A Method for Recognizing Prohibition Traffic Sign Based on HOG-SVM

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***Abstract*—In order to recognize prohibition traffic signs, based on the analysis of the color occupancy of prohibition traffic signs, this paper proposes a method to recognize the prohibition traffic signs based on the feature of Histogram of Oriented Gradient (HOG) and Support Vector Machine (SVM). The recognition method is mainly divided into three steps: the first step is image preprocessing, which realizes the size normalization processing, grayscale processing and Gamma correction of the image; the second step is the feature extraction of HOG; the third step is the recognition of prohibition traffic signs based on SVM. In the design and implementation of the prohibition traffic sign classifier, the prohibition traffic sign image training after linear transformation is used to train 42 binary classifiers, and then based on these 42 classifiers, the prohibition traffic sign classifier is constructed and implemented. Finally, the self-built data set was used to test and analyze the prohibition traffic sign recognition method, and the overall recognition accuracy rate was 90.2%.**

Keywords- Histogram of Oriented Gradient, Support Vector Machine, Prohibition Traffic Sign, Method of recognition

I. INTRODUCTION

With the popularization and development of 5G, Internet of vehicles and intelligent vehicles, traffic sign recognition (TSR) is becoming more and more practical and popular. Traffic sign recognition is an important part of intelligent assistant driving, intelligent vehicle and intelligent transportation, which plays an important role in vehicle traffic safety and pedestrian safety. During recent years, with the development of intelligent algorithms such as deep learning, convolutional neural network and machine learning, the intelligent learning algorithm is applied to establish the data model of traffic sign recognition. The image, video and other traffic sign sample data are used, and the correlation learning training method is used to make the learning model realize the traffic sign classification and recognition.

The Multi Column Deep Neural Network (MCDNN) was used to win the champion of the 2012 German traffic sign recognition competition, and its recognition rate exceeded the human recognition rate [1]. However, the fully parameterized GPU should be used in the implementation process of MCDNN. Based on the extraction of Histogram of Oriented Gradient (HOG) feature, the single hidden layer feedforward network trained by Extreme Learning Machine (ELM) is used to realize the efficient recognition of traffic signs [2]. Based on multi task convolution neural network, using a number of data for training, realized the traffic sign recognition [3]. Based on hog features extended to his color space combined with local self-similar descriptors, the random forest method is used to classify and recognize traffic signs [4].

HOG feature was first proposed by Navneet Dalal and Bill Triggs, and combined with SVM to realize pedestrian detection [5]. SVM is a classical algorithm of machine learning, which has a good performance in two classification and multi classification. In this paper, based on the HOG feature, support vector machine is used to realize the classification and recognition of ban traffic signs.

II. ANALYSIS OF PROHIBITION TRAFFIC SIGNS

Traffic signs are mainly divided into seven categories: warning sign, prohibition sign, indication sign, guide sign, tourist area sign, road construction sign and auxiliary sign. Prohibition traffic sign is one of the commonly used signs. According to the national standard of the People's Republic of China (gb5768.2-2009), there are 42 kinds of prohibition traffic signs. Some standard prohibition traffic signs are shown in Figure 1.

From the analysis of the composition color of the prohibition traffic sign image, the main composition colors are: red, white, black and blue. On the basis of color standardization [6] and

978-1-6654-2616-9/21/$31.00 ©2021 IEEE
DOI 10.1109/ICCEA53728.2021.00101

image capture of the sign image, the number of pixels of four colors involved in the prohibition traffic sign image is counted, and their proportion in the total pixels of the image is calculated respectively, then each sign can obtain four characteristic values of color proportion. The statistical results are shown in Figure 2

Figure 1. Schematic diagram of prohibition traffic signs

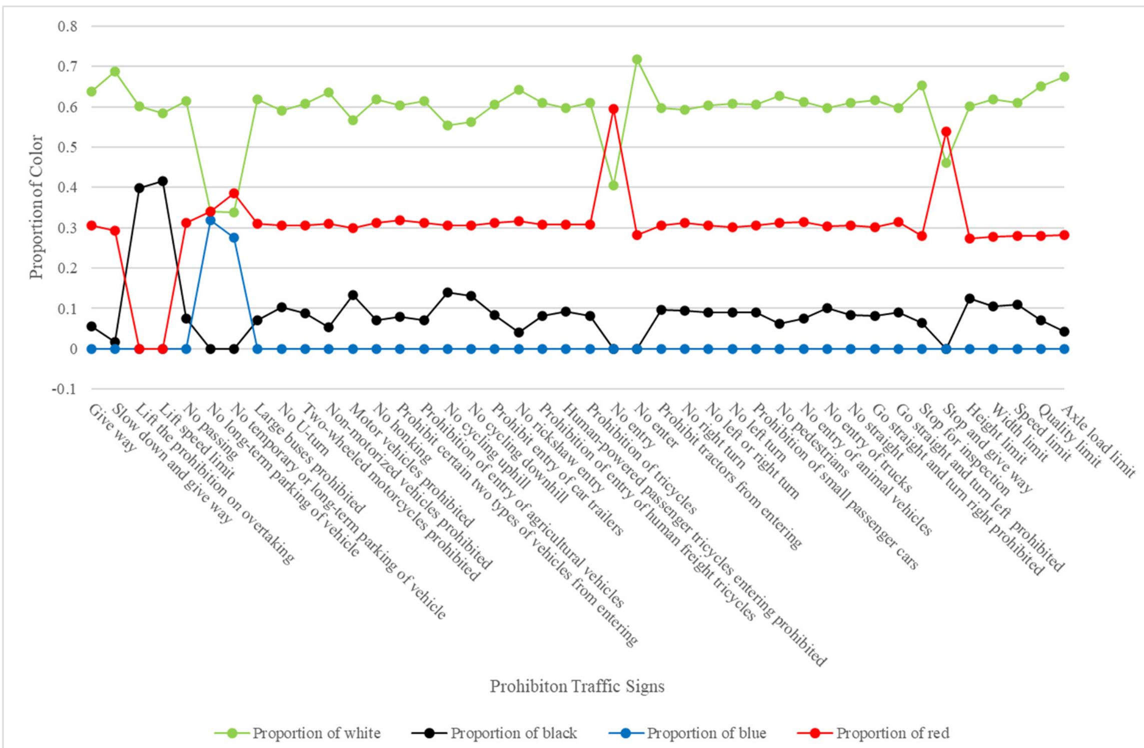

Figure 2. Color proportion of standard prohibition signs

As shown in Figure 2, there are obvious color differences in some of the prohibition signs. For example, the color composition of the long-term parking prohibition sign and the temporary or long-term parking prohibition sign is red and blue, regardless of the white background of the sign image. Considering the proportions of white, black, blue and red of all prohibition signs, only the rough classification of prohibition signs can be realized based on the color proportion information, and the fine classification of prohibition signs should be realized based on the texture, shape and other local or global features of prohibition signs. HOG feature describes the local detail features through the directional gradient data, and describes the global features of the image through the histogram statistical data of the directional gradient. Therefore, the HOG feature is used to describe the prohibition traffic signs.

III. PROHIBITON TRAFFIC SIGN RECOGNITION METHOD BASED ON HOG-SVM

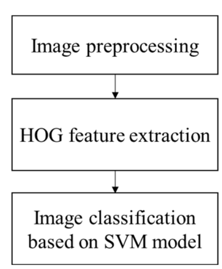

Figure 3. Flow chart of prohibition traffic sign recognition method

As shown in Figure 3, the method of prohibition traffic sign recognition is mainly divided into the following three steps:

1) Image preprocessing

In this part, we mainly complete the traffic sign image size adjustment, color image graying, gray image Gamma correction and HOG feature extraction. Gamma correction is mainly used to process the brightness of the image and weaken the influence of light and shadow on the image.

2) HOG feature extraction

While extracting HOG features, the corresponding spatial / orientation bins, cell, block and sliding step size are shown in TABEL I.

TABEL I. PARAMETER TABLE OF HOG FEATURE EXTRACTION

Spatial/Orientation bins	**0°~360°/9 bins**
Cell	8×8
Block	2×2
Sliding step	1

The image size and the corresponding HOG feature dimension are shown in TABEL II.

TABEL II. IMAGE SIZE AND DIMENSIONS OF HOG FEATURES

Serial number	**Image size**	**Dimensions of HOG features**
1	16×16	36
2	24×24	144
3	32×32	324
4	48×48	900
5	64×64	1764

The image size used in this paper is 24×24. Therefore, the dimension of HOG feature is 144.

3) Classification and recognition of prohibition traffic signs based on SVM

In this part, firstly, based on the training data set, support vector machine is used to generate the initial classifier of prohibition traffic signs. The initial classifier is constructed by 42 binary classifiers. Then the initial classification result is used to get the final classification result.

IV. GENERATING SVM CLASSIFIER BASED ON HOG FEATURE

A. Generation of training data

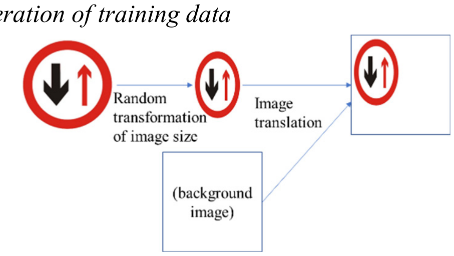

Figure 4. Schematic diagram of training data generation

As shown in Figure 4, the generation of data used to train the SVM binary classifier is carried out in two steps:

1) Image size random transformation

Based on the standard prohibition traffic sign image, the size of the image changes randomly. Let the standard image width be W, height be H, the image width after random transformation be W_r, height be H_r, the minimum width after image transformation be W_{min}, the minimum height be H_{min}, the maximum width be W_{max}, the maximum height be H_{max}, and the random number of width transformation be $num\_w(0 \leqslant num\_w \leqslant 1)$. The random number of height transformation is $num\_h(0 \leqslant num\_h \leqslant 1)$, the random transformation calculation of image size is shown in formula (1).

$$\begin{cases} W_r = W_{min} + (W_{max} - W_{min}) * num\_w \\ H_r = H_{min} + (H_{max} - H_{min}) * num\_h \end{cases} \tag{1}$$

2) Image translation

In this step, the image after random size transformation is randomly translated to the top left corner, top right corner, lower left corner and lower right corner of the background image. The background image is pure white background.

B. Classification of prohibiton traffic signs based on SVM

1) Training of single binary classifier

A single binary classifier is a classifier that uses support vector machine to distinguish one kind of prohibition traffic sign from other prohibition traffic signs. It can be seen from Figure 1 that the ban type traffic signs contain at least 42 kinds of signs, so at least 42 binary classifiers are generated. Let X_i be the HOG feature vector set corresponding to the i-th prohibition traffic sign, and F_i be the binary classifier of X_i (i = 1, 2, 3, ..., 42).

$$Y_i = F_i(x) = \begin{cases} 1, & \forall x \in X_i \\ 0, & \forall x \in \overline{X_i} \end{cases} \quad i = 1, 2, 3, \ldots, 42 \tag{2}$$

Obviously, there are 42 classifiers need to be trained one by one. It should be noted that if $\forall x$ can be accurately classified according to formula (2), then any prohibition traffic sign can be recognized only by judging all binary classifiers one by one. However, if

$$\exists x' \in \overline{X_i} \ \ s.t. \ F_i(x') = 1 \ or \ \exists x'' \in X_i \ s.t. \ F_i(x'') = 0$$

When the classifier is trained, there is

$$\forall x \in X_i \ s.t. F_i(x) = 1 \ \text{ and } x' \in \overline{X_i} \ s.t. F_i(x') = 1$$

. The purpose is to avoid any unrecognizable traffic signs.

2) Traffic sign recognition based on SVM binary classifier

On the basis of each trained binary classifier, 42 binary classifiers can be got. These binary classifiers can distinguish one kind of prohibition traffic sign from other prohibition traffic signs, but can not completely distinguish them. The results of these binary classifiers are processed to improve the classification accuracy.

As shown in Figure 5, the prohibition traffic sign recognition based on SVM binary classification is mainly divided into two steps:

a) Initial classification based on SVM binary classifier

In this part, the HOG feature data extracted after image preprocessing is input into 42 trained binary classifiers one by one for prediction, and the result [*label, score*] is obtained. *label* is the classification and prediction result of the input data image by the binary classifiers, which is used to indicate which category the image belongs to, and *score* is the credibility score of each category of the image classification results. In this paper, the *label* values are “1” and “2”, where “1” indicates that the image belongs to the corresponding prohibition traffic sign image class of the classifier and “2” indicates that the image does not belong to the corresponding prohibition traffic sign image class of the classifier.

b) Classification based on the predict result

In this part, based on the prediction result [*label, score*] in step *a)*, we can get the prediction result label data set LABEL and the prediction result score data set SCORE. The following is the steps:

- Analyze the dataset LABEL. If the prediction result of one binary classifier N_1 is *label* = 1, the prohibition sign image is considered as the corresponding traffic sign of the binary classifiers N_1; Otherwise, enter the next step and analyze the data set SCORE.
- Analyze the dataset SCORE. If the result score of the binary classifier N_2 is the maximum value of dataset SCORE, the prohibition traffic sign image is considered as the corresponding traffic sign of the binary classifier N_2.

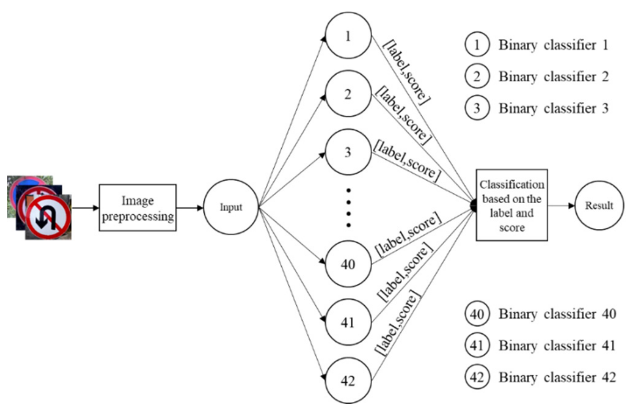

Figure 5. Schematic diagram of prohibition traffic sign recognition method based on SVM binary classification

V. Verification and Analysis

A. Source of verification data

Based on network collection, manual field collection, China traffic sign detection data set (CCTSDB) [7]and Tsinghua-Tencent 100K data set [8], a total of 610 test prohibition traffic sign pictures of 15 categories were collected. An example of test data is shown in Figure 6.

Figure 6. Sample of verification data

B. Test results

TABEL III. The test results

Abbreviation of traffic signs	Prohibition traffic signs	Correct recognition rate
TS1	No long parking	100.00%
TS2	No right turn	100.00%
TS3	Height limit	98.15%
TS4	No left turn	94.74%
TS5	No entry	94.44%
TS6	No pedestrian access	93.75%
TS7	No U-turn	91.67%
TS8	No motor vehicles	90.00%
TS9	No Temporary or long-term parking	88.64%
TS10	No honking	87.88%
TS11	Speed limit 60	86.00%
TS12	No overtaking	82.76%
TS13	No entry of trucks	81.82%
TS14	No entry of non motor vehicles	81.58%
TS15	Speed limit 40	81.58%
Total		90.20%

As shown in TABEL III, the test results of 15 kinds of prohibition traffic signs show that the correct recognition rate of 8 kinds of prohibition traffic signs (traffic sign of no long parking, traffic sign of no right turn, traffic of height limit, traffic sign of no left turn, traffic sign of no entry, traffic sign of no pedestrian access, traffic sign of no U-turn and traffic sign of no motor vehicles) is greater than or equal to 90%. The correct recognition rate of the other 7 kinds of prohibition traffic signs is within the range of (0.81, 0.9), and the total correct recognition rate of 15 kinds of prohibition traffic signs is 90.2%. Overall, the proposed classification model achieves the classification and recognition of traffic signs.

C. Result analysis

By comparing the spatial detail complexity O of the traffic sign TS1 ~ TS8 and the traffic sign TS9 ~ TS15, there is

$$O_{TS1\sim TS8} < O_{TS9\sim TS15}.$$

When the image size is reduced, the spatial detail information of the image is lost, thus the HOG feature data of the image is lost too. Besides if the adverse factors such as image rotation, illumination and so on are superimposed, the change of HOG feature of image exceeds the tolerance limit of SVM binary classifier, which leads to the decrease of classification accuracy. So the accuracy of recognizing the prohibition traffic sign TS1~TS8 is greater than the accuracy of recognizing the prohibition traffic sign TS9~TS15.

In addition, insufficient training samples is one of the reasons for the low classification accuracy. In this paper, the training samples consider the linear deformation of the image such as translation, horizontal and vertical unequal ratio deformation completely, and the nonlinear deformation caused by rotation and lens motion is not considered enough, which reduces the classification accuracy of the classifier for nonlinear deformation image.

VI. Conclusion and Future Work

In conclusion, for recognizing prohibition traffic signs, a classification model based on HOG feature and SVM is proposed. The classification model consists of three parts, which are image preprocessing part, initial binary classification part and final classification part based on the predict result. The classification model is validated. Analyzing the test result data, the validity of model is confirmed.

In the future work, on the one hand, we will pay attention to the completeness of training samples. Let the training samples cover the changes of prohibition traffic sign image in deformation, illumination and occlusion as much as possible, and improve the classification performance of SVM binary classifiers, and enhance the accuracy of a single SVM binary classifier. On the other hand, focusing on the appropriateness of image size and the optimal image size will be considered, so that HOG features can fully describe the details of the image, and also will not greatly increase the dimension of HOG features because the image size is larger, so as to improve the training efficiency of SVM classifier as much as possible. Of course, fusing other traffic sign classification and recognition methods to improve the accuracy of classification is also an important aspect of the future research work.

Acknowledgment

This work was supported by the Science and Technology Research Program of Chongqing Municipal Education Commission (Grant No. KJZD-K20201290).

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