CG1111 Engineering Principles and Practice I

The A-maze-ing Race Project 2020

Welcome to the grand project of CG1111: The A-maze-ing Race!

In this race, your mBot needs to find its way through a maze in the shortest time. Similar to its namesake TV program, your mBot will be facing a number of challenges at intermediate waypoints while attempting to complete the race. To successfully meet all the requirements, you need to have a good grasp of many of the principles you have learnt in CG1111 and apply them into good practice!

The following are the key requirements:

1. The mBot must not bump into any wall. Your mBot shall rely on a front ultrasonic sensor, and two side IR proximity sensors to accomplish this. You need to come up with your own algorithms to meet this requirement. Note that there will be penalty points for bumping into walls, even if your mBot doesn't get stuck.

2. When your mBot is not making a turn, it must travel as straight as possible. (It must not drive in a zig-zag manner like a car driven by a drunken driver.)

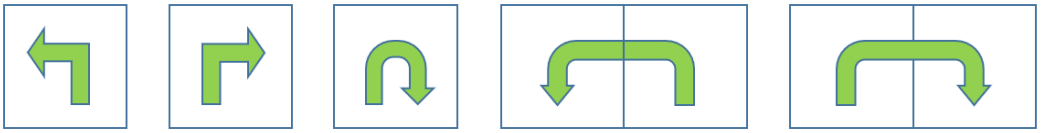
3. All turns in the maze are dictated by "waypoint challenges". Your mBot must not make any automatic turn without decoding a waypoint challenge.

4. When making a turn, your mBot must not over or under manoeuvring too much.

5. At each waypoint challenge, there will be a black strip (about 4 cm by 21 cm) on the maze floor. (Please refer to the video "Black Strip's Position.mp4" in LumiNUS for an illustration of how the black strip will be placed.) Your mBot needs to detect the black strip, stop, solve the waypoint challenge directly above it, and act according to the turn instruction decoded from the waypoint challenge.

6. Waypoint Challenge: Colour-sensing

   Your mBot has two RGB LEDs and one LDR built onto its mCore. You need to use them to implement colour-sensing. (Note that you need to remove the top cover of your mCore to accomplish this.) Depending on the colour of the paper that your mBot senses above it, it needs to execute one of the following five types of turns:



Left-turn	Right-turn	180° turn within the same grid	Two successive left-turns in two grids	Two successive right-turns in two grids

Note:
For the "two successive left-turns in two grids" and the "two successive right-turns in two grids", there will not be any black strip in the second grid to guide the mBot about where it needs to execute the second turn. Your mBot could rely on its ultrasonic sensor to decide where to execute the second turn; there will always be a maze wall in front of the mBot when it is in the second grid for such turns.

Table I summarizes how the colours are to be interpreted. Setups with colour samples for each type of turn will be provided in the lab. Note that the colour paper will be suspended at a height of about 14 cm from the maze floor. Hence, your mBot's maximum height (including all the wires) must not be taller than **14 cm**.

Table I: Colour interpretation for the Colour-sensing Challenge

Colour	Interpretation
Red	Left-turn
Green	Right turn
Yellow	180° turn within the same grid
Purple	Two successive left-turns in two grids
Light Blue	Two successive right-turns in two grids

7. End of Maze:

   At the end of the maze, there will also be a black strip. The colour of the paper above the mBot at this grid will be **black**. Upon decoding that it has reached the end of the conquest, the mBot must **stop moving**, and **play a celebratory tune** of your choice (Yay!).

Final Project Evaluation:

The race will be conducted during your **Week 13 Studio 1** timeslot:

Studio Group 1: 09 Nov (Mon), 9am-12pm
Studio Group 2: 09 Nov (Mon), 2pm-5pm
Studio Group 3: 10 Nov (Tue), 9am-12pm
Studio Group 4: 10 Nov (Tue), 2pm-5pm

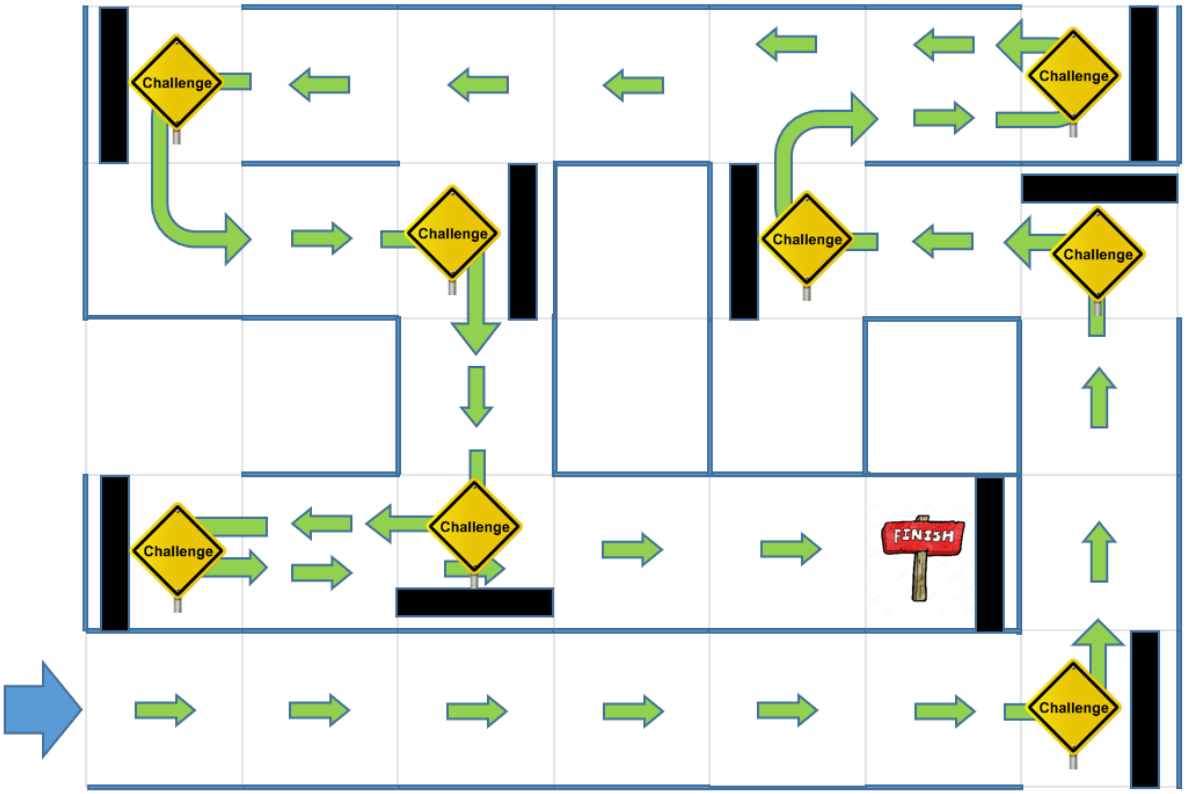
Rules:

1. At each challenge, if your mBot turns in the wrong direction, it will be teleported to one grid before the challenge to make a second attempt, and if necessary, a third attempt, while the clock continues to run. If it fails at the third attempt, it will be manually turned to the correct direction.

2. If your mBot gets stuck to the wall, you can move it to the correct position within the same grid; a 30-second time penalty will be added rather than letting the mBot get stuck indefinitely.

3. You are not allowed to add any commercial-off-the-shelf sensors that are not issued by us.

4. The actual maze layout for the A-maze-ing race will not be revealed beforehand. The figure below shows a **sample** maze layout.



5. As can be seen in the sample maze layout, some of the walls may be missing. You mBot must be able to handle such missing walls.

   Note:

   - There will always be a maze wall in front of the mBot within any waypoint challenge grid.

6. You can make any final tuning or adjustment of your software/hardware during the first hour of your studio's timeslot. During this time, you are not allowed to see the maze layout for the race. All teams must surrender their mBots to the instructors at the end of the first hour.

7. You are not allowed to perform any last-minute calibration right before the start of your team's turn during the project evaluation. Hence, all calibrations must have been completed before surrendering the mBots to the instructors.

Grading Criteria:

Criterion	Marks
Meeting the required features	15
Algorithms and coding (e.g., elegance of algorithms, well commented codes, etc.)	5
Short team report	5
Total	**25**

The following are the key grading criteria during the project demo:

- Number of bumps into the maze walls.
- Whether the mBot gets stuck to the wall.
- Successfully decoding the challenges: for each challenge, your mBot has up to 3 tries. You get full marks for a challenge if you succeed in the 1st attempt; some penalty marks will be incurred if you succeed in the 2nd or the 3rd attempts.
- Whether your mBot can travel in a near-straight line when not turning.
- Whether your mBot can execute a turn accurately without over or under manoeuvring too much.
- Whether the mBot plays a celebratory tone upon detecting the end of the maze, and stops moving.
- Total time taken to complete the maze.

Deliverables (Short Team Report and Source Codes):

Deadline: **13 Nov 2020 (Friday), 2359 hrs**

(10% will be deducted for every day it is late)

Zip all files into a single file (one submission per team), and name it according to your Sub-group and Team Numbers, e.g., **1a-6.zip** (for Sub-group 1a's Team 6), and upload it into the "Project Submission" folder in LumiNUS before the deadline. You must include the following:

1. Program source codes. The codes must be well documented by providing appropriate comments.

2. A concise written report, in PDF format. You may use your own discretion for the number of pages. Your report must describe your design in detail, especially about how the required features are met. Please include:

   - A cover page with your Studio Group Number, and Team Number, along with the team members' names.
   - Description of the overall algorithm your mBot uses to solve the maze. You may include pseudocode/flowcharts or other pictorial aids to assist in your explanation.

- Implementation details of the various subsystems – algorithms for keeping mBot straight, colour sensing, end of maze detection, etc.
- Steps taken for calibration.
- Details about work division within your team – each member's role in the project.
- Any significant difficulties and the steps taken to overcome them.

Note that CELC has prepared some useful report writing guidelines, which you can download from LumiNUS (Files->CELC Workshops->Report writing).

Peer Evaluation:

You will submit a confidential peer evaluation about your teammates' contribution in the project. More details will be announced at a later date. If there is any teammate who is not contributing to the project, **please inform us as early as possible**.

Academic Integrity:

Plagiarism will not be tolerated. You are **not** supposed to share any code with other teams. You **may** discuss the project requirements or your solution strategies at a high-level, without sharing details at the code level. We do **not** distinguish between those who copy others' work, and those who allow their work to be copied. If you are involved in plagiarism, you will be given 0 mark for the project, and referred to the University for disciplinary action.