e-Yantra Robotics Competition - 2017

Theme and Implementation Analysis – TB

<Team ID>

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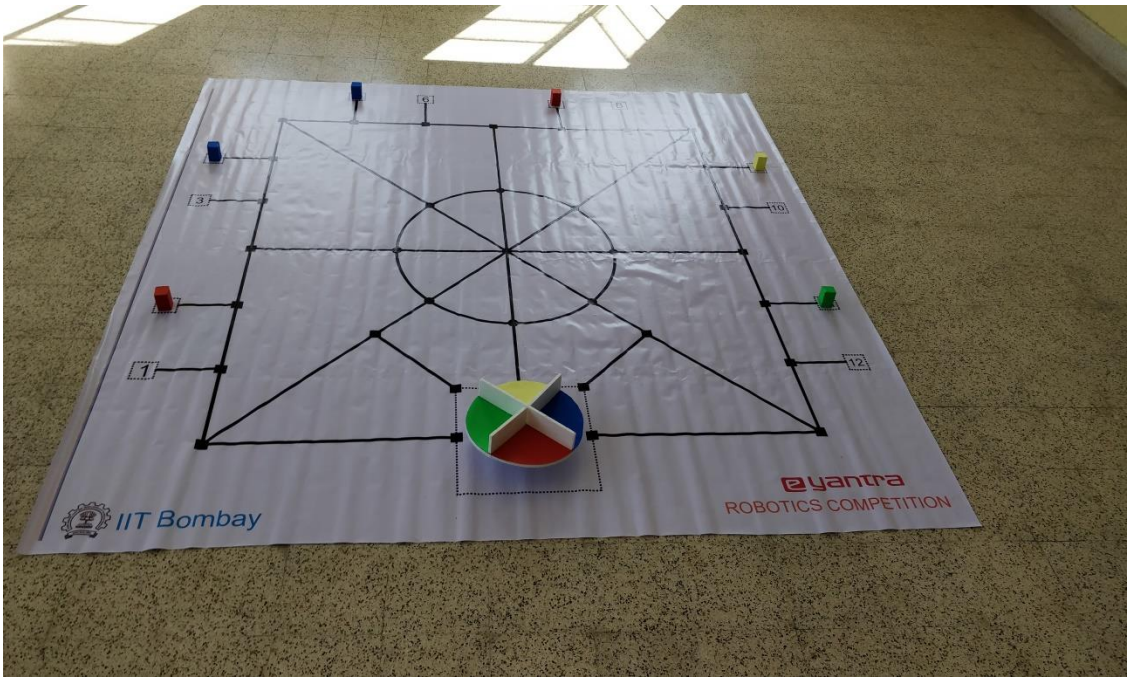
Scope and Preparing the Arena

Q1 a. State the scope of the theme assigned to you.
(3)

Transportation is regarded as an important factor in agricultural production. Agricultural commodities produced have to be transported to the market without considerable loss to the crops. This can be achieved by the help of autonomous robots. So here comes the need of Transporter bot. It not only reduces the dependence on human beings, also it increases the reliability, increases safety and reduces time. Automated robot has the potential to work constantly and thus transporting the agricultural commodities to the market in short duration. This not only saves the time but also saves the crop from damage.

b. **Attach the Final Arena Images.**
(20)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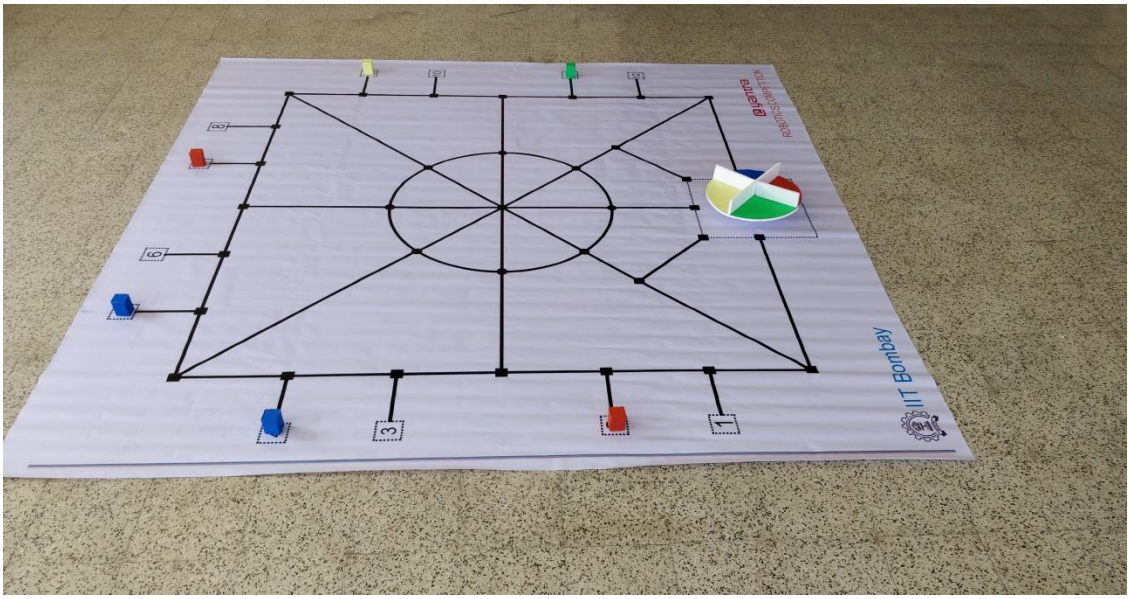
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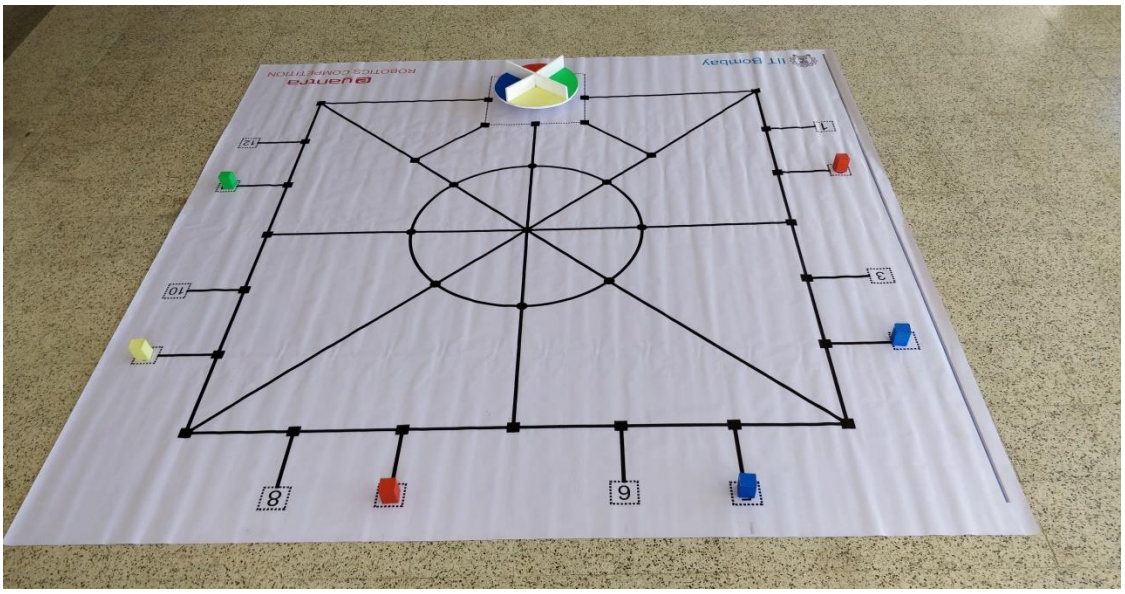
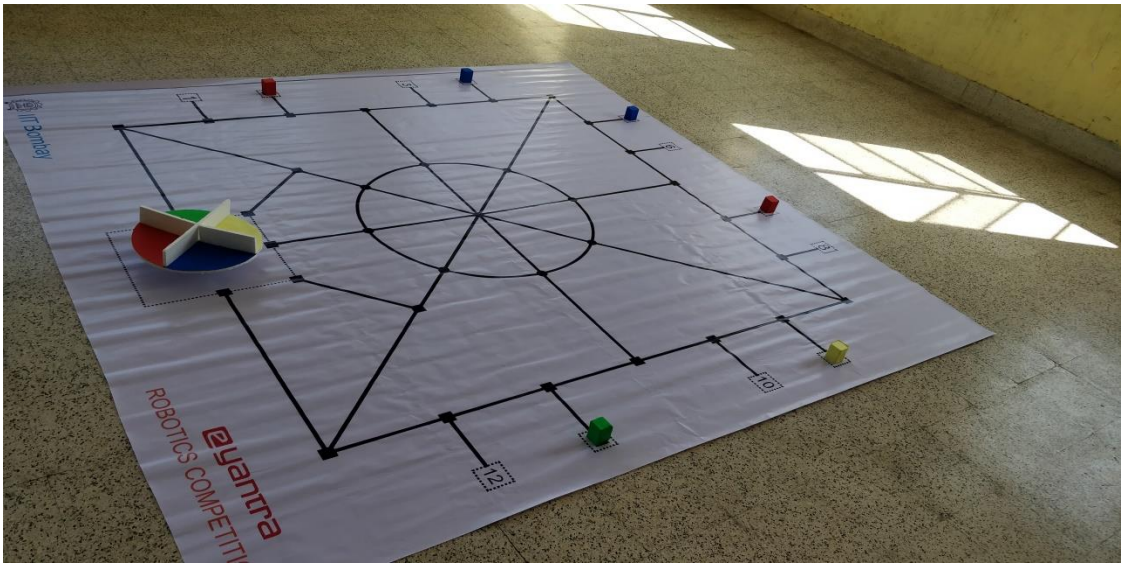




Building Modules

Q2. Identify the major components required for designing the robotic system for the theme assigned to you.

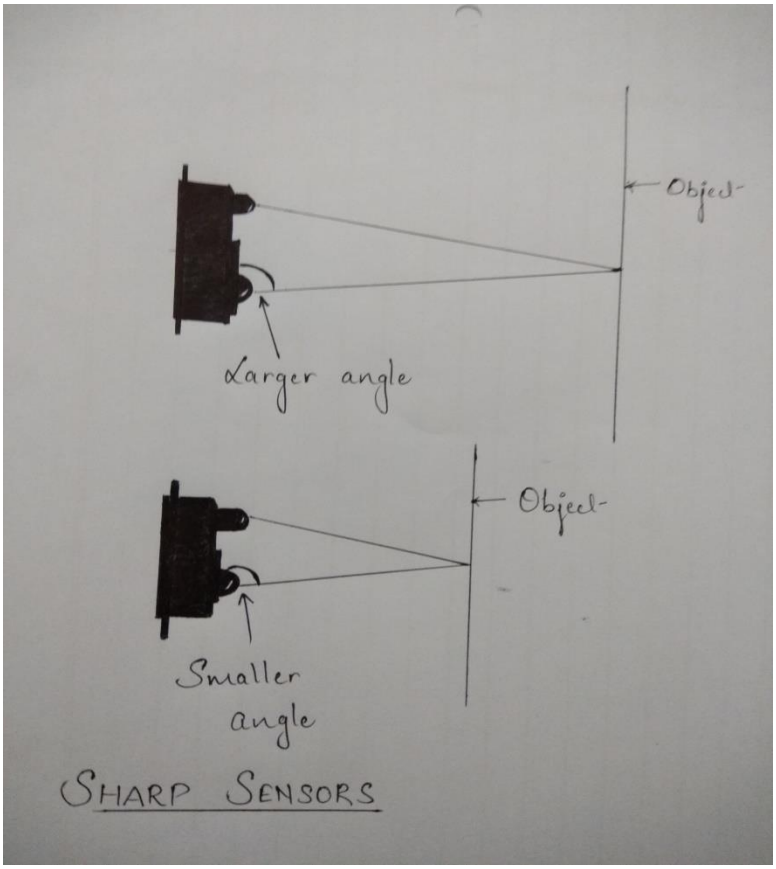
(5)

The major components required are as follows:-

1. Electronic System:-
    - XBee Module: It is a wireless communication module used for communicating between Firebird and rotating structure, Firebird and blender.

2. Optoelectronic System:-
    - White Line sensors: These sensors are used to follow the black lines on the flex. They consist of a highly directional photo transistor for line sensing and bright red LED for illuminating.

    - Sharp sensors: These sensors are used for accurate distance measurement .It consists of IR LED and linear CCD array, contained in housing with lens assembly mounted in front of them. This sensor is used to detect the blocks and function accordingly.



    - Position Encoder: Position encoder gives position/velocity feedback to the robot. The position encoder that we use in Firebird V is the optical encoder. We use position encoder to move the robot in desired position accurately.

3. Electrical System:-
    - DC geared motor: Firebird V uses two 75 RPM Geared DC Motors for its locomotion. Gears are used to increase the torque of motor.

4. Mechanical System:-
    - Chassis: The base frame of the Firebird V.
    - Wheels: It is used for motion of the robot.
    - Stepper Motor: It is a brushless DC electric motor that divides a full rotation into no. of equal steps. In our case, it is used to rotate the rotating structure.

5. Electromechanical System:-
    - Servo Motor: Servo motor is a rotary/linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It is required by us for the making of the robotic arm.

6. Electrochemical System:-
    - Batteries: Firebird V uses on board rechargeable Nickel Metal Hydride battery to power it.

7. Piezoelectric System:-
    - Buzzer: Firebird V has 3 KHz piezo buzzer .It is used to indicate the end of the task in our theme.

Actuators

Q3. List all the actuators present on Firebird V robot. Besides the existing actuators, please mention any additional actuators that may be required for implementing a solution for the theme. (5)

Actuators that are required for implementing a solution of the theme is as follows:

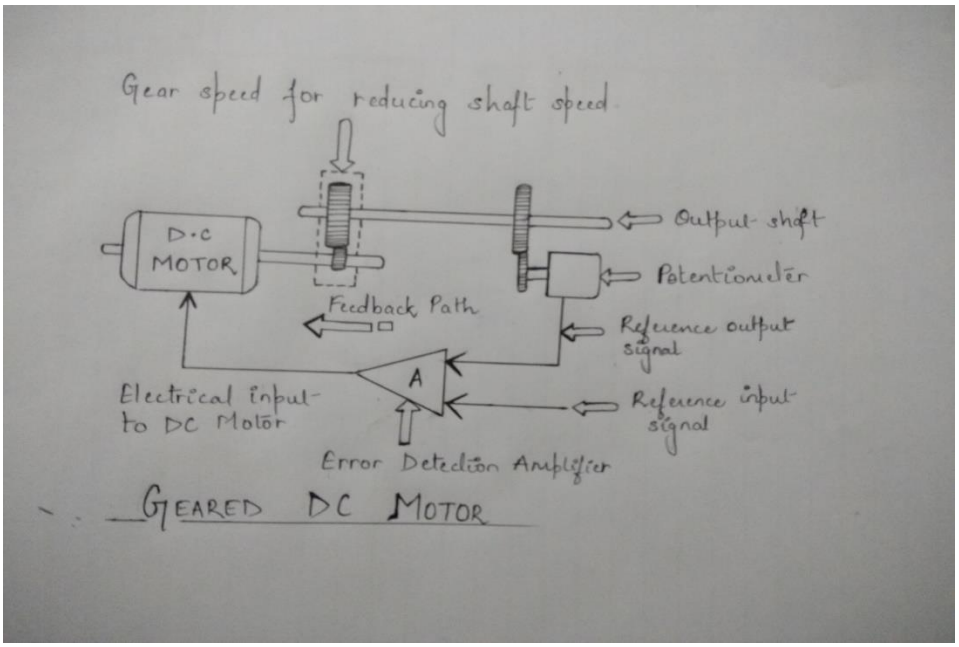
(i) Actuators that are already present on Firebird V Robot:-

1. DC Geared Motor: A geared DC motor has a gear assembly attached to the motor.

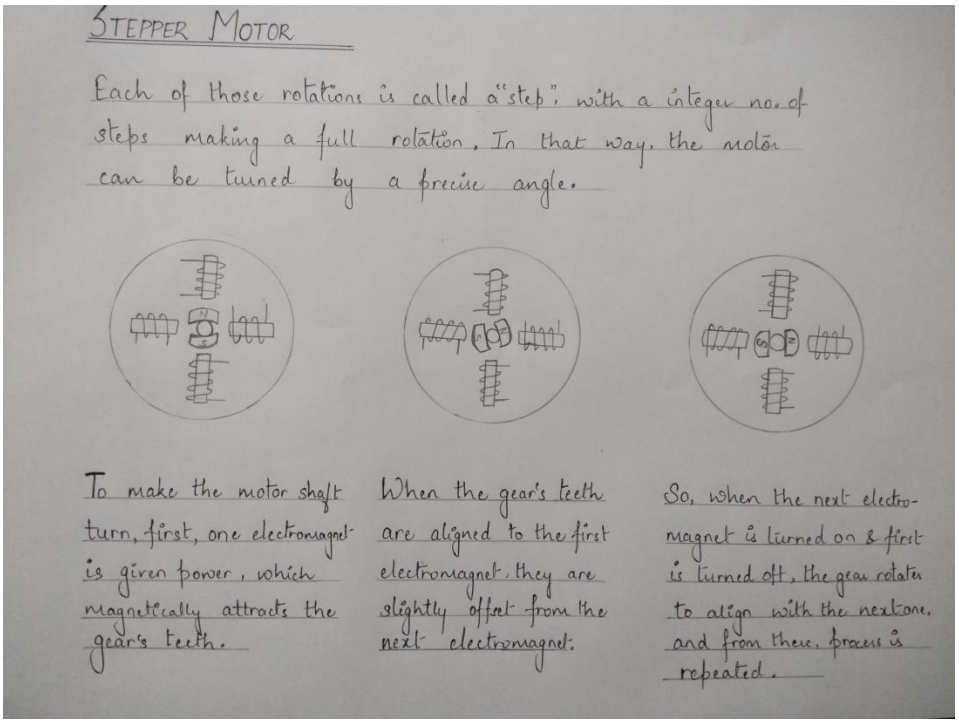
The speed of motor is counted in terms of rotations of the shaft per minute. Firebird V Robot has two 75 rpm DC geared motor in differential drive configuration. It has a top speed of 24cm/sec. It is required for the motion of the Firebird V Robot.

(ii) Additional actuators that are required for the implementation of the theme:-

1. Servo Motor: Servo motor is a rotary/linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It is required by us for the making of the robotic arm. We need 2 Servo motors for the robotic arm to make a 2 DOF model.



2. Stepper Motor: It is a brushless DC electric motor that divides a full rotation into no. of equal steps. It is used to rotate the rotating structure.



Power Management

(2)

Q4. Explain the power management system required for a robot in general and for Firebird V robot in particular.

The main sources of electrical power for robots are batteries. There are two types of batteries in general, rechargeable and non-rechargeable batteries. Non-rechargeable batteries are generally more powerful. Other mode can be through external auxiliary power supply.

Firebird V has on board rechargeable NiMH battery. Current and voltage rating of the battery is 2.1Ah and 9.6V respectively. The mode that we prefer depends upon its requirement as both modes have certain advantages and disadvantages. Auxiliary mode is better, when the robot needs to be powered for extended period but it resists to a smaller area and needs constant power supply. Unlike Auxiliary, batteries are more reliable and convenient to use.

Design Analysis

Q5. Teams have to design a mechanism for picking and dropping the Blocks into the Rotating Structure.

a) Choose an option to position the mechanism on the robot and justify your option (4)

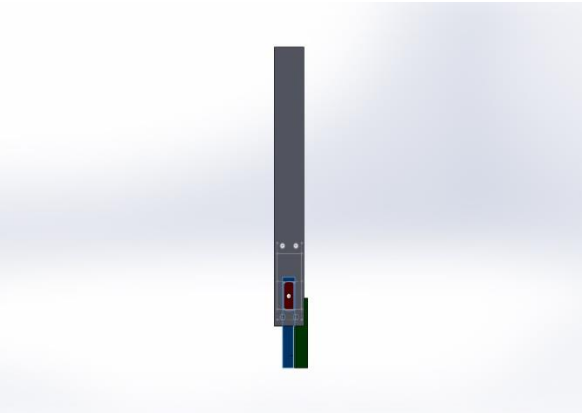
1. Front 2. Back 3. Right/Left

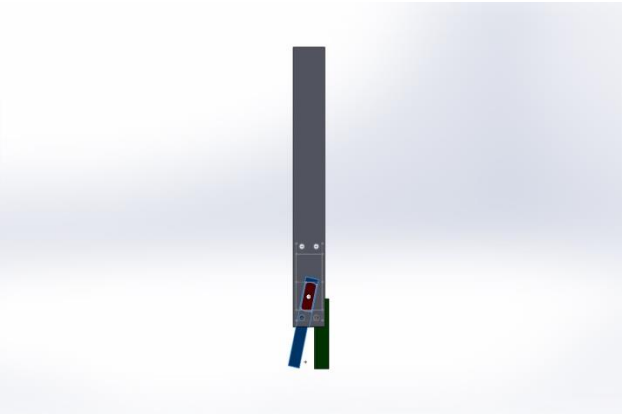
Answer: Front

The mechanism for picking and dropping the blocks in the rotating structure requires the need of

robotic arm. We are positioning the robotic arm at the front. Firebird V robot contains two wheels at the back and one castor wheel at the front on the chassis for supporting the robot. Thus placement of robotic arm on the front would be more appropriate as that would maintain the stability of the structure due to presence of castor wheel. If the arm had been placed at either of the other positions, then the stability of the robot might have affected and there might be a chance that robot topples due to unbalanced system and movement of the robot might hamper. Secondly, we need sharp sensors, mounted on the robot for detecting the presence of blocks (crates) in the arena. Since, these blocks have to be picked up by the robot and it would be easier to pick blocks when the robotic arm is at the same position as the sharp sensor. It is evident that as the bot traverses them arena, the blocks can appear on either side of the bot (left or right). So if left/right positioning is used, there would be some instances where we will have to rotate the bot accordingly. Similar is the case with back positioning of the arm. So to properly pick the objects we will have to impose some conditions every time, this will make the algorithm unnecessarily messy and would result in a bad code. As we know that before rotation we stop the firebird for 0.5 sec, then this process will consume more time during placing of the block as it will have to rotate twice to align back to the centre, which could have been achieved in one rotation by placing the arm at the front.

b) Explain the design of the mechanism and how it is mounted on the robot. (4)





The mechanism consists of a robotic arm placed on the firebird V robot in a way such that it picks the blocks from the front end of the bot with the help of gripper controlled by servo motor. The robotic arm consists of two servo motors, one for the upward and downward movement of arm and other for the movement of the gripper as shown in the image attached below. The arm has one degree of freedom. The gripper has two parts. One part is fixed while the other is actuated by servo to grip the blocks. The robotic arm is mounted on the firebird with the help of L Clamp or use strong adhesives (if the L Clamp mechanism fails) .The arm directly attached with firebird is fixed while the other (the one containing the gripper) is coupled with it which performs upward and downward motion with the help of servo motor. This is mechanism which

helps to pick and drop the blocks in the rotating structure.

c) To design the mechanism for picking and dropping the Blocks, what challenge/s do you expect to face and how you will overcome them?
(2)

1. Challenge: To make a Light weight robotic arm - This is one of the major challenges that we would be facing during the pick and place mechanism. Since the arm is placed on the firebird V externally and the weight has to be balanced by the surface of the firebird so the arm should be light in weight.

Solution: We would do this by making the arm either with acrylic sheet or plywood so that the weight would be less as compared to other materials available.

2. Challenge: Size and placement of the arm on the firebird - If the size is large then it may hit the placed blocks or the rotating structure while traversal. And if it is small then it will have difficulty in picking up the blocks.

Solution: To tackle this problem we will keep the arm at the front position of the bot and use sharp sensors to know its distance from the rotating structure. Hence we can keep the size as per our convenience.

3. Challenge: Mounting of the robotic arm on the Firebird - Mounting of the robotic arm on the firebird is a difficult task as the surface is made fibre and we only have 2 holes on it to attach the robotic arm.

Solution: To tackle this problem we would use an L clamp to attach the arm on it or would use strong adhesive for this purpose. We would also try to make a light weight arm so that it would not create any problem in mounting.

d) Choose the actuator/s you will use to design the mechanism.
(2)

1. DC-Motor 2. Servo Motor 3. Stepper Motor 4. Others
Answer: Servo Motor

The actuator that we prefer to use to design the mechanism is servo motor as it has following advantages:

1. The difference between servo and stepper is a trade-off between complexity and certainty in control. With position feedback on a servo one can tune performance much more aggressively and since one knows if it fails to reach its target position or velocity then ones servo loop will get to find out about it and correct it. With a stepper one has to

tune the system so that it can guarantee that it can always make the step, irrespective of the desired speed of move or weight of the payload.

2. Stepper systems operating in a constant current mode creates a significant amount of heat in both the motor and drive, which is a consideration for some applications. Servo control solves this by only supplying the motor current required to move or hold the load. It can also provide a peak torque that is several times higher than the maximum continuous motor torque for acceleration.

3. Being battery operated device power consumption is an important aspect. Using servo one can achieve the same goals at low power usage.

4. Stepper motors operate at full torque while the advantage of a servo motor is the ability to control torque in an application.

Disadvantages of dc and stepper motor are:-

1. When one supply power to a DC motor it will start spinning until that power is removed. The position and the angle of turn can't be controlled easily when compared to servo. And control over position is must in the robotic arm hence DC motor can't be used.

2. Stepper motors operate at full torque. They lack the ability to control the torque.

3. Stepper motor consumes more power and produced more heat hence not suitable.

Environment Sensing

Q6. Explain how you will use the following to decide the course of action.
1. Sensors
2. Placement Sequence and
3. Structure Sequence **(5)**

We have various sensors like Sharp sensor, Xbee module, a White line sensor, Buzzer which we would be using to decide the course of action along with the help of Placement Sequence and Structural Sequence.

1) Sensors

- The Sharp sensor placed in front of the Firebird V will give us the distance of an object near it, allowing us to sense the blocks and the rotating structure and function the bot accordingly if required.
- XBee Modules are used to communicate between the Firebird and rotating structure as well as Firebird and blender to synchronize the motion of the Firebird with that in the blender game.

- White line sensor helps the bot to follow a black line accurately.
- The buzzer is used to depict the end of the task.

2) As the placement sequence defines the position of blocks on pick up points, knowing it initially will help us to decide which pickup points should be visited first and which ones should be visited at the end. This will help in planning the motion and shorten the path effectively to complete the task at least possible time. Placement Sequence also provides information regarding the colour of blocks in arena and the type of crates in blender, this information is very useful while placing the blocks in the desired section of the rotating structure/truck, because according to the type of block/crate the information is fed to the rotating structure to rotate accordingly.

3) The blocks can be placed on the structure via many points (5 in total) in the arena. So the bot can place the block in the structure through the deposition point nearest to it, traversing the minimum possible distance. The structure is rotated through a specific angle such that afterward the block is placed in its corresponding section only. This fixed rotation is only possible if the rotating structure sequence is known to us. Otherwise, we would not be able to configure the right section for the block. This sequence also plans the path of the bot in the blender interface while it places different crates in the different sections of the truck.

Q7. Name the sensors (if any) on Firebird V used to complete the task. If used, describe the placement of these sensors on the robot and briefly explain the reason for their placement. If not, justify not using these sensors. (2)

The sensors on Firebird V that we use to complete the task are as follows:-

1. White Line Sensors: These sensors are used to detect the black lines on the flex sheet for the traversal of the bot. There are 3 white line sensor module soldered on the main board at the bottom of the bot.

2. Sharp GP2Y0A02YK IR range sensor: These sensors are used for accurate distance measurement. We use these sensors to detect the presence of blocks and for maintaining a proper distance from blocks for picking mechanism. There are 5 sharp sensors in Firebird V platform mounted in front side of the robot.

3. Position Encoder: Position encoder gives position/velocity feedback to the robot. The position encoder that we use in Firebird V is the optical encoder. It is used to control the robot's position and velocity. We use position encoder to move the robot in desired position accurately. The placement of position encoder is near to the DC geared motor.

The sensors on Firebird V that we didn't use are as follows:

1. IR proximity sensor: These sensors are used to detect an obstacle in a short range. We doesn't use IR proximity sensor as these sensors work for only short range and there placement is such that they encircles the robot but need sensor just only in the front with wider range.

2. TSOP: TSOP is a member of IR remote control series. We didn't use this sensor as TSOP sensor works with IR remote but as per our theme we need to make an autonomous robot.

Communication

Q8. Explain the synchronization between Firebird V, Rotating Structure and Blender Interface.
(8)

The Firebird V, Rotating Structure and Blender Interface are synchronized as mentioned in the steps below:

Step 1: Initially the Placement sequence and Structural sequence are entered into the codes before the start of the game. We would be referring Firebird V robot as Robot1 and the blender robot as Robot2 just for this answer.

Step 2: Now the robot starts from the Start position with the castor wheel positioned on the black line and robot facing the depletion zone. At this time the robot communicates the information (through Xbee modules) to blender interface to start the robot communication : One Xbee module is connected on the firebird , other on rotating structure and third to the laptop .This third Xbee module conveys the information received to the blender interface.

Step 3: Robot1 starts moving according to the algorithm mentioned in Ans. 11. Whenever the robot1 moves or changes it direction it communicates the same to robot2 through Xbee module and blender interface so that both move in a synchronized manner.

Step 4: When the robot1 reaches the junction, in front of the block it has to pick. It turns such that the castor wheel faces the block and stops in that position. Now it sends data to the arm for picking the blocks which is controlled by servo motors and it also sends command to robot2 to pick up the crates in blender interface.

Step 5: Robot1 picks up the block by setting the angle rotated by servo motor. Now it communicates this information to the rotating structure to turn accordingly and also communicates the robot2 to start moving towards the truck to deposit the crates.

Step 6: Now the robot1 reaches the rotating structure. It places the block in the designated section of the rotating structure with the help of the gripper placed on the robotic arm which is mounted on Firebird V.

Step 7: Robot1 communicates the same to robot2 to place the crate at appropriate section of the truck.

Step 8: Similarly robot1 traverses the arena and places the blocks at appropriate section of rotating structure, simultaneously communicates it to robot2 through blender interface and controls the rotating structure.

Step 9: When the last block is deposited in the rotating structure, robot1 stops at that position and communicates deposition complete information of final block to the blender interface.

Step 10: Robot1 sounds a continuous buzzer to indicate the end of the task.

Step 11: In blender interface the robot2 deposits the last crate in the truck and the truck moves from farm to the market.

Hence the task is completed and this way the Firebird V, Rotating Structure and Blender Interface are synchronized.

Testing your knowledge (theme analysis and rulebook-related)

Q9. Attach the Final Blender Interface Image.
(8)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11
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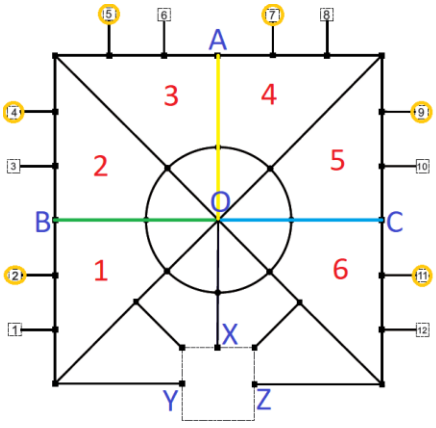
8

Q10. Provide the video of Rotating Structure. **(7)**

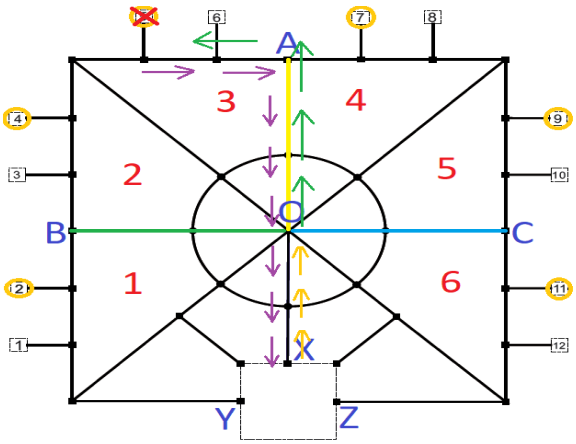
YouTube Link: https://youtu.be/Dyx13RvtWdQ

Q11. Explain in brief the algorithm you will use for navigation of the arena. (08)



The 12 pick-up points are divided into 6 zones, with 2 pickup points in each zone. The robot uses line sensors combined with encoders to calculate exact distances. After reaching the Nodes A, B, C, following the coloured lines, the bot decides to turn left or right according to the pickup point it is destined to.

The bot traverses from the centre to a zone, reaches the pickup points measuring distance from the encoders, picks the crate and retraces itself back to the centre. It then places

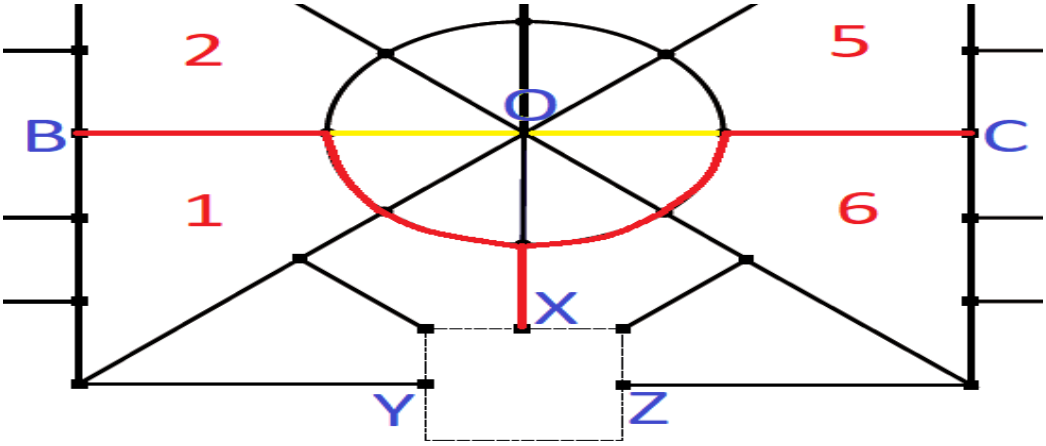


The green arrows show the way to the pickup point.
Red Cross indicates that the block has been picked.
Violet arrows show the way to deposition point.
Orange arrows show the way back to center.

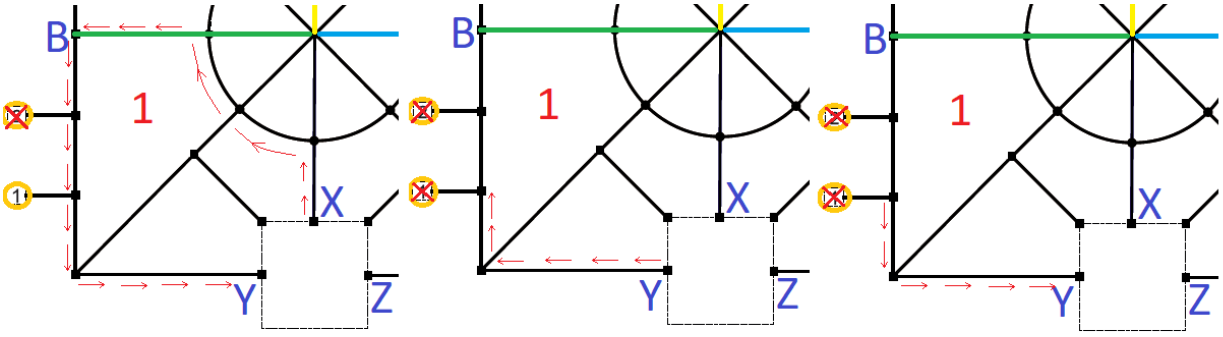
the block in the deposition Nodes(X, Y, or Z) and returns to the centre if it has to.

It is evident that clearing the top zones first and then the bottom ones will consume less time, less distance in comparison to picking up the blocks number-wise.

So the robot firstly clears Zone 3 and then Zone 4 depositing the blocks at Node X and then clears Zone2 and Zone 5 and stays at Node X.

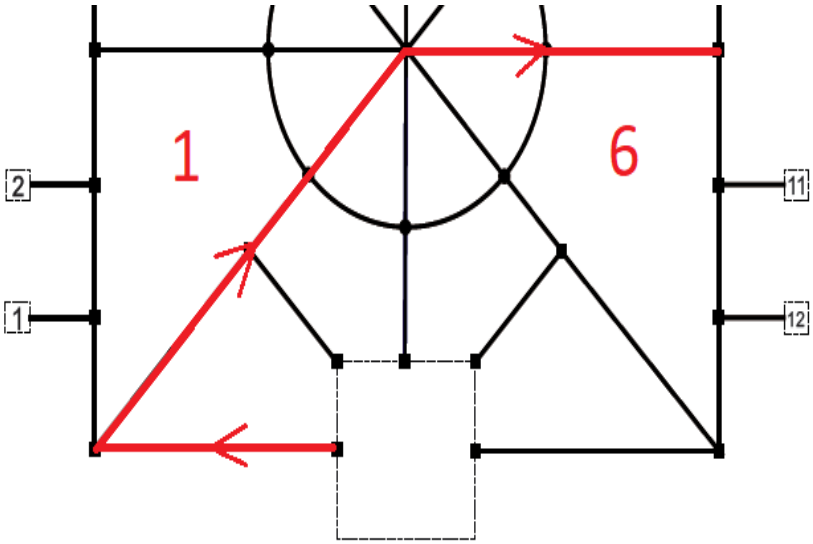


The red line being shorter than the yellow line is preferred to travel to zones 2,5,1,6.



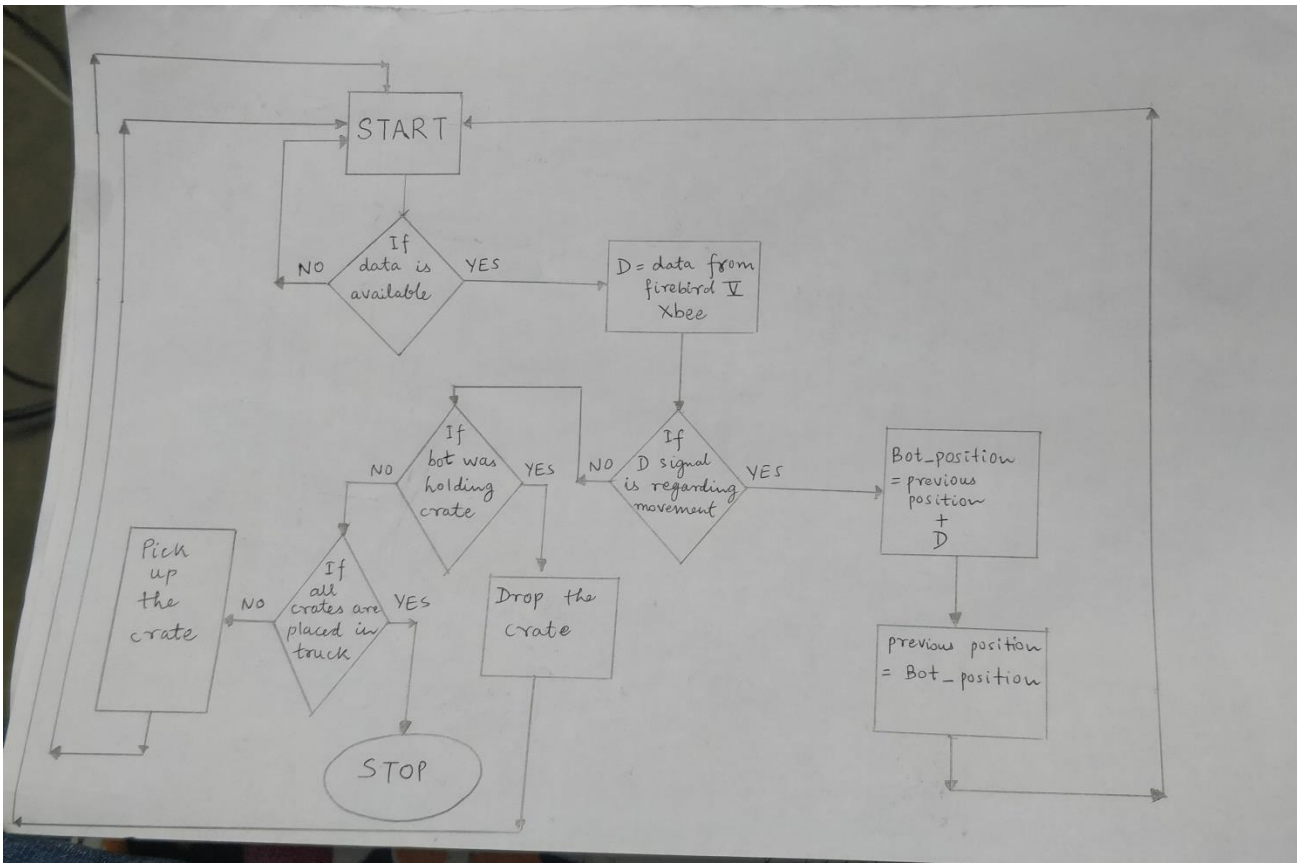
It then clears Zone 1, which only for this illustration is assumed to contain both the blocks, in the following manner depositing the blocks at Node Y.

If this had been the last Zone, the bot beeps the buzzer, if not the robot traverses to Zone 6 and completes the task in the same manner as described for Zone 1, with deposition at Node Z.

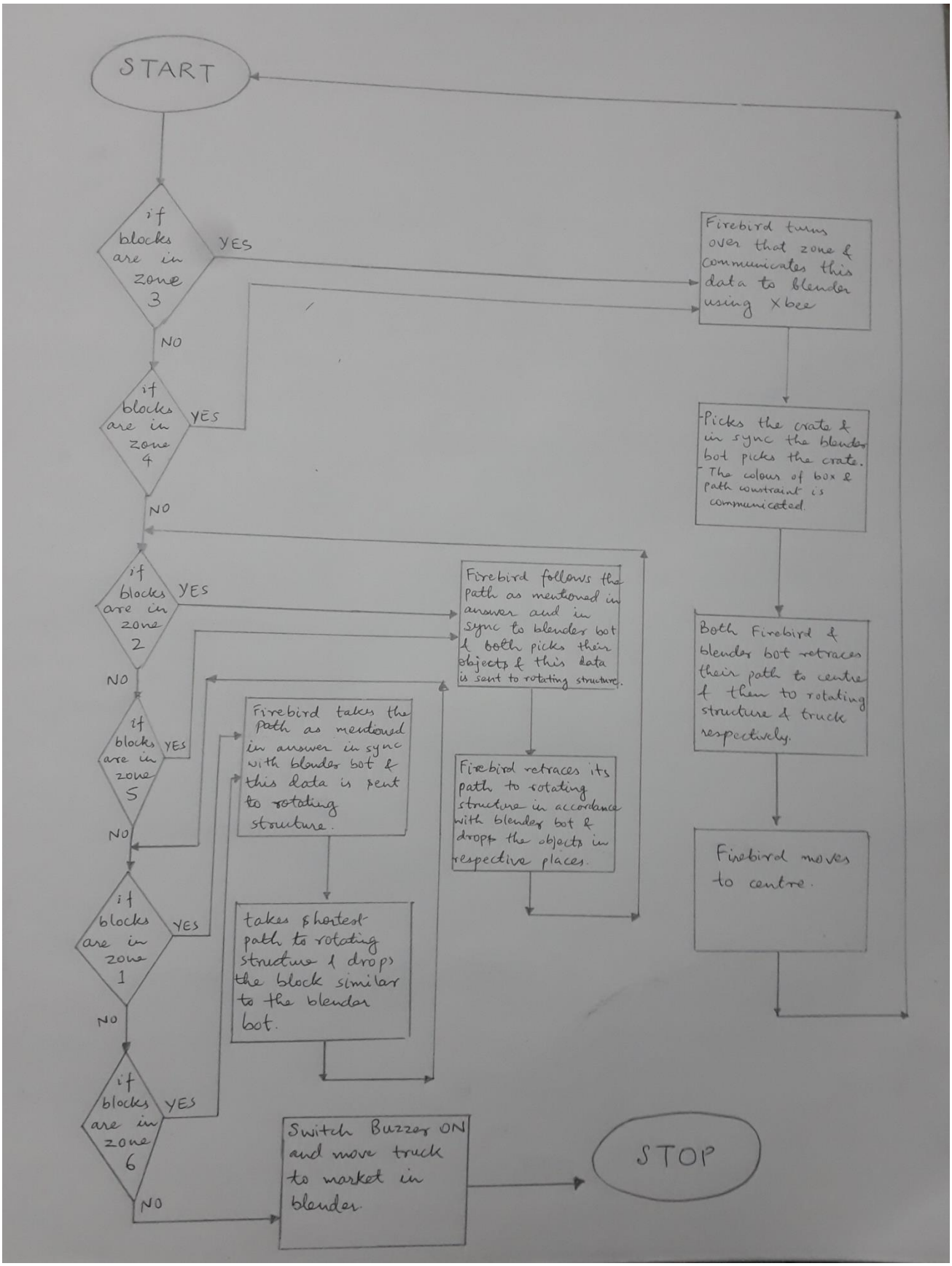


Algorithm Analysis

Q12. Draw a flowchart illustrating the algorithm you propose to use for Blender. (Include the action undertaken in blender like how robot picks the Crate, drops it in Truck using the information received from Firebird V)
(5)



Q13. Draw a flowchart illustrating the algorithm you propose to use for theme implementation.
(5)


START
if blocks are in zone 3
YES
NO
Firebird turns over that zone & communicates this data to blender using Xbee
if blocks are in zone 4
YES
NO
Picks the crate & in sync the blender bot picks the crate. The colours of box & path constraint is communicated.
if blocks are in zone 2
YES
NO
Firebird follows the path as mentioned in answer and in sync to blender bot & both picks their objects & this data is sent to rotating structure.
Both Firebird & blender bot retraces their path to centre & then to rotating structure & truck respectively.
if blocks are in zone 5
YES
NO
Firebird takes the path as mentioned in answer in sync with blender bot & this data is sent to rotating structure.
Firebird retraces its path to rotating structure in accordance with blender bot & drops the objects in respective places.
Firebird moves to centre.
if blocks are in zone 1
YES
NO
takes shortest path to rotating structure & drops the block similar to the blender bot.
if blocks are in zone 6
YES
NO
Switch Buzzer ON and move truck to market in blender
STOP

Challenges

Q14. What are the major challenges that you can anticipate in addressing this theme and how do you propose to tackle them?

(5)

1. Design of robotic arm - This is a major challenge we would be facing as we ourselves have to design the robotic arm and place it on the firebird. The arm should be light in weight and a bit long in size so that it can perform the picking and placing task easily.

   Solution - To tackle this problem we would be making the robotic arm either of acrylic sheet or thin plywood. We would be placing the arm at the front portion of the firebird to avoid other problems.

2. Synchronization between firebird V and blender interface - To synchronize both the firebird and the blender interface is a major challenge because we need to execute what's happening in real time in the blender interface.

   Solution - With the help of blender python we would communicate the data received from firebird to the robot in blender interface to pick the crates and deposit them in the appropriate section of the truck.

3. Traversal Time - We need to reduce the time of traversal as the bot needs to stop before making turns and the motion of the firebird and the robot in blender interface should be synchronized.

   Solution - We have designed such an algorithm (refer Ans. 11)which would traverse the arena taking path which would not only take the shortest path but also reduce the number of turns which is a time consuming task.

4. To place the blocks in the designated section of the rotating structure - Since we don't have any colour sensor to identify the blocks colour and place them in their designated section of the rotating structure so it becomes a bit lengthy and complicated process.

   Solution - We would be given the placement sequence and the structural sequence which we would use not only to traverse and communicate easily but also to identify the blocks colour and place it in the designated section in the rotating structure.

5. Size of the flex sheet - The flex sheet is larger in size than one side of our room due to which we can't work in our room and there is no other place where we can do it.

   Solution - We have to work in open veranda in our hostel during nights as we have lectures and labs during daytime. The temperature during the night in this area is below 10 degree Celsius.