AdVanScan: Computer Vision Team

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Abstract

The goal of this work is to answer the question: **How full is the van?**
One of the volume estimation methods we considered was integration on a 3D surface captured from a 3D camera. After comparing cameras, we chose the Intel RealSense, and captured four images from different angles. The exported point clouds were merged in MATLAB using an Iterative Closest Points (ICP) algorithm, and from the final point cloud a surface mesh was constructed. Using this, we obtained the value of the volume in the van by integration.

Workflow outline

1. Take pictures of the inside of the van from different angles.
2. Extract point clouds from images.
3. Merge point clouds via the ICP algorithm and fit a curve to this.
4. Estimate the value of the volume using numerical integration.

Challenges

1. Large point cloud files (approx 20Mb) slowed much of the procedure down and had to be simplified using well-known techniques.
2. Taking only one picture was found to have a lot of noise at the back of the van, so multiple pictures were taken in order to have a precise represenation.
3. The resulting point clouds would sometimes contain data from outside the van challenging the whole data processing.
4. When measuring in a scenario where we know the volume occupied, some space is impossible to detect using pictures. This included space behind/between boxes, especially closer to the back of the van.

Result Summary

- Volume estimation in less than 45secs worst case.
- 5 to 7 % error for ordered load and 9 to 11% error for disordered
- No camera needed for every van.
- Total average error of almost 5%, outliers excluded.

Hardware Overview

Three (3) cameras were considered. Pros and cons of each were weighted and the group ended up choosing Intel RealSense D435.

Intel Realsense SR300 is better for indoor locations due to infrared light while Zed Stereo Camera is better for outdoors. Our experiments using both of them, reassured this notion. After excluding the camera that didn't work, we settled on the Realsense *D*435 due to its superior price point and lack of dependence on environmental factors.

Workflow illustration

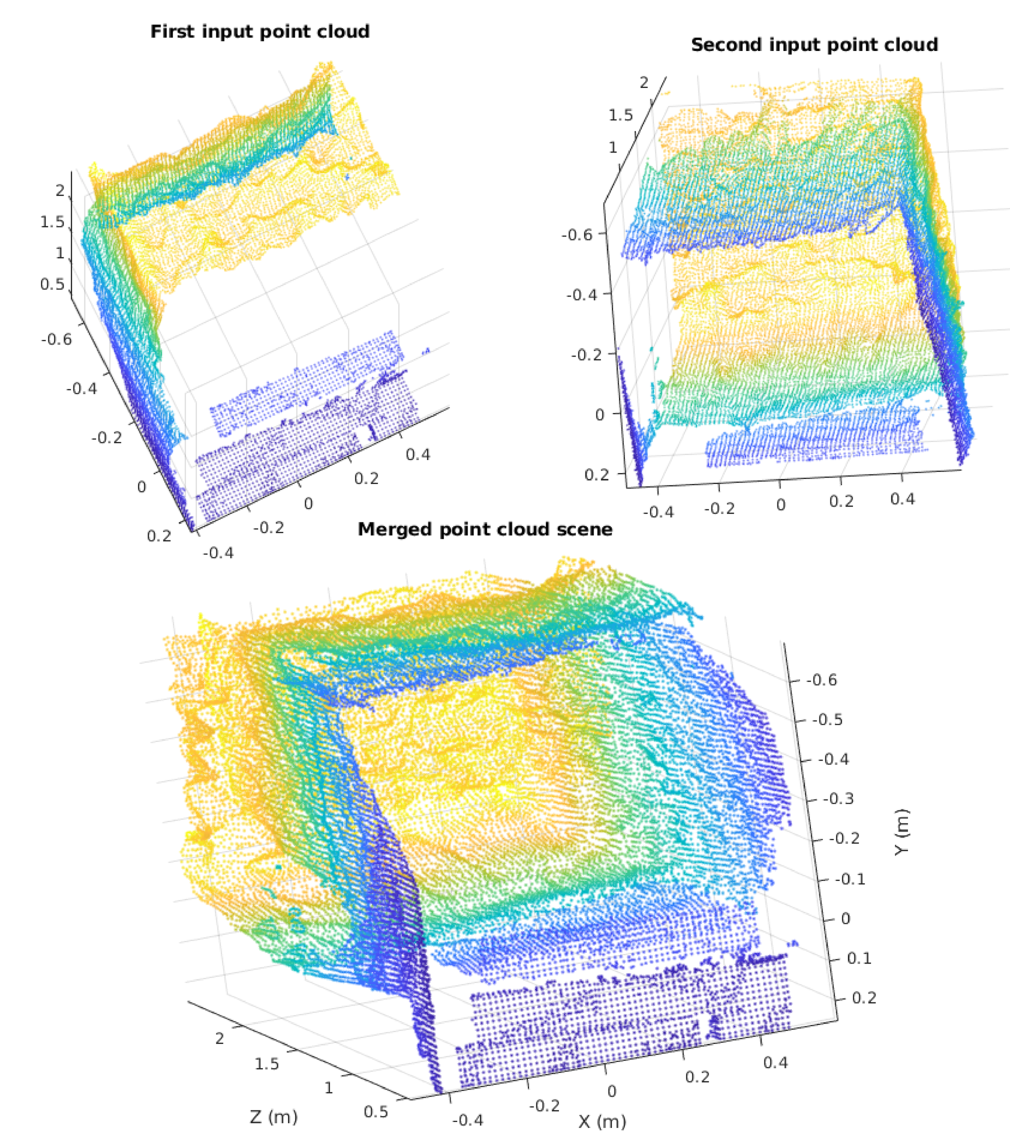

Figure 1: Intermediate merged pointclouds (left) and final point cloud (right). Denoised and downsampled version of final point cloud (bottom).

Four pictures of the inside of the van are captured from different angles. The point clouds obtained from the camera are noisy and contain several outliers as well as empty patches.

In order to obtain an accurate reading, the outliers are removed by using a threshold and denoising the image.

Fig.1 shows the point clouds after the first merging (top) and the final result (bottom). The back of the van has been clearly smoothed out, and while some white space has remained a lot has been filled by the merging procedure.
After this, the four images are downsampled and merged to obtain a final point cloud. The merging is done by using the well known Iterative Closest Points algorithm, thus not requiring to know the exact position at which the pictures were taken. (Independent of angle and direction)

Fig 2 shows a point cloud after removing the outliers and applying curve fitting. Notice the presence of empty spaces as well as the noise, specially at the back of the van (in dark red).

Using Mathworks' MatLab curve fitting toolbox we created a fit to the data using a Linear Interpolation and numerically evaluate the double integral.

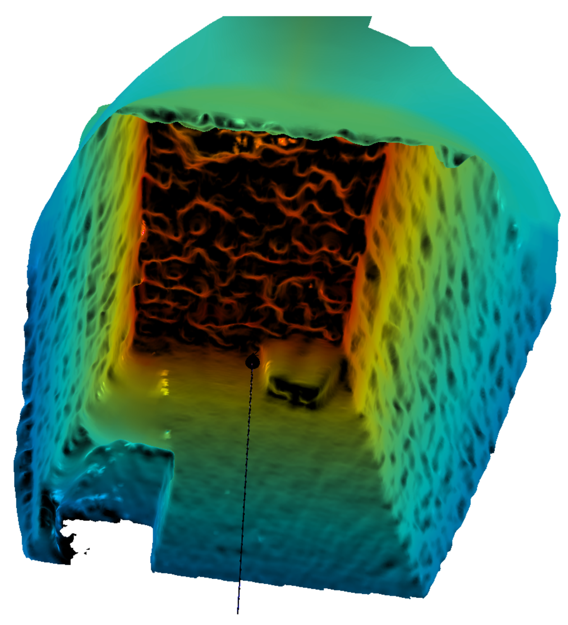

Figure 2: Point cloud curve fitting

References and acknowledgements

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