Term Project: Design Autonomous Shuttle Circulator for the Scioto Mile in Smart Columbus

Due Date and Place: April 27, 2020 (online submission)

Philosophy: Learning by doing, also called experiential learning, is a proven and effective method of teaching. It is expected that students taking the course will improve their understanding of the topics learned in class through applying them to a realistic case study.

Related Unit: all units

Project Aims: The main aim is to apply the methods learned in the course to a realistic case study on autonomous vehicles. The project is posed as an **open ended** (multiple solutions) design problem with partial verification of the approach used and requires the students to present their results both using an oral presentation (unlisted Youtube video) and in a written manner.

Project Background: As the US DOT Smart City Challenge winner, the city of Columbus is now operating an autonomous shuttle by Easymile as a circulator in the Linden Residential Area. The operation of this shuttle is temporarily suspended by NHTSA due to an unexpected emergency stop causing an occupant to fall down. The shuttle operation is also waiting for the stay-at-home order due to the COVID-19 outbreak to be lifted. Smart Columbus along with its partners operated a similar autonomous shuttle by May Mobility for about a year in the Scioto Mile area of downtown Columbus. This final project focuses on the Scioto Mile low speed autonomous shuttle operation shown below. You should concentrate on the main round loop and disregard the small loop at the top left of the first plot in Figure 1 below. In the second plot, you can see the signalized intersections, intersections with stop signs, and shuttle stop points. Please note that each intersection has pedestrian crossing paths.

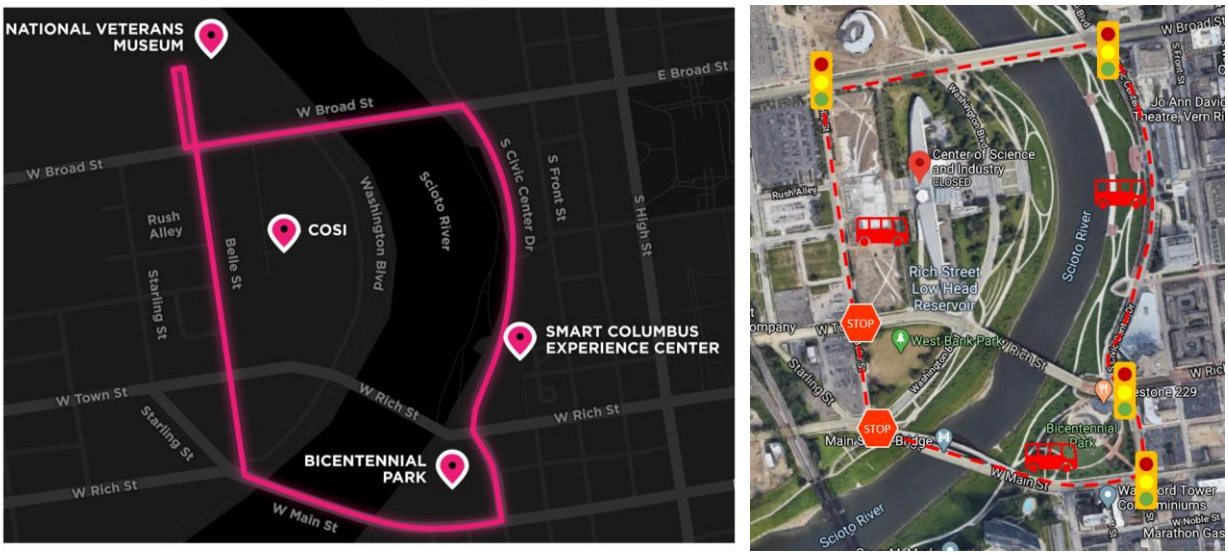

Figure 1: Scioto Mile Autonomous Shuttle Route

Format: Prepare your report using powerpoint. You should have a cover page and a final page. Convert your powerpoint report to pdf before submitting online. Submit both the pdf and powerpoint files. Submit any supporting files (Simulink models, Matlab m-files etc) with your solution. Submit two files. The first file will be your pdf report. The second file will be a zip file with your powerpoint report and supporting files. You should prepare an unlisted Youtube video (not to exceed 10 minutes) and give the link to the video in your report. You should be able to send a Zoom recording of your presentation to Youtube within Zoom. A copy of the video as a *.mp4 file (should be of low/moderate size) should be placed separately in a course box site to be provided by your TA for the course.

Software: It is expected that you will use Matlab/Simulink in this project. Please document any other software product that you use (if any).

Project Statement:

Shuttle Vehicle: Choose a shuttle vehicle that can accommodate 6-12 passengers. You can use the shuttles used by May Mobility or use a shuttle like the one used by Easymile or a shuttle of your choice. Obtain or estimate (if not easily available) the longitudinal and lateral dynamics parameters of your chosen shuttle. Tabulate your results. Your table should include where you obtained the data or how you estimated it. **(10 points)**

Autonomous Architecture: Choose localization and perception sensors and computer system for control and decision making. Present your results in tabular format. Assume that your vehicle is completely drive-by-wire and that all actuators are accessible via CAN commands. Draw your architecture diagram and sensor coverage diagram. You can use your homework/project 1 solution as a starting point. There is no cost constraint associated with this step. **(10 points)**

Consider the following **technical challenges** and present your solution method to each in your report.

1. **Low level longitudinal control:** Build a simple Simulink longitudinal model of your vehicle. You can use your previous homework solutions or existing examples in Simulink (please cite references in this case). Update parameters with your shuttle parameters and use simple simulation results to demonstrate following of desired speed. Do not exceed vehicle max. speed limits and legal speed limits in the area of interest. **(10 points)**
2. **Low level lateral control:** Build a simple Simulink lateral model of your vehicle. You can use your previous homework solutions or existing examples in Simulink (please cite references in this case). Update parameters with your shuttle parameters and use simple simulation results to demonstrate following a simple path. Do not exceed maximum steering angle limitations. **(10 points)**
3. **Path planning and following:** Choose a low speed and demonstrate following of the larger closed path in the figure above (do not use the small detour path) using the low level lateral control in the previous subsection. You can round/smooth the corners if you want. Your vehicle does not have to stop at the intersections. **(10 points)**
4. **Collision avoidance:** Demonstrate very simple collision avoidance capability using a simple Simulink simulation. You can use your previous homework solutions or existing examples in Simulink (please cite references in this case). Use shuttle parameters. Your shuttle should stop and wait in the event of a collision risk. **(10 points)**

5. **Localization and perception (cars and pedestrians):** Use any existing examples (please cite references) in Matlab/Simulink that can be used for detecting and tracking cars and pedestrians. You do not have to develop or modify algorithms. Just show ones that can be used. **(10 points)**
6. **Stateflow decision making:** Develop a simple Stateflow finite state machine and explain how it works. You can also apply it to following of the closed loop path in the Scioto Mile route given above. **(10 points)**
7. **List of real world implementation challenges:** Make a list of real world implementation challenges (like weather conditions, too many pedestrians, cars that do not obey traffic laws etc.). Present this in tabular format along with how severe/risky it is for operation. **(10 points)**

Powerpoint report: Present your results above in the form of a powerpoint presentation. A presentation template will be provided. Please cite any references you use and place your list of references at the end of the report. **(5 points for format and presentation)**

Youtube presentation: Present your powerpoint presentation and record it as a video. Upload it in an unlisted Youtube page. **(5 points for format and presentation)**

Your report and presentation should have the following:

- Cover page with your name
- Problem statement
- Presentation of your shuttle vehicle
- Presentation of your autonomous vehicle architecture
- Your approach to all the technical challenges listed above including the list of real world implementation challenges.
- Brief conclusions
- End page including contact info (name and e-mail)