e-Yantra Robotics Competition - 2017

Theme and Implementation Analysis – Collector Bot <#925>

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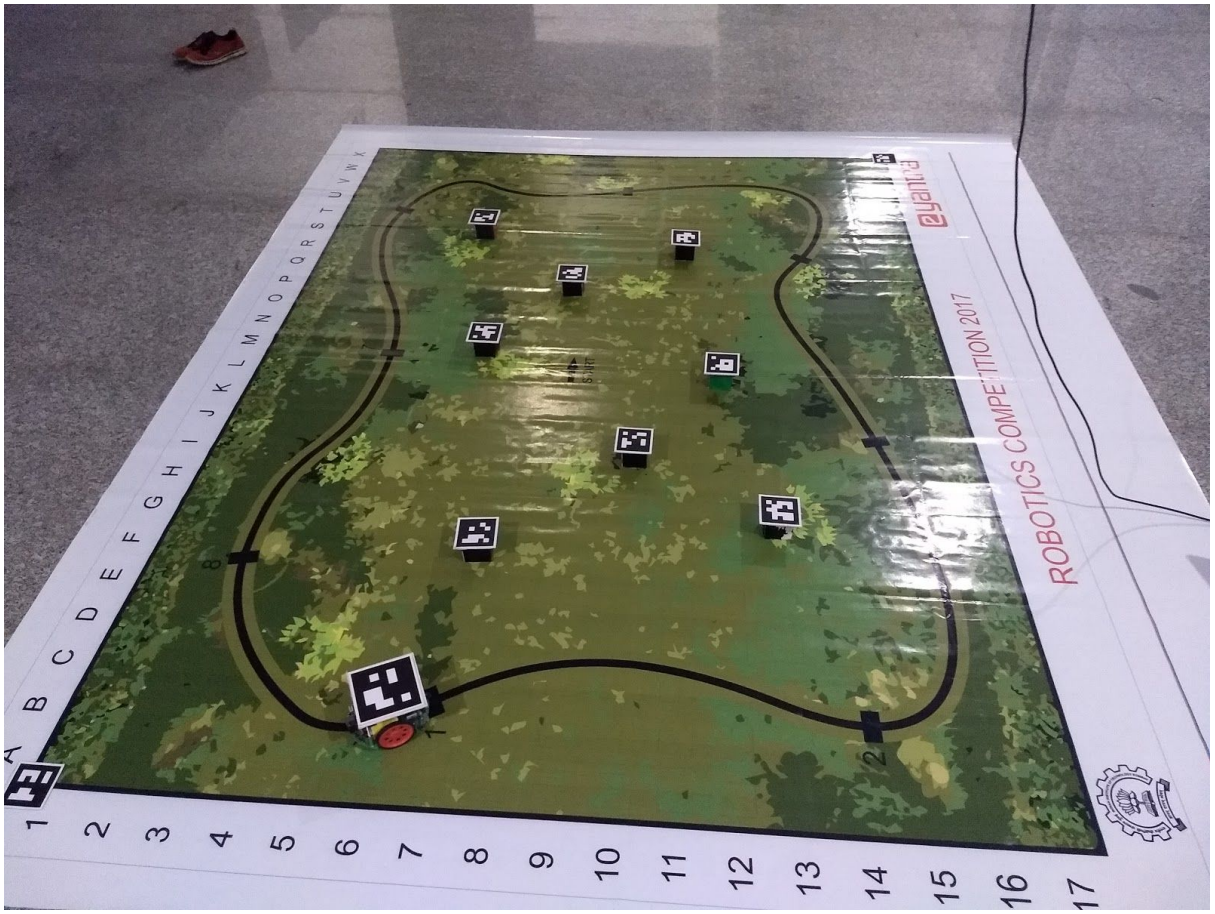
Scope and Preparing the Arena

Q1 a. State the scope of the theme assigned to you. (3)

The theme of the project is concerned with the collection of fruits that have fallen on the ground. The population of the world is increasing gradually, and to tend to the ever-growing demand for food, we have to make sure that we don't waste the produce grown by the farmers.

Therefore, the theme assigned to us is to tackle one of the major problems of wastage and to minimize waste. That is, the bot designed will pick up fruits which have fallen on the ground, which would otherwise have been left there to rot. Even though this may increase the produce marginally, it still makes a difference.

b. **Attach the Final Arena Images.** **(15)**



Building Modules

Q2. Identify the major components required for designing the robotic system for the solution of the theme assigned to you.

(5)

Electronic Components:

1. **Spark V:** It is used to collect the Fruits from the Collector Bot (CB). It moves in a fixed path stopping for 10 seconds at each collection point.

2. **ATmega 2560 Development Board:** This micro-controller is used to control the Collector Bot. The Xbee module mounted on it receives commands from the laptop as to what functions it needs to execute.

3. **XBee modules:** These modules are used to establish communication between the Collector Bot and the laptop.

4. **Overhead camera:** This is used to monitor the location of the fruits (Damaged and Fresh) and the locations of the Collector Bot and the Truck. This is used as a feedback mechanism to control the collector bot.

Mechanical Components:

1. **DC motors:** They are used to move the CB.

2. **Servos:** 3 servos have been used in the design, one for the claw, one for the arm which is used for putting the fruit into the CB storage. And the last one used to open the CB storage to deposit the Fruits into the Truck.

Actuators

Q3. List all the actuators which are going to be used by you in the theme completion. Justify their use. (5)

Truck:

1. Actuator 1 - The motors pre-mounted on the Spark V are used to make the Truck move in its path. No other actuators are used on the truck.

Collector Bot

1. Actuator 1 - Motors on the Collector Bot are controlled by the laptop are used to move the Collector Bot.
2. Actuator 2 - Servo for the claw is used to grab and hold the fruit and release it into the CB storage.
3. Actuator 3 - Servo for the arm is used to move the fruit into the CB storage once the fruit is grabbed.
4. Actuator 4 - Servo for dumping the fruits into the Truck. This servo controls the gate that holds the fruits in the internal bin.

Power Management

Q4. Explain the power management system required for the Collector Bot. What are the aspects that you should look into for power management? (5)

Servos: The CB has 3 servos mounted on it. As per our design specifications we run only 2 servos at a given time. In the worst case scenario the 9g servo and the GoTECK GS-5515MG are on.

GoTECK GS-5515MG at 6V operating point it consumes 300mA at idle and 2000mA at full

load.
The towerPro SG90 on the other hand operates at 6v consuming 170 mA at full load and 10-15mA at idle.
Motors: When the motors are on, the servos are all turned off. The motors operating at 6v will draw 800mA under no load and up to 7.5A under maximum load.

At any given point of time the maximum current drawn by the bot will be less than or equal to the power consumed by the motors.

Design Analysis

Q5. Teams have to design a mechanism for picking and dropping the Fresh Fruits into the Truck.

a) Choose an option to position the mechanism on the robot:

1. Front 2. Back 3. Right/Left

b) Justify your option.

(4)

Answer: _____

1. Front

a) The bot moves to the location of the fruit and the claw which is present in the front of the CB, then picks up the fruit and drops it in the CB storage.

c) Explain the design of the mechanism and how it is mounted on the robot.

(4)

c) Claw is mounted on the CB such that it picks up the fruits from the front and dumps it in the CB storage for the collector bot, which can hold a maximum of 4 fruits.

d) To design the mechanism for picking and dropping the Fresh Fruits, what challenge/s do you expect to face and how you will overcome them? (2)

d)

1. Challenge : Picking up of the fruit without dropping/slipping.
   Solution : Install rubber pads at the end of the claws to prevent the fruits from slipping.
2. Challenge : Transferring of all the fruits from the CB into the Truck bin within 10 seconds
   Solution : Design the slope in both the truck bin and CB internal storage such that it can drop all the fruits into the Truck bin within 10 seconds.
3. Challenge : Storage of all the fresh fruits in the CB before dropping it into the truck bin.
   Solution : Sloped internal storage of CB so that the fruits slide down to the bottom, to prevent it from falling off the CB internal storage.
4. Challenge : Positioning of the claw so that it can reach the top of the CB internal storage as well as pick up the fresh fruits which are on the ground.

Solution: Design the length of the arm to be exact so that it can reach both the CB internal storage on top and the fresh fruits on the ground.

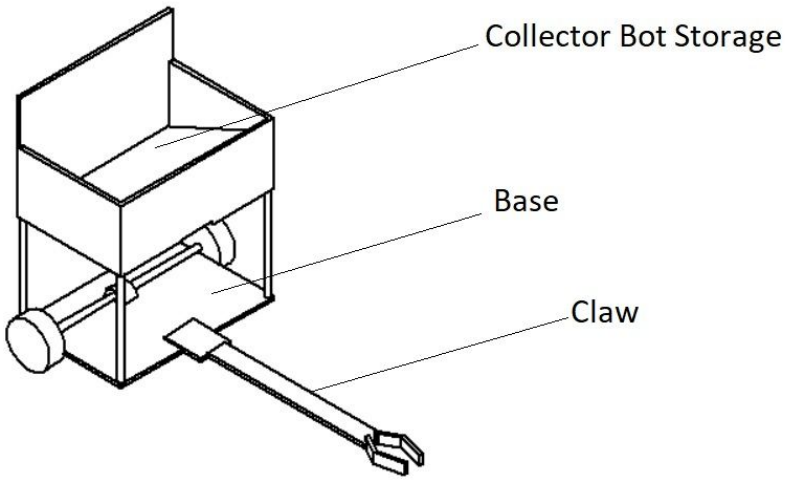
5. Challenge : Power management of the 3 Servos

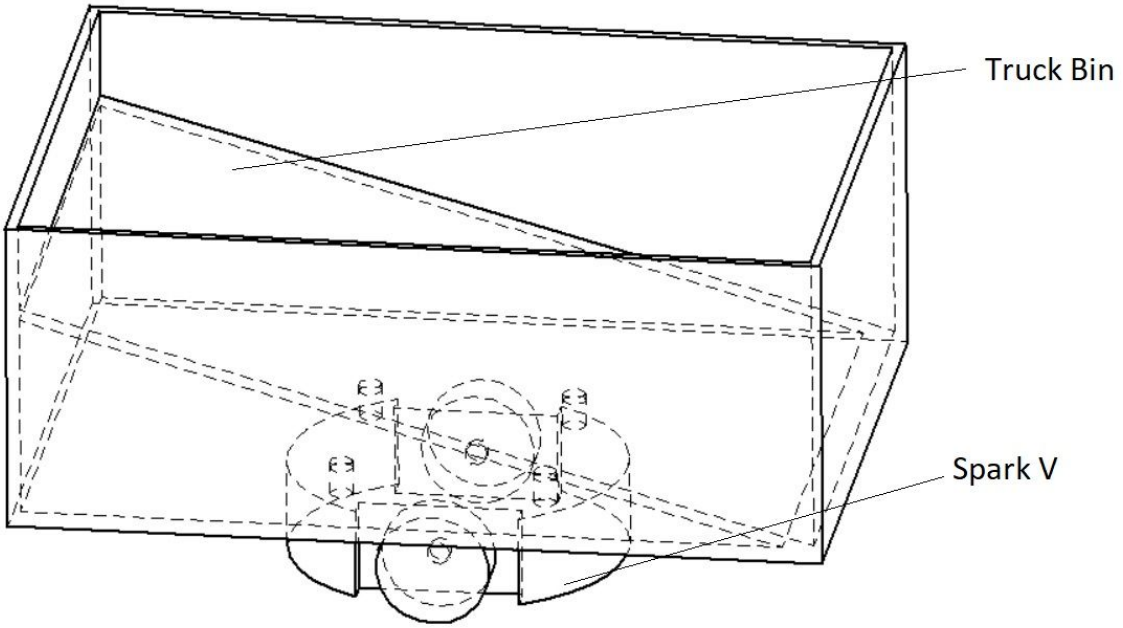
Solution: So as to not draw too much power at once, we limited the running of Servos to maximum 2 at any given point of time(one GoTECK GS-5515MG and one SG90).

Q6. Are you going to use any actuator for the bin on the Truck? (Yes /No). Justify your answer. (2)

No, we are not using an Actuator for the bin of the truck because we have designed the truck in such a way that the inside of the bin in the truck is sloped so that when the fruits are dropped in the truck the fruits will slide down so as to accommodate the maximum number of fruits in the truck.

Cons: The area of the bot increases.





Environment Sensing

Q7. How are you going to use path planning module of V-REP? How will you move the robot from one point to another on the path created? (7)

The overhead camera feeds in the realtime information to the laptop, which extracts the information of the location of the fruits, CB and truck using the ArUco markers.
Each object on the arena has unique ArUco ID which helps us to identify what it is and further get its position and orientation.

Now the pose of the CB, fresh fruits and damaged fruits are fed to the V-REP via python plugin and VREP emulates this as a scene and plans a path to the closest fresh fruit using OMPL path planning module and then the next closest fruit and so on.

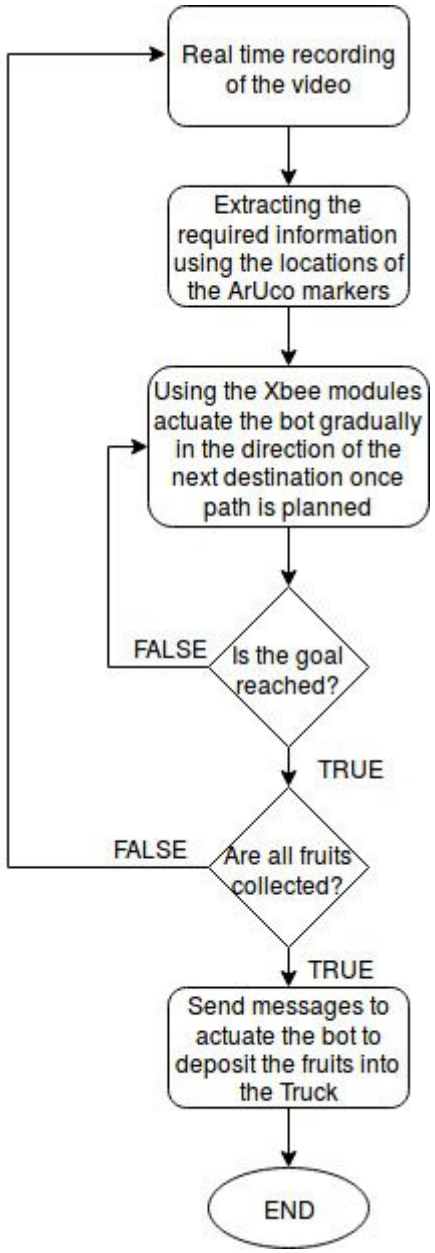
Each time a path is generated a table of coordinates is returned by the path planning module. Using the current coordinates of the CB and the next coordinates from the path, we calculate the angle and adjust the speed of the motors according to move the bot to that point on the path and as it approaches that point, the next point is selected and the same process is repeated until the goal point is reached.

The speed values are sent to the CB via XBee modules.

Communication

Q9. Describe the theme as a closed loop system.

(3)



There is a continuous video input from the camera to the laptop. The video streamed is analyzed frame by frame and the information regarding the location of the fruits and the bots are extracted. Once this is done the path the CB has to take is calculated. To follow the path information is sent from the laptop to the CB via Xbee communication.

The bot is controlled by the laptops whose decisions are based on the location of the ArUco markers. As there are no sensors on the CB, there must be a continuous communication between the CB and the laptop.

Testing your knowledge (theme analysis and rule-book-related)

Q10. Answer the following questions related to emulation.

1. **Why do we need to emulate the arena? (2)**

For the real-time motion of the collector bot we need some sort of feedback mechanism (in our case the overhead camera) without which the collector bot cannot move.
Also, we need to emulate the arena because the path planning module cannot be effectively used without emulation. Also, it provides a better representation, should there be an error it can be resolved easily by human intervention.

1. **Is it necessary to emulate the motion of Truck in simulation? (2)**
   Yes, it is necessary to emulate the truck
1. **Is it necessary to emulate the real-time motion of Collector Bot? (2)**
   Yes, it is necessary to emulate the motion of the CB, because we need to use the position and orientation of the CB to plan the path to the next goal position, ie the next fruit or the truck while simultaneously avoiding the damaged fruits.

Q11. Can you complete the theme by using only Regular APIs? If yes, how? If not, why? (4)

No, we cannot complete the theme using only the regular APIs that are provided because there are many subtasks such as moving the bot, collecting the fruits communicating with the collector bot that require user defined functions to be defined.

Q12. Answer the following regarding modeling in V-REP:

1. **It is important that the simulation model should resemble the actual robot. Justify. (2)**

It will be beneficial in a way as the collision boundaries of the bot will be precise and make the path that the bot takes much more accurate.

1. **Are you going to design your own model for CB, Truck? Why? Why not? (3)**
   Yes, we will be using our own model for the CB as it will be much more precise, accurate and realistic. As our model for the CB and Truck is different and unique and works on a different principle, we decided to use our own model so as to make it accurate and also to minimize errors during simulation.

1. **Are you designing the model from scratch, if yes, how?**

If not, what modifications will you make to the existing Collector Bot model (which we have provided) to resemble your physical robot? (5)

Yes, we are going to design the model from scratch. We are doing so because we have come upon what we feel is a very good design for effective and quick pick and collection of fruits and also transferring of them onto the truck.

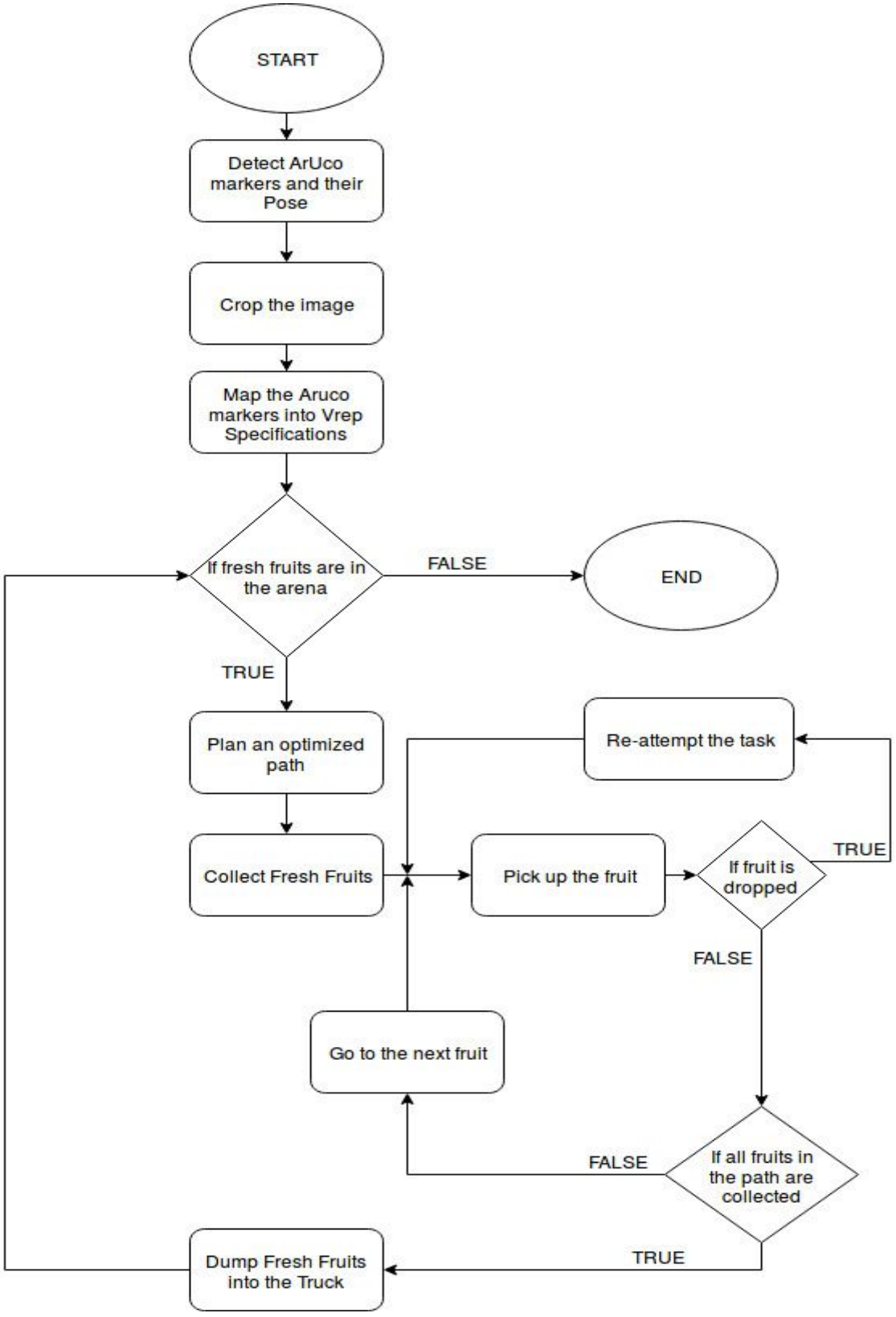
For the Truck, we have attached a large bin on top which can hold a maximum of 8 fruits. It has been designed in a way such that the bottom of the bin is sloped so as to accommodate maximum number of fruits in limited space.

For the CB, we designed in such a way that it also a storage (CB storage) which can hold a maximum of 4 fruits at once. It too has a sloped floor which is made to accommodate a maximum number of fruits in as little space as possible. One wall is designed in such a way that it can be opened so as to let the fruits move from the CB storage to the Truck bin.

As many such modifications have been done, we decided to make a model of our own so that it is very precise.

Algorithm Analysis

Q14. Draw a flowchart illustrating the algorithm you propose to use for theme implementation. (5)



Q15. How does the controller in motion planning affect the theme implementation?P What parameters should be considered for tuning the controller?
(3)

We are mapping a 9 X 7 feet map into a pixel map of 600 X 480 which results in a loss of accuracy about the position. Also, at given times in particular frames the ArUco markers aren't detected. This leaves a lot of room for error.

Hence a controller has to used in motion planning.

We are going with a PID Controller.

The PID controller has three parts to it,

P - is the proportional term which is product of the current error and proportional gain (Kp). If the Kp is set very high then there is large change in output which might cause the bot to overshoot. And if Kp is very low it may result in a very low change for a large error causing the bot to not reach the preferred pose.

I - is the integral term which is product of the accumulation of the error and integral gain (Ki). This term accelerates the process of reaching the desired pose but if the value is too high it maybe overshoot.

D - is the derivative term which is a product of the rate of change of error and derivative gain. The derivative term counteracts the overshoot causes by P and I.

The gain values have to set via trial and error method while working on the CB.

Q16. Let us consider the following two scenarios:

1. **CB correctly picked and dropped the Fresh Fruit in the bin of the Truck. But the orientation of the Fruit inside the Truck is such that the camera keeps detecting it.**

2. **CB correctly picked the Fresh Fruit but dropped it on the way. But the orientation of the Fruit is such that the camera still detects it.**

Explain how your algorithm will tackle (a) and (b) cases. (4)

a) Once the fruit is successfully placed in the internal bin of the collector bot, we can make sure to ignore the ArUco marker in the fixed vicinity from the center of the collector bot.

b) This case only occurs if the fruit is dropped from the claw, this can be kept in check by using an IR or an ultrasonic sensor on the claw, so that a failed attempt can be noticed and corrected.
Also, even if this isn't done the bot collect all the fruits and deposits it into the truck bin and checks if any other fruit is still on the arena. Then the fruit is collected.

Challenges

Q15. What are the major challenges that you can anticipate in addressing this theme and how do you propose to tackle them? (5)

Challenge 1: This theme has to be implemented on a real-time basis and if there is a lag in the system then real-time implementation fails and the collector bot doesn't get proper feedback.
Solution :

Challenge 2: Due to the loss of information from mapping a large arena into a smaller pixel map. It can result in the loss of information which requires a proper error control mechanism to be put in place before implementation.
Solution :

Challenge 3: We have chosen the collection of multiple fruits instead of collecting them one by one. This increases the size of the collector bot which makes it harder to navigate the terrain and avoid the damaged fruits.
Solution :

Challenge 4: The path planning module wasn't always returning the path that avoids all the obstacles. This can result in the CB colliding with the damaged fruits.
Solution:
Solution: We plan on using OMPL, which returns a much better and optimal path than the VREP path planning module.