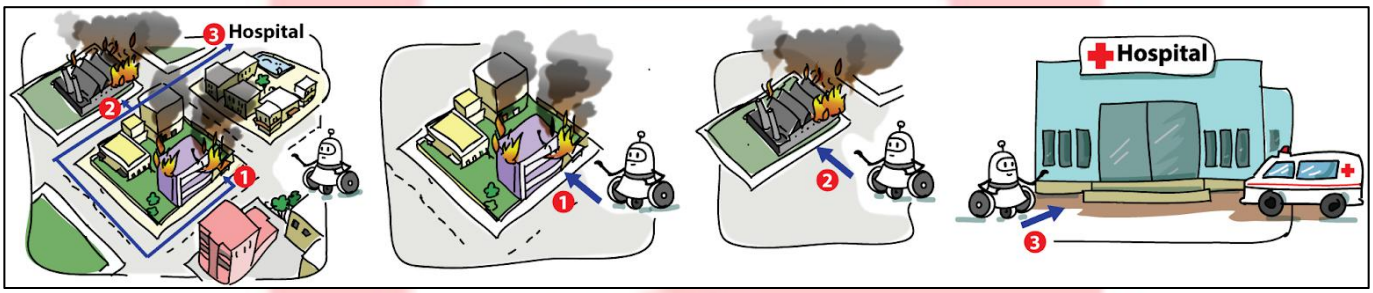
RAPID RESCUER

RULEBOOK



e-Yantra Team

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1. Introduction

Rescue operations pose a grave danger to victim as well as to those assigned the job of saving the lives of victims. Rescuing people in case of fire and explosion in any cityscape comprising numerous buildings (these may include residential, commercial, industrial, petroleum/chemical distribution, maritime, construction, and agricultural buildings etc.) is a risky and crucial operation.

Robots can be used in such applications to save lives of people and provide crucial information that can be used by experts for decision making.

Motivated by this idea, in the current edition of e-Yantra Robotics Competition (eYRC 2019-20) we have designed a theme, "***Rapid Rescuer***".

The purpose of Rapid Rescuer is to rapidly rescue victims from dangerous or unpleasant situations to safer locations.

The arena is an abstraction of a city as a maze. An image of a maze will be given to teams and using Image Processing, teams have to find the shortest path from start node to final node. This information is communicated to the Bot. The goal is to traverse the shortest path and evacuate people from different locations to a safe place whilst avoiding unknown obstacles.

Challenges in this theme include Image Processing, Algorithm building, Wireless Communication, Building a Bot, Embedded C programming.

The critical factor is time and the challenge is to complete the given tasks in the shortest time possible whilst incurring the least penalties. The teams that perform the task best in accordance with the rules will be declared the WINNER of the competition.

All the best !!

2. Theme Description

- Maze image consisting of digits will be given to the team prior to the start of theme execution. An example image is shown in Figure 1. The external boundary of the image is considered as wall. Digits are placed in cells surrounded by three walls. Cells containing digits are called **Firezones**. Numbers on the image indicate the number of people to be evacuated from that Firezone.

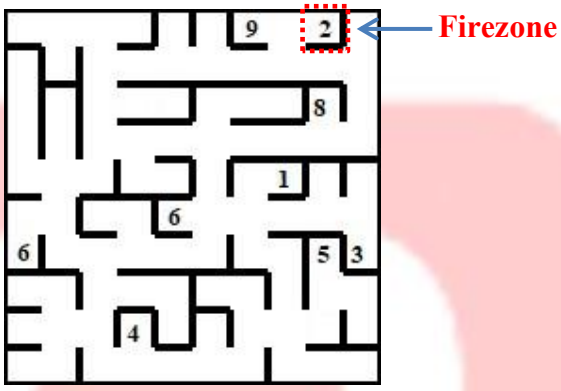


Figure 1: Example maze image

- Figure 2 shows the arena design for this theme. The arena for the theme is an abstraction of a city in the form of a maze.

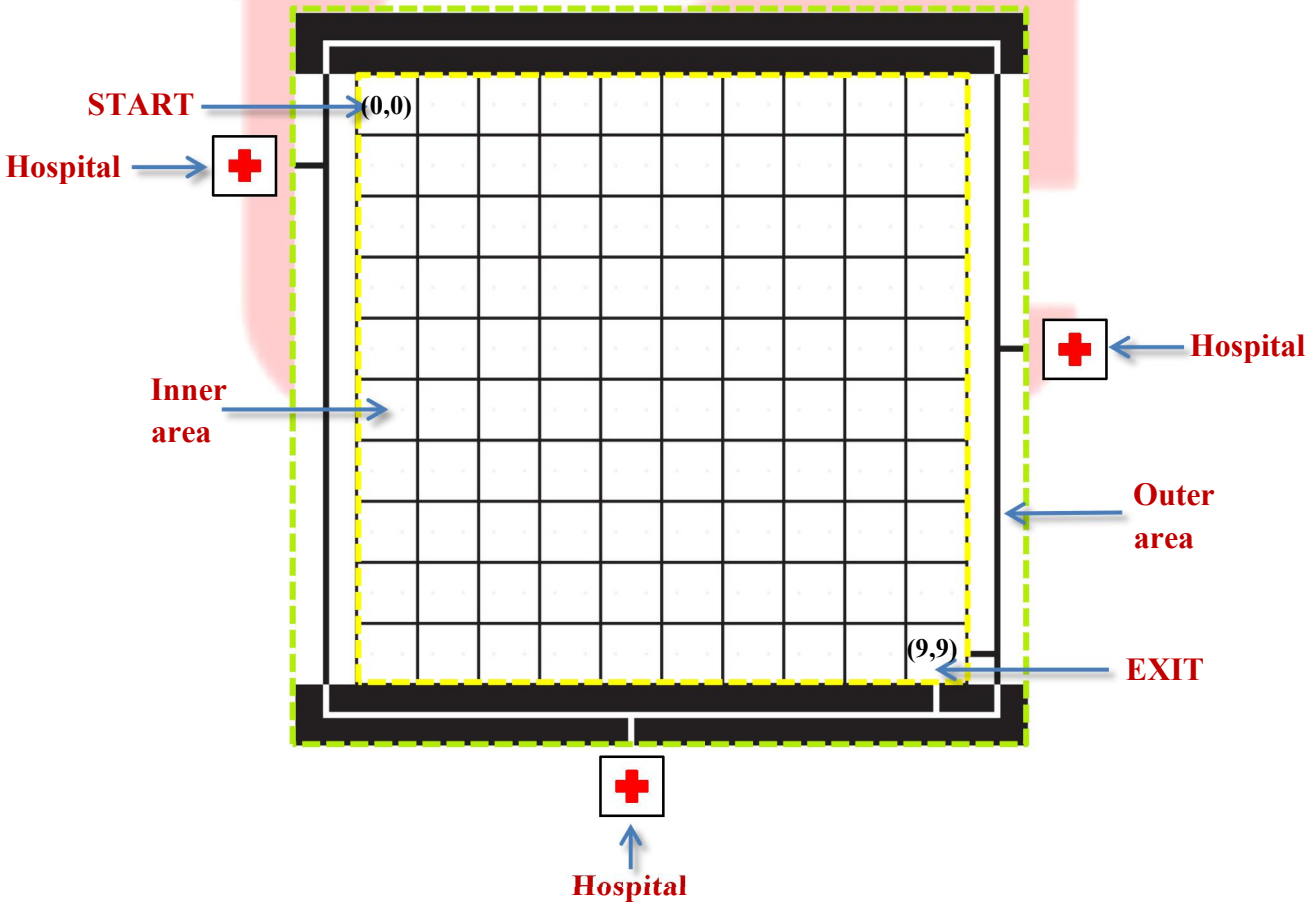


Figure 2: Arena design

- Arena indicates the following:
  - It is divided into two parts -
    - **Inner area:** Bounded by yellow dotted lines. Consists of 10 x 10 grid having 100 cells. Cell co-ordinate **(0,0)** indicates **START** position and cell co-ordinate **(9,9)** indicates **EXIT** position. Walls should be placed according to the image provided to the teams. **Additional Obstacle/s** (earlier referred as "*Dynamic Obstacle/s*") are represented by blocks and will be randomly placed in the path within the cell.
    - **Outer area:** Indicated by light green dotted lines. Consists of white and black patch having black lines and white lines respectively. **Hospitals** are indicated by three T-joints connected to black lines and white lines. No walls are to be placed in outer area.

Figure 3a gives an overall idea of maze image once all the walls are placed according to Figure 1. Figure 3b shows placement of additional obstacle.

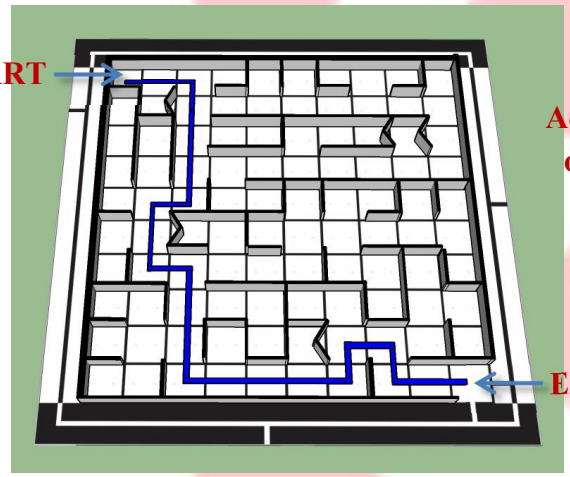


Figure 3a: Path from START to EXIT on arena

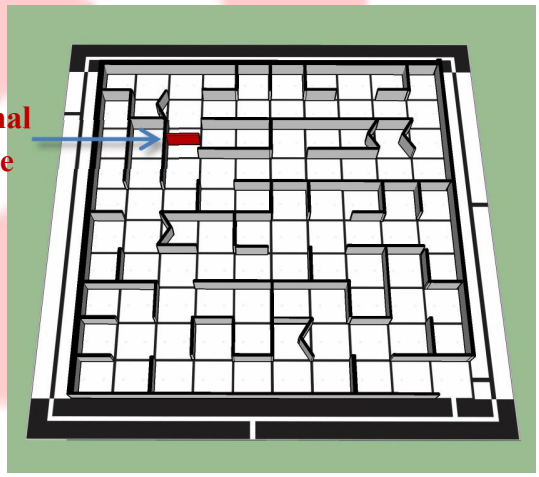


Figure 3b: Placement of additional obstacle on arena

Blue line indicates the **path** from START to EXIT position (refer Figure 3a).

Red block indicates the **additional obstacle** present on the arena (refer Figure 3b). Obstacle will be present in any cell (excluding START cell, EXIT cell, firezone cells).

- Goal of Theme:

  There will be predefined total number of vacancies in Hospitals. Robot has to traverse the arena, avoid additional obstacle/s, evacuate victims (people) from firezone/s and drop them to Hospital/s to fill the vacancies.

- Detailed explanation:
  - Assume the predefined vacancies in Hospitals is 12 (this includes all three Hospitals). This implies that ideally number of victims to be evacuated from firezone/s should be equal to 12.

- Along with maze image consisting of digits, total number of vacancies in Hospitals will also be given to the team prior to the start of theme execution.
- The team analyzes the given image by using Image Processing which generates the information regarding the cell co-ordinates of path.
- Along with the path, it should also detect the digits, and chooses a combination of digits whose sum is equal to number of vacancies (12 in this case).

  Example (in accordance to Figure 1):

  - Vacancies: 12
  - Digits detected from given image: 9, 2, 8, 1, 6, 6, 5, 3, 4
  - List of combinations of digits whose sum will be equal to 12: [2, 6, 4]; [6, 6]; [5, 3, 4]; [8, 4]; [1, 6, 5]; [9, 3], etc.
- Teams should select either one of the above combinations. List of digits in the selected combination will give the number of firezones to be visited.

  Example:

  - If combination selected is [2, 6, 4]; Number of firezones to be visited = 3
  - If combination selected is [6, 6]; Number of firezones to be visited = 2
- All this information (cell co-ordinates of path, all detected digits, combination of digit/s for sum and their respective cell co-ordinates) will be wirelessly communicated to the robot.
- Robot has to traverse the path communicated to it, reach the first firezone (digit). It then has to glow the **Red** LED for 1 sec. This will indicate that victims from that firezone have been evacuated.
- This process should be repeated for number of firezones to be visited. If the additional obstacle is present on the path/s, robot should avoid the obstacle and take a new path. There will be **maximum 5** numbers of **additional obstacles** (**range 1 to 5**) in the path.
- Once it has visited all the necessary firezones, next task is to drop the victims to the hospitals.
- Robot has to glow **Green** LED for 1 sec at each Hospital which indicates dropping of victims. Once all the Hospital/s are visited, run is complete.

Note: You have already completed "Image Processing" in Stage 1. You may integrate this to complete the Theme.

3. Arena

Preparing the arena:

Each team prepares the arena. Preparing the arena consists of the following major steps:

- Printing the arena design on flex sheet
- Preparing and Placing Additional Obstacle/s
- Preparing and Placing Walls

➢ **Printing the arena design on flex sheet:**

A PDF file containing the arena design is given to the teams. Each team prints the arena design on flex sheet according to the directions given along with the file.

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

Details of arena design (Refer to Figure 4):

Dimension of arena is 240 cm x 240 cm.

Arena consists of cells in the inner area each of size 20 cm x 20 cm.

Each cell is surrounded black line of thickness 1 cm and consists of 4 gray dots.

Black line and white line thickness in the outer area is 2 cm.

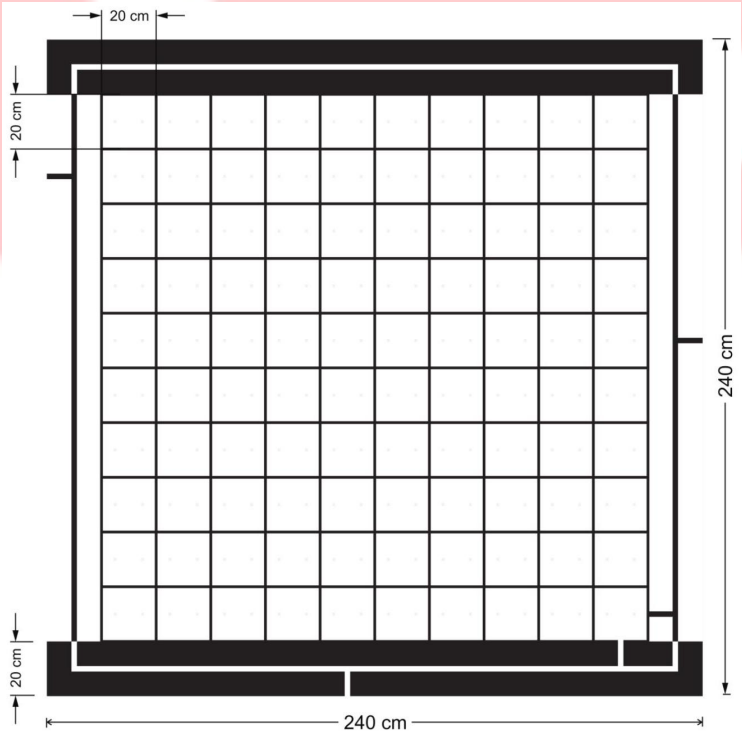


Figure 4: Arena design with dimensions

For practice and video submission, teams should prepare the following, exactly as per the dimensions specified.

➢ **Preparing and Placing Additional Obstacle/s:**

Preparing Additional Obstacle:

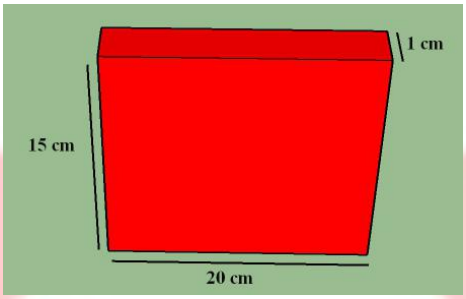


Figure 5a: Additional Obstacle dimensions

Teams must prepare obstacles of size 20 cm x 15 cm x 1 cm as shown in Figure 5a.

Material used for obstacle should be white colored **Sun board** (Foam board) of thickness 10 mm.

It may be made either by

- Using 5 mm thick (0.5cm) Sun board stuck to each other to make it 10 mm (1cm)
- Using 10 mm Sun board directly

The color of dynamic obstacle used in the Finals will be **red**. You may either paint it or cover with any **red** colored paper.

Placing Additional Obstacle:

Obstacle should be placed at the center of cell (either vertically or horizontally) using gray dots as reference as shown in Figure 5b.

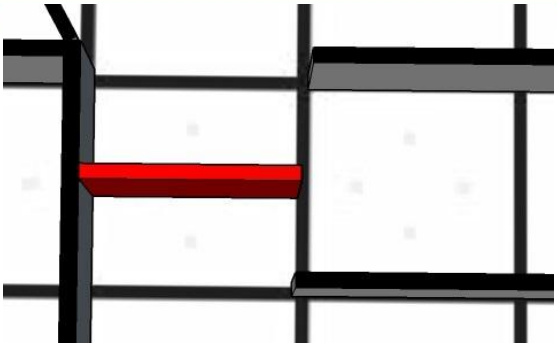


Figure 5b: Additional Obstacle placement

➢ **Preparing Walls:**

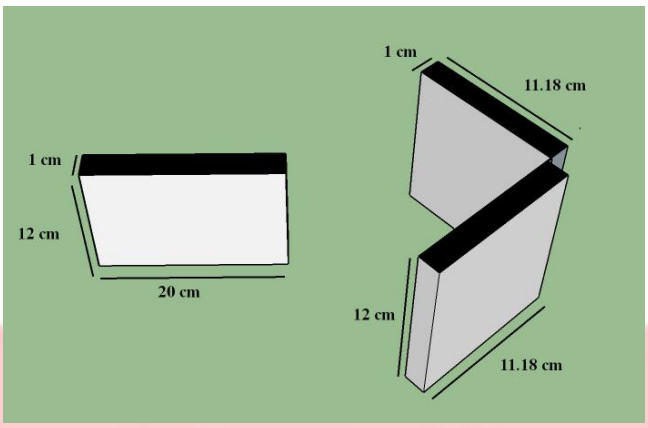


Figure 6a: Straight and zig-zag wall dimensions

Team must prepare straight walls and zig-zag walls as shown in Figure 6a.

Dimensions of straight wall: 20 cm x 12 cm x 1 cm

Dimensions of zig-zag wall: 11.18 cm (~ 11.2 cm) x 12 cm x 1 cm

Material used for walls should be white colored **Sun board** (Foam board) of thickness 10 mm.

It may be made either by

- Using 5 mm thick (0.5cm) Sun board stuck to each other to make it 10 mm (1cm) (Refer Figure 6b)
- Using 10 mm Sun board directly

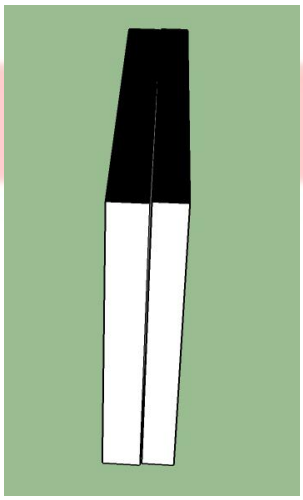


Figure 6b: Two 5mm Sun board stuck to make 10mm

In order to reduce making multiple walls, teams may make walls of greater dimensions (apart from 20 cm x 12 cm) such as (as shown in Figure 7):

- 40 cm x 12 cm
- 60 cm x 12 cm

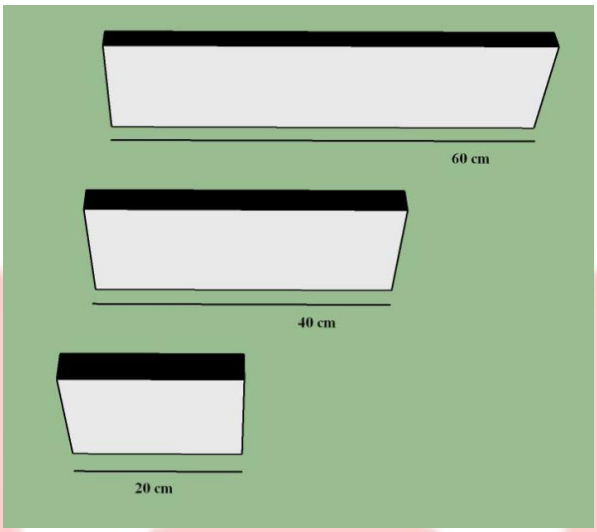


Figure 7: Walls with different dimensions

If you wish, you may make walls of length greater than 60 cm depending on the requirement.

Placing Walls:

Black lines and gray dots in Inner area provides reference for placement of walls.

Black lines are used to place straight walls whereas gray dots may be used as a reference to place walls in zig-zag fashion.

As shown in Figure 8, zig-zag walls should be placed using the gray dot as reference.

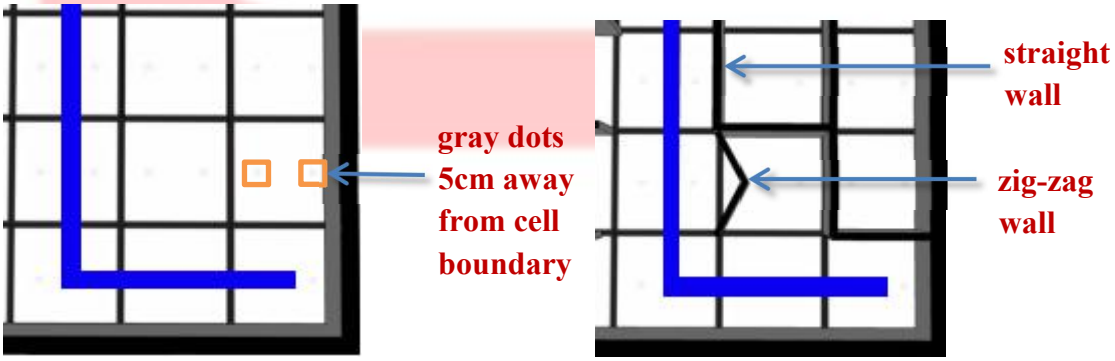


Figure 8: Placement of zig-zag wall

Figure 9 shows placement of different sized walls in arena in accordance with Figure 3a.

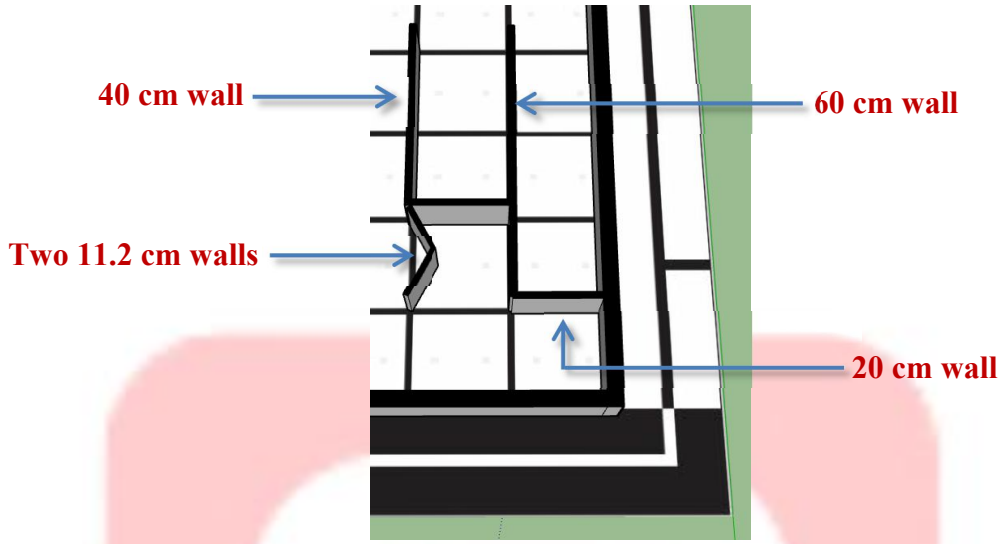


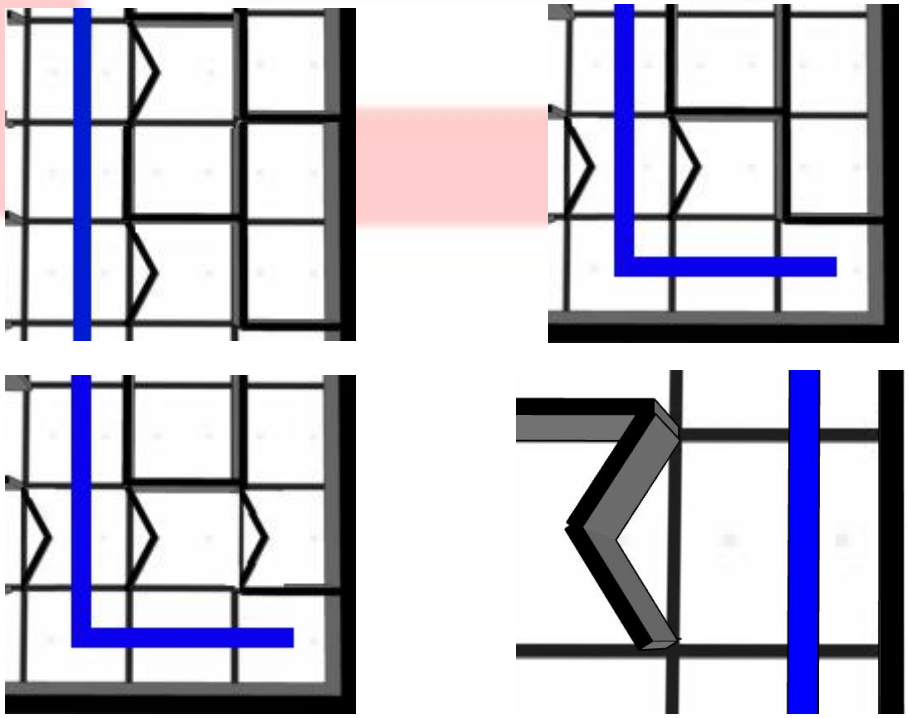
Figure 9: Walls with different dimensions on arena

In order to stick the walls on arena, you may use **double-sided tape of 1 cm** (10 mm) width. Please note, double-sided tape will be used during Finals at IIT Bombay.

The color of walls used in the Finals will remain white. Only the top part of the wall will be colored with **black**. You may use paint to color it.

Conditions of wall placement:

Following are **valid** conditions for placement of zig-zag wall/s for robot traversal and firezone (same conditions will be followed for Finals too).



Following are **invalid** conditions for placement of zig-zag wall/s for robot traversal and firezone (same conditions will be followed for Finals too).

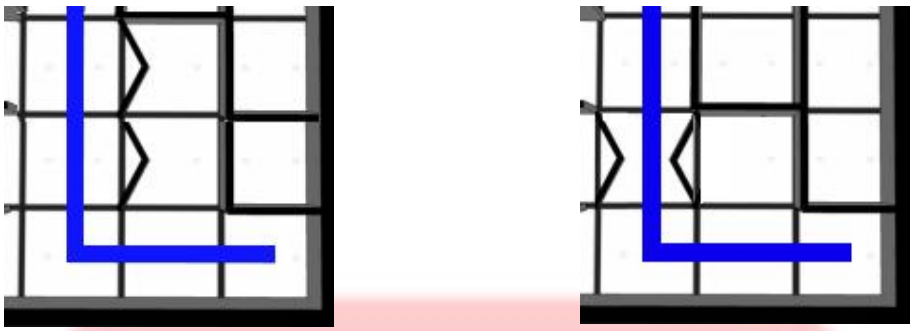


Figure 10a is view of arena in Figure 3a from the EXIT position.

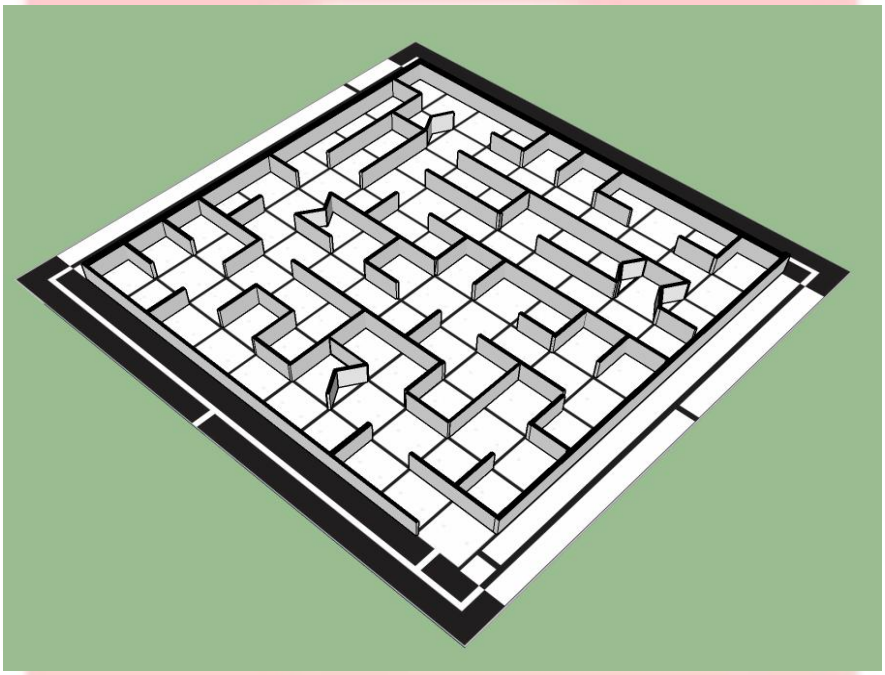


Figure 10a: View of arena in Figure 3a from the EXIT position

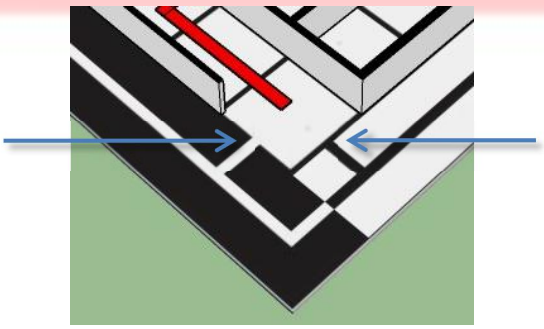


Figure 10b: EXIT position

As shown in Figure 10b, there are two ways (indicated by arrows showing small white and black line) from EXIT or to switch from wall following to line following. There is no predefined sequence to visit all Hospitals, robot may choose either way.

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

Points to remember:

The main idea of the theme is about avoiding fires (additional obstacles), evacuating victims from firezones and dropping them to safe places (hospital).

To make it more appealing for the audience, some kind of structure (hospital look alike) may be prepared by the e-Yantra team and will be placed in front of marking (black or white) as shown in Figure 11 during the Finals at IIT Bombay.

This will have nothing to do with the run as no difference will be caused whether or not the structure is placed.

Please note teams **do not** have to make such structure. Robot does not have to perform any task apart from line following and communication (explained in Theme Rules).

The presence of such a structure will not disturb the theme run as it will be placed at least 10 cm away from arena.

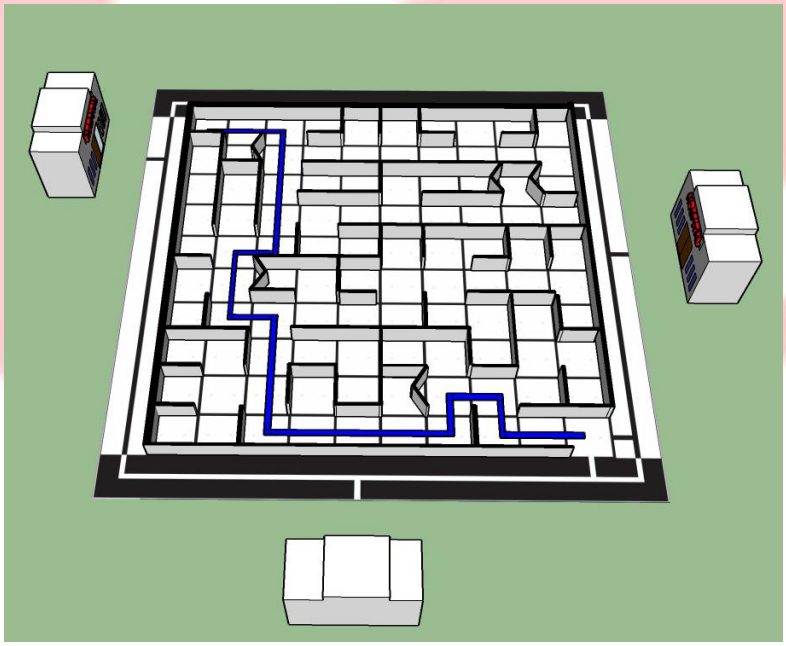


Figure 11: Structure (Hospital) outside arena

Note: The arena with wall structure used in above Figures is specific to the example considered in Figure 1. During the competition, placement of walls and obstacles will differ.

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems. 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. Best is to store the sheet rolled up.

4. Hardware Specifications

4.1 Use of additional components not provided in the kit:

- No other micro-controller based board shall be used other than the eYFi-Mega board provided in the kit.
- The team is not allowed to use any other sensors / actuators apart from those provided in the kit.
- The team must use a laptop / computer capable of running Python.

4.2 Power Supply:

- The team must use 2S Li-ion battery to power the robot provided in kit.
- The team cannot use any other power source for powering.
- The team can power the robot through USB during practice but the final demonstration should be made only by using the battery powered robot.

5. Software Specifications

- e-Yantra has provided all teams with Visual Studio Code, an open-source cross platform IDE.
- Teams are not allowed to use any other editing software for Python or C scripts.
- The teams must use Python ONLY to write their image processing related codes.
- 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). Maximum of **one Restart / Reposition** (explained below) is allowed per run.
- The robot should be kept at **START** position at **center** within the cell **(0,0)**. Direction of the robot can be decided by the respective team.
- The team should switch ON the robot when told to do so by e-Yantra reviewer. This is the start of a run. The timer will start at the same time.

The following are the steps of the task:

- Input image and total number of vacancies in Hospitals is given before the start of run.
- Robot is kept within the center of cell (0,0) and is turned ON.
- Teams use Python and Image Processing to find the path, use algorithms to detect all numbers on the arena, find the combination of digit/s that sums to the total number of vacancies and their respective cell co-ordinates.
- Teams must communicate this information (cell co-ordinates of path, all digits in image, combination of digit/s for sum and their respective cell co-ordinates) wirelessly from the Python script to the robot using socket.

With reference to Figure 1, communication from client (Python script) to robot should be done in following format:

Assume the cell co-ordinate of first firezone planned to be visited is: **(0,8)**

Shortest Path = **#[(0,0), (0,1), (0,2), (1,2), (1,3), (1,4), (1,5), (1,6), (1,7), (0,7)]#**

All digits in image = **#[9, 2, 8, 1, 6, 6, 5, 3, 4]#**

Combination of digits for sum with their locations = **#{2: (0,8), 6: (6,0), 4: (8,3)}#**

- Press the **USER_SW** switch of eYFi-Mega board to start the traversal of the robot. This will be considered as the start of a run. Once the run in started, human intervention is NOT allowed.
- Note that the robot waits at the START position until the **USER_SW** switch is pressed.
- Robot should follow the path from START to respective firezone/s and then to EXIT. If it encounters additional obstacle in the path, it should communicate the cell co-ordinate of the obstacle to client (Python script).
- Client should communicate the new computed path to the robot.

On encountering additional obstacle, communication from robot to client should be done in following format:

Cell co-ordinates of additional obstacle = **@(x,y)@**

- Robot then follows the new path and the process repeats till robot reaches the EXIT.

- Robot has to visit all the firezones depending on the combination chosen by Python script. On reaching each firezone, robot **MUST** face towards the firezone (refer Figure 12a and 12b), glow **Red** LED for 1sec and communicate that "**n**" victims are evacuated from firezone with cell co-ordinates **(x,y)** in the format as specified below.

On reaching a firezone, communication from robot to client should be done in following format:

Cell co-ordinates of firezone and number of victims evacuated = **@$|n|(x,y)@**

("**$**" indicates that **(x,y)** are the co-ordinates of the **respective firezone** and

"**n**" indicates the digit in that firezone)

- Once done, repeat the process till all firezones are visited.

- Once the robot reaches EXIT, it should enter into the Outer area. Based on the EXIT position chosen by the robot (refer Figure 10b), the first Hospital reached by the robot will be named as **HA**, next will be **HB** and so on.

- Robot should visit three Hospitals. On reaching each hospital, robot **MUST** face towards the hospital, glow **Green** LED for 1sec and communicate the following to client, respectively:

@HA reached@

@HB reached@

@HC reached, Task accomplished!@

- Once the **@HC reached, Task accomplished!@** is communicated, this indicates the end of run.

- A run ends and the timer is stopped when:

i. The robot stops and communicates @HC reached, Task accomplished!@ **or**
ii. If the maximum time limit for completing the task is reached **or**
iii. If the team needs restart but has used restart of that run **or**
iv. If the team needs reposition but has used reposition of that run

- Second run will start after the first 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.

Important:

Visiting firezone/s and **Hospital/s** will be considered **valid, only if the robot waits, faces towards firezone, hospital and glows respective colored LED as stated above.**

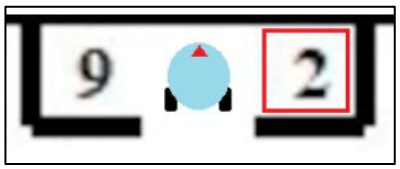


Figure 12a: Invalid visit to firezone "2"

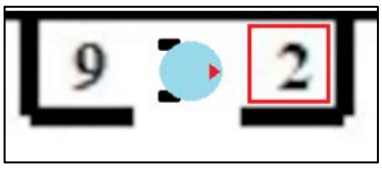


Figure 12b: Valid visit to firezone "2"

For the run to be considered valid, robot should visit at least one firezone.

- Teams are not allowed to keep anything inside the arena other than the robot. The time measured by the e-Yantra reviewer will be final and will be used for scoring the teams.
- Time measured by any team by any other means is not acceptable for scoring.
- Once the robot starts traversing, teams are not allowed to touch the robot.
- 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.

Restarting of Bot:

Suppose the robot fails due to some reason/gets stuck or dashes wall, a member of e-Yantra team who will be monitoring the task will allow one of the team member to **Restart** the run (if asked by team). **Restart** gives the team a second chance ***to start the same run from the beginning***.

It will be as follows:

- Team member should enter "**%**" on Python terminal.
- This should stop the robot and the Python client script.
- Robot should be placed within the center of cell (0,0).
- Communication will start again and the run restarts by pressing the **USER_SW** switch.

Note that the Timer will be continuously running during a Restart.

Repositioning of Bot:

Suppose the robot fails due to some reason/gets stuck or dashes wall, a member of e-Yantra team who will be monitoring the task will allow one of the team member to **Reposition** the robot (if asked by team). **Reposition** gives the team a second chance ***to continue the same run from the position it has stopped***.

It will be as follows:

- Team member should enter "**&**" on Python terminal.
- This should stop the robot but the Python client script **should not** be stopped.
- Team member should decide in which of the previously traversed cell the robot shall be placed.
- Communication will **not** start again and the run continues by pressing the **USER_SW** switch.

Note that the Timer will be continuously running during a Reposition.

IMPORTANT:

Either **one restart / one reposition** is allowed per run. If team requires a second restart / second reposition, the run will **be ended and the maximum time for the Task** (10 minutes) **will be considered for that run**.

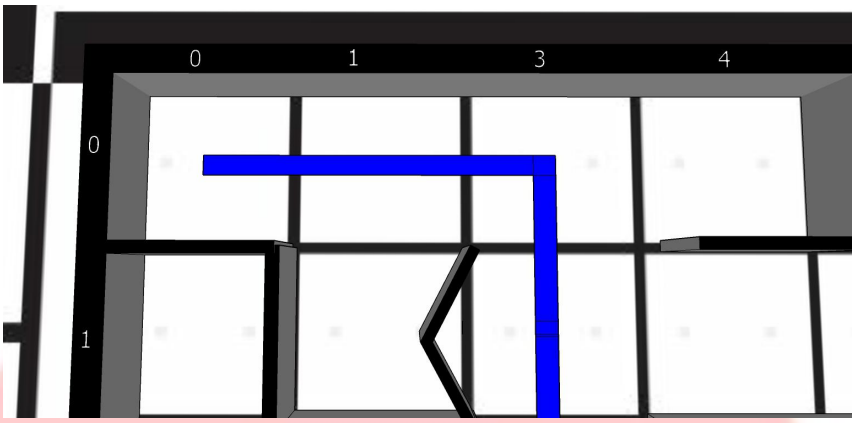


Figure 13: Numbers on the arena

As shown in Figure 13, numbers will be placed / written on the outer walls (boundary). These numbers can be used as reference by teams for placement of robot.

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.

7. Judging and Scoring Formula

- Better score of the two runs for a team will be considered the final score of the team.
- The team's total score is calculated by the following formula:

$$Total\ Score = (600 - T) + (VFC \times 100) - (VFI \times 50) - (|X - NVP| \times 50) + \left(\frac{NVC \times 50}{NFP}\right) - (NEC \times 100) + (NVH \times 100) - (P \times 30) + (B \times 100)$$

- **T:** Total time in seconds taken to complete the task
- **X:** Total number of vacancies available in Hospital (varies)

- **VFC**: Number of victims in firezones correctly identified
- **VFI**: Number of victims in firezones incorrectly identified
- **NFP**: Numbers of firezones planned to visit
- **NVP**: Sum of number of victims planned to be evacuated from firezones
- **NVC**: Number of firezones visited by robot
- **NEC**: Number of extra firezones visited than planned
- **NVH**: No vacancies available in all Hospitals (either 0 or 1)

- **P** is a penalty where **30** (thirty) points deducted:

  (i) for each reposition / restart **and**

  (ii) for each object in the arena that the robot dashes against or displaces during the run

- **B** is a bonus of **100** points awarded, when

  (i) VFC is maximum **and**

  (ii) NVH is one **and**

  (iii) Task is completed within 10 minutes **and**

  (iv) No penalty is incurred

!! … ALL THE BEST … !!