CG1112 Engineering Principles and Practice II

Semester 2 AY2019/2020

Project Specification: Alex to the Rescue

[Version: 27th February, 2020]

Impact of COVID-19 Virus

As noted in the announcement email dated 25th February, 2020, the project specification for this semester has been greatly scaled down. With the reduced scope, you should have an easier time to finish the project with the limited lab access time.

It is regrettable that we will lose our in/famous "EPP II camp" ☺. Hopefully you'll still find the project providing a glimpse of what CEG has in store for you in future modules.

Background

72 hours. That is the "golden period" to locate and rescue survivors in the aftermath of natural/manmade disasters like earthquake, landslide, terrorist attack, etc. Against the ticking clock, rescuers have to brave incredible difficulties like rubbles / debris, narrow / impassable passages and/or hazardous environment to look for any sign of life. Fortunately, recent robotic advancement opens up many new possibilities for the rescue team.

Alex to the Rescue!

You are going to build a robotic vehicle, **Alex**, with search and rescue functionalities. Although we would love to test your Alex in a real setting, we have to make do with a simulated environment for obvious reasons. Below is a summarized evaluation setup and functionality requirements.

Simulated Environment
An area of about $3m^2$ in dimension. The configurable "Maze Table" from EPP I will be used as the "outer walls" of the simulated environment. In addition, cardboards, boxes and other materials will be used as simulated obstructions / walls. The obstructions and walls will be at least as tall as the typical Lidar mounting height of ~18cm. Tentatively, the simulated environment will consist of 2-4 "rooms". Each room is guaranteed to have **at least one entrance / exit**. **There will be at least one clear path for Alex to navigate from the starting room to the last room.**

Main Functionality – Environment Mapping – 90%

Alex will be **tele-operated** (i.e., remotely controlled) from your laptop. An environment map will be relayed to the operator throughout the operation. The operator can then use the map to navigate the simulated environment **manually**. In its simplest form, you will communicate with a master control program (**MCP**) on the Pi. The MCP will in turn translate your commands into actual movement control signals for the connected Arduino board.

Minimally, Alex must be able to carry out the following commands:

a. **Go straight** (you can define how far / how long, speed control, etc).
b. **Turn left / right** (you can define the turning angle or the compass direction).

You can implement additional commands as you see fit.

During the evaluation, you have to manually take note of the environment mapped out by Alex. This "map" shall be submitted at the end of your evaluation.

Evaluation stops as soon as Alex explored and mapped the entire arena **OR** the time limit is up. Exact time limit will be announced nearer to the final evaluation.

Evaluation Criteria:

- Time taken. (Shorter == Better)
- Obstacle / Wall hit during navigation. (Less hit == Better)
- Completeness of the environment map. (More complete == Better)
- Accuracy of the room layout. Outer wall dimension (i.e., how wide is the wall) for each room should be estimated / measured by Alex and noted down. (More accurate == Better)

The main functionality contributes **90%** of the overall project score. As long as your Alex manages to complete this phase, **your team is guaranteed a good passing grade** for the project component.

Additional Functionality – 10%

[**"Alex" is green!**] The (average) power consumption of the Alex will be evaluated. You have to find ways to reduce the power consumption of Arduino + Pi + Lidar during the entire evaluation. We will supply a power measurement dongle to measure consumption from the power bank. **(Tentatively: this functionality is worth 10%)**

Evaluation Criteria:

- Power consumption of Alex

Bonus Features:

Bare Metal Programming – Bonus 3%
[**"Alex" goes native!**] You can use bare metal programming for Arduino. Minimally, you need to have at least 50% of the Arduino code written in bare metal to qualify. [Suggestion] It is more prudent to complete the project requirement using the simpler Arduino Sketch libraries before converting selected portions into bare metal. Use Git "religiously" so that you can always have a backup if something goes wrong.

TLS Programming – Bonus 2%
[**"Alex" is secure!**] You need to use the library provided in Week 9 to implement a TLS server + client on your laptop and Pi respectively to qualify.

Note the bonus features are **entirely optional**. Please plan your time properly and build your project incrementally. Complete the main functionality before the additional / bonus features.

Hints, Tips and Information:

1. Most of the components (hardware and software) needed for main evaluation will be covered in the studio sessions by week 9.

2. Alex may need to move **slowly** for mapping purpose. Focus on movement steadiness and accuracy. You will have a clearer picture (pun not intended) after the Lidar / SLAM studios in week 8 and 9.

3. The entire evaluation is going to take about **4-5 minutes**. Due to the length of the evaluation, it is unlikely that you can get more than 1 retry.

Timeline with Milestones:

<table>
<tr><th>Date</th><th>Milestones / Submssions</th></tr>
<tr><td>Week 8
13th March, 2359</td><td>a. Design report submission. [Constitute 10% to your CA]
b. Setup GitHub <u>Private</u> Repository with your team name XX-YY-ZZ and add your section's instructor as one of the members. Your group's instructor GitHub id:
<table>
<tr><td>Monday(9am), Colin</td><td>pbear1973</td></tr>
<tr><td>Monday(2pm), Uncle Soo</td><td>sooyj</td></tr>
<tr><td>Tuesday(9am), Ravi</td><td>raviragas</td></tr>
<tr><td>Tuesday(2pm), Prof.Soh</td><td>weesoh</td></tr>
</table>
Use GitHub to do versioning and collaboration with your team. We will also use it to gauge your progress.</td></tr>
<tr><td>Week 9
Studio 1</td><td>Feedback on design report.</td></tr>
<tr><td>Week 9
Tutorial Timeslot</td><td>CELC Workshop on report writing.</td></tr>
<tr><td>Week 10
Both Studios</td><td>CELC Workshops on team presentation. Will use your design report as a basis for mock presentation.</td></tr>
<tr><td>Week 12
Studio 1 (Tentative)</td><td>Mock Evaluation.
Submission of final report draft [Not graded, for CELC]</td></tr>
<tr><td>Week 12
Studio 2</td><td>CELC Workshop
Peer Review and discuss on final report draft</td></tr>
<tr><td>Week 13
Studio 2</td><td>Final Evaluation (Demo + Presentation)
[Demo: 20%; Oral presentation 20%]
[CELC evaluation contributes 10% of the oral presentation]</td></tr>
<tr><td>Reading Week
Monday</td><td>Final Report Due
[Constitute 10% to your CA]
[CELC evaluation contributes 2.5% of the final report]</td></tr>
</table>

The demo timeslots will be given by week 12.