Mini Project 3 – MAVS LiDAR Small Object Detection Study

Teams: Same teams as MP1 and MP2.

Writing: All writing uses 1" borders, 11-point Times New Roman font, and single spacing. Writing is required to be typed – not handwritten. Submit as a single PDF.

Project Objectives: (1) Use MAVS to simulate detecting a small object and determine how reliable this is versus distance to the object. (2) Investigate different LiDARs to see how the various LiDARs perform the task. (3) Write a report detailing results and conclusions. (4) Grads only: Discuss one state-of-the-art paper regarding lidar and automotive autonomy.

Instructions:

1. Download the MP3.zip file from Canvas and extract it to your MP3 folder.
2. To run the MP3 simulation, in Anaconda type

```
conda activate tf
cd xxx
python mp3_mavs_sim.py
```

where xxx is the directory containing the sim code.

Note: you need some packages installed (numpy, pil, matplotlib). If you have an error, try this:

```
conda install anaconda::numpy
conda install anaconda::pil
conda install conda-forge::matplotlib
```

Report: Write a report using the following format:

- Cover page with names of students and NetId's. Also include a team name, the assignment "Mini-Project 3" and the due date.
- Next page - Table listing each student, what their contributions were, and time spent on this project. **It is expected that all students will contribute to the report writing.**
- Start rest on a new page.
  Note: Include headers in your report, e.g., "Introduction."

Part 1 – Simulating LiDAR in MAVS – how many points are seen for a small object at different distances? (Note this question describes the simulation and does not go in the report!)

- Abstract – Briefly summarize what is done and final results (quantitative). Do this in one paragraph.
- Introduction – Briefly discuss how a scanning LiDAR works.

  Answer the following questions (in paragraph form):
  a. Briefly describe the data provided by a scanning LiDAR.

b. For the HDL-32E, assume each point of data contains ten bytes of data. Estimate the data rate in Mbytes/second for 10 and 20 Hz operation.
c. [Graduates only] Determine the frame-to-frame latency in ms for 10, 15, and 20 Hz scanning lidars. A frame of data is one complete rotation of the lidar.
d. Prepare a table discussing the differences in the LiDARs supported by MAVS. Discuss the differences.

- Methodology – Discuss (high-level) details of the code. You do not need to provide code in an appendix. Also, give enough details so that someone can recreate your experiments. Explain about using each of the lidars below.

  Run the simulation for the following LiDARs (set lidar_type = XXX). Use scan_spacing=0.25.
  a. "M8"
  b. "HDL-64E"
  c. "HDL-32E"
  d. "VLP-16"
  e. "OS1"
  f. "OS2"

  Answer the following questions (paragraph form):
  a. How does the code count the points on a brick?
  b. How does it ignore ground points?
  c. Is the car moving and brick stationary or the other way around?

  Prepare a table listing each lidar. For each lidar, list the number of beams, frame rates, and the manufacturer.

- Results. List results. For each LiDAR, show plot of # points versus distance. For each figure and table, provide a figure or table caption and reference the caption in your text. For performance assessment, assess qualitatively (e.g., it did very well, or it completely failed after the brick was XXX meters away…) and quantitatively (we were able to detect object reliably XX% of time, or plot detections versus distance), etc.

  You can assume that you have software that can reliably detect the brick with **four points or more** from the lidar.

  Answer the following question for each LiDAR:
  a. Are there some distances where the lidar does not see the brick? Explain. *One good approach is to use a table and then a paragraph or two for discussion.*

  Answer the following questions:
  a. Which performed the best?
  b. Which performed the worst?
  c. Compare each LiDAR result qualitatively.
  d. [Graduates only] If you were doing this study for an autonomy company, what else might you also do? Discuss in a few paragraphs.
  e. [Graduates only] We used four points as a threshold for detection. Discuss in a paragraph or two how you might validate this threshold or choose another one.

- Conclusions. Draw conclusions. Answer the following questions:
    a. Are the LiDARs in MAVS capable of detecting small obstacles on the road?
    b. What are the limitations?
    c. How do the different parameters of each LiDAR tested affect the overall results?
    d. What is the maximum distance that guarantees detection for each lidar tested?

- References – list in IEEE format. Please provide at least two references.

  Hint: For websites, list the website and show the date accessed.

  Citations are to be in IEEE format. For examples of IEEE format citations, refer to https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf

- Note: I'm supplying the Python codes, so codes are not required in this assignment.

- Appendix A – Start on new page. Copy the program output from the OS2 here. You do not need to report outputs for other runs.

Grading Rubric:

Area	**Percent**
Followed directions. First two pages have required materials.	20
Abstract is one paragraph, and some quantitative results are listed.	10
Methodology is complete. A knowledgeable person can replicate these experiments.	20
Introduction contained required materials.	20
Results & discussion contained both qualitative and quantitative discussion, tables, figures, etc. All figures and tables referenced.	20
Citation's format and adequate citations	5
Good grammar and proper technical writing style	5