e-Yantra Robotics Competition - 2019-20

Implementation Analysis: Construct-O-Bot

#3469

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Date	08/01/2020

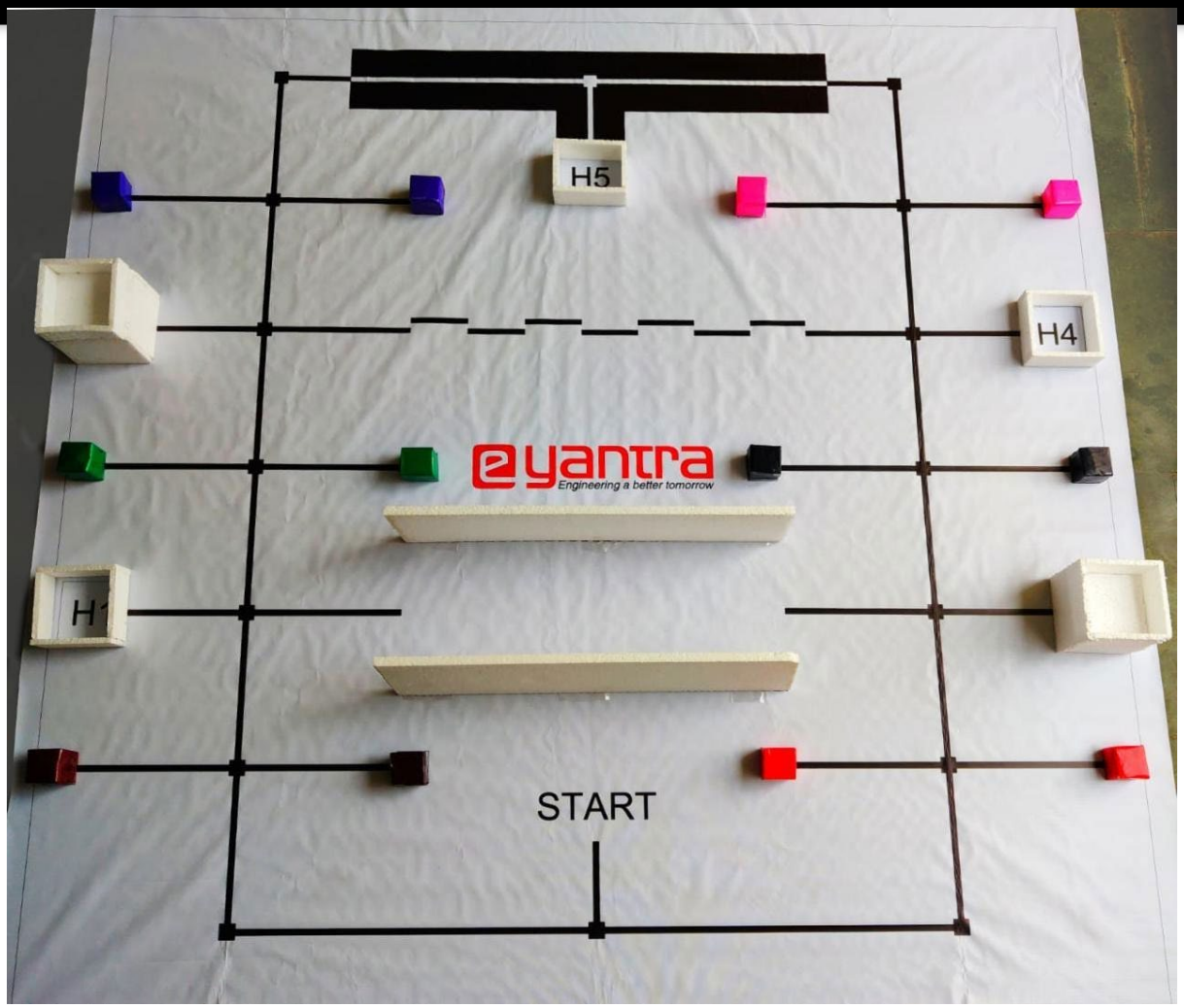
a. State the scope of the theme assigned to you.

(5)

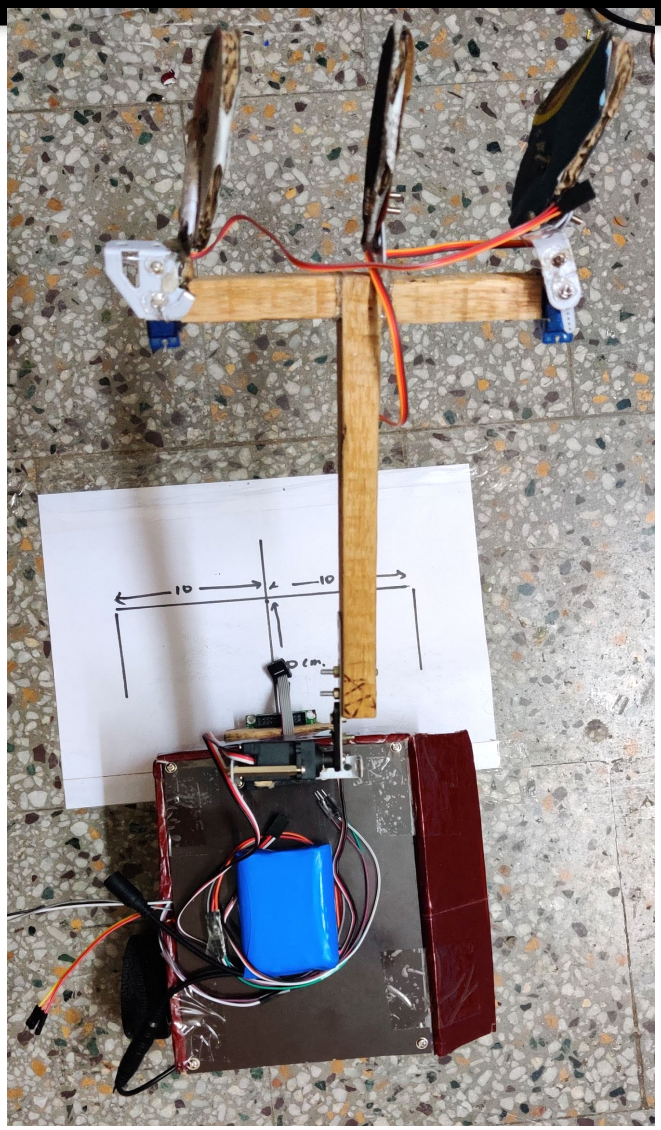
Unforeseen and uncontrollable disasters disrupt the flow of our society and halt its progress. Any Reconstruction process after such a disaster in the affected area is very dangerous due to the unstable nature of the terrain. Hence comes the idea of the Construct-O-Bot, an autonomous robot that can operate in a disaster-affected region effectively to pick, transport construction materials, drop them at different heights from ground level while moving via the shortest path available in order to save time and effort. Such a robot will prevent manual work in the region saving life and injury.

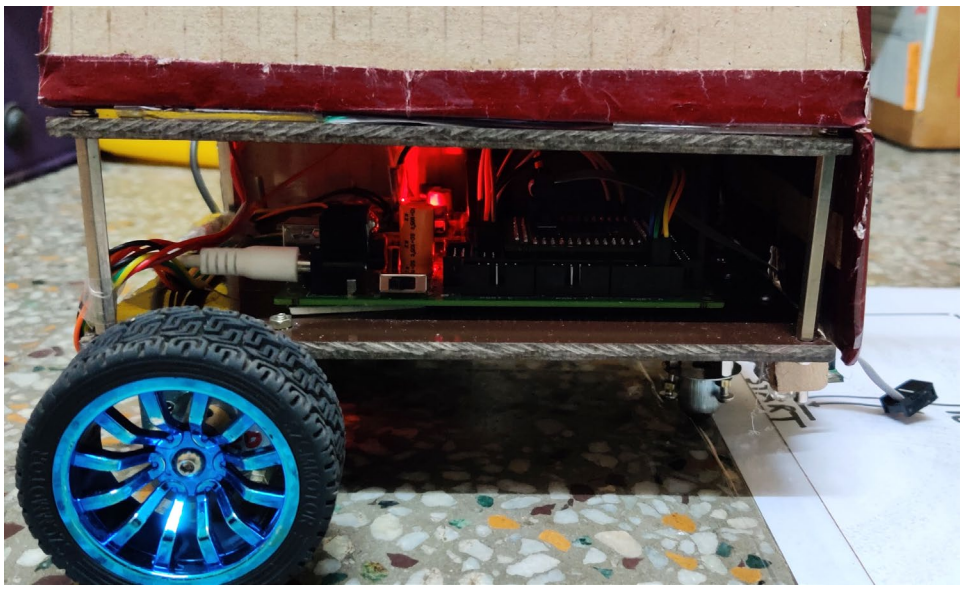
b. Upload the Final Arena Images as per configuration given in the rulebook.

(5)



c. Team have to design a robot to solve the problem as mentioned in the rulebook. Attach the final robot design in the answer. Why have you come up with such a design? (20)

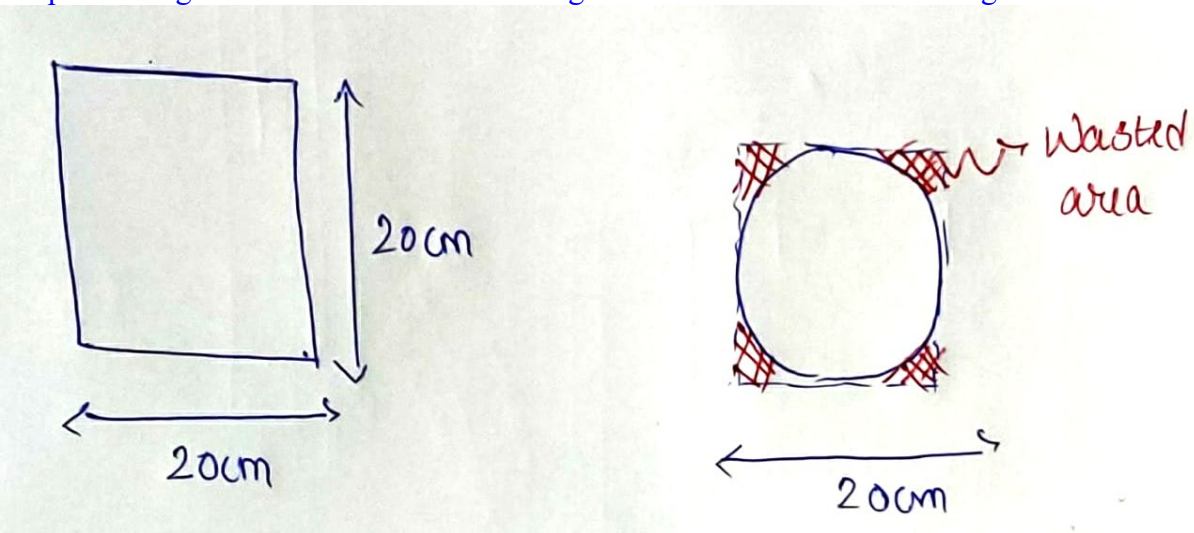




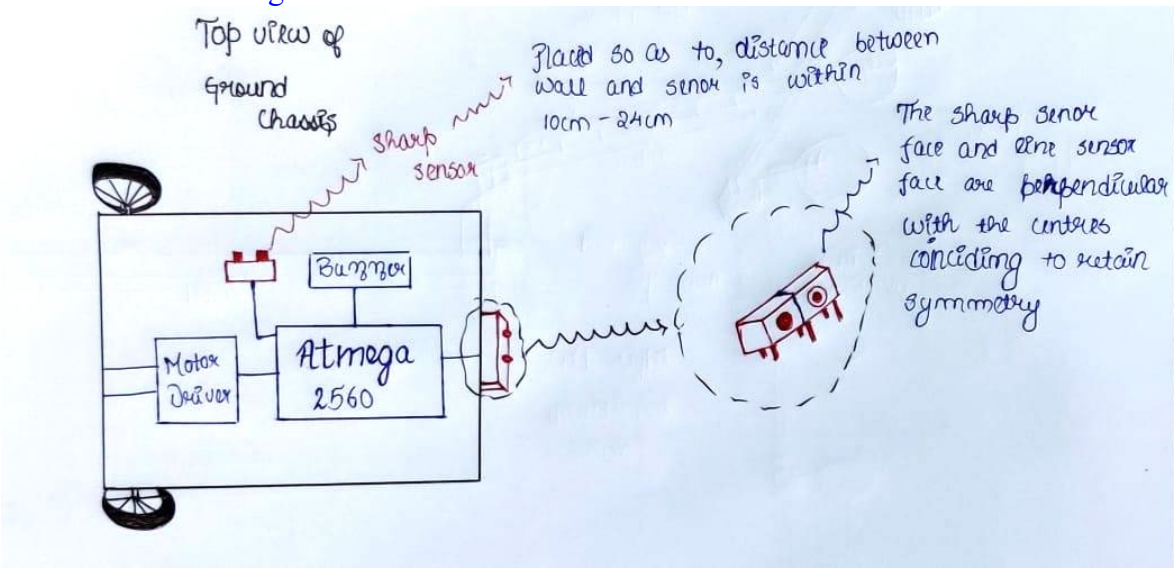
More images of our robot can be found here -- https://amzn.to/2FNTbgj

The design of the robot can be formulated on four bases:

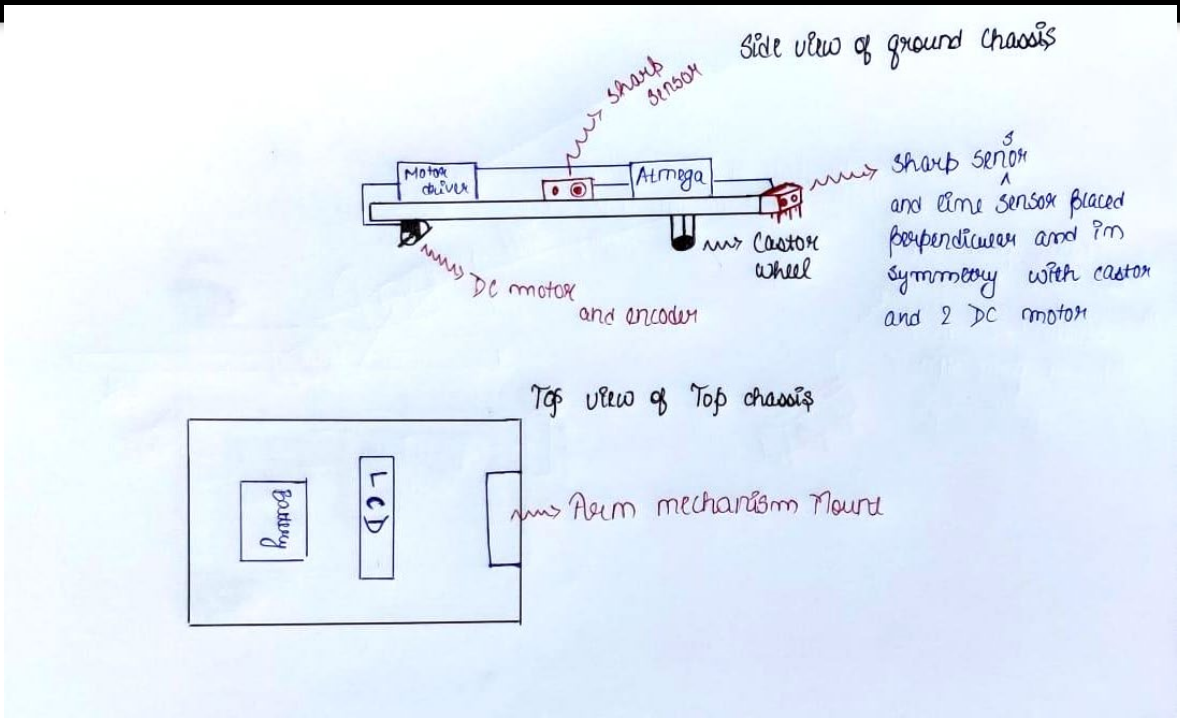
- Chassis: As per the diagram we can see that under the given parameters, square gives more utilisation area, also the major components are rectangular in shape hence no part of chassis goes to waste but the circular chassis would provide more advantage while performing turns. Yet we selected rectangular chassis for former advantage.



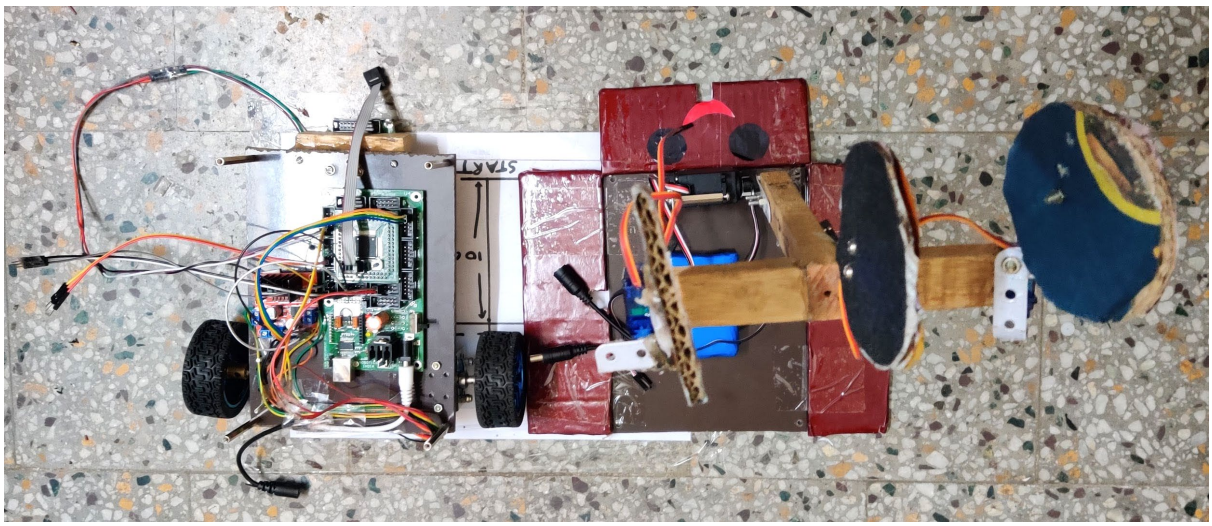
- Wheels: Both the wheels are fixed along the same axis at the rear end of the chassis with castor wheel being placed along the perpendicular bisector of that axis to provide smoothness in turning.



- Sensors: The line following sensor was placed just ahead of the castor wheel with the IR array facing downwards so that it would read '010' while the bot is along the line. This was done to maintain symmetry in all operations. Perpendicular to this sensor, sharp sensor was placed for object detection and another on the side for wall following.



- Arm: The arm mechanism is made using, 2 servos for directional movement, 2 micro servos powering 2 grippers, allowing the arm to pick 2 CM simultaneously and its length is adjusted to pick or place blocks directly from the node hence, saving time.



d. Using the designed robot, make it move by 10 cm forward, 10 cm right, 10 cm left and 10 cm backward. (15)

https://youtu.be/lDrcOotHkA0

e. Identify the major components provided to you and explain the role/purpose of each component that is required for designing the robot for the theme. (5)

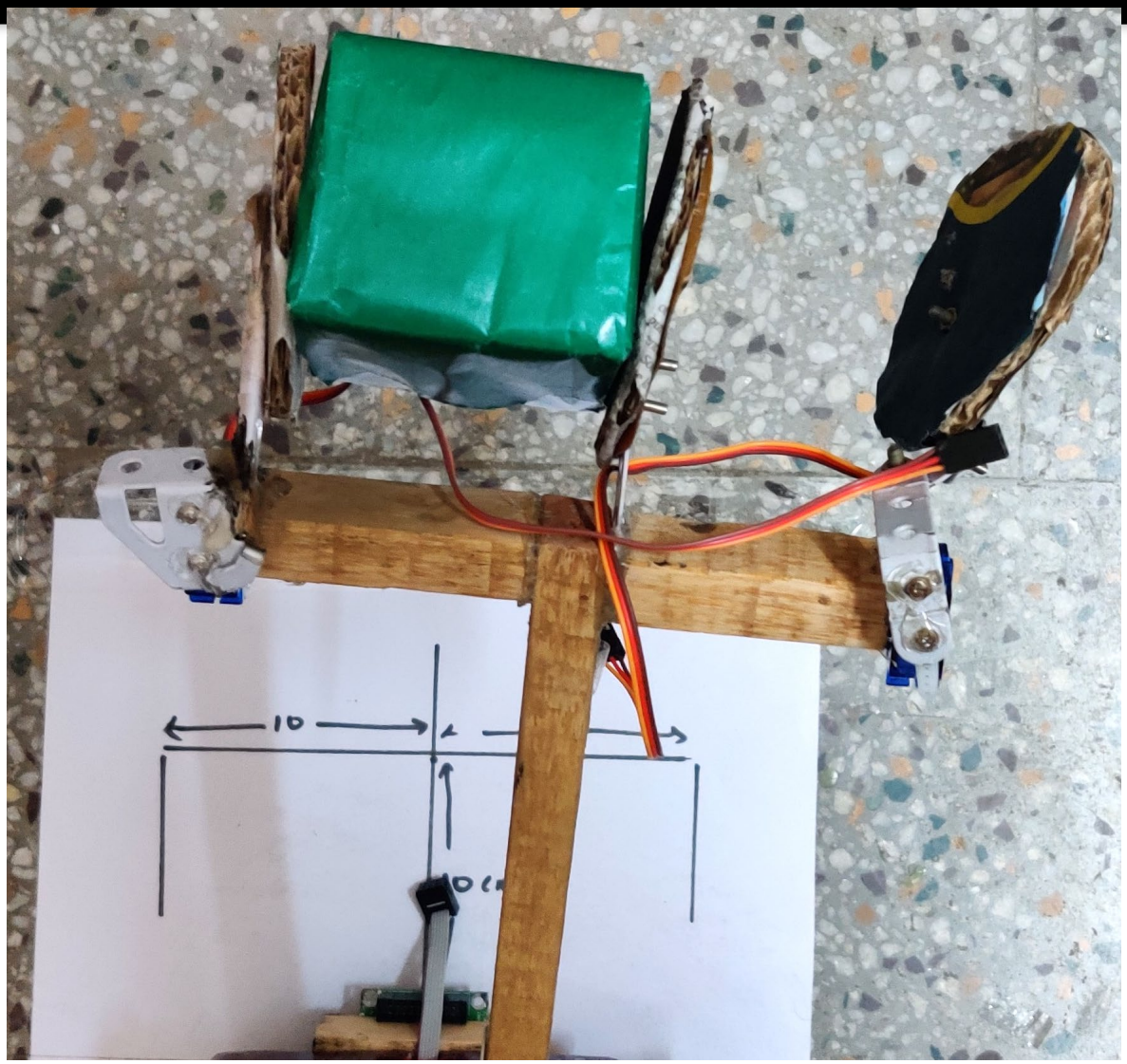
Mechanical--

1. Chassis: Provides a framework to the robot, similar to the way the skeletal system provides to the human body.
2. Wheel and Castor: Allows locomotion similar to the way the legs work for the human body.
3. Wooden Bar: Used in the arm mechanism, it connects the directional servo motors with the gripper also extending its reach.
4. Gripper: Used to grab CM, similar to the way fingers work.

Electronic--

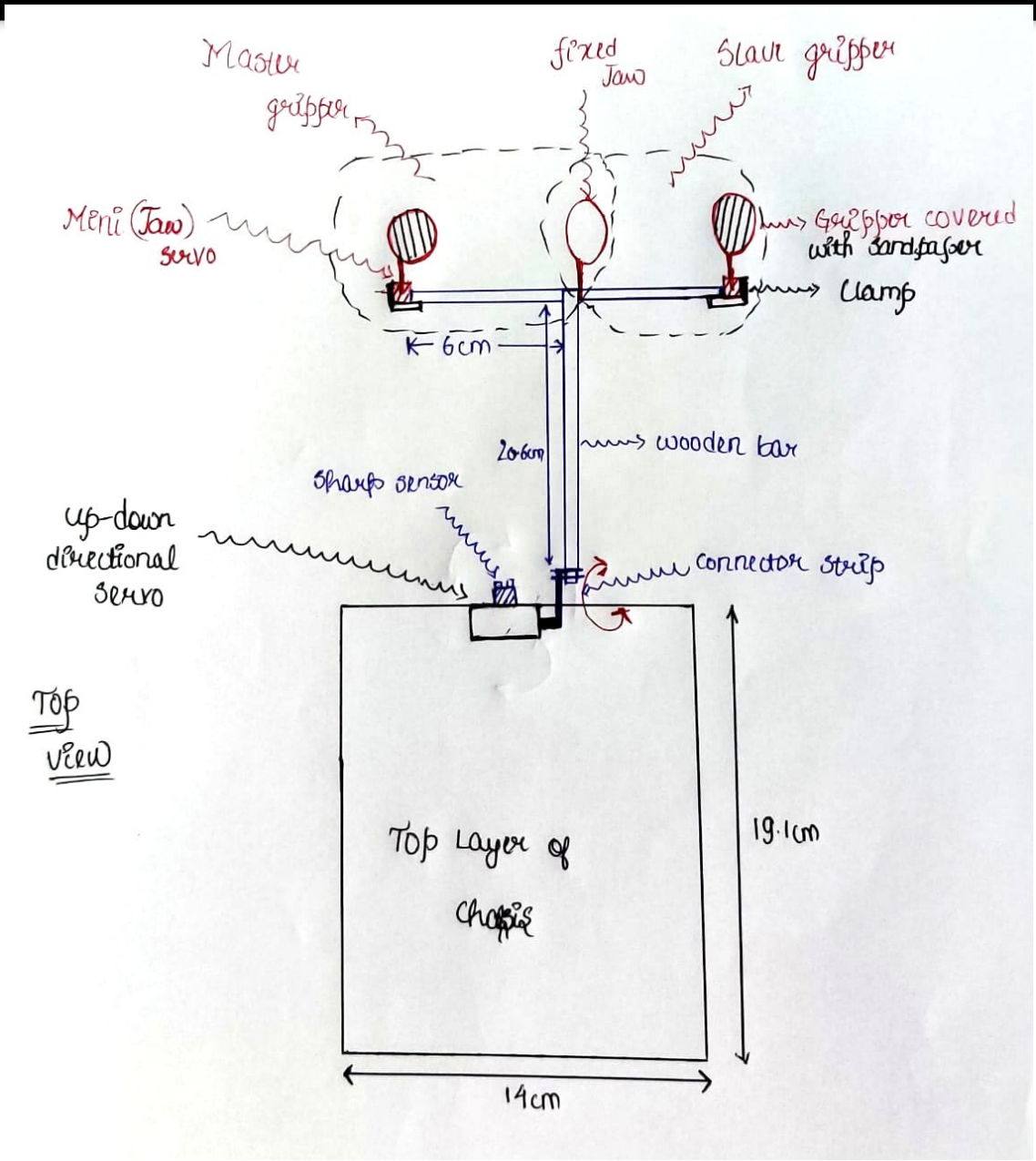
1. Microcontroller: It the CPU of the robot. It controls, coordinates and stores data flow and operations performed by the robot. It can perform only specific tasks. It has its own memory and processing unit.
2. Motor Driver: It is connected to the microcontroller and coordinates the DC motors as per the code burnt in the microcontroller.
3. Servo Motor: 2 Servo motors are used to provide directional movement to the arm mechanism and two micro servo motors are connected to control the gripper.
4. Battery: It is used to power the microcontroller and motor driver which in turn control the other components.
5. LCD: Displays various data values that are needed and acquired during operation, for example, sensor output.
6. Buzzer: Produces a buzzing sound. It is configured to beep under any desirable conditions, for example when a node is detected.
7. Sensors--
    - Sharp Sensor: Detect objects from 80cm and measure the distance between the object and itself when the range is 24cm to 10cm.
    - Line sensor: Distinguishes between black and white colour. It has IR emitters; the black colour absorbs the IR rays and the white reflects them which are received by the sensor; hence it can distinguish between the two colours. It is used to follow the path of the black or white line.
    - Encoder: It is fixed in the shaft of the DC motor, and can tell the number of rotations the wheel performed allowing calculations about the distance that it has covered.

f. Explain the components that you will be using to design the robotic arms and its working for the theme. How the arm will be mounted on the robot (left, right, back, front) , also justify your mounting strategy. (10)



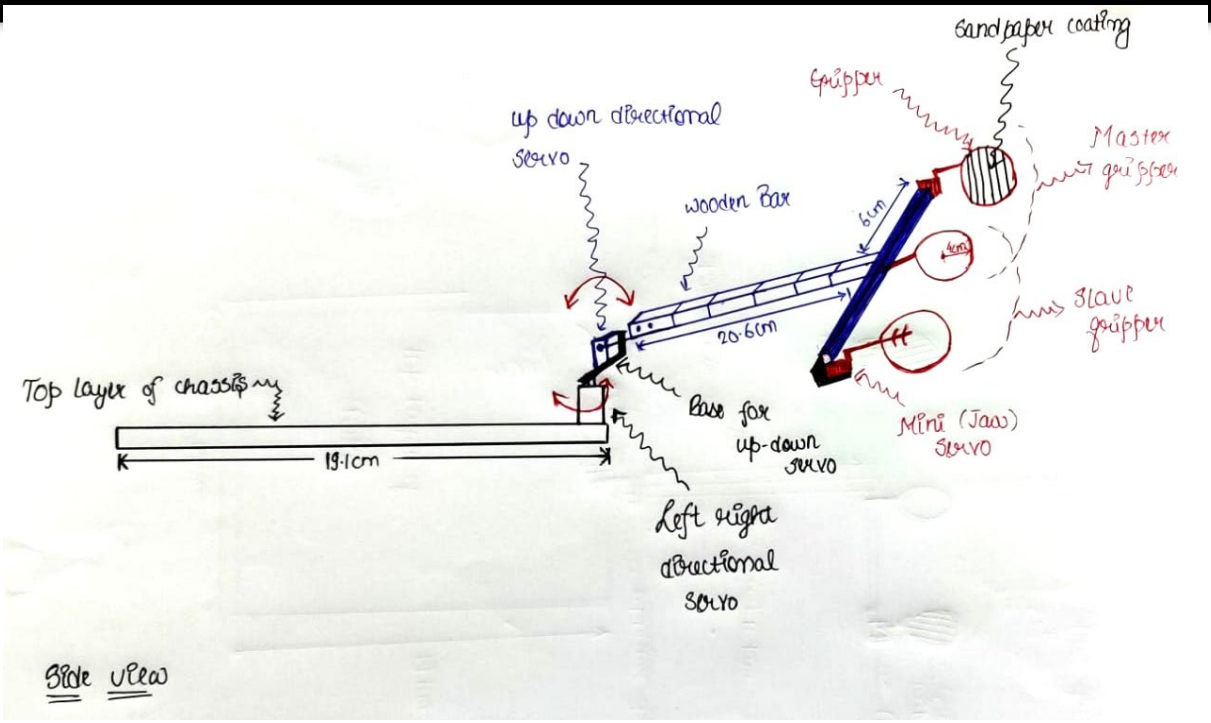
Mechanical--

1. Wooden Bar: It helps in extending the arm to a suitable length. We have used wood as it is suitably stiff and is fairly light, which helps in quick movements.
2. Cardboard gripper: Cardboard is light, and since the block to be lifted in the task is light too cardboard becomes the best choice. Its lightweight ensures less strain on the micro servos.
3. Sandpaper: The gripper is coated with sandpaper due to which the CM cannot slip due to high frictional force.
4. Clamps/Brackets: Metal strips that are used to connect servos with the mechanical elements.



Electronic--

1. Servo motor: The bot has 2 directional servo that provides left-right and up-down movements, along with 2 micro servos that operate the dual gripper.
2. Front edge Mounting: The front edge mounting right above the sharp sensor enables the arm to pinpoint the CM and also increases its reach, this allows the bot to directly pick the CM from the node itself.
3. Arm Mechanism: It compromises of 2 operations:
    - Directional Movement: The two-directional servos work together to provide left-right and up-down movement. Its movement is based on the output of the sharp sensor and height of house I which we must drop the CM.
    - Dual Gripper: The gripper consists of 3 jaws out of which 2 have a servo attachment and one of them is fixed. The master gripper is built along is centre aligning with the sharp sensor and can easily pick up CM. But the slave gripper is calibrated to move slightly left to align with the sharp sensor when it has to pick a CM.



g. What are the challenges would you expect to face while designing the robotic arms to pick and place the Construction Materials and how will you overcome them?

(5)

Challenge 1: The block might slip from the arm after picking it up.
Solution 1: The CM is covered with glaze paper which is smooth and may slip from the gripper. To overcome this issue the part of the gripper that comes in contact with the CM is covered with sandpaper, that has a huge friction coefficient.

Challenge 2: The block may fall due to excessive jerking.
Solution 2: Angular impulse is proportional to the perpendicular distance from the point of rotation. Moving servo induces vibrations that travel to the gripper and the CM may fall. To overcome these impulses wooden bar was used to connect the directional servo to the gripper servo. Wood is lighter than metal and absorbs vibrations rather than transmitting them, hence limiting the jerking. Also, the directional servos are fixed firmly to further reduce jerking.

Challenge 3: The arm length is slightly more to drop of CM in houses.
Solution 3: Arm length or the length of the wooden bar was determined so that the bot can pick a block directly from the node without moving closer to it. But this length is slightly more if we want to drop CM directly from the node in the house. To overcome this the bot must move back slightly so that the drop is possible.

Challenge 4: The slave gripper doesn't align with the sharp sensor.
Solution 4: The master gripper was aligned with the sharp sensor given it precision on pinpointing the block and picking it up but the slave it not aligned making it blind to the CM position. To overcome this issue, we must calibrate by how much the directional servo must move left so that the slave is aligned with the sharp sensor and can pick up the CM.

Challenge 5: The orientation of gripper causes trouble while picking and placing CMs.

Solution 5. If the gripper was taken to be rectangular then it would be differently oriented for different angles of the up-down directional servo. Also, the area of contact would be less for a rectangle. A circular gripper has taken for its absolute symmetry and also it would provide more area of contact.

h. In this theme, we use the following formula as mentioned in Judging and Scoring section of Rulebook:

Total Score = (600-T) + (CP*30) +(CD1*80) + (CD2*100) + (WHB*100) + (B*100) – (P*50)

What will be your strategy to earn maximum points and Bonus points in a run (given the following Configuration Table)?

(10)

House		Construction Materials Required	
H1	low-rise	Brick	Sand
H2	high-rise	Gravel	
H3	high-rise	Cement	Brick
H4	low-rise	Electrical fittings	Sand
H5	high-rise	Gravel	Paint

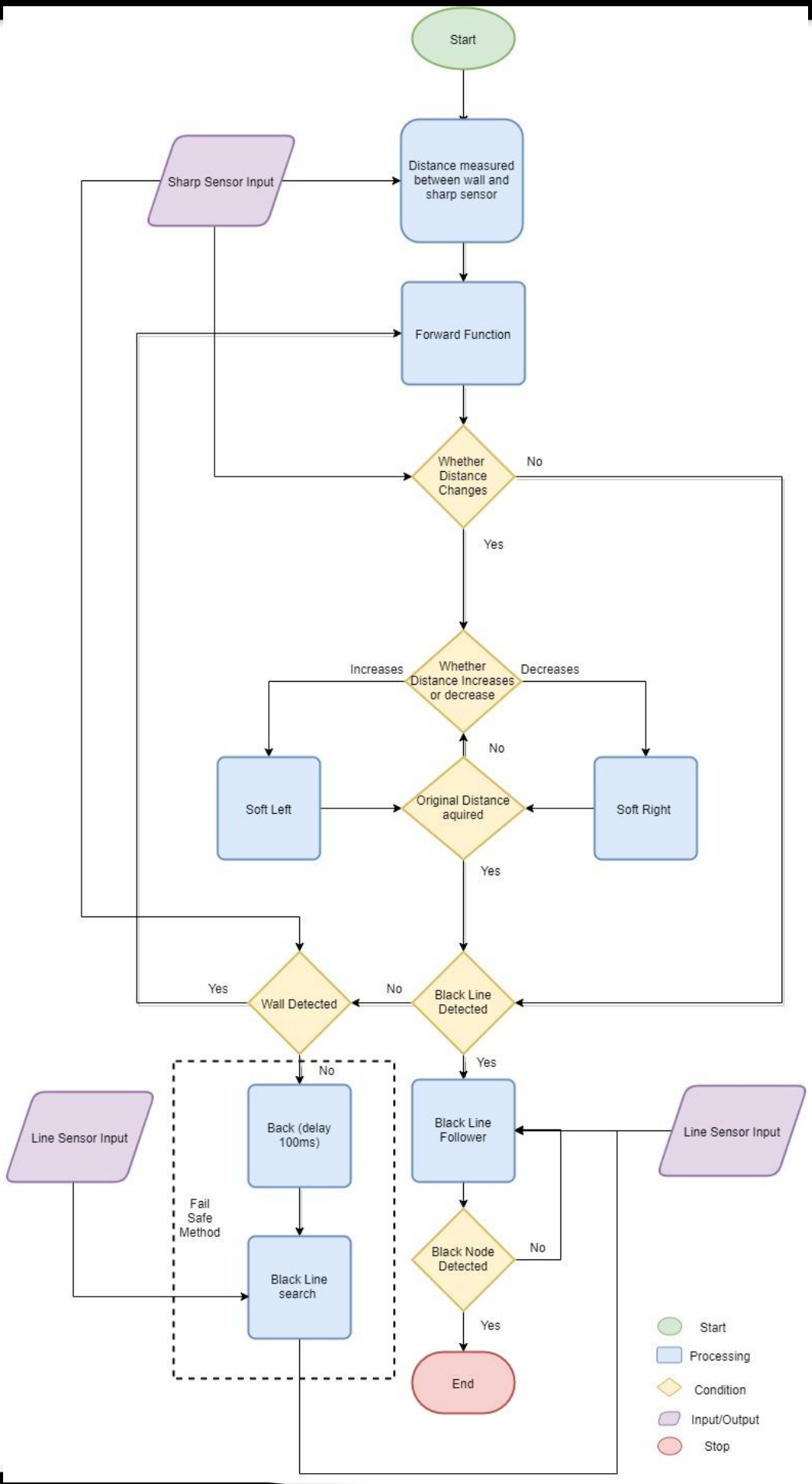
For this configuration, we want the robot to complete the task in less than 10 minutes and we also want the white house bonus. So, first of all, the robot will pick Gravel and Paint CM and place them in H5 using the shortest path calculated using Dijkstra Algorithm. Then without changing its direction, it will come out of the Inversion area and pick the nearest CM. Then it will calculate the shortest path of this CM from its house using the Dijkstra algorithm. It will then check if that house needs another CM or not. If yes, then it will see if it can pick that another CM on its way to this house. If possible then it will pick this CM also and will place both the CMs in this house. Then it will again go to the nearest CM and repeat the above steps until no CM is left. Then it will reach the Home position using the shortest path calculated.

i. Explain your strategy in following

(10)

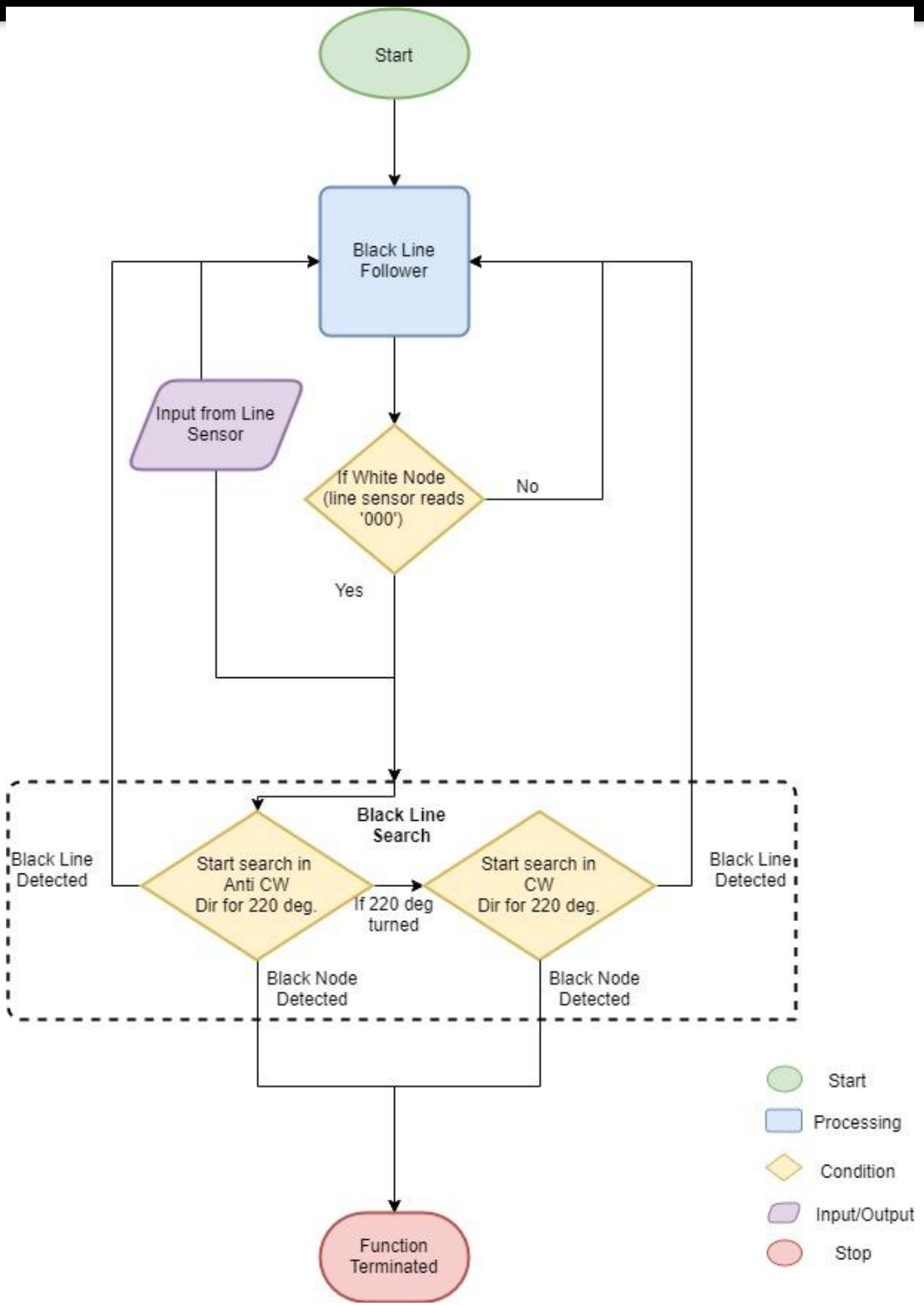
I. Wall,
II. Zig- Zag and
III. White line

- Wall: The sharp sensor detects the distance between the wall and itself, which is maintained by moving soft left or right as per the sensor data so that the bot moves in a straight line. Once the black line is detected objective is achieved.
  Flowchart for Wall Following--

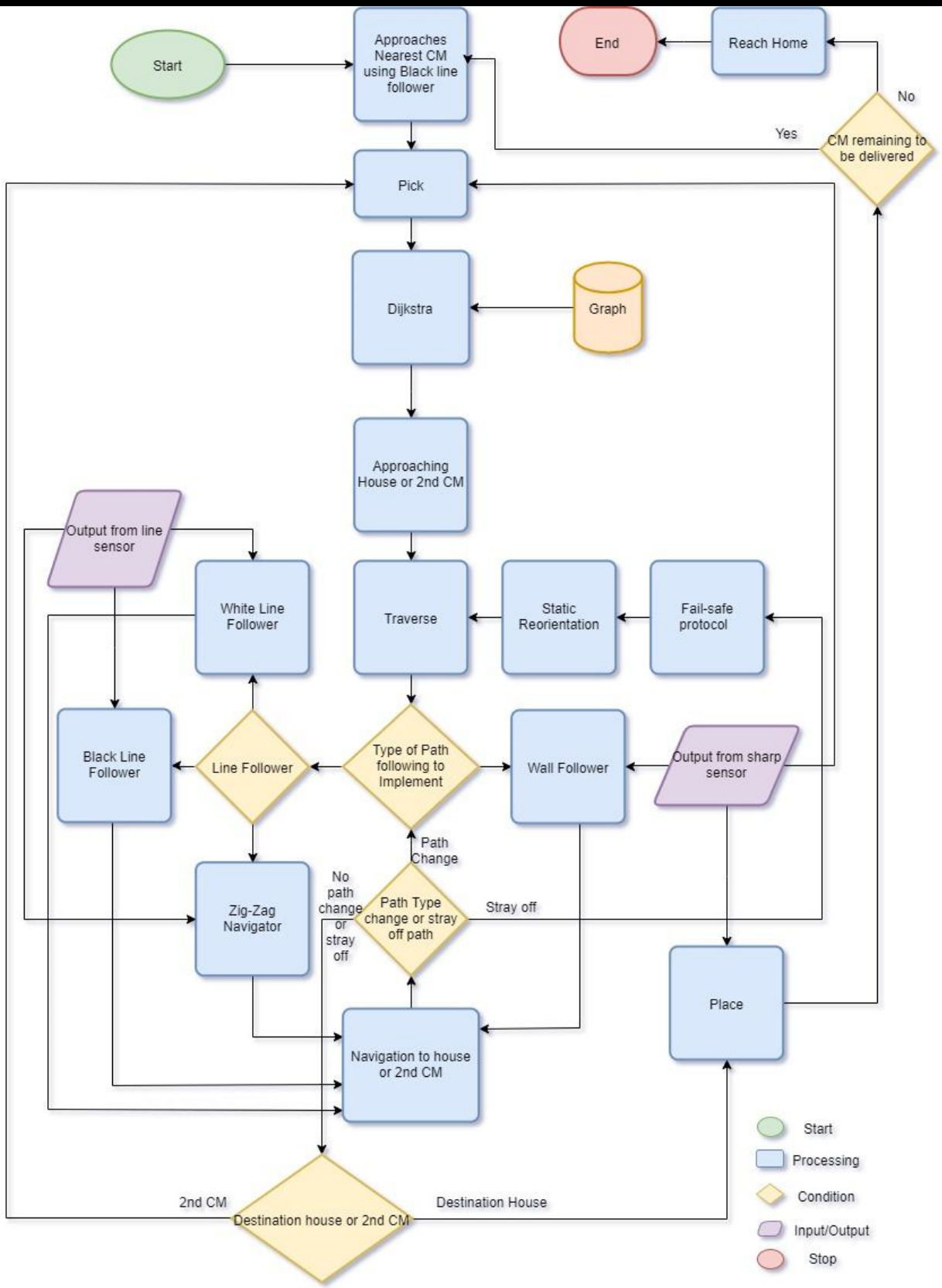

Start
Sharp Sensor Input
Distance measured between wall and sharp sensor
Forward Function
Whether Distance Changes
No
Yes
Increases
Whether Distance Increases or decrease
Decreases
No
Soft Left
Original Distance aquired
Soft Right
Yes
Yes
Wall Detected
No
Black Line Detected
No
Yes
Line Sensor Input
Back (delay 100ms)
Black Line Follower
Line Sensor Input
Fail Safe Method
Black Node Detected
No
Black Line search
Yes
End
Start
Processing
Condition
Input/Output
Stop

- White line: All functions of the black line can be used after substituting '0' and '1', the function is called when the line sensor reads '101'. Nodes are detected at '000'.
- Zig-Zag: The robot rotates in a defined mechanism to detect the black line and call black line follower whenever sensor read '000'.

Flowchart for Zig-Zag--



j. Draw the complete flow chart of the algorithm used to solve the problem. (15)



- Dijkstra: Weighted shortest path algorithm, the entire arena is feed into the memory in the form of nodes and weighted segments altogether known as a graph. This function merely determines the path the robot has to take.

- Traverse: This function simply calls all necessary functions that the robot needs to travel the path provided by Dijkstra.
- Line Follower: It consists of black line follower, i.e., the standard function to navigate on the black line, white line follower, i.e., function to navigate on the white line, and zig-zag to navigate on the fragmented path.
- Wall Follower: It is the function used to travel between the walls.
- Static reorientation: The robot stops and aligns the sensors with the path it is on, '010' for the black line and '101' for the white line.
- Fail-safe protocols: Each function has a small failsafe condition that can correct errors to a certain degree. In wall following, if the robot misses the black line at the end it will rotate and search for it. In black line and white line follower if the sensor reads '000' and '111' respectively it will go back for some time until the line is again detected and call static reorientation.
- Pick and Place: It is done using master and slave gripper to pick and place CM.

Best of Luck!