

# Milestone 5: Integrated System

*(Last modified: 12 Oct 2022)*

Milestone 5 (Week 10 and 11) is the integration of all the modules you completed in the previous milestones. Integrate your work from M1 to M4 so that the robot can create a map of the arena containing the estimated poses of 10 ArUco markers (M2: SLAM), 5 types of fruits, i.e. redapple, greenapple, orange, mango and capsicum (M3: CV), and then perform the fruit searching task (M4: navigation). The actual task is very similar to Level 3 M4 task, which is

M5 task: Given a random list of 3 fruits contained in `search_list.txt`, your task is to autonomously navigate to the given list of fruits in order, while avoiding obstacles along the way. The robot should stop within 0.5m radius of the target for 3 seconds before moving onto the next target. The following also applies to M5:

- A true map will be not given in M5.
- You need to teleoperate your robot to generate a map of the arena and the pose estimation of the fruits before running the autonomous fruit search task.
- There will be 10 ArUco markers and 5 fruits (3 to search, 2 as obstacles) in the arena.
- You may choose to perform manual waypoint navigation (same as M4 Level 1) to get partial marks if you are struggling to complete the autonomous aspect.

The final demo will follow the same procedure as M5. Therefore, M5 is a trial run to help you identify improvements to be made before the final demo.

## **Marking schemes**

We have divided M5 into 3 components:

### **Arena mapping (40pts)**

After teleoperating your robot to map the arena, you should have `slam.txt` for the aruco markers and `targets.txt` for the pose estimations of the fruits. We will evaluate your files using the following equations:

$$\text{map\_score} = (0.2 - \text{aligned\_rmse}) / (0.2 - 0.05) * 16 + \text{NumberOfMarkersFound} * 0.4$$
$$\text{target\_score} = (1 - \text{avg\_estimate\_error}) / (1 - 0.025) * 16 + \text{NumberOfFruitsFound} * 0.8$$

### **Waypoint navigation (10pts)**

If your robot shows indication of performing waypoint navigation, either through manually entering waypoints or autonomously navigating the arena, and there is evidence of waypoint navigation implementation in your code, then you will receive 10pts.

### **Fruit searching (50pts)**

Your robot has to perform the fruit searching task autonomously in order to get any point for this sub-task. You will receive 20pts for reaching the first fruit, and 15pts for each of the remaining fruits, which make up a total of 50pts. If you choose to do this semi-autonomously (same as M4 Level 1), then you will receive a max of 20pts for this component: 8pts for reaching the first fruit and 6 pts for each of the remaining fruits. The following conditions applies:

- Penalty of -2pts for each fruit that the robot collides with
- Penalty of -5pts for each ArUco marker that the robot collides with
- Penalty of -5pts each time the robot goes out of the boundary (+/-1.6m from the origin, in both the x- and y-axis)
- The end-condition of a run is when your robot has made a visible attempt to find all the target fruits, even if it may not accurately stop within 0.5m of the target. You will not receive any score until the end-condition of a run is satisfied. For example, if your robot only reaches the first fruit and stops there, you will not get any score.
- The robot wheels have to be within 0.5m of the target fruit to be considered as a successful collection.
- If the robot reaches the target fruits in the wrong order, you will not receive any score for that run.

## **Important Note**

- Although the final demo is likely to be the same as M5, minor details/rules/markings scheme are still subject to change.
- You are not allowed to use the transformation specified in SLAM\_eval and apply it to the maps used in subsequent tasks, since this transformation is calculated using the true map.

## **Demo Procedures**

1. Before your lab session, submit your M5 implementation as a zip folder to Moodle > Assessment > Lab M5 Malaysia - Code. You will be asked to download and run your submission during demo, so ensure that all necessary files are included.
2. Each team will have a STRICT 20-minute time limit for demo. Refer to this [sheet](#) for your respective schedule. You can come early to prepare.
3. When the demonstrator starts to mark you, download your submission from Moodle. Your demonstrator will also tell you the three fruits you have to search, so you can edit this in your search\_list.txt.
4. There will be 10 markers and 5 fruits in the arena. Place your robot in the middle of the arena. Your 20-minute timer will start when you are ready.
5. You are allowed to run more than one script during the demo. For example, you may have one script for generating the map and another for fruit search.
6. After generating the map by teleoperating your robot, you can immediately start the fruit search without going back to the origin. However, you are also allowed to drive/place the robot back to the origin before you start the fruit search, if you wish to do so.
7. Within the time limit, you can perform SLAM/fruit pose estimate/fruit search as many times as you want. Communicate with your demonstrator to make things clear.
8. During demo, you can use the evaluation scripts (SLAM\_eval.py, CV\_eval.py) to check your error. However, you can only perform checking *after* every run. In other words, when you decide to use/call any evaluation script, you must not be running any other program/your robot must be idle.
9. After demo, submit your slam.txt and targets.txt under Moodle > Assessment > Lab M5 Malaysia - Result.