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THE METHOD OF ROAD FACILITY EXTRACTION FROM LIDAR POINT CLOUDS

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ABSTRACT

Various researches and technologies are being developed and utilized to improve the function of autonomous vehicle. These systems have been developed from simple systems that assisted drivers for safe driving. More recently, an autonomous vehicle, which can be driven without driver with control the steering wheel through the vehicle object recognition, has passed a test driving and is driving on real roads. To travel on the public road, it is necessary to recognize road facilities and have positioning technology, which are the basic technologies for the safe driving of autonomous vehicle. The target facilities to be recognized by autonomous vehicles are medians, curbs, and lanes among facilities that must be recognized for the safe driving of autonomous vehicle. In particular, the recognition of road facilities should be applicable under various conditions to reflect actual driving environments and accuracy at a certain level should be guaranteed. In this study a research is conducted on the mapping of road facilities using Light Detection and Ranging (LiDAR) and the extraction of information of road facilities. Surrounding information was mapped using LiDAR data acquired while driving vehicle, and road facility information was obtained using mapped PointCloud.

Keywords: *LiDAR, Road Facilities, Mapping System, Extraction System, PointCloud.*

I. INTRODUCTION

Various researches and technologies are being developed and deployed to improve the function of autonomous vehicle. The representative technologies that have been developed are Advanced Driver Assistance Systems (ADAS), Lane Departure Warning System (LDWS), Adaptive Cruise Control(ACC) and Smart Parking Assist System (SPAS). In the past, these systems had been developed only to assist drivers to ensure safer driving. However, autonomous vehicle based on the vehicle's object recognition are currently being driven. These autonomous vehicle need to recognize the road facilities and verified the locations for keeping safe driving and prevention the obstacle on the road. To keep the travel trajectory, the median, curb and lane should be recognized by aitonomous vehicle. Also these facilities should be recognized under various conditions such as daytime, nightime, rainy, foggy and so on, to reflect actual driving environments and guarantee a high level of accuracy. Therefore, this study tried to extract road facilities using point-clouds mapping data, acquired from Light Detection and Ranging (LiDAR), and presented the method of recognizing the road facilities.

II. LITERATURE REVIEW

In this section, previous studies were reviewed concerning autonomous vehicle.

Kim and Lee (2008) conducted a study on the automatic generation of 3D geometric models on roads using LiDAR data and numerical maps. Points measured at the road surface were identified through division and the grouping of data within the road section and the linear and surface information of the road was extracted [1]. Choi and Park (2012) studied a visual odometry that estimated a location of driving vehicle. For position recognition, stereo cameras that acquired 3D information in front of vehicle, and a single camera that acquired rear images were employed. Experiments were conducted on two long-range travel paths acquired from real driving environments and greater than a 97% of match success rate was achieved [2]. Kim et al. (2013) generated several estimation factors for tracking through the combination of background subtraction, LK-optical flow, and local histogram-based features extracted from external environments, and proposed a relatively robust tracking method against noise and changeable objects. A method that enabled reliable tracking in external environments was also proposed through a verification technique of feature points and local histogram-based verification, and a combination of the above tracking methods [3]. Jang et al. (2015) extracted a difference in brightness between lane and the road surface based on the fact that lanes are always brighter than the road surface. A straight lane was detected using the feature extraction results. A candidate group of curves was also generated on the 3D road surface using the detected straight lines and camera information, thereby determining curved lanes. Furthermore, inaccurate speed estimation was improved by using detection information contained in the previous frames of the consecutive frames to track the curved lanes properly [4].

III. OUTLINE OF SYTEM

Sensor Configuration

In this study, 3D LiDAR and image sensors were used to recognize road facilities. As for the LiDAR sensor, PUCK (16-channel) of Velodyne was attached to the vehicle. PUCK (16-channel) of Velodyne has a detection range of 360° horizontally and 16 layers at 2° intervals are produced and measuring up to 100m. The 3D LiDAR sensors are operated at a different measurement cycles, with each sensor logging data including global positioning system (GPS) times, GPS coordinates (longitude and latitude or TM) at the time of sensor measurement for every interval, and vehicle posture information (Roll, Pitch, Yaw) measured by the inertial measurement unit (IMU) sensor. The LiDAR sensor data consisted of GPS/IMU information (time, position, and posture) and PointCloud information acquired by the LiDAR. Each point contains position coordination (X, Y, and Z) based on the reference of sensor-mounted position, and the intensity information. Therefore, a local (LiDAR acquired position) coordinate system required a conversion to the global coordinate system, and the position coordinate at each point was stored at an "m" unit. A Charge Coupled Device (CCD) camera (Manta-G 125) was used to recognize road facilties. The resolution of the camera was 1936 X 1456 with a frame rate of 40 Frames Per Second (FPS). The camera had a CCD progressive type sensor and the communication standard used was IEEE 802.3.

Point Cloud Mapping

The Point Cloud mapping data applied Little-Endian was stored in a binary format. As the volume of Point Cloud Data was so large, it was stored after classifying data into an index and data files. The index data consisted of sequence number, timestamp, location, position, data file ID, and offset information. Table 1. presents the structure of the index data in details.

Table 1. The structure of index data

Sequence Number	Item	Description	Sequence Number	Item	Description
1	Sequence Number	Sequence Number	4	Roll, Pitch, Yaw	IMU Position
2	Timestamp	GPS time	5	Data File ID	Data file ID
3	Position X, Y, Z	GPS location(TM)	6	Data File Offset	Data file offset

Concerning the road facility extraction using LiDAR data, this study concentrated on the method of detecting the precise position of objects in 3D space. In case of BirdView, which only shows X-Y coordinates, it was difficult to extract the position of objects in ambiguous boundary or a location covered by leaves. To solve the problem, this study selected the criteria range in the Z axis, but not all the Point Cloud. Figure 1. shows a process of distinguishing road signs and trees.

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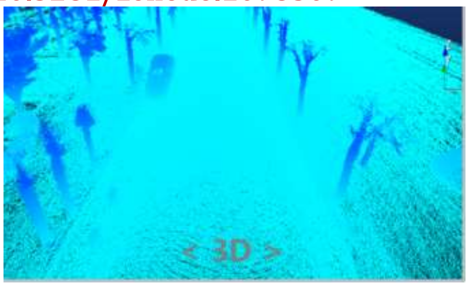
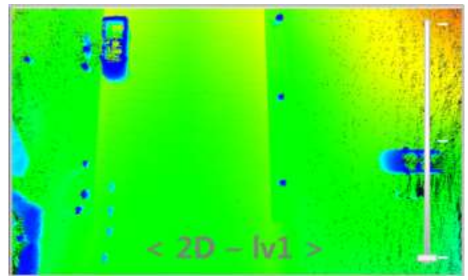
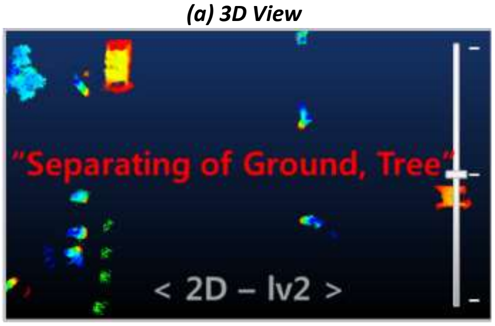


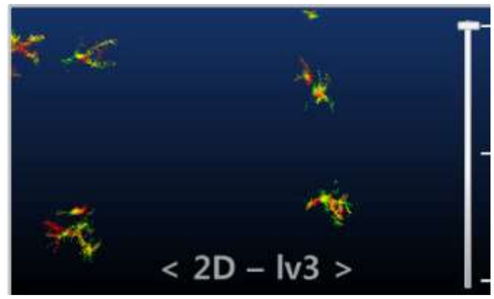
(a) 3D View



(b) 2D View-Level 1



(c) 2D View-Level 2



(d) 2D View-Level 3

Figure 1. A process of distinguishing road signs and trees.

Road Faciltiy Extraction Process

This study proposed to recognize fixed objects on the road and roadside. Getting an attributable position and location for each image, it is feasible to efficiently construct the database for multiple images by utilizing the calibration parameter. Two sets of data collected from the camera and LiDAR were syncronized based on the time step. By setting the calibration parameter, which indicates the relations between WGS84 and image pixels, and any camera images can be overlapped on the Point Cloud. Figure 2. shows the matched result of the images and LiDAR data logged in the test field.

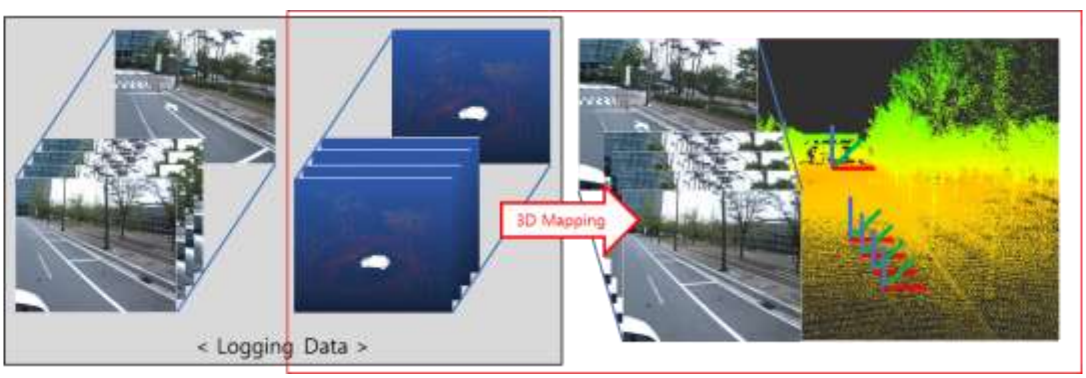


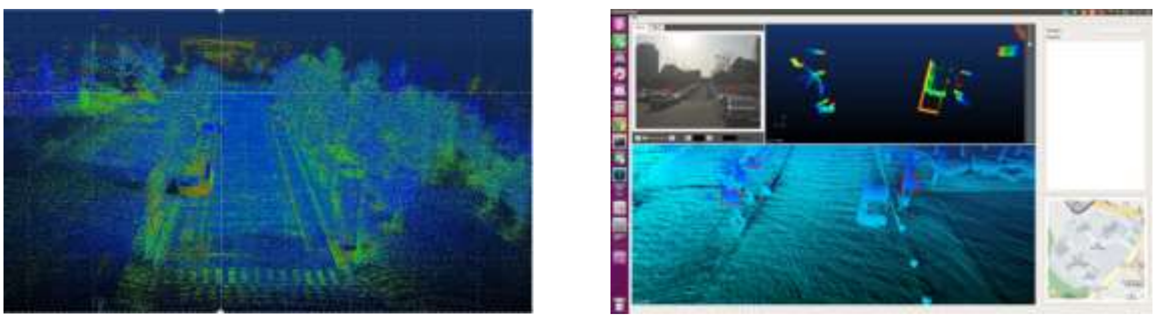
Figure 2. Testing samples result from traffic sign recognition using camera

The test field was mapped with LiDAR and information of the road facilities was collected from mapped data. Table 2. presents the attributes of the fixed objects logged on DB set.

Table 2. The attribute of the fixed objects logged on DB set

Index	Description	Type	Attribution
Center	Center of Objects	Point / Plane	TM(x), TM(y), Altitude(z))
Orientation	Position of Objects	Point / Plane	Quaternion(w, x, y, z)
Volume	Volume of Objects	Point / Plane	Width, Height, Depth
Points	Array of Point Cloud	Line	TM(x), TM(y), Altitude(z)

Figure 3. shows the 3D LiDAR mapping and the extraction system of road facilities. The data obtained from a 100m road section the using the Advanced Institutes of Convergence Technology was used by mapping and extraction systems. They have the ability to display a test section and an image of 3D LiDAR coordinates simultaneously and to identify the position of acquired section. Road sign information was extracted from the mapped information through 3D LiDAR and the results can be mapped in images.



(a) Mapping System *(b) Extraction System*

Figure 3. The result of mapping and extraction system

IV. CONCLUSION

The recognition and extraction technologies have been developed and utilized for autonomous vehicle. To ensure the driving safety for autonomous vehicle, it is necessary to recognize road facilities in the road sections where vehicle are driving. Therefore, it also requires positioning technology. This study presented the method for road facitliy extraction from LiDAR. Also, the study conducted a research on mapping of road facilities using LiDAR and the extraction of the road facilities information. The test field was mapped with LiDAR and the information concerning the road facilities was collected from mapped data. The following factors are needed to develope the method for extraction and the recognition of the road facilities. The extraction accuracy should be enhanced and the definition of the attributes for these objects should be clarified. Furthermore, the results of this study should be utilized as foundational technology for autonomous driving to improve the accuracy of road facility information extracted through accurate calibration of sensors and vehicles. The results of the this study are expected to provide foundational data for safe driving and road facility recognition by autonomous vehicle.

V. ACKNOWLEDGEMENT

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