Spring 2018 Research Project Proposal
The Laboratory for Embedded Machines and Ubiquitous Robots

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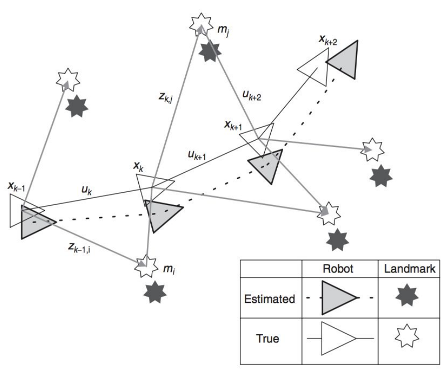
Big Picture

Simultaneous Localization and Mapping (SLAM) is the problem where the robot is placed at an unknown location in an unknown environment, and determine if it is possible for the robot to procedurally build a consistent map of the environment based on previous states as well as determine its own location within the map. This problem is important because it enables robots to communicate with one another and detect landmarks procedurally in an ad-hoc manner, which provides a more reliable way of communication.

As of now, there are multiple ways to tackle the SLAM problem, which include the Kalman Filter, extended Kalman Filter (EKF), and Rao-Blackwellized particle filter, along with newer alternatives that attempt to fix the weaknesses of the existing solutions. Developing and testing these algorithms are expensive, considering time costs of mounting the code to the robots for testing and monetary costs of purchasing and replacing malfunctioning robots that may be due to potentially fatal bugs in code. Thus, a simulation is necessary for testing and further development and thus the primary focus of this research.



Simultaneous Localization and Mapping Diagram from [1].

Real-world application: robot placed in a field with landmarks (other robots)

Specific Project Scope

This research will focus on designing, implementing, and modifying the simulation of multiple robots with CoLo, a simulation environment for cooperative localization. There are various algorithms (variations of the Kalman filter) to run CoLo with, which will be executed to generate data points. These include GS-CI, GS-SCI, LS-BDA, LS-CI, and LS-CEN. For these data points, analysis of various attributes such as accuracy of the location reported will be conducted to determine which algorithm is the most preferred when moving forward with the development of SLAM. For the simulation itself, this research will focus on researching newer algorithms and establishing data generation to provide additional data to supplement the real world data set that we will use to run the algorithms.

Goals

Ideally, by the end of this quarter, we would have a prototype of the simulation working, supplemented with extensive documentation in order to allow other users who are not familiar with the topic be able to use the simulation for their learning and potential research. This simulation will allow easier testing of existing algorithms and development of new algorithms. In the long term, we would like to mount the simulation code to paper robots to simulate a real-time environment of the project, which should be possible after ensuring and receiving approval of the simulation in terms of quality and impact. By providing this simulation environment, not only can we analyze the existing algorithms, but also, in the future, we can further conduct research and develop alternative algorithms that may be more accurate in terms of SLAM.

Deliverables

For the simulation, we would have a number of Python scripts, some for the actual algorithms and some for testing said algorithms. The scripts will be written in the latest Python version, which should be Python3. Along with the simulation, we will have documentation associated to the functions and, if necessary, sources from which we got sample code from. By running the code, the simulation functionality can be seen.

Tasks

In general, I will familiarize myself with the existing codebase which provides the current simulation environment and what exactly is the input and output of the simulation script. Then, I will implement the algorithm for the project and definitely test incrementally. At the end, I will finish any writeups and documentation to make it polished and friendly to use for other people interested in the research.

Main priority is to set up and ensure CoLo is working as intended and move around code to make the codebase easier to navigate, since we have to get this done before Shengkang's Annual Research Review. Then, work on setting up ROS + stage which is an essential component of integrating SLAM. Afterwards, work on further implementing CoLo along with the documentation, which is tentatively on data generation functionality to provide more data points in addition to the data points acquired from the real world dataset.

Breakdown of tasks:

- April 3: Meet with Shengkang about the project and project proposal
- April 4: Finalize research proposal
- April 5: Submit the research proposal
- April 6-10: Read over the existing code base and familiarize myself with the simulation environment
- April 11-April 16: Test the code and run analysis of the five algorithms
- April 17-April 20: Finish up current writeups and documentation
- April 23-April 30: Read documentation and set up ROS + stage as seen here http://wiki.ros.org/stage/Tutorials
- May 1-May 4: Set up ROS on lab computer
- May 7-May 11: Conduct further research on CoLo (tentatively: work on data generation to supplement data from real world dataset)
- May 12-May 18: Implement algorithms and documentation for CoLo
- May 21-June 1: Test code and create test script
- June 4-June 8: Finish writeups and documentation

References

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4. Roumeliotis, Stergios I, and George A Bekey. "Distributed Multirobot Localization." *IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION* 18, no. 5 (2002). doi:10.1109/TRA.2002.803461.
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7. Welch, G. & Bishop, G. An Introduction to the Kalman Filter. *Department of Computer Science, University of North Carolina at Chapel Hill* (2006).