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A Study of Effective Stereo Matching Method for Long-Wave Infrared Camera Module

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Abstract. In this paper, we have described an efficient stereo matching method and pedestrian detection method using stereo types Long-Wave Infrared Camera (LWIR) camera. We compared with two types stereo camera algorithm as efficient large-scale stereo matching (ELAS) and semi-global matching (SGM). For pedestrian detection using stereo LWIR camera, we used that SGM stereo matching method, free space detection method using u/v-disparity, and histogram of oriented gradient (HOG) feature based pedestrian detection. According to testing result, SGM method has better performance than block matching and ELAS algorithm. Combination of SGM, free space detection, and pedestrian detection using HOG features and SVM classification can detect pedestrian of 30m distance.

Keywords; component; night vision system; pedestrian detection; stereo matching method; long-wave IR camera

1. Introduction

vision-based system for detecting the road environment for driver assistance is an emerging research area. Many researchers have developed techniques for recognizing interesting vehicles and obstacles from images of road environments, to facilitate applications on the camera-assisted system that assists drivers in understanding possible hazards on the road [1]. Vision system using camera module can be detected object types but cannot be detected distance. for extract distance, stereo vision using two cameras can be detected distance. There are three types algorithms in the stereo mating algorithm. First, local matching method is fast, but its performance depends on

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window size [2], [3]. Second, global matching method has better performance but more processing time because of energy function [4]-[9]. Third, semi-global matching (SGM) method is based on the idea of pixel wise matching of mutual information and approximating a global, 2D smoothness constraint by combining many 1D constraints [10]. In this paper, for pedestrian detection, we developed mono long wave IR camera such as thermal camera and captured stereo image with base-line of 140 mm. We compare with stereo matching method and apply to the pedestrian detection.

2. LWIR Stereo Matching Method

We focus on comparison with stereo matching methods and application of pedestrian detection on the dynamic road environment at the day-time and night-time using stereo long-wave IR camera.

A. LWIR Camera Module

We developed long-wave-IR camera. The camera's specification is spectral band of 8~14 μm, detector format of 320 by 240, frame rate of 60 fps, thermal sensitivity 50 mK, and uncooled cooling method.

B. Stereo LWIR Camera System

We developed long-wave-IR stereo camera system. The camera's specification is base-line of 140 mm, image resolution of 320 by 240, frame rate of 60 fps. The camera system obtained only same sync images. This system is developed by Xilinx ZC7020 platform. Using captured stereo image, we compare with stereo matching method such as efficient large-scale stereo matching (ELAS) [11] and semi-global matching (SGM) [10].

C. Free Space Detection

To extract free space detection, we used to u and v of disparity. Ref. [12] was the first to introduce the name v-disparity approach and proposed a real-time accumulation strategy. It is possible to extract ROI of object candidates using v-disparity and u-disparity approach method.

D. Pedestrian Detection

Our pedestrian detection method is based on disparity of stereo long-wave-IR camera. We detect candidates of pedestrian using threshold method in the free space region of LWIR image. In the region of candidates, we extract histogram of oriented gradient (HOG) features [13] and classify pedestrian using support vector machine [14].

3. Test Results

The proposed system is tested on Xilinx ZC7020 platform. The frame rate of test videos is 60 frames per second, and the size of each frame of grabbed image sequences is 320 pixels by 240 pixels. Figure 1 describes the results of stereo matching and pedestrian detection with LWIR stereo images compare with ELAS and SGM stereo matching method according to LWIR input images in the 20m distance. Figure 2 shows the results of pedestrian detection using stereo types LWIR camera and SGM stereo matching method on the real-road. For the comparison of distance accuracy of pedestrian detection, we use IBEO Lidar sensor with test system. In the results, accuracy between of real distance using Lidar sensor and calculated distance using LWIR stereo camera has distance error about 30 cm.

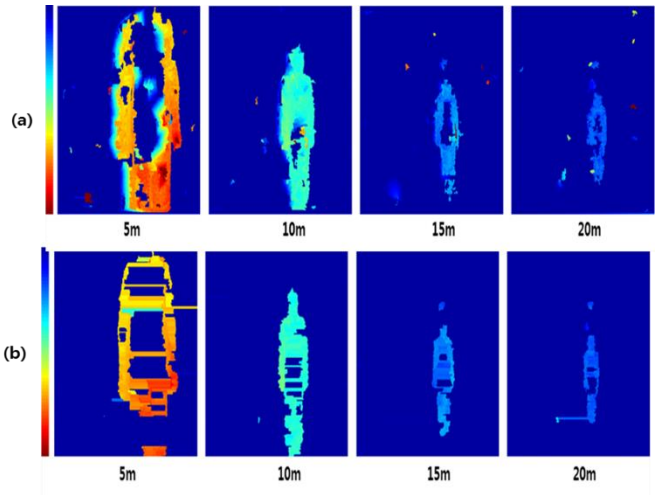

Figure 1. Results of stereo matching algorithms of (a) ELAS and (b) SGM

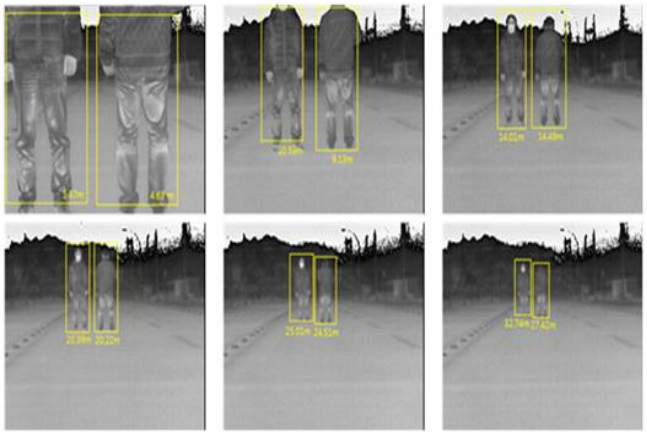

Figure 2. Pedestrian detection of LWIR stereo matching using SGM

Table 1. Results Of Distance Accuracy Of Pedestrian Detection

Real Distance (m)	Average Distance (m) using LWIR Stereo Camera
5	5
10	9.86
15	14.25
20	20.31
25	24.76
30	30.08

5. Conclusion

In this paper, we propose an efficient stereo matching method using stereo types LWIR camera. In addition, we propose the LWIR camera based pedestrian detection method. To find efficient stereo matching algorithm, we compare with LWIR camera based three types stereo matching algorithm as block matching, ELAS, and SGM. For the detection of pedestrians within 20 m, LWIR based SGM algorithm has a performance which is better than the other algorithms. In the ROI of stereo matching and free space detection using u/v-disparity, we extract HOG feature for pedestrian detection and classify using SVM. It can detect pedestrian in the 30m distance and has a distance error about 30 cm compared with Lidar sensor.

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References

[1] Alcantarilla PF, Bergasa LM, Jimenez P, Sotelo MA, Fernadez D (2008), “Night Time Vehicle Detection for Driving Assistance Light Beam Controller”, IEEE Intell. Vehicle Symp, pp. 291-29.

[2] Scharstein, D., Szeliski, R.,"A taxonomy and evaluation of dense two-frame stereo correspondence algorithms", Journal of Computer Vision 47 (2002) pp.7-42.

[3] Weber, M., Humenberger, M., Kubinger, W., "A very fast census-based stereo matching implementation on a graphics processing unit", IEEE Workshop on Embedded Computer Vision. (2009).

[4] Boykov, Y., Veksler, O., Zabih, R., "Markov random fields with effcient approximations", CVPR. (1998) pp. 648-655.

[5] Kolmogorov, V., Zabih, R., "Computing visual correspondence with occlusions using graph cuts", International Conference on Computer Vision. (2001) pp. 508-515.

[6] Felzenszwalb, P., Huttenlocher, D., "Effcient belief propagation for early vision", International Journal of Computer Vision 70 (2006) pp. 41-54.

[7] Woodford, O., Torr, P., Reid, I., Fitzgibbon, A., "Global stereo reconstruction under second-order smoothness priors", PAMI 31 (2009) pp. 2115-2128.

[8] Cheng, L., Caelli, T., "Bayesian stereo matching. Computer Vision and Image Understanding", 106 (2007) pp. 85-96.

[9] Kong, D., Tao, H., "Stereo matching via learning multiple experts behaviors", BMVC. (2006) pp.97.

[10] Heiko Hirschmuller, "Accurate and Efficient Stereo Processing by Semi-Global Matching and Mutual Information", IEEE Conference on Computer Vision and Pattern Recognition (CVPR), San Diego, CA, USA, June 20-26, 2005.

[11] Geiger, A., Roser, M., Urtasun, R. “Efficient large-scale stereo matching”, Asian conference on computer vision. Springer Berlin Heidelberg, 2010. pp. 25-38.

[12] R. Labayrade, D. Aubert, and J.-P. Tarel, “Real time obstacle detection on non-flat road geometry through ‘v-disparity’ representation,” in Proc. IEEE Intell. Veh. Symp., Versailles, France, 2002, pp. 646–651.

[13] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," In Proc. of CVPR 2005.

[14] S. Kang, H. Byun, and S.-W. Lee, “Real-Time Pedestrian Detection Using Support Vector Machines,” Lecture Notes in Computer Science, vol. 2388, p. 268, Feb. 2002.