

# Berryminator

## Introduction

The market size of Agriculture and allied industries was a whopping US\$276.67 Billion dollars in fiscal year 2020\* for the Indian scenario. We are encountering a new revolution in modern agriculture being driven by constant technological innovation. These range from the usage of drones to the use of smart sensors (IoT) and from research involving rural as well as urban farmers using robots in all aspects of growing food.

The introduction of technology in agriculture directly leads to greater crop yield. Since robots have high precision and accuracy, their use improves the efficiency and speed of the entire process thereby increasing profitability. Through the *Berryminator* theme of e-Yantra Robotics Competition (eYRC 2021-22) we are trying to emulate the same.

The theme is set in an indoor environment where concepts of urban farming are being explored. The arena is abstracted in a simulator where berries are grown in vertically stacked trays in rooms. The omnidirectional robot in the simulator navigates the rooms and galleries of the complex where the environment is controlled to provide optimal berries' growth. The robot identifies Berries and harvests them.

Challenges include **Robotic Simulation, Image Processing, 3D Designing, Algorithm Building, Robot Navigation and localization, Python programming and Lua programming.**

The critical factor is time and the challenge is to complete the given tasks in the shortest possible time 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 !!

\*<https://www.ibef.org/uploads/industry/Infographics/large/Agriculture-and-Allied-Industries-Infographic-June-2021.pdf>

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## Theme Description

The arena for this theme represents an urban farm. In this theme, teams will design a robot that is capable of navigating through the rooms and galleries of the arena in a CoppeliaSim simulation and pluck the berries using a mechanical arm built upon the designed robot.

The robot navigates the arena with QR codes using a vision sensor in the simulation (Fig. 1 shows the bare floor in the scene embedded with QR codes).

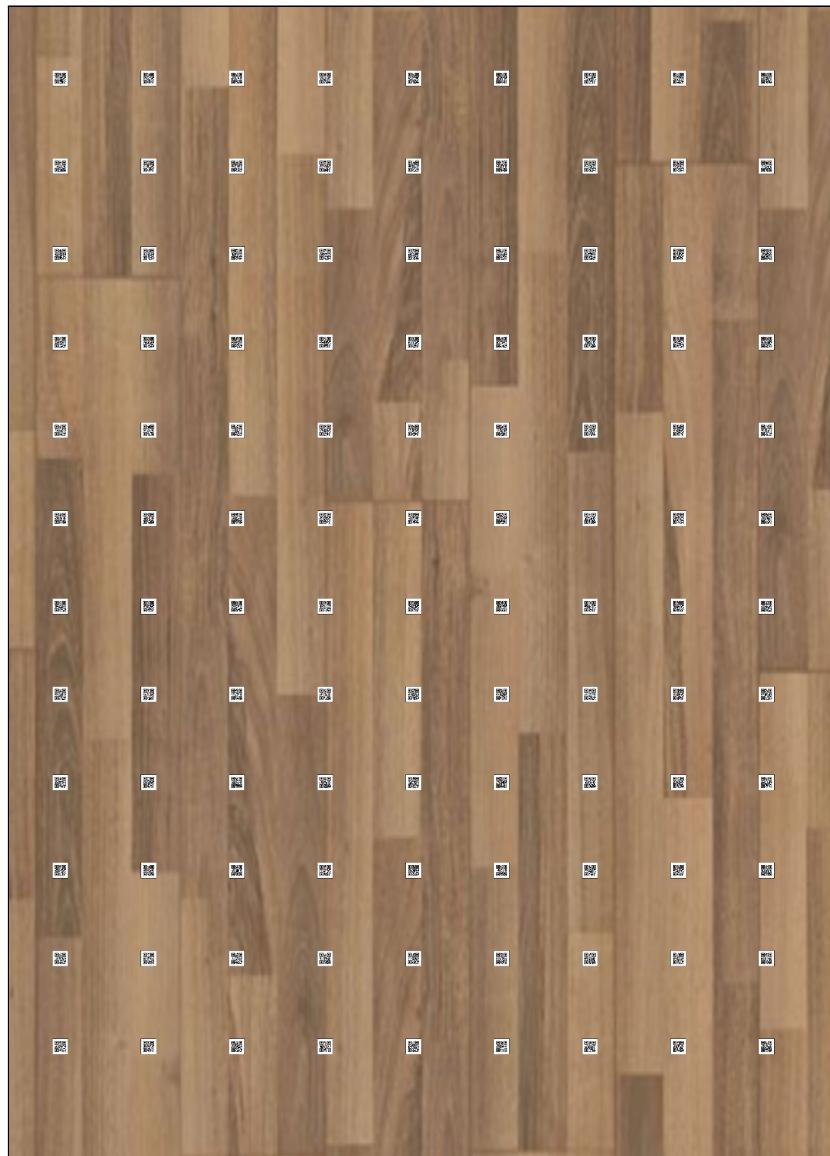


Fig. 1: Bare Arena Floor with QR codes

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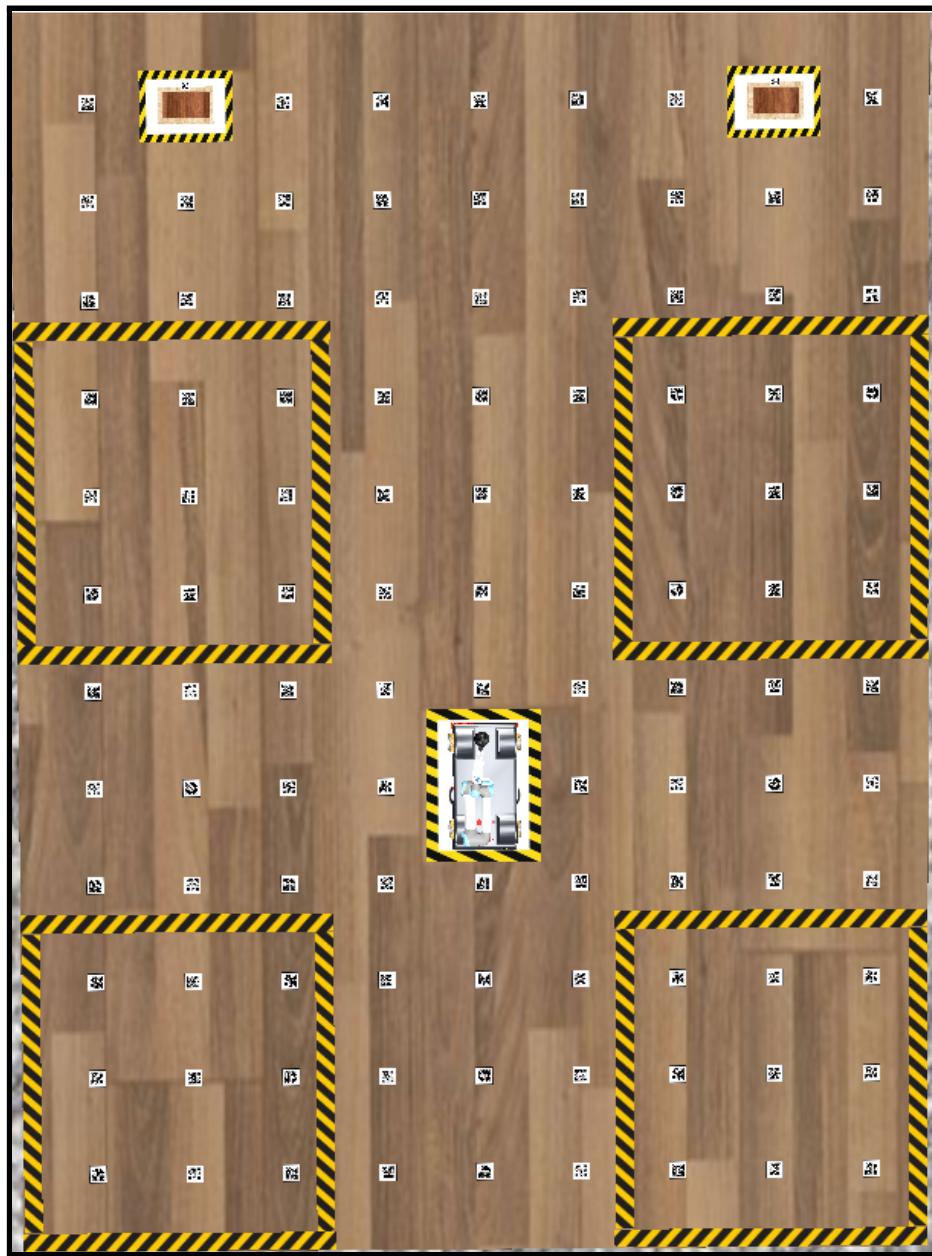


Fig. 2: Arena with rooms

There will be 4 Rooms in the arena. Rooms with outline are shown in Fig. 2.

## Major Arena Components

This section defines a few arena components which will be used in this theme.

1. **Robot Home:** This is the area at the centre of the arena where the robot will begin its traversal (refer to Fig. 3)
2. **Rooms:** There are 4 Rooms namely, R1, R2, R3 and R4 as shown in Fig 3. These are the rooms where the Plants/Plant's Rack will be placed. Each room will have one entry for the

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robot.

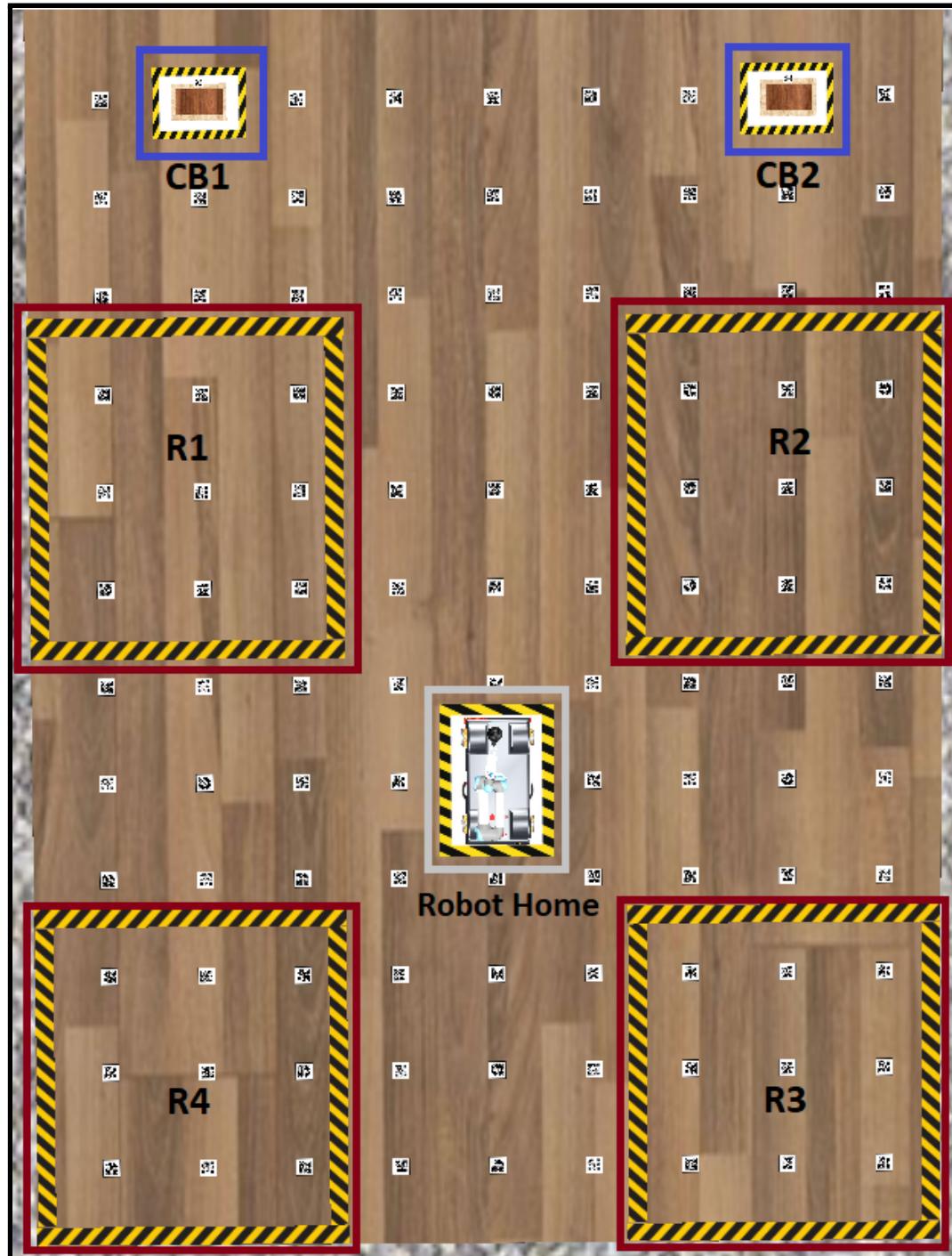


Fig. 3: Arena with labelled Rooms, Collection Boxes and Home

3. **Plants:** These are the plants that will bear the Berries. There will be three types of berry plants namely, *Blueberry (B)*, *Lemon (L)* & *Strawberry (S)*. These will be the same as the ones you encountered in Task 2 (2A specifically).

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**Fig. 4(a), 4(b) and 4(c): Blueberry, Lemon and Strawberry Plant**

Plants would be placed on a Plant Rack inside the room/s. An example Plant Rack is shown in Fig. 5



**Fig. 5: Sample Plant Rack**

4. **Collection Boxes (CB):** There are two collection boxes for depositing the berries at the top of the arena. There are two Collection Boxes CB1 and CB2 as shown in Fig. 3.
5. **Vision Sensor (VS):** There are 2 Vision Sensors: one VS for navigation using QR codes and one for Berry detection on the Plants.

Both these VS will be provided as simulated components in the CoppeliaSim scene to the teams.

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## Theme Run Requirements

For the theme run, the teams will be provided with the following files/documents:

1. **Theme\_Arena.ttt** - The theme arena scene file in which the final theme run will take place.
2. **BM\_GUI.exe** - will be provided to the participants to run and evaluate their implementation.
3. **Theme\_Config.json** - The required Berries and their respective deposit locations (CB1 and/or CB2) are provided via this file from which the team will extract the information.

**Theme\_Config.json** file will comprise various elements pertaining to a theme run. This includes the type and the number of Berries to be plucked and the Collection Box information where the plucked berries need to be deposited.

Consider the following dictionary:

```
{“B”: “3_CB1”, “L”: “1_CB1”, “S”: “2_CB2”}
```

The given dictionary format conveys the following information:

- A. **Required Berries** - There are 3 Blueberries (B), 1 Lemon (L) and 2 Strawberries (S) that need to be plucked.
- B. **Total Berries to be plucked** - There are going to be 6 total berries to be plucked based on the Required Berries (defined above).
- C. **Collection Box** - The Collection Box where the plucked Berries will be deposited.

**From the previous example,**

```
{“B”: “3_CB1”, “L”: “1_CB1”, “S”: “2_CB2”}
```

there will be 3 B, 1 L and 2 S to be plucked.

B and L are to be deposited in the CB1 whereas plucked S are to be deposited in the CB2.

**Note:** This is just an example configuration that would change in the later stage of the competition.

## Theme Play

1. Firstly, teams will be provided with the **Theme\_Arena.ttt** scene file.
2. Then, the **Theme\_Config.json** file is shared which must be read and extracted (explained in the previous section).
3. The run is then started by executing the **BM\_GUI.exe** file. The GUI will remotely trigger the simulation of the scene.
4. **The objective is to deliver all the berries to the appropriate CBs.**

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## Arena Description

Arena for a sample configuration is shown in Fig. 6a and Fig. 6b. The scene would have the following:

- A floor with QR codes for navigation
- One entry point into each room - generated randomly each time
- Plants on racks placed inside the rooms

NOTE: Teams are not allowed to make any changes in properties of elements already present in the arena scene. Changing the position, nature, orientation or script(s) of any element is prohibited.



Fig. 6a: Final Arena without Room entries (Sample Configuration)

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Fig. 6b: Final Arena with Room entries generated randomly (Sample Configuration)

## Software Specification

- You are ONLY allowed to use CoppeliaSim software.
- You may use other components for arm designing [you may refer to Task 2B and Task 4]
- **Note:** As per e-Yantra policy and NDA, all the tasks, resources (everything pertaining to the theme) & all your code, solutions and documents are solely the property of e-Yantra (IIT Bombay). **You are not permitted to make them publicly visible on any website like GitHub etc.**

## Theme Rules

- The theme run starts by starting the simulation using the Python remote API by running **BM\_GUI.exe**
- The timer will start as soon as the ***simulation starts***.
- The robot can move to any room based on the team's developed algorithm.
- Teams can get any type of configuration in the later tasks and hence should create a **generic solution**.
- For a run to be considered valid, the robot must correctly identify, pluck and deposit at least one required berry in the Collection Box (more details in the section below).
- Entry into a room would be randomly generated in the scene; ensure the team develops a generic solution.

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- The position of plants and berries inside the rooms would be randomly generated.
- The team may use extra components(sensors, actuators) within the described specification and constraints.
- BM\_Bot along with the robotic arm is together considered the “**robot**”.
- If the *robot* collides with any other component/artefact in the arena, a penalty (refer to the next section) would be incurred.
- The maximum number of Berries to be harvested in each run would be 8 in a run.
- Team is free to design their *pluck, storage and deposit mechanism* within the constraints of the “**robot**”.
- **Theme run will be considered finished automatically after 600 simulation seconds are passed from the start of the timer.**

## Judging and Scoring

The team's total score is calculated by the following formula:

$$\text{Score} = (600 - T) + (CI * 10) + (CP * 50) + (CD * 50) - P*30 + B + DB$$

**Valid Run:** Given a theme configuration, a run is considered valid only when the robot starts from the Robot Home position in the scene and:

- extracts the given **Theme\_Config.json** configuration file correctly and identifies at least 1 correct berry on the plant in a room (by sending the data to our auto evaluation script) (CI) AND
- picks at least one correct berry (CP) AND
- deposits at least one correct berry (CD) AND

### **CI: Correct Identification**

CI count is incremented if the robot traverses to a plant and correctly identifies the berry and shows it on the terminal.

### **CP: Correct Plucking**

CP count is incremented if the robot traverses to a plant, identifies the required (based on the given configuration file) berry correctly and plucks it from the plant.

### **CD: Correct Depositing**

CD count is incremented if the robot identifies and plucks a required berry and deposits it correctly (based on the given configuration file).

### **P: Penalty**

A penalty P is incurred each time the robot (including the arm) dashes against the arena elements (including plants, room boundaries, etc.).

### **B: Bonus**

A Bonus B of 200 points awarded in a run when:

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- *No Penalty ( $P$ ) is incurred*
- *Robot correctly identifies, plucks and deposits all the required berries from the given configuration.*

## **DB: Design Bonus**

*A bonus of upto 100 points will be awarded to the team based on various subjective factors like*

- *Design & Innovativeness of Pluck & Deposit mechanism (out of 50)*
- *Aesthetics & Creativity (out of 50)*

All rules, scoring parameters etc. are subject to change without notice. In case of any disputes/discrepancies, the e-Yantra decision is final and binding. e-Yantra reserves the right 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.

ALL THE BEST!