

**e-Yantra Robotics Competition - 2018**

**Theme and Implementation Analysis – Ant Bot**

**2268**

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**Scope and Preparing the Arena**

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

**(5)**

< Team should briefly explain in their own words the theme assigned. What in your opinion is the purpose of such an application?

Answer format: Text, Word - limit: 100 words >

The Ant Bot theme includes simulating full functioning of an Ant i.e. collection of food and placing it in an ant hill and also cleaning the ant hill. This is carried out by using pick and place mechanism for transportation of supplies and trash. To recognize the supplies, colour detection will be employed. Requirements of ant hill will be conveyed through ArUco markers. Main purpose of pick and place is for fast and precise handling of hazardous object in industries. Additional purpose of such an application is to appreciate systems present in nature and make most efficient possible algorithm.

**b. Upload the Final Arena Images.**

**(20)**

< Prepare the arena according to the steps given in Section 4: Arena, of the Rulebook. Please follow the sample SIM Placement Document (provided in Task 2) and example Supply Placement Table and Trash Placement Table in section 3: Theme Description of arena. Your final arena should look like as shown in Figure 7 of Rulebook.

**Take 4 photos** of the completed arena from different angles such that the entire arena along with its components such as SIMs, Supply Blocks, Trash Blocks, AH Walls, etc., are clearly visible in the photos.

Answer Format: The four image files should be uploaded as **.jpg** along with this document as per instructions in Read Me for Task 3. >

**Building Modules**

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

**(5)**

< Team should classify the components into various categories: mechanical systems, electronic systems etc. and mention how these units will be used in the theme. You may draw diagrams/figures to illustrate your answer.

Answer format: Bulleted form

1. Component 1

2. Component 2

3. Component ….etc. >

The Ant Bot is a big system from execution point of view. It can broken down into smaller problem statements for ease of execution.

Nested list of the components :

* Ant Bot
  + Mechanical Systems
    - Pick and Place
      * Servo Motor
    - Chassis
    - Wheel assembly
      * DC Motors
      * Wheels
    - Pi Camera Stand
      * Micro Servo
  + Electronic System
    - Raspberry Pi
      * Nano
        + Line Sensor

Path following

* + - Pi Camera
      * Direction
      * Colour Detection
      * ArUco Detection
    - Locomotion
      * Motor Driver
        + DC Motors

The following Tree Diagram illustrates sub-modules included in the Ant Bot system :

**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)**

< Team should mention the power requirement of their system with current rating and voltage requirement. You can also draw some diagrams/figures to illustrate your answer.

Please provide the answer in your own words.

Answer format: Text, Word-limit: 100 words>

The power specifications of all the electronic components has been mentioned in its datasheet from which the following table is made.

|  |  |  |  |
| --- | --- | --- | --- |
| Specifications | Raspberry pi | DC Motors | Standard Servo |
| Voltage | 5V | 12V | 4.8V – 6V |
| Current (min) | 2.0A | 0.8A | 0.25A |
| Current (max) | 2.5A | 9.5A | 2.2A |
| Required (Estimated) | 2.1A - 2.2A | 2A | 1A |

Power consumption of Raspberry Pi won’t change significantly while operating in the headless mode. So most of the power will be required for actuations of motors, but since we will be controlling speed of DC motors by giving it pulse width modulated signals we will be able to decrease the power dissipation.

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

**(5)**

< Support your answer.

Answer format: Text, Word - limit: 200 words >

No, I don’t feel it is possible to use a single power due to following reasons :

1. First of all voltage and current requirements of all the electronic components are different.
2. Similarly, discharge current capacity of Li-ion battery and power bank is different.
3. Raspberry pi needs 5V voltage and minimum 2 A current.
4. Whereas, DC motors needs minimum 12V voltage and up to 1A – 2A current as ant bot won’t be very heavy.
5. Moreover, servo motors needs 4.8 V to 6 V and up to 1.5 A current on load conditions.

This makes it very complicated to use such a single power supply which will satisfy all the voltage as well as current requirements of the system.

**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)**

 < Explain your path planning technique(s). Clearly specifying the hardware components, inputs and outputs for your technique. You can explain multiple techniques.

Word-limit: 500 words. >

Input and output devices will not change along with change in techniques. Line sensing will be done via line sensor. The same can also be used for detection of node (i.e. where two lines intersect ). But for generalized solution we will have to use PiCam to detect node.

Output will be given through motors. But the output of the motors will also vary according to various parameters. While turning in a specific direction the wheel in the opposite direction will rotate at faster speed than the wheel in that direction etc.

Path Planning techniques :

Kruskal’s Algorithm:

This algorithm is used to find a minimum spanning tree and is normally employed in graph. A spanning tree is a subset of a graph (i.e. sub graph) which includes all the nodes of the graph. Whereas, the minimum spanning tree is a spanning tree but with bare minimum edges of least weight.

1. Make two sets one of total number of nodes in the forest say ‘A’ where each node is a tree and other set containing all the edges in the forest say ‘B’.
2. Take an edge of minimum weight from B if it is connecting two different nodes from A, remove it from set B and add it to set A. Combine those two nodes to form a single tree.
3. Repeat step 2 till B is a non-empty set.

At the end of the loop, set A will finally contain a minimum-spanning-tree. This technique can be used to determine the shortest path but it is not necessary that this whole part should be done at runtime as it will consume significant time.

**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)**

< Justify your answer by stating the advantage(s) of the chosen actuator(s) over others.

Answer format: Text, Word - limit: 200 words>

For designing of a pick and place mechanisms, at least two actuator will be required. One actuator (servo motor or BO motor) will be used for controlling movement of the claws of the gripper. Whereas, other actuator will be used to control movement of the of the gripper (elevation).

We will be using servo motors as actuators as it gives us some advantages over BO motors. The advantages are as follows :

1. Torque provided by servo motor is several times greater than that provided by BO motor.
2. Taking feedback from BO motor is very difficult whereas, it is possible for servo motor due to its construction.
3. Moreover, accurate position control is possible for servo motor i.e. we can move it by 1 degree precisely where as it is not possible for BO motor.

**Environment Sensing**

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

**(5)**

< Team should explain in detail how they will use the Line Sensor to traverse between two points/nodes in the arena.

Answer format: Text, Word - limit: 300 words>

***Line Detection*** :

As long as the outer LEDs (on left side and on right side) are sensing white surface and the central LED is sensing the black surface means that it is correctly aligned along the black line. This is the condition required for the motors to rotate. That is when the specified condition is satisfied both motor will rotate with same speed. Since both the motors will rotate with same speed bot will travel rectilinearly along the line.

***Node Detection (over lapping with Junction of two lines)*** :

When all the three LEDs simultaneously detect black surface means, that it has reached a junction of two lines. At this point there will be a decision making step whether to move straight or turn right or left according to the destination that is to be reached. For turning right, left wheel will have to cover more distance than right wheel. So left wheel will rotate at faster speed than right wheel. Similar technique will be used for turning left.

***Traversal*** :

Traversal will be done by first detecting the node and the moving towards the desired node by following the black line. So this includes line detection as well as node detection along with turning right or left etc.

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

**(5)**

< Think which a better option is: using a webcam or Picam? Support your answer by listing pros and cons of choosing each option.

Answer format: Text, Word - limit: 200 words >

Following camera depicts comparison between Pi Camera and a Web Camera :

|  |  |  |  |
| --- | --- | --- | --- |
| Specifications | | PiCam | WebCam |
| Resolution | 5MP | | 2MP mostly |
| GPU | Directly connected to GPU . Leaves it free for other Graphical processing. | | Does affect GPU as it is not directly connected to the GPU. |
| CPU | Need smaller time slice of CPU processing.  Hence, little effect on the CPU. | | Takes significant amount of time of CPU. Therefore, affecting the performance. |
| Speed | Fast | | Relatively, slow. |
| Frame Rate | Faster Frame Rate | | Slower Frame Rate |
| Camera Stand | Absent | | Present |
| Length of Connection | Very Small | | Long |
| Structure | Delicate | | Sturdy |

So from the above comparison, as long as, performance on Raspberry pi is concerned, PiCam is relatively the better option out of two. Since it is the faster out of two. Moreover, it gives better resolution. Though it has some disadvantages we can overcome them manually. So I would prefer PiCam over webcam.

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

**(5)**

< Answer format: Bulleted form

1. Sensor 1

2. Sensor 2

3. Sensor 3 ….etc. >

* **Encoder for motors** : This sensor would have helped us in taking feedback from the motors. It would enable us to traverse our bot perfectly straight, since no two motors rotate at same RPM at same PWM signal in any practical situation. Moreover, it would also enable us to calculate the distance travelled by the bot in runtime.
* **Proximity Sensor** : Proximity sensor can be calibrated for a specific distance. This would allow us to stop the bot at a specific distance from the wall for accurate placement of the supply block or trash block etc.

**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)**

< Answer format: Bulleted form

1. Step 1

2. Step 2

3. Step 3 ….etc. >

* Strategy 1 :

To try to capture all the SIM ArUco markers in one frame. Which will allow us to detect all the IDs simultaneously. This also includes identification of the position from which this can be accomplished.



Stops

* Strategy 2 :

Another strategy is to identify all the SIMs in two stops as shown in the adjacent diagram by rotating the bot or the stand of the picam from the specific spots shown in the image.

Or we can detect all four SIM in two stops . We will read all the SIM initially and accordingly provide the services.

1. Stop between SIM 3 and SIM 2
2. Detect SIM 3 turn 180 degrees Detect SIM 2
3. Stop between SIM 1 and SIM 0
4. Detect SIM 1 turn 180 degrees Detect SIM 0

* Strategy 3 :

This strategy includes scanning all the SIMs in one go. This will be done by stopping the bot at the central node and scanning all the markers by either rotating the whole bot or by rotating the pi camera stand.

**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)**

< Explain in your own words. Answer format: Bulleted form, word-limit: 30 words

Ant Hill Number:

Ant Hill type:

Service Requirements:

>

* *Ant Hill Type* : Regular
* *Ant Hill Number* : 2
* *Service at Requirements*:  Honey Dew at Location 2 and Leaf  at Location 1
* *Cleaning of Trash : Not required*

**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)**

< Explain in your own words. Answer format: Bulleted form, word-limit: 300 words

Reason 1:

Reason 2:

Reason 3:…etc. >

The table below depicts the binary number equivalent to the ArUco IDs mentioned above :

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number** | **QAH** | **Ant Hill Number** | | **Service at location 2** | | **Service at location 1** | | **Trash** |
| ***25*** | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| ***60*** | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| ***217*** | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| ***226*** | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |

Mentioned combination of SIMs is not possible for following reasons:

1. There are two QAH in the given example, which is not possible .
2. Three Ant Hill out of four needs Wood as supply whereas there are only two units of wood are available in a single run.

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

**(3)**

< Explain in your own words. Answer format: Bulleted form, word-limit: 300 words

Condition 1:

Condition 2:

Condition 3:…etc. >

Following are the conditions which indicates end of a run :

* The Ant Bot completes the task and switches on buzzer for 5 seconds at start position.
* The total time duration of the match is over (i.e. at the end of 10 mins).
* The team needs a reposition but has already used two repositions.

**Algorithm Analysis**

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

< The flowchart should elaborate on every possible function that you will be using for completing

all the tasks in the assigned theme. Follow the standard pictorial representation used to draw a

flowchart.

Answer format: Text, Word-limit: 1000 words >

Start

Raspberry Pi

PiCam

Standard Servo Motors

Micro Servo

Stop

Arduino Nano

Line Sensor

Is only central LED HIGH ?

DC Motors

Motor Driver

Speed of Right Wheel = Speed of Left Wheel

Is central and right LED HIGH

DC Motors

Motor Driver

Speed of Right Wheel < Speed of Left Wheel

Is central and left LED HIGH

DC Motors

Motor Driver

Speed of Right Wheel > Speed of Left Wheel

Has destination arrived ?

Yes

No

Yes

No

Yes

No

Yes

No

Grip by gripper

Is the object detected ? 

Is the place detected ? 

Standard Servo Motors

Release the gripper

Yes

No

No

Yes

**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)**

< Answer format: Text, Word-limit: 450 words >

We will serve queen first in any of the case mentioned above. Because serving queen first gives us extra hundred points. Moreover, even if we lose 20 seconds it is not only compensated by the bonus points but we also get extra 80 points. If after losing 20 seconds there is some time remaining those may points will also get added into the tally. Most importantly, by serving queen we are providing ourselves with the opportunity to be eligible for the overall bonus points of 300 points, provided we don’t draw any penalty.

**Challenges**

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

**(8)**

< Answer format: Bulleted form

1. Challenge 1

2. Challenge 2

3. Challenge 3, etc. >

1. Path Planning :

Major challenge in the theme will be automation of this bot. We will have to enlist all the combinations possible and create a sequence for each one of them. We will also have to reduce the computation to speed up the whole process. We will also have make a general solution.

1. Picking and placing the supplies/trash :

This process involves co-ordination between the pick and place mechanism and image processing. This can be achieved by maintaining a specific distance between the box and the bot from where it can be picked up appropriately.

1. Completing the theme before 10 mins :

Completing this complicated theme before 10 mins will give us extra points. This can be done by hard coding some part of the theme execution where it is possible. Because as the number of feedback increases in the system, it becomes more slow. Moreover, it can also be done by increasing the baud rate between Arduino and Raspberry Pi which will increase the volume of the data being transferred between the Arduino and Raspberry Pi.