MTRN4010 – Project #3

Applying EKF for map-based robot localization

Project 3 involves applying the EKF, for solving a robot localization problem, based on maps. We intend to use it with real data. For achieving it, we solve this problem incrementally, so we are able to secure that its many parts are working well, before we try the full solution under real data conditions.
The first part of the project asks the student to adapt the EKF to solve the map-based localization, in a purely synthetic simulation context. The second part aims to use it dealing with real data, but still in an off-line fashion. Real time conditions, such as receiving and processing the data in real-time, as it was usually performed in previous years, is not required in 2019.

Part 1)
Modify the example “DemoEKF_2019.m” for
a) Processing bearing (angle) observations (in addition to the range ones which are already implemented in the example.)
b) Using a proper Q matrix, based on the assumed noise in the inputs of the process model.
Note: for solving item (a) you need to also modify certain parts of the simulator components.

Part 2)
Simulate the existence of bias in the gyroscope’s measurements. Extend the EKF solution in (1) for estimating the gyroscope’s bias, as explained in lecture notes “[AAS2019]EKF_Localizer_estimating_bias.pdf”. Test your implementation by simulating cases having a bias= -1 degree/second, and having a bias =+1 degree/second.

Part 3) Use (1) for implementing the EKF based on the data and code used in Project2.Part4.
This program is based on the data used in Project 2. It is OFF-LINE but using real data, in the same way we solved Project2. You are requested to adapt your solution for Project2.Part4, adding the EKF component. The estimates should be more accurate than those obtained in P2.4, which were based on simple dead-reckoning.
Assume the following realistic conditions:

Noise in angular rate measurements:	standard deviation = 1.4 degrees/second.
Noise in speed sensor:	standard deviation = 0.4m/s.
Noise in range measurements:	standard deviation = 0.16m.
Noise in bearing measurements:	standard deviation = 1.1 degree

You need also to consider that the LIDAR sensor is located at the front of the platform. There is a document, in the lecture notes, which describes how to treat that matter.

Note: you must remove the bias which is present in the angular rate measurements (this is not required in part 4)

Part 4) Include the capability implemented in (2) for extending the solution developed in (3).
Consider that the gyroscope’s bias can be, in the worst case, limited in the range [-2,+2] degree/second.

Note: you must not remove the bias which is present in the raw angular rate measurements; because your estimation process estimates and remove it on run-time.

Part 5) Modify (4) for estimating longitudinal velocity. This means those measurements are not provided, and, consequently, you need to estimate the longitudinal component of the velocity, in addition to the platform's 2D pose and the gyroscope's bias.

Recommendation: you may solve it first modifying your solutions in pure simulation, for verifying performance; before trying it with the real rata. Assume that the maximum acceleration which the platform can achieve is $1.5 m/s^2$ (in forward or in reverse gear)

Showing results

For item (1), you will plot the result at the end of the process. The style of the plots may be as the ones produced by the provided example program ("DemoEKF_2018.m").

For item (2), you will include plots as in (1), and, in addition, the plot of the estimated bias (its expected value). You will also indicate the real bias (the one you simulated being polluting the measured angular rates in that test). The style of the plot should be as the one presented in the lecture notes (file [AAS2019]EKF_Localizer_estimating_bias.pdf), in which an example of performance is shown.

For (3) you will show results in the same way you did in Project2.Part3/4, using the same graphics resources you implemented in that project.

You may (this is not mandatory) simultaneously run the pure dead-reckoning solution, for visualizing the better performance of the EKF solutions. The lecturer showed a solution, in class, in which both estimation processes were performed simultaneously, and their estimates compared.

For visualizing that the pose estimates are consistent with the real ones, we will infer it by inspecting the expected global position of the detected OOIs. Those will appear close enough to the map landmarks. This visualization is the same you had implemented for solving Project2.part3/4.

For (4) you will simply reuse the visualization resources used in item (3). In addition, you will print/show, at low frequency (e.g. @1Hz), the currently estimated gyroscope's bias. You may simply print it as text in the console; or show it as text in some of the graphic visualizations you have.

For item (5) you simply show the results in the way you do in items (3) and (4); in addition, you will show the estimated speed (its expected value) and the real (but unused by the EKF) one. The style used for showing that information is up to you.

Units for reporting/showing variables: For positions and distances: use meters. For angular variables: degrees. For rates: Use units derived from the units of the derived variables "per second" (e.g. speed will be expressed in meters/second.)

Relevance of project items

From parts 1 to5, in percentages of the project marks, [(1):15%, (2):20%, (3):15%, (4):25%, (5):25%]

Submission details

Deadline:

For parts 1 and 2, the deadline will be Week 8, during your nominal lab session.
Submission of files: You will submit your solutions before or immediately after your nominal demonstration time. The specifications, about how the files must be submitted, will be given via Moodle, during week 6.

For parts 3,4 and 5: Demonstration can be given anytime between week 8 to 10 (including weeks 8 and 10).

(*) Note about holidays. If your last possible demonstration day happens to be a holiday day, you can give your demonstration before it, or the following week. However, your programs (which are to be used in your demonstration) must be submitted not after 8PM that day, even if that day is a holiday.

Late demonstrations/submissions: We will apply the penalties according to the course outline.

Quiz

There may be a quiz which will take place during the lab time, in your lab session.
The marks for project 3 will be affected by your result in the quiz, according to a formula which will be given by week 8.
The questions included in the quiz are fully related to concepts which you apply for solving the project.

Questions: Ask the lecturer, via Moodle or via email (j.guivant@unsw.edu.au)