e-Yantra Robotics Competition - 2018

Theme and Implementation Analysis – Ant Bot

6338

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Date	2nd Jan 2019

Scope and Preparing the Arena

Q1. a. State the scope of the theme assigned to you.

(5)

The theme assigned to us is Ant Bot. The work of a single ant is depicted in this theme. In real life, the ants work with cooperation and coordination where an ant collects food from a supply location and while providing the food to the Ant Hill(the service location), it leaves behind a trail for the other ants to follow. The tasks done by the second ant is the same as the first ant.
Similarly, the Arena is designed such that the first ant bot has left a black path behind for its other fellow ant bots which our robot follows. Hence our robot is the teammate AB.
The Robot AB needs to collect the supplies which can be Leaves, Honey Dew or Wood from the Shrubs Area(SA) and supply it to the correct Ant Hill and throw out the trash to the Trash Disposal Zone if it exists. We need to make sure that the Queen Ant Hill is given preferential treatment during the whole task.
In this way we learn a lot from the way ants work together in harmony for the welfare of their society. This process is known as biomimicry (learning from nature and emulating it to solve our problems in a better way). Ant robots are usually implemented in the context of path following. They can be used for guarding terrain, mine sweeping, surface inspection and developing efficient traffic management systems.

b. Upload the Final Arena Images.

(20)

The 4 arena images have been uploaded and are present in the 6338_images folder.

Building Modules

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

(5)

Mechanical system:

1. Robotic arm for picking and placing the supply requirements and for trash removal
2. Servo motors for the accurate tilting of the robotic arm
3. DC motors to power the wheels
4. Wheels for movement of the robot
5. Clamps, studs and screws to make the essential contact between wheels and motors

Electronic and electrical system:

1. Arduino Nano for controlling the motors, buzzer and line sensor
2. Raspberry Pi for motors and PiCam
3. RGB LEDs to display the colour of the supply requirements
4. Li-ion battery to power the L298N motor driver
5. L298N motor driver for communication between Arduino and DC motors
6. Power bank to supply power to Raspberry Pi
7. USB cable to connect Pi and Nano
8. Adaptor to charge the battery

Power Management

Q3. a. Explain the power management system required for a robot in general and for the theme assigned to you in particular.

(5)

The main power source in any general robot is for the micro-controller. The most general micro controller being Arduino Uno it will draw 9V DC and 40-45mA of current. Whereas, an Arduino Nano draws 42mA and needs a minimum voltage of 7V DC. The Pi works on an input of 5V. The key point is to separate the motors power supply from any other circuitry which is a safety mechanism to protect interference. The remaining sensors and components will take 5V or 3.3V (whichever is the output given by the micro-controller)

For the theme we have been assigned, we need almost a similar kind of power management. We can power the Pi using a power bank(5V and 2A). The USB cable connecting the Pi to the Nano will power the Nano. A Li-ion battery(11.1V and 4.4A) will be connected to the L298N motor driver to power the 100rpm 12V DC motors.

b. Can there be a single power supply for your robot? - Yes/No/Don't know. Please elaborate/justify your answer choice.

(5)

The power bank is the main source of power supply for the robot. It provides a 5V output which is used to power the Pi. All the electronic components connected to the Raspberry Pi extract power from the Pi for their functioning.
However the 100rpm, 12V DC motors provided in the kit need a significantly higher voltage(12V). This voltage must be supplied through another source so that the other components are not affected by the change in power consumption of the motors thus ensuring safe functioning. This higher voltage is supplied to them by connecting a Li-ion battery(11.1V) to the L298N motor driver.
Hence, a single power source cannot be used for our robot.

Design Analysis

Q4. Team have to design a robot which traverses the arena following a given path.

a. How will you design a robot to traverse the arena given in the rulebook?

(5)

We will design the chassis with one main component (e.g. wood, cardboard, metal etc). On it, we will mount the Pi and the power bank that powers it. Also, we will connect the Arduino Nano to the Pi. This is to effectively distribute some of the functioning to the Arduino and reduce the work load on the Pi. The required sensors, actuators, buzzer, camera will be then connected to the Pi or Arduino accordingly to perform the input/output functions as explained further.
The image of the ArUco ID as extracted from the PiCam and the light sensed by the 3 photo diodes are the inputs to the robot. The output components will be the RGB LEDs, DC and servo motors, buzzer. The hardware components are the wheels, the chassis, the robotic arm, the Servo and DC motors.
The aim of the robot is to follow the black line while avoiding the walls and catering all the service locations. It has to turn(if necessary) at the nodes and reach the ant hills and then the correct service locations to perform its tasks.
The algorithm we intend to follow is based on ant-hill as priority as described below:
Once the robot starts from the START point, it will travel to the Central Node along the black line. Following it, it will scan and detect all the ArUco IDs. The information held by the ArUco ID is then processed to determine the task for each ant hill giving preferential service to the queen ant hill i.e. the queen ant hill is found first if it exists and serviced. All the other ant hills are then serviced in order going from Serv 1 to Serv 2.
An alternate path following algorithm could be based on block priority where the supply blocks and thrash blocks are given preference over the ant-hills. The supply blocks are picked up in order and delivered to their respective ant-hill and then the thrash is taken out from all the hills together. However if a queen ant hill is present that would be serviced completely first as a part of the preferential treatment.

b. How many actuators do you feel are sufficient for designing a pick and place mechanism? If you are going to use additional actuators (apart from those provided in the kit), how and for what purpose do you plan to use them?

(5)

We think that two actuators are sufficient for designing a pick and place mechanism. Using only two actuators will simplify the code and construction of the arm. We will use one standard servo at the end attached to the robot and one micro servo motor to build a claw like structure in order to grab the blocks. This way, the standard servo motor will help the arm move up and down in angular motion and the micro servo motor will help in acquiring possession of the boxes.

An additional actuator may be used to rotate the robotic arm in 3-dimensions. This will help in perfect placing of the blocks in the Thrash Deposition Zone as we have to ensure that the blocks are not placed on top of each other.

Environment Sensing

Q5.a. Explain how you will use the Line Sensor to decide the course of traversal (identifying line and nodes).

(5)

The line sensor has 3 red LED transmitters and 3 photo diodes. The photo diode detects the amount of reflected light producing a leakage current that alternates the output voltage enabling it to determine black lines from the arena. If the left and right photo diodes are sensing white, the robot will continue to move forward. This is how it will traverse on the lines. When the robot enters the nodes, both the left and right diodes will sense black colour. This will cause the robot to come to a halt. The robot will then take a left or a right turn depending on the task it has to perform. However when the robot encounters the nodes at the shrubs area one of the left or right diodes will sense black and the other will sense white. Then the robot will turn towards the side that is sensing black.

b. Would the webcam be a better choice of camera over the PiCam? Explain.

(5)

We feel that the PiCam is a better choice over the Webcam. This is because the PiCam has its own port on the Pi and hence a better performance will be expected as the PiCam connects directly to the GPU for capturing and encoding videos without any CPU assistance. With the supplied software for the Pi Cam , we have better control over the technical bits of taking stills and videos.

However if you use a USB webcam there is no GPU assistance so all the work is handled by the CPU alone to communicate with the device to extract frame data at the cost of higher CPU load.

On the other hand, some of the few advantages of using a web cam would be movability, since the PiCam can't go pretty far with its ribbon cable and the USB port can be used on other systems, handled independently whereas the PiCam cannot.

c. What other sensors will the robot require to complete its task successfully?

(5)

The robot may require the following other sensors to complete its task successfully without colliding with the walls of the arena :

1. **Sharp Infrared Sensor:**
   For accurate distance measurement, we may use Sharp IR range sensors. Sharp IR range sensors consists of IR LED and linear CCD array, both encapsulated in the housing with precision lens assembly mounted in front of them. IR LED with the help of the leans transmits a narrow IR beam. When light hits the obstacle and reflects back to the linear CCD array, depending on the distance from the obstacle, angle of the reflected light varies. This angle is measured using the CCD array to estimate distance from the obstacle. The sensor gives out analog voltage corresponding to angle of reflection and thus determines the distance of objects from itself. However these sensors have blind spot in the range of 0mm to some specific distance depending on the type of the sensor. In the blind spot region sensor gives incorrect readings. This can be used to maintain a specific distance from the walls.

2. **Infrared proximity sensors and Directional Light Intensity Sensors:**
   Infrared proximity sensors are used to detect proximity of those obstacles in the short range which cannot be detected by Sharp Infrared Sensors (present in the blind spot of the Sharp IR sensors). In the absence of the obstacle there is no reflected light 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. This can be used to alert the robot if it's straying too close to any of the objects.

3. **Ultrasonic sensor:**
   Ultrasonic sensors can be used as an effective alternative for the sharp IR sensors as they are not easily available in the market. Ultrasonic sensor transmits a narrow beam of ultrasonic pulse and measures time taken for echo of the beam. It gives output proportional to time taken for the ultrasonic beam to return echo from the obstacle.

d. Explain the strategy you will follow to detect and indicate the SIM placed around the Central Node (This includes traversing strategy to reach different SIMs).

(4)

The strategy we will follow to detect and indicate the SIM placed around the central node is

1. The robot will reach the central note first. The PiCam will be placed on the top of the robot. At the central node the robot will turn 45 degrees and move forward until the PiCam is directly over the ArUco Marker where a picture will be taken.
2. The ID's of the ArUco Markers are then detected using the detectMarker() function of the ArUco module that we have learnt in Task 2. The ID is then converted to binary form of 8 bits which is used to execute the service requirements.
3. After the service requirement of the first SIM are met, the robot will come back to central node to detect the second SIM and so on.
4. To serve the QAH first, we can make the robot detect all the ArUco Markers in the first go itself until the Marker with the QAH is detected and serve it first. Then follow the same procedure as above to serve the remaining Ant Hills.

Testing your Understanding (Theme Analysis and Rulebook-related)

Q6. a. If at a given SIM location ArUco ID is found to be 76 (Decimal), what is the Ant Hill Number and type (Regular Ant Hill or Queen Ant Hill) and what are the Service Requirements of this Ant Hill?

(3)

The binary form of the number 76 is 01001100
Ant Hill Number: 2
Ant Hill type: Regular Ant Hill
Service Requirements: Server 2 requires Honey Dew(HD)
Server 1 requires Leaves(L)

b. Is SIM0: 25, SIM1: 60, SIM2: 217, SIM3: 226, a possible combination of SIMs to be placed on the arena? If not explain with reasons.

(3)

SIM 0: Binary for 25 is 00011001
Ant Hill Number: 0
Ant Hill type: Regular Ant Hill
Service Requirements: Server 2 requires Wood(W)
Server 1 has no requirement
Trash Disposal is required.

SIM 1: Binary for 60 is 00111100
Ant Hill Number: 1
Ant Hill type: Regular Ant Hill
Service Requirements: Server 2 requires Wood(W).
Server 1 requires Leaves(L).
Trash Disposal is not required.

SIM 2: Binary for 217 is 11011001
Ant Hill Number: 2
Ant Hill type: Queen Ant Hill
Service Requirements: Server 2 requires Wood(W).
Server 1 has no requirement.
Trash Disposal is required.

SIM 3: Binary for 226 is 11100010
Ant Hill Number: 3
Ant Hill type: Queen Ant Hill
Service Requirements: Server 2 has no requirement.
Server 1 requires Honey Dew(HD).
Trash Disposal is not required.

This possible combination of SIM's is not possible because,

1. Both SIM2 and SIM3 are Queen Ant Hills which is not possible.
2. SIM0, SIM1 and SIM2 require Wood(W). However, there are only two supply locations of Wood(W).

c. What are the different conditions that indicate end of a run?

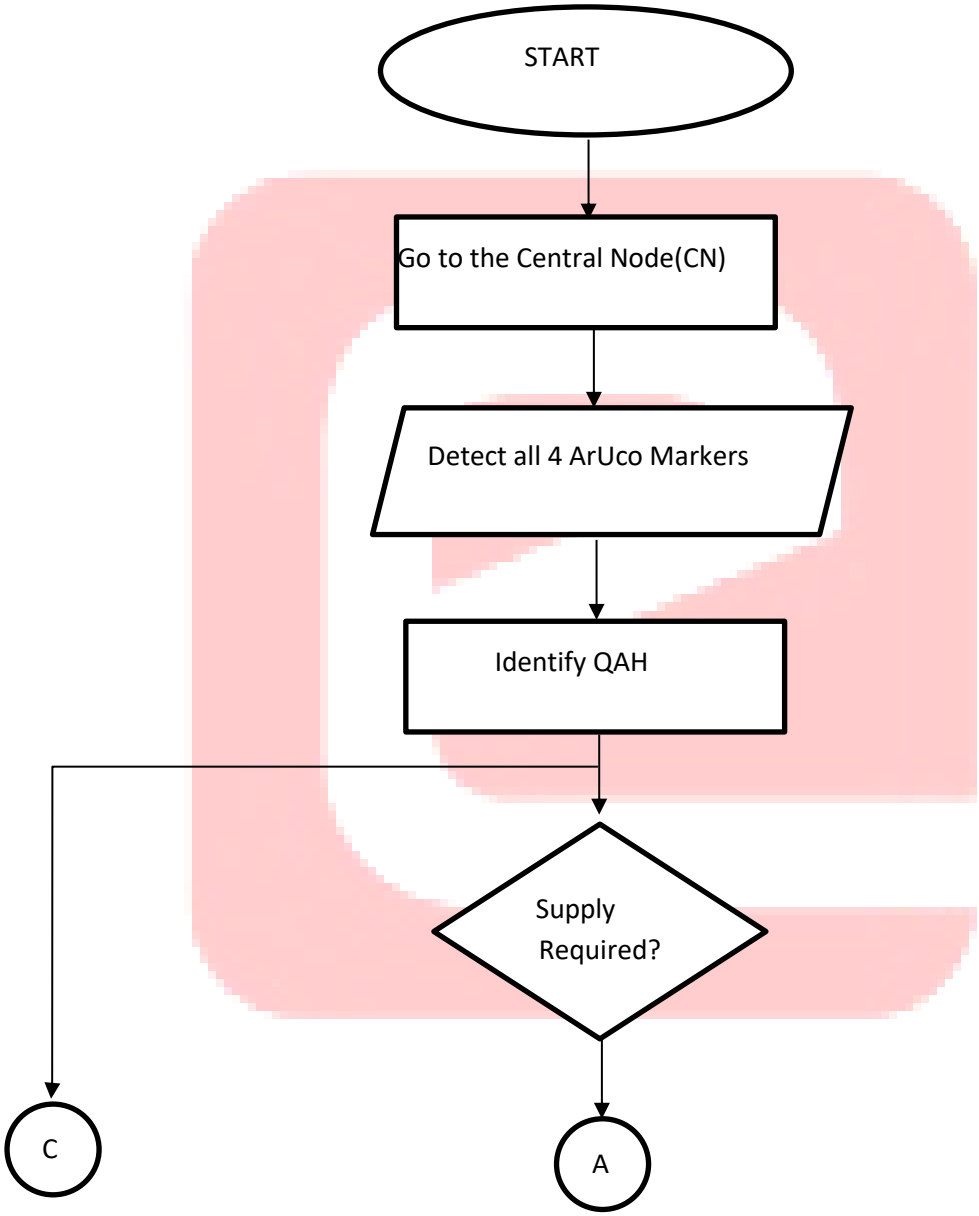
(3)

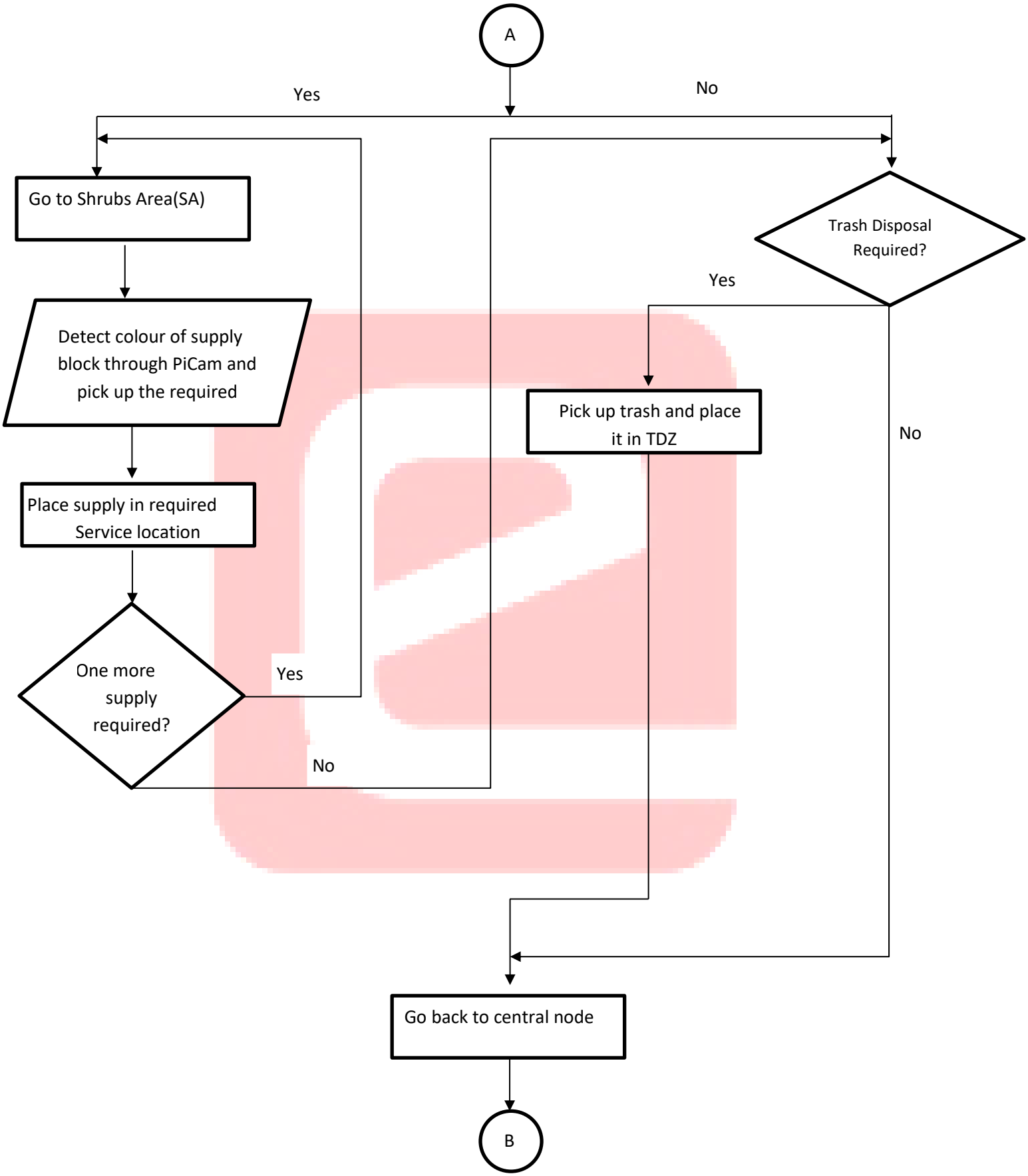
The different conditions that indicate the end of a run are:

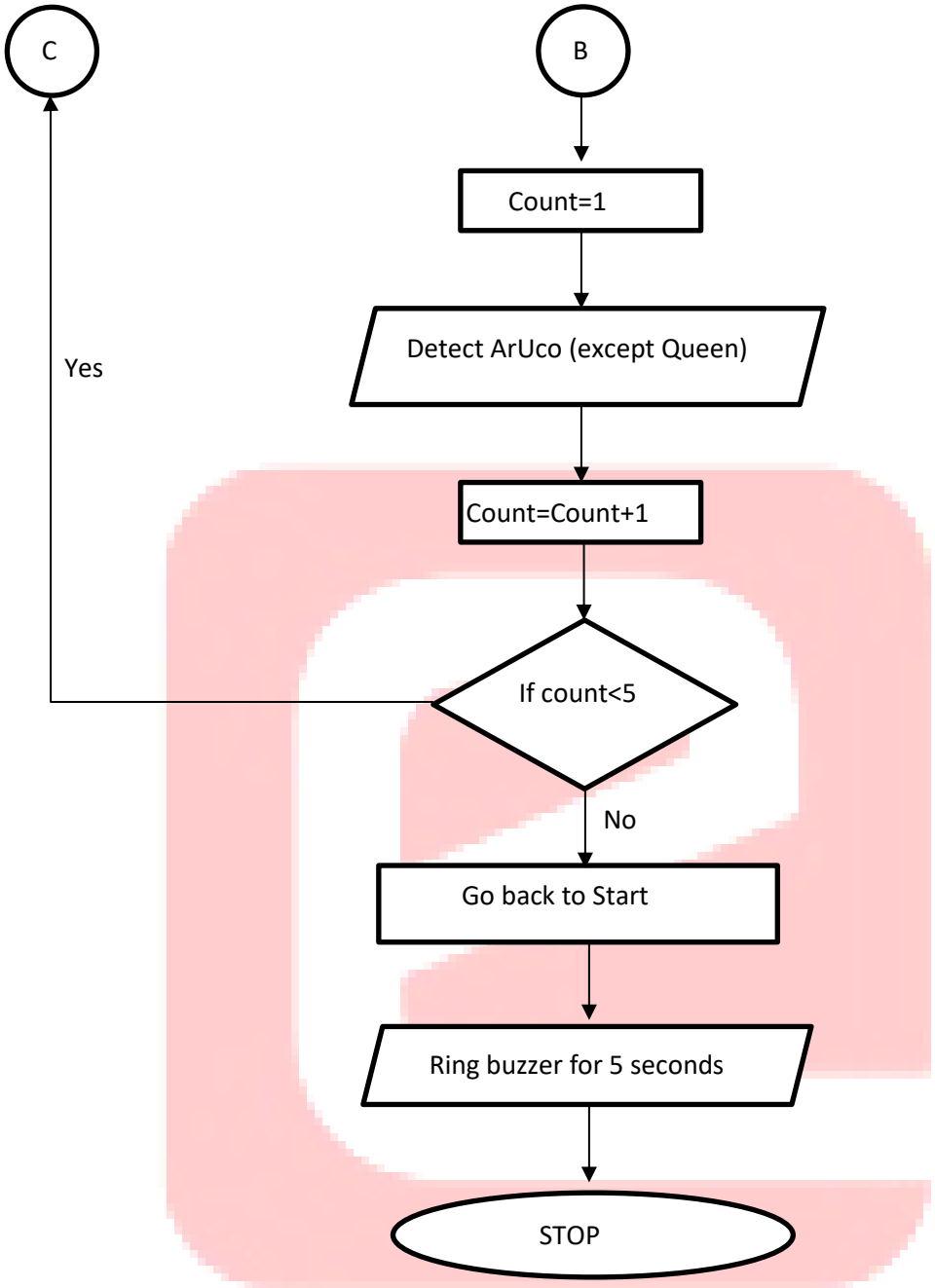
1. The AB completes the task and turns ON the buzzer at "Start" position for 5 seconds.
2. The maximum time limit (600 seconds) for completing the task is reached.
3. The team needs repositioning but has used maximum allowed repositioning options of that run.

Algorithm Analysis

Q7. Draw a flowchart illustrating the algorithm you propose to use for theme implementation. (10)




A
Yes
No
Go to Shrubs Area(SA)
Detect colour of supply block through PiCam and pick up the required
Place supply in required Service location
One more supply required?
Yes
No
Trash Disposal Required?
Yes
No
Pick up trash and place it in TDZ
Go back to central node
B


C
B
Count=1
Detect ArUco (except Queen)
Yes
Count=Count+1
If count<5
No
Go back to Start
Ring buzzer for 5 seconds
STOP

Q8. Suppose for a given arena configuration, it takes 20 seconds more to execute the task while keeping the Queen Ant Hill in priority. What will be your logic to traverse the arena in order to secure maximum marks i.e. you will serve Queen Ant Hill first by taking 20 seconds more or complete the run faster by not serving Queen Ant Hill first (Assuming, points scored for all other parameters in Total Score in both the cases remain same). Please explain and justify your logic and strategy.

(4)

To complete the task we get a total time of 600 seconds. For every second that we use, one point is reduced from the total score. If we execute the task while keeping the Queen Ant Hill in priority, we will lose 20 marks for the additional 20 seconds taken.
However, if the QAH is served first before other Ant Hills, we will receive one QB bonus point. This point gets multiplied by 100 and gets added to our final score as given in the rule book.
Also there is an Overall Bonus of 300 points if we are able to complete the task with no penalties applied and with the Queen Ant Hill serviced first if it exits. So, if we ignore the QAH, then we also lose out on the chance of securing these 300 points also if there is a QAH present in the arena.
Thus, to secure maximum marks, we feel that it is better to start by serving the Queen Ant Hill first even though it takes 20 extra seconds.

Challenges

Q9. What are the major challenges that you can anticipate in addressing this theme and how do you propose to tackle them?

(8)

The major challenges that we may face while addressing this theme are

1. **Placing the supply cubes at the desired location-**
   The robotic arm needs to pick supply boxes and place them on the correct deposition zone marked for the particular service. Placing the supply boxes perfectly will be a major challenge. We need to make sure we orient the robotic arm properly to tackle this problem.
2. **Detecting the Queen Ant Hill-**
   The Queen Ant Hill needs to be given preferential treatment while doing the service. If the Bit-7 of the ArUco Id is 1, then that particular Ant Hill is the Queen Ant Hill. For this, the robot needs to detect go to each ArUco Marker one by one, check which of them is the Queen Ant Hill and provide its service first. However this will take extra time which will result in the loss of marks. We need to make clear strategy with and without the Queen Ant Hill and check in which case more marks could be secured.
3. **Preventing the robot from hitting the walls-**
   The robot may hit the walls of the Ant Hill, while following the lines. To tackle this problem, we may have to introduce a proximity sensor in the robot to make it stop when it detects a wall in front of it.
4. **Design of the robot-**
   The other major challenge we can see right now is how to organise all the connections on the chassis. Also, we need to decide the most efficient material for the chassis (eg. Wood, cardboard, steel). We can decide this by trying various prototypes and constantly trying to improve the design.