MTRN4010 – Project 2. Parts A, B, C and D

(Early Release)

Deterministic processing of speed, gyro and LiDAR measurements

Implementing feature extraction

In this project we commence using (and processing) data from multiple sensors, simultaneously. We do it in a simple way: deterministically. These are preliminary steps, which are useful for solving, later, the localization problem through stochastic Sensor Data Fusion (which will be applied in a subsequent project).
This project involves processing multiple sensing capabilities: LIDAR, wheel encoder and gyroscope (yaw rate, provided by an IMU).
All the modules which are implemented in this task will be used for solving parts of a subsequent project. Properly solving this project does not only give you a good mark in this assignment but also facilitates the solution of that subsequent project.
One of the purposes of this project is for understanding and implementing localization by applying "dead-reckoning". The second purpose is getting used to using different coordinate frames, and for implementing a simple feature extraction for detecting objects of interest (OOIs) in the area of operation.

Part A

You are required to implement a "dead-reckoning" process, based on the kinematic model of the platform, and on the measurements provided by certain onboard sensors (speed encoder and gyroscope). The kinematic model is explained in the lecture document "**[AAS_2021]_KinematicModels.pdf**". The way for implementing it, in a discrete time fashion, is explained in that document as well.
The inputs of the process model are the angular rate ω_z and the speed encoder measurements. The necessary data is contained in the Matlab data file "**Measurements_AAS01.mat**" Example code, showing how to use the data, is provided in the M-files "**ShowData2021_Example2.m**" and "**ShowData2021.m**". Read those small programs to understand how to use the data, and how to use some basic Matlab programming.

Validation: You will compare your estimated path (by simply inspection) with a solution provided by the lecturer. Additional validation of these results will be done in subsequent parts of this project, when LiDAR data is processed as well.

Part B

This part of project 2 involves processing LIDAR measurement. This processing is necessary for modules which will be implemented in a subsequent project. Those modules need certain features extracted from the LiDAR scans. In this part of the project you will implement a function which will actually perform the required processing. The LIDAR used for producing the data is a SICK LMS291 (LMS200 family). The provided example programs do also show how to read and use the LiDAR data.
You are required to implement a module, for processing individual scans, providing the following capabilities:
a) As the native raw scans are in "polar" in the LiDAR's coordinate frame, you are required to show those in a cartesian representation.

b) Show the “brilliant” pixels (those pixels that correspond to highly reflective surfaces), in a different color to that of the rest of the pixels (the “opaque” ones). One of the example programs shows the way to use the intensity information of the LiDAR scans.

The following picture shows some of the poles (which we used as landmarks), which had been deployed in the lab for the purposes of localization. These poles are covered by highly reflective tape which the LiDAR can discriminate from other surfaces that are less reflective (“opaque”)

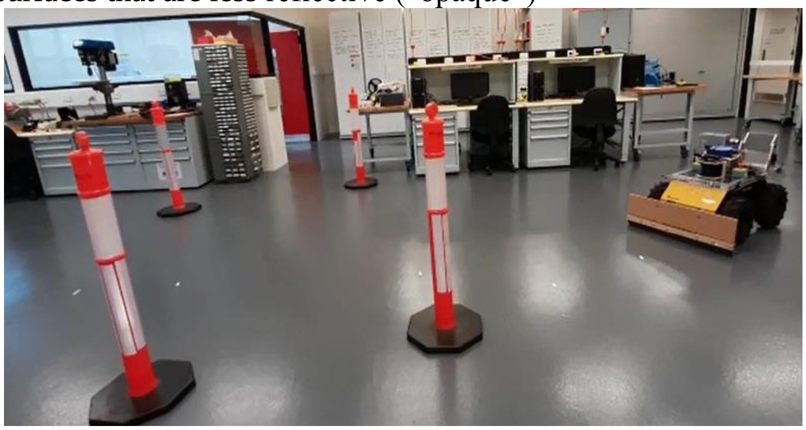

Figure 1: Some poles (“landmarks”), and the UGV, operating in the MTRN lab.

Part C

Based on the set of brilliant pixels, which you discriminate using your implementation in part B, you are required to detect the poles. As a pole can produce more than one pixel (depending on the distance between that pole and the LiDAR), you are required to implement a segmentation process, whose output will be the centers of geometry of clusters of brilliant pixels. Each of those clusters is the image of a pole (we also call those objects, “Objects of Interest” or OOIs). You can exploit the fact that the OOIs are relatively isolated; each OOI is separated from other OOIs and from opaque objects, by no less than 1 meter (you can appreciate that fact when you inspect the raw scans).

You are free the choose and implement the segmentation approach that you prefer.

To verify consistency of the results, you will show those detected OOIs (their estimated centers of geometry), in a figure, jointly with all the original pixels (you may reuse the visualization you implemented in part B).

Part D

In this part you are required to show the LiDAR scans and the detected OOIs, in the global coordinate frame. For achieving that, you will use the estimates of the platform’s pose (position and heading) which you obtain applying your solution for part A. Based on those estimates you will apply a coordinate transformation, for showing, in the global coordinate frame, the LiDAR scans and the detected OOIs. Those have been obtained in parts B and C (but were represented in the LiDAR’s coordinate frame). The position of the LiDAR on the platform is shown in Figure 2.

Additional specifications

1) It is required that the processing time, per LiDAR scan, must be lower than 50ms, in a normal computer (such those in the MTRN lab). This required processing time is well feasible, even in Matlab programing language.

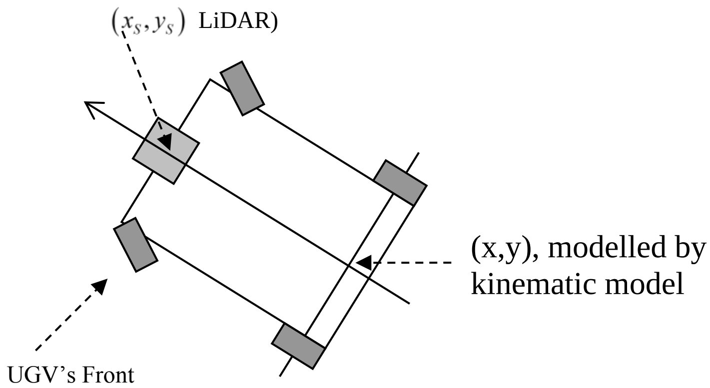

Figure 2: The position of the LiDAR is displaced 46cm, ahead the modelled platform's position. The LiDAR is aligned with the platform, point ahead.

The rest of the parts, of Project 2, will be released on week 3.

Deadline: submission of this part of project 2 will be done with the rest of the project's parts, on Friday Week 6, 10PM. Your demonstration of project 2 will be on Week 7.

Marks:

Part A:	16% of project 2
Part B:	03% of project 2
Part C:	16% of project 2
Part D:	10% of project 2

Quiz: A brief online questionnaire (associated to this project) will take place during week 7. The score in the quiz has a defined relevance in the final mark of the project. Details of it will be given with the release of the rest of this project (to be released on week 3).

Questions: Via Forum or email to lecturer (j.guivant@unsw.edu.au)