e-Yantra Robotics Competition Plus (eYRC+ Pilot)

Implementation Analysis - Caretaker Robot

eYRC+#246

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Scope _ (5)

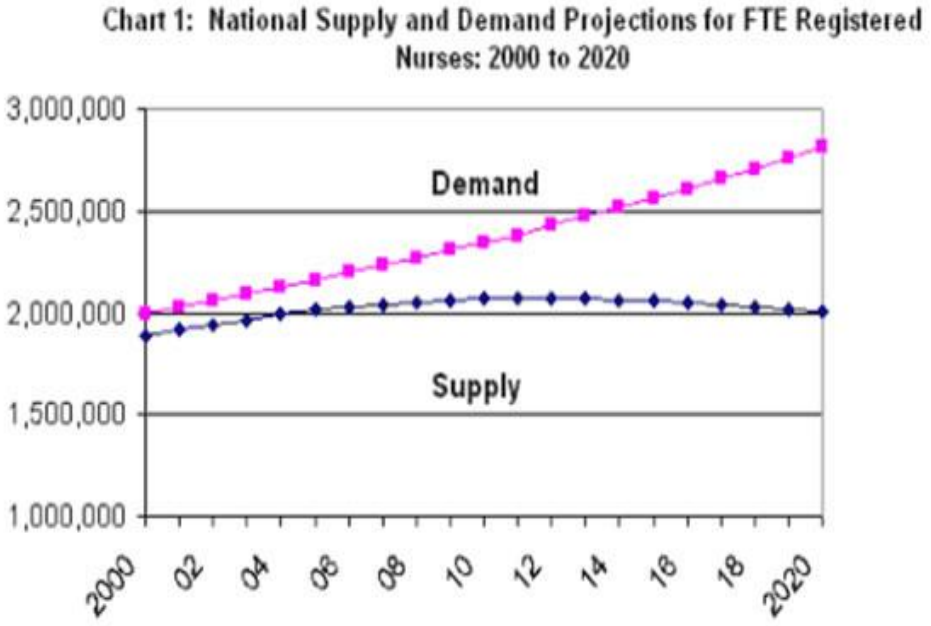
Q1. State the scope of the theme assigned to you.

<Teams should briefly explain in their own words the theme assigned. What in your opinion is the purpose of such an application? You may use figures / diagrams to support your answer.

Answer format: Text - limit: 50-100 words

Ans1.

- The theme "Caretaker Robot" revolves around how robotics can be used in health care sector.
- It aims at programming a robot which can perform specified jobs (like a nurse) in a hospital.
- The robot can deliver medicines to the patients at specified time and keep track of patient's well-being.
- Today, in many countries especially India there is a need of nurses.
- As compared to number of patients the number of nurses are very small.
- Non-availability of nurses can even lead to even death of a patient.
- The conditions of government hospitals are even worse.
- In most countries, there is a shortage of nurses but nowhere is it so acute as in the developing world.
- The developed world fills its vacancies by enticing nurses from other countries, while developing countries are unable to compete with better pay and better professional development.
- Therefore, this theme is very useful as it will fulfill simple needs of a patient in a hospital.
- This theme can be used in hospitals to make them automated.
- According to United Nations, one nurse were available for a population of 638.64 in India till 2011.
- According to the World Health Organisation, India will need 2.4 million nurses by 2015 to achieve the government's aim of a nurse-patient ratio of one nurse per 500 population.



Building Modules _ (5)

Q2. Identify the major components in your robotic kit required for designing a solution to the theme assigned.

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

Answer format: Bulleted form

1. Component 1
2. Component 1
3. Component ….etc.

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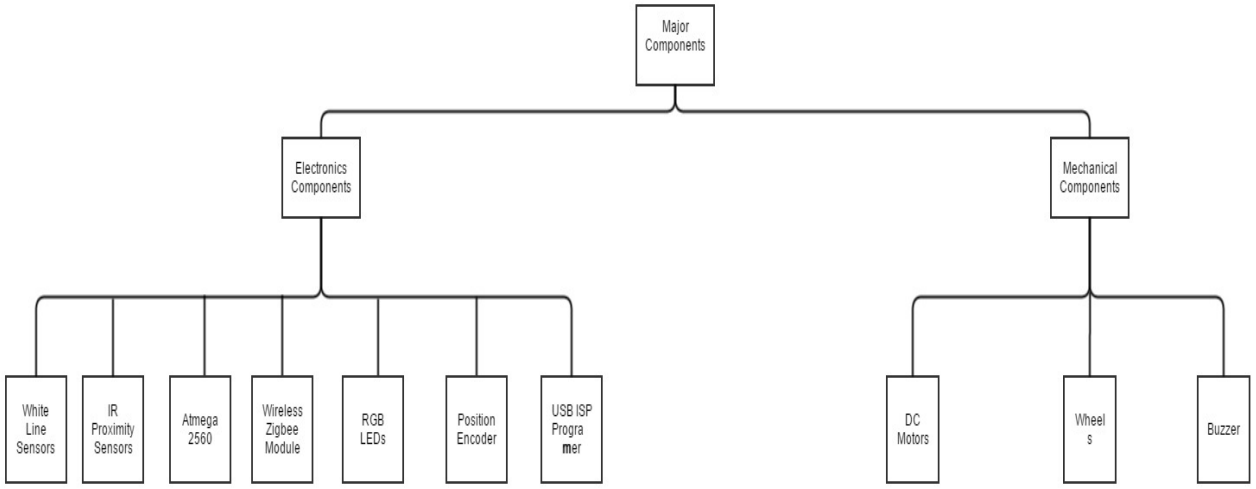


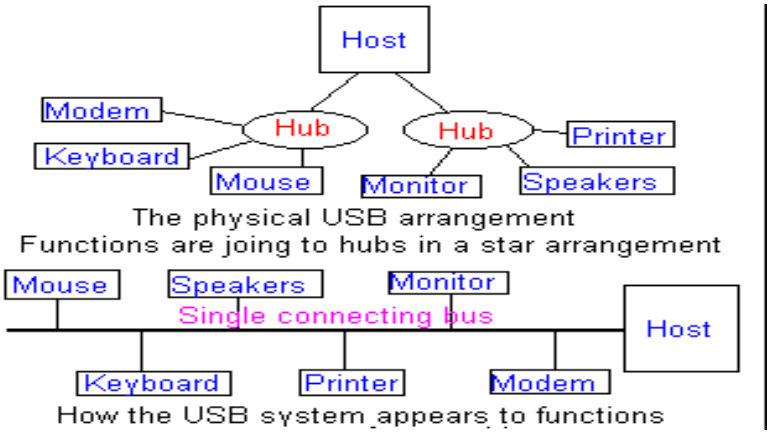
1. Mechanical Components:-
    a. DC Motors-⟶For the controlled movement of robot.
    b. Wheels⟶For movement of robot.
    c. Buzzer⟶To indicate the end of the task/run.
2. Electronic Components
    a. White Line Sensors⟶ To prevent robot from moving outside of the arena.
    b. IR Proximity Sensors⟶ To detect walls coming in the way of robot.
    c. Atmega 2560 Microcontroller⟶ For programming robot to perform the given task.
    d. Wireless Zigbee Module⟶ For wireless communication between robot and laptop.
    e. RGB LEDs⟶To Signal about the item being picked and dropped.
    f. Position Encoders⟶For encoding the position and controlling the speed.
    g. USB ISP Programmer/usb burner⟶ For burning the program in Atmega 2560.
    h. Battery⟶For powering up the robot for the given task.

Communication (10)

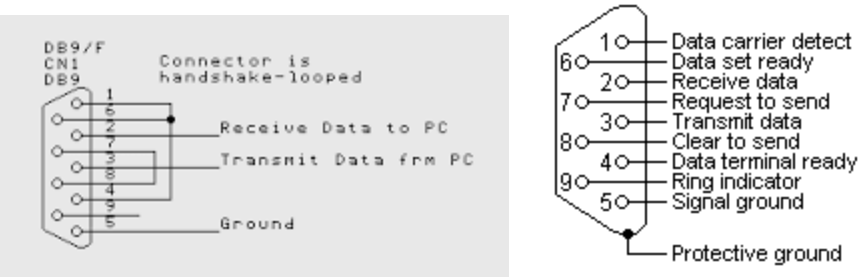
Q3. Describe the method of communication between the computer and the Fire Bird V robot. Please draw a block diagram illustrating the same.

<You can also draw some flowcharts/figures to illustrate your answer.
Answer format:
1. Description
2. Block Diagram
>

1. USB⟶ USB is a system for connecting a wide range of peripherals to computer, including pointing devices, displays, data storage and communication products. Today a huge range of peripheral equipment's including sensors, digital cameras, special pointing devices need their own connection to the PC. While parallel and serial sockets can be used by many different devices but they cannot be shared by more than one device at a given time. USB is a solution for such a system. When the software requires data transfer to occur between itself and the USB, it sends a block of data called an I/O Request Packet (IRP) to the appropriate pipe, and the software is later notified when this request is completed successfully or terminated by error.In our case this type of communication is used to burn hex code with the help of BootLoader software. It transfers data serially between laptop and robot.



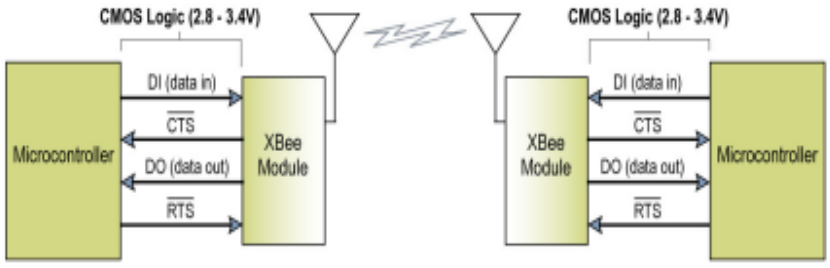
2. Communication through serial Female DB9 connectors→Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. They are used to transmit data over relatively long distances. For eg→keyboards and mouse work through serial communication. A female DB9 connector uses 9 holes.They are widely used on DB9 cable assemblies for data connectivity. This type of communication uses female DB9 connectors to communicate between laptop and robot.



FEMALE DB9 CONNECTOR

3. Zigbee Wireless Module→ This is an enhanced feature used to wirelessly connect robot with the laptop.The XBee RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device. It consumes low power and its transmission distance is from 10 to 100 metres of Line of Sight. ZigBee is typically used in low data rate applications that require long battery life and secure networking. ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks, such as Bluetooth or Wi-Fi. ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer.

System Data Flow Diagram in a UART-interfaced environment
(Low-asserted signals distinguished with horizontal line over signal name.)



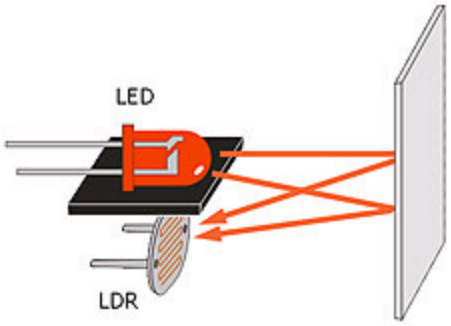
Environment sensing (10)

Q4. Explain the functioning of environment sensing technique used by you.

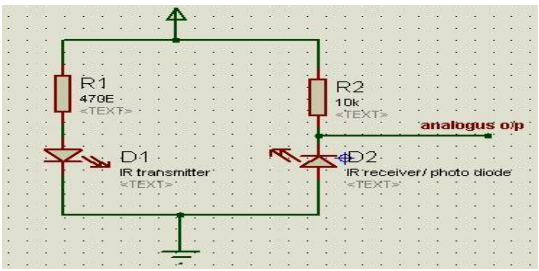
<Teams should mention the type of sensors they would need for their robot to sense the environment (for example, the configuration of the arena) associated with their theme. Teams should also justify the need for such sensors, and may even suggest alternate sensors that may be used. You can also draw some diagrams/figures to illustrate your answer.

Answer format:
1. Explanation
2. Alternatives
>

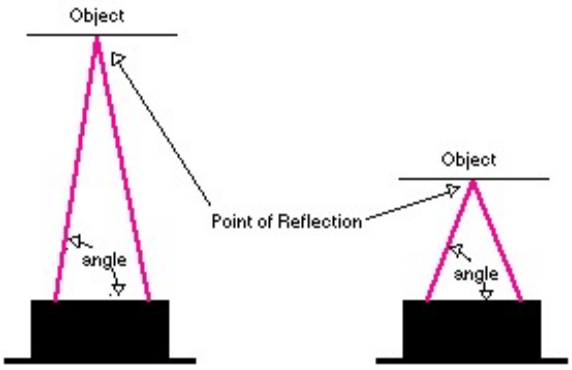
1. White line sensors⟶ They are used to detect white line present on the surface. They can also be used to ensure stable movement of the robot in the required direction. In our task, white line sensors prevent the robot from moving outside of the arena. They are highly directional in nature. Whenever the robot tilts from white line sensors detects the change and microcontroller gives instruction to the motor accordingly so that bot continues to move on white line. It consists of photo transistors for line sensing. Leakage current flowing through photo transistor determines whether the bot is on white line or not. Whenever the bot is not on the white line the leakage current decreases leading to an increase in voltage and vice-versa. These sensors can be calibrated according to requirement. Sensors need to be calibrated according to environmental conditions. Calibration of white line sensors of firebird V robot can be done by using trimming potentiometers located at top center of the board. Red LEDs are used in white line sensors instead of IR LEDs



2. IR Proximity sensors⟶ IR sensors are used to detect obstacles lying in the range of approx. 10cm. They can be used in our project to detect wall divisions, fixed partitions and bed from a distance and sense the direction accordingly. When there is no obstacle around the robot leakage current reduces and as a result output voltage increases to about 3V. In the presence of obstacle in the specified range there is reflected light which causes voltage to fall. It is by this mechanism that IR sensors detect the presence of any object in its nearby surrounding.The given circuit diagram represents IR transmitter-receiver pair. Whenever transmitter detects active high, receiver sends high voltage as output and vice-versa.



Alternatives⟶1.Sharp IR sensors (For IR proximity sensor)⟶ Used to detect the distance of an obstacle from the bot. It is more accurate than IR sensors. The position of the robot with respect to an obstacle can be easily determined using them. Sharp IR range sensors consists of IR LED and linear CCD array, both in a housing with precision lens assembly mounted in front of them. IR LED transmits a narrow beam which 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. Measured distance is function of the angle of reflection, therefore it gives same response for all coloured objects. Its main disadvantage is that when obstacle comes very near to the robot that is in the blind spot region the sensor gives incorrect readings.



Power Management (5)

Q5. Explain the power management system required for a robot in general and for Fire Bird V robot in particular.

< Teams should mention the power requirement of their system with current rating and voltage requirement. You can mention the mode (auxiliary/battery) you prefer to use in your system with necessary justification.
You can also draw some diagrams/figures to illustrate your answer.
Answer format: Text
Word-limit: 100 words
>

GENERAL ROBOT

- A general robot needs voltage supply in range of 6-24 volts and current rating in the order of milli amperes.
- Power needs depend on various factors such as type of micro-controller used or speed of robot.
- Voltage or current supply should lie within the range specified by the producer. If it exceeds rating of micro-controller then will lead to more power dissipation which in turn causes damaging of micro-controller.

FIRE-BIRD V ROBOT

- Works on voltage ranging from 8 to 12 V. NiMH battery is used which provides 9.6 V to power up the robot.
- Battery should not be discharged below 8V for extended battery life.
- Power supply of 5V is given to sharp sensors, LCD and various IC's. 3.3 V is required by proximity sensors and white line sensors. XBee module runs at 3.3 V.
- Special power management block has been provided which monitors battery voltage and smart battery charging, regulates on-board supply and does battery current sensing.

Preference of the mode of power depends on the condition under which we perform our task.
For example-If constant power supply is available for the robot for the whole time then auxiliary mode is preferred. In tasks like Quad copter, battery mode is preferred.
In theme provided to us, it is better to use the robot in battery mode because:-

- Fire-Bird V Robot can tolerate the load of a battery.
- Free movement is must in performing the task efficiently.
- Battery provided is sufficient to provide enough power to complete the task.

Navigation Scheme (10)

Q6. Explain in brief the basic navigation technique for path traversal in the arena. Explain the concept and list the components required for basic navigation.

< Teams should explain the basic idea of how the robot would navigate in the arena fulfilling the task assigned in the theme.
You can also draw some diagrams/figures to illustrate your answer.
Answer format: Text
Word-limit: 100 words
>

- First of all, image of arena is captured and processed to determine the orientation of the robot and the obstacles (green color). Also location of colored markers are determined.
- Image processing will also be used to determine the provisions requested by the patients.
- First of all, robot will change its orientation according to the instruction given by the laptop.
- Then it will start moving in the direction specified according to shortest path algorithm.
- In its way it will check whether some obstacle is in its range and it will resolve it. For eg. IR sensors can detect wall divisions from a distance. We can use sharp ir sensors if needed as an alternative.
- White line sensor will ensure that the robot does not move out of the track.
- Distance covered can be determined by position encoders.
- It will first move to get the provisions requested by patients of service zone .
- After reaching to first marker it will glow the LED, capture the image, determine the position of the robot and calculate shortest path to either patient or next marker (depending on number of requests and number of provisions robot is carrying).
- Finally it will move to patients who want provisions (at most 2 in 1 delivery) and then reach to their table choosing shortest path.
- On reaching the tables of respective patients,it will turn off the respective LED.

- Following the same conditions robot will reach to all patients who have requested for provision and stop glowing respective LED .
- After the completion of job,a long buzzer is sounded.

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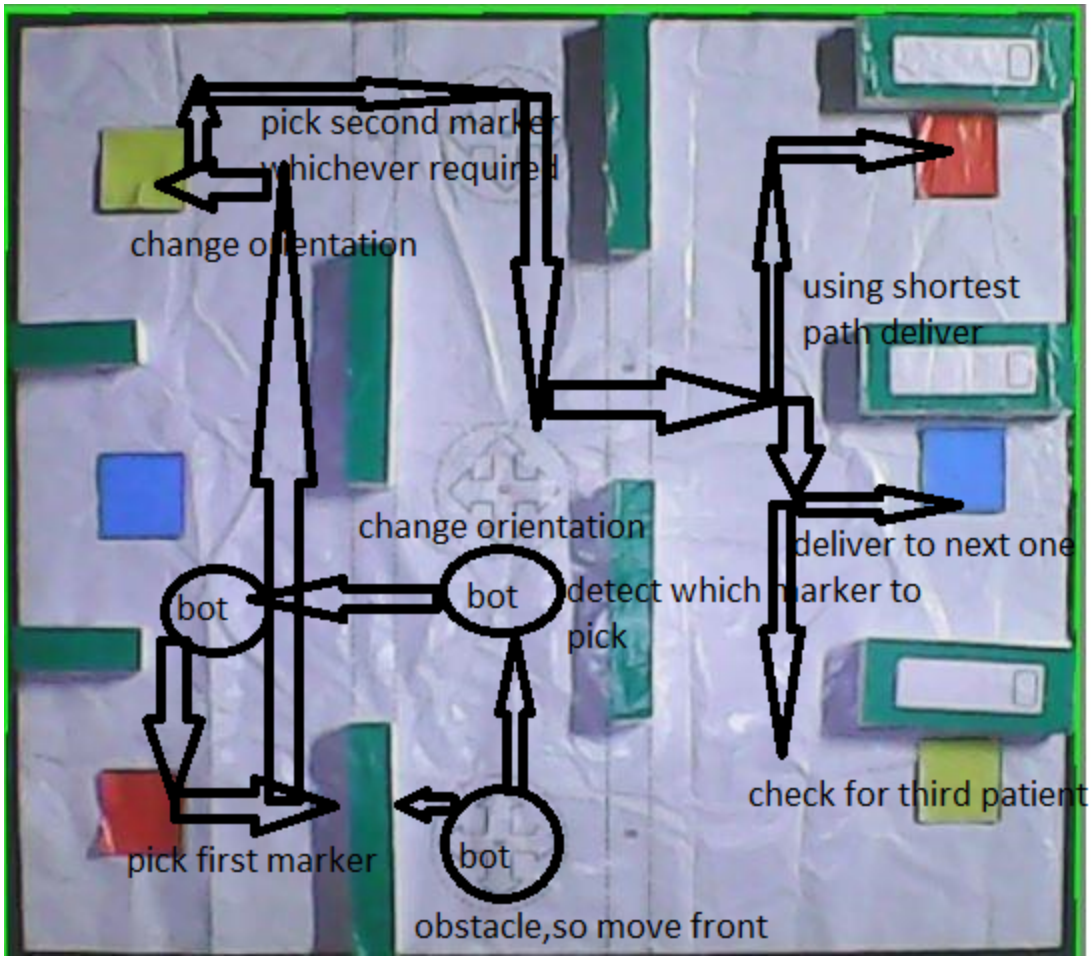
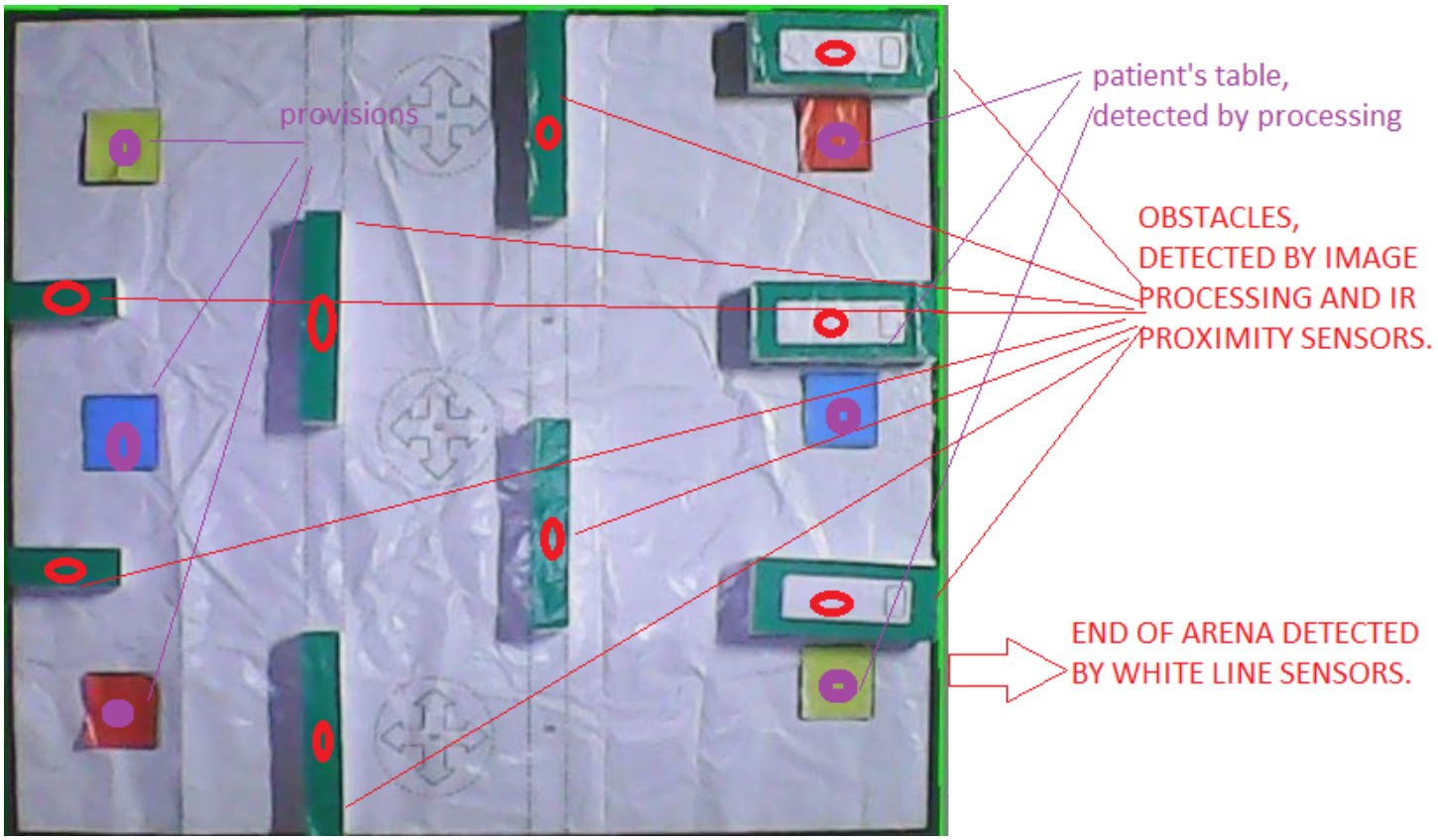
Components required for basic navigation are-

- IR Proximity sensors/sharp ir sensors
- Position encoders
- White line sensor
- Wireless Xbee Module
- Wheels and other miscellaneous components(like DC motor etc.).



BASIC NAVIGATION TECHNIQUE

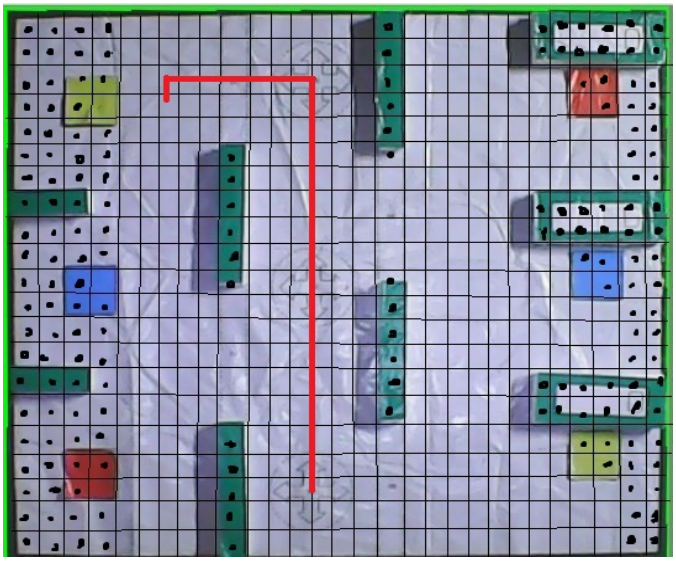


Testing your knowledge (Based on theme and rulebook) (10)

Q7. Explain in your own words how the robot will avoid the obstacles in the arena.

< Teams should explain the basic idea of how the robot would avoid obstacles. You can also draw some diagrams/figures to illustrate the concepts.
Answer format: Text
Word-limit: 100 words
>

- IR sensor can detect 3-D obstacles like walls.
- for example-->



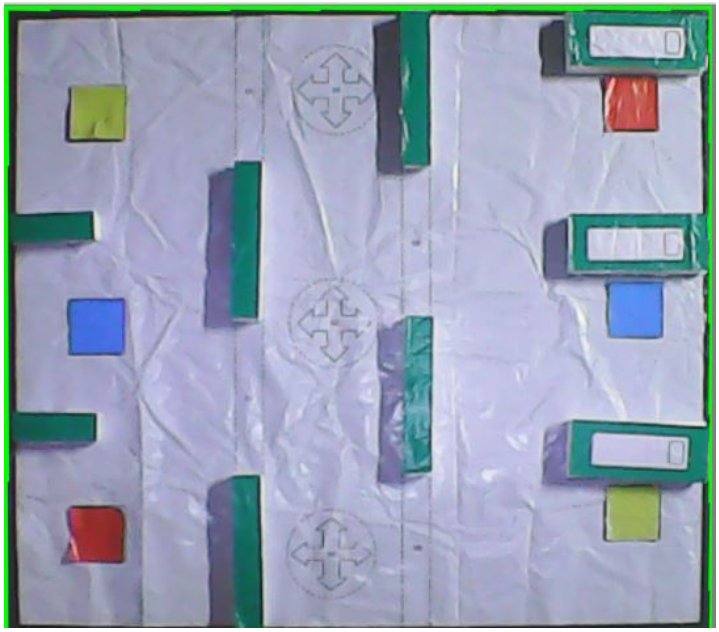
- By image processing we know that first obstacle is in the left side, second obstacle is in the right side, third obstacle is the left side, fourth obstacle is right side of the robot.
- So initially right side IR sensor is off and left side IR sensor is on.
- After a certain time as robot move in forward direction, right side IR sensor switch from off state to on state.
- So now we know approximately where is our robot now .
- To find the correct position we stop the robot and use image processing to correctly identify the position of robot(by finding the centroid of robot).
- We know the previous position of robot thus can identify whether robot is moving straight or not.
- If IR sensors state is not changing for long period of time(5-7 sec), we stop the robot and using image processing and find the position of the robot.

- We can use sharp sensor to avoid collision.
- Sharp Sensor can identify the distance of obstacle. Thus if robot is close to any obstacle we can identify that and thus can prevent robot to collide the obstacle.
- White line sensor at the bottom of the robot can identify white and black surface.
- Arena is white surrounded by black solid line.
- Detecting black solid line by the help of white line sensor situated at the bottom of robot we can make sure that robot does not leave the arena.

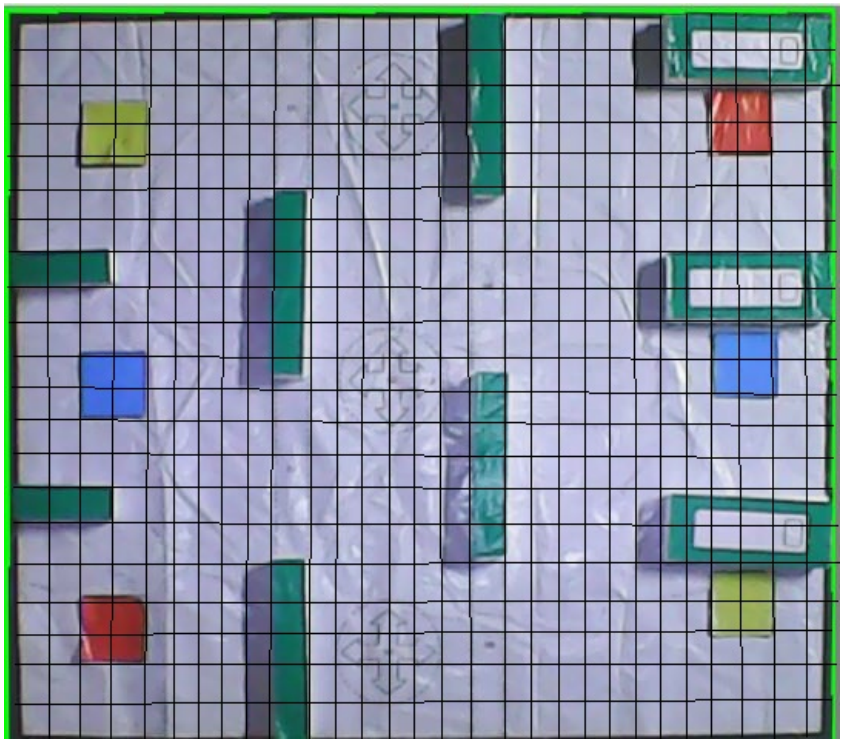
Q8. Explain how you will find the best path to follow.

< Teams should explain in their own words, the basic idea of path selection.
You can also draw some diagrams/figures to illustrate your answer.
Answer format: Text
Word-limit: 100 words
>

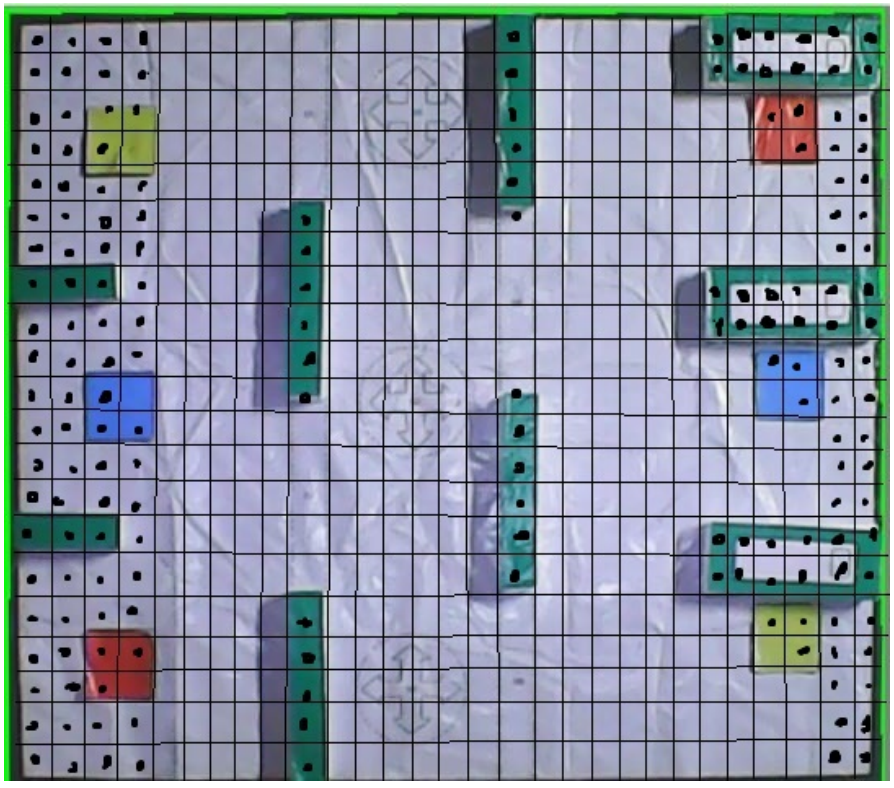
1. Take picture from camera and trim the image by the python code provided.



2. We make grid of horizontal and vertical lines and the distance between them is of 5cm.



3. Cell marked with black dots is dead end. We use Dijkstra (which is explained below) algorithm. Black dot cell is obstacle. So path length connecting black dot cell to its neighbour is infinity.



4. Colored cell which is not marked with black dot is considered as provision markers(left side) or tables (rightside).

Dijkstra algorithm:

- In this we take various destination as graph nodes and path between various nodes as edge of graph.
- Initially we define two sets, set A and set B.
- Set A contains nodes and edges of processed graph and set B contains unprocessed graph.
- Initially set A is null and set B contains whole graph
- We take start point from B and move it to set A and set start point equal to zero.
- Now we pick up an edge going from set A to set B such that we select minimum value of its length plus node value in set A and assign this value to the node in set B and move this node to A and repeat this process until we reach the destination point.
- In image we consider centroid of a cell as a node of graph and define edge between two centroids of length 1.
- Black cell ignored and no edge is defined connecting black cell to any other cell.
- From the picture we find the centroid of robot and this centroid is the starting point.
- For selecting minimum value of node length + node value we use heap.

Pseudo code for Dijkstra algorithm:-

```
Dijkstra(G,s,t)        //G: graph    s: starting vertex of graph      t:desired destination
        known = {s}
        for i = 1 to n, dist[i] = ∞
        for each edge (s,v), dist[v] = w(s,v)
        last = s
        while (last = t)
                select vnext, the unknown vertex minimizing dist[v]
                for each edge (vnext,x), dist[x] = min[dist[x],dist[vnext] + w(vnext,x)]
                last = vnext
                known = known ∪ {vnext}
```

Challenges (5)

Q9. What are the major challenges that you can anticipate in addressing this theme?

<Answer format: Bulleted form
1. Challenge 1
2. Challenge 2
3. Challenge 3, etc.
>

- First major challenge will be to process the image and divide it into a graph with each point representing a specific co-ordinate.
- After the decoding of image next challenge would be to give instructions to the robot to move in correct direction.
- The most important challenge lies in using image processing in task and to interface robot with the
- To determine the orientation of the robot at the start.
- Implementation of Dijkstra algorithm will be a major task.

- After each delay we take a picture of the image ,process it, implement the algorithm and then give instructions to the robot.This is one of the most important challenge.
- We have to keep track of dimensions of the robot.
- At each point we have to ensure that robot is safe from obstacles.
- After bot reaches the patients table glowing LED and starting buzzer is also challenging.