License Plate Segmentation and Recognition of Chinese Vehicle Based on BPNN

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Abstract—In order to make the computer own the knowledge about Chinese vehicle license plate segmentation and recognition, the paper put forward a set of algorithms about license plate segmentation and recognition. The algorithms are divided into four parts: image preprocessing, license plate location, license plate segmentation and character recognition. The aim of image preprocessing is quickly and easily location the license plate, so the image preprocessing algorithm is one of the important factors that affect total system performance. Because the algorithm of license plate location directly affects the accuracy of character segmentation and character recognition. So, the algorithm of license plate location is proposed according to characteristics of Chinese vehicle license plate. The algorithm of license plate segmentation uses the vertical projection method about license plate in this paper. According to the license plate segmentation character, the training model can be generated using tool of BPNN(back propagation neural network), which is the key of the character recognition algorithm about license plate. The results of experiment based the algorithms in the paper illustrate that accuracy rate of character recognition is very high, and the algorithms can fully meet the actual demand of automatic recognition. The algorithms can take advantage of the training model to perfectly realize recognition the license plate, and have application value in the real work.

Keywords-image processing; license plate segmentation; BPNN(back propagation neural network); training model; license plate character recognition

I. INTRODUCTION

With rapid economic development and urban expansion, transportation volume increased year by year. The traffic management has also become more complex. In order to alleviate traffic pressure and improve vehicle management efficiency, a set of license plate segmentation and recognition algorithms should be put forward. The algorithms are based on a computer vision system on vehicle license for a specific target, are one of the important research topics of computer vision and pattern recognition technology in the field of intelligent transportation applications. The algorithms can be widely used in automatic toll management system of highways, bridges, tunnels, urban transport vehicle management, intelligent community, intelligent parking management, license plate validation, detection of stolen vehicle tracking, traffic statistics, and other fields, The algorithms are broad application prospects.

License plate location is to find the location of the vehicle license from the intake of car images, and accurately segments the character of license plate. Therefore, the determination of the license area is one of the important factors that affect system performance. The accurate positioning of a license directly affects the accuracy of character segmentation and character recognition, and has a direct impact on the efficiency of the license plate recognition system. Vehicle images are collected from the natural environment, which the imaging conditions of the license plate and the background in the natural environment in general is not controlled, especially lighting conditions and complex background information brought great difficulties to the target search, coupled with the shooting different distances, angles, the plate area is very difficult to distinguish from the various interferences. And the special nature of application requires completing license plate location quickly and accurately.

So if there is no efficient search method, a lot of computing time and storage space will be consumed. License plate positioning technology has always been a difficult thing, is a key technology in the license plate recognition technology.

This paper describes the image preprocessing algorithm, license plate location algorithm, license plate segmentation algorithm and character recognition algorithm. The entire algorithms use edge detection, image erosion operation, image clustering, rand transform, morphological processing, window searching and BPNN(back propagation neural network) technologies etc. Especially, this paper detail describes the processing of the training model generated by tool of BPNN. The training model is the key of the character recognition algorithm about license plate.

II. IMAGE PREPROCESSING ALGORITHM

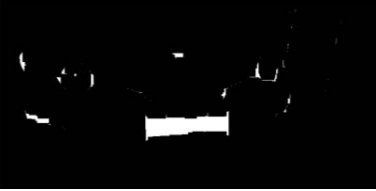The original image is shown in Figure 1.

Figure 1 original image

The purpose of image preprocessing is to quickly and accurately locate the position of the license plate. However, the location of license plate is one of the important factors that affect the performance of the entire system.

TABLE Ⅰ illustrates the step and result of original image preprocessing.

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TABLE I.　　　Step and result original image preprocessing

Step	Result
1.Original image is converted to gray image which has cuted top.	
2.Edge detection using Roberts operator.	
3.Image erosion operation, and image clustering, fill the image.	

Step (cont.)	Result
3. According to the location of the license plate region, in the corresponding position of the gray image interception of license plate image.	
4. To determine the tilt angle of the license plate, and use the Radon transform to correct the license plate image.	

III.　LICENSE PLATE LOCATION ALGORITHM

Because the accurate location of a license directly affects the accuracy of character segmentation and character recognition, and has a direct impact on the efficiency of the license plate segmentation and recognition system.

The length and width of the Chinese license plate are as follows: The ratio of the length and width of the license plate is 4.5:1, that is, the area and perimeter of the relationship as equation (1).

$$(4.5*L*L)/ (2*(4.5+1)*L)^2 \approx 1/27 \qquad (1)$$

In order to locate the accurate positioning of the license plate, the following steps should be deal with on the basis of the original image preprocessing. The aim is to find and exact location the license plate.

TABLE Ⅱ illustrates the step and result of location the license plate.

TABLE II.　　　Step and result of location the license plate

Step	Result
1.It is certainly not the image of the license plate area removed which is too small.	
2. To locate the license plate, the white area expansion, corrosion removal of irrelevant small objects (including the license plate characters). According to the formula 1 standard to determine and find all the connection area, which is the most likely area of the license plate area.	

IV.　LICENSE PLATE SEGMENTATION ALGORITHM

In order to accurately extract the characters in the license plate, the structure and format of the China standard license plate must be clearly known.

China standard license plate format: A1 A2 ▪ A3 A4 A5 A6 A7, A1 is a Chinese character, which is the abbreviation of the provinces, municipalities and autonomous regions; A2 is the English alphabet; A3 A4 A5 A6 A7 respectively represent a number or English alphabet; there is a dot delimiter between A2 and A3.

Figure 2 China small vehicle license plate standard format

As shown in Figure 2, license plate outline size is 140mm * 440mm; character size is 90mm * 45mm; gap character is 90mm * 12mm; characters and plate outer contour of the distance between the bottom border is 25mm; the distance between characters and plate outer contour of the left and right borders is 15.5mm; the distance between the second and the third character is 34mm; the distance of dot diameter is 10mm. Using these prior knowledge can help us to effectively segment the license plate.

Character segmentation refers to segmenting the rectangular image area into small regions; each region has an independent character.

In this paper, the vertical projection method for character segmentation is adopted. The steps of the vertical projection method are as follows.

A. Statistic Pixe to Array

After locating the license plate position, according to the license plate image standard format of Figure 2, the width of each character is certain, the space between second and third characters is greater than the space between the other characters. Thus, after performing a vertical projection, the width of each character is defined as the length of the segment, the left and right ends of the image are used as the boundary.

Binary image of the license plate is vertical projected, the statistics of each column of white points are saved in sum[j]

array, J is the value of the corresponding column. Analyze projection value, character regions are generally correspond to peaks which accounted for position, and character is shown between the trough; Figure 3 illustrates the graphics for sum[j] array.
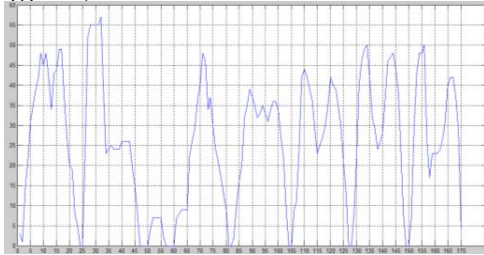

Figure 3 sum[j] array of graphics

B. Character Segmentation

According to giving the threshold value t, get each crest of the starting point and ending point coordinates which are stored in the array left[j] and right[j]. J is the corresponding wave number.

According to the above steps, the character segmentation results are shown in Figure 4.

Figure 4 character segmentation results

V. CHARACTER RECOGNITION ALGORITHM

A. Sample Collection of Training Mode

The license plate character recognition needs to have a good recognition model, so, the license plate character of the training samples must be collected. In order to collect the sample of the license plate character, locate bellow of the segmented character images, and manual input corresponding correct character information as shown in the following Figure 5.

Figure 5 input corresponding correct character information

Character images (Figure 4) are classification stored in the corresponding folder according to the corresponding correct character information (Figure 5).

Collection of license plate training samples of Chinese characters "苏", license plate training samples of the English letter "B" and number "8" are respectively shown in figure 6-a, 6-b, 6-c, which respectively is one of Chinese characters, English letters and digitals representation.
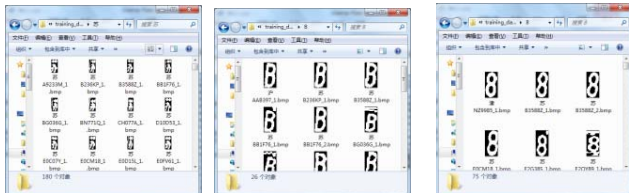

Figure 6-a Chinese character Figure 6-b English letter Figure 6-c digital

B. Generate Training Model using BPNN

According to character images are classification stored in the corresponding folder generate train model.

1) Run the toolbox of the neural network pattern recognition, and then fill neural network parameters of inputs and outputs.

2) Validation and test data sets are each set to 15% of the original data. With these settings, the input vectors and target vectors will be randomly divided into three sets.

a) 70% are used for training;

b) 15% are used to validate that the network is generalizing and stop training before over fitting;

c) The last 15% are used as a completely independent test of network generalization.

3) Hidden numbers of neurons have a great impact on the generation of the training model, so select the appropriate value in the course of the experiment is very important. Experiments are repeated, at last, the number of hidden neurons is defined 30. Figure 7 shows the relation of input, hidden layer, output layer and output.
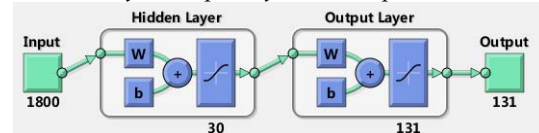

Figure 7 the relation of input, hidden layer, output layer and output

4) Train the neuron network to classify the inputs according to the targets using scaled conjugate gradient back propagation, and then generate the training model.

The scaled conjugate gradient back propagation is the simplest optimization algorithm. It updates the network weights and biases in the direction in which the performance function decreases most rapidly, the negative of the gradient. The iteration of this algorithm can be written as following equation (2):

$$\mathbf{x}_{k+1} = \mathbf{x}_k - \alpha_k \mathbf{g}_k \qquad (2)$$

Where $\mathbf{x}_k$ is a vector of current weights and biases, $\mathbf{g}_k$ is the current gradient, and α_k is the learning rate. This equation is iterated until the network converges.

5) Click the "Train" button to generate the training model, which performance is shown in Figure 8.
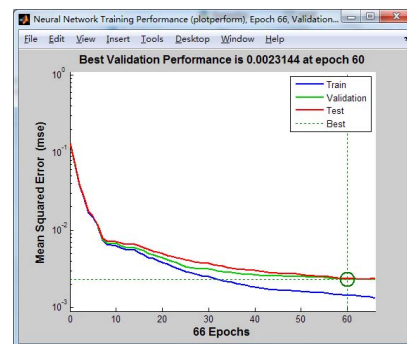

Figure 8 the result of training model performance

VI. EXPERIMENT OF VERIFICATION RESULT

A. Verify License Plate Segment Algorithm

In order to verify accuracy of the license plate location and segmentation algorithm, any vehicle image need tested. Figure 9 is the experiment result of verify segmentation algorithm.

Figure 9 experiment result of verify segmentation algorithm

B. Verify Character Recognition Algorithm

The recognition algorithm is based on the generated the training model. Figure 10 shows the recognition result of the License Plate.

In order to verification convenience, filename of license plate image is named as same as charter of the license plate. If character of figure 10 is not same as character of the License Plate, the character will be displayed by red color. Figure 10 shows the verification result of license plate recognition, which has error code marked by red color.

Figure 10 recognition result

In order to verify the accuracy of the recognition, figure 11 shows the accuracy of license plate recognition.

Figure 11 verify recognition accuracy rate

There are 13 license plates recognition which have been verified. Eleven license plates are correctly identified. The correct license plate recognition rate is 84.62 percent.

There are total 91 characters which have been verified. Characters of 89 are correctly identified. The correct character recognition rate is 97.80 percent.

VII. CONCLUSION

Four algorithms of image preprocessing, license plate location, license plate segmentation and character recognition are introduced in this paper. License plate location is the basis of image preprocessing. The location of license plate has a direct impact on the accuracy of character segmentation.

The image preprocessing algorithm, license plate location algorithm, license plate segmentation algorithm not only are prepared for generating training mode, but also are prepared

for character recognition algorithm. The training model is generated using the character segmentation images by BPNN. The training mode is the key of entire algorithms in this paper, the tool of BPNN is the important method. Training model is involving in parameters configuration of neural network function. If license plate has been wrongly identified, you need to mark the wrong recognition character, which should be stored in the sample library of character images. The sample data has been added in order to generate the excellent training model which can enhance the recognition accuracy rate of license plate. This process can continue to cycle until the training model substantially reaches the required recognition accuracy rate.

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