CARETAKER ROBOT

1. Introduction

Robotics today has made big strides in helping people automate tasks in many areas like industries, self-driving cars, and even in healthcare. In the space of healthcare, robots can help doctors perform remote operations, help diagnose diseases, keep track of medical history and assist in caring for patients.

We live in a world that is fast moving towards longer life expectancies and nuclear families giving raise to care centers for the aging population. This creates the need for a large workforce to care for those who can no longer take care of themselves. Advances in robotics and computer vision have enabled us to build machines that interact with humans naturally, require no training to operate and carry out simple tasks. Thus, caretaking is a need that can be satisfied by robots, specifically designed to fulfill requests for simple services in a timely manner.

e-Yantra Robotics Competition Plus has designed a theme to bring our awareness to the issue of catering to the needs of patients, for example, automating the task of serving them, even in the absence of human supervision.

In this theme, the arena is an abstraction of a floor in a hospital, which includes a Corridor, a Patient zone and a Service zone. The robot is informed of the patients' requests via a computer that processes the images from a camera and it autonomously seeks the provisions to be picked up and delivered to the corresponding patients.

You are free to design the algorithm for (i) detection of provisions requested by the patients, (ii) matching them with provisions at the Service zone and (iii) delivering them to the patients in the Patient zone.

2. Theme description:

1. The arena design is as shown in Figure 1:
   - There are two zones in the arena: (i) **Patient zone** and (ii) **Service zone**, connected by a **Corridor**.
   - There are three types of provisions that a patient can request: Medicine, Water, or Thermometer.
   - These provisions are represented by **Provision markers** of different colors:
     - Red (R) for Medicines
     - Blue (B) for Water, and
     - Yellow (Y) for Thermometer.
   - The Patient zone consists of:
     - Three **beds** for patients: BED1, BED2, BED3
     - Each patient has a **table**: T1, T2, T3
     - Provision markers (R, B or Y) will be placed on the tables to indicate request for a provision.
   - The Service zone consists of:
     - Three **storage cupboards** marked by positions, P1, P2, P3.
     - Each storage cupboard (P1, P2, or P3) contains one type of provision: Medicine, Water, or Thermometer, marked by a corresponding Provision marker.
     - P1, P2, P3 are separated by **Fixed Partitions**, FP1 and FP2, as shown in Figure 1.
   - The Corridor is made of **wall divisions** placed at positions marked by D1, D2, .. , D8.
   - There are 4 wall divisions – 2 on either side of the corridor – placed at 4 specified positions among D1, D2, .. , D8. Placements of the wall divisions will be provided as input as explained in Section 3.3. An example is shown in Figure 1.
     Note that the **vacant divisions** will be used by the robot to navigate between the two zones.
   - There are 3 possible **Start positions,** S1, S2, or S3, for the robot, marked on the corridor.

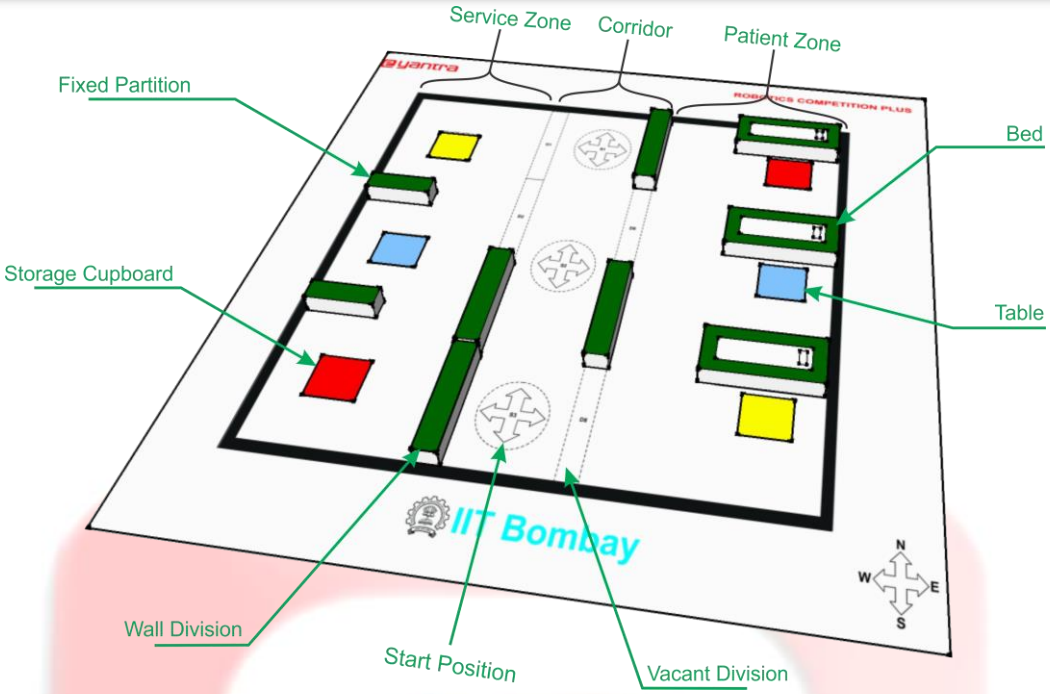

Figure 1: Arena

2. There is an overhead camera that captures the entire arena and is above the center of the arena. Instructions for mounting the camera are provided in Section 3.8.

3. The camera is connected to a computer that uses Python and OpenCV to analyze the image obtained by the camera in order to detect the locations of the Firebird V robot and compute the path to be followed. This information is conveyed to the robot by using a pair of Zigbee modules, one connected to the robot, and the other connected to the computer. A tutorial on the usage of Zigbee modules will be available on the Portal Interface under the **Resources tab**.

4. Since the emphasis is on image processing, the robot need not literally pick up the provisions, but instead indicate the same by use of 2 RGB LEDs provided in the kit.

5. The robot may carry either zero, one or two provisions at the same time. In order to indicate the same, the teams must use 2 RGB LEDs and display them prominently on the robot.

6. In order to indicate that it is carrying a provision, it must turn on the appropriate color of LED:
    - Medicines – Red
    - Water – Blue
    - Thermometer – Yellow
    - For example, if the robot is carrying 1 thermometer and 1 medicine, it must turn on the two RGB LEDs, one showing yellow and one showing red. If it is carrying 2 glasses of water, it must turn on both RGB LEDs showing the color blue. If it is carrying only 1 glass of water, it must turn on only one RGB LED showing the color blue. If it is carrying nothing, it must turn all LEDs off.

7. The robot starts from a specified Start position in the Corridor and does the following:
    i. Detects (i) the positions of the wall divisions, (ii) the provisions requested by the patients in the Patient zone and (iii) the positions of the corresponding storage cupboards in the Service zone.
    ii. Moves to the appropriate storage cupboard/s in the Service zone.
    iii. When the robot has reached a storage cupboard, it can indicate the pick-up of a provision by turning on an RGB LED with the color corresponding to the provision contained in that storage cupboard. The robot can only pick up a provision if it is presently carrying either none or one provision.
    iv. When the robot has to deliver a provision to the patient, it must move close to the appropriate table, and indicate it has delivered the appropriate provision by turning off the RGB LED with the color corresponding to the provision requested by that particular patient. The robot can only deliver a provision if it is presently carrying either one or two of that provision.

8. Once the robot has delivered all the requested provisions to the patients, it must indicate the end of the run by sounding a continuous buzzer.

3. Arena

The arena for this theme is a simplified abstraction of a Hospital floor, consisting of a Patient zone and a Service zone connected by a Corridor.

Preparing the arena:
Each team prepares the arena. Preparing the arena consists of four steps.

1. Printing the arena design on flex sheet.
2. Preparing and placing the fixed partitions, wall divisions, beds and provision markers.
3. Preparing and placing the overhead camera.
4. Preparing the robot.

3.1. Printing the arena design on flex sheet:

- Arena design is shown in Figure 2. It is divided into two sections,
  - Arena section (left) and
  - Marker section (right).

- A Corel draw (.cdr) file containing the arena design will be given to the teams. Each team prints the arena design on flex sheet according to the directions given along with the .cdr file. **Note: <u>The team must print the entire arena design having both the Arena and Marker sections.</u>**

Teams are not allowed to make any changes to the arena design. Any team making any unauthorized modifications will be disqualified from the competition.

3.2. Preparation of markers:

- Once the entire arena design has been printed, the team must cut along the indicated line to separate the Arena section and the Marker section.
- The teams must then cut out the markers from the Marker section as follows:
  - Provision markers – 10 Colored squares:
    - 3 Red squares,
    - 3 Blue squares and
    - 4 Yellow squares
  - Wall markers – Green strip, divided into 6 parts:
    - 4 long strips for wall divisions
    - 2 short strips for fixed partitions
  - Bed markers – 3 Images of beds:
    - 3 images, one for each patient bed
- Dimension of arena design is 213cm x 152cm
  - The arena section is 175cm x 152cm
  - The Marker section is 38cm x 152cm
- Dimension of arena is 130cm x 115cm.

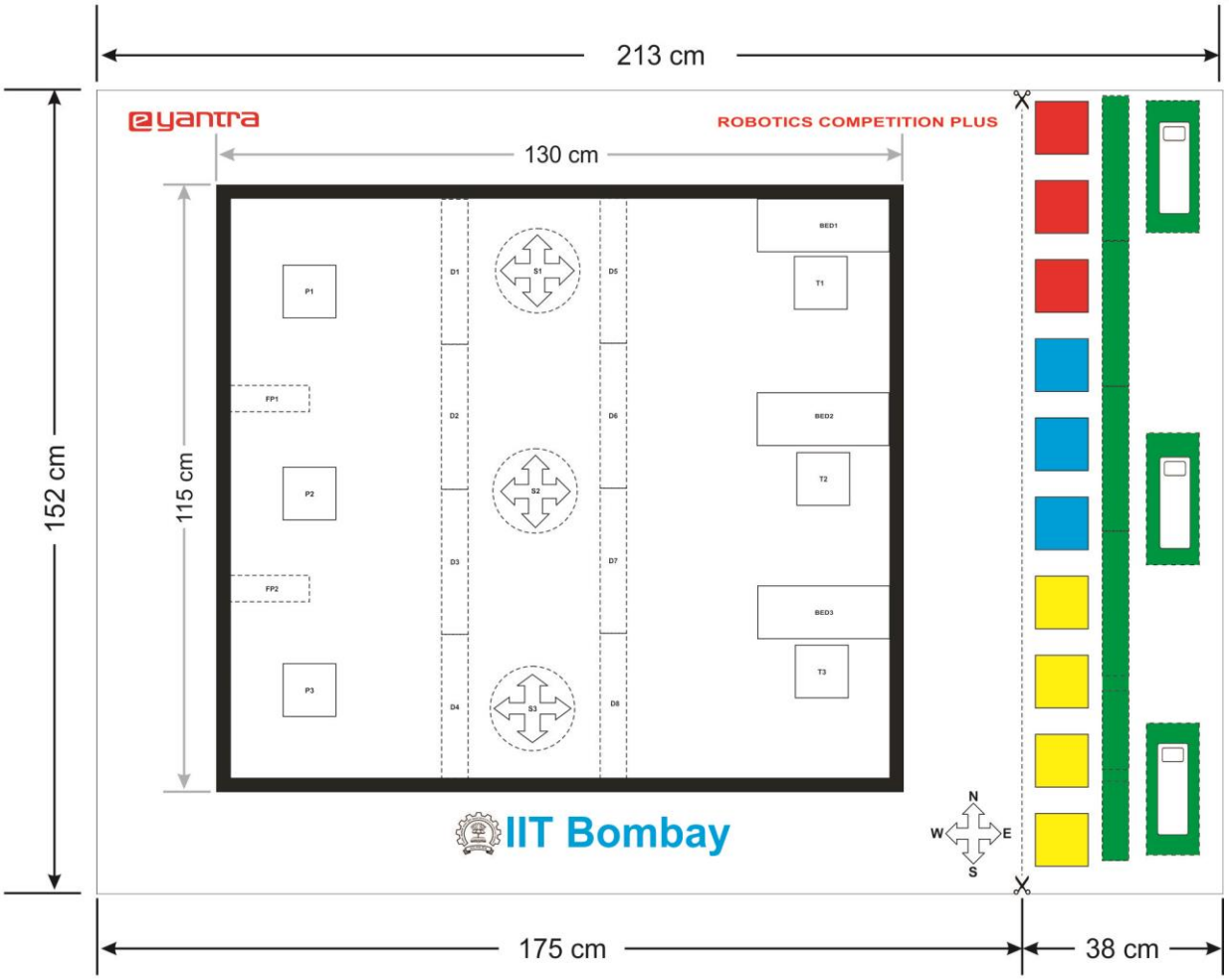

Figure 2: Arena design; Left – Arena section, Right – Marker section

3.3. Preparing and placing the wall divisions:

Materials required for preparing the wall divisions:

- Thermocol
- Wall division markers from the Marker section

Cut out four thermocol blocks of size 4cm x 27.5cm x 5cm. Paste the wall division marker (long green strip) on top of each block as shown in Figure 3. The placement of the wall divisions on the arena will be as per the Placement Table explained in Section 3.7.

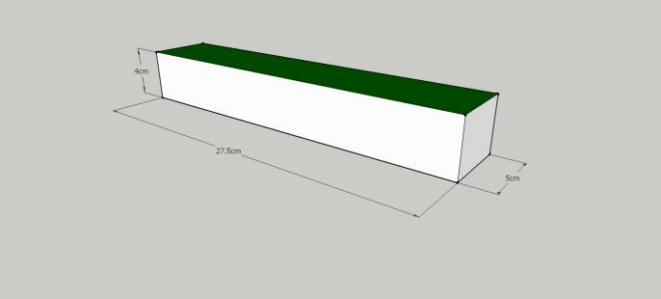

Figure 3: Wall divisions

3.4. Preparing and placing the fixed partitions:

Materials required for preparing the fixed partitions:

- Thermocol
- Fixed partition markers from the Marker section

Cut out two thermocol blocks of size 4cm x 15cm x 5cm. Paste the fixed partition marker (short green strips) on top of each block as shown in Figure 4. Place the fixed partitions on the positions FP1 and FP2 in the Service zone. You may use adhesives such as Fevicol or double-sided tape to fix the partitions.

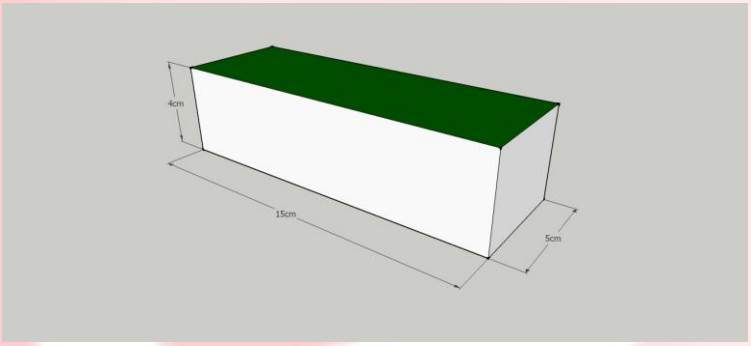

Figure 4: Fixed Partitions

3.5. Preparing and placing the beds:

Materials required for preparing the beds:

- Thermocol
- Bed markers from the Marker section

Cut out three thermocol blocks of 4cm x 25cm x 10cm. Paste the bed markers on top of each block as shown in Figure 5. Place these beds in the positions marked BED1, BED2 and BED3 in the Patient zone.

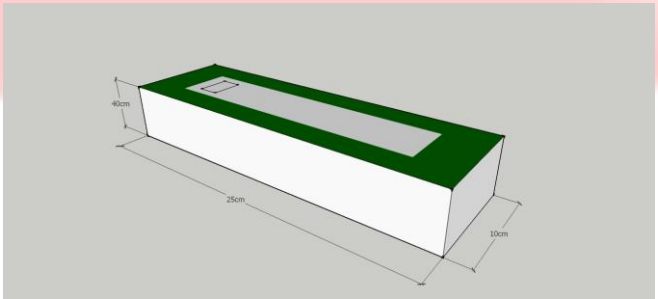

Figure 5: Beds

An example of an arena with the fixed partitions and beds placed is shown below in Figure 6. Note that the fixed partitions and beds are **always in the same position** and independent of the Placement Table.

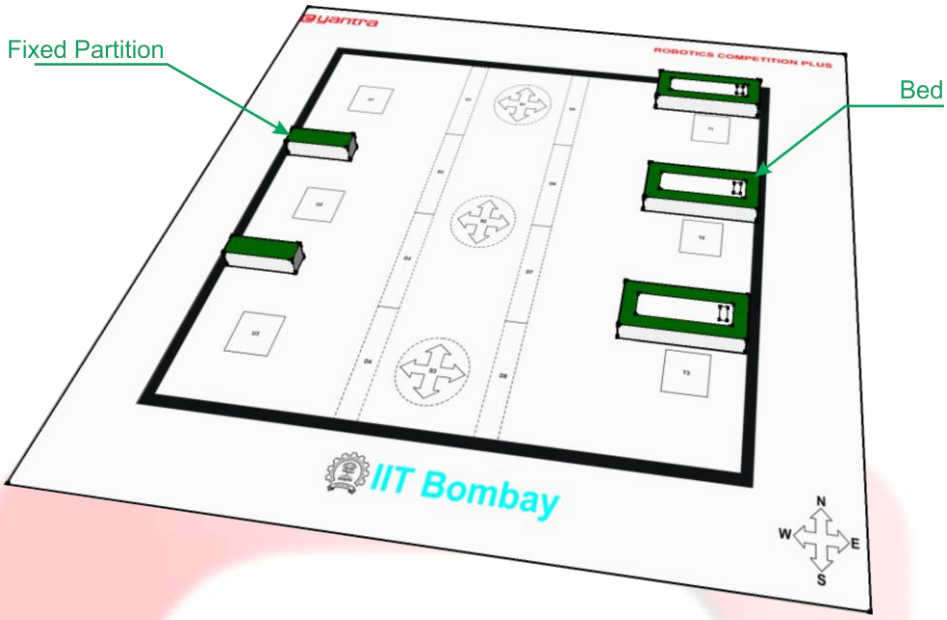

Figure 6: Arena with Beds and Fixed Partitions

3.6. Preparing and placing the Provision markers:

Materials required for preparing the Provision markers:

- Provision markers from the Marker section

The teams must stick the Provision markers onto the arena in accordance with the Placement Table as explained in Section 3.7. An example is shown in Figure 7. In this example:

- Medicines are in the storage cupboard marked by position P3
- Water is in the storage cupboard marked by position P2
- Thermometers are in the storage cupboard marked by position P1
- Patient 1 has requested for Medicines in T1
- Patient 2 has requested for Water in T2
- Patient 3 has requested for Thermometer in T3

Note: Since the placement of the Provision markers may change with different configurations of the arena, the teams are advised to stick the Provision markers to the flex in a non-permanent way, for example, by the use of double-sided tape.

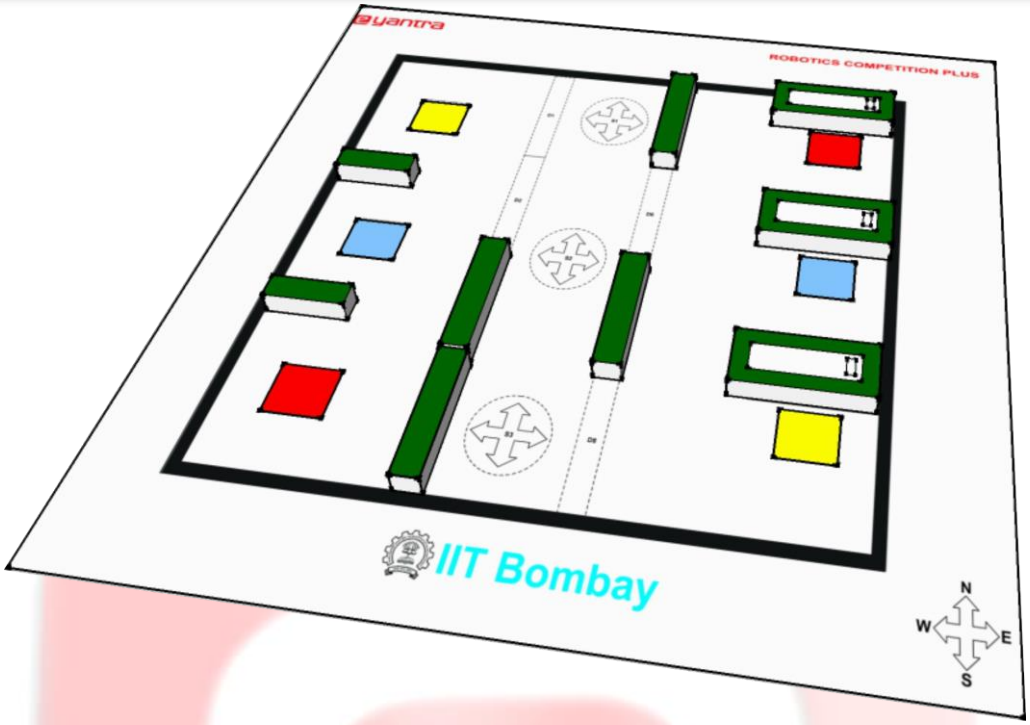

Figure 7: Example Configuration of Arena

3.7. Preparation of the robot:

- The robot must be modified to prominently display the RGB LEDs that indicate the provision that the robot is carrying as explained in Section 2.4.
- The teams must find a way of identifying the position and orientation of the robot from the images obtained using the camera. (*Hint: Remember Task 1!!*)

3.8. Placing the robot, service markers and wall divisions on the arena:

- Placement of the START position, orientation, provision markers and wall divisions is given in the form of a **Placement Table**. One example of a Placement Table is shown below.

Marker	Position
START	S2, North
Wall divisions	D3, D4, D5, D7
Red (Medicine)	P3, T1
Blue (Water)	P2, T2
Yellow (Thermometer)	P1, T3

Table 1: Placement Table

Suppose this table is used for placing the wall divisions and markers on the arena, the arena will be as shown above in Figure 7.

- This is an example used to illustrate the placement of markers and wall divisions. In the competition, markers will be placed as per a random placement table.

- **Thus, it is advised that you use the input from the camera to identify the type of markers, their positions and the positions of the wall divisions.**

3.9. Placement of camera:

- The provided camera must be mounted such that it has a complete view of the arena, and above the center of the arena at approximately a height of 7 feet 7 inches.
- Teams are expected to use their creativity to design an arrangement to mount the camera, for example, hang it from a ceiling, construct a frame, etc. Post your creative solutions to the problem of mounting the camera by taking a picture and sharing it on Piazza! ☺
  An example is shown in Figure 8.

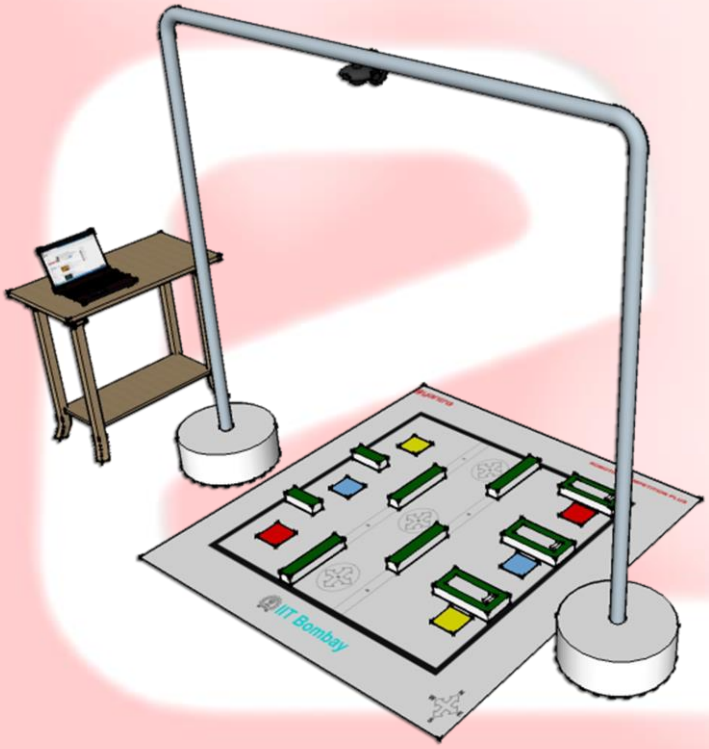

Figure 8: Camera Placement

Now, we are ready with the arena. Please maintain the arena in a good condition. If the arena is found damaged or in a condition not good enough to properly evaluate the team, e-Yantra has the right to disqualify the team. **The final decision is at the discretion of the reviewer.**

- **Note: The arena shown in Figure 7 is specific to the example placement table considered. During the competition, the placement table will be different and hence, the placement of provision markers and wall divisions will vary accordingly. You will be given a placement table just before the submission of Task 5: Theme Implementation along with complete instructions to complete this task.**

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems while the robot moves. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sun -- it tends to straighten out. Never attempt ironing it or applying heat of any kind -- it may be a fire hazard.

4. Hardware Specifications:

4.1 Use of Firebird V:

- All participating teams must use **only** the Firebird V robot sent to them in the kit. **Only one** robot given in the kit is allowed per team.
- All participating teams must use **only** the camera sent to them.
- Team shall not dismantle the robot.
- The robot should be **completely autonomous**.

4.2 Components:

- Along with the robot, teams shall receive 2 Zigbee modules and 3 RGB LEDs (one extra RGB LED is provided as backup).
- The teams must use a laptop/computer capable of running OpenCV and Python.
- The teams must use only the iBall Robocam camera which was used in Task 0. They may elect to use the extender cable in case the cable of the camera does not reach the laptop/computer.

4.3 Power Supply:

- The robot can be charged through battery or auxiliary power supply. These are shipped with the robot.
- The team cannot use any other power source for powering the robot.
- The team can use auxiliary power during practice but the final demonstration should only be made using only battery-powered robot.

Note: No other microcontroller-based board shall be attached to the Firebird-V robot.

5. Software Specifications:

- e-Yantra has provided all teams with ATMEL STUDIO 6, a free software for programming AVR microcontroller. Participating teams are free to use any other open source Integrated Development Environment (IDE) for programming AVR microcontroller.
- The teams must use OpenCV and Python to write their code.
- Use of any non-open source libraries is not allowed and will result in disqualification.
- As per e-Yantra policy, all your code and documents are open-source and maybe published on the e-Yantra website.

6. Theme Rules:

- The maximum time allotted to complete the task is 10 minutes. A maximum of **two runs** will be given to a team (the better score from the two runs will be considered as the team's score). A maximum of **two repositions** (explained below) will be allowed in each run.
- The team should switch **ON** the robot when told to do so by reviewer. This is the start of a **run**. The timer will start at the same time.
- Robot should be kept in the Corridor at the Start position and orientation indicated by the Placement Table.
- Once the robot is switched on, human intervention is NOT allowed.
- The team must detect the provisions requested by the patients based on the provision markers placed on the tables in the Patient Zone, the positions of the appropriate storage cupboards in the Service Zone and the positions of the wall divisions separating the zones using the overhead camera.
- The team must detect the position and orientation of the robot using the overhead camera.
- The team must use OpenCV and Python to plan a path to deliver the appropriate provisions to the respective patients.
- The teams must use the Zigbee modules to communicate the same from the computer to the robot.
- After a storage cupboard has been reached, the robot should indicate picking up the provision by **turning on** the appropriately colored LED corresponding to the provision.
- A maximum of 2 provisions can be picked up by the robot.
- The robot moves to the patient zone and delivers the appropriate provision to the corresponding table. Delivery of provision is indicated by **turning off** the appropriately colored LED corresponding to the provision.
- After delivering all the requested provisions, the robot should sound a continuous buzzer, to indicate the end of task.
- A run ends and the timer is stopped when:
    - The robot stops and sounds the continuous buzzer or
    - If the maximum time limit for completing the task is reached or
    - If the team needs repositioning but has used both repositioning options of that run.
- Buzzer sound for more than **5 seconds** will be considered as continuous buzzer.

- Second run will start once again whilst resetting the score, timer and arena. The score of both runs will be recorded and best of two runs will be considered as the team's score.
- Participants are not allowed to keep anything inside the arena other than the robot. The time measured by the reviewer will be final and will be used for scoring the teams.
- Time measured by any participant by any other means is not acceptable for scoring.
- Once the robot starts moving on the arena, participants are not allowed to touch the robot.

- The robot is not allowed to make any marks while traversing the arena. Any robot found damaging the arena will be immediately stopped; repositioning will be allowed as per the rules. **The final decision is at the discretion of the e-Yantra team.**

Repositioning of robot:

1. Robot repositioning is done under following circumstances:
   - If robot is found to be displacing any fixed partition, wall division or bed or damaging the arena then it will be kept at the **START** position.
   - If the robot gets stuck in the arena or goes off the arena, teams can ask for the reposition.
2. For a reposition, the robot should be in Power Off mode, and turned on again at the **START** position, upon signal from the reviewer. **During a reposition, the timer will not be set back to zero.**
3. Each team is allowed a maximum of two repositions in each run. All repositions require the approval of the reviewer; the team will be disqualified if the robot is handled within the arena without approval.
4. During repositions, a participant must not feed any information to the robot. A participant may not alter a robot in a manner that alters its weight. The reviewer's decision is final.
5. Note that during reposition, any provision that is not delivered at the appropriate Patient zone will have to be picked up again.
6. After reposition the robot has to complete the remaining task; the provisions that were previously delivered correctly will be counted in the score.

NOTE:

- **After completion of all tasks, teams will be selected as finalists based on their cumulative scores across all the tasks. Complete rules and instructions for the finals at IIT Bombay will be sent to those teams that qualify for the finals.**
- **In case of any disputes/ discrepancies, e-Yantra's decision is final and binding. e-Yantra reserves the rights to change any or all of the above rules as we deem fit. Any change in rules will be highlighted on the website and notified to the participating teams.**

8. Judging and Scoring System

- The competition time for a team starts from the moment the robot is switched ON. The timer will stop as soon as the robot finishes the task.
- The better score of the two runs for a team will be considered as the final score of the team.
- The team's total score is calculated by the following formula:

Total Score = (600-T) + (C x 100) - (W x 70) + B – P

Where:

- **T** is the total time in seconds to complete the task.
- **C** is the total number of provisions that are delivered correctly to the appropriate Patient Table.
- **W** is the number of provisions delivered incorrectly. A delivery is considered incorrect in the following cases:
  - When a provision is delivered to an incorrect Patient Table.
  - When a provision is not delivered to a Patient requesting for it.
- **B** is a bonus of 100 points, awarded if
  - The robot delivers every provision correctly,
  - Completes the task within 10 minutes, and
  - Does not displace or damage any part of the arena.
- **P** is a penalty where 30 points are deducted for each fixed partition, wall division or bed that the robot dashes against or displaces during the run.

ALL THE BEST…!!!