Progress Review 1

Individual Lab Report 2

Aaditya Saraiya

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Team E:

Wholesome Robotics

Teammates:

Aaditya Saraiya

John Macdonald

Dung-Han Lee

Aman Agarwal

Hillel Hochsztein

Individual Progress

Capstone Project

Team E is creating an organic monitoring and weeding robot which has to autonomously navigate through crop rows. For this phase of the project, my task is to create an efficient SLAM pipeline for creating robust maps of the crop rows. A geometrically consistent map of the crop rows will be built after manually driving the robot in the farm. The map will be used for later runs as an input to the localization algorithm for efficiently localizing itself within crop rows.

Simultaneous Localization and Mapping

Previously, after setting up the VLP-16 LIDAR for real-time data collection (with assistance from Dung-Han Lee), the last work sprint was focused on creating a detailed understanding of the Lidar Odometry and Mapping algorithm (LOAM). Using an inbuilt encoder, the laser scans are projected into the LIDAR frame which is utilized by LOAM.

Figure 1 showcases the pipeline of the LOAM algorithm. A brief summary of the key aspects of the algorithm can be summarised as follows:

1) **LIDAR Odometry**- From the raw point cloud data acquired, the first step which is carried out is LIDAR Odometry. The main aim of this process is to find robust feature correspondences between successive laser scans and generate a 6-DOF motion estimate at a rate of 10 Hz.

    a. **Feature Extraction-** Extract edge and planar features using a ‘roughness value’ metric. The maximum number of features are limited per ‘sub-region’. Occluded regions, as well as planar features parallel to the plane of the laser-beam, are ignored.

    b. **Feature Correspondences-** The point clouds from the previous time-step are transformed into the coordinate frame of the LIDAR scan in the next time-step. Using the nearest neighbors approach, correspondences between two successive matches are found by minimizing a distance metric.

    c. **Motion Estimation-** Using the Levenberg- Marquardt algorithm, the 6-DOF pose transformation is calculated between the correspondences from two successive LIDAR scans.

2) **LIDAR Mapping**- This process runs at a frequency of 1 Hz. This part of the algorithm makes optimizing using local point feature clusters on a large scale. Hence, the focus of this part is to capture the global geometry of the map

(transformations of feature points with respect to the world frame), instead of local similarity in geometry.

3) **Transform Integration-** The transform integration is done at the end of every odometry loop (10 Hz) and it is the combination of both the odometry and the mapping transforms.

A link to the detailed summary and analysis of the LOAM paper [1] has been put up in Appendix 1.

After developing a deeper understanding of the algorithm, the LOAM ROS Package was utilized. Figure 2 shows how the raw LIDAR scans are converted into global point clouds. Figure 3 shows the global point clouds with the corresponding registered LIDAR scans.

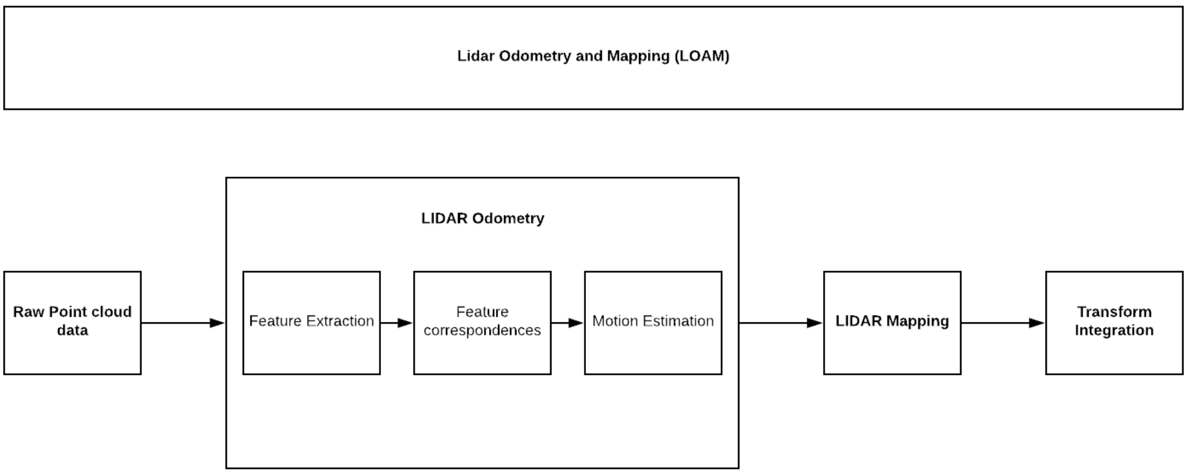

Figure 1: LIDAR Odometry and Mapping pipeline

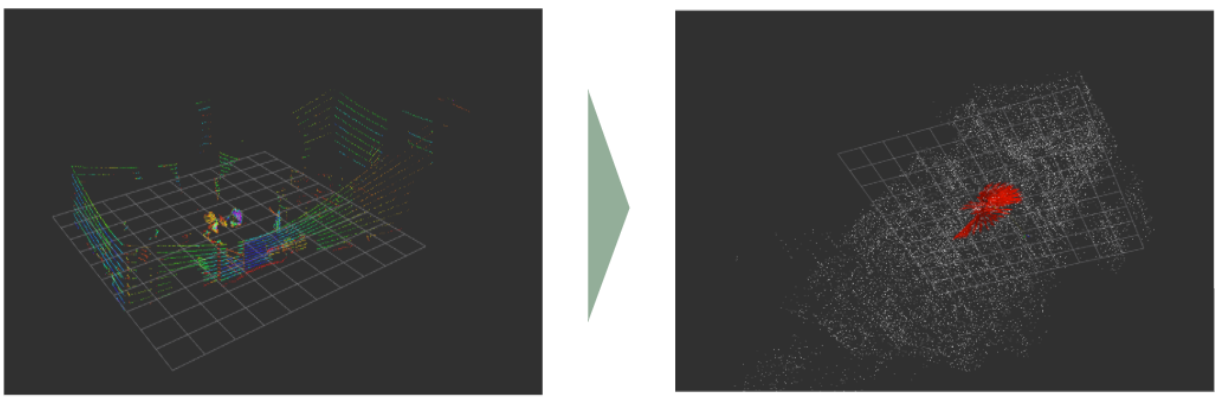

Figure 2a (left): Raw LIDAR point clouds obtained from Velodyne Puck 16

Figure 2b (right): 3D point cloud (map) obtained using the LOAM algorithm

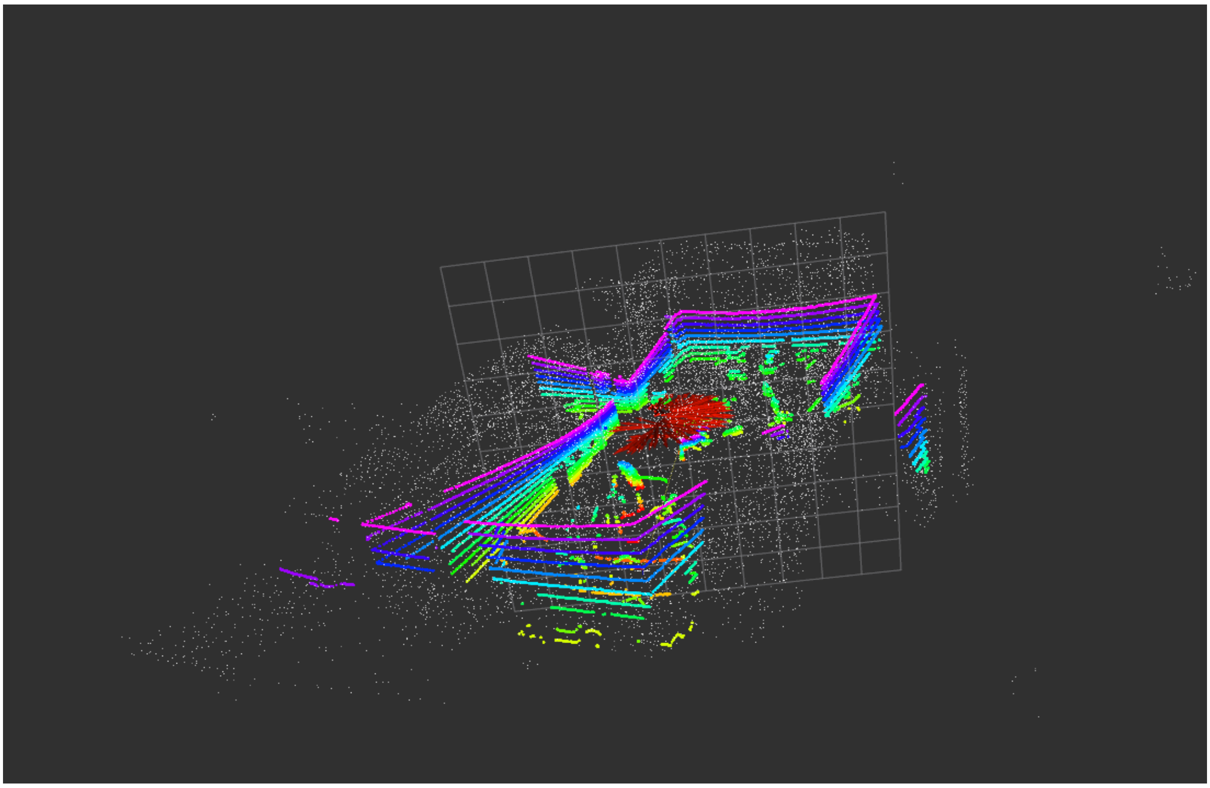

Figure 3: 3D point cloud with the registered LIDAR laser scans

Labeling images for Masked R-CNN

As a group exercise, we helped Dung-Han Lee in the process of labeling images and creating the relevant masks for training the Masked R-CNN network. Along the way, our discussion leads to us developing an automated pipeline for labeling images and assigning different colors to masks. John led the work in the development of the automated pipeline.

Challenges

Capstone Project

While working on the LOAM algorithm, I faced some significant challenges in getting started off in understanding and debugging the ROS package. The first challenge was that I had to read a huge amount of C++ code (which was written by researchers from Prof. George Kantor's lab) to understand the LOAM pipeline. The C++ familiarisation game assignment was helped me get used to code in an organized way, which alleviated the problem. Better documentation methods need to be set up in order to understand the huge amount of code efficiently.

Secondly, there was a communication gap between me and the members of George Kantor's lab. I spent 4-5 days trying to run a LIDAR SLAM package without realizing that it was meant for Visual-Inertial SLAM. This algorithm required a camera as well as an IMU to produce results. This time could have been saved with better communication with the lab members.

Teamwork

Capstone Project

John Macdonald

John worked on improving the measurement model for the particle filter which will be used for creating a localization within plant rows. With his recent work, he showed significant improvement in prediction of the position likelihood.

Aman Agarwal

Aman designed plant guards to prevent plants from getting stuck in the wheels. He also designed custom sensor mounts for the ZED stereo camera and Velodyne-16 Puck. He is currently working with Hillel to design the PCBs for the MRSD project assignment.

Hillel Hochsztein

Hillel designed the first prototype of the 3D CAD designs for Cultivator. He worked on wiring the HEBI Motor drivers. He is currently working with Aman to design the PCBs for the MRSD project assignment.

Dung-Han Lee

Dung-Han Lee re-trained the Masked R-CNN network and showcased an increase in accuracy for plant detection. He worked with John in order to develop an automated pipeline for labeling of images.

Future Plans

Capstone Project

The future tasks which are planned for the coming weeks can be summarised as follows:

1) Work with the ZED stereo camera and extract visual odometry from the camera. Extraction of visual odometry is required as there is a certain class of baby plants which are not properly captured in the Velodyne Lidar. Hence, visual features will be used in the loop for SLAM.

2) Rigorous testing needs to be done with the LOAM algorithm in order to understand the limits of the algorithms. This will include a thorough understanding of the algorithm parameters and tuning those parameters to receive optimum results.

3) Work on getting the HEBI motor drivers to work properly using the related ROS packages. Basic tests will be performed to check the accuracy of the motor.