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A STUDY ON RECOGNITION SYSTEM OF PRECEDING VEHICLE BY IMAGE PROCESSING

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Abstract This study deals with the problem of the recognition of the preceding vehicles by image processing. The purpose of this study is the development of the equipment to prevent a collision with preceding vehicles during driving the vehicle. In order to decrease the processing time and increase reliability, at first, the traffic lane is extracted. It is determined by detecting road edges and calculating their tangent. After the traffic lane is gotten, the position of the vehicle is searched inside the lane. The features used to detect the vehicles in the algorithm are shadow of the vehicle, vertical edges, horizontal edges, and symmetrical segment. The preceding vehicles are extracted successfully by this method.

Keywords Machine Vision, Obstacle Detection, Intelligent Vehicle, Hough Transformation, Road Image

1 INTRODUCTION

Recently, as vehicles are increasing in number, the problems of big traffic accidents and chronic traffic jams are becoming more serious. Then, for the safety and efficiency of the traffic, it is required to develop intelligent vehicles.

There have been many studies on the road environment recognition system based on image processing [1-5] because of reliability. However, many of them limit the applying road environment to the good conditioned freeway.

We propose an image recognition system which detects the preceding vehicles on the city road by extracting the features of the vehicles. The system can recognize plural vehicles in one lane and also the motorcycles that have less horizontal edges. Fig.1 shows the flow of detection process. The road images are assumed to be,

size : 256 × 256 pixel,
data : gray scale 8bit data.

In Chapter 2 we describe the method of extracting traffic lane. Chapter 3 shows the way to detect a vehicle , and Chapter 4 explains the process of the recognition. In Chapter 5 gives the application example to show the validity of the method.

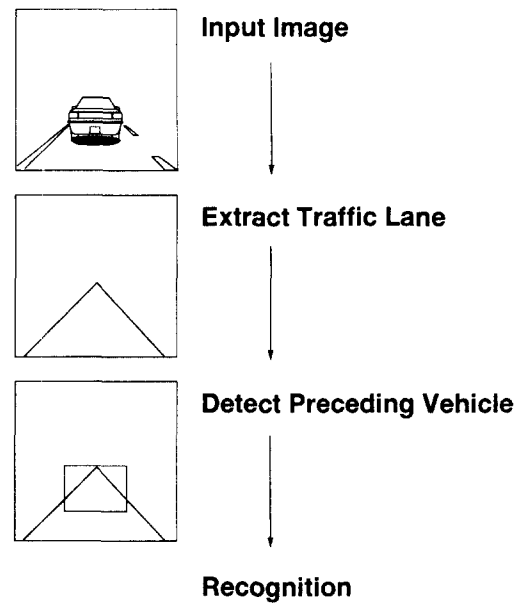

Figure 1: Flow of detection process

2 TRAFFIC LANE

To decrease the calculations of the process, it is effective to find out the traffic lane before seeking the features of the vehicles on the case of determining the position of the vehicles in the images of the road environment. In this chapter, we show the method to obtain the traffic lane. It is expressed by two straight lines running parallel to road edges. The processes of

extracting the traffic lane are as follows:

- detect road edges,
- get the lines by using the Hough transformation.

2.1 Detection of The Road Edges

In order to extract the traffic lane, this method detects the road edges such as lane marker or white line along both sides of the lane. Road edges will be obtained in low half area of the image because these edges are almost always in this part of the image. The extraction of the road edges is done from lower part to upper part until the edges are found(Fig.2). It is possible to reduce the processing of unnecessary area by using the method described this section.

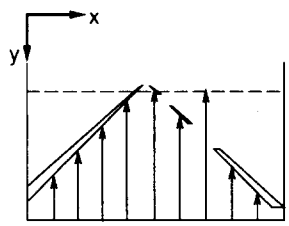

Figure 2: Detection of the road edges

2.2 The Hough Transformation

The traffic lane is expressed by two lines on which there are the most numerous edge points. The lines are gotten by using the Hough transformation. The transformation is done in the ranges (1), and (2) to reduce calculations(Fig.3). (1) is the range for half left of the image and (2) is that for half right.

$$20° \leq \theta \leq 70° \quad (1)$$

$$110° \leq \theta \leq 160° \quad (2)$$

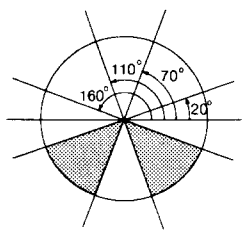

Figure 3: The searching range of angle

3 DETECTION OF THE PRECEDING VEHICLES

Using the information of the traffic lane, the position of the preceding vehicle in the image will be determined. In this chapter, we explain a method to detect a preceding vehicle.

The shadow, vertical edges, horizontal edges of the vehicle, and their symmetrical components are extracted to decide the position of the preceding vehicles.

3.1 Detection of The Shadow

Most of the vehicles have horizontal and vertical edges. But painted lines on the surface of the road like zebra crossings and so on have such type of edges, too. It is difficult to distinguish vehicles from the lines by only using their edges, then, at first this method detects the shadow in the road area. And the left and right side, and bottom of the vehicles are determined roughly here.

Extraction of the shadow is done from lower part to upper part within the area of the traffic lane until the shadow is found, and the bottom of the vehicle is set at the position where there is the shadow. The shadow of the vehicle is detected by binarizing the image.

The window is designed near the bottom of the vehicle(Fig.4(a)), and the shadow is obtained inside the window. By searching a frequency distribution of the shadow, the left and right sides of the vehicles are decided. When the shadow is extended to adjoining traffic lane, the window is expanded to the width included whole of the shadow.

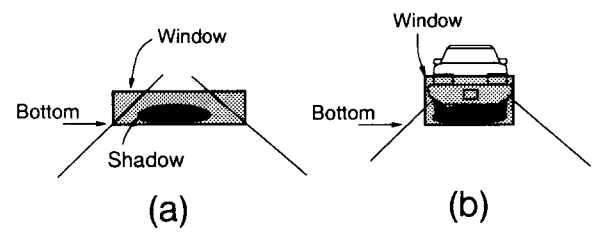

Figure 4: The window:(a)for detecting shadow, (b)for detecting vertical edges

3.2 Detection of The Vertical Edges

It often happens that there are the shadows of roadside trees and buildings on the road, and such shadows are also extracted by using the method described above. Then, to distinguish the area of the vehicle from backgrounds, the vertical edges of the vehicle are detected.

A window is set near the bottom of the vehicle, and edges are obtained inside the window(Fig.4(b)). Edges are emphasized by Sobel operator. This process is done from left and right side to the center of the vehicle. The left and right side of the vehicle are decided by using a frequency distribution of the edges.

If there are not enough vertical edges inside the window, this algorithm judges that the shadow is not vehicle's.

3.3 Detection of The Horizontal Edges

Because most of the vehicles have horizontal edges (for example bumper, tail light, and roof), it is effective to extract the edges for estimating the position of the vehicle. In this section, we show the way to detect the horizontal edges and decide the top of the vehicle.

A window is set as Fig.5(a). Most of the vehicles are included inside the window enough. The horizontal edges are obtained by using Sobel operator inside the window(Fig.5(b)). The top of the vehicle is determined the highest position of the edges.

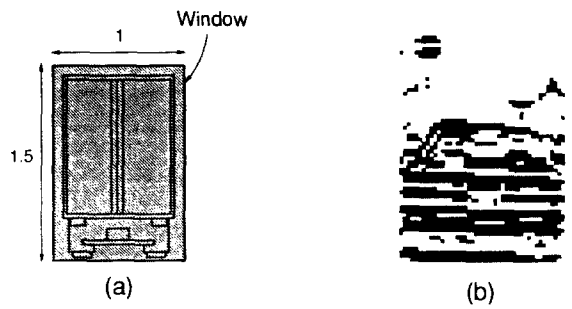

Figure 5: Detection of the horizontal edges:(a)the window for extracting edges, (b) detected edges

3.4 Extracting of The Symmetrical Segment

There are also horizontal edges in background, and it is difficult to distinguish them immediately. Then, by using the feature that vehicles are symmetrical, the edge of background are eliminated and the position of the vehicle is decided correctly.

The axis of symmetry is calculated from the average of the location of the edges, and the symmetrical image is extracted by using the axis(Fig.6).

3.5 An Exceptional Case

In this section, we state the processing of obtaining the area of a vehicle in the following case as:

1) preceding vehicle is a motorcycle
2) two vehicles exist in one lane

Figure 6: Detected symmetrical segment

3.5.1 A Motorcycle. Because motorcycles have less horizontal edges than cars or trucks(Fig.7(a)), if the method described above are applied to motorcycles, it is difficult to get a right position of the vehicle. Then, when the left and right sides are determined, by the length of the width, if the preceding vehicle is judged the motorcycle, vertical edges are detected instead of horizontal edges(Fig.7(b)).

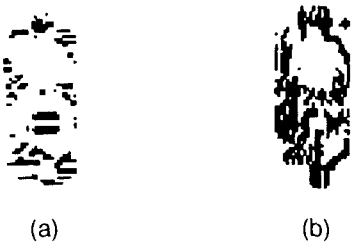

Figure 7: Extraction of a motorcycle: (a)detected horizontal edges, (b)detected vertical edges

3.5.2 Two Vehicles in One Lane. Sometimes it happens that two vehicles exist (for example parking one and moving one getting out of the way of it) in one lane. By using the following method, the position of the vehicle is decided correctly in such cases(see *3.1*).

When the shadow is extracted, if the area of the shadow is separated into two parts obviously, the extraction of the vehicles is applied for each part to determined the position of the vehicle.

4 RECOGNITION

Whether the vehicle exists or not are recognized by looking into the distribution of the edges in the area. As the number of horizontal edges or vertical edges is counted, if a total of them is greater than preassigned number, then it is recognized that the vehicle exists.

5 RESULT

The above methods are implemented on NEC PC-9801BA that consists of *i*486DX2 (40MHz) CPU board. Photographs of the road environments are used for the recognition experiment. Fig.8 - 10 shows the result of vehicle detection. Fig.8 shows the result that a car exists. Fig.9 shows the result that a motorcycle exists. Fig.10 shows the result that two cars exist side by side in one lane. The success rate of the vehicle recognition is 94.3%.

6 CONCLUSION

In this paper, we described the method to detect the preceding vehicle on the city road. The method has the following characteristics:

1) As it makes the processing area small, cost of calculation is lower.
2) As it uses the information of the vertical edges, it can recognize the motorcycles also.
3) Plural vehicles in one lane can be extracted.

By applying the method to the practical road scenes, it found that moving vehicles are successfully detected.

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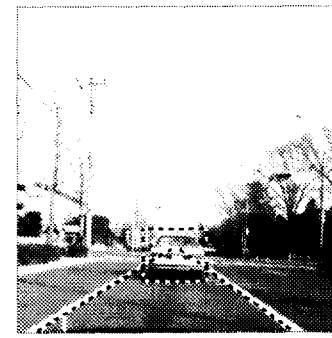

Figure 8: Result : Recognition of a car.

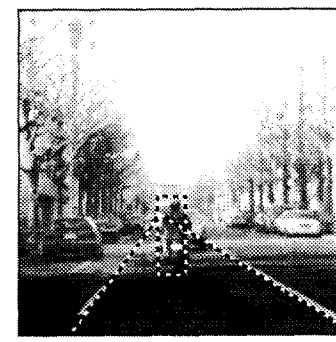

Figure 9: Result : Recognition of a motorcycle.

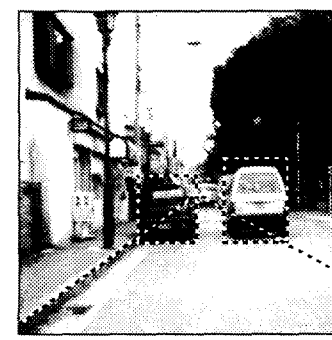

Figure 10: Result : Recognition of two cars in one lane.