論文の内容の要旨

Towards Automatic Road Mapping for High-definition Road Spatial Data by Fusing Vehicle-based Multi-Sensor Data

（和訳）車載マルチセンサデータを融合した、
高精度高精細道路空間データの自動作成に関する研究

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（要旨）

The demand of spatial data has been an explosive growth in the past 20 years. This demand has numerous sources and takes many forms, but it is an ever-increasing thirst for spatial data, which is *more accurate* and *higher density* (Called as High-Definition Spatial Data), which is produced *more rapidly* and acquired *less expensively*.

This research aims to satisfy with the high demands for the spatial data. We presents an automatic technology by fusing vehicle-based navigation data, stereo image and laser scanning data for collecting, detecting, recognizing and positioning road objects, such as road boundaries, traffic marks, road signs, traffic signal, road guide fences, electric power poles and many other applications important to people's safety and welfare. In the hand of hardware, a hybrid inertial survey system (HISS) which combined an inertial navigation system (INS), two GPS receiver, and an odometer acquires the posture data was developed. Two sets of stereo camera systems are used to collect color images and three laser scanners are employed to acquire range data for road and roadside objects. On the other hand, an advanced data fusion technology was developed for the purpose of *precise/automatic* road sign extraction, traffic mark extraction, road fence extraction and so on, by fusing collected initial navigation data, stereo images and laser range data. The major contributions of this research are *high-accuracy positioning* and *automatic road mapping*, which are described as below.

The accuracy of a GPS-based positioning system is depended on the environment conditions like multi-pass and obstacle problems. In some cases, the mapping accuracy of a GPS-based positioning system will reach meter order. Such a positioning accuracy

usually can not meet the demand of high definition mapping. In order to get the high and stable accuracy, *Multi-sensor data fusion based photogrammetry bundle adjustment technology* is developed and described in this study. The photogrammetry bundle adjustment is proofed as a powerful technology for improving mapping accuracy in the field of Aerial photogrammetry. However in traditional bundle adjustment, automatic extraction of tie point is a well-known difficult task, which affects speed and robust of the processing. Because laser can collect 3D coordinate directly, the information is very helpful for extracting tie points in stereo image rapidly and robustly. With co-ordinates of extracted tie points and initial position from navigation sensor, photogrammetric Bundle Adjustment is utilized for improving the mapping accuracy to 0.3 meter even in bad GPS signal condition, which can meet the accuracy demand of high-definition mapping.

In the domain of *automatic road mapping*, image based recognition technologies have been widely studied for several decades. However, since images taking by digital cameras are easily affected by environmental conditions like reflection, occlusion, noise, etc., it is very difficult to develop a robust stereo matching algorism. On the other hand, laser sensors can acquire 3D information directly and is insensitive to environment condition. But the problem is that laser scanners can not obtain texture information of objects. So we believe that the fusion of stereo images and laser range data is an efficient way to overcome each other's shortcomings. In this paper, an automatic road mapping technology which can fuse stereo images with laser data accurately and can extract road objects such as road boundaries, traffic marks, road signs, and so on, automatically is proposed and described.

A lot of experiments were performed to certify and check the accuracy and efficiency of the proposed fusion technology. The results show that our proposed vehicle-based mobile mapping system can reach very high accuracy and efficiency for road spatial data collection. A comparison of our technology with two other traditional mapping technologies (terrestrial survey with total station, and aerial photogrammetric surveys) are performed to certify the accuracy and efficiency of our system. Furthermore, our proposed vehicle-based mobile mapping system can provide more complete coverage than aerial photogrammetric system because we use close-range images and laser range data which involve abundant information. Additionally, our system can operate in all but the most extreme weather conditions.