HUNGRY BIRD

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HUNGRY BIRD

1. Introduction

Birds take care of their young when they hatch. Newly born chicks depend on their parents to bring them food and require feeding every half-an-hour. Knowing this, we can now appreciate the diligence of parent birds. They go from their nest to a food source, carry it in their beaks and go back to feed their young. In fact, many birds that eat seeds, will switch to insects during the breeding season. Parents eat smaller insects themselves and take the larger ones back to the nest for the fledglings. This allows them to carry more food less frequently to their ever-hungry offspring. This process continues until the fledgling's feathers and muscles have developed sufficiently for flight.

Navigating in 3-D space is a task that birds perform routinely but is extremely challenging, and their proficiency at this is worth not only marveling but also emulating!
In this theme contestants are given a drone which represents the bird in this theme, that seeks to emulate the 3-D navigation ability of the avian species. The drone performs a task routinely performed by most birds, namely going through the process of feeding itself and its young, and henceforth this theme is called Hungry Bird and the drone is referred to as "**Bird**". Through this theme, we help you learn control system design and controlling a drone using the Virtual Robot Experimentation Platform(**V-REP**) and Robot Operating System (**ROS**).

The challenge is to complete the task of navigating the Bird through hoops in the shortest time possible. An image from the overhead camera is processed by a PC using V-REP and ROS to direct the Bird. The team that performs the task best in accordance with the rules set for this task will be declared the **WINNER**!

2. Theme Description

- **Bird:** This is the drone which navigates in the arena. It has a **WhyCon marker** on it for its localization.
- Arena is a representation of a Jungle as shown in Figure 1. The arena is divided into 6x6 **Cells.** Rows are referenced using roman numerals from I through VI and Columns are referenced using English alphabets A through F. An intersection cell on the grid would be referenced as IA, IIIC, and so on.

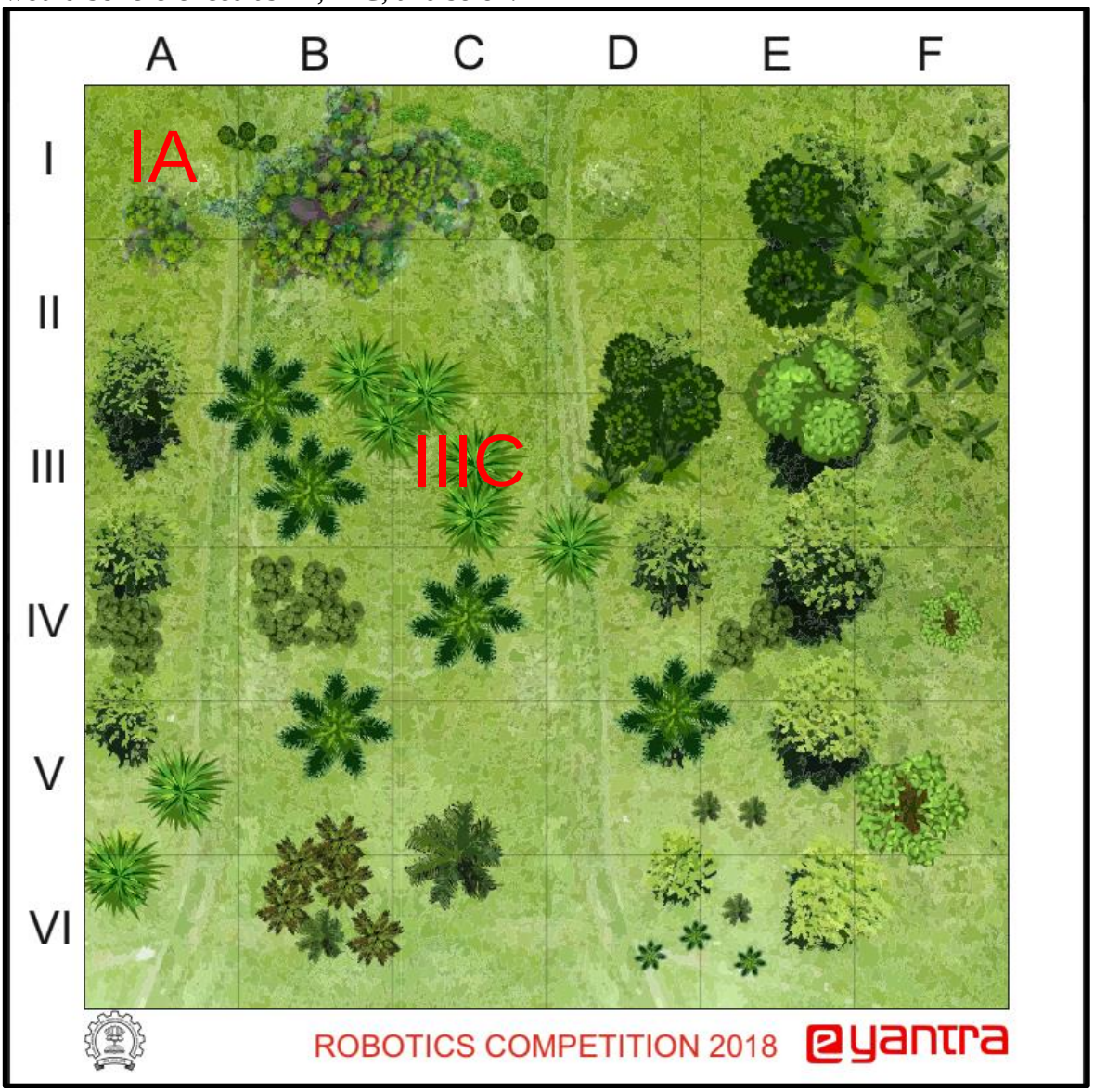

Figure 1: Arena

- **Trees (T):** In the eyes of a Bird, Trees are of 3 types:
  - **Food Trees (FT):** These are food (insects) bearing trees represented by hoops. The Food Trees in our jungle are represented as **Mango**, **Sal** and **Cashew** trees. These trees are depicted on the arena by yellow, green and red hula hoops respectively. Position and orientation of these trees are determined by the PC using WhyCon marker and **ArUco marker** respectively which are mounted on the respective hula hoop.

- **Non-Food Trees (NFT):** They are represented as obstacles in the arena which the Bird must avoid. These are the trees on which insects are not found for e.g. Neem and Teak. Position of Non-Food Trees are determined by the PC using WhyCon marker mounted on them.
- **Home Tree (HT): Home Tree** is a **Food Tree** that is the **Bird's** home. It can be any of the Food trees mentioned as present on the arena.

- **Start:** Starting position of the Bird. Start can be at any of the cells for e.g. IB.
- **Orientation scale:** This is the scale as shown in Figure 2 which is used to determine the orientation of the Food trees to be set in the arena. Instructions for how to paste this scale on the Food trees are given in section 3-a-iii**.**

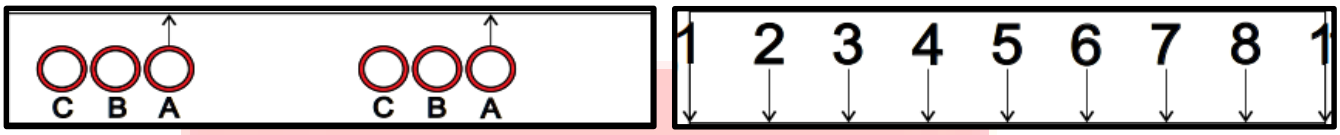

Figure 2: Orientation Scale

Inputs:
The following inputs are provided,

a. **Tree Configuration Table**: This determines the locations and orientations of Food Trees. Position is given by the cell number and orientation is specified by combination of the two scale markers as shown in Figure 2. For e.g.: One of the possible orientations can be 1A. **Note that this input is only for a reference to be used to place in the arena. These should not be used anywhere in the code**. Your code should be generic to find out the location (Trees) and orientation (Food Trees). An example of Tree Configuration table is shown in Table 1.

b. **Food Configuration Table**: This table determines the Home tree and number of insects i.e. food the Bird must carry. An example of Food Configuration table is shown in Table 2.

c. **Start**: This indicates the starting position of the Bird. It is given by the cell number. The Bird must be placed at the center of the specified cell. For example, IB can be the Start. Then the Bird must be placed at the center of IB cell. **Note that the Start is only for a reference to be used to place Bird in the arena. These should not be used anywhere in the code**

Tree (T)	Location	Orientation
Cashew Tree (red)	IIIE	1A
Mango Tree (yellow)	VB	5B
Sal Tree (green)	IIIB	8C
Non-Food Tree	IID	-
Non-Food Tree	IVC	-
Non-Food Tree	VE	-

Table 1: Tree Configuration Table

Food Tree (T)	Number of Insects
Cashew Tree (red)	Home
Mango Tree (yellow)	1
Sal Tree (green)	2

Table 2: Food Configuration Table

In summary, this theme involves the following:

- Arena is set up using Tree and Food Configuration Table. The above table is an illustration of such table.
- Position and orientation of Food trees are emulated in V-REP using WhyCon and ArUco markers respectively.
- Position of Non-food trees are emulated in V-REP using WhyCon markers.
- Bird starts to fly from the Start.
- An overhead camera, mounted above the center of the arena, captures the entire arena. Instructions for mounting the camera are provided in section 3.D.
- PC processes the camera feed, plans the path using V-REP and guides the Bird on the Arena through commands using ROS. Simultaneously, V-REP should emulate the movement of the Bird.
- Bird navigates through the Food trees avoiding Non-food Trees as per the Food configuration table.
- Bird lands at the Start after completing the task.

3. ARENA

Preparing the arena:

Each team has to prepare the arena. Preparing the arena consists of

A. Printing the arena design on flex sheet
B. Tree construction
C. Marker Construction
   a) ArUco marker construction
   b) WhyCon marker construction
D. Setting up overhead camera
E. Setting Arena with respect to camera frame
F. Final Arena Setup

A. Printing the arena design on flex sheet:

Flex design is shown in Figure 2. A Portable Document Format(.pdf) file containing the flex design is provided to teams. Each team prints the flex design according to the direction given in the Readme file

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems in placing the hoops. Always roll your flex. If creased one way of "flattening" flex it 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.

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

Dimensions of arena are as shown in Figure 3:

- Outer dimension of arena is 210cm x 210 cm
- Dimension of each Cell is 35 cm x 35 cm.

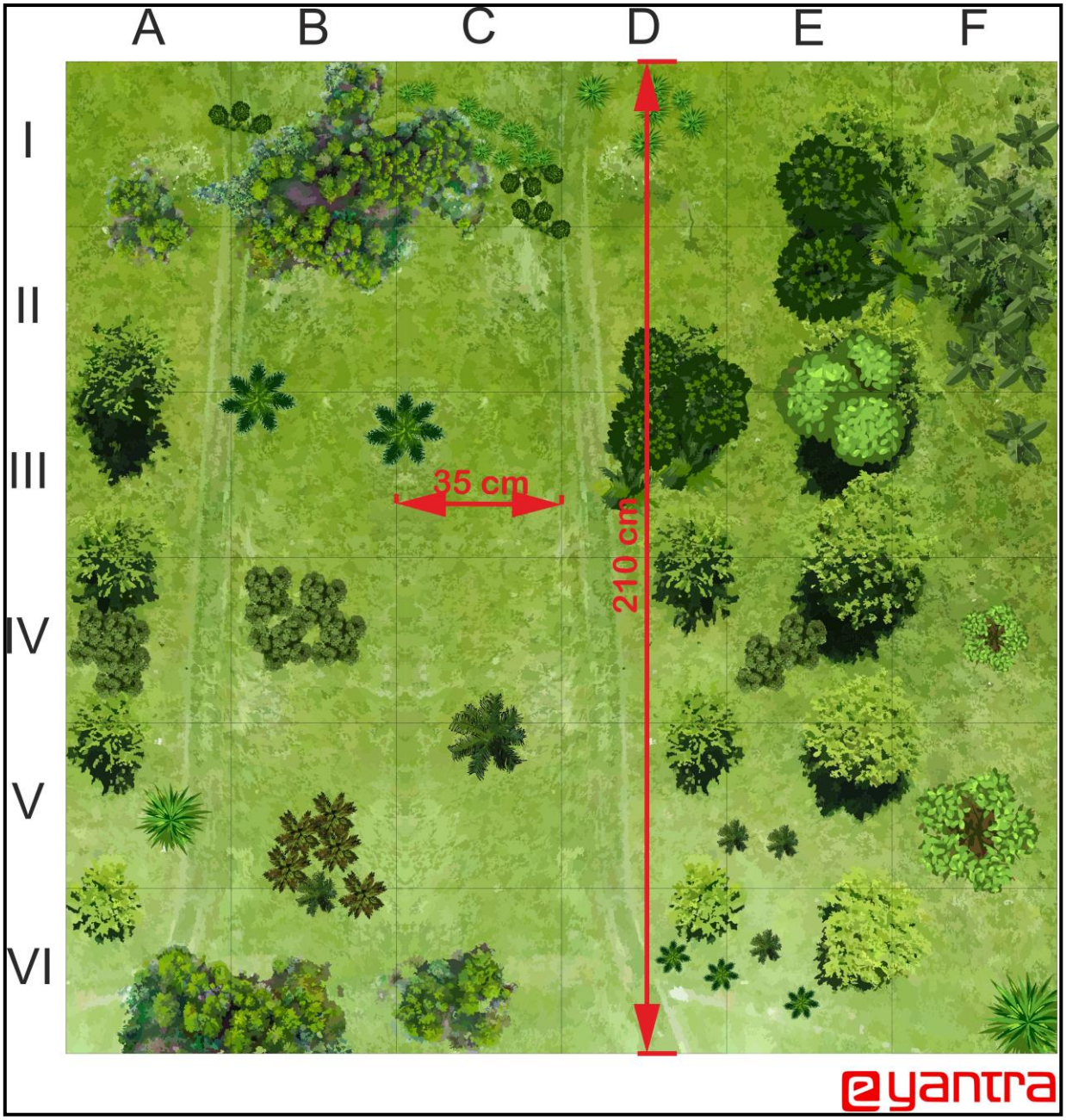

Figure 3: Arena with dimensions

B. Tree Construction

- Please go through this video to learn how to make Food and Non-food tree.

a) Food trees

- There are three varieties of food trees namely, Cashew tree, Sal tree and Mango tree.

i. Base of the Food tree

- The Base of the Food tree as shown in the video has the configuration as shown in Figure 4. Dimensions of the Base is the same for all food trees.

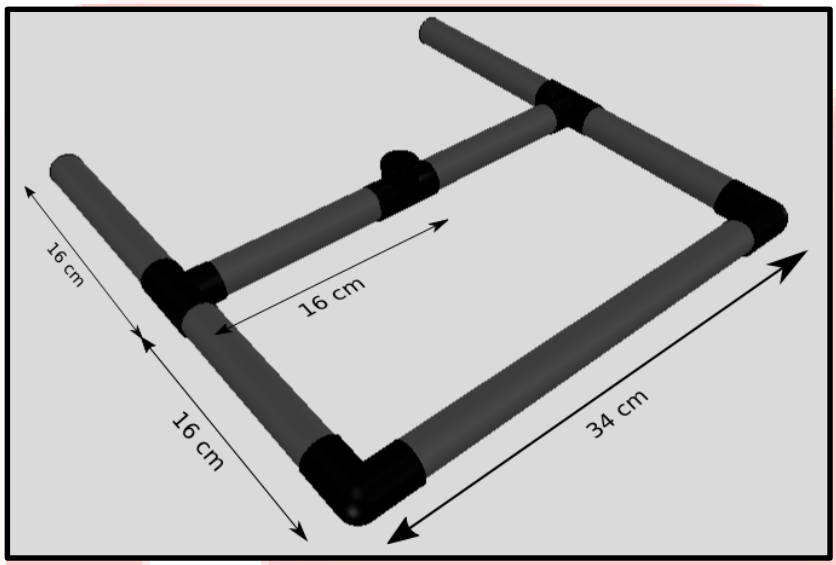

Figure 4 : Base of Food-Tree

ii. Height of Food trees

- Each of the three types of Food trees have different heights as given in Table 3. An example of the base with the attachment (Sal tree) is given in Figure 5.
- The closed side of the base represents front of the Tree. It is denoted by the green arrow mark as shown in Figure 5.

Food Tree	Length of hoop attachment pipe (cm)
Sal Tree (green)	100
Mango Tree (yellow)	60
Cashew Tree (red)	40

Table 3: Length of Food trees

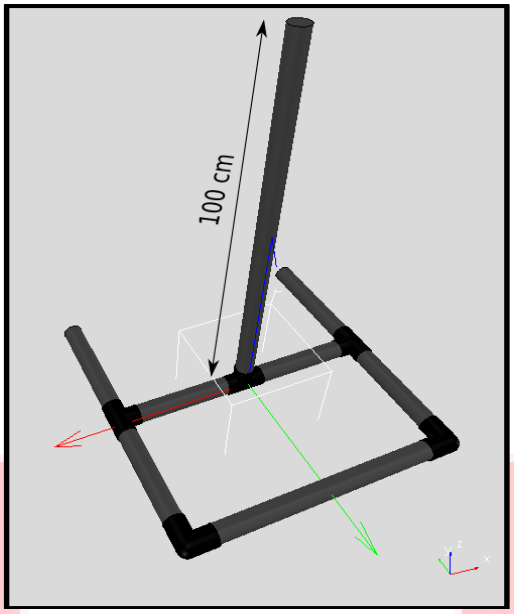

Figure 5 : Base of Sal tree

iii. Top of the Food tree

- Top of the Food tree is shown in Figure 6. This is also shown in the video. This figure illustrates a possible configuration of a Food tree. Colours of hoops are different for different Food trees as shown in table1.
- Stickers have to be placed on the top and base of the Food tree. The stickers with scale as shown in Figure 7-10 are placed in designated places at top and the base. This has been properly explained in the video.

Figure 6: Top of Sal Tree

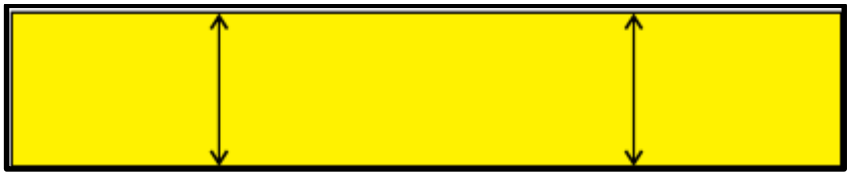

Figure 7: Sticker “a” (yellow for yellow hoop)

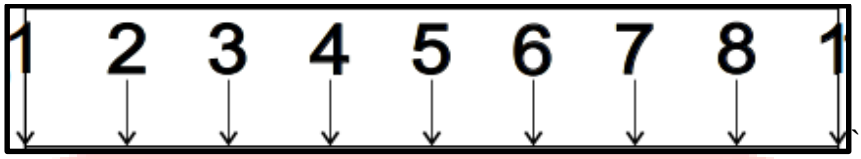

Figure 8: Sticker “b”

Figure 9: Sticker “c”

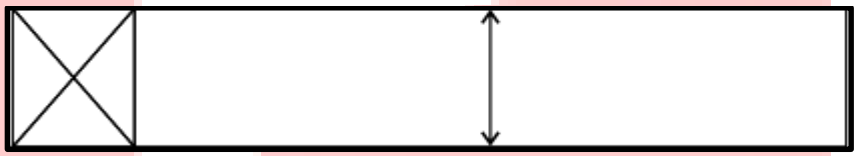

Figure 10: Sticker “d”

- These stickers are used to set the orientation of the Food trees. An example of Cashew Tree with orientation 3B is shown in Figure 11. Top view of the same Cashew tree is shown in Figure 12.

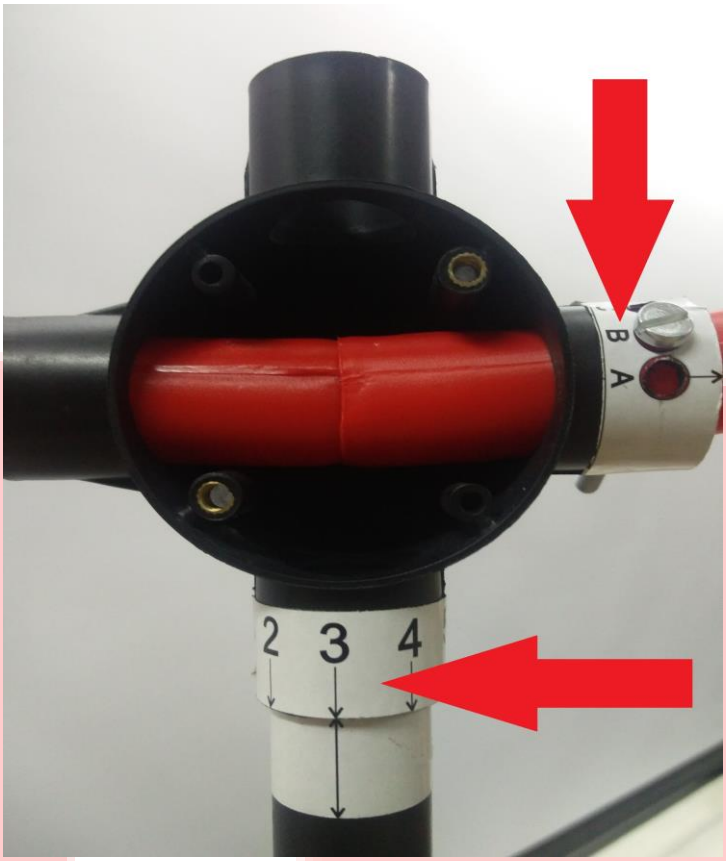

Figure 11: Front view of connector Cashew Tree of orientation 3B

Figure 12: Top view of the Cashew Tree of orientation 3B on the arena.

Non-Food Tree

- Non-Food tree as shown in the video have configuration as shown in Figure 13. All Non-food tree have the same configuration. Base of the Non-food tree have same dimension as that of Food-tree as shown in Figure 3. Closed side of the base is the front of the Tree as shown earlier in Figure 5.

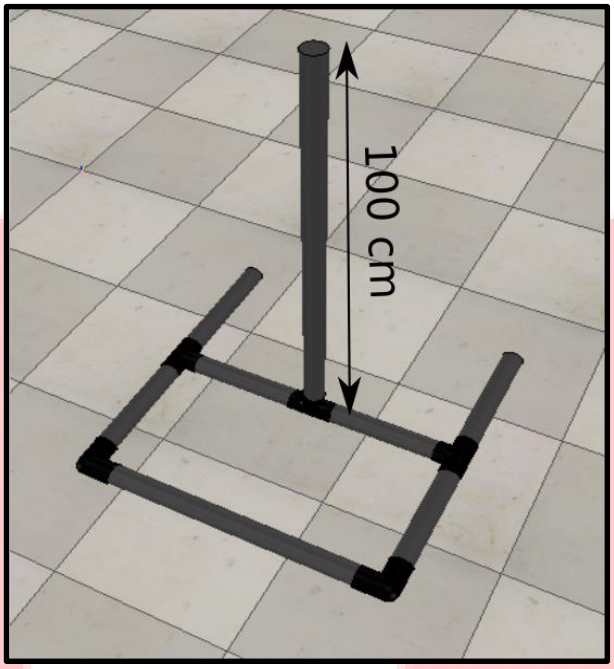

Figure 13: Non-food tree

C. Marker Construction

a) ArUco marker construction

- Please print ArUco markers provided to you in Task 2. Teams are free to use same or different ArUco marker for all the Food trees. Make sure that ArUco markers are of dimensions 150mm x 150mm.
- Follow the instructions in the video to understand how to construct the same.
- Make sure you place the mechano or any such extension as shown in the video at the centre of the marker itself.

b) WhyCon marker construction

- Please find the WhyCon markers in the package which has been shipped to you.
- Follow the instructions in the video for construction of the WhyCon marker holder for the trees.
- Make sure you place the pipe in the center of the WhyCon marker as shown in the video.

D. Setting up of overhead camera

- Team is provided with a camera and an extension cable.
- The provided camera must be mounted such that it has a complete top view of the arena. Camera should be mounted above the center of the arena at a certain height. **The height of the camera should be in such a way that the Z coordinate of a WhyCon marker placed at ground level should be between 33 and 36 as shown in Figure 15.** Z coordinate in Figure 15 is 34.83 which is in between 33 and 36 and hence acceptable. Make sure you fix the camera parallel to the ground and not inclined.

- 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.
- Extension cable will be useful to connect the camera to the PC/laptop. Figure 14 shows an example setup for overhead camera.

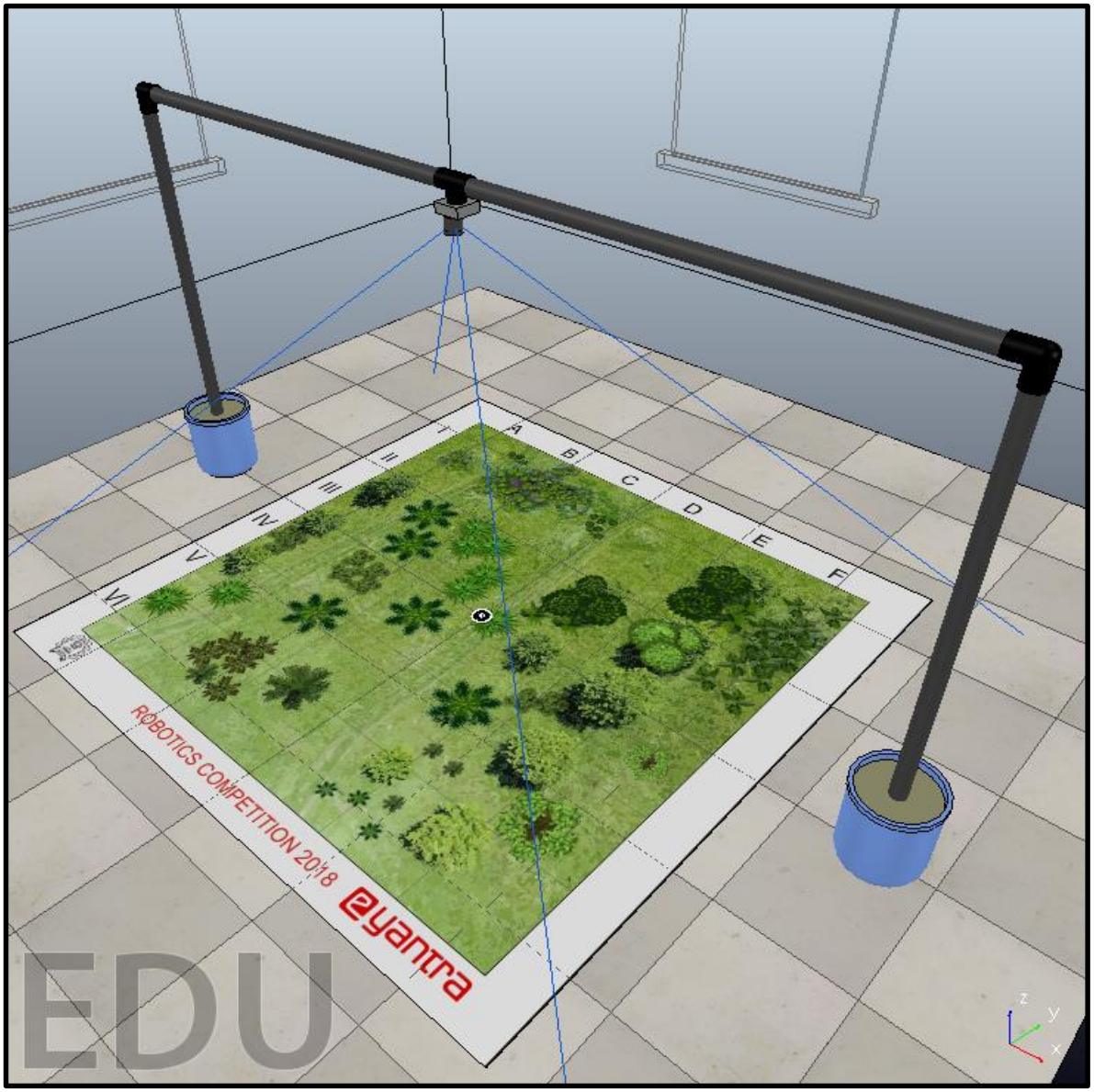

Figure 14 : An example of overhead camera setup

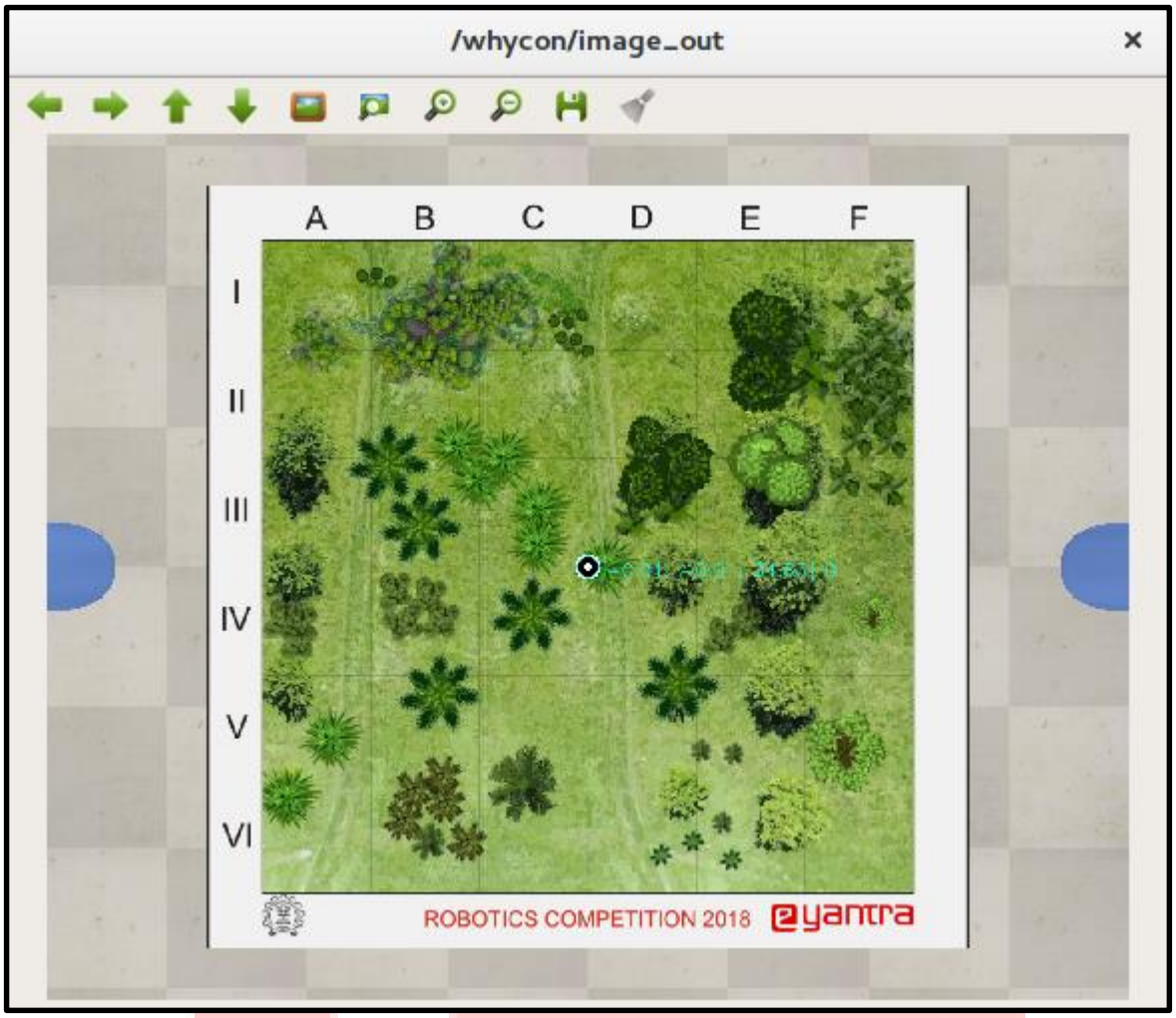

Figure 15: WhyCon image output

E. Setting Arena with respect to camera frame

- Place a WhyCon marker at the intersection of vertical line midway between C and D and horizontal line between III and IV as shown in Figure 16.

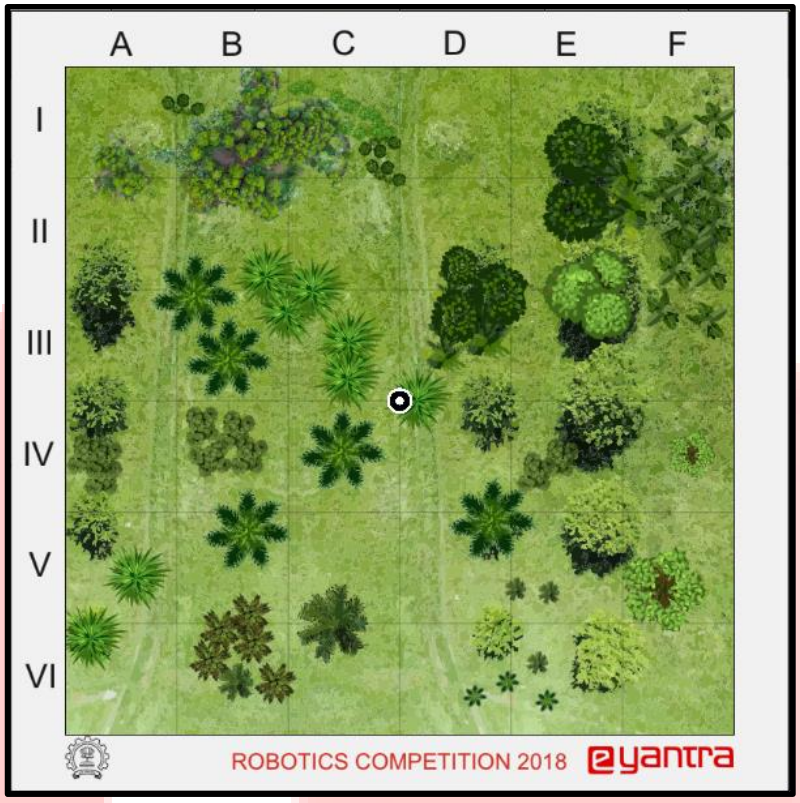

Figure 16: Placement of WhyCon marker

- Fix the position of the arena in such a way that the X and Y coordinates of the WhyCon marker range between **-0.05 to 0.05** as shown in Figure 15. Also note that **the arena is positioned in such a way that the arena in the image from the camera have the marking A, B and I, II etc in the top left position as shown in Figure 15**.
- To fix the orientation of the arena, place another WhyCon marker at the intersection between III and IV as shown in Figure 17.
- The difference in the reading of the Y coordinates of the two WhyCon markers **should not exceed 0.05** as shown in Figure 18.

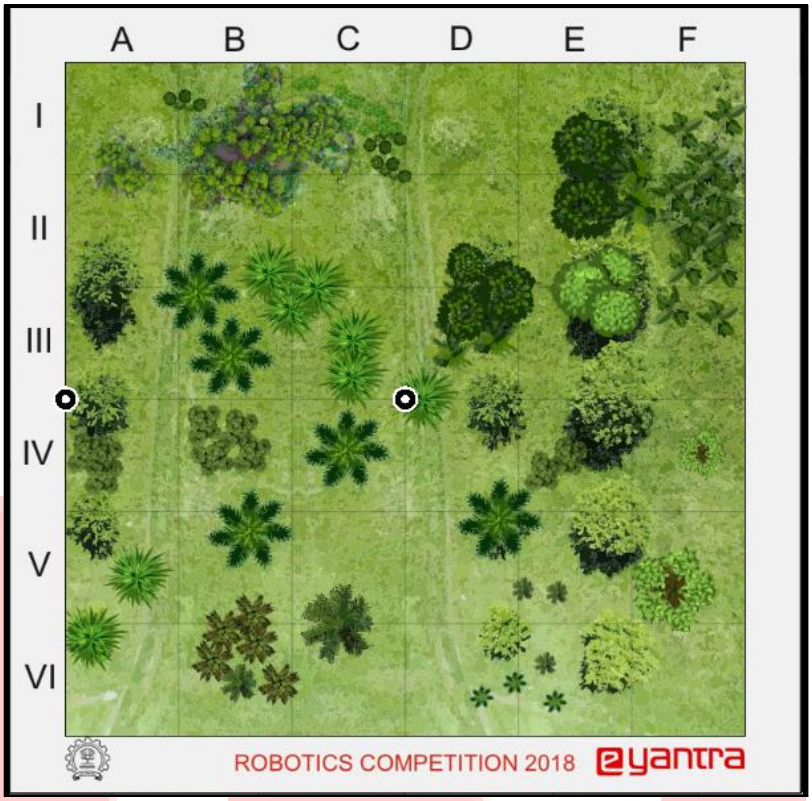

Figure 17: Placement of two WhyCon markers

Figure 18: WhyCon marker readings

F. Final Arena Setup

As specified in the inputs in Theme description section, Food and Non-Food trees are placed and oriented on the Arena. Figure 19 shows an example of the final arena setup.

Figure 19: An example of final arena setup

Note: The arena shown in Figure 19 is just for illustration. Placement and orientation of Food Trees and Non-Food trees will be random. The pattern of placing Food trees and Non-food trees in the cells are valid only for Final task (Video and Code submission). For finals, the Food trees and Non-food trees can be placed anywhere on the arena and need not be inside the cell.

4. Hardware Specification

A. Use of Components:

- All the participating teams must use only the components which were sent to them in the kit. Only one set of components given in the kit is allowed per team.
- The Bird should be completely autonomous. The team is not allowed to use any wireless remote for its manual control.
- Teams are allowed to create any type of mechanical mount for mounting camera above the arena.

Note: No other expansion and/or microcontroller-based boards shall be attached to the Bird.

5. Software specifications

- e-Yantra has provided all teams with an e-Yantra version of the Whycon package that has been already given to the teams in Task-0. This library is tailored to be used for the theme. **Use only this library.**
- The teams must use Python and Lua to write their code.
- You are allowed to use only inbuilt Python libraries. Use of any other external libraries is not allowed and will result in disqualification.
- As per e-Yantra policy, all your code and documents are open-source and may be published on the e-Yantra website.

6. Theme Rules

- The maximum time allotted to complete the task is 7 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 six reposition requests in a run (explained below) will be allowed.
- Team must detect the position of the Bird using the overhead camera.
- Team must detect the position and orientation of the Trees using the overhead camera.
- Teams are allowed to control the Bird only using ROS commands.
- Turn ON the Drone and place it on the Start before running the script.
- After running the script, teams will be given 3 minutes to setup the arena. It involves the following:
    - Placing WhyCon markers on Food and Non-Food trees. WhyCon markers must be placed only on the defined positions of the trees as specified in the video under Arena section. Manual entry of the detected WhyCon coordinates to the script is not allowed.
    - Placing ArUco markers on Food trees. ArUco markers must be placed only on the defined positions of the trees as specified in the video under Arena section. Manual entry of the detected ArUco coordinates to the script is not allowed.
    - Teams can press keys of the keyboard to input the coordinates to the script as you have done in Task 2. Teams are free to press any number of keys on the keyboard in these 3 minutes. However, **you are not allowed to manually type the WhyCon or ArUco coordinates before running the script**.

  - Teams will not be allowed to place WhyCon and ArUco markers other than on the specified locations. Teams not complying with the instructions may be disqualified.
- Once the emulation of the arena is done, the team must initiate the Drone using an input key when told by the reviewer. This will be the start of the run. Timer will start at the same time. Timer will automatically start if the team exceeds the 3 minutes given for arena setup.
- Once the run starts, human intervention is NOT allowed. If any intervention is made, it will be treated as request for re-position. (Re-position Rules are discussed below).
- A run ends and the timer is stopped if:
  - Bird navigates through the food trees as specified in the Food configuration table and comes back and lands at the Start.
  - The maximum time limit for completing the task is reached
  - The teams need re-positioning but has used six repositioning options of that run.
- Task will be considered incomplete and time will be considered maximum (420 seconds) if:
  - Bird does not go through Home tree even once.
  - Bird needs repositioning after using their maximum repositions.
- Bird can follow any order to collect food from food trees. But after traversing through food tree it must come back to home tree. Mere traversal through food trees without coming to the home tree will not be considered.
- Bird is said to successfully collect or deliver food only if it passes through the hoop ie it crosses the plane of the hoop. It can pass through the hoop in any direction.
- For second run, teams are not allowed to make any software changes. Hardware changes like battery replacements are allowed.
- Participants are not allowed to keep anything inside the arena other than the Bird and the Trees.
- The time measured by the reviewer is final and will be used for scoring.
- Time measured by any participant is not considered for scoring.
- Bird is not allowed to make any marks on the arena. If found damaging the arena, it will be immediately stopped; repositioning will be allowed as per the rules. **The final decision is at the discretion of the e-Yantra reviewers/judges.**
- Teams are allowed to use their own V-REP scene. However, during the run the V-REP scene must be shown on the screen. The computed path must be visualized in V-REP.

Reposition Rules:

- Teams can ask for re-position if the Bird gets stuck in the arena or goes off the arena.
- Each team is allowed a maximum of six repositions for the Bird. All re-positions require the permission from e-Yantra: the team stands disqualified if the drone is handled in any manner within the arena without permission.
- During re-position, Bird should be placed at the Start. Team can input maximum of two keys to re-initiate the Bird at each re-position. Teams will be allowed to restart the script if required, however teams will not be allowed to place WhyCon and ArUco markers again on trees to emulate the scene on V-REP. Teams are not allowed to make any changes in the code. **The final decision is at the discretion of the e-Yantra reviewer/judges.**

- If Trees in the arena are displaced, they will be placed back in the original locations. If this is caused by collision with the Bird, teams will be penalized according to the Judging and Scoring parameters.
- Any arena setup during re-position is done by members of e-Yantra team.
- During a re-position, the timer keeps running.
- Team cannot make any changes in the code during a re-position.

NOTE:

- **You will be given Input configurations 24 hour before the submission of Task 4.**
- **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 System

Total score: (420 - T) + (FP * 200) + (HC * 200) - (CP * 20) - RP + LB + B

- T is the total time in seconds to complete the task.
- FP is the Food picking point:
  - Scored when Bird crosses the hoop. This point is awarded only if the Bird crosses the plane of the hoop.
  - No FP for subsequent crossing until it crosses Home Tree
- HC is the Homecoming point:
  - Scored when Bird crosses the Home tree. This point is awarded only if the Bird crosses the plane of the hoop.
- CP is a collision penalty applied:
  - for each collision between Bird and trees/
- RP is a reposition penalty applied:
  - $RP = 20 * (e^{(Tp/2)}-1)$,
    - Where,
      - T_p is the number of times the Bird is being repositioned.
- LB is the landing bonus of 30 points if the Bird lands at the Start.
- B is a bonus of 100 points awarded:
  - When the task is completed within 10 minutes,
  - no penalty is incurred.

ALL THE BEST…!!!