Detecting Dynamic Objects in Consecutive Lidar Scans

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***Abstract*— This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.**

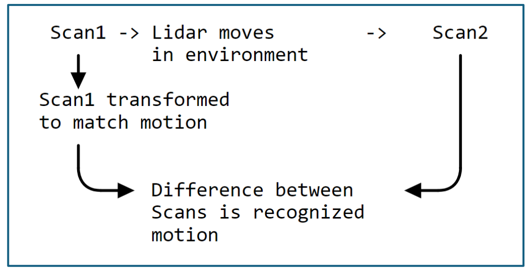
I. Introduction

Lidars are a popular sensor used in robotics to get an accurate scan of the environment. In situations that call for accurate distances and depth measurements, lidars are more accurate than cameras. They are also less susceptible disturbances from illumination changes in the environment. Hence, they are especially useful in robotics problems that involve navigating in an unfamiliar environment.

Simultaneous Localization And Mapping (SLAM) is the problem of making a map of the environment by scanning it, while keeping track of the one's position in the map of the environment. While there are different strategies for implementing SLAM depending on the available sensors and other requirements; Zhuang, Bing, et al demonstrate a solution to the SLAM problem of using only a Lidar as the sole sensor to the SLAM system [1]. This implementation uses a lidar to scan the environment, and an algorithm inspired by rat hippocampal activity to construct the map and keep track of oneself in the map. However, in the presence of dynamic obstacles, their algorithm is susceptible to remembering dynamic objects present in the scan as part of the static environment scanned in using the lidar. In this paper I propose an algorithm to recognize dynamic obstacles within consecutive lidar scans so that they may not be remembered as part of the static environment during the SLAM process.

II. System Design and Implementation Details

In principle the method of recognizing dynamic objects in consecutive scans is simple. Just identify which data points change between the two scans. However, since the lidar scanner itself will be moving during the scanning process every point, even the static environment, will appear to be dynamic by this method. Instead, we will need to transform the previous scan accounting for the motion of the lidar between the two scans. Then after the transformation we can check which data points don't line up. These data points will belong to dynamic obstacles in the environment.



General Flow of Dynamic object detection

This algorithm to detect dynamic obstacles in being implemented in python using numpy and tensorflow. To test the algorithm it is being applied on data generated using a Slamtec RPLIDAR A2M7 Lidar Sensor and on simulation data generated to replicate the lidar data.

III. Experiments / Proof of concept evaluation

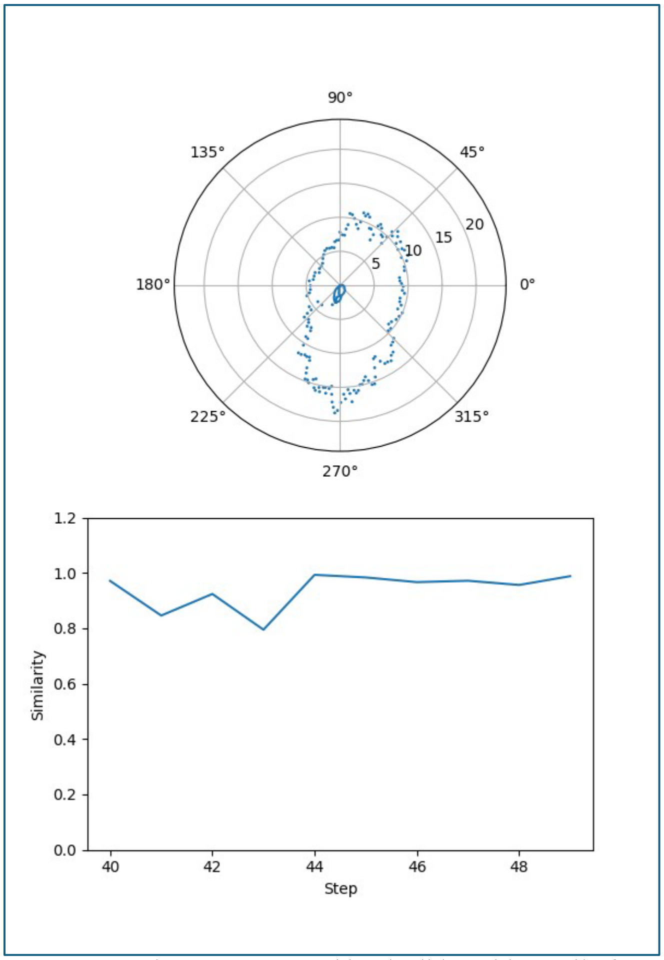
The algorithm to recognize dynamic obstacles has two critical tasks.

1. Identify the current immediate motion of the Lidar sensor.
2. Recognize the difference between the transformed previous scan and the current scan.

A solution to the first task is to frame the problem of finding the correct transformation (delta p) as a non-linear optimization to maximize the similarity between consecutive Lidar scans (S)

$$\Delta p_i = \underset{\Delta p'}{\operatorname{argmax}}\, Similarity(S_i, Transform(S_{i-1}, \Delta p'))$$

I implemented this optimization as a Gradient descent problem using tensorflow and numpy in python. In this way I was able to track how the lidar sensor moved between consecutive scans.



TOP: Environment scanned by the lidar with a trail of motion
Bottom: Cosine similarity of transformation with actual motion at each step of the simulation

However, doing the optimization between consecutive scans was too slow so I also experimented with the following optimization techniques.

1. Maximizing similarity on fraction of scanned points instead of all points

2. Using a heuristic to partially solve the optimization before gradient descent.

IV. Discussion & Conclusions

The optimization methods seemed to show limited but promising results. I will further develop on them to make implementation of this system realistic. More visualization of the results can be found on https://rk22000.github.io/DynamicLidar

References

[1] G. Zhuang, Z. Bing, Y. Huang, K. Huang and A. Knoll, "A Biologically-Inspired Simultaneous Localization and Mapping System Based on LiDAR Sensor," 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Kyoto, Japan, 2022, pp. 13136-13142, doi: 10.1109/IROS47612.2022.9981362. keywords: {Point cloud compression;Location awareness;Simultaneous localization and mapping;Laser radar;Biological system modeling;MIMICs;Rodents}.