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Smart AGV system using the 2D spatial map

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Abstract

In this paper, the method for an effective and intelligent route decision of the automatic ground vehicle (AGV) using a 2D spatial map of the stereo camera system is proposed. The depth information and disparity map are detected in the inputting images of a parallel stereo camera. The distance between the automatic moving robot and the obstacle detected and the 2D spatial map obtained from the location coordinates, and then the relative distance between the obstacle and the other objects obtained from them. The AGV moves automatically by effective and intelligent route decision using the obtained 2D spatial map. From some experiments on robot driving with 480 frames of the stereo images, it is analyzed that error ratio between the calculated and measured values of the distance between the objects is found to be very low value of 1.57% on average, respectably.

Keywords: *AGV, Vehicle Driving, 2D Spatial Map, UGV, Stereo Camera System, Disparity Map*.

1. Introduction

Typically, obstacle detection and warning system is the most important one in the unresolved vehicle set. If a system can detect the existence of an obstacle and tell if it may affect the safety of the vehicle driving, then the diver can be asked to be more careful of such a condition so that a possible traffic accident may be avoided [1]. This is especially important when the driver is drunk or when the vehicle is traveling at a very high speed, and then many lives, including the driver and pedestrians, could be saved. On the other hand, the system may also facilitate the subsequent design of an automatic vehicle guiding system whereby the driver only needs to specify the destination or to choose the strategy for cruising when he is inside a vehicle for driving. Moreover, in case of autonomous vehicle driving itself, relatively few complete and working systems have been reported [2~3]. Accordingly, to the practical intelligent operation of obstacle warning system, the pedestrian's real 3D location coordinates and the relative distance between the other obstacles in the world space has been considered as the very important factors for identification of pedestrian under vehicle driving. That is, some information such as the intelligent judgment for the vehicle driving can be

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estimated from pedestrian's 3D location coordinates and the relative distance between the other obstacles obtained in the real world. However, conventional obstacle detection and warning systems have been developed mostly basing on the monocular camera system, so that gathering 3D information for the target object and highly accurate and robust tracking of a moving pedestrian from the stream of monocular image are known to be a very hard to be achieved in these systems. These limitations of the conventional obstacle detection and warning system make it difficult to exactly measure and estimate the pedestrian behavior and movement under tracking and monitoring.

For this purpose, in this paper, as an new approach to achieve a more intelligent automatic-tracking system for various surveillance applications, the 2D spatial map construction for a safe vehicle driving is proposed by using a stereo camera system, which can detect three-dimensional objects, discriminates target from other detected objects and outputs their position and direction of movement to the host vehicle so as to warn the AGV of a potential collision with a target. From some experiments on the obstacle tracking by using 480 frames of the sequential stereo images, it is analyzed that the error ratio between the calculation and measurement values of the distance is found to be very low value of 0.7 % on average. Also, the proposed target detecting system achieved a speed of 0.04 sec/frame for face detection and 0.06 sec/frame for face tracking. This good experimental result finally suggests a possibility of implementing a practical visual system of the AGV having a very high degree of accuracy.

2. Proposed Stereovision-based 2D spatial map construction

Figure 1 shows an experimental setup for a safe driving and navigation of the moving target. As shown in Fig. 1, the sequential input stereo image pairs are caught up by a stereo camera embedded on the AGV system and transferred to the host computer through a general graphic card.

Figure 1. Experimental setup for navigation of the moving target

In the experiment, 480 frames of the stereo image pairs having a resolution of 640x480 pixels and a frame rate of 20 frames/sec are captured from the stereo camera system for testing the performance of the proposed target tracking system.

Fig. 2 shows the left image and the depth map and 2D spatial map extracted by using the perspective transformation between a 3-D scene and an image plane, respectively.

In Fig. 2, the white color region means unmatched or occlusion region, this is disregarded for disparity detection processing.

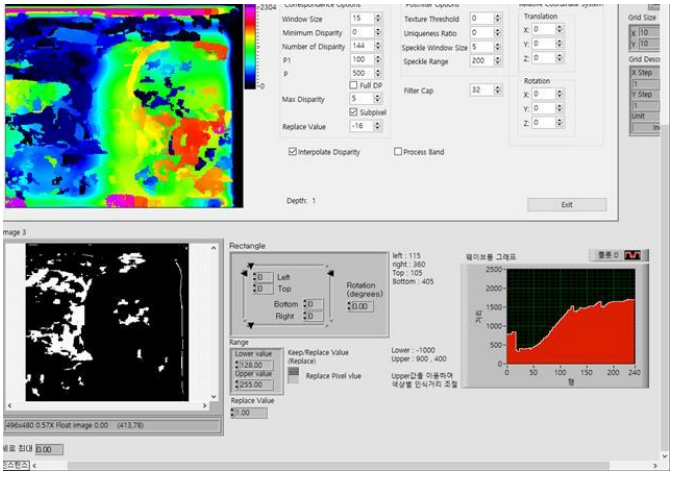

Figure 2. Extraction of the depth map and 2D spatial map for driving of the mobile robot

Also, in Fig. 2, 2D spatial map shows the color-cale disparity images of 640x480 pixels and the bottom right shows the column-by-column projection of the disparity images, taking the maximum valid disparity in each column. And Fig. 10 illustrates the AGV's moving trajectory in (X, Z) for calculating the distance and moving velocity of a target person. Accordingly, 2D spatial map constructed through Fig. 3 can be used for a safe driving and navigation of the mobile robot.

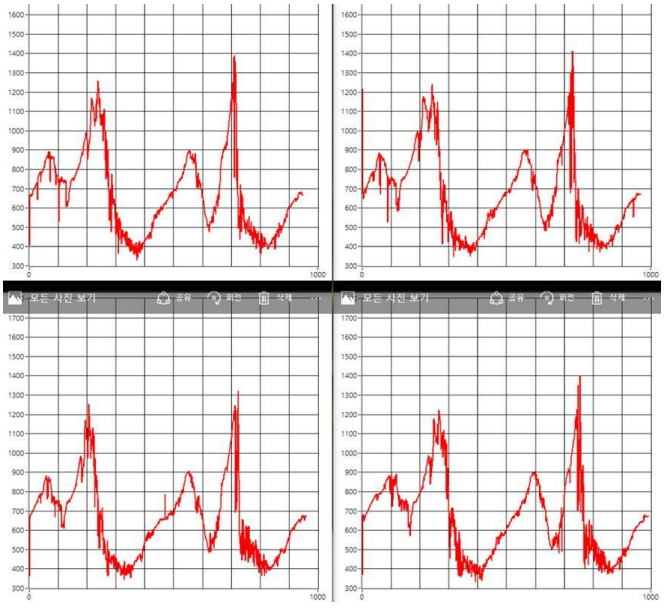

Figure 3. 2D locations and moving trajectory of the AGV system.

3. Conclusion

In this paper, the method for an effective and intelligent route decision of the automatic ground vehicle (AGV) using a 2D spatial map of the stereo camera system is proposed. The depth information and disparity

map are detected in the inputting images of a parallel stereo camera. The distance between the automatic moving robot and the obstacle detected and the 2D spatial map obtained from the location coordinates, and then the relative distance between the obstacle and the other objects obtained from them. The unmanned ground vehicle moves automatically by effective and intelligent route decision using the obtained 2D spatial map. From some experiments on robot driving with 480 frames of the stereo images, it is analyzed that error ratio between the calculated and measured values of the distance between the objects is found to be very low value of 1.57% on average, respectably.

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