5C-04

An Application of Automatic 3D Reconstruction with Velodyne HDL-32E LiDAR to GEXPO2016 Indoor Exhibition

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Abstract

In the recent years, LiDAR devices are being widely used in reconstruction of the environment. Especially, mobile 3D LiDAR sensors like Velodyne HDL-32E are attracting more interests for these mobility, portability and the low cost compared to the stationary LiDAR sensors. In this work, we discuss an approach for automatically reconstructing the indoor environment both on point cloud level and surface level with the raw data acquired by a Velodyne HDL-32E LiDAR. Our approach consists of many existing methods of registration, segmentation, surface fitting and surface reconstruction. The approach is implemented and applied on the real-word of the indoor environment, which is acquired with the Velodyne HDL-32E LiDAR in the exhibition area of GEXPO-2016 in Tokyo. The processed result shows the feasibility and the practicabilityof the proposed application.

Keywords: LiDAR, Point Cloud, 3D Reconstruction

1 Introduction

3D sensors such as depth sensors and LiDAR sensors are being popularizing in the fields of 3D mapping and modeling for applications like VR games or indoor navigation. A general method for 3D maps and models generation is by processing the point cloud acquired with 3D sensors. The characteristics of different types of sensors are compared in Table 1. In this work we collect the exhibition area of GEXPO2016 in Miraikan with the Velodyne HDL-32E LiDAR sensor, which is a representative 3D mobile LiDAR sensor. Furthermore, we applied the method proposed in our earlier work [1] to process the acquired data to map and reconstruct the environment automatically.

Sensor type	Price	Coverage	Portability	Density
Depth sensor	good	bad	good	good
3D Static LiDAR	bad	good	neutral	good
3D Mobile LiDAR	neutral	good	good	neutral

Table 1: Comparison of different types of sensors

2 Methodology

The process flow of the application is shown as Figure 1. Raw data from Velodyne HDL-32E are extracted into individual point clouds first. Then transformation matrix between every two consecutive frames of point clouds are calculated with the General-ICP method proposed in [2]. Calculated transformation matrix are utilized to register and segment the point cloud with incremental Region Growing method [1, 3]. Voxel grid filter is also applied in this work to downscale the redundant points. Surfaces of segmented point clouds are reconstructed parallelly either by fitting the point cloud to the plane or by 3D alpha shape. Finally, the Visualization Toolkit(VTK) is used for visualization of the reconstructed surfaces in this work.

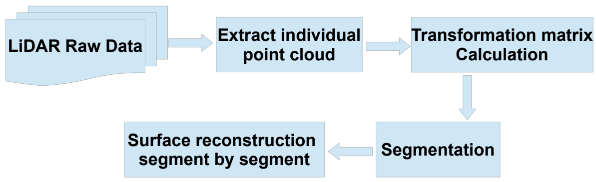


Figure 1: Process pipeline

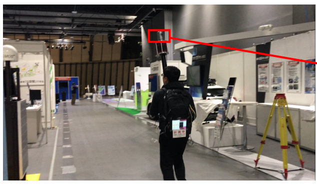
3 Evaluation

3.1 Dataset

The 3D data are collected by holding a Velodyne HDL-32E LiDAR sensor and walking around the exhibition area. An picture of data collection is shown as Figure **??**. A Ladybug3 panoramic camera is also set for image data collection, however, the images are not used in this work. The calculated bounding box of the exhibition area is approximately $50.1 \times 120.2 \times 19.6$[m] and the data used in this work consists of 350 frames of point clouds acquired in only 35 seconds.

3.2 Results

We apply the process pipeline shown in Figure 1 to process the acquired data. The processed results are shown in Figure 4. The 2D floor map of the exhibition area is shown in Figure 3a for comparison. The registered point cloud of 350 frames consists of 2.7 million points after

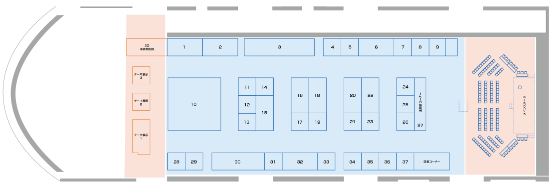


(a)

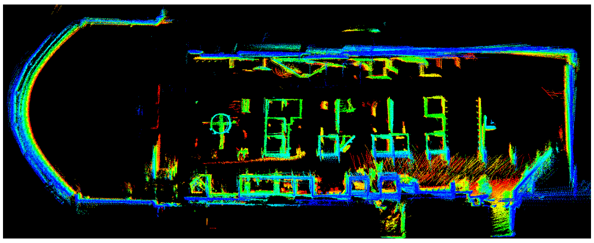
(b)

Figure 2: Data collection. (a): the scene of data collection. (b): the working Velodyne HDL-32E sensor

the simplification with the voxel filter (the leaf is set to 0.1,0.1,0.05[m]). Figure 3b shows the result after removing the roof and ground for clearer visualization. Although small drift caused by the registration error can be seen in Figure 3b, the layout is almost the same with the manually created floor map in Figure 3a.



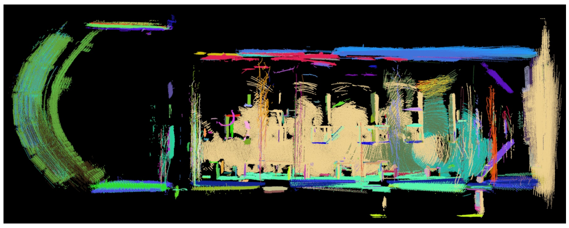
(a) Floor map of the exhibition booth with the area 50.1 × 120.2[m]



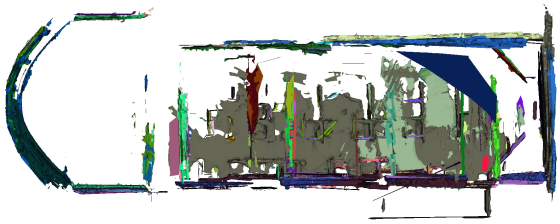
(b) Registered result with 350 frames. Colors indicate the altitude. (The roof and ground are removed for clearer show)

Figure 3: Processed results with the application

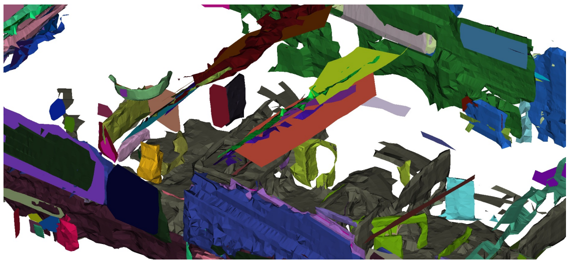
To increase the visibility of the registered point cloud and decrease the redundant points, we fit the points that can be represented by the planes into planar model and reconstruct surfaces with alpha shape. Segmentation by incremental region growing is performed for better efficiency and reconstruction. The segmentation results are shown in Figure 4a. Surface reconstruction results for individual segments are shown in Figure 4b and 4c. The surfaces of walls and the partition boards of the exhibition booth can be clearly seen in Figure 4b.



(a) Segmentation result of the registered point cloud



(b) Surface reconstruction result (top view)



(c) Surface reconstruction result (side view)

Figure 4: Processed results with the application

4 Conclusion

In this work we implemented an application for 3D mapping and surface reconstruction of the exhibition area of GEXPO2016 in Miraikan. The data are collected in less then one minute. The processed results verified the practicability and efficiency of the proposed application in mapping and surface reconstruction for the large scale indoor environment.

References

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