e-Yantra Robotics Competition - 2014

Implementation Analysis – Waste Segregating Robot

e-YRC#1044-WS

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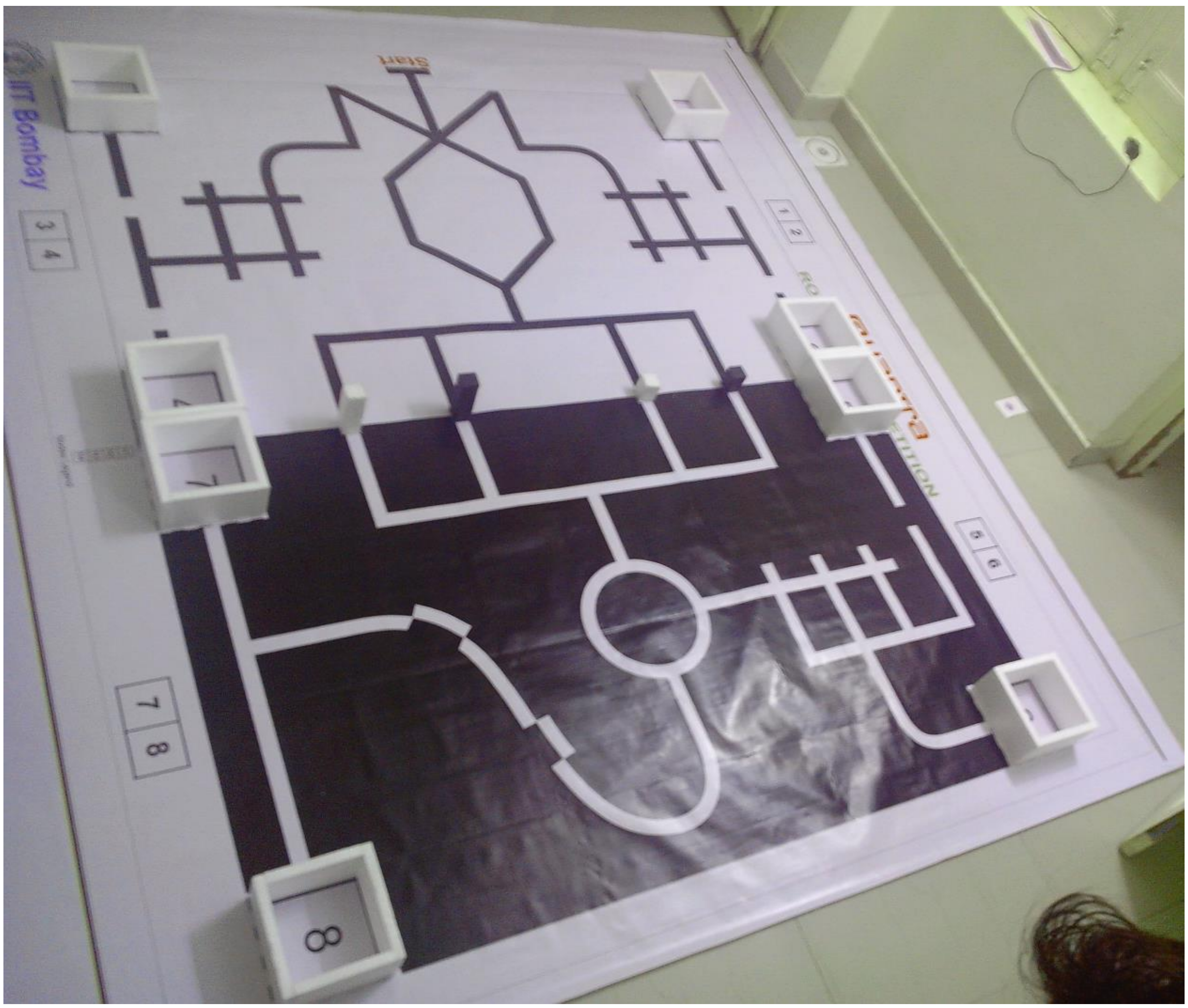
Preparing the Arena (5)



Design Analysis

Q-1. How will you detect the different size of blocks? (10)

The sensors we will use to detect the different blocks are

1. Two Sharp IR range sensor
2. One IR Proximity sensor

In our theme we have four different type of blocks to detect. Two blocks having the height of 6 cm, one white and the other of black color while the other two of 12 cm height, one white and the other black in color.

To detect the different type of blocks we will use two Sharp IR range sensors, out of which one is already mounted on the fire bird V robot and we will place the other one near the caster wheel. Here the height of the first sensor is above 6cm from ground and the height of the second sensor near the caster wheel is approximately 2 to 3cm from ground.

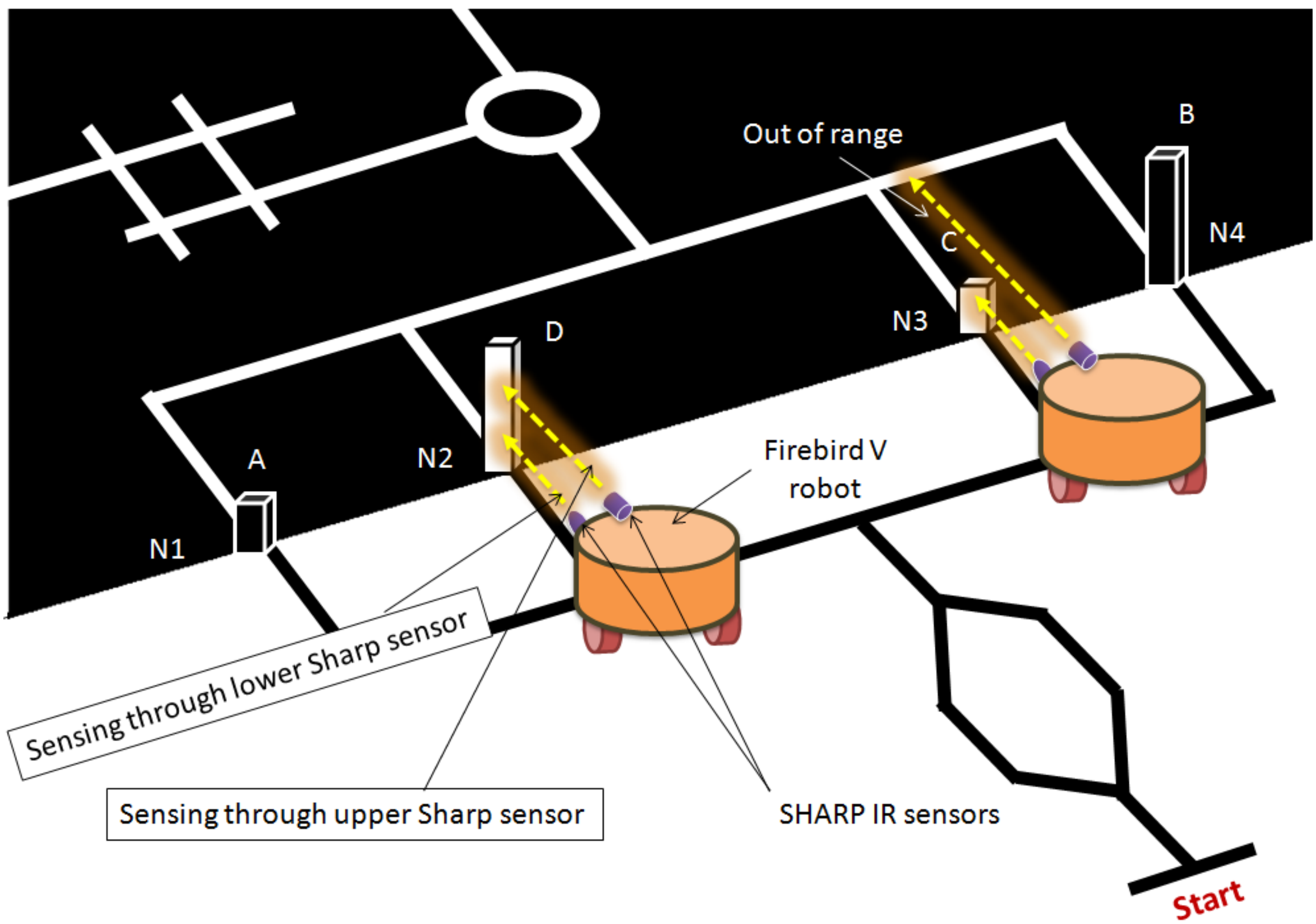


Figure 1 : Finding Block in Waste disposal zone

Detection of the blocks using the sensors can be explained as below:

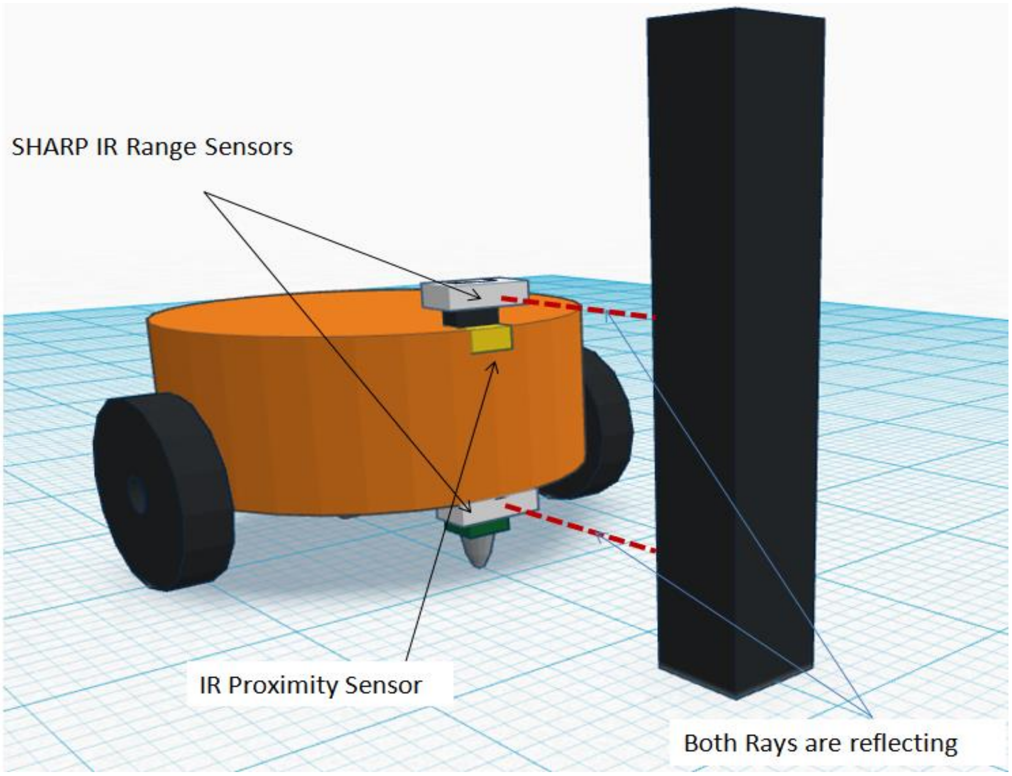


Figure 2 : Detection of block of 12cm

When a block of height 12 cm comes in front of the sensor arrangement, the rays emitted from both the sensors will be reflected back as the block obstructs their path and these reflected rays will be detected by the sensors giving a specific input to the microcontroller.

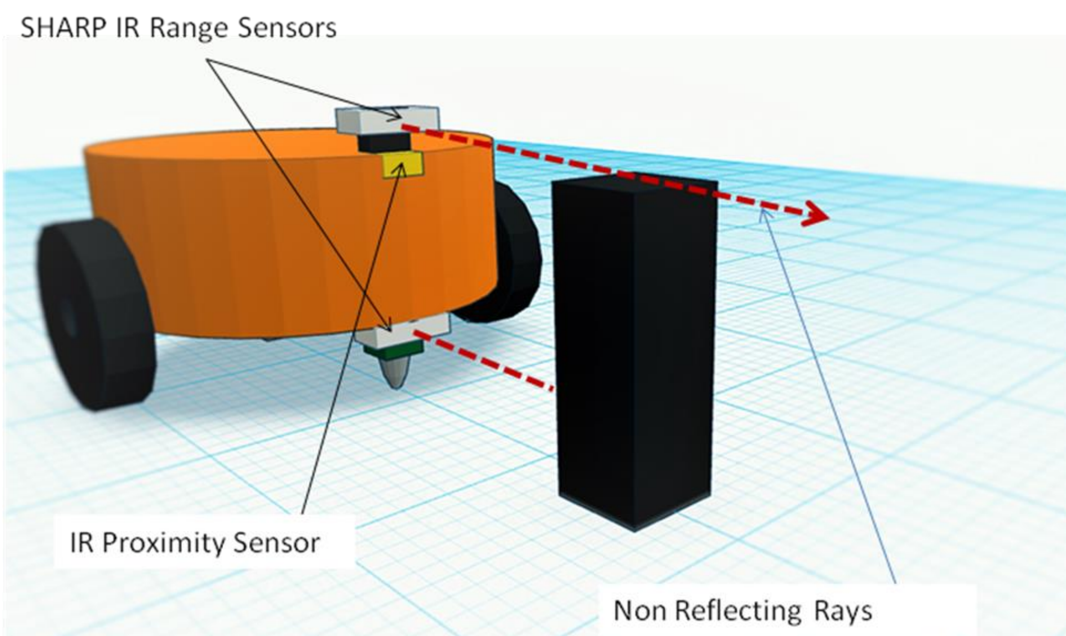


Figure 3 : Detection of block of 6cm height

while in the case when a block of 6 cm comes in front of it, the rays emitted from the lower sensor attached near the caster wheel will be reflected back and detected by it, but the rays emitted from the upper sensor won't be reflected back and passes without any obstruction as it is located somewhat above 6 cm from the ground level. And hence this sensor will give a different output as compared to the other one resulting in a difference and hence detecting the smaller block.

Working of sensors

1. SHARP IR Range sensors

Sharp IR sensors use Infra-Red light to detect the objects with precise distance. They have one IR LED, which is source of the IR light. For detection of reflected light from the object, it uses linear CCD array. CCD stands for Charged Coupled Device, whenever Light falls on the CCD, charge is stored on the capacitor of single CCD and it is shifted in the array.
Sharp Sensors use 1 dimensional CCD array. The charge stored on the capacitor is proportional to the intensity of the light. Thus using charge distribution on the entire CCD array, estimation about the direction of the light incident on the CCD array can be made. In the following figure, we can see that whenever the direction of reflected light and direction of incident light makes larger angle, we get higher charge on right side of CCD array. Now, as shown in the Figure 4, we can find the distance of the object from the sensor using the angle described above. If the angle is smaller, object is away from the sensor and if the angle is larger, the object is closer to the sensor. Note that the angles shown in the figure are not to scale. It is just shown for the purpose of understanding.

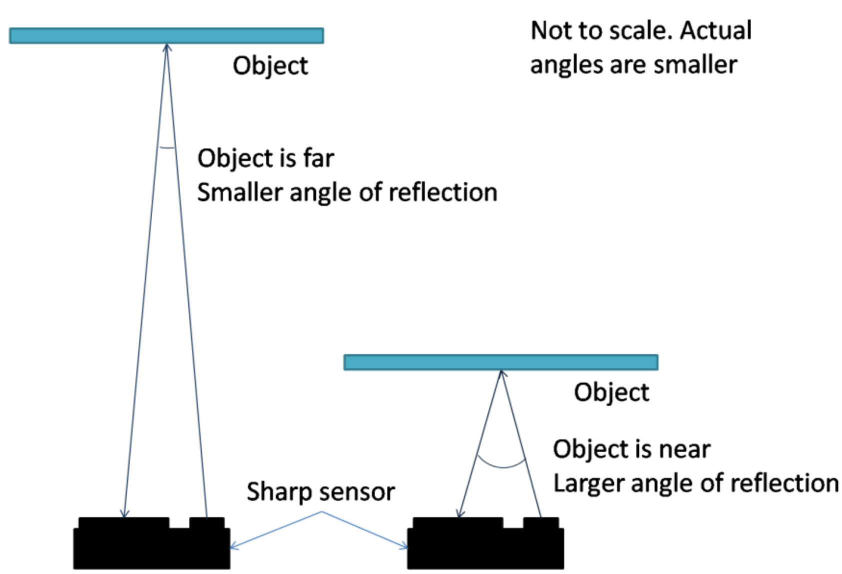


Figure 4 : Working of Sharp Range Sensor

Depending on the position of the charge distribution of the CCD array, the controller generates an analog output which is related to the distance by the formula,

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Distance in mm = 10.00 * ( 2799.6 * ( 1.00 / ( pow( adc_reading , 1.1546 ) ) ) )
                    Where adc_reading = (voltage / 5) * 1024
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2. IR Proximity sensors

IR proximity sensors are used to detect proximity of any obstacles in the short range. IR proximity sensors have about 10cm sensing range. These sensors sense the presence of the obstacles in the blind spot region of the Sharp IR range sensors. In the absence of the obstacle there is no reflected light and hence no leakage current will flow through the photo diode and output voltage of the photo diode will be around 3.3V. As obstacle comes closer, more light gets reflected and falls on the photo diode and leakage current flowing through the photo diode starts to increase which causes voltage across the diode to fall.

Q-2. Draw a labeled diagram to explain how you have planned to place the sensors on/around the robot? (10)

We need different type of sensors for detecting the size and color of different blocks in our theme. For detecting the size we will use the Sharp IR range sensors and for color detection we will use an IR proximity sensor.

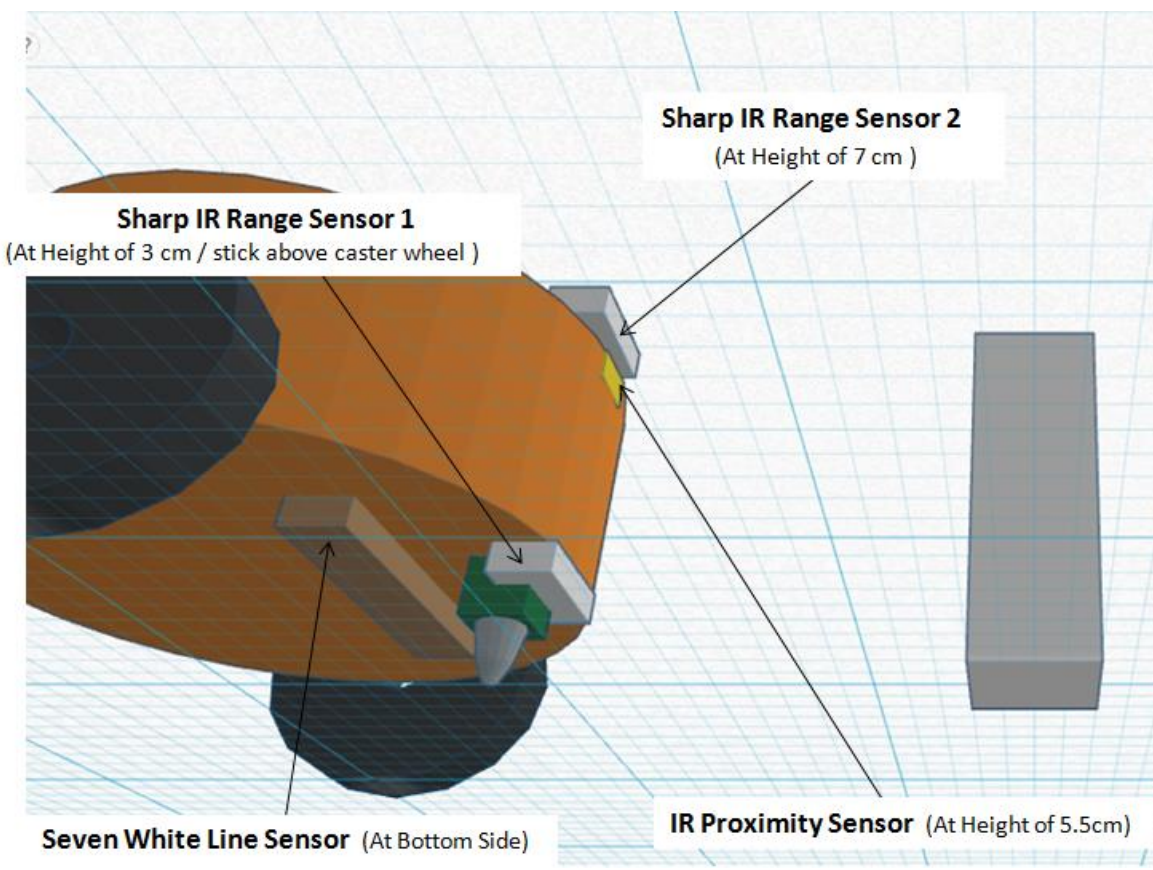

Figure 5 : Arrangement of different sensors

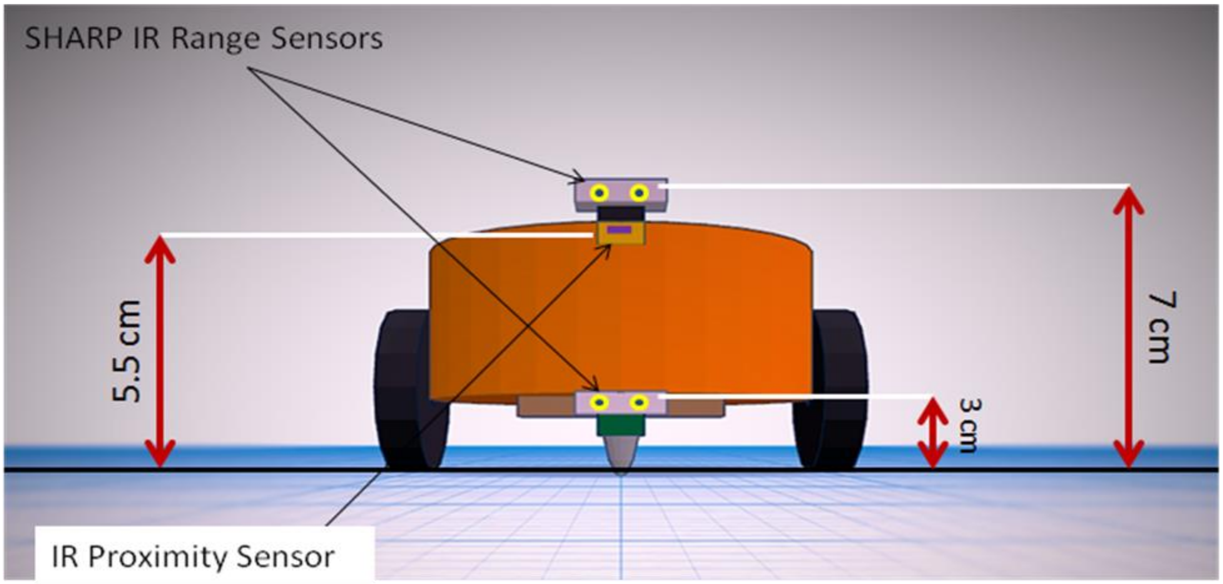

Figure 6 : Position of Sharp range & IR Proximity sensor

As the robot comes across only one block at a time and as all the blocks are located separately and are having the same orientation we will use the IR proximity sensor connected at port no.3, one Sharp IR range sensor is already mounted at font side is connected to port no.3 and we will attach an extra Sharp IR range sensor near the caster wheel exactly below the previous sharp sensor connected to port no.2. So in all for the block detecting mechanism we will use 3 sensors as described in the above figure.

Q-3. Teams have to make the robotic arm for picking up/placing the blocks in the arena.

a) Choose an option you would like to use to position the robotic arm on the robot and why? (5)

1. Front 2. Back 3. Right/Left 4. On both sides

Answer: 4. On both sides (Front and Back)

In our theme we have to sense one block at a time and then pick it up and drop it in the desired drop box. Here if we pick and place the blocks one by one the path to be traversed by the robot increases and simultaneously the time taken for the completion of the task also increases so we have used two arms. By using two arms we will pick two blocks in one run and place them in the desired drop boxes which are adjacent to each other as per the given possibilities of the sequences, and hence we can reduce the distance to be traversed and hence the time by one half.

We prefer to position the first arm at the front side because the sensors we have used to detect the block are located at the front side. So the robot can directly pick the desired block after sensing or detecting it from the front side. Here if we place the arm at left or right side then we will have to rotate the robot by 90 degrees either to left or to the right side as per the position of the arm to pick the desired block after detecting it.

After picking one block by the front arm the robot will move further to detect the second desired block as per the sequence. After sensing this block it will rotate by 180 degrees and pick the second block with the help of the back arm.

Here to move the front and the back arm we are using a single servo motor geared with both the arms, hence reducing the load on the robot and fulfilling the power management requirement.

b) Draw a diagram to show the robotic arm and how it is mounted on the robot. Also show the mounting of the sensor. (10)

- In the below figure we can see that there are two arms mounted on the robot, one at the front and the other at the back side. These arms are geared with a single servo motor.

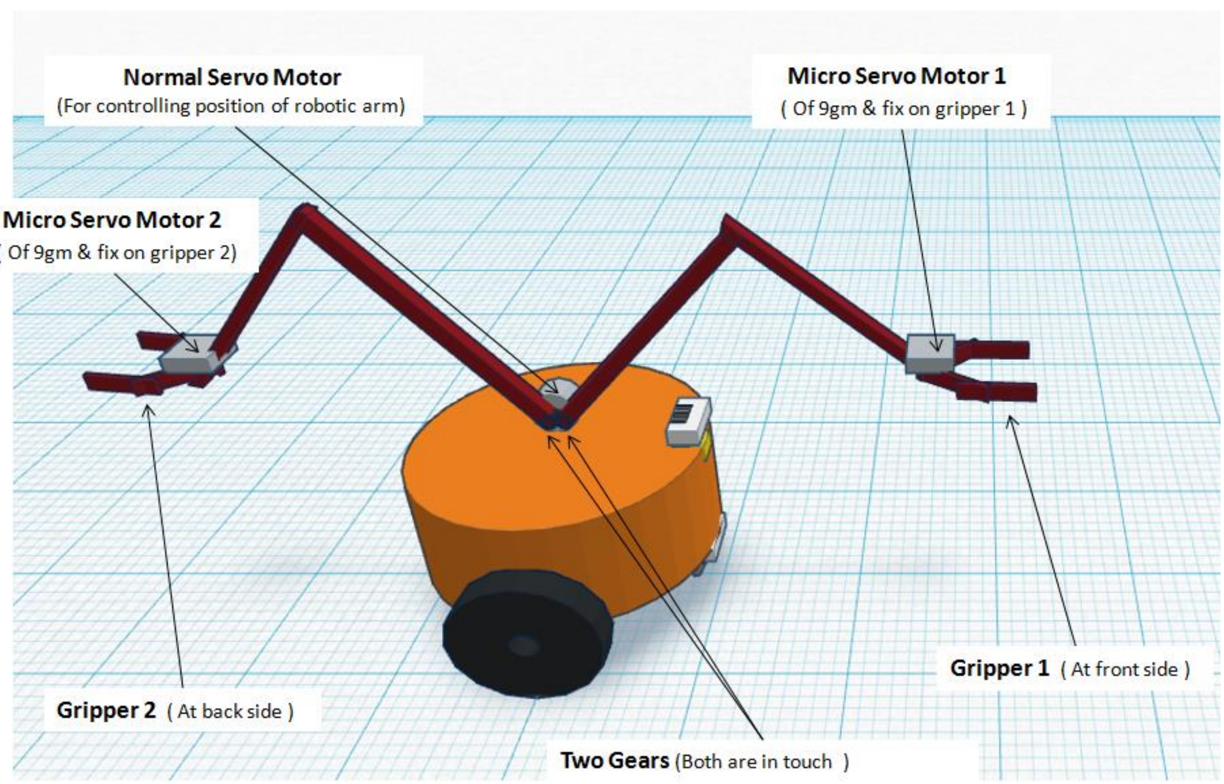

Figure 7 : Mounting of the robotic arm

- This figure describes the arrangement of different sensors and the gripper assembly attached with the robotic arm.

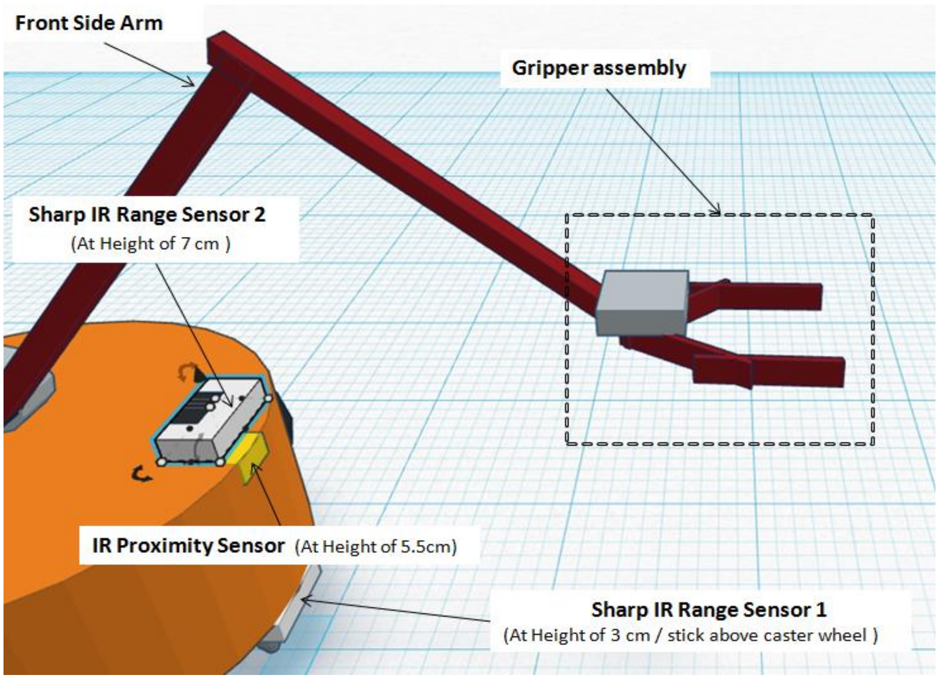

Figure 8 : Arrangement of sensors and the gripper

- The figure shows the top view of the robotic arm assembly mounted on the robot and how it will pick the block using the gripper.

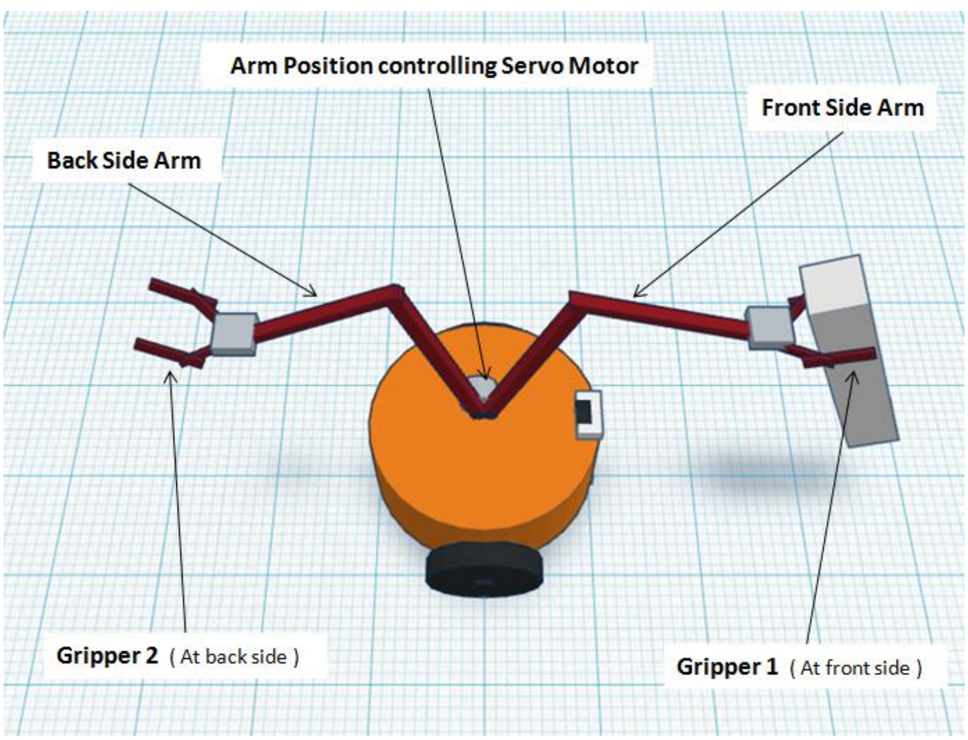

Figure 9 : Top view of whole assembly

Q-4. Choose the actuator you will use to design the robotic arm. (5)

1. **DC-Motor** 2. **Servo Motor** 3. **Stepper Motor** 4. **Others**

Answer: _________________

Justify your answer by stating the advantage of the chosen actuator over others. Also give reasons for not using other actuators.

Servo Motor: A servo motor gives precise closed-loop control over the angle of rotation which is needed by this application.

- The servo controlling the arms should be precise to provide an accurate angle to the arms to lift the block by desired amount.
- The other servo, which opens or closes the jaws of the gripper, also needs to be precise so as to have the correct amount of grip on the block.
- Also the servo motors are available in different size and weight so we can choose as per our requirement.

The reasons for not choosing the other actuators are :

1. A DC-Motor has continuous rotation and virtually no control over its angle of rotation, which renders it unsuitable for this application.
2. A Stepper motor is a close candidate to a servo motor due to its precise angle control, but since it is heavier than a servo, it becomes less preferable.
3. Other actuators, let's say a push-pull solenoid for opening/closing the jaws, is cumbersome and does not offer precise gripping control.

Q-5. How will you identify black and white color? Which sensor will you use? What are the threshold values for detecting black and white color? (15)

We have to detect four different type of blocks in our theme. We can detect the size of the blocks using the Sharp IR range sensors, but we have to differentiate between them by color, for this we will use an IR Proximity sensor.

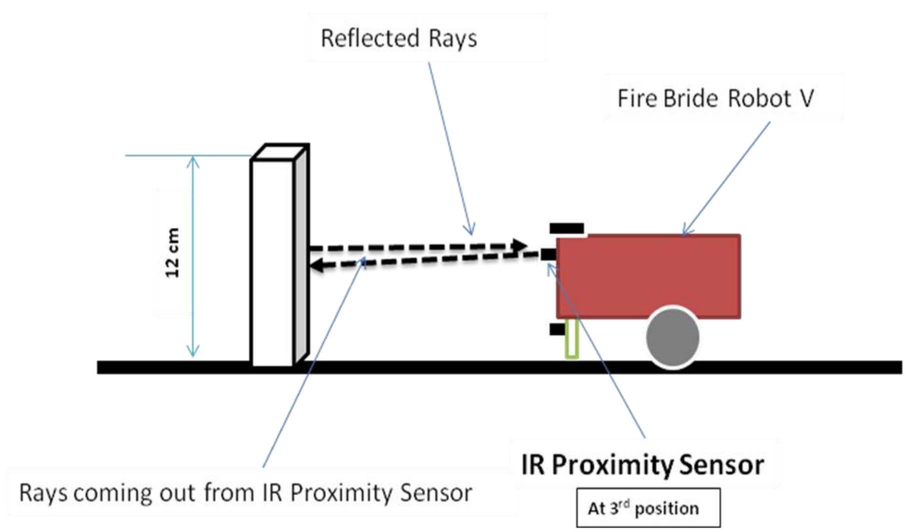

Figure 10 : Detection of White block

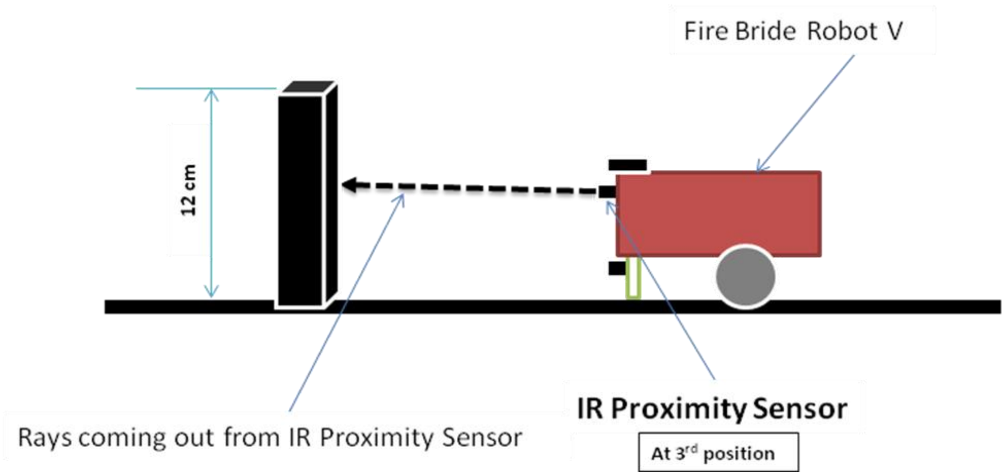

Figure 11 : Detection of Black block

At the front side of the FIRE BIRD V robot there is an IR Proximity sensor already mounted. This sensor has a range of 0 - 10 cm. It consists of an assembly of two components out of which, one emits IR rays which get reflected if there is any white colored obstacle present in range and are detected by receiver.

Now if the block to be detected is white in color, then it will reflect most of the IR rays emitted by the IR Proximity sensor and the intensity of the reflected rays detected by the sensor is more while on the other hand if the block to be detected is black in color then most of the IR rays will be absorbed by the block and the intensity of the reflected rays detected by the sensor will be very low. Using this phenomenon we can differentiate between two colors of the block.

The threshold values for detecting black and white color depends upon the distance of the obstacle from the sensor. The threshold values at different distances are as shown in the table. From table we can say that it is better to take reading of IR proximity sensor as near as possible from the block.

Distance (in mm from robot)	**Threshold Values**	
	White Block	**Black Block**
30	11	148
50	90	156
100	140	160

Table 1: Threshold values of Black and White

Q-6. **(15)**

a. What algorithm will you use to navigate the robot between the white and black parts of the arena?

The arena of our theme is divided into two parts. The first part is having white background with black line in it while the second part is having black background with white line to follow.

After dropping block A and B in to their respective deposition boxes, the robot will move back to the disposal zone and will detect block C and after picking this block it will move further to detect block D. Here comes the crucial point where the robot has to traverse from white part to the black part after picking block D. So after detecting the block D the robot will move towards it and pick it up but it cannot traverse the node by using simple line follower to reach the deposition boxes located in the other part of the arena because there are letters printed black on a grey texture in the node square of side 4cm where the white line sensors cannot give an appropriate output.

So to solve this problem we have used position encoders over here. By using position encoders we will move the robot 9cm forward partly following line follower after picking block D. Now the robot is in the second part of the arena having black background and white colored path to follow. Here onwards the robot will use simple white line follower to traverse the path and deposit the C and D blocks in the respective deposition boxes.

b. Upload a video showing identification of type of waste.

NOTE : Link of the video is http://www.youtube.com/watch?v=zWA4ybRAUWs

Algorithm Analysis

Q-1 Draw a flowchart illustrating the algorithm used to complete the entire task. (50)

1. **Main Strategy :** This flowchart module is on the top level of abstraction . Each of its processes will be expanded into its own flowchart.

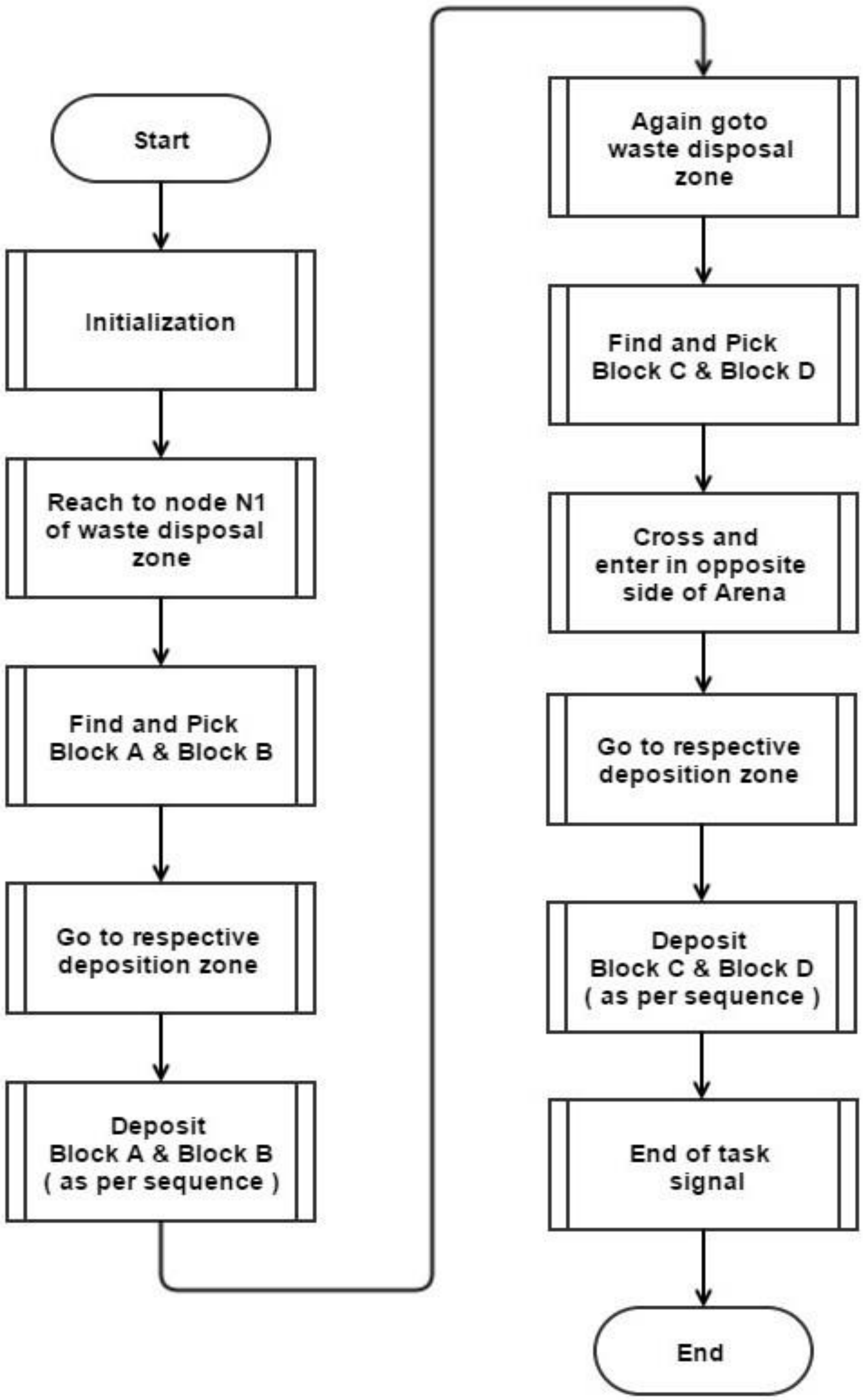

Fig.1 Main Strategy

Note : Here we use Subroutine Shape  to represent a large process and its sequence of action described in more detail on separate flowchart.

2. **Initialization :** This module initializes all the units to make them ready for task.

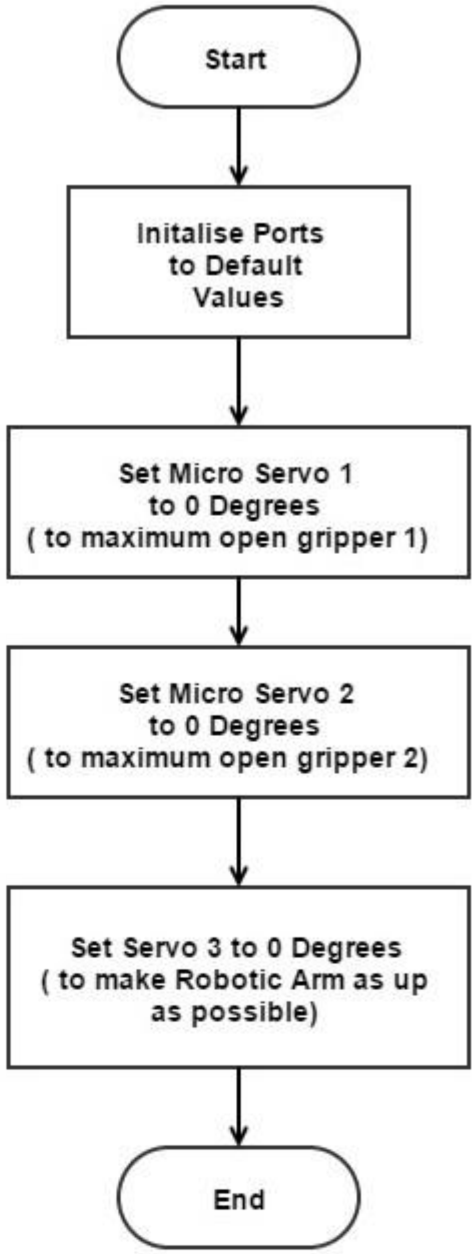

Fig.2 Initialization

3. **Reach to node N1 of Waste Disposal zone :** This subroutine describe how robot will reach to Node N1 of waste disposal zone from starting point.

Fig.3 Traverse to node N1

3. a) Black Line following : This subroutine describe how robot will move forward on a straight black line without getting distracted from its path.

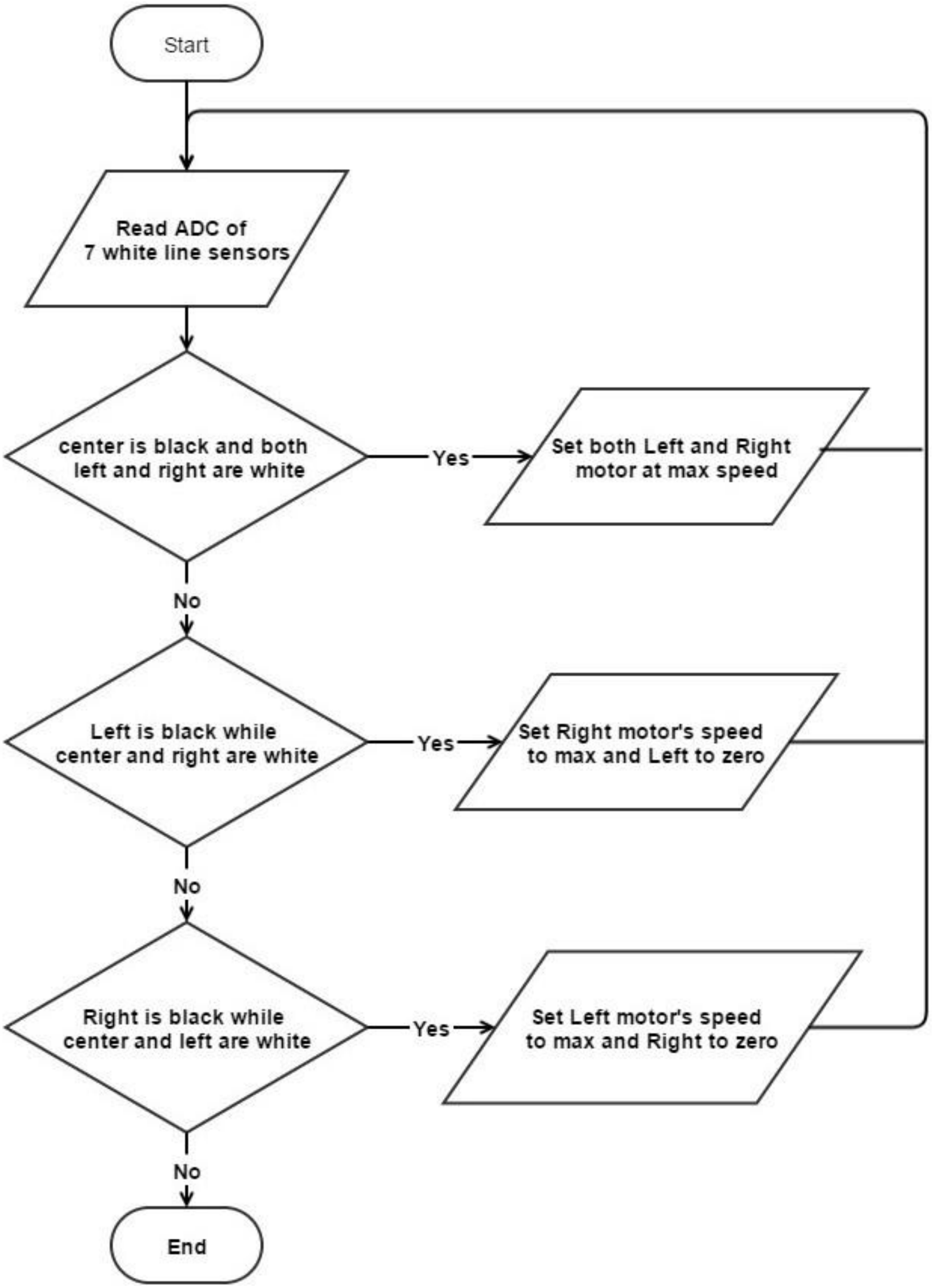

Fig.3(a) Black Line following

4. **Find and Pick Block A & B :** This sub-routine describes the process of picking blocks A & B after detecting them. If in between, block C or D is encountered then the robot will store the value of their position. Here sensing block is sub-routine of this flowchart which is described below.

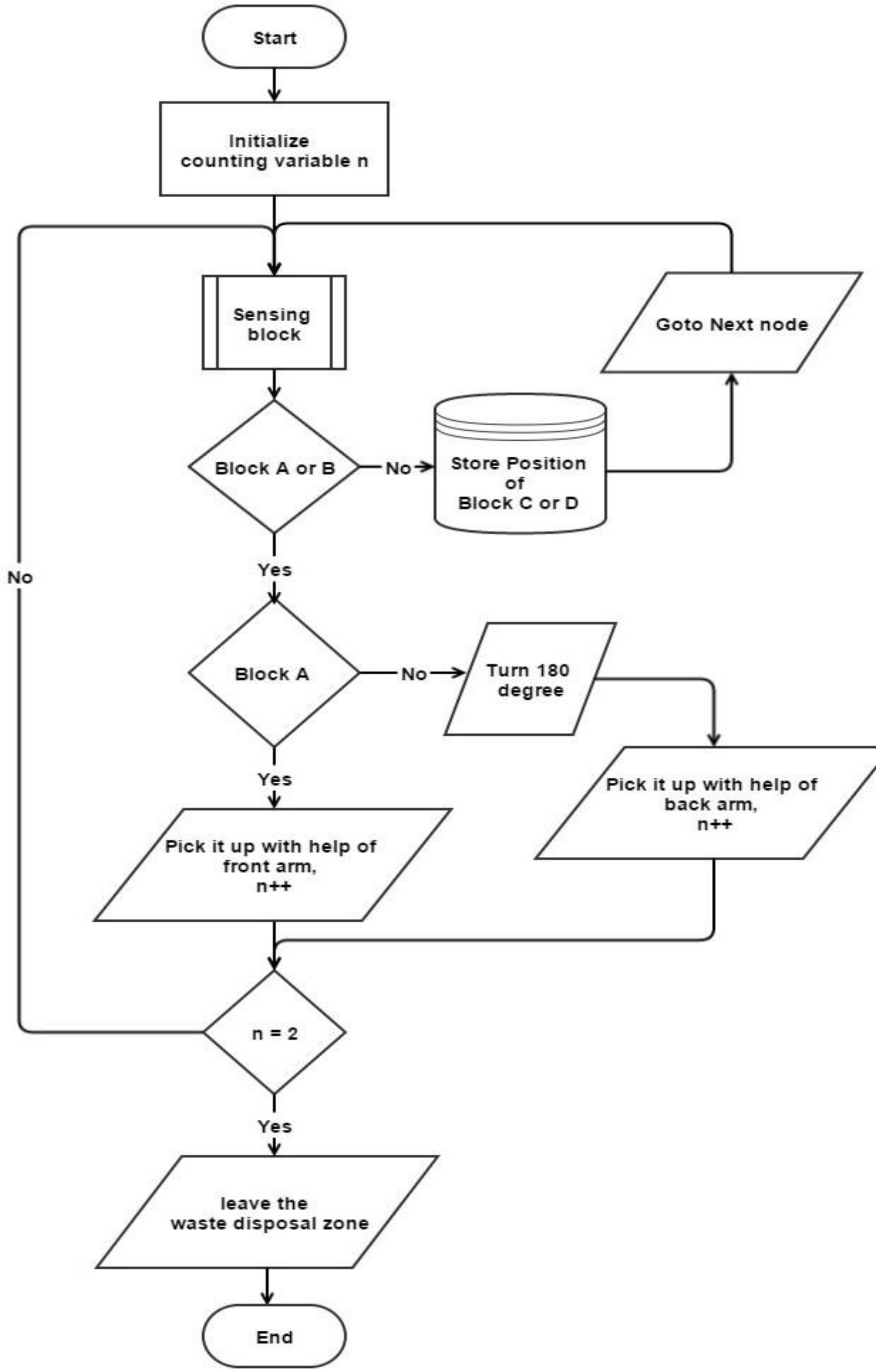

Fig.4 Pick block A & B

4. a) Sensing Block : This subroutine describes how the robot will detect different blocks on the basis of their size and color.

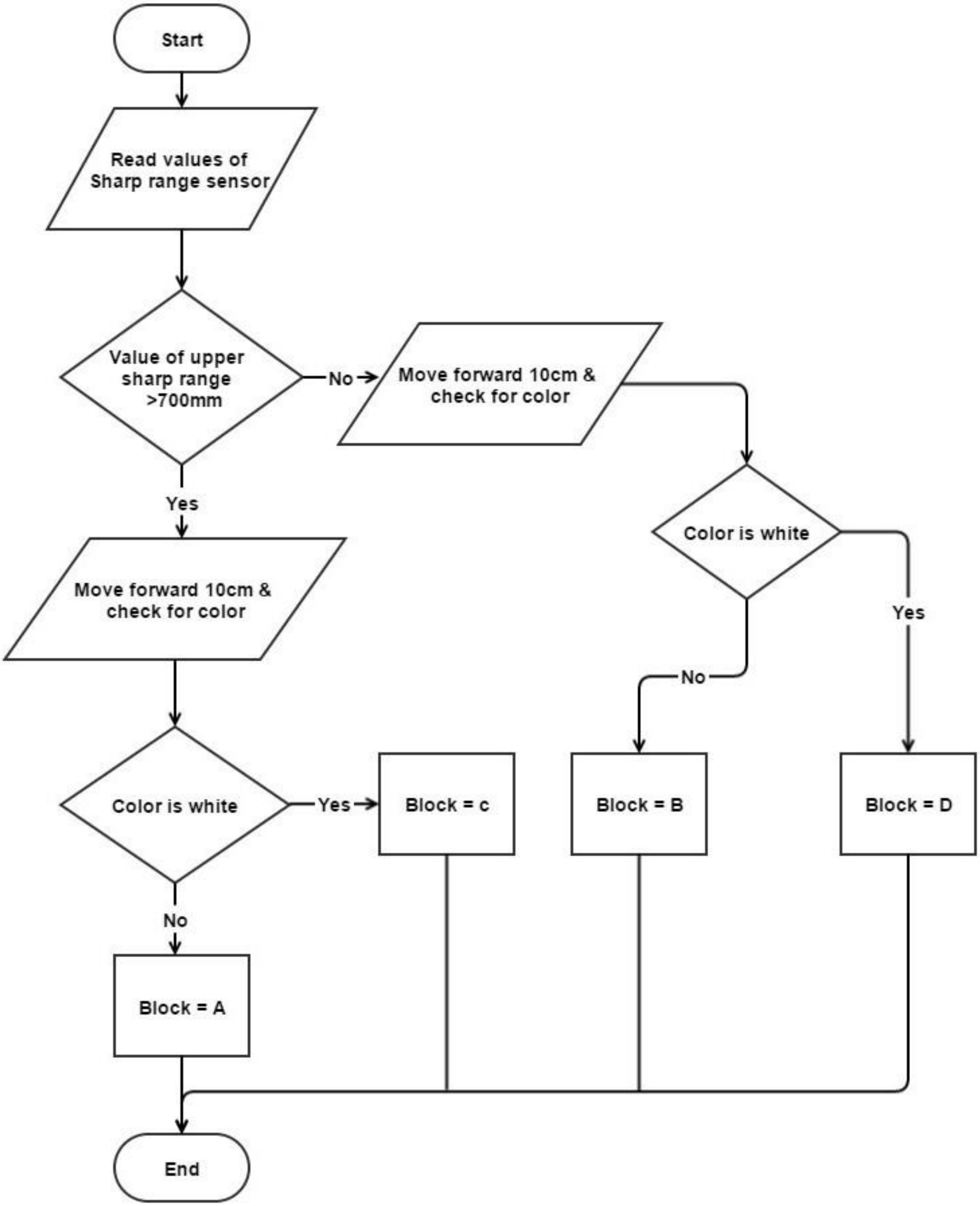

Fig.4 a) Sensing Block

5. **Go to respective deposition zone :** This subroutine describes how the robot will choose its path to reach the deposition zone according to the sequence.

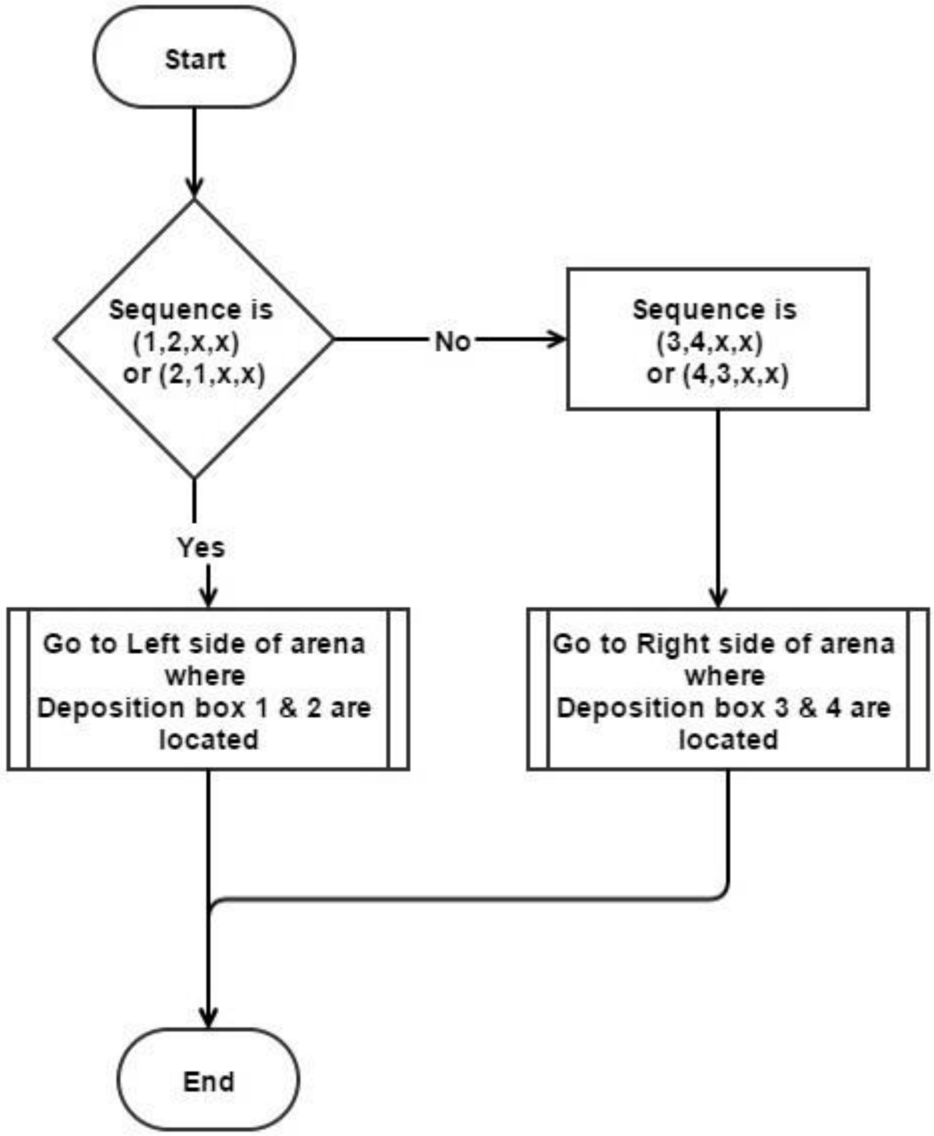

Fig.5 Reaching to respective deposition zone

6. **Deposit block A & B :**

i) If sequence is (1,2,x,x) or (2,1,x,x):

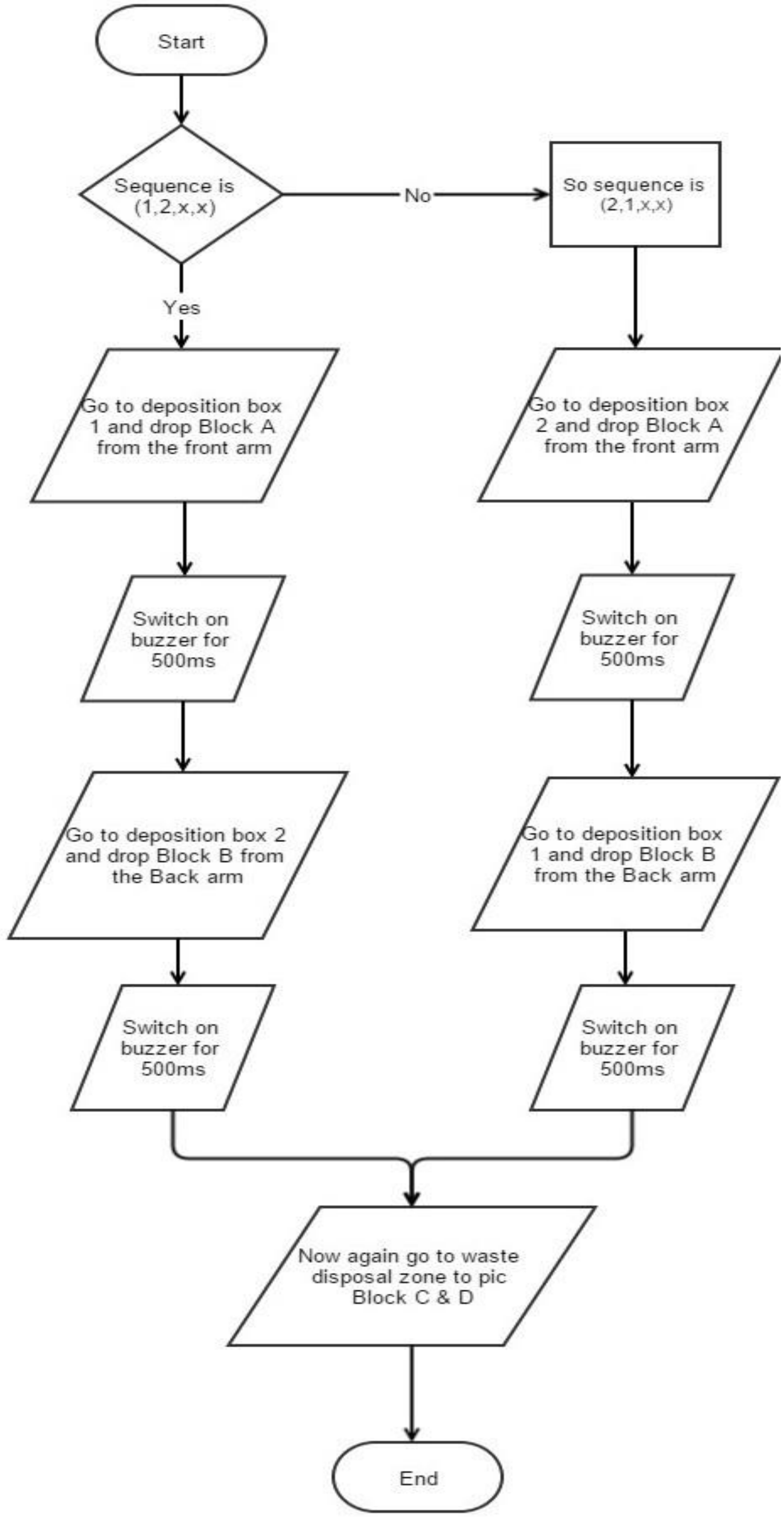

Fig.6 i) Logic for sequence (1,2,x,x) or (2,1,x,x)

ii) If sequence is (3,4,x,x) or (4,3,x,x):

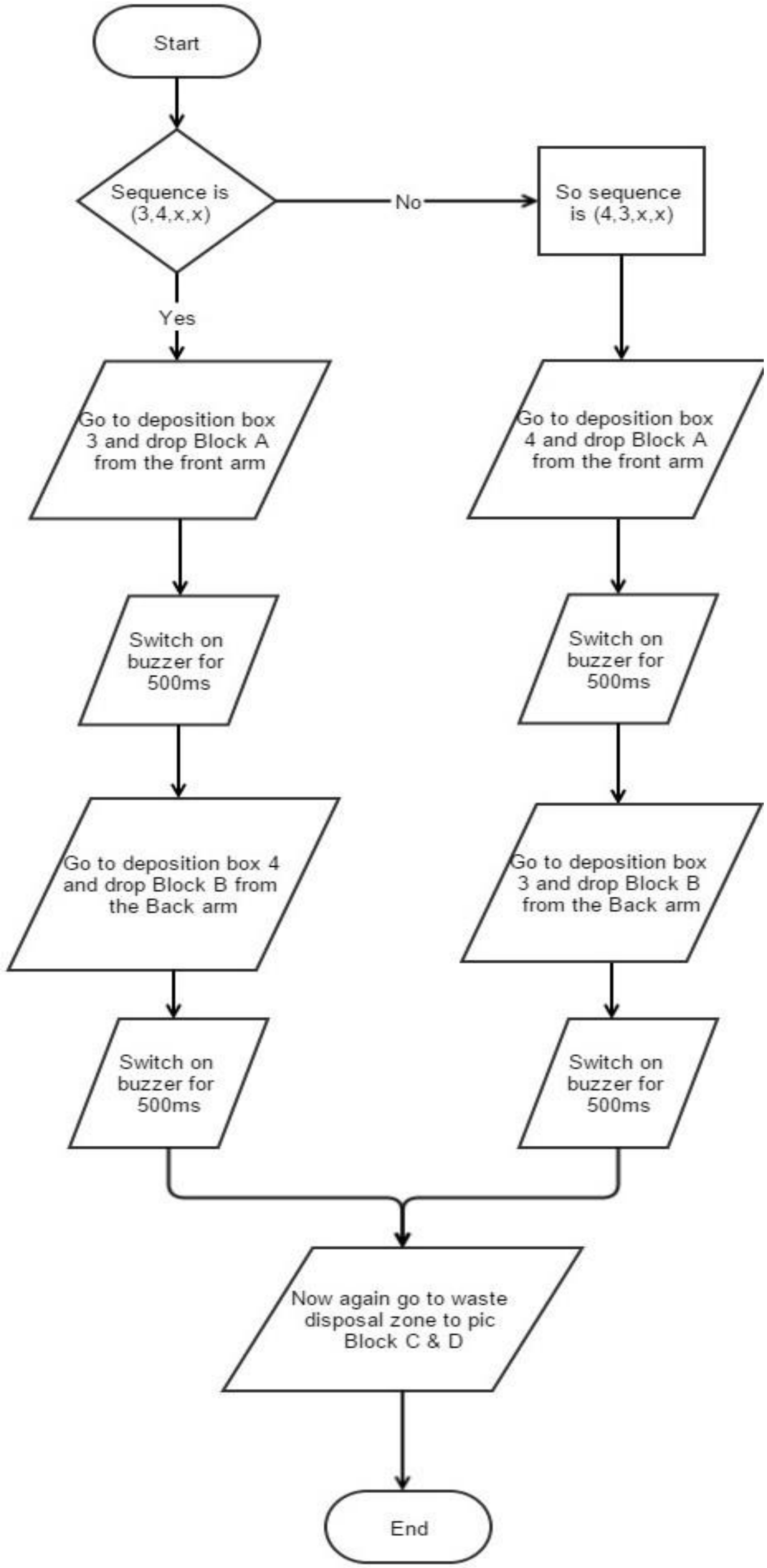

Fig.6 ii) Logic for sequence (3,4,x,x) or (4,3,x,x)

7. **Pick Block C & D, then enter in opposite part of arena :** This subroutine describes how the robot will detect and pick block C & D. It also describes how the robot will cross the node and enter in to the opposite part of the arena.

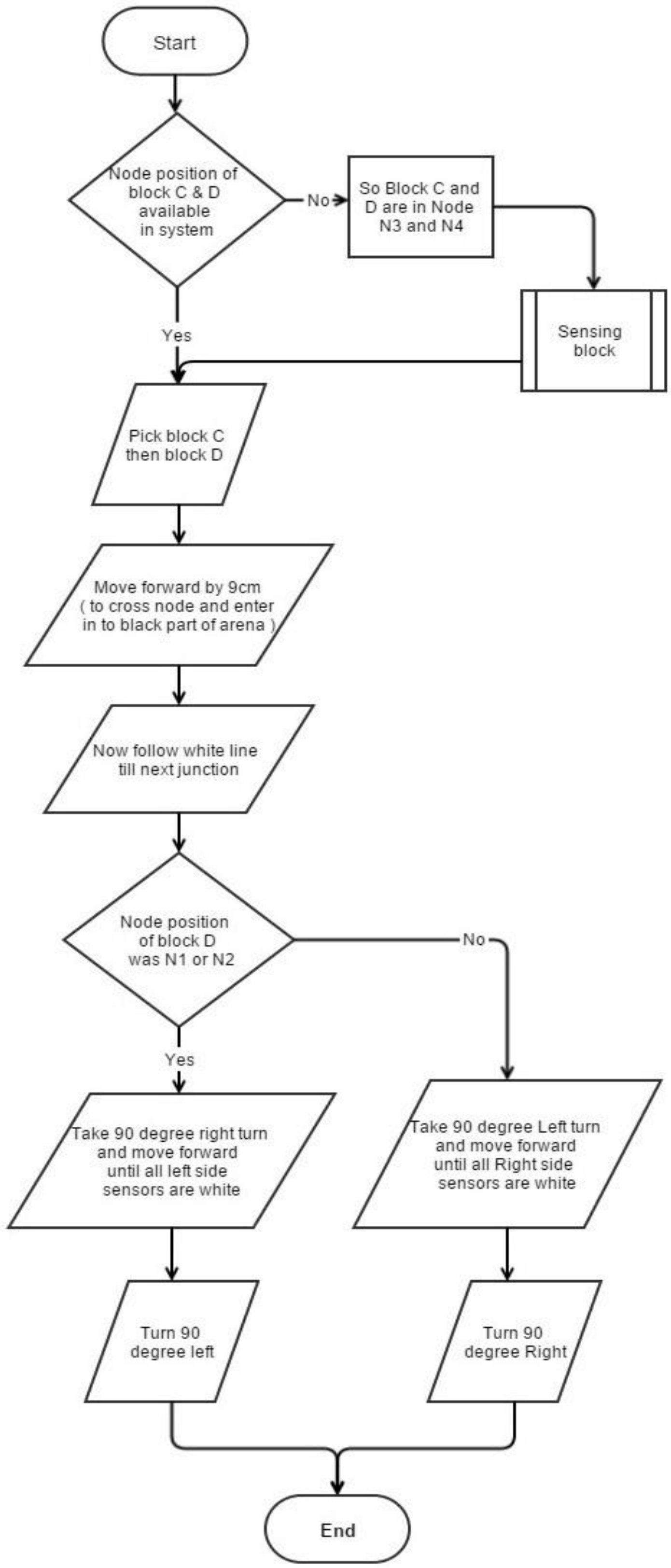

Fig.7 Pick Block C & D and enter in opposite part

8. Go to respective deposition zone : This subroutine describes how the robot will choose its path to reach the deposition zone according to the sequence.

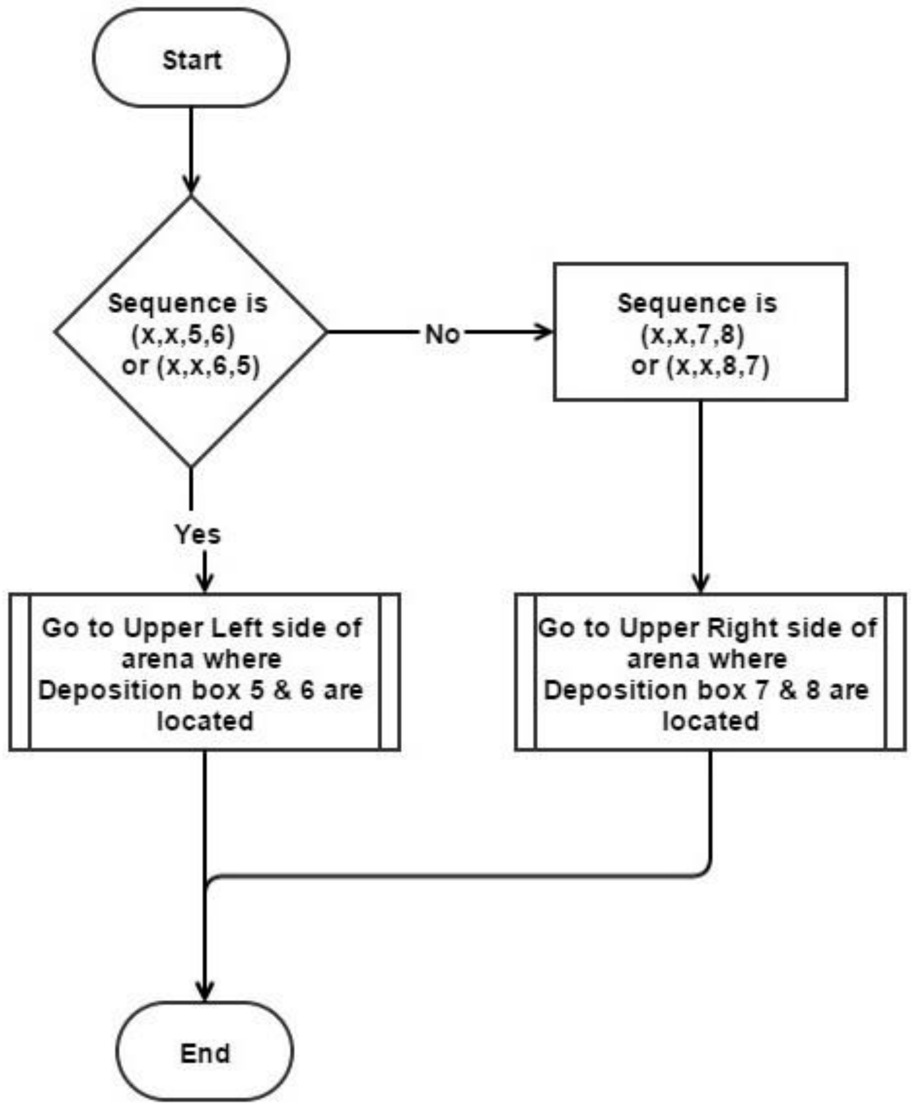

Fig.8 Reaching to respective deposition zone

9. Deposit block C & D :

i) If sequence is (x,x,5,6) or (x,x,6,5) :

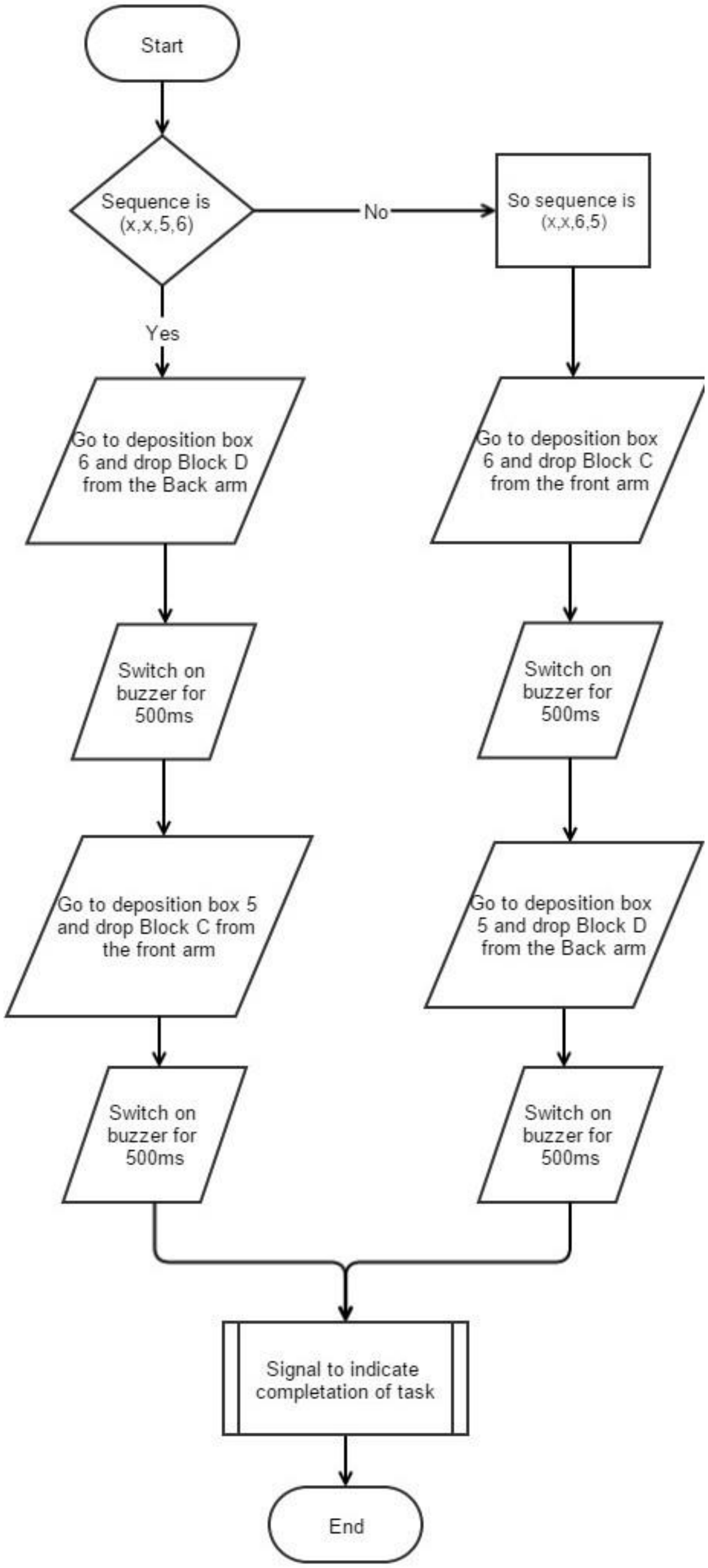

Fig.9 i) Logic for sequence (x,x,5,6) or (x,x,6,5)

ii) If sequence is (x,x,7,8) or (x,x,8,7) :

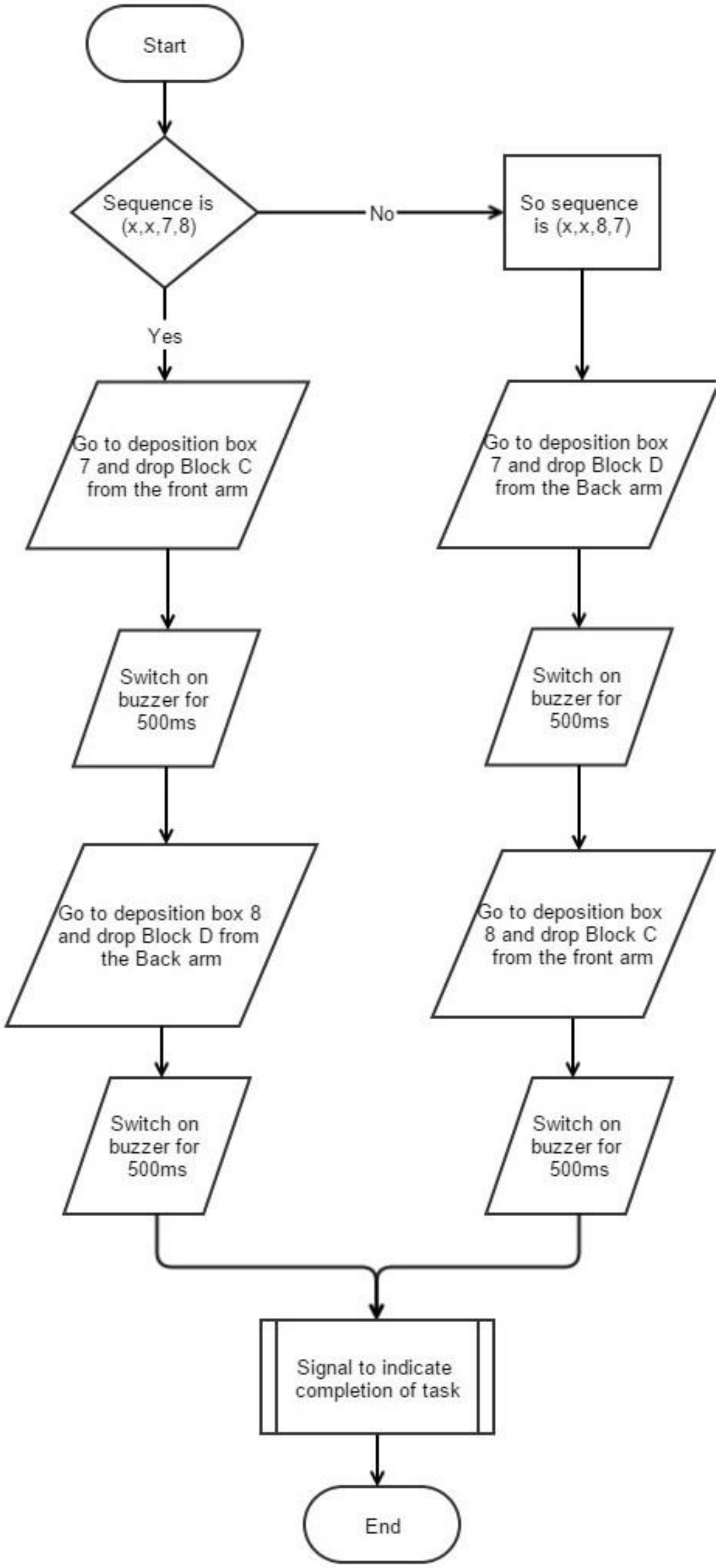

Fig.9 ii) Logic for sequence (x,x,7,8) or (x,x,8,7)

10. Signal to indicate completion of task : This simply involves sounding a continuous buzzer to indicate completion of task.

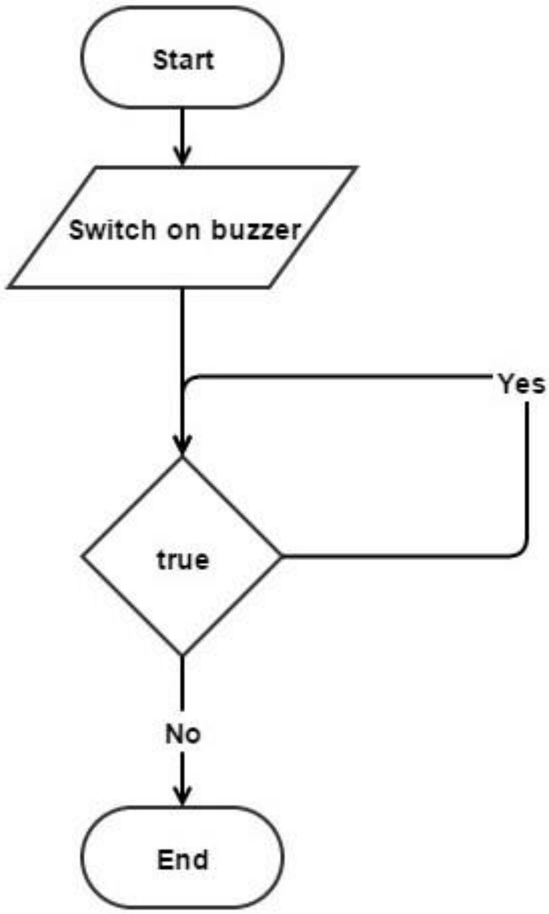

Fig.13 Signaling completion