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Traffic Sign Detection and Recognition Based on Color Features and Improved Support Vector Machine Algorithm

Sen Zhao and Tong Han*

Hebei Agricultural University, Baoding, China

**corresponding author*

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Abstract: With the continuous development of intelligent transportation system. Traffic sign recognition system as a key part of it, its research and practice can bring more convenience to people's lives. In order to solve the problems in the research of traffic sign detection and recognition methods, based on the discussion of image preprocessing technology, target detection technology, target recognition technology and improved support vector machine algorithm principle in recognition, this paper briefly discusses the traffic sign area screening and actual data samples, and discusses the design of recognition model. Finally, the recognition model designed in this paper is compared with the cyclic neural network (CNN) and decision tree (DT) through experimental tests. The experimental results show that the improved support vector machine (ISVM) has an average recognition accuracy of 97.03% for red speed limit, blue, danger and speed limit removal. ISVM has better detection and recognition rate than cyclic neural network (CNN) and decision tree (DT). Therefore, the algorithm proposed in this paper has high practical value in traffic sign detection and recognition.

1. Introduction

The detection and recognition of traffic signs can ensure road traffic safety, and it is an important part of the intelligent assistant driving system to judge traffic conditions.

Nowadays, more and more scholars have done a lot of research on traffic sign detection and recognition methods through various technologies and system tools, and have also made certain research achievements through practical research. Farhat W proposed a traffic sign detection method based on color feature pair and maximum stable extreme value region. In order to solve the problem of different image brightness caused by weather change, a multi threshold method is adopted. An image cutting method is proposed for candidate regions with similar background. Finally, SVM and HOG are used to classify the proposed region, and high detection and recognition

rates are obtained in complex environments [1]. Ibrahim N B uses convolutional neural network method and neural network model based on fast region to train traffic signs in data set based on the idea of deep learning and transfer learning. The neural network model is trained using scene image data sets. According to the marks on the test sample set, the data shows that the traffic sign detection model can be rapidly constructed using the pre trained neural network model [2]. Taylor fused double support vector machines (TWSVM) with high computational efficiency into a CNN classifier, proposed a CNN TWSVM hybrid model, and applied it to the task of traffic sign recognition. Wavelet kernel function is introduced to deal with nonlinear classification tasks to improve the generalization ability of the model. This method can extract highly abstract features of traffic signs. Finally, the traffic sign recognition based on this method effectively solves the over fitting problem of traffic sign classification [3]. Although the existing traffic sign detection and recognition methods are very rich, there are still many problems in their real practical applications.

Firstly, this paper introduces the kernel function and cross validation principle in support vector machine. Then three types of traffic signs are introduced, and image preprocessing technology, target detection technology and target recognition technology are summarized. And through the use of support vector machine two-level classification. The first level classification mainly uses an improved grid search method based on the color and shape characteristics of traffic signs, which greatly reduces the time for parameter optimization. The second level classification mainly uses the regional characteristics of traffic signs for training to further distinguish the specific content information of traffic signs.

2. Research on the Design of Traffic Sign Detection and Recognition Based on Color Features and Improved Support Vector Machine Algorithm

2.1. Traffic Sign Detection and Recognition

(1) Image preprocessing technology

Image preprocessing is a step in the process of image analysis and processing before segmentation, feature selection and recognition of the input image. Before processing the image, irrelevant information can be removed or greatly reduced from the original image [4].

1) Color space segmentation method: the segmentation of color space is to extract each component of the color model and set a threshold for each component, so that a large number of background area interferences can be effectively removed to obtain the target pixel area [5]. Next, we need to further detect and recognize the target pixel area. In this paper, color segmentation algorithm is based on standard R/B graph [6].

2) Image enhancement: For traffic signs, color is the most obvious feature of traffic signs. Therefore, when detecting traffic sweeps, the MSRCR algorithm with brightness separation is used to make up for the shortcomings of color distortion and insufficient contrast during image enhancement [7].

3) Feature extraction

In this paper, Canny operator is used for edge extraction to calculate the gradient direction of each point. Normalize the edge direction histogram, as shown in Formula (1) [8].

$$G_n[l] = G[l] / M \tag{1}$$

$$M = \sum_{l=1}^{9} M[\delta / 40], 0 \le \delta \le 360°$$

Where, $G_n[l]$ is the normalized histogram , M is the total number of edge directions [9].

Smooth the histogram. The smoothing formula is shown in (2) [10].

$$G_x[l]=\frac{\sum_{t=l-f}^{l+f} G_n[t]}{2f+1} \tag{2}$$

Where, G_x is the smoothed histogram, G_x is not affected by image rotation, and parameter f determines the smoothness. In this paper, $f=1$. The edge direction histogram thus obtained has translation, scale and rotation invariance [11].

(2) Target detection technology

Traffic sign detection is a specific application of target detection technology. It can accurately detect and locate the area where the target is located, and then accurately segment the target object, which can bring great convenience to the next step of recognition. This paper mainly carries out detection according to the color and shape of traffic signs [12].

(3) Target recognition technology

Traffic sign recognition is a specific application of target recognition technology. With the development of modern science and technology, especially the wide application of computer technology, pattern recognition technology has become an indispensable technology in various fields. It is a technology that simulates human recognition ability and belongs to the theory of automatic discrimination and classification [13]. The identification process to be adopted in this paper is shown in Figure 1.

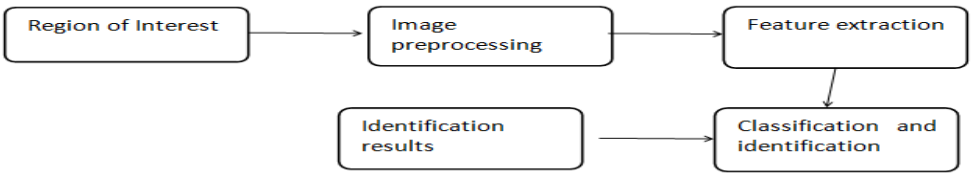

Figure 1. Target identification system process

2.2. Support Vector Machine Algorithm

(1) Kernel function

The nonlinear vector machine is relatively favorable for the case where the linear sample is unavailable, mainly by using the selection of the kernel variable in the relaxation variable C. In this paper, formula (3) of radial basis function is selected as the kernel variable of vector machine [14].

$$F(u,u_x)=\exp\left\{-Gamma^*\left\|u-u_x\right\|^2\right\} \tag{3}$$

Where Gwnwa refers to the width of the basis function.

(2) Cross validation

Cross examination is to classify the original data in a sense, including first training the model with training set, and then training the model with test set, which is used as the main performance index of the evaluation module [15].

3. Research on Traffic Sign Detection and Recognition Based on Color Features and Improved Support Vector Machine Algorithm

3.1. Traffic Sign Area Screening

(1) Image binarization

In order to prevent the traffic sign area from being filtered out, the empirical threshold combined with adaptive threshold is used to replace the empirical threshold. It reduces the possibility of being filtered out due to the small area of traffic signs [16]. The specific implementation steps are as follows.

1) Calculate the area of connected areas in the image;
2) Set experience threshold;
3) The empirical threshold is used to divide all connected regions into two regions;
4) The maximum and minimum values of the calculation area;
5) Do not calculate the sum of the average gray values of the region;
6) Calculate the area threshold;

(2) Traffic sign positioning

After filtering the interference area, the traffic signs are located. Especially when the obtained traffic sign image contains multiple traffic signs, the location of traffic signs is very important. When locating traffic signs, the method of scanning pixels from left to right and from top to bottom is generally adopted, and traffic signs are labeled [17].

3.2. Test Data Sample

This experiment passes the dataset GTSDB, which is a collection of 900 natural scene images taken by the vehicle camera. The size range of images is 1360 * 800 pixels. The number of traffic signs in each scene is different, usually 0 to 6, and the size of traffic signs is between 16 * 16 and 128 * 128 pixels. The detection task of GTSDB is to detect four types of traffic signs, namely, warnings. Table 1 shows the quantity distribution of each category [18].

Table 1. Quantity distribution of four signs

Category	Number of identification types	Number of training samples	Number of test samples
Speed limit	7	1876	5400
Blue	6	4859	1650
Red	6	1238	760
Remove speed limit	8	6531	1320

4. Research on Application of Traffic Sign Detection and Recognition Based on Color Features and Improved Support Vector Machine Algorithm

4.1. Establishment of Traffic Sign Detection and Recognition Model

Because the external environment where traffic signs are located is very complex, a series of operations that can reduce interference are required during detection, such as noise removal, image enhancement, image segmentation based on color characteristics, and traffic sign area screening. In the recognition phase, this paper classifies traffic signs according to their shape and color characteristics. The first level classification divides the candidate areas into three categories according to the color characteristics of traffic signs: yellow, red and blue; In the secondary classification, each candidate area is further identified, and invariant moments are used to describe the features of the candidate area to determine which specific traffic sign the candidate area is, and its corresponding standard image and text interpretation are displayed. The overall flow chart of the algorithm is shown in Figure 2.

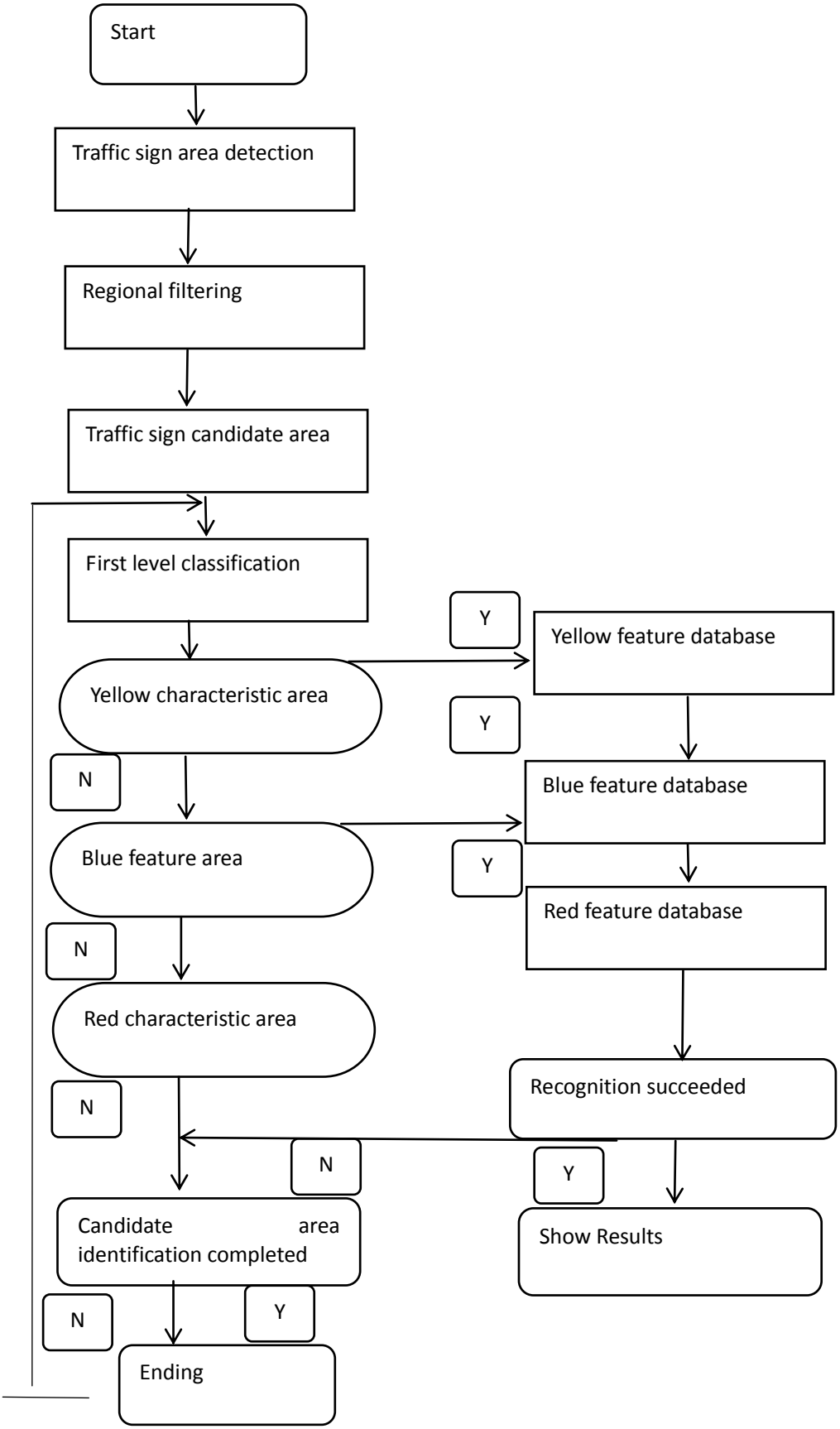

Figure 2. Identification model

4.2. Application of Traffic Sign Detection and Recognition Model

In order to further analyze the algorithm, 50 kinds of traffic signs are divided into six types according to their meanings, and four of them are selected for comparative experiments with cyclic neural network (CNN) and decision tree (DT). It includes red speed limit sign, blue sign, danger sign and speed limit lifting sign. The test results are shown in Table 2.

Table 2. Comparison results of algorithm identification

Algorithm	ISVM	CNN	DT
Danger signs	98.65%	90.21%	89.45%
Red sign	95.39%	92.11%	87.23%
Blue sign	97.43%	91.68%	88.76%
Release flag	96.65%	90.89%	96.79%

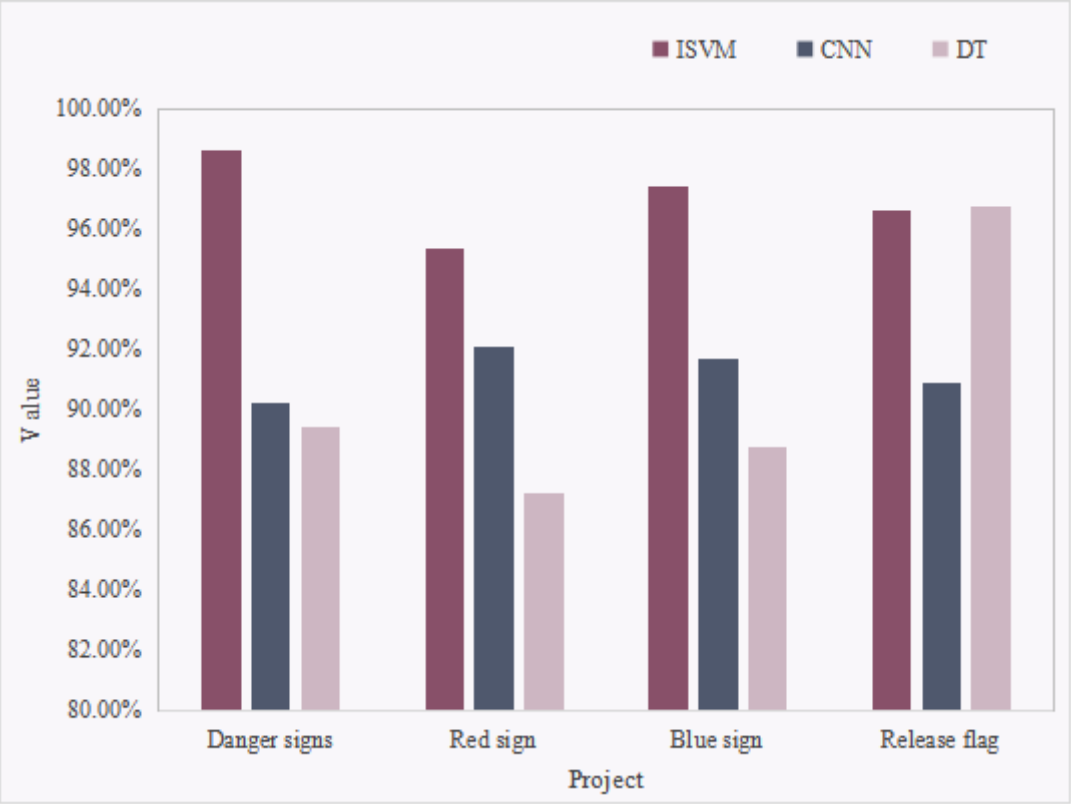

Figure 3. Comparison of algorithm detection and recognition performance

It can be seen from Figure 3 that the improved support vector machine (ISVM) algorithm achieves 98.65% accuracy in hazard sign recognition. The accuracies of recurrent neural network (CNN) and decision tree (DT) are 90.21% and 89.45% respectively. The recognition accuracy of ISVM algorithm for red speed limit sign reached 95.39%, and the accuracy of cyclic neural network (CNN) and decision tree (DT) reached 92.11% and 87.23% respectively. ISVM algorithm achieves 97.43% accuracy in blue mark recognition, 91.68% accuracy in cyclic neural network (CNN) and 88.76% accuracy in decision tree (DT). The recognition accuracy of ISVM algorithm for speed limit release sign reaches 96.65%, and the accuracy of cyclic neural network (CNN) and decision tree (DT) reaches 90.89% and 96.79% respectively. To sum up, the improved support vector machine (ISVM) algorithm and cyclic neural network (CNN) are superior to the decision tree (DT) algorithm.

5. Conclusion

In this paper, the algorithm combining color features and shape features is used to detect traffic signs. First, by analyzing the image enhancement algorithm and color segmentation method in traffic signs, this paper uses the color component color difference method based on the standard R/B map to segment the image color, and remove a large number of background areas in the image. Secondly, a large number of noise regions in the binary image are removed by setting the area threshold and aspect ratio with the area marking method, and the multi-scale MSRCR algorithm is used to further enhance the image and improve the image quality. Then, Canny operator is used for feature extraction. Finally, the projection method is used to locate and segment the traffic sign area. Because the classification recognition rate trained directly using features cannot meet the system requirements, this paper uses an improved grid search method to find the best parameters. Experiments show that this method can effectively improve the classification recognition efficiency.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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