MVA '98 IAPR Workshop on Machine Vision Applications, Nov. 17-19, 1998, Makuhari, Chiba, Japan

2—3 Detection of the Front Vehicle from the Stereoscopic Image using Hierarchy Process.

Nobuhiro TSUNASHIMA*
Faculty of Science and
Technology, Keio University

Masato NAKAJIMA*
Faculty of Science and
Technology, Keio University

Abstract

In this paper we described a new technique for measuring a distance to the front vehicle using stereo images. Only vehicles traveling in the driver's lane need to be detected. Thus the driver's lane is determined as the processing region in the images. Usually detecting lane markers does this. However, when the front vehicle appears in the near sight, it is not necessary to detect lane markers to the far sight. On the other side, when the front vehicle appears in the far sight, it is necessary to detect lane markers to the far sight. So we adopt the hierarchy process to detect the front vehicle.

1 Introduction

To prevent the collision accident it is necessary always to calculate the distance from the driver's vehicle to the one in front. So stereoscopic image processing has been used to calculate this distance. Only vehicles traveling in the driver's lane need to be detected. Thus the driver's lane is determined as the processing region in the images. Usually detecting lane markers does this. However using those makers causes the following problems. On a curve, most of the front of the driver's vehicle is outside the processing area. As a result, vehicle can't be detected. When the processing area is expanded outside the lane to adapt for curves, side walls of the road may be detected as the vehicle. Using stereoscopic image processing, it is very difficult to detect only the vehicle in front of the driver.

This paper proposes the new method for detecting a vehicle in front. First the disparity map is calculated from the stereoscopic images. Then this map is projected in the direction of the ordinate axis. This map is called projected disparity map. The vehicle's disparities can be recognized as matching the disparity map. Thus they are translated into horizontal lines segment on the projected disparity map. On the other side, side walls and lane markers are translated into the obliquity lines. So the front vehicle is detected by extracting the horizontal line segment from the projected disparity map.

The following includes the principle of the method and experimental result.

2 Projected disparity map

Stereoscopic image processing requires determining the correspondence between the right and the left images. However, pixels with no characteristics near by often cause correspondence errors. So, an edge-based stereo matching method is used. This reduces both the calculation required and the number of correspondence errors. In addition, horizontal edges are free from a correspondence. Therefore only vertical edges are detected. The SSD (Sum of Squared Difference) method is used to calculate the correspondence between edges.

If the rear of the vehicle in front has a simple profile such as a truck, we can only acquire edges of the both side of the vehicle. In such case it is difficult to detect the front vehicle. So we interpolate the disparity map. The vehicle can then be recognized as having the same disparity as that on the disparity map. Therefore the edges of both side of the vehicle have the same disparity. And the pixels between them have the same disparity, too. Then we search two continuous edges that have same disparity, and the space between the edges is filled in by the their disparity. Using this process we can interpolate the disparities of the vehicle' non-edge points. Incidentally a vehicle is a higher than the road surface. So we detect the disparity that has the same value as the

----

Address: Keio University 3-14-1 Hiyoshi Kouhoku-ku Yokohama-Shi 223 Japan.
E-mail: tuna@njima.elec.keio.ac.jp

road surface. Next the interpolated disparity map is projected in the ordinate axis direction. We call this map "Projected Disparity Map". The vehicle's disparities are translated into horizontal line segment on the disparity map. On the other side, the disparities of the side walls are translated into the obliquity line. The projected disparity map shows a frequency distribution of the disparity. Then we can find the horizontal line segment to detect the vehicle.

However vehicles in the another lane are projected on the projected disparity map. So lane markers are projected on the projected disparity map. The projected disparity map is a kind of the upper perspective projected Therefore the area surrounded by the projected lane markers can be included in the property-processing region.

3 Hierarchy Process

The reference area is determined to detect the lane makers. However when the front vehicle appears in the near sight, it is not necessary to detect lane markers to the far sight. On the other side when the front vehicle appears in the far sight, we must detect the lane markers to the fat sight. So we adopt the hierarchy process to detect the front vehicle.

We divide the image into three zones that based on the distance from the camera. Zone① is 10-25m, Zone② is 25-50m, and Zone③ is 50-100m. At first we extract the lane makers and detect the front vehicle in the zone①. If the front vehicle doesn't appear in the Zone①, we apply it to the next zone. We continue to apply it until finding the vehicle or to the last zone.

4 Experimental result

The proposed method was applied to the stereoscopic images obtained by a stereo camera mounted on the vehicle running on the Tokyo Expressway. The focal length of the lens is 12mm. The base line length between two cameras is 420mm. The height from the ground to the cameras is about 1800mm.

Fig.1 shows the original stereoscopic images, and Fig.2 shows disparity maps. We create the projected disparity map to project the disparity map in the depth direction (Fig.3). In the projected disparity map the disparities of the front vehicle are translated into the straight line-shaped. And this straight line-shaped has higher value than the other structure such as a sidewall (Fig.4). So we find the front vehicle to detect the straight line-shaped that has high values.

Many researchers were proposed the technique to extract the road region in the image. They fitted the quadratic (cubic) curve into the lane markers. But when the front vehicle appears in the near distance from the own vehicle, the front vehicle hides the far lane makers. So we adopt the hierarchy process. At first we extract the lane makers in the Zone①, and search the straight line-shaped in the projected disparity map. When the front vehicle is detected in the Zone ①, we finish the process(Fig.5-(a)). If no vehicle is detected in the current zone, we continue the process (Fig.5-(b)(c)).

We applied proposed method to the curve road. In the case of the curve road, there is a vehicle on the neighbor lane and the sidewall at the middle position in the image. When the reference region is determined at the stereoscopic image, these structures are detected as the obstacle. The projected disparity map is a kind of top view image. So we can determine the reference region on the own lane. As the result, proposed method can be applied to the curve road(Fig.6).

5 Conclusion

A new technique is proposed here to detect the vehicle in front of driver's vehicle. A projected disparity map is constructed, and used to determine the processing area. As a result, vehicles in front of driver's vehicle can be extracted even on a curve road.

REFERENCES

1. F. Ferrari, E. Grosso, G. Sandini, M.Magrassi:"A stereo vision system for real time obstacle avoidance in unknown environment", IROS'90, pp. 7-3-708, 1990
2. G. Zhao, S. Yuta:"Visual Sensing of Obstacles on the Road for Mobile Robots", 10th Annual Conference of Robotics Society of japan, pp. 175-178, 1992
3. Hiroyuki Takahashi, Renaud Zigmann, Koichi Kojima, Patrick Stelmaszyk:"A FAST AND RELIABLE OBSTACLE DETECTION TECHNIQUE FOR THE VEHICLE ON THE HIGHWAY", 1stInternational Conf on Motion and Vibration Control, pp. 724-729,1992

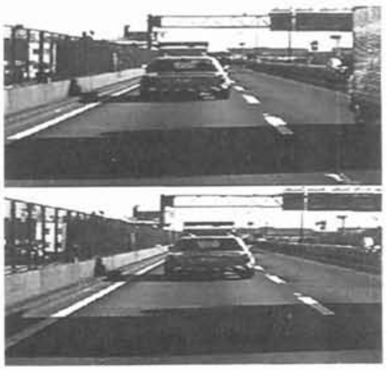


Fig.1 Original stereoscopic images.

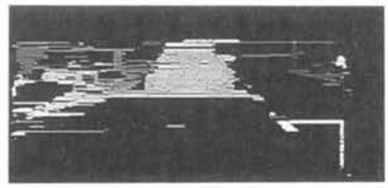


Fig.2 Interpolated disparity map.

Fig.3 Projection Disparity map.

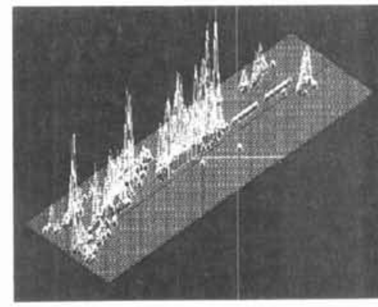
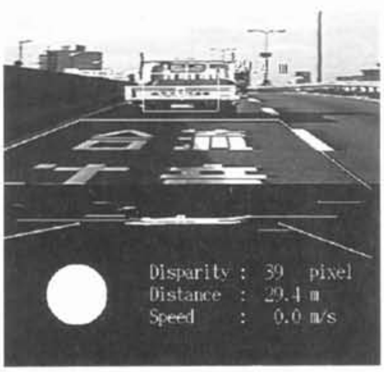
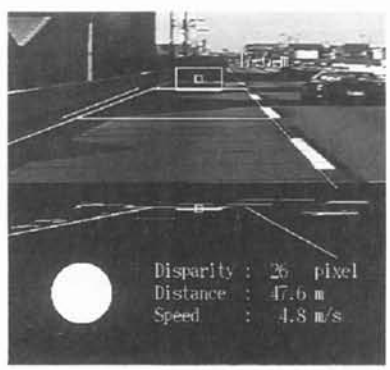


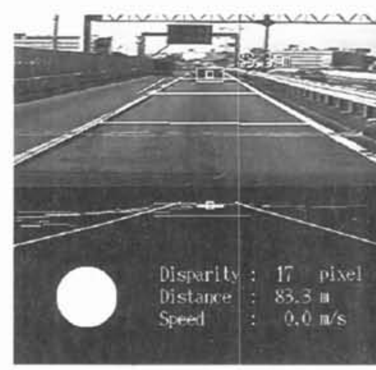
Fig.4 Projection disparity map.(bird view)



(a)In the case of Zone①



(b) In the case of Zone②

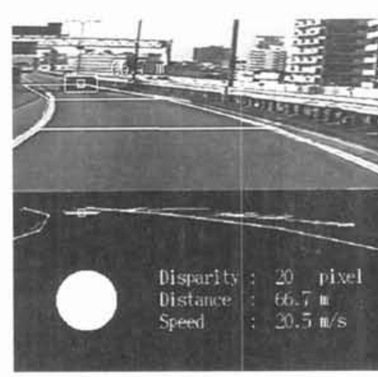


(c) In the case of Zone③

Fig.5 Experimental results using the process of hierarchy.

(a)Case 1:There is a vehicle on the neighbor lane at the middle position in the image

(b)Case 2: There is the side wall in front of the camera.



(c)Case 3: There is the front vehicle at the left edge position in the image.

Fig.6 Sample results on the curve road images.