A Method of License Plate Recognition Based on BP Neural Network with Median Filtering

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Abstract. With the rapid increase of cars, the research of license plate recognition in intelligent traffic algorithm has attracted much attention. In this paper, pointing at the shortcomings of the existing recognition algorithm, we adopt a license plate recognition method based on BP neural network with a median filtering. The method consists of a median filtering algorithm for denoising and a BP neural network for training and testing. First the character library is processed by median filtering to remove the influence of noise. Then, utilizing the strong learning ability of BP, the character library is passed into the network for classification. Compared with the traditional algorithm, our method not only speeds up the recognition efficiency, but also obtains more robust results. Therefore, the proposed approach can provide a technical support for the practical application of license plate recognizing.

1. Introduction

With the popularity of cars in people's homes, traffic management becomes more and more complicated. Therefore, it is urgent to develop the Intelligent Transportation System (ITS). As the technical support of the Intelligent Transportation System, the License Plate Recognition (LPR) technology has irreplaceable significance in traffic management. In this paper, we propose a license plate recognition method based on BP neural network with a median filtering. It is demonstrated by experiments that the method has an excellent effect on Chinese character recognition.

For many years, scholars have done a lot of research on license plate recognition technology. There are two main types of approaches. (1) License plate recognition based on template matching algorithm [1-5]. This method is easy to implement and has less time complexity. This method is sensitive to noise, resulting in a large error in the calculation distance. This will reduce the recognition accuracy. (2) License plate recognition based on feature statistical matching [6-8]. This method has better robustness than plate recognition based on template matching algorithm. However, it is time-consuming to extract features manually. In view of the problems existing in the above methods, we adopt the BP neural network with median filtering for character recognition. This method saves the time of feature extraction and ensures a high recognition rate. BP neural network [9-15] has the advantage of strong generalization ability and wide application prospect.

The main contributions of this paper are as follows: (1) We proposed the median filter algorithm to remove the influence of noise on the character library. This ensures that the result of character recognition is more accurate. (2) We adopted a method of automatically extracting character features using BP neural network. This method saves the time of feature extraction and ensures a high recognition rate.
2. Proposed algorithm

2.1. The median filter is used for denoising

Character images of the character library are subject to a lot of noise pollution during the formation process. In this paper, the median filtering algorithm is used for denoising processing. Median filtering is a nonlinear signal smoothing technique based on sorting statistics theory that can effectively suppress noise. It sets the gray value of each pixel to the median of the gray values of all pixels in a neighborhood window at that point.

In this paper, we chose to use the 3×3 template, then we get 9 pixels in the field. We need to sort the 9 pixel values. (1) Sorting the pixels in each row in the template in descending order to obtain the maximum, the intermediate, and the minimum. (2) Compare the minimum obtained by the three rows and take the maximum. (3) Compare the maximum obtained by the three rows and take the minimum. (4) Compare the median of the three rows and take the median. (5) The median obtained by sorting the three values in (2), (3), (4) is the median of the template. The idea of the algorithm is shown in Figure 1.

![Figure 1. The sorting algorithm](image)

2.2. Use BP neural network for identification

In order to learn 65 kinds of features from the character library, it is necessary to have a neural network model with strong learning ability. The BP neural network can learn and store lots of input-output pattern mapping relations when the mathematical equation of the mapping relation is unknown. In addition, The BP neural network is a multi-layer feedforward neural network. It consists of two processes: the forward propagation of the free signal and the back propagation of the error.

![Figure 2. BP neural network model](image)
2.2.1. Node setting. In this paper, we adopted the simplest BP neural network model, which consists of three layers: input layer, single hidden layer and output layer. Since our image size is 12×24, we set the number of input layer nodes to 288. Since we need to learn 65 types of features, we set the number of output layer nodes to 65. Generally speaking, the more hidden layer nodes, the better the training effect. However, it also increases training time. The basic rules for determining the number of hidden layer nodes are as follows: Under the premise that the accuracy is high enough, the nodes of the hidden layer should be as few as possible. According to empirical formula (1), In this paper, the hidden layer nodes are set to 137.

\[ m = \sqrt{n l} \]  

(Where m represents the nodes of the hidden layer, n represents the nodes of the input layer, and l represents the nodes of the output layer)The network model is shown in Figure 2.

2.2.2. Forward transfer process. The output value of each layer node is based on the output value of all nodes in the upper layer and the weight and current threshold and activation function between the nodes in the two layers. Here we use the sigmoid function for the activation function. See formula (2) for details.

\[ S(x) = \frac{1}{1 + e^{-x}} \]  

2.2.3. Reverse transfer process. The reverse transfer process is more complex. It is based on the Widrow-Hoff learning rules. The main purpose of BP neural network is to modify the weights and thresholds repeatedly to minimize the error function. See formula (3) for details.

\[ E(w, b) = \frac{1}{2} \sum_{j=0}^{n-1} (d_j - y_j)^2 \]  

In equation (3), \( d_j \) is the output result, \( w \) is the weight, and \( b \) is the offset. See equation (4) for the jth output node.

\[ \Delta w(i, j) = -\eta \frac{\partial E(w, b)}{\partial w(i,j)} \]  

Where \( \eta \) is the learning rate. According to the gradient descent method, the weights and thresholds between each layer are adjusted as follows:

\[ w_{ij} = w_{ij} - \eta_1 \frac{\partial E(w, b)}{\partial w_{ij}} \]  

\[ b_{ij} = b_{ij} - \eta_2 \frac{\partial E(w, b)}{\partial b_{ij}} \]

2.2.4. Improvement of BP neural network. In order to speed up the convergence, we introduce the momentum term. See formula (7) for details.

\[ w_{ij} = w_{ij} - \eta_1 \frac{\partial E(w, b)}{\partial w_{ij}} + \alpha \Delta w_{ij} \]

The momentum factor \( \alpha \) is generally selected from 0.1 to 0.8. Introducing the momentum term so that the adjustment changes to the average direction without causing a large swing. The effect of the momentum term is to buffer the smoothness so that the error changes very little.

3. Experiment results and analysis
Our algorithm is based on MATLAB 2017a and Windows 10 operating system. The computer is configured as an intel i7 CPU and 8G RAM. At the same time, a character library containing Chinese characters, letters and numbers is used for training.
3.1. Image preprocessing
Image preprocessing consists of gray processing, image enhancement and edge extraction. Gray-level processing transforms the original color image into gray-level image, reduces the amount of calculation and reduces the burden of operation. Then the histogram equalization method is used to enhance the image. This makes the boundaries between the license plate part and the non-license plate part clear and easy to extract. Finally, Canny algorithm is used for edge detection and edge extraction. The results are shown in Figure 3.

![Figure 3. Image preprocessing](image)

(a) Grey processing          (b) Image enhancement          (c) Edge detection

3.2. License plate positioning
The so-called positioning license plate, simply means that in order to accurately search for the license plate position. This part consists of positioning license plates, split license plates, and correcting license plates. The first step is to locate the license plate according to the closed field of the license plate color, the length to width ratio value, and the license plate located at the position of the vehicle. The second step is to statistically mark the area distribution of the license plate area, and find out the edge of the license plate to complete the division operation. In the third step, the segmented license plate is Radon transformed to determine the tilt angle. Then use the Imrotate function to perform rotation correction to get the final license plate. The results are shown in Figure 4.

![Figure 4. License plate location](image)

(a) locate the license plate          (b) license plate segmentation    (c) correct license plate

3.3. Normalized processing
For the convenience of recognition, we segment the whole license plate into a single character style and normalize it. In this paper, we uniformly process the segmented characters into images with a pixel size of 12×24. The results are shown in Figure 5.

![Figure 5. Character segmentation](image)
3.4. Character recognition

Input the character library into the BP neural network, set the parameters of the BP neural network and conduct 500 iteration training. The BP neural network automatically analyzes and extracts character features. In the BP neural network training process, statistical learning is performed on complex information, and the learning result is used as a prior knowledge to guide the subsequent identification process. This ability can improve the recognition rate of characters. We perform median filtering on the character library and then passed into the neural network for training and testing. We compared this method with the traditional BP neural network, and the results are shown in table 1. In order to show the effectiveness of the algorithm, we also compare it with Match Template and SVM. The results are shown in the table 2.

| Table 1. Comparison of result 1. |
|----------------------------------|
| Model                           | The total number of the license plate | The number of wrong license plates | The accuracy of license plates |
|----------------------------------|--------------------------------------|-----------------------------------|-------------------------------|
| BP [9-15]                        | 100                                  | 7                                 | 93.00%                        |
| BP with median filtering         | 100                                  | 4                                 | 96.00%                        |

From the comparative experiments in Table 1, we know that our method outperforms the traditional BP neural network [9-15]. The quality of the character image is enhanced by median filtering. The process leads to an increase in recognition rate.

| Table 2. Comparison of result 2. |
|----------------------------------|
| Model                           | The total number of the license plate | The number of wrong license plates | The accuracy of license plates |
|----------------------------------|--------------------------------------|-----------------------------------|-------------------------------|
| Match Template [1-5]             | 100                                  | 18                                | 82.00%                        |
| SVM [8]                          | 100                                  | 16                                | 84.00%                        |
| Our Model                        | 100                                  | 4                                 | 96.00%                        |

From the table 2, The accuracy of template matching and SVM are 81% and 84% respectively, and the accuracy of our method is 96%. We know that Match Template [1-5] and SVM [8] are not ideal for recognition and our algorithm has better recognition effect than traditional methods.

4. Conclusion

In this paper, in order to realize the correct identification of Chinese license plates, we introduce a license plate recognition method based on BP neural network with a median filtering. Through median filtering, image quality is enhanced, which facilitates the BP neural network learning features. The correctness of the method is verified by experiments. Our experiment has achieved the accuracy of more than 93%, which is better than the traditional recognition method.

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