E205 - Lab 4

PF Localization

Due: 9:30am Tuesday Oct. 25, 2022

1. The Data

In lab4, we will use the same data set as in lab 3, i.e. lidar/IMU data from an experiment where a bot navigated a 10x10 meter square path located in the center of an open field. At the center of the square was a pylon – the only object discernable by the lidar data. This pylon will serve as the landmark at known location (5.0, -5.0) with which PF localization will be conducted. The two data files are:

a) 2020_2_26__17_21_59.csv
b) 2020_2_26_16_59_7.csv

Figure 1: Images from data collection

If you want to watch the data collection in action, watch the video Screencast_2020-02-19_09_57_00.mp4.

Other notes:

- East is x-axis, North is y-axis, 0 is along the x-axis for the global coordinate frame. The positive yaw angle direction is CCW. This means you must transform the IMU yaw measurements before using them, (while the IMU has measurements 0 along the x-axis which points east, the positive IMU yaw angle direction is CW as noted in lab 1.)
- For the accelerometer, the x-axis is forward, y-axis is to the left.
- The lidar outputs x, y point's in a local coordinate frame where the y-axis is forward, and x-axis is to the right.
- Make sure you understand the data before you start. In particular, ensure that all angles are in radians (and convert any degrees to radians).
- The robot starts at the north west corner of the square path, and heads east.
- Assume the data is logged at 10 Hz. The time stamps seem corrupted.

- Double check your measurements (z_t) to make sure they make sense before you check the output of your KF. If z_t isn't roughly a box, the your KF definitely won't track a box.

2. PF Design

Your PF performance will largely be determined by the following parameters, algorithm choices:

a) Number of particles – We suggest 100's or 1000's of them.
b) Particle Definition – We suggest using a state representation that includes at minimum x, y, theta.
c) Motion Model – A few motion models will work. The double integration of IMU data (from Lab 3) is feasible. Also, simply using a perturbed compass measurement and random forward motion (that assumes no side slipping) may work just fine and demonstrate the robustness of the filter in terms of global localization.
d) Correction Step – you can use the same conditional probabilities for your sensor model as in lab 3. Again, you will find that various measurement models will work for your PF's performance in global localization.

Hint: Don't forget to use an angle wrap function EVERY time you take the difference of two angles.

3. PF Integration

Integrate your PF in python or Matlab. Create the following plots:

a) The estimated path followed, and the expected path (that follows a perfect square). Include the GPS track on the plot, as well as particle distributions at different time steps where you think they are relevant.
b) Assuming the square was tracked perfectly, plot the path tracking error as a function of time.
c) Performance plots or tables that compare the PF performance with and without a known start position.

Bonus points for those who demonstrate they have a PF that can solve the kidnapped robot problem.

3. Deliverables

A lab report should be submitted by 9:30am Tuesday, October 25th on Gradescope under Lab 4. You NEED to use the IEEE conference paper template, (similar to E80), but the report should be no longer than 3-4 pages. The report should include details of your PF design (including all 4 items mentioned in question 2 above), performance plots (including those listed in question e), and a discussion on the performance.