e-Yantra Robotics Competition Plus (eYRC+ Pilot)

Implementation Analysis - Caretaker Robot

eYRC+ #1673

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Scope (5)

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

Theme:

The theme consists of an arena representing a floor of a hospital having three zones: Patient zone, Service Zone and Corridor connecting the two zones. An overhead camera captures the image of the arena. Using Python and OpenCV, the provisions and obstacles are detected and a path is sent to the robot wirelessly. The robot attends to the needs of the patient (provisions such as Medicine, Thermometer or Water) and delivers them autonomously avoiding any obstacles.

Applications:

1. It can be used in hospitals as well in smart homes, offices, hotels and restaurants to efficiently deliver the needs requested by people (Eg: TUG Delivery Robots).
2. They can be used as automated guided vehicles (AGVs) in transportation and sorting of goods around large facilities, such as warehouses, container ports and logistics.
3. In automobile industries, they can be used to deliver parts requested by the mechanics.
4. Using information from GPS, cameras and other sensors, it can be used in unmanned cars which can detect traffic/obstacles and reach a particular destination.
5. They can be used by defense to deliver arms or autonomously perform certain tasks using drones.

Building Modules (5)

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

FIRE BIRD V ROBOT:

MECHANICAL SYSTEMS:

Locomotion:

1. DC Motors: Two DC geared motors are used in the controlling the motion (based on the path) of the robot with a caster wheel at front as support.
2. Position Encoders: Used to provide position/rotation feedback to the robot while traversing the path.

ELECTRONIC SYSTEMS:

Indicators:

1. RGB LEDs: Used to indicate the provisions the robot is currently carrying.
2. LCD: Used to display information of any sort such as the delivery status.
3. Buzzer: The buzzer will be programmed to buzz after completion of all deliveries.

Microcontroller:

1. ATmega2560 Microcontroller: This forms the brain of the robot. All the inputs given are processed to produce the desired output.

Communication:

1. XBee Wireless Modules (with adaptor board): These components establish communication between the robot and the PC wirelessly to send the movement commands to the robot.

Power Supply:

1. NiMH Battery Pack: It acts a power source to all the components of the Fire Bird V robot.

OTHER COMPONENTS:

1. **VISION:**
   iBall Robocam (Webcam): It captures the image of the arena which is analyzed to compute the path and track the robot.
2. AVR USB ISP STK500V2 Programmer: Used to program the Fire Bird V alternatively.
3. USB cables for wired communication and programming.

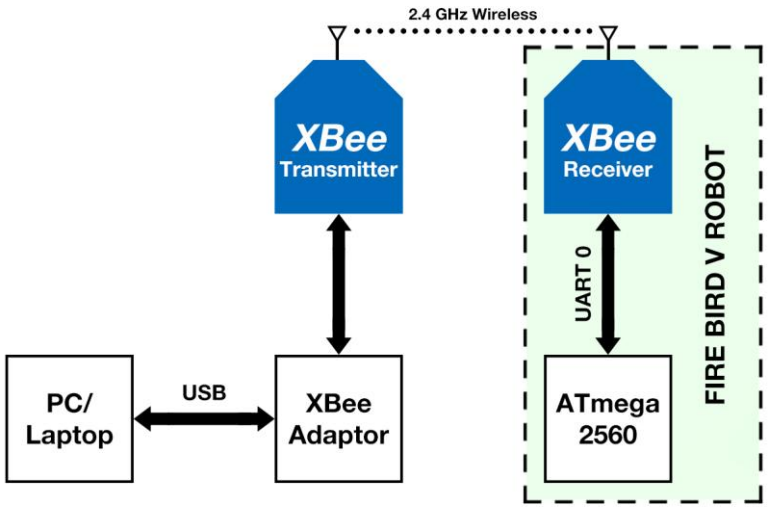
Communication (10)

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

The communication between the computer and the Fire Bird V robot takes place wirelessly over radio frequency (2.4GHz) using Zigbee protocol. XBee wireless modules are used for this communication.

The computed path data and commands are transmitted in the form of serial data, using Python, via the Transmitter XBee module (using FT232 USB serial converter). The data is received by the Fire Bird V robot by the Receiver XBee module connected to UART 0 of ATmega2560 microcontroller. The robot then performs required the task based on the commands. The robot also sends feedback to the computer, so as to make sure it follows the correct path without any deviation.

USB cable is used for wired communication with the robot while programming the microcontroller of the robot.



Block Diagram Representing Communication between the Computer and Fire Bird V Robot using XBee Wireless Modules

Environment Sensing (10)

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

To sense the environment, the primary detection of the arena configuration is done by capturing an image from a steady overhead webcam and using Image Processing. Using Python and OpenCV, the environment is analyzed. The provision markers and the wall obstacles are identified using color detection functions. Using two different colored stickers placed on the robot, the position and the orientation of the robot is also sensed by finding the centroids of the colored regions, joining them by a line and thus the orientation is known by finding the slope of this line. Thus a map of the arena is created as shown in **Fig. 2** below.

Then, the robot is constantly tracked using the webcam to ensure it follows the correct path without any deviations. Position encoders are used to track the position and rotation and provide the feedback.

ALTERNATIVE SENSORS:

1. Color Sensor Module can be used to detect the provision markers when the robot moves over it.
2. By orienting the IR proximity sensors and the Sharp IR range sensor so as to detect obstacles less than a height of 4cm, the obstacles can be avoided.
3. Similarly, Ultrasonic range finder and Bump sensors and can be used to detect and avoid the obstacles in the arena.
4. IR LEDs at given waypoints can be installed, and have the robot sense those LEDs and drive towards each waypoint in series.
5. Gyroscope/compass sensors and rotary encoders can be used to take accurate turns.

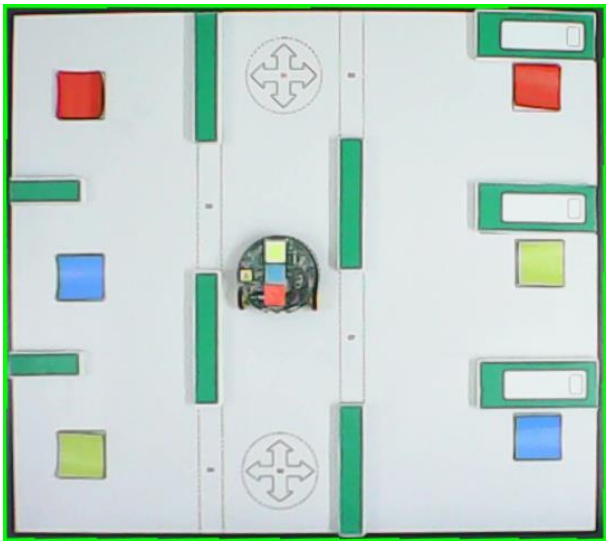


Figure 1: Webcam Image of the Arena

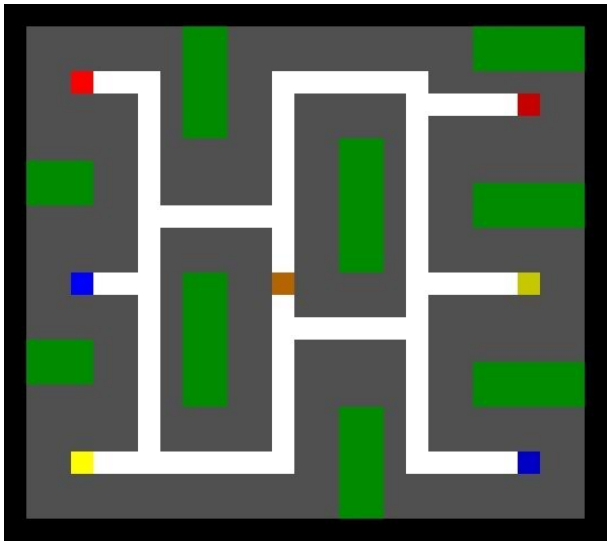


Figure 2: Arena Map Created

Power Management (5)

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

The main sources of electrical power for robots are batteries and photovoltaic cells. A robot power supply system is designed to provide the subsystems with all of the necessary voltage and power demands.

Fire Bird V is powered by 9.6V rechargeable NiMH battery pack. The battery voltage can vary between 12V (fully charged) to 8V (discharged) and the robot can use a maximum of 2Amp current.

To power the robot for longer duration, auxiliary power can be supplied which provides continuous regulated 12V, 1Amp supply to the robot.

We would be using the battery as our power source since the robot in our task would be powered only for a shorter duration and this also would avoid the hassle due to external wiring for auxiliary power source and make the robot portable.

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.

Navigation Technique:

1. A webcam is placed above the arena at a height which captures the entire arena.
2. Using Python and OpenCV, the input image from the webcam is read and the arena boundary is cropped. The position and colors of the various provision markers and position of the walls (obstacles) are detected.
3. The position and orientation of the robot is detected using colored stickers placed on the robot, then calculating their centroids, joining them by a line and thus determining its orientation (from slope of line). Thus the robot is localized in the arena.
4. This information is used to make an arena map (**Fig. 2**) which provides a simplified traversable path and also maintains a safe distance from the obstacles to avoid touching them.
5. The shortest overall path is planned (using A* algorithm) and matching of provisions is done. Serial data (movement commands) are sent to the Firebird robot via the XBee Module.
6. Position encoders are used to provide position/rotation feedback to the robot to follow the accurate path.
7. The webcam monitors the arena throughout the run and tracks the robot. In case of any deviation from the path, an interrupt command is sent so as to bring the robot back to the original path.

Components Required:

1. Overhead webcam (with USB extension wire)
2. Computer/Laptop with Python and OpenCV
3. XBee module to transfer the path data to the robot

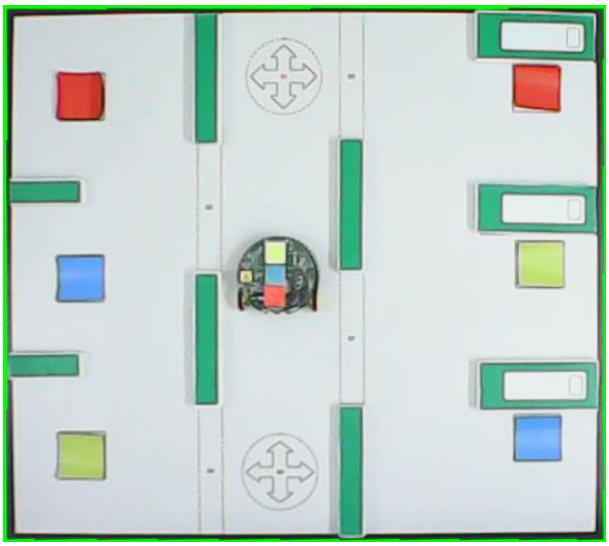


Figure 1: Webcam Image of the Arena

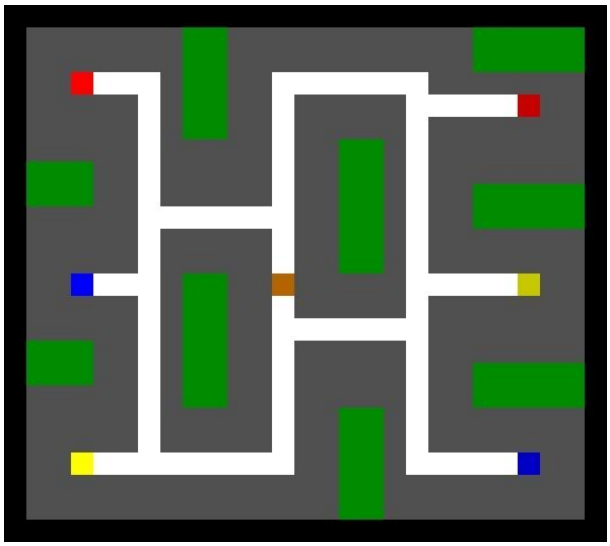


Figure 2: Arena Map Created

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.

Using Python and OpenCV, the positions of the walls, beds and fixed partitions are detected. Based on this detection, a new arena map with a uniform grid of suitable resolution (Eg: 20 px / 4.8 cm in arena) is created (as shown above in **Fig. 2**).

If a wall at certain position exists, then the corresponding squares of the grids are blocked (in green). If not, a white traversable path is placed. Furthermore, to keep the robot in the safe zone and to avoid it from touching the obstacles, the squares surrounding the obstacles are also blocked (gray region) which creates a simplified white path where the robot can move. The robot is constantly tracked to avoid deviation from its path.

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

Basically, the robot would have to travel a maximum of six different paths. A maximum of three paths to be traversed to the markers in the service zone (one of which would start from the starting point) and three more to deliver the provisions in the patient zone. A* algorithm is used to find the shortest distance for these individual paths. The correct combination for which, the length of the overall path (sum of the individual paths) is shortest and the path with least number of turns, is chosen. The individual paths are represented using different colors in the image below (**Fig. 3 & 4**).

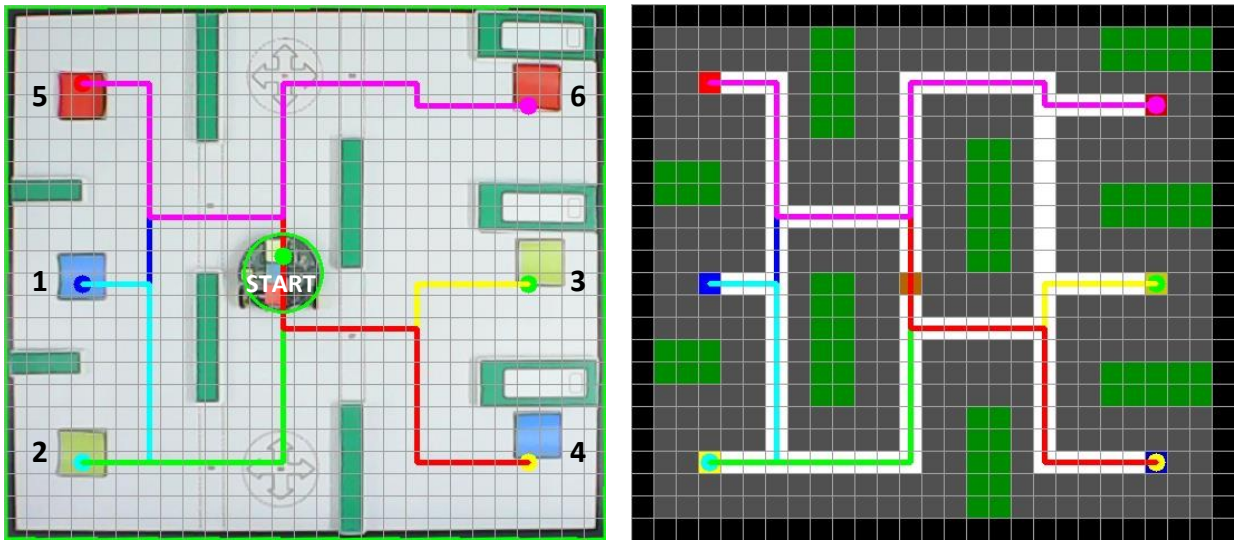


Figure 3: Detection of Robot Position and Obstacles, and Path Planning
(Sequence of Paths: Blue, Cyan, Green, Yellow, Red and Purple)

Challenges (5)

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

1. Designing an algorithm for planning and choosing the most efficient/shortest overall path for pickup and delivery of all the provisions. This also includes correct matching of provisions for all possible combinations.
2. Suitable system or technique of communication with the PC and Fire Bird V using XBee Modules.
3. Converting the received path co-ordinates (from PC via XBee) into the precise motion of the robot.
4. To ensure that the robot maintains the correct linear path (avoiding obstacles) till completion of the task by travelling the exact distance and taking accurate turns as specified to it using feedback from webcam and position encoders.
5. Interfacing the RGB LEDs on the robot and algorithm for correct LEDs to be on or off during pickup and delivery.