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Detection of the Road Area at the Ordinary Road

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Abstract

In the field of ITS (Intelligent Transport Systems), it is important to automate the cruising and safety driving. We consider to detection the area of the cruising lane of the vehicles. The method has been presented to detect the road area uses the division line such as the white or yellow marking line. Although, when we regard to the ordinary road environment, we suppose that the division lines don't always exist on the road. Therefore, we propose a method to detect the road area where the vehicle can cruise regardless of the division line at ordinary road. When we assume that the camera is carried in the vehicle, the road area exists in the front, appears at center of images, and occupies the large region in the image. Then, we use the features of road surface, for example, the position and size, to decide the region where the vehicle can cruise. Furthermore, our method corresponds to the change of sunlight by determining some threshold values automatically.

1 Introduction

In the field of ITS (Intelligent Transport Systems), the purpose of the safe driving support is important, and many researches have been studied [1]~[8]. The studies on the recognition of the traffic conditions and the hazardous phenomena to aim at the automated driving have been presented [1][2].

Generally, the detection of the road area where the vehicle can cruise is done by using the division line such as the white or yellow marking line. This typical technique is used in [3]~[5].

However, when we consider the situation of the ordinary road, the existence of the division line is not necessarily guaranteed. Therefore, it has been studied to recognize the road area that doesn't depend on the existence of the white line [6].

In this paper, it has been reported that their method doesn't work well in the case of unfavorable weather and the lower contrast situation in the evening. Then, we consider the method is weak in the case of the sudden change of the road surface color, because it detects the road area by comparing the sample area in lower portion of image.

Our proposed method corresponds to the lower contrast situation, that is, the change of sunlight by determining some threshold values automatically, and the change of the road surface color, that is color is not unified.

Since our purpose is the detection of road area, we doesn't construct the road model though the model is constructed the road shape in [6].

2 Detection of the Road Area

We consider the technique not to depend on the existence of the division line in order to detect the area where the vehicle can cruise. In the image in the front of vehicle, the cruising lane is at the center below, the opposite lane is at the right. The road area is usually flat and unity. Then, we consider that the size of the area of the cruising lane is relatively large.

Our purposed method uses the features which the cruising area in the image has the large size and unified texture in the same color area though it's color changes.

The flow of our proposed method is shown in Figure 1.

At first, we execute the edge detection for the input image, and we call the result the edge image. Then, we do the thinning process for the image detected edges for the purpose of the segmentation into the unified regions. Here, we do the thinning and binarization by the control of the non-maximum value. We search for the closed curve by the complement of the broken edge lines.

We perform the labeling process for the regions divided by the closed curves.

And then, we merge them from the region of the largest size till the sum of size becomes more than the threshold value.

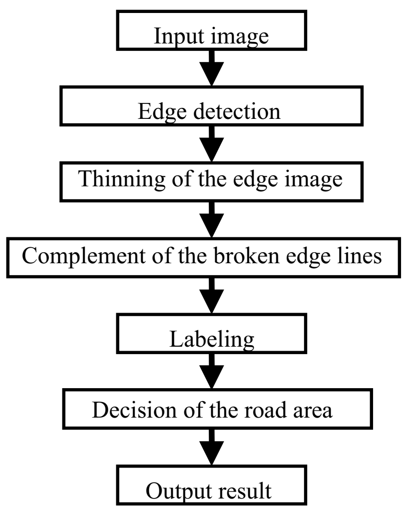

Figure 1: The flow of our proposed method

2.1 Edge detection

We perform edge detection as a preparation for the region segmentation for the input image. The method used to detect the edge from input image is the color differential edge detection[6]. We explain the procedure of the color differential edge detection method as follows.

In the color differential edge detection process, the strength and the angle of the color differentiation of the edge are obtained by Equations (1) and (2) with the pixel values consisted of three elements (R, G, and B) in the input image.

$$X_f = f(i+1, j-1) + f(i+1, j) + f(i+1, j-1) - f(i-1, j+1) - f(i-1, j) - f(i-1, j-1)$$

$$Y_f = f(i-1, j+1) + f(i, j+1) + f(i+1, j+1) - f(i-1, j-1) - f(i, j-1) - f(i+1, j-1) \quad (1)$$

$$\gamma = \tan^{-1}\left(\frac{\sum_{f=R,G,B} Y_f(i,j)}{\sum_{f=R,G,B} X_f(i,j)} \right) \quad (2)$$

The example of an input image and the result of edge detection are shown in Figure 2.

(a) (b)

Figure 2: (a) Input image. (b) Result of edge detection.

2.2 Thinning of edge image

The edge corresponds to the outline and the boundary of the unified regions, and it’s width is thick. Then, we consider that we perform the thinning of the thick lines of edges.

We use the method of the control of the non-maximum value. In this method, the edge points of which differential values is lower than the neighbor’s values where is in the perpendicular to the edge direction are rejected.

Then, the binarization is done simultaneously. The threshold value in this binarization is determined automatically as described in the following subsection.

2.3 Dynamic determination of a threshold value

When we perform the control of the non-maximum value and the binarization, we use a threshold value. Whether the threshold value is proper is different by the environment of the input image, though the threshold value is usually fixed.

Therefore, we decide this threshold value dynamically by using the discriminant analysis method. The discriminant analysis method is a technique used when we solve the threshold value in the binarization for the tone image. It is a technique for separating the tone-value of the input image into two classes that the separation of classes becomes the maximum.

When the discriminant analysis method is applied to the image after the edge detection, non-edge parts, which are tone value is zero, occupies the majority of the input image.

For the influence of non-edge parts, we cannot solve the proper threshold value by the conventional discriminant analysis method. Then, we obtaion the threshold value by applying the discriminant analysis method to the edge parts excluded non-edge parts.

The result performed by the thinning and binarization by the threshold value solved dynamically by the discriminant analysis method is shown in Figure 3(a).

The result by the fixed threshold value which we assume proper is shown in Figure 3(b) for the comparison.

(a) (b)

Figure 3: Thinning and binarization (a) the threshold value by th diminant analysis method. (b) the fixed threshold.

2.4 Complement of the broken edge lines

Though the edge corresponds to the outline and the boundary of the unified regions, the edge line is not always enclosed because it is obtained as broken line.

Then, we obtain the closed curve by complement of the broken edge line, which is tracking and repairing the weak part of edge.

When we repair the edge, we extend the edge along the weak edge which is lower than the threshold value for the binarization in the direction of the extension of the direction of strong edge of the edge.

2.5 Labeling

We perform the labeling process for the regions after the thinning and binarization.

The labeling is performed for the connected components of four-adjacent, because regions divided by the oblique line is merged by the labeling for the connected components of eight-adjacent.

Then, the features of every labeled region are obtained, for example, the size, the standard deviation of pixel values, etc.

2.6 The feature of road surface

There are these features about the road region that is filmed on the image.

- The road area is large.
- The part of the road is on the lower half of the image.
- The color information of road surfaces is unified.

The portion where the possibility that the labeled region is the road area is high is decided by the features, the sum of area and the texture.

Then, we explain the actual procedure of the decision of the road area where our vehicle can run.

At first, we select the region which is the largest. The region which has the largest area is the first candidate road surface area.

We solve the standard deviation of R, G, and B each element value and values of monochrome tone in the region which has the largest area.

The region which has the second larger area is merged to the first candidate road in the case that the standard deviation of the region is low.

Thus, we enlarge the road candidate region by repeating the similar merging process till the sum of the road candidate area is more than the threshold value.

Then, the road candidate area is determined as the road area. The sample result of the road area is shown in Figure 4. The area painted by black is the road area.

Figure 4: Result image 1 of road area

3 Experimental results

The result for the input image shown in Figure 2(a) is shown in Figure 4. In Figure 2(a), the road does not have the lane mark on left side of roadway. In Figure 4, the region which is the road is judged as the road.

Figure 5(b) is output image of road area when the Figure 5(a) is an input image. Though the color of the road surface in Figure 5(a) changes on the way, the road area is merged between regions which have different colors each other, and the white lane marks are excluded.

We show the other input image and the output image applied our proposed method in Figures 6~9.

In Figure 6, there are oncoming vehicles on the opposite lane and there is antecedent car on the cruising lane. The region detected by our method is on is obtained the road area excluding vehicles.

In Figure 7, there is the antecedent track near the own vehicle, and the situation is similar to Figure 6. The detected region as the road area is not including the region of antecedent vehicle. Though, the road area covers the center line and the wall which is existing right side front.

In Figure 8 and 9, the road is curve. Though the left side walk is detected as the road area, the area painted by white stripes at the right side is excluded. In the Figure 9, the road area is decided excluding the region of pavement marking.

In Figure 10, it is night. The region of the car side parking area is excluded. By obtaining the threshold value dynamically, the road area can be detected in the night.

(a) (b)

Figure 5: Result image 2 (a) input image. (b) result image

(a) (b)

Figure 6: Result image 3 (a) input image. (b) result image

(a) (b)

Figure 7: Result image 4 (a) input image (b) result image

(a) (b)

Figure 8: Result image 5 (a) input image (b) result image

(a) (b)

Figure 9: Result image 6 (a) input image (b) result image

(a) (b)

Figure 10: Result image 7 (a) input image (b) result image

4 Conclusion

We propose a method to detect the region where the vehicle can cruise. Our proposed method based on the region's area can detect the road area from the image which does not have the division line.

The road area is detected excluding the other vehicles, lane marks and the side walk. And our method applies to nighttime.

The issue which we need to resolve is improvements of accuracy. Now, our proposing method decides the road region based on region's area, position, and color. In the future we add the new criteria to get better result of the road region. From the result which the detected regions are avoiding the pavement markings, we consider that we can get the information of pavement marking.

Acknowledgments

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