e-Yantra Robotics Competition - 2018

Theme Analysis and Implementation - Nutty Squirrel

<NS#4889>

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Scope and Preparing the Arena

Q1. State the scope of the theme assigned to you. (5)

The theme assigned to us i.e. Nutty Squirrel demonstrates the activities performed by a squirrel in the search of nuts.

In this theme, we have to design a bot which can implement path planning to reach the nus while avoiding the obstacles and smartly choosing the shortest path from its current position towards the nuts, and if it encounters any obstacles in its path, it again calculates the shortest path from that position towards one of the nuts, hence avoiding the obstacles.

Once the bot reaches one of the nuts, it decides the destination point for that nut based on the colour of the nut, then based on its current position and shortest delivery point, it decides its path again.

The bots repeats this process i.e.: -

Path planning → Avoiding obstacles → Picking Nuts → Placing Nuts

The theme can find its application in warehouses, where objects are to be stored based on some given requirements. Obstacles can be replaced by humans, and any other real life objects and path planning can be implemented to reduce the time required in this process. This will reduce manual labour and increase the productivity of the industry.

Q2. Attach the image of final arena that you have prepared. (5)

< Prepare the arena according to the steps given in *Preparing the Arena* section in Rulebook. Please follow the arena configuration shown in Final Arena of the Rulebook.
Place the Nuts (Red, Blue and Green) in the Pick-up Area and Lift structure in lift section.
Take 3 photos of the completed arena from different angles such that the entire arena is clearly visible in the photos.
The three image files should be uploaded along with this document in zip format.>

Building Modules

Q3. Identify the major components required for designing the robotic system and lift mechanism for the solution of the theme assigned to you. (5)

Robotic System:

Mechanical System

1. Wheels: Motion of robot
2. Motors: Motion of robot
3. Chassis: Body of the robot
4. Pick & Place Arm: To accomplish the pick and place task
5. Pick & Place Gripper: To grip the object to be picked

Electronic System

1. Microcontroller Board: Controls the motion and actions to be taken by the robot.
2. Line Sensor: Line following sensor senses the line to be followed
3. Colour Sensor: Senses the colour of the object to be picked
4. Motor Driver: Drives the base motors on the control of microcontroller
5. Power Supply/Battery: Powers the devices on the robot.

Lift Mechanism:

Mechanical System

1. Spur Gear: Used to transmit the power to lead screws from the motor.
2. 8 mm bearing with Bearing Brackets: Provides room for lead screws to rotate.
3. 8 mm bore Timing Pulley: Timing pulleys are mounted coaxially on both lead screws, timing belt rotates other lead screws.
4. 8 mm Lead Screw: Rotates with the help of timing belt that is driven by the motor.
5. Timing Belt: Used to transmit power to other lead screw
6. Motor Clamp: Used to clamp motor or the vertical surface.

Electronic System

1. DC Motor: The whole lifting mechanism revolves around the DC motor.
2. Limit Switch: To detect that the platform is reaches at the extremes (i.e. at top and bottom).
3. IR Sensor: To sense the presence of robot on the lift mechanism platform
4. Battery/Power Supply: To power the DC motor and other devices.

Q4. Can you optimize the given sensors and actuators to perform the tasks. If yes, then how? (5)

Robot:
1. Line Following Sensor: Can be used to sense the line for line following as well as node detection.
2. IR Proximity Sensor Module: Can be used to detect the obstacle/presence of an object in a certain range.
3. Sharp Sensor: Can be used to sense the distance of object/obstacle.

Lift Mechanism

1. IR Proximity Sensor Module: Can be used to detect the obstacle/presence of an object in a certain range.
2. 60 RPM DC Motor: Can be used to lift the platform in lift mechanism.

Actuators

Q5. What are the different actuators you are planning to use in the robot and lift mechanism. Justify their use? (5)

1. Actuator1 : 100 rpm johnson motor used for traversing of bot.

2. Actuator2 : 60 rpm johnson motor for lifting mechanism.

Power Management

Q6. Explain the power management system required for a robot and lift mechanism in Nutty Squirrel theme implementation. What are the aspects that you should look into for designing the power management? (5)

The aspects that we are looking into for designing the power management system is

1. Current and voltage ratings of components.

2. Wattage of each component and total wattage.

Components used and their ratings :

1. 2 johnson motors (100 rpm)

2. 1 dc motor (60 rpm)

3. Arduino mega and nano

4. Color sensor

5. Motor driver

6. Line sensor

7. IR and sharp sensor

8. LCD

9. LEDs

Power management system is designed for higher efficiency and longer sustainance.

Design Analysis

Q7. How are you planning to design the robot to detect the presence of Obstacles, Nuts and Lift structure? (4)

The bot is equipped with color sensor (TCS3200) and Sharp Proximity Sensor. If the IR sensor indicates distance less than a given threshold then the bot has to decide whether the object in front of it is an obstacle, nut or lift.

An object can only be a nut if it is of either color i.e. Red, Green, Blue hence once the thresh value of IR sensor is reached it checks with the colour sensor to verify the above condition and decides the drop location of the nuts.this process is simplified even more by adding another condition of the location of the bot , if it is at a nodenext to the nuts only then will it check for the color else it will check for other conditions.

The object is an obstacle if the bot is traversing from one node to another and proximity reads distance less than threshold then the object is declared as obstacle and accordingly action is taken.

The object will be recognized as a lift if the bot is at closest node towards the lift and distance is less than threshold, on being declared as a lift the bot moves on lift platform and stops in middle, the lift then takes the bot from one level to another.

Q8. Teams have to design a mechanism for picking and placing the Nuts in Deposit zones.

a) Choose an option to position the mechanism on the robot and why? (4)

1. Front 2. Back 3. Right/Left 4. Other position

FRONT

The pick and place mechanism on our robot will be on front side. The nuts are placed at 12 'O' clock position of the bot always. The mechanism will be simple, small and easy to assemble by placing in front of robot. Another aspect will be centre of mass of bot that will play an important role in proper traversing of bot. Since back side of bot consists of other heavy components, it is better to mount pick and place mechanism on front portion of bot.

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

Pick and place mechanism is mounted on front side of bot consisting of two hands. One arm is stationary straight facing forward and the other arm is rotating with the help of servo motor motor that will pick and place the nuts in proper positions. The servo motor is mounted above front IR sensor, this servo motor arm will pick the nuts along with stationary hand mounted on the bot.

c) What challenge/s do you expect to face while designing the picking and placing mechanism of the Nuts and how you will overcome them? (2)

Challenge: Correctly positioning of bot in front of nuts for proper lifting

Solution: One arm is stationary and the other arm is moved with the help of servo motor. This makes it possible for bot to pick the nuts from enough distance.

d) Explain the design and working of the lift mechanism. (4)

The lift mechansim is designed to lift a bot of approx 1kg. The components we used in lift mechanism are lead screw, gear, 60 rpm johnson motor, timer belt, pulley, composite platform, 8mm strud, limit switch and IR sensor. The lead screw mechanism is placed on right hand side of the box. As soon as the bot comes on composite platform, IR proximity sensor detects the presence of bot on platform and the platform starts moving up till the upper limit switch is pressed. The platform stops and bot traverses forward. Again when bot returns on platform, the IR proximity sensor detects its presence and the composite platform stops moving downwards till it presses the limit switch mounted at the bottom.

e) What challenge/s do you expect to face while designing the lift mechanism and how

you will overcome them? (2)

Challenge: Speed is less of johnson motor i.e 60 rpm.

Solution: That particular thing is required for high torque I.e lifting up of more weight.

Challenge: Manufacturing of levelled arena

Solution: As the arena is meant to be of thermocol at the beginning, but it was a relief as it is allowed to manufacture it with wooden plank.

Testing your knowledge (theme analysis and rulebook-related)

Q9. Answer the following questions related to the sensors

a. What is the principle of operation for: (i) the color sensor and (ii) Sharp Sensor (iii) IR Sensor? Also, for each sensor mention the threshold value for sensing. (15)

i) Colour Sensor:

The color sensor shines white light at object and then records its color as well as intensity of the reflection. It consists of an 8*8 array of photodiodes, 16 for each Red, Green & Blue, the remaining set of 16 photodiodes are clear. These photodiodes generates an equivalent amount of current for each color. This current further is input to current to frequency convertor which generates square wave of frequency proportional to the intensity of light.

ii) Sharp Sensor:

There are two types of Sharp IR sensors Analog ranges provide information about the distance to an object in the ranger's view. These rangers all use triangulation and a small linear charge coupled device (CCD) array to compute the distance and/or presence of objects in the field of view. A pulse of IR light is emitted by the emitter. The light travels out into the field of view and either hits an object or just keeps on going. In the case of no object, the light is never reflected, and the reading shows no object. If the light reflects off an object, it returns to the detector and creates a triangle between the point of reflection, the emitter and the detector

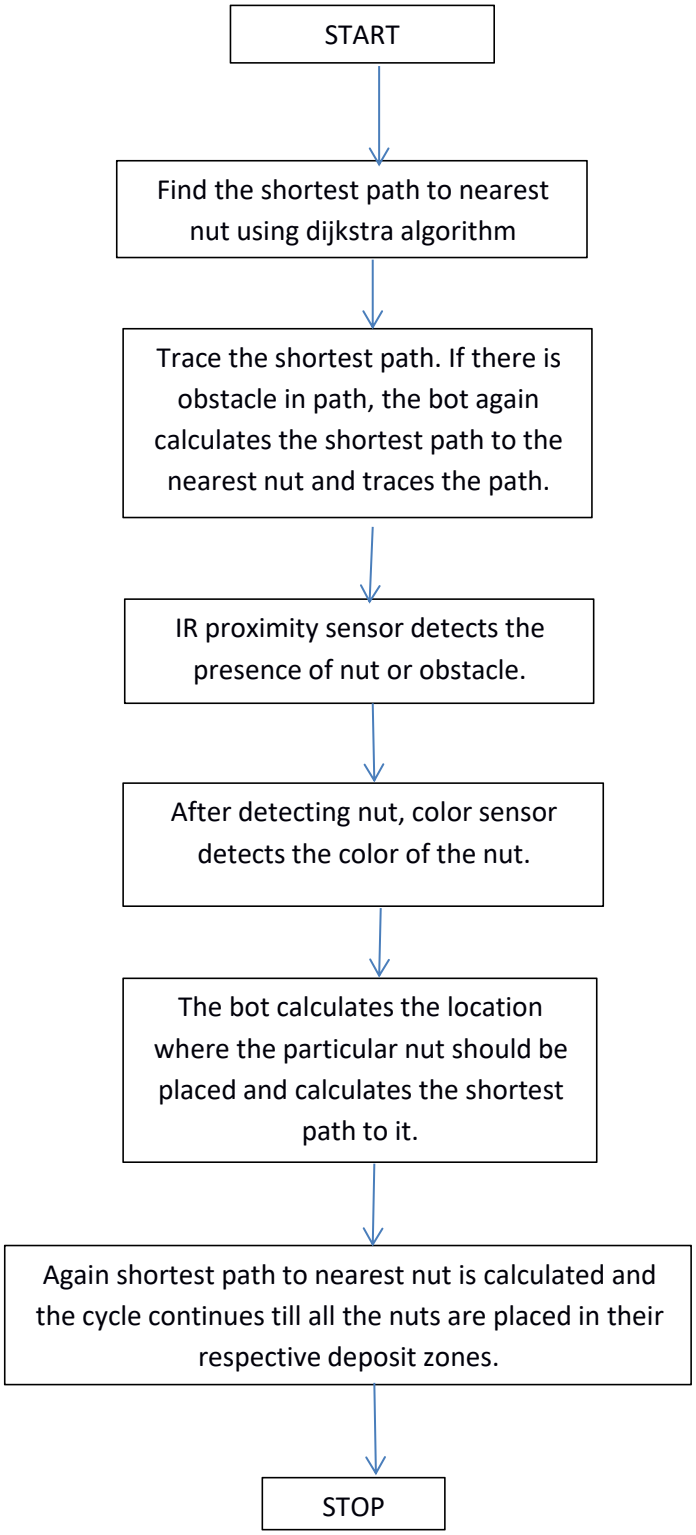
iii) IR sensor:

The infrared sensor is a combination of two devices, one of them is an infrared LED and other is a photodiode, both of them are placed next to each other. Infrared LED emits infrared light and photodiode senses the infrared light. The sensor when placed against a surface, if the surface is bright almost all of the emitted light gets reflected back and is sensed by the photodiode. However if the surface is dark very less amount of light is reflected back and hence nothing is sensed by photodiode.

Algorithm Analysis

Q10. Draw a flowchart illustrating the algorithm you propose to use for theme

implementation. **(10)**



Q11. What path planning algorithm you are planning to use and how it is going to affect the theme implementation? (5)

After studying various path planning algorithms which include Djikstras, A* shortest path algo, BFS , DFS, we decided to go with Djikstras algorithm.

Djikstras algorithm gives the shortest path from a start node to an end node in a weighted undirected graph. At every node it checks for the nearest adjacent node until it reaches the destination, the process is repeated recursively until each and every possible path from start to end node is analyzed and the shortest of all those paths is returned.

We decided to go with djikstras algo because other than calculating shortest path from one node to another our bot had to calculate nearest path everytime a new obstacle was encountered which is easy in djikstras implementation as all paths are already calculated and all we had to do is travel on next nearest path. Djikstras is easy to implement and when dealing with fewer nodes it is rather fast with time complexity O(E*log(v)) where E is the no. of edges and V is the no. of vertices.

We stored the graph in an adjacency matrix with weights calculated as per the rough length of the path from one node to another.

Programming

Q12. How do you plan to synchronize the actions of robot and lift mechanism? (5)

The lift mechanism includes 2 limit switches and an IR proximity sensor mounted at the centre of the lift structure.

The role of the lift structure is to indicate the presence of the bot on the lift, if the distance indicated by the IR is less than a certain threshold the lift has to start moving up or down based on its own level i.e. if it is at bottom it goes up and vice versa.

The bot on reaching the node of the lift structure waits at rest until the IR proximity mounted on the bot indicates a distance of more than the distance from the wall, it continues its motion when thresh is crossed.

The limit switches decide when the lift has to stop its motion and the current level of the lift. Initially bottom limit switch is pressed indicating it is at base and has to move up, when the top limit switch is pressed the lift stops moving up allowing the bot to move to another level. If the lift is at top level and bot moves on the lift the lift starts going down until bottom limit switch is pressed.

Challenges

Q13. What are the major challenges that you can anticipate in addressing this theme and

how do you propose to tackle them? (5)

1. Challenge 1: Motor shafts are too lengthy increasing the total dimension of the bot, thus making line following little more complicated.

   To avoid this problem we decided to keep the motors side by side rather than matching their shafts, thus the length of the bot reduces solving our problem.

2. Challenge 2: Feedback of colour sensor is not accurate and varies a lot with change in lightning

   Condition.

Cost Analysis

Q14. What is the approximate cost of theme after considering individual component?

(You may include fle x printing cost as well, list it separately)

Considering individual component the approximate cost of the theme is estimated around Rs. 7800. Some of the major cost consuming components are Arduino Mega 2560, Johnson Motors, Servo Motor, Li-ion battery, Sharp Sensor.

Rules and Scoring

Q15. Nutty Squirrel theme consists of the following formula for scoring as mentioned in Judging and Scoring section of Rulebook:

Total Score = (600-T) + (CD*50) + (CDP*100) – (ID*20) – (IDP*40) + B – P

What will be your strategy to earn maximum points in a run? (10)

We will try to earn maximum points by completing the task in the least time possible.

Our program is written in such a way that there are very few chances of wrong output given by sensor thus eliminating the chances of wrong color detection.

As per the tests taken in vrep simulator we tried to maximise the accuracy of our bots pick and place mechanism

We will try to earn more points in this zone.

We are in the hunt of the bonus points as we are confident enough that our line follower can be made speed enough to complete the task in less than 10 minutes of time. This will be the main aim for getting more points in the game.

We will try our best not to damage the arena and keep safe distance from the obstacles.