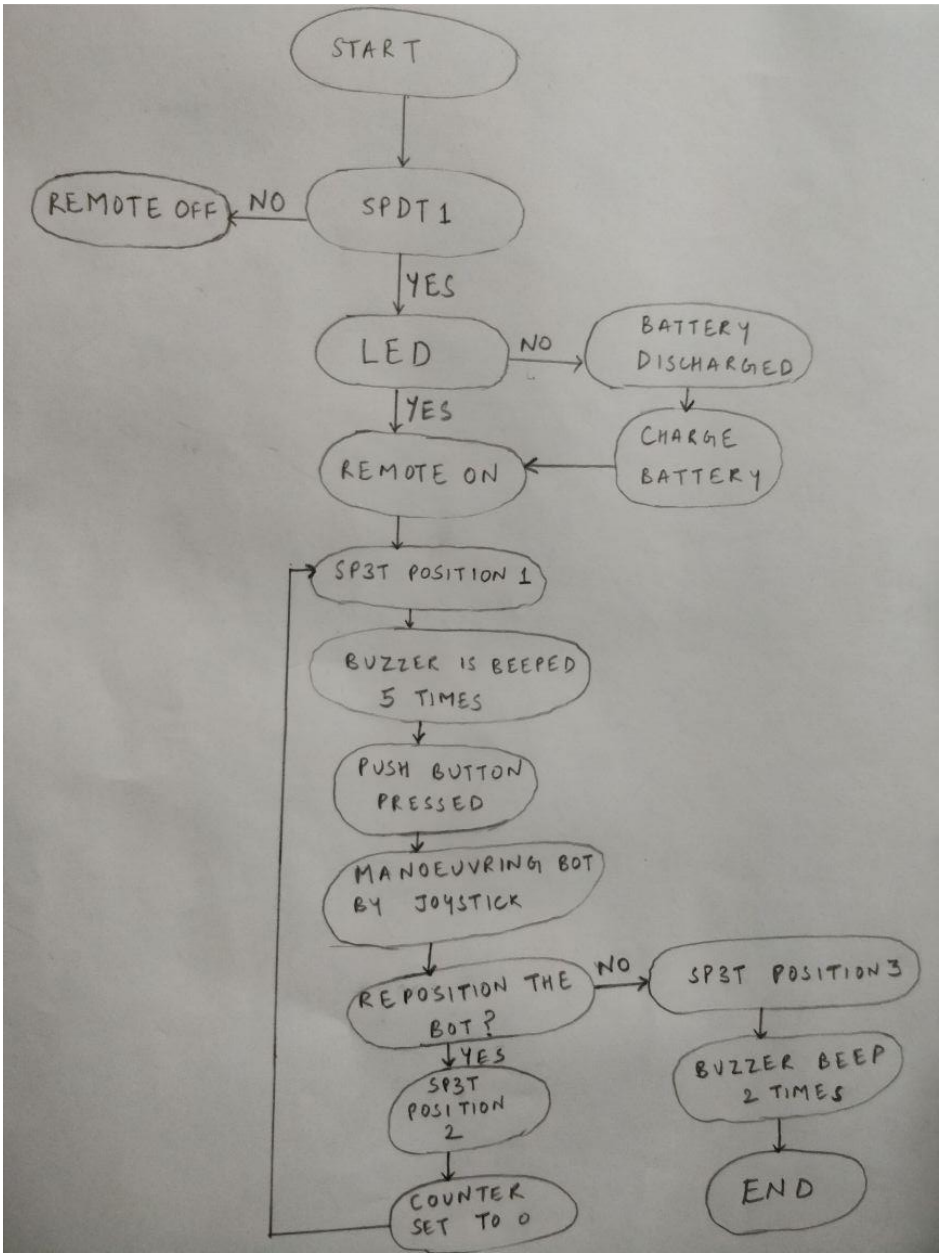
- As there are two potentiometers in the joystick module therefore the two values from the x axis potentiometer and y axis potentiometer will help in deciding the direction in which we want the spotter snake to move.
- One SPDT switch(SPDT-1) is connected to power up the whole remote i.e. to connect it to the 9V battery. Another SPDT (SPDT-2) switch is used to activate/deactivate the Colour detection sensor.
- We do not intend to use the in-built push button on the joystick module because if a person is operating it and accidently presses the button then it might give false results.
- One potentiometer(POT 1) is connected to control the value of amplitude and another (POT 2) for controlling the frequency of the sine wave motion adopted by the spotter snake.
- One SP3T switch is connected to control the buzzer beeps.
    1) SP3T switch position 1 : It would beep the buzzer 5 times. This is done using a counter in the program so that the buzzer beeps stops after 5 times even if the switch is kept at position 1 afterwards.
    2) SP3T switch position 2 : It would reset the counter to zero.
    3) SP3T switch position 3 : It would beep the buzzer 2 times and has a counter system similar to switch position 1.
- Push button switch is used to position the Servo Motors at an angles which give us a desired 'S' shape required before starting the gait of the spotter snake.
- A capacitor is connected between the Vcc and Ground of the NRF module to ground the noisy peaks which will increase the range of our NRF module.
- An LED is there on the remote which will indicate whether the remote is powered on or off.

The design of the remote is shown below :

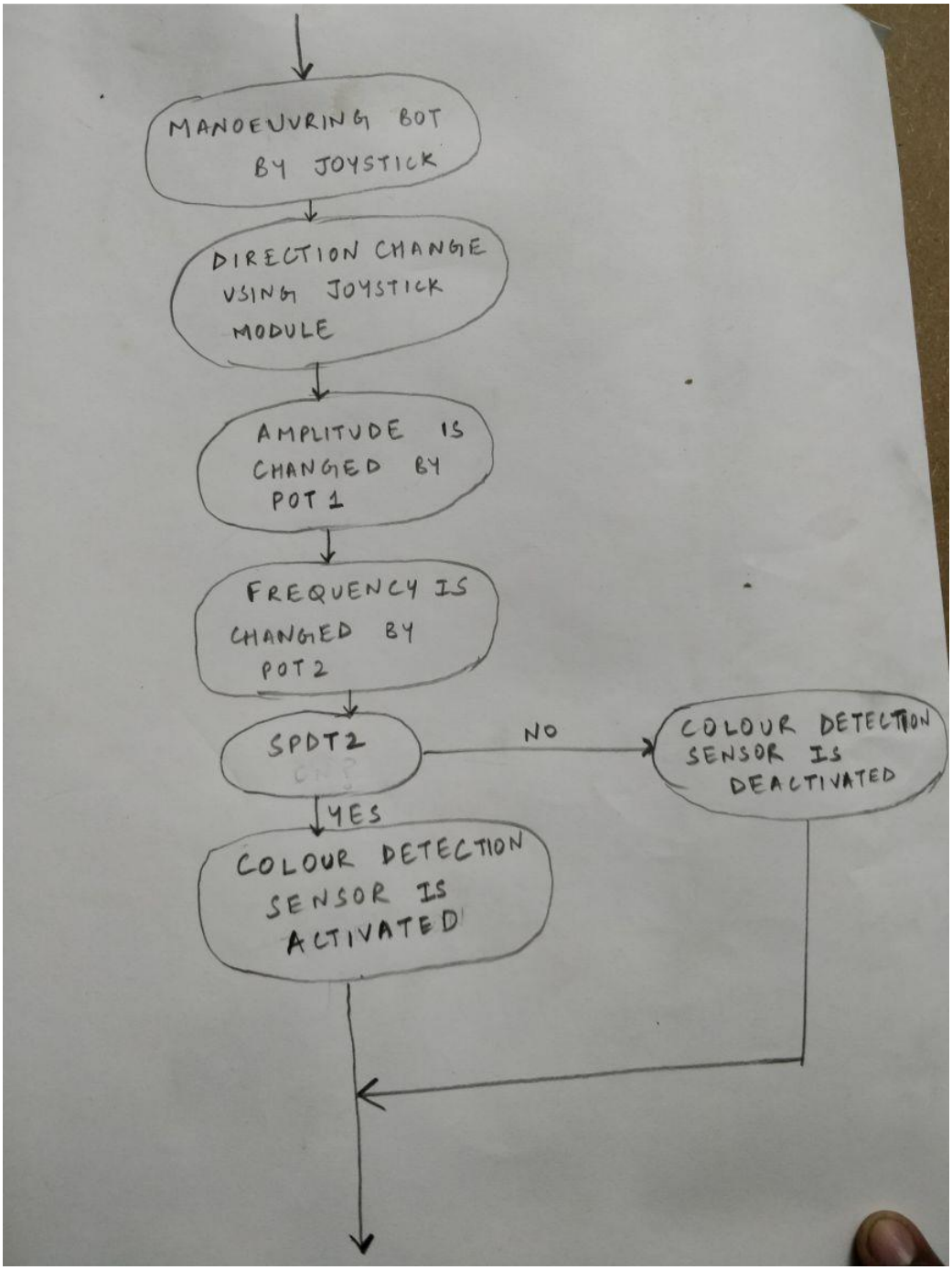


The circuitry for the remote will be placed between two acrylic sheets. The upper acrylic sheet will be laser cut according to the mountings shown in the above picture. The acrylic sheets are connected with each other and perf board with the help of nuts and below. The designing is done taking all the ergonomic parameters in consideration.

The basic working of our remote is explained through the following flow chart:



The maneuvering of the bot during our run by our remote is further explained through another flow chart :



The connections of various components are made as follows:

- The NRF24L01 is connected to the respective pins of the Arduino in order to establish communication.
- The potentiometer is connected such that one end is given logic 1 (i.e. 5V) and the other end is given logic 0. The middle port is connected to the analog pin to read the value.
- The Vx and Vy of the joystick module are also connected to the analog pins.
- The SP3T switch is connected such that all three ports have three different logics. First one is to send to indicate that Buzzer should beep to start the simulation.. The second is for the case when during the simulation if we would have to place the snake again in the start zone and buzzer would have to be beeped. The third is to beep the buzzer to end the simulation
- The SPDT switch for the color sensor is connected such that one port is given logic 1 and the other logic zero.
- Another SPDT when switched on will power up the Arduino.
- The push button when pressed would give a logic 1 as output otherwise zero.
- LED is connected to a digital pin.

Our working of the code is explained through the following steps :

Step 1

- The variables are defined as follows
- 1)x axis variable and y axis variable
- 2)two variables for storing the values from the two potentiometers
- 3)one variable for storing the data from the SPDT switch
- 4)one variable for SP3T switch
- 5)one for storing value from reposition switch.

Step 2

- In void Setup, the pins for the radio are set, the other pins are set as input and output according to there functions and the pins that are supposed to be high or low to facilitate the SPDT to act as a switch. Three separate logics are set for SP3T switch. The pin of push button switch is also set.
- An address is set so that the data to be transmitted is stored in that address.

Step 3

- A funtion will be defined to step down the values from the potentiometer as they will give a value from 0 to 1024 and we will send the scaled value which would be between 0 to 9.

Step 4

- In the void loop, first communication is established between the two NRF modules.
- LED pin is set high in order to switch in the LED.

Step 5

- An arrary is defined which will contain all the data to be transmitted.

Step 6

- First, the condition of the SPDT switch for the colour sensor is read. It is stored as the first value of the array as 1 for on and 0 for off.

Step 7

- The second value of the array denotes the condition of the buzzer. It has three conditions as defined before. (SP3T-1, SP3T-2, SP3T-3)

Step 8

- The values from the two potentiometers (POT-1 and POT-2) will be read, they would be stepped down using the funtion and these will be the next two values of the array.

Step 9

- Fifth term of the array will be the reposition condition. When we will want the snake to make an "S" shape with desired angles, we will press this button. One side is connected to logic 1 pin. As soon as we press it, "1" will be transmitted.

Step 10

- The last term of the array will give the directions.
- As per the figure 1 below we will set the sixth term of the array as 1 for forward motion, 2 for right, 3 for backward, 4 for left and 0 for no movement i.e. when the joystick is in the middle.

Step 11

- This data is then transmitted throught the NRF Module.

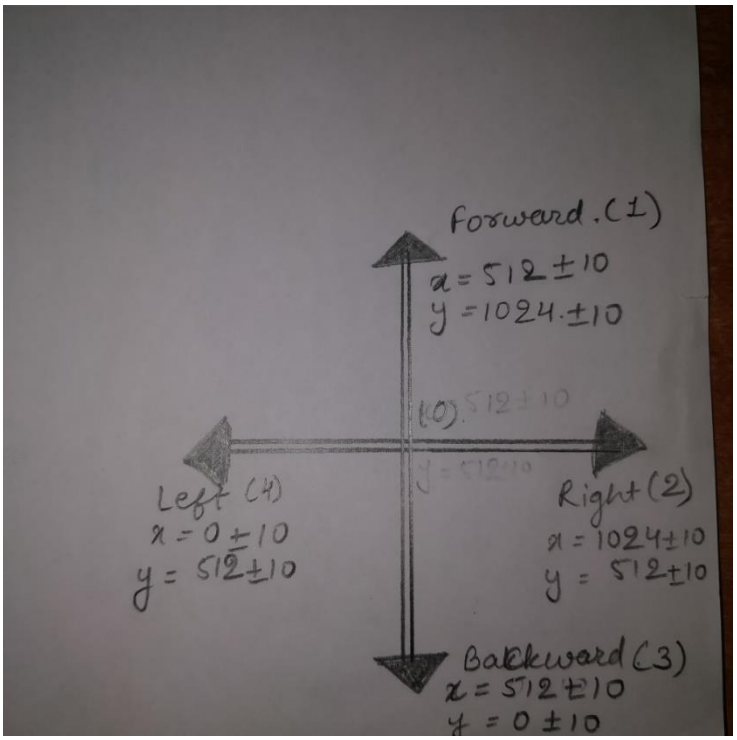


Figure 1

Q6. Describe the exchange of information you plan to establish between robot and joystick along with your algorithm. (10)

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Mention the various types of data that will be communicated to the robot and how this will be used.

Answer format for algorithm: Bullet form

Step 1:

Step 2:

Step 3…etc.

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Answer : The data will be transmitted in an array form. If in case we will be facing clipping of data or interference, we will use a start bit and a stop bit and between those bits we will send the data to be transmitted.
The data type of array transmitted is integer type.

The array will contain 6 elements. They are described as follows:

1. Element for Switching the color sensor on/off
2. Element to decide the number of beeps of the buzzer to be beeped.
3. Element that will describe the value of the frequency of motion of the snake.
4. Element that will describe the value of the amplitude of motion of the snake.
5. Condition of reposition switch.
6. Direction of Motion.

Algorithm for the use of transmission data is as follows:

Step 1: There are two Arduinos placed in the spotter snake, one in the tail to control the servo motor and one in the head for rodent detection. The NRF module in connected to the arduino in the tail and the colour sensor is connected to the one in the head

Step 2: The two Arduinos in the spotter snake are will have a master slave relationship. Arduino in the Tail to which the receiving module is attached, is the master and the Arduino in the head is the slave. The first element of the array will be sent to the Arduino in the head.

Step 3: Whenever the value of first element will be 1 then the colour sensor will be switched on else switched off therefore avoiding false detections.

Step 4: The buzzer will be connected to the Arduino in the head. There will be three values for the second variable in the array. The value would depend on the position of the SP3T switch (SP3T 1, SP3T 2, SP3T 3).

Step 5: As the transmission will be continuous and we don't want the buzzer to continuously beep, we will introduce a counter variable in the program of the head arduino. It will count the number of times the buzzer was switched on for the required number of beeps.

Step 6: The counter variable facilitates that even when the switch is kept at position 1(SP3T 1) the buzzer won't continuously beep.

Step 7: If in case we would have to replace the spotter snake in the starting zone again(during repositioning) , then we need the 2nd logic of this element(transmitted when the switch is at SP3T -2) which when sent to head Arduino using master slave relation, will reset the counter variable. Thus the buzzer can be beeped again.

Step 8: The next element is for setting the frequency of the sine wave motion adopted by the snake. This will also be a integer value.

Step 9: The fourth element is the amplitude value.

Step 10: In the Arduino placed in the tail, while setting the angle of rotation and the amplitude of the servos, we will introduce variables such that they will keep on updating according to the values of the frequency and amplitude received.

Step 11: The reposition switch is for the case when we want spotter snake to form a desired “S” shape which is the prerequisite for starting of snake’s gait.

Step 12: The last element will give the direction. As it can be inferred form figure 1, the number received will give the direction. Accordingly, we will set the angle of the servo motors.

Theme Implementation

With the end of Task 3 you must have finished designing and 3D printing of all types of brackets for the Spotter Snake. Now, study the Rulebook and try to implement the solution for the theme. Final task of the competition is to submit the video and code for the theme implementation. Submission date for video and code will be notified in future.

Start early and be ready for video submission of Final configuration. Stay tuned for further instructions.