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Dynamic Map Management for Vehicle Localization in Large Scale Area

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Abstract: As the point cloud data are widely utilized in a vehicle localization, it is important to manage enormous point cloud data especially in a large scale area. Therefore, this paper proposes an effective data compression method of point cloud by saving only essential information as a form of image format for localization. In this paper, all essential data for localization are saved as image patches using PNG format for online localization in a large scale area. Moreover, this paper also proposes a dynamic map management to generate a local map from image patches in real-time. The proposed method is verified by online vehicle localization with the generated local map within 19.9 km distance of a large scale city area.

Keywords: Point cloud, 2D grid map, dynamic map management, MCL

1. INTRODUCTION

Since autonomous vehicles have widely developed, a vehicle localization becomes one of important issues for navigation. For precise localization, a prior 3D point cloud map based localization is generally utilized. However, the size of the point cloud data is too big to handle a large scale area. Therefore, this paper proposes an efficient compressed method to store and a dynamic map management method in city scale area.

It is inefficient to store all of point cloud data for real-time localization and is very hard to load all the data on RAM memory. Thus, the point cloud map is generally simplified to 2D grid map for localization. J. Levinson *et al*. [1] proposed a precision vehicle localization using a elevation map and its intensity data of LiDAR sensor. For using a localization method using vertical information of point cloud, multi-resolution Gaussain mixture maps algorithm [2] was proposed to include all the vertical information into a grid cell as Gaussain mixture model. R. Triebel *et al*. [3] also proposed a multi-level surface map to handle multi-level road such as bridges and interchanges. However, these methods are many disadvantages by storing only limited information. These are also hard to cover a large scale area for real-time localization. Therefore, the paper proposes a novel compressed method by saving essential information of point cloud into a image format. Furthermore, a dynamic map management method is proposed by conducting image patches to handle a large scale area.

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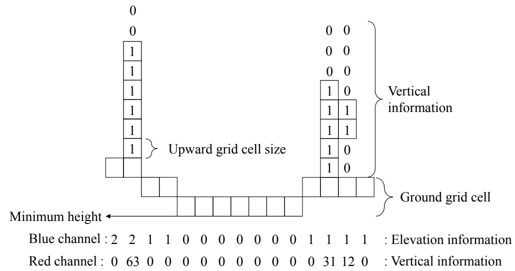

Fig. 1 The concept of map representation method that includes a elevation map (blue channel) and vertical information (red channel).

2. THE MAP REPRESENTATION

This section describes to extract essential elements from point cloud for localization of vehicle. First and foremost information for vehicle localization is a elevation map and intensity information of a road. As point cloud projects with z-axis to 2D grid cells, a elevation map is generated by selecting a minimum height value among the all height values in a grid cell. By saving each intensity information of each elevation grid value, a intensity map is generated. The other important information is vertical information. The vertical information have several data within each grid cell when projecting point cloud into a grid cell. Since essential vertical information is below a certain height from the road, upward grid cells are stacked on the elevation map to represent vertical information.

In this paper, a image format is utilized for effective store and management in real-time. The image format generally is composed of three channels (RGB) of eight bytes. The elevation map and its intensity map simply save into blue and green channels by converting to eight bytes, respectively. The elevation map is saved into 0-255 range by binary quantization step by a grid cell size

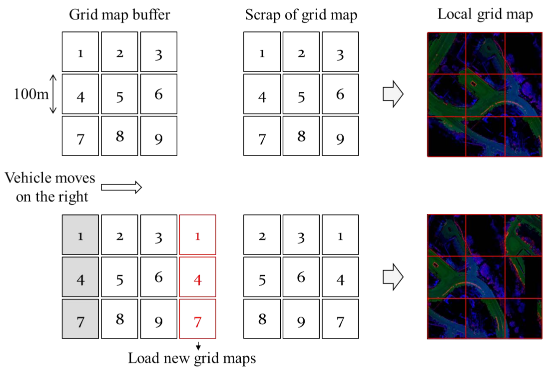

Fig. 2 The concept of the dynamic map management when the vehicle moves on the right.

as set to 0 for a minimum elevation value of the map. Thus, the maximum height range of eight bytes is 255 × *the grid cell size* (*e.g.* 25.5 m = 255 × 0.1 m). The intensity map also converts to 0-255 range by binary quantization. The upward grid cell of vertical information are stacked on the elevation map as shown in Fig. 1. The maximum number of upward grid cells is eight since one channel has eight bytes. Therefore, 00001100 in binary as shown in right side of Fig 1 converts to 12 in decimal system. Similarly, 00011111 and 00111111 in binary are 31 and 61, respectively. As the binary data is saved in a red channel, the vertical information is stored in a image format. If adding more channels for vertical information, more upward grid cells can be allocated.

3. DYNAMIC MAP MANAGEMENT

This section introduces a effective dynamic map management using image patches. The size of a image patch is decided by considering a range of sensor system (*e.g.* 1000 pixel × 0.1 m resolution = 100 m). The each image patch is saved as a PNG (Portable Network Graphics) format with a origin point and a minimum height value of the image patch. To generate a local map near a vehicle, nine patches are loaded on grid map buffers as shown Fig.2. When the vehicle moves to the right patch from the middle patch, new three near patches are loaded on the left map buffers. Instead of rearranging all the near patches, only the indicators of patches are shifted to reduce unnecessary image patches loading. The final local grid map is generated for localization by reordering grid map buffers using indicators.

4. EXPERIMENTS AND RESULTS

The results of a elevation map, its intensity map, and a height map are shown in Fig. 3. The result of the combination of all the maps into RGB channels is shown in Fig. 3(d). The total size of point cloud data in experiment area is 30.5GB, which consists of 6,292,573,705 points. The proposed method is compressed the point cloud as 380 image patches with 218.2MB. Through Section 3, a local map from the image patches is generated as shown in Fig. 4. The proposed method is demonstrated by MCL (Monte Carlo localization) with the local map through 19.9 km way in city area.

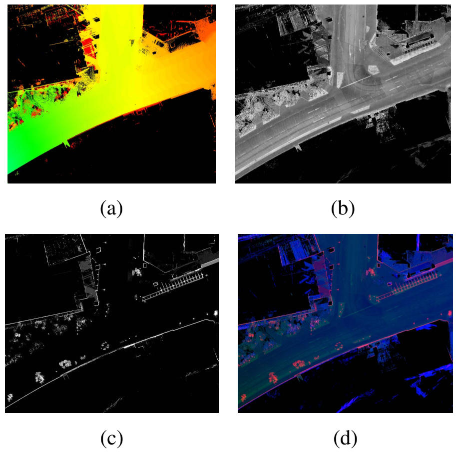

Fig. 3 (a) the elevation map represented by height map color. (b) its intensity map. (c) the vertical map, (d) the image format to combine with all the maps.

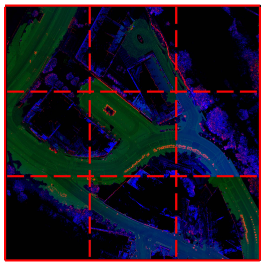

Fig. 4 The result of a grid map patch.

5. CONCLUSIONS

This paper proposed a effective data extraction method from enormous point cloud by considering a image format. A dynamic map management is proposed to generate a local map for real-time localization using image patches. The proposed method can cover in a huge city area.

REFERENCES

[1] J. Levinson, M. Montemerlo, and S. Thrun, "Map-Based Precision Vehicle Localization in Urban Environments," in *Proc. Robotics: Science and Systems*, Vol. 4, p. 1, 2007.

[2] R. Wolcott and R. M. Eustice, "Fast LIDAR localization using multiresolution Gaussian mixture maps," in *Proc. IEEE Int'l Conf. on Robotics and Automation*, pp. 2814-2821, 2015.

[3] R. Triebel, P. Pfaff, and W. Burgard, "Multi-level surface maps for outdoor terrain mapping and loop closing," in *Proc. of Int'l Conf. on Intelligent Robots and Systems*, pp. 2276-2282, 2006.