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Combining Color Feature and Morphology Operations for Lane Detection

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Abstract: Lane detecting under structural road environment is an important research topic in the field of unmanned systems development.Aiming at resolving the problem that traditional Hough transform will detect many useless straight line in a complex environment,this paper proposes a new method which consists of four parts. In this article,first,the characteristics of the color of the lane lines were studied and then binary image by filtering the original image was generated; Second, morphological operations on binary image were implemented; Third, edge detection on the image which obtained from the previous step was implemented; Finally,Hough transform on the image obtained by the third step was carried out. The method was realized by MATLAB and the experimental result shows that the method can effectively remove the lines which are not related to lane lines from original image.
Keywords:color feature,morphological operations,Hough transform,lane detection

I. INTRODUCTION

Recently, automatic vehicle have become a hot research topic. The tasks of automatically driven vehicles include road following and keeping within the correct lane, maintaining a safe distance between vehicles, regulating the speed of a vehicle according to traffic conditions and road characteristics, moving across lanes in order to overtake vehicles and avoid obstacles, searching for the correct and shortest route to a destination, and driving and parking within urban environments [1]. All of these tasks are inseparable from the road recognition. And on the structured road, the most important task of road identification is lane detection based on machine vision. So far, there are a lot of vision based lane detection algorithm is proposed. They usually utilized different lane patterns (solid or dashed white painted line, etc.) or different road models [two-dimensional(2D) or three-dimensional(3D), straight or curved] and different techniques (Hough, template matching, neural networks, etc.)[2].

The algorithm based on Hough transform which does not employ any tracking or image-to-world reasoning solves the problem in roughly 90% of the highway cases[3] has several problems to solve. One of the problem is that the reliability of algorithm based on Hough transform is difficult to meet the requirements because of the significant gaps in research, high reliability demands, and large diversity in case conditions[4]. And the other problems is requirement for real time.

In urban environment, lane detection is interfered by many factors, such as the tall buildings on the roadside. In this paper , we use the method of combining color feature and morphological operation to detect the lane lines and obtained satisfactory results.

II. PROPOSED METHOD

1 Binary image generating based on color feature

In general,the road images captured directly by the camera are true color.In other words,each pixel of the image is expressed by three components named red,green and blue and each component have 256 shades.This also means that each pixel of the image have a total of 16,777,216 color variations.Therefor,it is useful for us to get the information we want.However, the vast amounts of data also brings a dilemma on data processing.It is natural to screen and streamline image information.In this paper, we extract the lane information by creating a filter based on the color feature.The common colors of lanes are white or yellow.In this article we discuss the method in the case of the line color is white.

First of all,we collect a lot of road image which contain lanes by camera and then we divide them into several groups according to illumination differences.Take a 50 sample points from each group and record their data respectively**[Fig 1].**

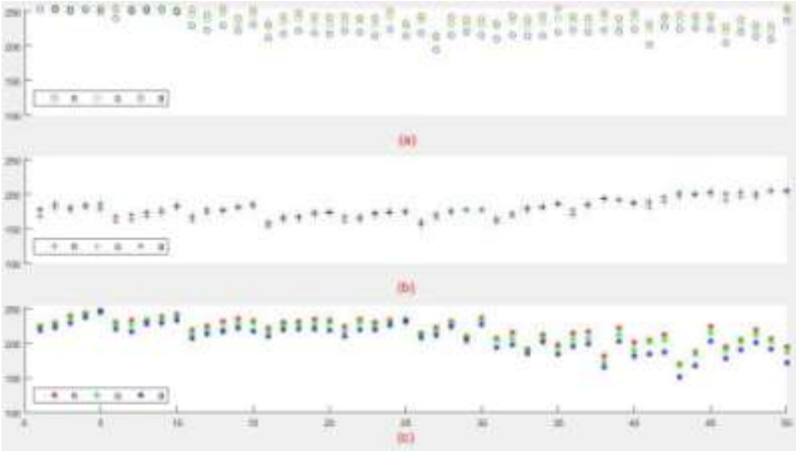

Fig 1. The value of the R G B components.

(a) shows the value of lines in the sunshine;(b) Shows the value of lines in the shadow;(c) shows the value of lines in the rain.Red represents the red channel,green represents the green channel and blue represents the blue channel.

We then calculate the mean of each component through Equation 1, Equation 2 and Equation 3,calculate the mean of difference between each of the two components through Equation 4 , Equation 5and Equation 6 and calculate the mean as shown in Equation 7.

$$R_{mean} = \left(\sum_{i=1}^{n} r_i \right) / n \quad (1)$$

$$G_{mean} = \left(\sum_{i=1}^{n} g_i \right) / n \quad (2)$$

$$B_{mean} = \left(\sum_{i=1}^{n} b_i \right) / n \quad (3)$$

$$DR_{mean} = \sum_{i=1}^{n} (| r_i - R_{mean} |) / n \quad (4)$$

$$DG_{mean} = \sum_{i=1}^{n} (| g_i - G_{mean} |) / n \quad (5)$$

$$DB_{mean} = \sum_{i=1}^{n} (b_i - B_{mean} |) / n \quad (6)$$

$$D_{mean} = \sum_{i=1}^{n} (| r_i - g_i | + | r_i - b_i |) / n \quad (7)$$

Where, n means the number of samples in each group;
r_i , g_i and b_i represent color components in position i.

The result of calculation are shown in the following table**[Table 1]**.

Groups	R_{mean}	G_{mean}	B_{mean}	DR_{mean}	DG_{mean}	DB_{mean}	D_{mean}
In the sun	243.98	238.22	225.46	6.5408	7.7752	11.3056	24.6
In the shadow	178.02	182.32	181.38	10.3816	9.7184	10.1608	8.06
In the rain	220.5	215.88	207.7	13.86	14.1344	16.588	17.5

Table 1. Details of calculation results

According to the results above,it is not difficult to find that most of the RGB components of the pixels of the lane were higher than 150 and the difference among the three channel for the same pixel is not huge. Therefore, we can make the following bold assumptions.

- $r_i \in [150,255]; g_i \in [150,255]; b_i \in [150,255]$;
- $|r_i - g_i| < 10 \& |r_i - b_i| < 10 \& |b_i - g_i| < 10$;

According to the above assumptions,we can realize it in MATLAB and the pseudo code is shown as follows.

If $r_i > 149 \& g_i > 149 \& b_i > 149$

  If $|r_i - g_i| < 10 \& |r_i - b_i| < 10 \& |b_i - g_i| < 10$

    $mask_i = true$

  End

  $mask_i = false$

Else

  $mask_i = false$

End

The resulting image of the operation is shown in Fig 2 (b) and the original picture is shown in Fig 2 (a) for comparison.

Fig 2. Generated binary image.

2 Execution of morphological operations on binary image

Binary image obtained by the previous step contains not only the information of lane but also interference Information of things which are similar with lane in color.If we implement edge detection directly ,the program will spend a lot of time in the Hough transform. So we need to remove these unnecessary portions.This paper adopt the method of the opening and closing operation based on mathematical morphology.

The opening is obtained by the erosion and followed by dilation of the resulting image.It is used to eliminate small objects,separate objects at the fine points and smooth larger object boundaries while not significantly changing the area .

The closing is obtained by the dilation and followed by erosion of the resulting structure.It is used to stuff small hole in the object,connect proximity object and smooth object boundaries while not significantly change the area.

Firstly,we implement opening operation on the binary image as shown in Fig 3 (a).Then we remove the smaller area from the resulting picture as shown in Fig 3 (b).Finally,we implement closing operation on the resulting picture as shown in Fig 3 (c).

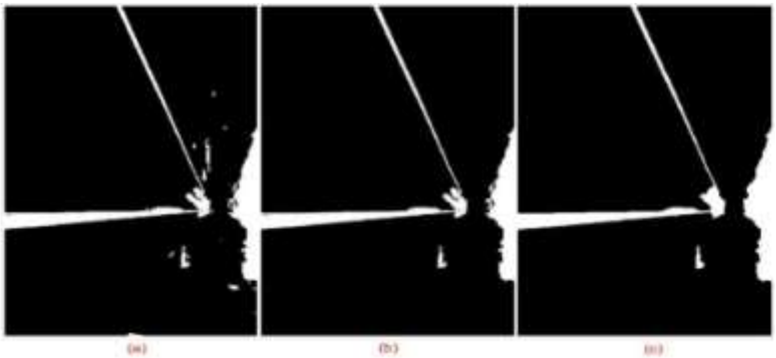

Fig 3. The process of morphological operation

3 Implement of edge detection

Edge detection is detection of object edges in the image, here is for the detection of lane edge. Edge detection is often faced with a difficult problem, that is, to determine the detection threshold. Selecting the threshold have a significant impact on the results. If the selected threshold value is too large, will make the algorithm to become less sensitive to edge .This will result in some of the edge will be ignored and the rupture of lines.On the contrary, if the selected threshold value is too small, it will make the algorithm too sensitive.This will lead to a lot of places where no edges are considered to be edges and it will significantly increase the amount of computation. Since this article carry out edge detection on binary image directly, and therefore there is no problem in this regard.

The resulting picture of edge detection is shown in Fig 4 (a)and the resulting picture of edge detection without any pretreatment is shown in Fig 4 (b) for comparison.

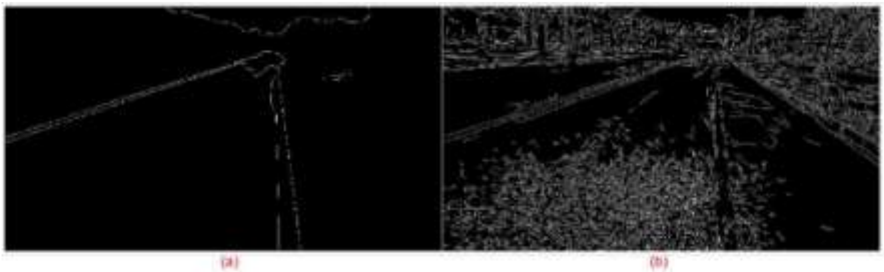

Fig 4. Process for edge detection

4 Hough transform

Hough transform is used to find objects (such as lines) which are not perfect by a voting procedure.In this case we adopt this method to detect the lane lines.By transforming the image obtained by edge detection,we get the image of parameter space as shown below[Fig 5].Then we extract the parameters with the maximum value from the parameter space.

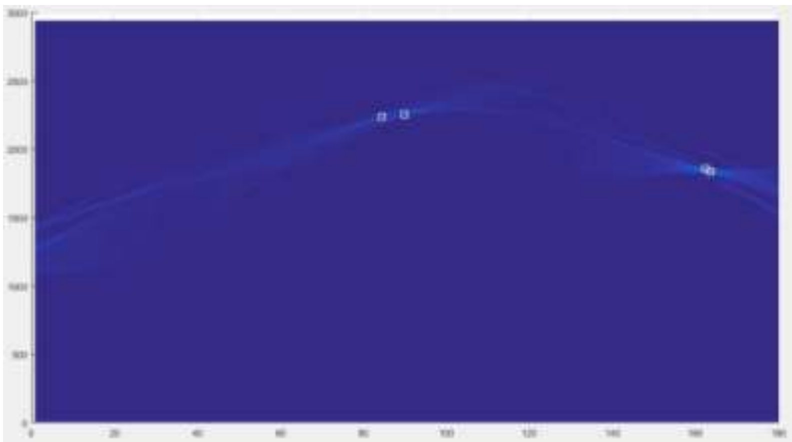

Fig 5. Parameter space of Hough transform

III. EXPERIMENTAL RESULTS

As we can see in the Fig 6 & 7,Fig 6 (a)indicates the line detected by the method proposed in this paper while Fig 6 (b)indicates the line detected by Hough transform directly and Fig 7 (a)shows the final result obtained by the algorithm used in this paper while Fig 7 (b) shows the result obtained by Hough transform directly.

Fig 6. Comparison of the results of Hough transform in the detection of lines

Fig 7. Comparison of the final results

IV. CONCLUSION

From the above experimental results, it is easy to see that the method proposed in this paper can effectively remove the interference in the image caused by some obstacle such as houses, street lamps and so on.However, this study in the paper still has some limitations. First of all, we do not consider the case of yellow lane. Secondly, we have not considered the case light is extremely weak. In addition, we also did not consider the adequacy of the real-time performance of the algorithm. As a result, we will start the research work in the above aspects.

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