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TRAFFIC SIGN LOCALIZATION BASED ON EDGE-COLOR PAIR AND FEATURE FILTERS

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Abstract. *Traffic sign localization is a key part of the traffic sign recognition system. A novel algorithm for traffic sign localization based on edge-color pair combined with feature filters is presented in this paper. Firstly, the color edge detection is taken by the method of distance measure of direction region in a color image. Secondly, the suspected regions of the traffic sign are localized roughly based on edge-color pair. Finally, a two-level feature filter is designed to localize the traffic sign accurately. The experiment on 200 traffic sign images that were taken under various conditions shows the extraction rate of 96.1%. The experimental results show that the algorithm in this paper can effectively eliminate the color fade effect and the analogue interference effect on traffic sign localization.*
Keywords: Traffic sign localization, Color edge detection, Edge-color pair, Feature filter

1. **Introduction.** Traffic sign recognition as an important part of intelligent transportation system has become a hot research topic and is also one of the key unresolved problems. Traffic sign recognition includes the localization module and the classification module [1]. The localization is the key module. Whether the traffic sign can be localized accurately will directly affect the success or failure of the traffic sign recognition system.

Traffic sign localization is mainly based on color feature and geometric feature at present. There are three main implementation schemes. The first one is based on only color feature [2,3]. It has the advantages of scale invariance, rotation invariance and visual invariance, but it is relatively sensitive to environment change and fading. The second scheme is based on geometric feature [4]. It is not sensitive to environment change and fading, but it is greatly affected by the shooting angle, the shooting distance and the deformation of traffic sign. The third scheme combines color feature and geometric feature to localize the traffic sign [5,6], and it can effectively make up for the defect existing in the two schemes mentioned above. The last one is currently a very effective scheme of traffic sign localization.

In recent years, many traffic sign localization methods are proposed by scholars at home and abroad. For example, [7] improves the traffic sign localization based on HOG feature extraction by increasing a color conversion link. [8] proposes an algorithm for significant object localization based on the color properties and the spatial information, using it for traffic sign localization. [9] proposes a method based on color invariants and tower gradient direction histogram. [10] proposes an approach based on visual attention mechanism. [11] proposes a method for construction of a cascaded traffic sign detector.

The methods mentioned above can improve the performance of traffic sign localization, but they fail to consider an important color feature, that is, the traffic sign has a fixed color combination. When there are some distractors which have the same background color with the traffic signs or when the color of the traffic signs is faded, the localization accuracy will decrease.

Our main contribution in this paper is that we put forward a novel algorithm for traffic sign localization based on the fixed color combination and the geometric feature filters. The proposed algorithm makes full use of the fixed color combination and the geometric feature. It can greatly reduce the pixels which do not conform to the fixed color combination, can effectively eliminate the color fade effect and the analogue interference effect on traffic sign localization, and improves traffic sign localization accuracy.

The organization of this paper is as follows. Section 2 introduces the concept of edge-color pair. Section 3 introduces the detail method of traffic sign localization presented in this paper. Section 4 presents experimental results. We conclude the paper in Section 5.

2. **Edge-Color Pair.** The traffic sign can be mainly divided into three categories: indication sign, prohibition sign and caution sign. The characteristics of traffic signs are shown in Table 1.

Table 1. The characteristics of traffic signs

category	shape	background color	border color	pattern color
indication sign	circular or rectangular	blue	white	white
prohibition sign	circular	white	red	black
caution sign	triangular	yellow	black	black

Based on the research, an important conclusion is acquired. Traffic signs have a fixed color combination and it is called an edge-color pair [12]. The edge-color pair of indication sign is (*blue*, *white*), prohibition sign is (*white*, *red*) and (*white*, *black*), caution sign is (*yellow*, *black*). We use $Color(x)$ to represent the color of pixel x. $Color(x) = \{1, 2, 3, 4, 5, 6\}$ represents {*white*, *blue*, *red*, *black*, *yellow*, *other colors*}. We use $COCP(p)$ to represent the edge-color pair of a point p.

We use Figure 1 to illustrate the edge-color pair. A is a point in edge L. A $1\times(2m+1)$ linear window is made. The window's direction is perpendicular to the tangent of point A and its center is point A. We extract point B on one side of point A in the linear window and extract point C on the other side of point A. The edge-color pair of point A is $COCP(A) = (Color(B), Color(C))$.

The edge-color pair collection of traffic signs is $\{(1,2), (1,3), (1,4), (4,5)\}$, as shown in Table 2.

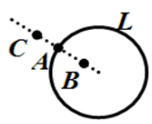

Figure 1. The schematic diagram of edge-color pair

Table 2. The edge-color pair of traffic signs

traffic signs	indication sign	prohibition sign	caution sign
COCP	$(1,2)$	$(1,3)$, $(1,4)$	$(4,5)$

3. The Method of Traffic Sign Localization.

3.1. **Color edge detection.** In this paper, we use the method based on the direction region distance measure on HIS (Hue Intensity Saturation) color model for color edge detection [13]. A color image can be represented by a function and the color edge can be defined as a collection of discrete points which have the edge character on the function. The color edge describes local mutation of the function. A color distance [13] is defined to describe the mutation of color function. If the color distance of a pixel is greater than a certain threshold, the pixel is an edge pixel. This method can obtain more edge information than other methods and has a good robustness for noise.

Figure 2 is the original image. Figure 3 is the image after median filtering. Figure 4 is the image after color edge detection.

Figure 2. Original image

Figure 3. After preprocessing

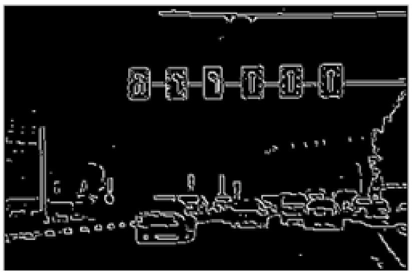

Figure 4. After color edge detection

3.2. **The coarse localization based on edge-color pair.** A 1×7 linear window is made for every edge pixel, and its direction is perpendicular to the direction of the edge. As the parallelism of the BP (Back Propagation) neural network is high, its adaptive learning ability and the fault tolerance ability are strong, and it can realize the nonlinear mapping from input to output; we use BP neural network in the RGB (Red Green Blue) color space to judge the color value of the pixels on both sides within the window. In the process of judging the color value, we firstly train the BP neural network. We use a set $\{1, 2, 3, 4, 5, 6\}$ to represent $\{$*white*, *blue*, *red*, *black*, *yellow*, *other colors*$\}$. Using the white as an example, we choose 100 arrays $(\mathrm{R}, \mathrm{G}, \mathrm{B})$ as the input of the neural network, and the values of the R, G and B are selected randomly from 210 to 255, and the output of the neural network is 1. After training, we use the neural network to judge the color value of the pixels on both sides within the window. If the color values combination of an edge pixel is in Table 2, then the edge pixel is reserved, otherwise is removed. The finally preserved edges are the suspected edges of the traffic signs. Then, the closing operation in morphology is used to get the connected regions which are called the ROI (Region of Interest). The image after edge-color pair detection is shown in Figure 5, and the ROIs are shown in Figure 6.

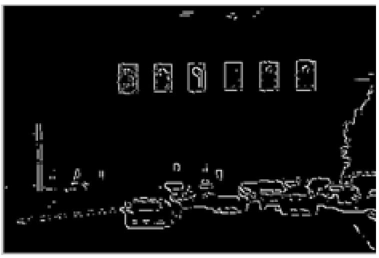

Figure 5. The edge-color pair detection image

Figure 6. The ROIs

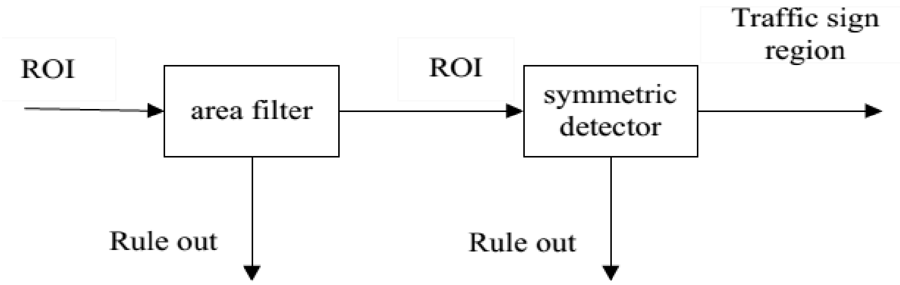

Figure 7. The two-level feature filter

3.3. **The precision localization based on feature filters.** This paper designs a two-level feature filter to further screen the ROIs. The first level filter is an area filter, and the second level filter is a symmetric detector. The two-level filter is shown in Figure 7.

We calculate the area of an ROI by counting the number of pixels in the ROI region. $f(m,n)$ is a function defined on the image space. If a pixel is in the ROI region, then $f(m,n) = 1$. Otherwise, $f(m,n) = 0$. If we use A to represent the area of ROI, then $A = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n)$. After calculating A, two thresholds are chosen, and they are the maximum area $A_{\max}$ and the minimum area $A_{\min}$. If A is between $A_{\max}$ and $A_{\min}$, then we keep the ROI. Otherwise, we remove the ROI.

This article adopts the method of calculating the center of symmetry of ROI to construct the second level filter. Firstly, we calculate the edges of an ROI by the canny filter. Secondly, we calculate the gradient magnitude and the gradient direction of every edge pixel, and then the gradient magnitude is multiplied by a weight K in the direction of gradient, so that the potential symmetry center can be weighted. Finally, we set a threshold T. If there is a weight value in an ROI which is greater than T, then the ROI is symmetric, and it can be judged to be a traffic sign region. Otherwise, the ROI should be excluded.

Using $I(x,y)$ to represent an edge, the method of calculating the gradient of a pixel in the edge is as follows.

$$\nabla I = \begin{bmatrix} I_X \\ I_y \end{bmatrix} = \begin{bmatrix} \partial I/\partial x \\ \partial I/\partial y \end{bmatrix}. \tag{1}$$

The method of calculating the gradient magnitude is as follows.

$$mag(\nabla I) = \left[I_X^2 + I_y^2\right]^{1/2}. \tag{2}$$

The method of calculating the gradient direction is as follows.

$$\alpha(x,y) = \arctan(I_X/I_y). \tag{3}$$

The traffic signs regions accurately localized are shown in Figure 8 and the extracted traffic signs are shown in Figure 9.

Figure 8. The traffic signs regions

Figure 9. The extracted traffic signs

4. **The Experimental Results and Analysis.** In order to verify the accuracy of the algorithm proposed in this paper, an experiment has been performed on 200 images that were taken under various conditions. Among them, 67 images were faded and 42 images contained distractor. The computer used in this experiment has 4GB (Giga Byte) memory and 2.5 GHZ (Giga Hertz) core I5 CPU (Central Processing Unit). We use Matlab to run the code. For proving the advantage of our algorithm, we compare the results with two different algorithms included in [9] and [10]. The two algorithms are representative methods which take the color feature into account, but they do not use the fixed color combination. The comparison is shown in Table 3. In this paper, we use the correct localization rate, leak rate and the false localization rate as evaluation indices.

Table 3. The experimental result

algorithm	corrected rate	leaked rate	false rate
This paper	96.1%	3.9%	2.3%
Reference [9]	94.5%	5.5%	3.9%
Reference [10]	92.8%	7.2%	2.7%

The experimental results of the algorithm in this paper verify that the correction localization rate is 96.1%, the leaked localization is 3.9% and the false localization is 2.3%. Compared with the experimental results in [9] and [10], the correction localization in this paper is higher, and the leaked localization rate and the false localization rate in this paper are lower.

The algorithm in this paper is effective to localize the faded traffic signs and the signs interfered by similar objects. We calculated the correct localization rate and compared with [9] and [10]. The comparison is shown in Table 4.

Table 4. The correct localization rate

algorithm	faded image	included distractor
This paper	94.0%	95.2%
Reference [9]	92.5%	90.5%
Reference [10]	88.1%	92.9%

5. **Conclusion.** This paper has proposed a new algorithm of traffic sign localization based on edge-color pair combined with the feature filters. The edge-color pair detection can greatly reduce the edge points which do not match the color collocation of traffic signs. It can not only reduce the computational complexity but also effectively eliminate the interference of the objects which have the similar background color with that of the traffic sign. Using edge-color pair detection can also eliminate the effect on traffic sign

localization brought by color fade. When combined with a two-level filter, it can localize the traffic signs accurately. Experiment shows that this algorithm has a good localization effect, and has good robustness. However, the real-time performance is not very good. Improving the real-time performance is our next work.

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