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High Definition Corridor Mapping From Images Sequences

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ABSTRACT

The density, high accuracy, and rapid collection of geographical data for road surface and surrounding objects and the extraction of meaningful information from these data increases its importance in line with technological developments. Artificial intelligence studies and developments in cloud technology have affected the automotive industry as well as every sector and have enabled the development of driverless vehicle technology. In order to safely drive with autonomous vehicles, high definition maps that contain detailed information for road surface and its surrounding objects with high precision at centimeter-level must be used. In this context, in recent years, the development of mobile mapping systems (MMS) consisting of low-cost sensors and the development of algorithms for the evaluation of the data obtained from these systems have become increasingly popular. In this study, it was investigated whether HD maps can be obtained by using low-cost imaging sensors.

KEYWORDS

Digital Terrain Model, HD Mapping, Image Sensor, Low-Cost Camera, Mobile Mapping, Orthoimage, Road Extraction, Structure From Motion

INTRODUCTION

The densely, high accuracy and rapid collection of geographical data for road surface and surrounding objects and the extraction of meaningful information from these data increases its importance in line with technological developments. Artificial intelligence studies and developments in cloud technology have affected the automotive industry as well as every sector and have enabled the development of driverless vehicle technology (Figure 1). Designing and development of self-driving vehicles has been great interest to world-renowned automotive manufacturers (General Motors, BMW, Audi, Tesla…) and information technology companies (Google, Uber, Apple…) (Sisson, 2019). To ensure autonomous

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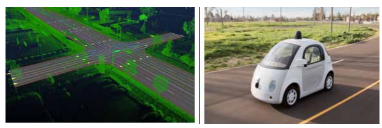
driving, these vehicles are equipped with different sensors such as radar, lidar or camera (Ma, 2017). However, these sensors are not sufficient for autonomous vehicles to detect their environment. There is a need for maps designed to understand the traffic situation far beyond the reach of these sensors and to make instant decisions while driving. These maps produced specifically for self-driving cars is called as high-resolution maps (HD maps). High-resolution maps (Figure 1) are three-dimensional and high-accuracy maps that containing very detailed information about road and surrounding objects (Vardhan, 2019). High-resolution maps must contain all the details that a normal driver needs to see on and around the road in order to ensure a reliable ride such as traffic signs and lamps, lane type and boundary information. In addition, these maps contain rich metadata such as speed limits and turn restrictions (Chellapilla, 2019). In order to safely driving with autonomous vehicles, high definition maps which contain detailed information for road surface and its surrounding objects with high precision at centimeter-level must be used instead of commonly used navigation maps.

Figure 1. Examples of high-resolution maps (Kent, 2015) and driverless vehicles (Knight, 2016)



In order to create high resolution maps, 3D geographic data with high accuracy of the objects in and around the road is required. Many different measurement techniques are used to obtain the dense point cloud data of the road and its surroundings. These methods and systems include classical geodetic methods (GPS, Total Station), satellite imagery, aerial and terrestrial photogrammetric techniques and lidar (air, mobile and terrestrial) systems. Each of these methods differs with regard to the time, cost and accuracy (Gong, Zhou, Gordon, & Jalayer, 2012). Some of the methods used for road inventory mapping (air, terrestrial and mobile lidar) are costly, moreover, considerable technical knowledge and experience are needed for the processing and storage of data (Olsen et al., 2013). Mapping the road surface and its surroundings with conventional measurement methods is time consuming and costly because it requires intensive labor. And also it is a dangerous process where heavy traffic flow occur (Findley, Cunningham, & Hummer, 2011). Satellite images or aerial photographs are affected by a large number of variables such as weather, light changes, resolution, ground characteristics and shadow of objects. In addition, it is not possible to identify road signs and lamps on the sides of road from these images (Wang, Yang, Zhang, Whan, Cao, & Eklund, 2016; Gonçalves & Pinhal, 2018).

Due to the disadvantages of the aforementioned systems, the use and development of mobile mapping system (MMS) and development of algorithms for the evaluation of the data obtained from these systems have become increasingly popular (Li, 2018). MMS enable fast, accurate and secure acquisition of geographic data at a high level of detail and consist of positioning devices (GPS, IMU and DMI) and measuring sensors (cameras, radar and lidar) to collect geographic data (Tapken, 2018). High-density and high-accuracy three-dimensional (3D) point cloud data can be obtained by laser-based (Mobile Lidar System (MLS)) MMS (Figure 2a). However, these are high cost system and data pre-processing times are very long (Li, 2018).

In this context, the development of MMS using low-cost imaging sensors (action camera, mobile phone) and the use of these systems for mapping of road and its environment has become an important research topic that has increased its popularity (Koehl, Delacourt, & Boutry 2016; Gonçalves & Pinhal, 2018). Since image data obtained with image-based mobile mapping systems (Figure 2b) provide important information such as color and texture, this system is starting to using road detection and extraction studies (Guan, Li, Cao, & Yu 2016; Marinelli, Bassani, Piras, & Lingua, 2017). Especially

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