Localization using GPU based Iterative Closest Point (ICP) algorithm

Amol Vagad

Aniket Pendse

Introduction

Localization is an important aspect in the Autonomous Vehicles technologies, especially in an Urban environment. For cars to follow traffic rules and regulations, it should have precise information about its current lanes and the path to be taken ahead. In order to obtain this information, it needs to localize itself in a given HD Map. This localization is carried out using Iterative Closest Point algorithm (ICP). It is also crucial to implement ICP algorithm fast enough to be suitable for real time localization. We intent to implement a parallel ICP algorithm for localizing a development vehicle in a given HD Map.

Description

Iterative Closest Point (ICP) is an algorithm used to minimize the difference between 2 point clouds. It gives the rotation and translation required to be applied to one point cloud(source) in order to match it with the other(reference). The matching parameter used is nothing but a mean square error between the 2 point clouds. So the general process involved in ICP is you apply the transformation R and t to the source point cloud Ps and calculate the mean square error between the transformed point cloud and the reference point cloud. The objective is to minimize the mean square error between the 2 point clouds for a certain Rotation R and translation t.

Objective

We intend to implement this application at a local automotive research company **VSI-Labs** , St. Louis Park facility where we both project members currently are employed as interns. The main objective is to use HD maps data from the map developer company HERE and carry out Localization of our development vehicle. In order to obtain precise localization we will be implementing ICP to find the best fit for our LIDAR data after comparing it with the HD map point cloud data. As the point cloud data is very large , carrying out ICP on that is very computationally expensive making it difficult to obtain results in real time. Since for an Autonomous Vehicle, real-time processing is very crucial we intend to use the GPU to ease this task. For development purposes initially the programming would take place using NVIDIA GTX 1060 GPU and then ported onto NVIDIA's Automotive computer DRIVE PX-2 equipped with 2 Pascal GPU's if time permits.

Background

We both are currently graduate students in the EE department with background in Robotics, Computer Vision, Algorithms and Optimization theory. The key skills required to understand and implement ICP is a basic knowledge of Linear Algebra, Kinematics, understanding of convergence of functions (Calculus) and Estimation theory.

Resources

- A. Ratter, C. Sammut and M. McGill, "GPU accelerated graph SLAM and occupancy voxel based ICP for encoder-free mobile robots," *2013 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Tokyo, 2013, pp. 540-547.
- C. Langis, M. Greenspan and G. Godin, "The parallel iterative closest point algorithm," *Proceedings Third International Conference on 3-D Digital Imaging and Modeling*, Quebec City, Que., 2001, pp. 195-202.
- A. Milstein, M. McGill, T. Wiley, R. Salleh, and C. Sammut, "Occupancy voxel metric based iterative closest point for position tracking in 3d environments," in ICRA. IEEE, 2011, pp. 4048-4053.
- https://www.coursera.org/learn/robotics-learning/lecture/1jDix/iterative-closest-point