Assignment 5: Localization
CS 393R: Autonomous Robots
Due Date: 11:59:59 PM Wednesday, October 21, 2015

Your task is to design and implement a particle filter. You will demonstrate the accuracy of your filter by programming your robot to localize from an arbitrary starting position and walk to the center of the field.

The field will be organized with 6 beacons on the edges. The field will be 3 meters long and 2 meters wide, with beacons at each corner, as well as at the center of the 3-meter sidelines. Thus the bounds of the field will be (±1500,±1000), with beacons at (±1500,±1000) and (0,±1000). You can see an example of the field setup if you load `LocalizationSim` in the World window of the tool. This simulator will also be useful for debugging your particle filter.

To use the localization simulator, you should modify the current `LocalizationModule.cpp` file to use your particle filter implementation. Your implementation should supply particle locations and fill in your robot's `loc` and `orientation` variables so that these can be properly displayed by the simulator. Additionally you will probably find it useful to add plenty of logging statements so you can inspect your filter's updates frame by frame. More documentation can be found in the codebase:

https://github.com/utaustinvilla/robotics/blob/master/documentation/simulation.md

Once you're able to achieve good results in simulation it will be time to start testing on real data. Take a log with the Localization checkbox selected in the Log Select window, open the log in the tool, and then view the log in the simulator by selecting `Localization` from the dropdown. From here you can either review what is in the log, or you can use the Run Core radio button to reprocess the log with your latest code. Remember to rebuild the tool whenever you make code changes that you want to see in the simulator.

You will be evaluated based on your robot's ability to reliably estimate its position and use this estimate to guide its movements. The robot should be able to walk to the center of the beacons, continuously checking to see if it has been moved and if its position needs to be adjusted. Evaluations will take place on the **physical robots**.

As with Assignment 4, you are expected to implement your filter and any auxiliary code using only the C++ Standard Library and your choice of linear algebra library.

Checklist:

1. [____] (2 points) Implement a particle filter that estimates the robot's 2D position and orientation.

2. [____] (2 points) Demonstrate that your robot can localize by walking to the center of the field.

3. [____] (4 points) Demonstrate that your robot can relocalize after being kidnapped. Robots may be placed outside of the beacons, but within the bounds (±2500,±1250). Your robot will be kidnapped exactly 4 times. Each time, you will earn one point if your robot successfully moves to the center of the field and then stays within 10cm of the center for 10 seconds. It is your choice whether you walk or stand in place upon reaching the center.

4. [____] (2 points) Clarity and quality of your memo. Email it (along with a compressed folder of your code) to Peter and Jake by the due date. At the top of your memo please clearly indicate where your Particle Filter implementation can be found.

Extra Credit:

5. [____] (2 points) Implement and apply a clustering algorithm such as K-Means or Mean Shift to separate your particles into clusters and better estimate the robot's position. To receive credit you must apply use this technique during your evaluation.

6. [____] (3 points) Use two beacons and the ball for localization for Tasks 2 and 3. The two beacons will be at opposite corners of the field, and the ball will be placed in an arbitrary position on the field within the bounds (±1500,±1000). The ball will be moved after two of the four kidnappings between picking your robot up and placing it back down. You will receive one extra credit point for completing Task #2 with this configuration, and two points for completing task #3 (.5 extra points per kidnapping). You are permitted to attempt both the extra credit and the basic version of this assignment and receive points based on the best performance. If you plan to do this you must sign up for two consecutive evaluation slots.

Initials: _____ TA _____ Teammates _____ _____