e-Yantra Robotics Competition - 2018

Theme and Implementation Analysis – Ant Bot

<Team ID>

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Scope and Preparing the Arena

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

(5)

The theme assigned is Ant Bot. The Robot has to traverse along the path given and provide desired services to the Ant Hills precisely. The purpose of this theme is to make us familiar with:

1. Image Processing
2. Color Detection
3. Wireless Communication
4. Bond Software with Hardware
5. Bridge the gap between theory and practical knowledge

Such an application of this robot is to traverse through the farms and plant seedlings thus reducing the manual work and provide a better way of automation.

Applications of line follower robot:

- **Industrial Applications**: These robots can be used as automated equipment carriers in industries replacing traditional conveyor belts.
- **Automobile applications**: These robots can also be used as automatic cars running on roads with embedded magnets.
- **Domestic applications**: These can also be used at homes for domestic purposes like floor cleaning etc.
- **Guidance applications**: These can be used in public places like shopping malls, museums etc to provide path guidance.

b. Upload the Final Arena Images.

(20)

Images Included.

Building Modules

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

(5)

Electronics System:

1.Arduino Nano : Used to write and control computer code to physical board
1. Actuators: To drive the robot to required position using DC motor (Quad Encoder)
2. Control: Microcontroller used is RASPBERRY PI to control the activities of robot.
3. Intelligence: Python Code was used to program the robot.
4. Battery(Power Bank) : 11V, 2200mAh Li-ion battery is used to power the DC motors and intex power bank to supply 5V of 2A rating to the Raspberry Pi.
5. Communication: Wifi Communication using SSH is used between RASPBERRY PI and PC.
6. Pi-cam: To follow path by sensing black and white line and to detect the zone indicator and colour markers.
7. L298N motor driver: motor driver which will control speed and direction of Ant-Bot
8. PCB :printed circuit board is used to group electrical components

Mechanical System:

1. Wheels: To drive the robot throughout the course of traversal.
2. DC motors: machine that transforms electrical energy into mechanical energy in form of rotation
3. Micro Servo motors: rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.
4. Line Sensor : detect lines or nearby objects using reflected light coming from its own infrared LED
5. Buzzer : Buzzer is the most common choices for audio communication eg: Ant-Bot notifies that its task has been completed

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)

Solution:

- For DC Motor: Power required is 1.1 Watt with current rating of 410 mA so for two motors 2.2 watt is required.
- For Raspberry Pi: Typical bare-board current rating of Raspberry pi is 400 mA
- We will prefer battery mode for our robot. We are dealing with wireless communication so to make it happen we will use power bank and Li-ion battery to power our system, it will provide enough power to our system.

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

(5)

Ans. No, single power supply cannot be used as microcontroller is operated on less power supply and motor requires high power supply which may damage the microcontroller.

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)

The basic parts the robot requires throughout the course of traversal are wheels for mechanical movement, motors which cause the wheels to move, microcontroller which needs to have an input based on which after programming provides output which causes the motors to work and so on. The input to microcontroller which we can term feedback is basically received through sensors in most of the cases but here instead PiCam is used so that it circulates the entire data based on which robot works. The communication between raspberry pi and display is done through wifi communication using SSH.

PiCam takes the data whatever comes and processes the data to microcontroller and here the microcontroller used is Raspberry Pie which is programmed using python for image processing. No of frames are received to the Raspberry Pie which acts as a input. The output purely depends upon the programming done to the microcontroller. Here programming is done to detect the ArUco ID of SIM through image processing and provided desired service to detected Ant-Hill. Types of services detected by ArUco ID are provided using the Color Detection (image processing). The PiCam provides the data relevant to color boxes and the necessary services are provided near zone indicator. The bot detects the zone indicator and through wifi communication between raspberry pi.

1. The Robot begins its journey from the Start point.
2. **Different-Terrains**:-

Ant-Hill(AH),Trash Deposistion Area(TDA),SIM-Zone(SZ),Central-Node(CN),Shrubs Area (SA) Queen Ant's Hill (QAH). On its path, it comes across Zone indicators. Robot follows the black line path and only white line path in Inverted Plains where nothing is to be done.

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 will need minimum three Actuators for designing a pick and place mechanism.
The list is as follows:-

- Servo motor (0-180' rotation): required in the mechanism of lifting of blocks
- DC motors: required for primary motion of the robot along the arena.

External Actuators:

- Servo motors(0-360' rotation) : required in the mechanism for rotation by a specific angle for dropping a the service requirement at a time of service completion.

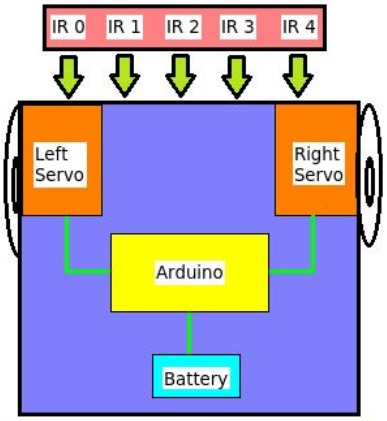
Environment Sensing

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

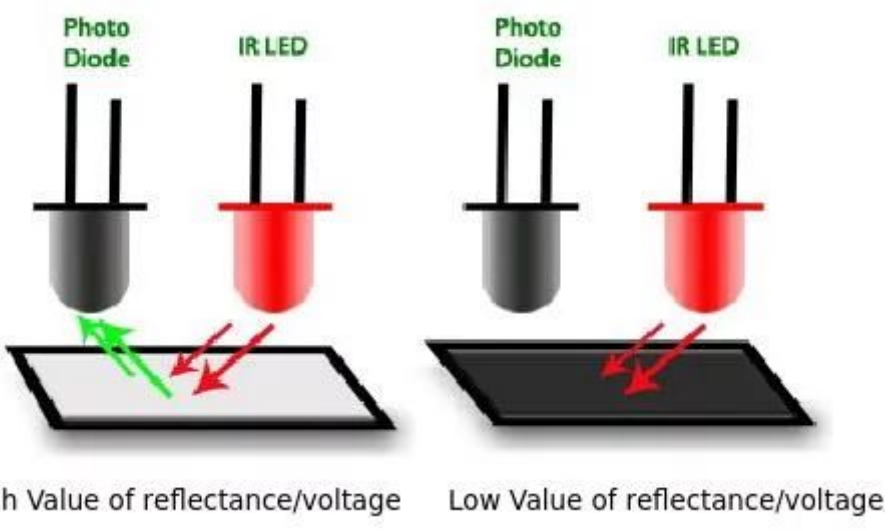
(5)

The workings of a line follower robots are pretty straightforward. These robots have Line Sensor which have the capability to detect a black or dark line on a lighter surface depending on the contrast. They estimate whether the line underneath them is shifting toward their left or right as they move over them. Based on that estimation, they give respective signals to the motors to turn left or right so as to maintain a steady center with respect to the line.

These robots usually use an array of IR (infrared) sensors in order to calculate the reflectance of the surface beneath them. The basic criteria is that the black line has a lesser reflectance value (black absorbs light) than the lighter surface around it. This low value of reflectance is the parameter used to detect the position of the line by the robot. The higher value of reflectance will be the surface around the line. So in this linear array of IR sensors, if the leftmost or rightmost IR sensor presents the low value for reflectance, then the black line is toward the left or right of the robot correspondingly. The controller then compensates for this by signaling the motor to go in the opposite direction of the line.The IR sensor array consists of individual IR LEDs and IR photodiodes. The IR light emitted by the LED strikes the surface and is reflected back to the IR photodiode. The photodiode then gives an output voltage proportional to the reflectance of the surface (high value for a light surface and low for a black or dark surface).



Line Follower Block Diagram



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

(5)

PiCam pros:

1:Better resolution.
2:Faster frame rate.
3:Less resource intensive.
4:Compact.

PiCam cons:

1:No camera stand.
2:Short ribbon.
3:No way to focus.
4:Drivers need to be installed.

Webcam Pros:

1:Long USB wire for easy movement.
2:Two fields of view,close and kind a close.Built in array mic.

Webcam cons:

1:Bad frame rate.
2:Would cause Wifi dongle or SD card to stop working after few days requiring a hard reboot.

The Pi camera is 'run' by the GPU and can dump full frames into RAM at 15 frames a second .. this is 7.5MB/frame, 15fps = 112.5 Mega BYTES per second .. or you can have full HD resolution 30fps H264 encoded (by the GPU) along with some simultaneous still photos (Google MMAL) all at virtually zero CPU loading.

On the other hand, the Pi USB is 'run' byte at a time by the CPU, and, at the cost of 100% CPU loading you might achieve a couple of hundred Megabytes per second, not that a Webcam is going to deliver that anyway (even if it could, you then don't have any CPU cycles to do anything with it.

SO, unless CCTV resolutions (320x240 pixels) are what you want, it has to be the Pi camera.

Overall above summary between Picam and webcam suggests that Picam is a better choice than webcam.

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

(5)

No, other sensors will be required as the complete task is done through PiCam. Only Camera module is used. PiCam does the work.

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)

Step 1:- Identify Central Node using the Line Sensor.
Step 2:- Once Identified, guide the BOT to the SIM1 which is inclined 45 degrees to the Central Node using the Servo Motor.
Step 3:- Provide Required services and Carry the Task for each SIM in above manner.

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)

If we convert 76 to Binary we get (01001100),
Bit-7 Represents Ant Hill Type,
Bit-6 and Bit-5 represents Ant Hill Number,
Bit-4 and Bit-3 represents Serv 2,
Bit-2 and Bit-1 represents Serv 1.
and Bit-0 represents the status of Trash Removal required.

Ant Hill Number: AH2
Ant Hill type: Regular Ant Hill
Service Requirements: Serv 1-Leaves, Serv 2-Honey Dew

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)

Ans: Above combination is not valid combination because,
Converting the SIM ID to Binary we get,

SIM ID	Serv 2	Serv 1	Ant Hill Type
SIM0: 25	Wood	Trash Removal	Regular Ant Hill
SIM1: 60	Wood	Leaves	Regular Ant Hill
SIM2: 217	Wood	Trash Removal	Queen Ant Hill
SIM3: 226	No Service Required	Honey Dew	Queen Ant Hill

Reason 1:- We cannot have 1 Service for more than 2 times. Here, WOOD is required for 3 Times.
Reason 2:- We cannot have more than one Queen Ant Hill. We have Queen Ant HILL in SIM2 as well as in SIM3.

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

(3)

The different conditions that indicate end of a run are:

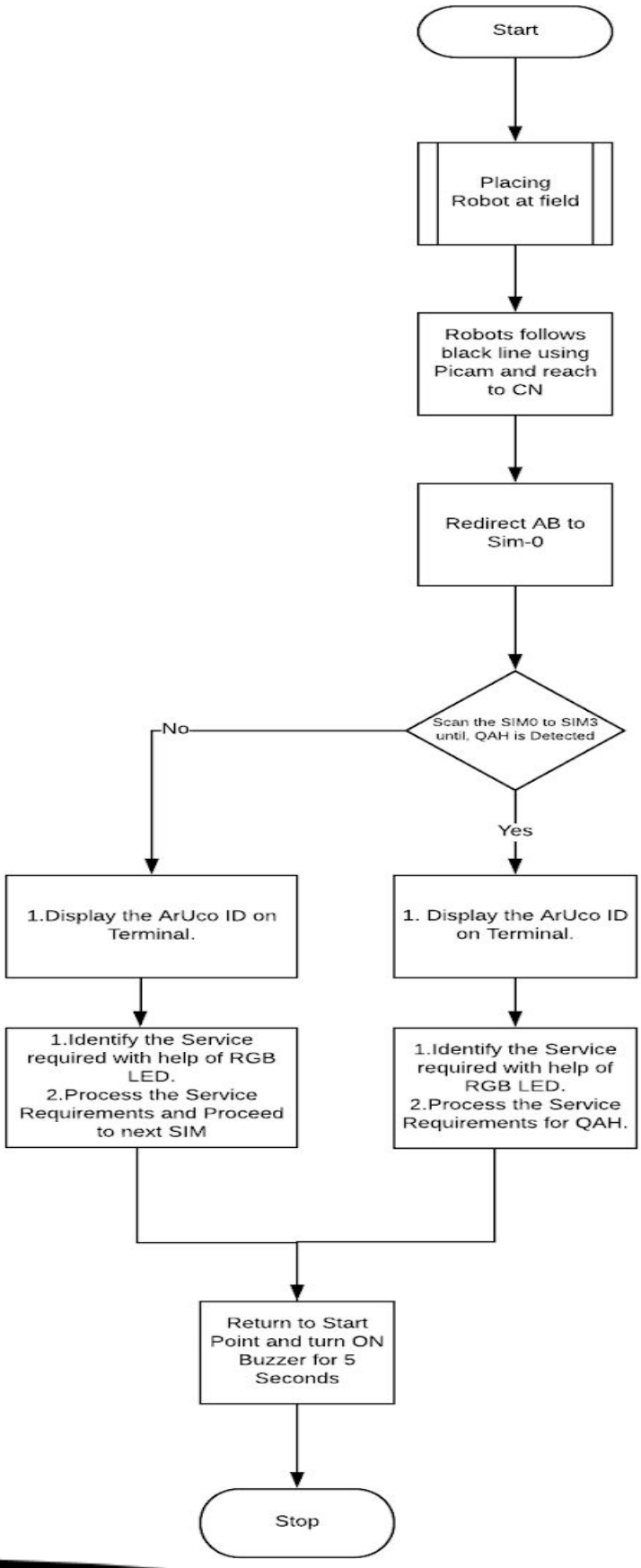
1. The AB completes the task and turns ON the buzzer at "Start" position for 5 seconds.
2. The maximum time limit (600 seconds) for completing the task is reached.
3. Repositioning of robot has been done twice.

Algorithm Analysis

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

(10)

Ans: Refer next page.


Start
Placing Robot at field
Robots follows black line using Picam and reach to CN
Redirect AB to Sim-0
Scan the SIM0 to SIM3 until, QAH is Detected
No
Yes
1.Display the ArUco ID on Terminal.
1. Display the ArUco ID on Terminal.
1.Identify the Service required with help of RGB LED.
2.Process the Service Requirements and Proceed to next SIM
1.Identify the Service required with help of RGB LED.
2.Process the Service Requirements for QAH.
Return to Start Point and turn ON 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)

Ans: We will serve Queen Ant Hill First by taking 20 seconds more.
Justification:-

Total Score:-
(600-T) + (30*CSD) + (30*CSI) + (75*CSEP) + (75*CSED) + (100*QB) + (300*OB) + (DB) - (50*P)

Case 1:- Serving Queen Ant Hill
Assuming other parameters (CSD,CSI,CSEP,CSED,DB,P) constant in both cases, we will get 1 point for QB and 1 for OB which adds 400 to our total and serving 20 seconds more will deduct our score by 20 points only.

Case 2:- Not Serving Queen Ant Hill
Assuming other parameters (CSD,CSI,CSEP,CSED,DB,P) constant in both cases, we will not get 1 point for QB
and 1 for OB which incurs a loss of 400 to our total and serving 20 seconds less will add only 20 point to our score.

Challenges

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

(8)

- **Service Providing Mechanism:** One of the major challenges would be to design an accurate and efficient mechanism right from scratch, to drop the service blocks into assigned area precisely.
- **Servo Motion Management:** Based on the analysis done by us on the desired mechanism, we would require servos included in the kit. The major challenge would be to manage the order of operation of these servos as operating more than one servo at a time may draw a large amount of surge current damaging the microcontroller.
- **Power Management:** Since we would be using servos and sharp IR range sensors we need to take into consideration there current and voltage ratings, and control there switching so that they are off when not in use thus preventing drainage of excess power.
- **PCB Mounting:** As we all are from CSE major, the major challenge is to mount all the components on PCB Board.