Development and Evaluation of Roadside/Obstacle Detection Method Using 3D Scanned Data Processing

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SUMMARY In this paper, we have reported the development of a snowblower support system which can safely navigate snowblowers, even during a whiteout, with the combination of a very accurate GPS system, so called RTK-GPS, and a unique and highly accurate map of roadsides and obstacles on roads. Particularly emphasized new techniques in this paper are ways to detect accurate geographical positions of roadsides and obstacles by utilizing and analyzing 3D laser scanned data, whose data has become available in recent days. The experiment has shown that the map created by the methods and RTK-GPS can sufficiently navigate snowblowers, whereby a secure and pleasant social environment can be archived in snow areas of Japan. In addition, proposed methods are expected to be useful for other systems such as a quick development of a highly accurate road map, a safely navigation of a wheeled chair, and so on.

key words: snowblower, obstacle map, 3D laser scanner, RTK-GPS

1. Introduction

In an area of high snowfall such as Niigata prefecture, Japan, snowblowers are sometimes damaged by obstacles (e.g., fire hydrants, manholes) and roadsides (e.g., guardrails, curb stones) hidden by snow, which markedly decreases efficiency of their snow removals. Therefore, in this paper, we develop a new snowblower support system which creates an obstacle map including highly accurate geographic positions of roadsides and obstacles, and which alerts operators of snowblowers to dodge the obstacles/roadsides [1].

There are some existing systems which provides map information through the Internet (e.g, Google map). However, the map does not include positions of obstacles and roadsides, and the accuracy of the absolute position is low. On the other hand, a camera which takes a picture of road surface and detects obstacles by analyzing the picture has been put to practical use, but cannot find the obstacles under snow. Furthermore, the existing systems cannot obtain the accurate positions of detected obstacles.

2. Development of Snowblower Support System

2.1 Overview of System

Figure 1 shows an overview of the snowblower support system. The system utilizes a very accurate GPS system, so called RTK-GPS (Real Time Kinematic GPS), and a highly accurate map of roadsides and obstacles. The RTK-GPS enables the snowblower to obtain its position with centimeter-level accuracy [2]. By evaluating the position of the snowblower on the obstacle map, the system judges whether the snowblower approaches to the obstacles [3].

2.2 3D Laser Scanner

A 3D Laser scanner derives three-dimensional coordinates of points to which the scanner irradiates the laser. The coordinates can be calculated from a geographic position of the scanner, a glancing angle of the laser, and time interval between when the scanner applies the laser and when it receives the reflection. In this study, we attached onboard 3D laser scanner, which has become available in recent days, to a car and obtained the data shown in Table 1 during driving the car. Error of the obtained coordinate was evaluated by using RTK-GPS, and was smaller than 7 cm.

3. Proposed Roadside/Obstacle Detection Function

First, a roadside detection function of the system detects accurate geographic positions of roadsides by analyzing 3D scanned data. The function extracts positions whose Z-axis (height) are larger than the neighborhood, because of the
height of curb stones (15 cm) or guardrails (60 cm) on the roadsides. And then, in order to reduce the amount of data, the coordinates of positions are translated to vector format.

Next, an obstacle detection function detects accurate geographical positions of obstacles (e.g., manholes, gratings) on the roads. In order to process data corresponding to only the road surface, the function extracts 3D scanned data located between two vector data corresponding to roadsides. As shown in Fig. 2, reflection intensity at a position of the manhole is smaller than the neighborhood. Therefore, the function chooses positions whose reflection intensities are smaller than the neighborhood, and judges that the obstacle exists where the selected positions form a circle.

4. Performance Evaluation and Experiment of Proving

Effectiveness of the proposed methods has been evaluated by using 3D scanned data obtained by the on-board 3D laser scanner in Myoko city, Niigata prefecture, Japan in 2009 and 2010. The proposed methods have detected accurate positions of all obstacles without residual error, but misdetection has been occurred as shown in Fig. 3. As a result, the methods achieve a precision ratio (the precise number of obstacles divided by the total number of outputs) of 80%.

In addition, time required for detecting obstacles has been shorter than 4 hours per kilometer. The total length of road in Myoko city is about 700 km, so that, the cloud computing with 20 CPUs can finish detecting all roadsides/obstacles within one week. On the other hand, about three kilometers of road in the city is reconstructed each year. Therefore, the process in each year can be completed within 12 hours, even when only one CPU can be used.

Furthermore, we have built a prototype of the system and have installed it into a snowblower. In the prototype, the snowblower has been equipped with GPS receiver as shown in Fig. 4(a). A laptop PC of the operator shown in Fig. 4(b) calculates the accurate position by using RTK-GPS, and compares it with the pre-produced obstacle map. The experimental evaluation has shown that the alert message has been displayed on the laptop PC when the snowblower has come near to the roadside or obstacle.

5. Conclusions

In this paper, we have proposed ways to detect accurate geographical positions of roadsides and obstacles by utilizing and analyzing 3D laser scanned data whose errors have been smaller than 7 cm. The experiment has shown that the proposed methods have detected accurate positions of all obstacles very quickly (about 4 hours/km) without residual error. Furthermore, the map of roadsides and obstacles and RTK-GPS can sufficiently navigate snowblower, whereby a secure and pleasant social environment can be achieved in snow areas of Japan.

The proposed methods are expected to be useful for other systems such as a quick development of a highly accurate road map, a safely navigation of a wheeled chair, and so on.

Acknowledgments

This study has been supported in part the Ministry of Internal Affairs and Communications, Japan (SCOPE).

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