e-Yantra Robotics Competition - 2019-20

Implementation Analysis: Construct-O-Bot

CB#3149

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

(5)

Natural disasters, such as earthquakes and tsunamis, can strike whenever and wherever all over the globe.

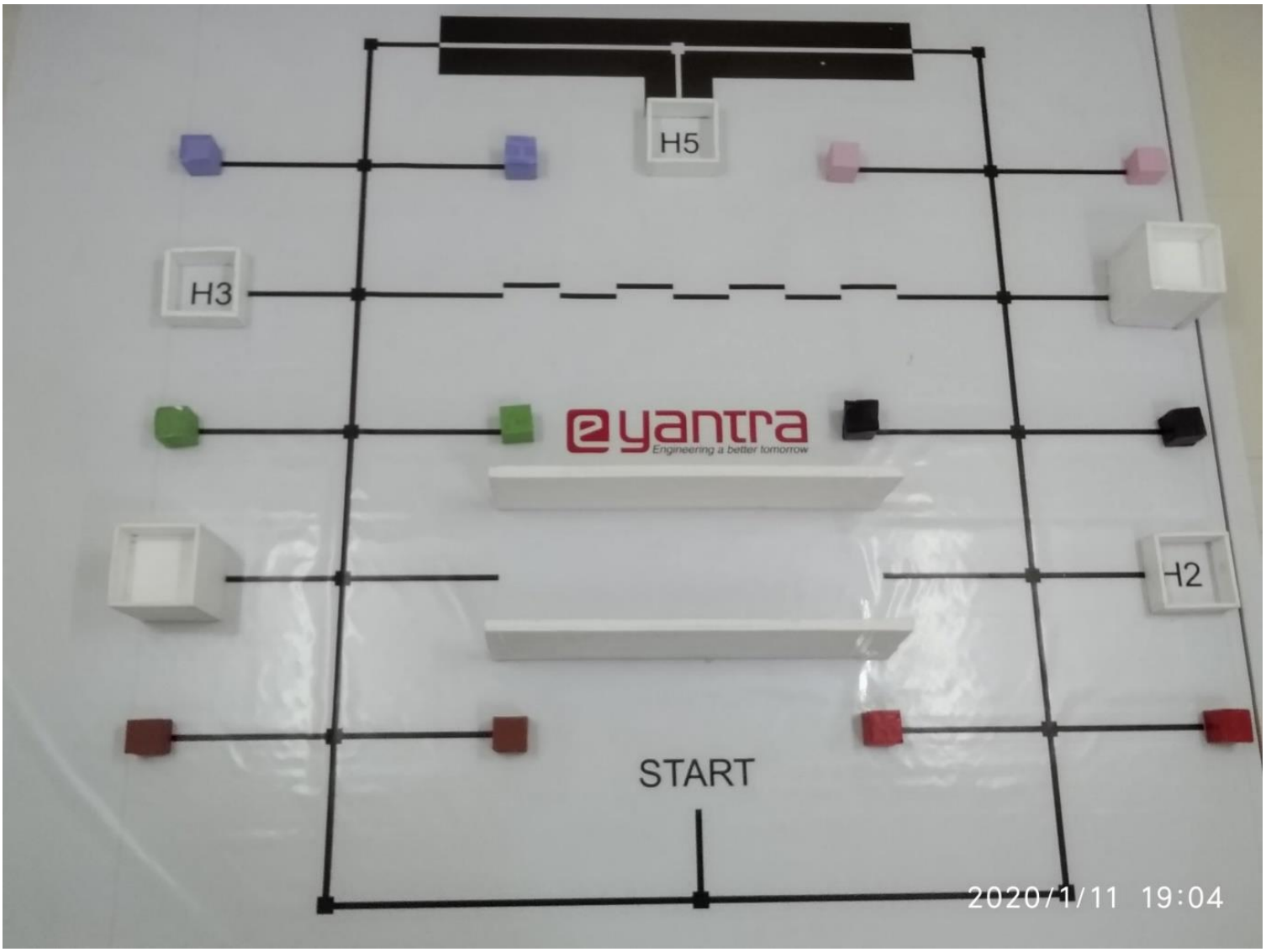
When that happens, rescuing the affected people is the first priority. The next priority is to restore all the damages to people's homes and other public properties. Not only can this be a huge financial burden on the government, it is also risky for the construction laborers.

To reduce this risk to the lives of people already struck by such a grave tragedy, we make an attempt to create a Construct-O-Bot. The sole purpose of this bot is to pick up the construction material from pickup sites and to deliver this to the required destination. To improve efficiency, we use a shortest path algorithm.

The area affected by such a calamity is simulated in the laboratory using a printed arena. The bot has to traverse this arena in minimum time. While following the path, the bot faces a number of challenges, such as zig-zag paths representing damages roads, walls representing debris.

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)

I. Bot Shape (Chassis):

- For the bot, we have used a square shape as shown. However, instead of the common design, wherein the wheels are attached to one of the edges of the square, we have attached the wheels along the diagonal.
- This gives a larger wheel-to-wheel distance in a smaller area.
- The bot will also have a second tier of the same shape. This will raise the bot's height so, the arm in the picking mechanism can be made a little smaller.

II. Sensor Placement:

-The white line sensor is placed in front of the castor ball. This is because when starting the bot, the castor ball must be placed on the black line. If the line sensors are in front of the caster wheel, then they will be on the black line when the bot starts.

- The sharp sensors are placed on two sides of the white line sensor.
This is to ensure that as soon as the sharp sensors detect that the wall is over, the white line sensors will be over the black line.
These sensors need to be placed at exactly equal distance from the edges of the bot.

III. Arm Mechanism:

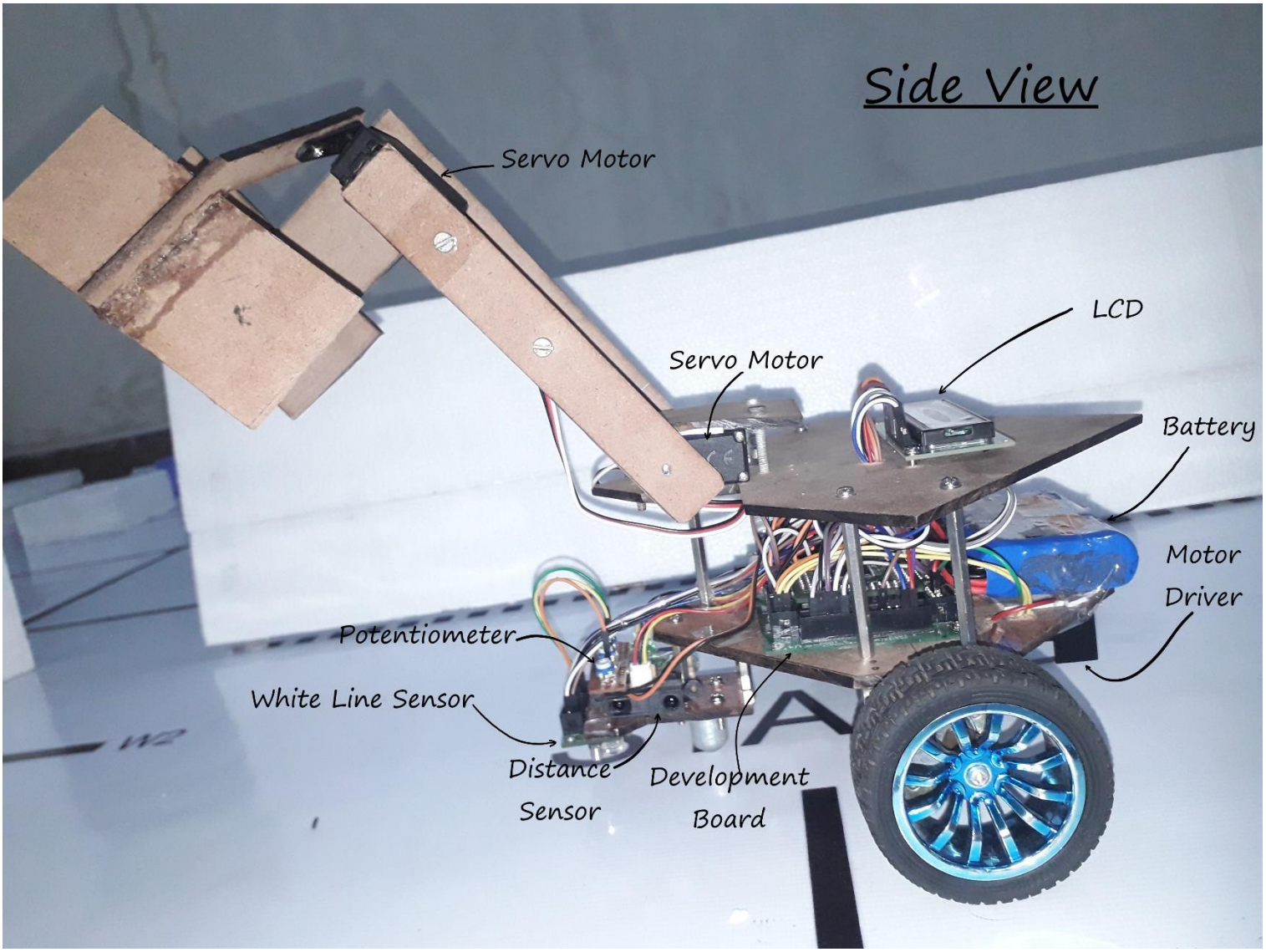
- As the wheels are along the diagonal and the castor ball to the front, the rear side of the bot is unbalanced.
- To overcome this, the Pick and Place Mechanism is placed to the front.
- This will make it easier to pick and place materials while at the same time balancing the center of mass of bot between the castor wheel and wheels.

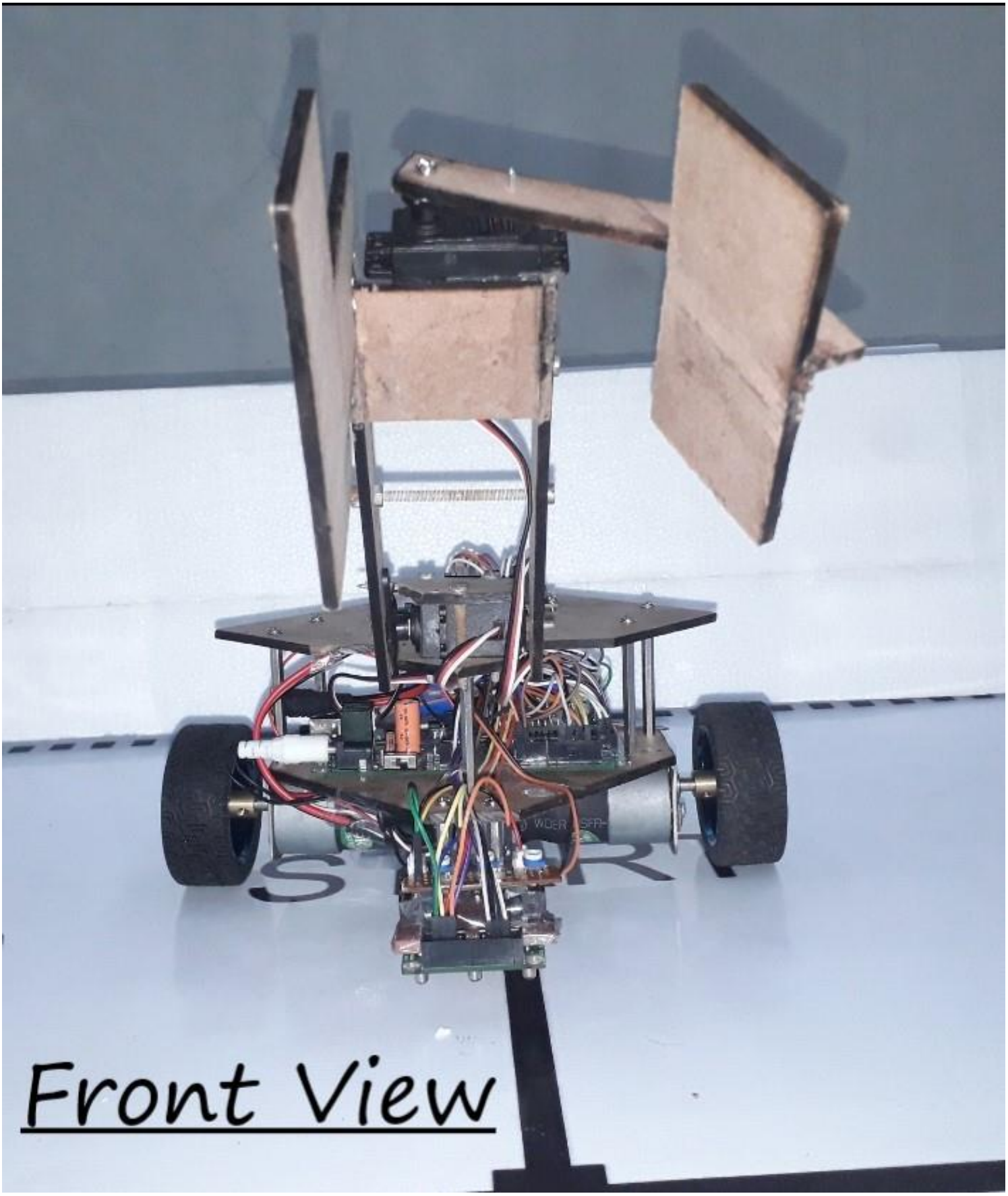
IV. Circuitry:

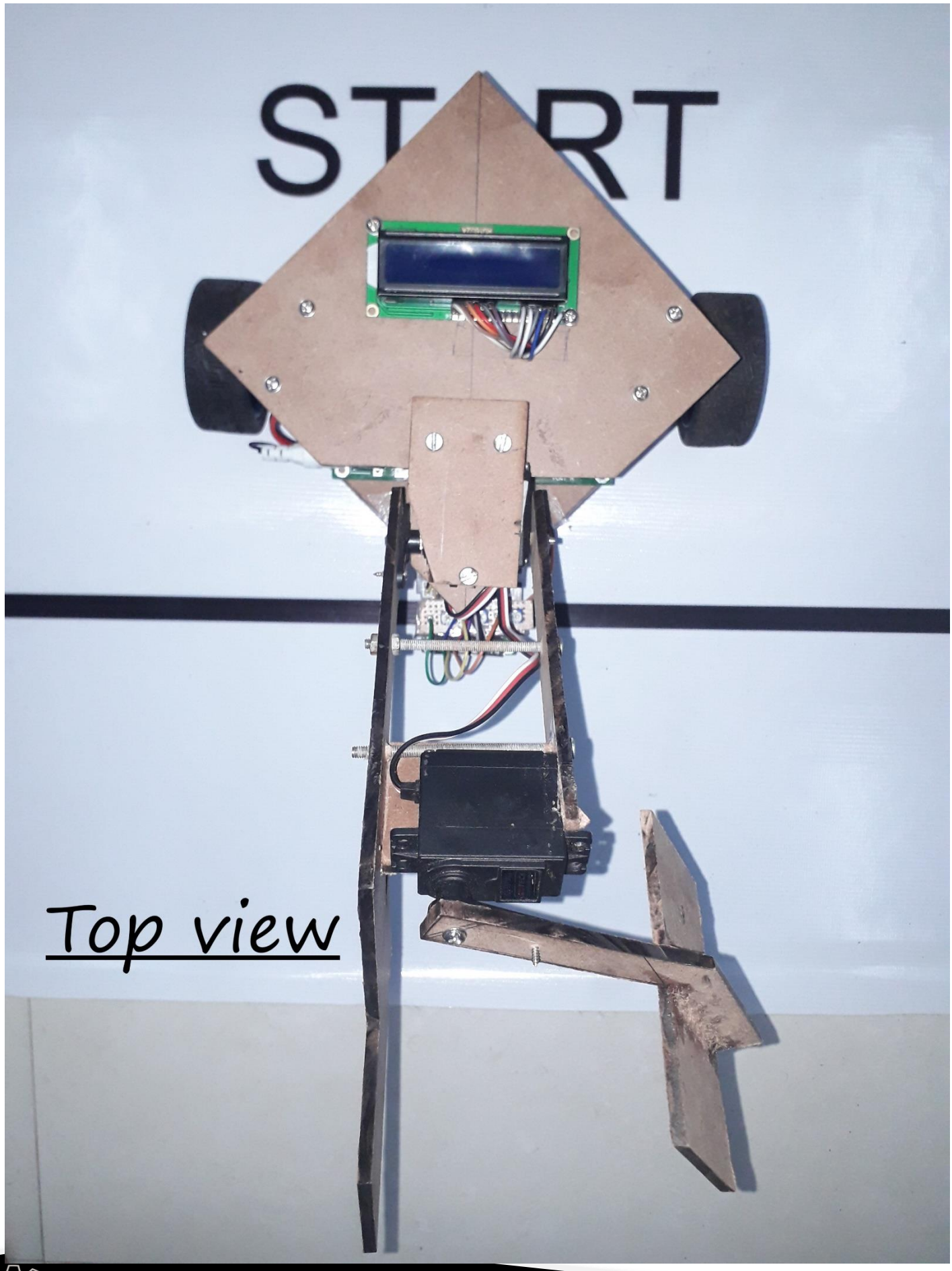
- Development board: The development board will be placed along the diagonal of the square shaped base.
- Motor Driver: It will be placed below the square base of the bot as it is light and will also be close to the motor.
- Battery: The battery will be placed on the lower diagonal of the square base. This

will balance the weight of the picking mechanism.

- LCD: The LCD will also be placed on the second tier to make it easier to read what it Displays.




Front View


START
Top view

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/TBpzCcEL1ls

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)

I. Mechanical components:

- Wheels

  They will be used for converting the rotary motion of the motor to linear motion. This will make the bot move forward, backward, right or left.

- Castor Ball

  It is used for balancing the bot and bearing its weight along with the 2 motors. As the castor ball can rotate in all directions, it will also enable the bot to turn easily in any the direction.

- Studs and Screws

  They form the main support system for the whole assembled bot. The tiers present in the bot will be primarily supported by these studs.

- Motor Clamps

  They are responsible for holding the motors in position.

II. Electronic Components:

- ATmega Development Board

  This is the main thinking brain of the bot. All the sensors and actuators in the bot will be controlled by the Atmega2560 processor present on the development board.

- Motor Driver(L298)

  It is used for interfacing the DC motors to the development board. It is used for direction controlling and for providing the PWM signal to the motors.

- LCD

  It displays the messages sent to it by the processor. It acts as an interface between the bot and the outside world

III. Power Sources

- Battery + Charger

  It is the power source for running the bot as well as the motors.

IV. Sensors:

- White Line Sensors

  These sensors are used for detecting the black line, and white line the bot must follow.

- Distance Measuring Sensors

  These sensors are used for detecting the walls during the wall following phase of path traversal.

V. Actuators:

- Geared DC Motors with Encoders

  They are used for the linear motion of the bot. The processor connected to the motor driver will provide variable PWM to the motor and rotate it at different speeds.

- Servo Motors

  They are used in the picking and placing mechanism. Controlling the duration for which the PWM is applied to these motors can control their displacement.

- Buzzer

  It is used for signalling the end of the given task by producing a loud noise.

VI. Other Components

- Jumper Cables

  It is used for connecting various peripheral devices to the microcontroller.

- Perfboard

  It used for mounting various components like potentiometers and the power supply to the bot

- STK500

  It is used while loading the program hex file into the processor

- A to B Cable

  It is used for connecting the computer to the development board wile loading the program

- 6-10 Pin ISP Converter

  It connects the development board to the STK500.

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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)

1. Mechanical Components:
   a. Arm: It is the long plate attached to the top tier of the bot. it is the part that gives length to the gripper. It has been made long so that the bot can place objects into the High-Rise Houses. There are two such plates to hold the gripper.
   b. Bolt and Nut: It is present between the two arm plates to hold them in place.
   c. Gripper: It is the main component of the picking mechanism. It consists of two plates, one of which is servo controlled. The servo-controlled plate moves back and forth to grip and hold the CM's.
2. Actuators:
   a. Servo Motor 1: It is attached to the top tier of the bot. It is responsible for moving the arm up and down while picking up the CM and placing them in the high- and low-rise houses.
   b. Servo Motor 2: It is responsible for moving the gripper while picking and placing the CM's.
3. Working of the Arm:
   - One of the servos will be placed on the base tier of the bot.
   - This servo is responsible for controlling the angle of the arm. Changing this angle changes the height of the mechanism.
   - Thus, for placing materials at a larger height, we will use a larger angle.
   - However, this angle must be precisely controlled by the microcontroller, otherwise we might damage the arena.
   - The gripper used for holding the CM is placed at the other end of this arm.

- One of the gripper plates used for picking up the CM is fixed to the arm.
- The other servo motor is connected to the other gripper plate.
- By controlling the servo angle, we can move this gripper plate and hold the CM firmly held while picking and placing it.

4. Mounting Strategy

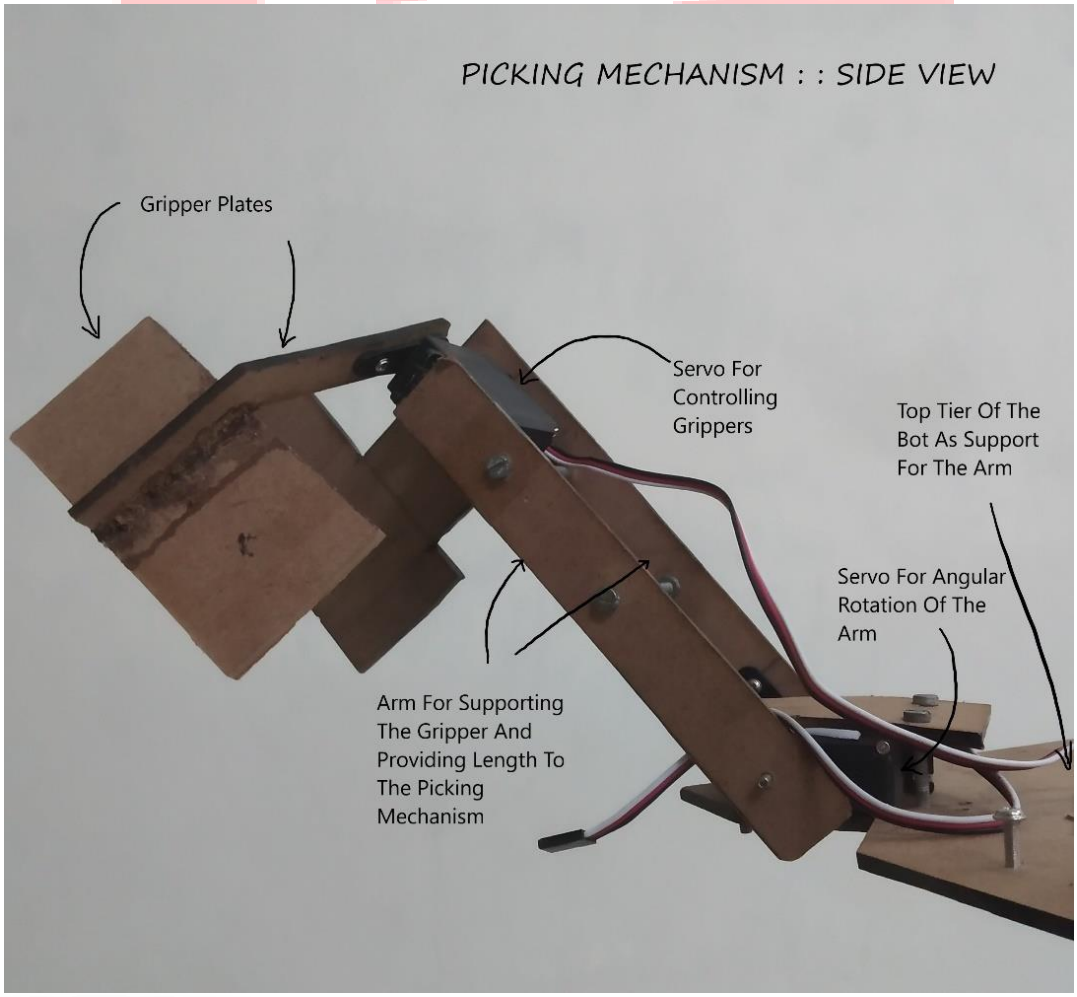
-As the distance between the CM and the nearest node is very large, and our bot being small, we cannot have a very long picking mechanism.

-So, we have placed the picking mechanism at the front end of the bot.

-If the arm were fitted at any other position (left, right or back), the bot would have to turn every time while picking up CM

- Also, if the arm were to be placed at the centre of the bot, it would have to move a little forward, after turning, for picking and placing. This is very time consuming.

Thus, placing the Picking Mechanism at the front end seems like the best strategy.



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: Height differences in warehouse and house during pick and place

Solution 1: We can use trigonometry to calculate the optimal length of the arm at which it becomes easy to pick material from the Warehouse as well as to place it in the House

Challenge 2: Designing a system for controlling both the gripper plates with is single servo was challenging.

Solution 2: For this we would have needed gears which in turn would have complicated our work. Of course, we could have 3D printed the required parts, but we wanted a completely handmade bot.

To overcome this problem, we changed the design of the gripper. Instead of moving both the gripper plates, we control only one of the plates. This plate is attached to the servo motor using servo mountings. When the servo rotates, the plate moves and increases the gap between the two gripper plates to facilitate picking.

Challenge 3: Misalignment of the bot during picking operation might result in improper picking

Solution 3: To avoid this we will make the distance of the gripper fins larger so that even with a little misalignment, the gripper can catch the Construction Material.

Challenge 4: Strength of arm if it is made long

Solution 4: To overcome this, we must choose the right material for the arm as well as the chassis

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

I. The first trick would be to complete the task in the minimum amount of time. This way we get a bonus of 100 points and as evident from the term (600 - T), negative marks will also be avoided. To do so however, we need to find the shortest path. To find the shortest path, we explore all possibilities of path that exist and select the best on possible.

II. We can also score the 100-point bonus for placing the objects in the White House first. The shortest path we find must have the first house as the White House. This is the most challenging part of the task as not only does the bot have to traverse a white line, the placing distance available is also very small.

III. Correctly picking up the Construction Material results in 30 points. To score this, the picking mechanism must be perfect. We must make sure not drop the materials while traveling the path.

IV. The CM placement of the bot must also be proper. When placing two CM in the same house, the second CM must be placed properly so that it doesn't topple over and fall down. Failing to do so, we risk losing the marks for Correct Placement.

V. Most important of all is to avoid penalties. All the hard work done in scoring the above points is lost if the bot loses marks in penalties. Some of the instances where penalties apply are requiring more than two repositioning, placing wrong CM, damaging the arena, etc.

i. Explain your strategy in following **(10)**

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

I. Wall Following:

- For following the wall, we make use of the analogue comparator in the ATmega2560.

- The two sharp sensors will be placed on two sides of the bot, and will give the distance of the nearest obstacle (wall) from them.

- The output obtained from these sensors will be fed to the analogue comparator.

- If the difference in the magnitude of these two signals is zero, implying that both the walls are at the same distance from the bot, the bot will move forward.

- If the reading from the right sensor is greater than that from the left sensor, implying that the bot has deviated to the right, then the bot will move to the left.

- Similarly, if the reading from the left sensor is greater than that from the right sensor, implying that the bot has deviated to the left, then the bot will move to the right.

II. Zig-Zag Line:

- To follow the zig-zag line, we will create a separate function that will be called only when the bot needs to traverse the zig-zag path.

- This function will first check whether the bot is crossing the line from the right side

of the arena or the left. This will be done by checking its START and END address.

- The bot will then follow the black line until it reaches its end, i.e. all the sensors detect a white area.

- Depending on the direction in which the bot is moving, the bot will either turn to the left or to the right.

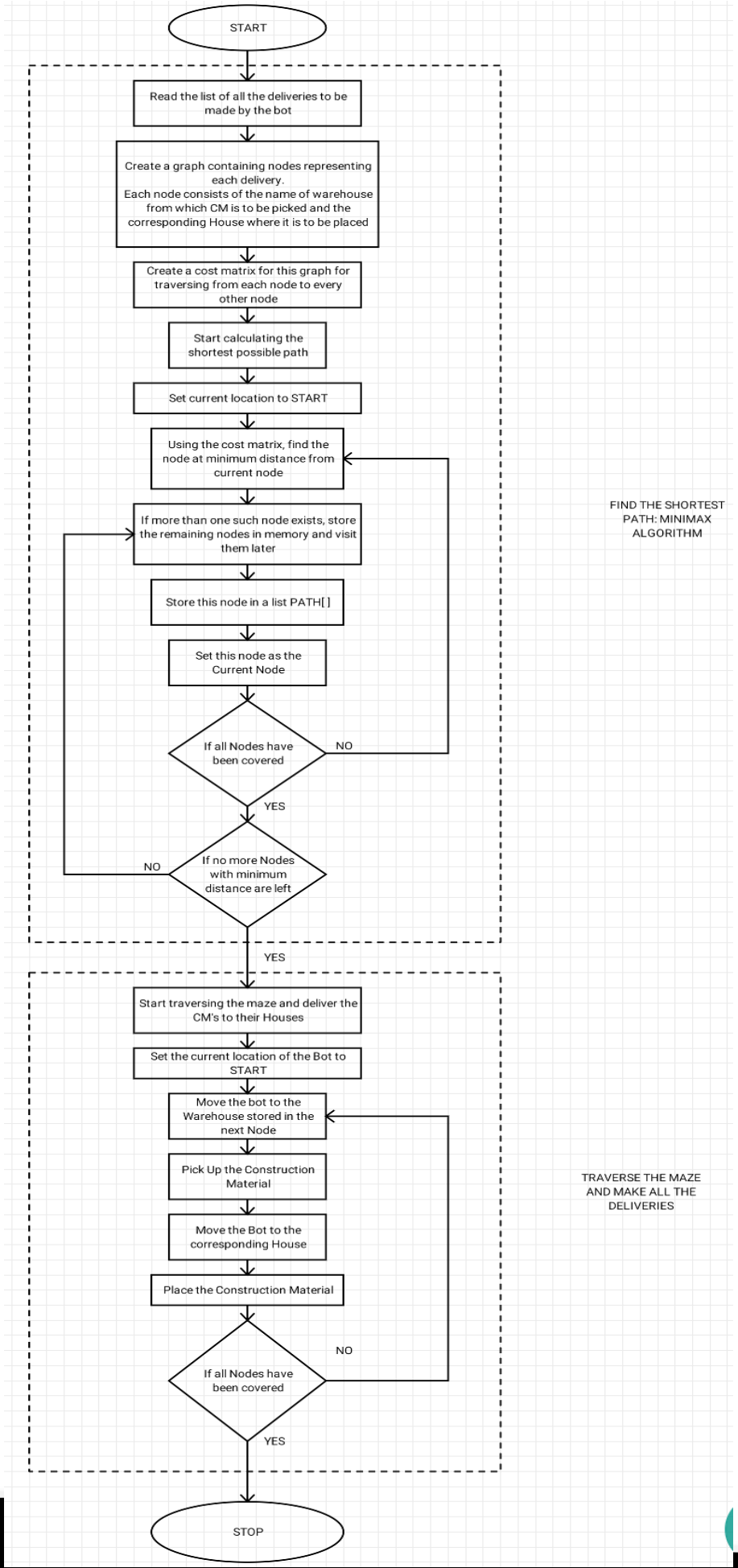
-For all the subsequent points where the sensors read a white background, the bot will alternatively take right and left turns. For example, if the first turn was right, then the bot will turn left, then right, then left, then right and so on. And if the first turn was left, then the bot will turn right, then left, then right and so on.

- This will continue until the line sensors detect a node

III. White Line:

- For white line following, we will have two while loops.
- The first loop corresponds to the black line.
- This loop also contains the while loop for white line following.
- Check the values of all the three sensors.
- If the left and right sensor detect a black line and middle sensors detect a white line, then move the bot forward.
- If the right and middle sensor detect a black line and the left sensor detects a white line, then take left turn.
- If the left and middle sensors detect a white line and the right sensor detects a black line, then take a left turn.
- If the right and middle sensor detect a white line and the left sensor detects a black line, then take right turn.
- If the left and middle sensors detect a black line and the right sensor detects a white line, then take a right turn.
- If all the three sensors detect a white line, then we have reached a node. So, stop the bot.
- Repeat this process until the right and left sensors detect a white line and the middle sensor detects a black line.

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


START
Read the list of all the deliveries to be made by the bot
Create a graph containing nodes representing each delivery.
Each node consists of the name of warehouse from which CM is to be picked and the corresponding House where it is to be placed
Create a cost matrix for this graph for traversing from each node to every other node
Start calculating the shortest possible path
Set current location to START
Using the cost matrix, find the node at minimum distance from current node
If more than one such node exists, store the remaining nodes in memory and visit them later
Store this node in a list PATH[ ]
Set this node as the Current Node
If all Nodes have been covered
NO
YES
If no more Nodes with minimum distance are left
NO
YES
Start traversing the maze and deliver the CM's to their Houses
Set the current location of the Bot to START
Move the bot to the Warehouse stored in the next Node
Pick Up the Construction Material
Move the Bot to the corresponding House
Place the Construction Material
If all Nodes have been covered
NO
YES
STOP
FIND THE SHORTEST PATH: MINIMAX ALGORITHM
TRAVERSE THE MAZE AND MAKE ALL THE DELIVERIES