Precise Point Cloud Generation Framework using Multi-layer LiDARs

Hyungjin Kim[1], Seungwon Song[1], *Student Members, IEEE*,
and Hyun Myung[1], *Senior Member, IEEE*

***Abstract*— This paper proposes a general framework to generate precise point cloud using multi-layer LiDARs in indoor and outdoor environment. With the advancement of IT, precise point cloud map is required in various fields. The point cloud data is collected mostly from RTK GPS-based Mobile Mapping System (MMS) which is hard to cover various environments. Therefore, this paper introduces a point cloud map generation method in various environments. This paper proposes two step robust and fast matching method by using only LiDARs. The proposed algorithm has been verified by testing in complex indoor and outdoor environments.**

I. INTRODUCTION

With the advances in autonomous vehicle and robot technology, point cloud map generation becomes more important. The most successful technology to generate point cloud data is MMS (Mobile Mapping System) [1]. However, this system is heavy and can be performed only on streets. The point cloud map should cover various environments to provide localization services. Thus, this paper proposes a general point cloud framework using a multi-layer LiDAR system for indoor and outdoor environments.

II. THE PROPOSED METHOD

This paper proposes a point cloud generation method using multi-layer LiDARs as shown in Fig 1. The robot position is predicted using LiDAR-based odometry by matching previous accumulated LiDAR data with current data using NDT (Normal Distribution Transform) [2]. The local map is generated for a certain distance using the LiDAR-based odometry. The loop closure is detected by matching among local maps. Since 3D point cloud matching is time consuming, the local map is matched in two steps. The first step is 2D-to-2D matching and the second step is 3D-to-3D matching. In the first step, the robot position (x, y, and θ) is roughly estimated as an initial pose of the second step. In the second step, the final 6-DoF (Degree-of-Freedom) transformation is estimated from the initial pose. To generate precise point cloud map, a graph structure-based SLAM algorithm is exploited based on the NDT-odometry and loop closures. The final precise point cloud map is generated from SLAM result.

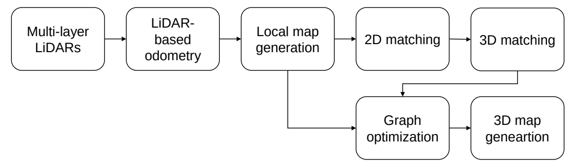
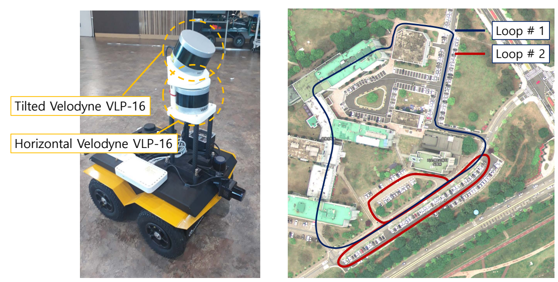
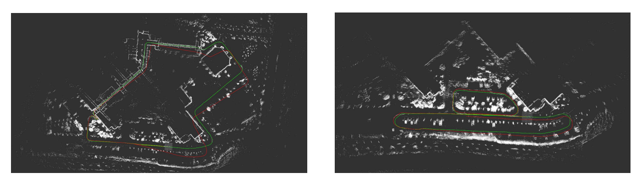


Fig. 1. Point cloud generation framework.



(a) (b)

Fig. 2. (a) The sensor system to collect point cloud data. (b) The experiment loops.



(a) (b)

Fig. 3. The point cloud result (white), SLAM path (red) and odometry path (green) for experiment loop (a) #1 and (b) #2.

III. RESULTS AND CONCLUSIONS

The sensor system to collect point cloud data is shown in Fig. 2(a). The two multi-layer LiDARs (Velodyne VLP-16) are equipped on a mobile robot system.The experiment loops are shown in Fig. 2(b). The point cloud map result is represented in Fig. 3. The proposed method is verified by measuring the position error within 20cm at the starting point.

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[1]Hyungjin Kim, Seungwon Song, and Hyun Myung are with the Urban Robotics Laboratory, Korea Advanced Institute of Science and Technology (KAIST) Daejeon, 34141, South Korea {hjkim86, sswan55, hmyung}@kaist.ac.kr