PROJECT #1

Part A - Dead reckoning localization.
Part B - Feature extraction from LIDAR data.
Part C - Basic data association.
Part D - Applying deterministic localization (triangulation/trilateration).
Part E - Processing real data.

Part A requires implementing a dead-reckoning process. This process generates predictions of the platform’s pose, based on a kinematic model, which has speed and angular rate measurements as inputs, as it has been seen in problem 4 of tutorial 2.

Part B focusses on processing LiDAR scans, individually. Outputs generated by this module will be crucial for the whole project; however, you are developing and testing it separately, to be sure it performs properly, before being integrated with other modules.

For solving part B, you do not need part A, consequently, you can solve them in any order.

Part C is focuses on combining parts A and B, and on implementing a process called “Data Association” (which will be described in Lecture 3.). Then part A and part B need to be successfully solved before attempting part C. To verify the accuracy of your solutions of part A and part B follow the procedure described in the section “validating the accuracy of your solution”.

Part D focuses in implementing a classic approach for localization based on processing measurements from sensors such as the LiDAR.

Part E focuses in working with data from a real platform, dealing with noise and other issues for which our deterministic approach is not well suited.

Deadline for submission, of the full project, is Tuesday Week 7 (29/March), 23:55
Submission will be via Moodle. Details about how your program files must be organized (names, author details) will be specified in the release document of parts D and E.

Marking criteria

Project 1 if 100% successfully completed provides 23 points of the course final mark.

In addition to the submission of your implementation, you need to demonstrate, to a member of the teaching staff, that your submitted program is working.
Both, submission and demonstration are necessary conditions. A project which is not submitted or not demonstrated will get no marks.

The **demonstration will take place one week after the nominal submission deadline**, and it will be based on the submitted material (which is to be kept, securely, in the Moodle submission repository).

Your achieved project mark depends on the implementation and demonstration of the project parts, and on a knowledge factor about the project (Q).

The relevance of the implementation and demonstration of the project parts is as follows:

Part A:	up to 15% of the project maximum mark (23 marks)
Part B:	up to 20%
Part C:	up to 11%
Part D:	up to 30%
Part E:	up to 24%

The addition of the values obtained in each part is the "Submitted and Demonstrated Project Mark".

The factor Q, used in the calculation of the overall mark, is obtained based on your performance answering questions, during the demonstration, and/or via a quiz if needed. Factor Q is represented in scale [0:100]

The influence of Q in the overall project mark can be seen in the following formula.

Overall Project Mark = [Submitted and Demonstrated Project Mark] * (0.6+0.4*Q/100)

For instance, if you fail in answering all the questions, your Q factor will be 0, which means you would get 60% of the achieved marks of your submitted/demonstrated programs.

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

Part D -Implementing Trilateration and Triangulation

Implement a function for estimating the platform's pose (or at least its position) based on trilateration and/ or triangulation, when, from a LiDAR scan, enough number of OOIs are detected and associated to map landmarks.

Based on your implementations of parts A,B,C, and on mathematical concepts from previous courses, you have the necessary resources for solving this task.

Each time a LiDAR scan is available, you will process the scan, for detecting OOIs, and you will perform data association (as done in parts A, B, C of the project), to associate those detected OOIs to known landmarks. If enough number of OOIs have been associated to map's landmarks, you will call your new pose/position estimation function. The result of it will be recorded in a separate buffer (as we did for other estimates), and then plotted at the end of the run, jointly with the ground truth (you may, alternatively, show this estimated position, dynamically in the main figure). This estimation process runs simultaneously with those modules implemented for parts A,B,C. This requirement is because the triangulation and trilateration calculations do require to know the landmarks that are associated to the OOIs that are intended to be used in the calculations.

You are not expected to apply advanced approaches (such those based on Bayesian estimation, or based on optimization, which will be learnt in subsequent weeks, in MTRN4010. You are required to implement a solution based on Mathematical concepts that you had learnt in previous years, or on deterministic approaches you may infer or research from public domain. In any case, you will need to understand your approach, and be able to prepare a brief report for describing it.).

Part D is worth 30% of the full project mark. Part is composed by two parts: implementation of the solution 75% of part D) , and the report describing the approach (25% of part D)

Part E -Using Real Data

In this task you will test your previously implemented components (for solving parts A and B), using real data (which is contained in dataset "DataLab01_2022.mat".)

This data is more challenging than that used in parts A, B and C, which had relatively low noise pollution.

You will verify, visually, that the certain OOIs being detected are located close enough to map landmarks, and that the few walls provided in the a priori map are also properly matched by parts of the LiDAR scans when shown in the GCF. If that was the case, it would imply all your modules A and B are working well.

Keep in mind that in this case we have few landmarks (4 in total), and that the number of detected OOIs may be well higher than the number of landmarks, as the context of operation is highly cluttered, and there are many objects which look similar to landmarks, but are not actual landmarks.

There is no ground truth provided; so that the verification is indirect, by comparison of poles and walls in the GCF. We do not require you to perform any data association in part E; we simply require a visual inspection, to verify the accuracy of the platform's pose is adequate.

An extra step is necessary for having proper accuracy: As the provided gyroscope measurements are polluted by noise, which is composed by a GWN (Gaussian White noise) component plus a bias; you must compensate the presence of the bias (estimate it and remove it).

Read document "Basic_off_line_approach_for_removing_gyro_bias.pdf".

Dataset "DataLab01_2022.mat'" involves a trip in which the platform stayed still during some initial period of about 25 seconds, for allowing calibrating the gyroscopes. Because of that, you may assume that during the first 2000 events, the platform was fully stationary.

Demonstration: You will show part E working. The evaluator will inspect how close are certain infrastructure objects, and their equivalent images in the LiDAR scan, when both are simultaneously shown in the GCF. A discrepancy of less that 30cm, at any time, is required for your solution being considered satisfactory.

Submission of your solutions (full project, parts A to E): You will submit all your solutions in a zip file. For parts A,B and C, those would be integrated in a sole program, which should run and show results in graphical fashion, for the evaluators being able to infer accuracy.

You may also add part D in that sole program, or you may have a second version, including that part.

You may separate your solutions, for instance, if implemented parts A and B but not part C, you would submit a program "Solution_AB.m".

If you solved parts A,B and C, those would be offered in a program "*Solution_ABC.m*"

If have integrated part D, jointly with parts ABC, you may provide it as "S*olution_ABCD.m"* or separately.

Part E is to be submitted in a separate program, which, when being run, must open the specified MAT file, "DataLab01_2022.mat and process that dataset", by default.

The rest of the solutions, related to parts A,B,C,D, must be able to be told to use different dataset files, via an input argument , in the form “*Solution_XXX(* ***FileName)”***. All the datasets have identical structure, allowing the programs to run in a transparent way. The programs must initially plot all the validation components (walls and positions of landmarks), for allowing verification of accuracy during operation.

Each file that you submit, must have certain information, about the author, date and purpose of the program/file.

Information about the author will specify,

student ID number

student’s full name.

Purpose of the program of file.:

E.g “this file is the main program for solving project 1, parts A and B.”

You may have part of your code implemented in separate files (although it would be convenient to have those functions in the same file of the main part of the program. However, this is not a necessary condition). In any case, each of the separate files must have details about author and purpose of the file

If you have included code which was not made by you, you must explicitly and clearly cite its source,

A brief TXT file may be included if you want to inform evaluators about particular matters, such as the way to run the program, if your program does require to be run in a different way. The file should be named “Read.txt”.

All the submitted files must be located in a compressed folder, using ZIP format (no other compressed formats, such RAR, etc; only ZIP format is expected.).

The compressed folder (and so its associated zip file) will have the following name convention:

P1_Z123456_surname”

In which “P1” has capital P, and Z123456 must be replaced by your ZID number, being “Z” also capitalized. The component “surname” is your surname.

NO dataset files are to be submitted in that folder. (We do have those files.)

You may include some MAT file if that is part of your program (e.g. a LuT, etc; we do not expect that, but it is possible/allowed)

Report: you will submit a brief report (up to two pages), for explaining your approach for solving part D. The report will be submitted in PDF format, having the filename "*P1_PartD_z123456_surname.pdf*". The file will be located in the same folder in which you have your program files.
The size of the PDF file, will be limited to 3MB

Submissions that do not fully satisfy all the mentioned specifications will lose 1 mark.

You can submit your ZIP file multiple times, being the last submitted one (before the deadline), the one assumed to be the actual submission.

A section for submissions will be available in Moodle, a week before the submission deadline. Submission deadline is **Tuesday Week 7, 23:55**.

Questions about this project: ask the lecturer via Moodle or by email (j.guivant@unsw.edu.au)