16-833 Robot Localization and Mapping

Final Project Proposal - Team Slam Dunk

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Proposed Project:

Dynamic SLAM Using Landscape Theory of Aggregation

We propose to implement (from scratch) SLAM algorithm that works robustly in a dynamic environment using landscape theory of aggregation as outlined in [1]. Of all the places, Landscape Theory of Aggregation was proposed in British Journal of Political Science in 1993. [2] It describes the organization of elements of a system into patterns that tend to put highly compatible elements together and less compatible elements apart. These elements can be political, economic, and social. In our case, these elements are features obtained from sensors that needs to be classified into static and dynamic. Compatibility would be estimated using various cost functions such as distance from neighbouring features and motion similarity. Once the classification is performed, the filtered static features are passed to traditional SLAM to get improved results compared to unfiltered features as input. Once baseline method is implemented as described in the paper, we plan to improve upon by adding additional cost function for classification of static and dynamic.

Questions:

1. ***What are some impacts of the proposed research?***

Majority of the traditional SLAM problems have been addressed for static environments. Addressing SLAM problem in dynamic environments is quite limited. With the advent of self-driving cars and factory automation robots, impact of robot localization in dynamic environment has become more profound. With this project, we expect to implement the existing Dynamic SLAM approach described in [1] and

improve upon this approach. (eg additional cost functions for getting better compatibility score)

2. What is novel about the approach you are taking?

Proposed approach utilizes theory originally proposed in political science journal titled Landscape Theory of Aggregation of all places. While traditional SLAM algorithm assumes that all the features are static and hopes that high number of static features will counter the misleading measurements provided by dynamic features, Landscape Theory of Aggregation will allow us to classify the features into static and dynamic set and will enable explicit use of just stationary features in our SLAM pipeline resulting in the improved map and localization output. Also, the structure of the proposed approach allows for integration with any existing SLAM system to get improved results in dynamic environments.

3. What methods from class does it use?

Novelty of the paper is in classifying features in static and dynamic class. Concepts of probabilities such as bayes rule and maximum likelihood estimate will be utilized for the classification. Also, proposed approach requires traditional SLAM once classification is performed to get robot trajectory and map. We plan to implement Extended Kalman Filter (EKF) or Factor Graph methods described in the class to work along with the classifier.

4. What is your metric for success?

The metric of success for this project will be to check the accuracy of the maps built using this approach compared to the ground-truth or traditional SLAM algorithm which does not use any dynamic feature removal. Also another metric would be the localization accuracy in terms of error in the trajectory and accumulated drift of proposed algorithm and traditional algorithm.

5. What are the key technical issues you will have to confront?

Implementation of the approach from scratch (learning how to use optimization library to set specific cost functions and obtain optimum classification of features), achieve nearly equal results quality as mentioned in the paper. Parameter tuning to achieve optimal performance and results will be a challenge as we faced this issue during the particle filter assignment. Integration of the classifier with SLAM pipeline in computationally efficient way would be a challenge.

6. *What software or datasets will you use?*

We propose to generate our own dataset using a robot equipped with a SICK planar LiDAR. We will also consider data provided for Particle Filter without the use of provided map. Also, the robot will have GPS to give us some estimate of ground truth for comparing our results. We plan to select C++ Optimizers (Ceres, G20 or GTSAM) after thorough analysis of approach. We might use python as wrapper for various modules and ROS for getting sensor data and visualization of the output.

7. *What is your timeline?*

7th October to 20th October	1. Project Proposal 2. Dataset collection 3. Reading the paper, understanding the math, and approach 4. Figuring out project dependencies from the course and also learning software libraries
21st October to 3rd November	1. Implement the core idea of “landscape theory of aggregation” by classifying features into static and dynamic 2. Work on midterm report
4th November to 17th November	1. Combine the feature classifier with traditional SLAM pipeline 2. Debug the system 3. Obtain preliminary SLAM results
18th November to 2nd December	1. Comprehensive analysis of the results (graphs, metrics) 2. Making code computationally efficient 3. Extension of the paper 4. Final report

References:

[1] HUA Cheng-hao, DOU Li-hua, FANG Hao, FU Hao, A novel algorithm for SLAM in dynamic environments using landscape theory of aggregation, 2016

[2] Robert Axelrod and D. Scott Bennett, A Landscape Theory of Aggregation, 1993