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The Research of Vehicle Plate Recognition Technical Based on BP Neural Network

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Abstract

In the aspect of character, after analyses of license plate recognition technology home and abroad, we use weighted statistics to make plate in the image in a more prominent position. At the same time, we combine the thick grid feature extraction and momentum BP algorithm to distinguish license. This method improves the accuracy and speed of character recognition.

Keywords: vehicle plate location; the thick grid feature extraction; Character recognition; BP neural network

1. Introduction

With the development of social economy, the automobile industry and the transport industry, road transport has become much more important than railway transport. But with the increasing popularity of motor vehicles, the phenomenon of traffic congestion is getting more serious and automated traffic management has become a serious problem. Intelligent Transport System (ITS)[1] produced an effective solution to this problem, which is proposed on the Intelligent Transportation Society of the United States in the 1990.

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License Plate Recognition (LPR) is an important component of ITS, applied in the field of electronic billing. As a special computer vision system in the real-tine case, the LPR system mainly includes the sub system of license plate detection and character recognition. The LPR system involves numerous discipline domains, such as Pattern Recognition and Artificial Intelligence, Computer Vision, Digital Image Processing etc. The LPR system can distinguish the license plate numbers, letters and Chinese characters, making the computerized monitoring and management a reality.

Based on image processing technology, the ultimate goal of LPR system is to identify all the license plate number and the color from the picture. It is difficult to search for license plate characters directly from the collected images. In order to reduce difficulty, the general part of the LPR software is divided into three modules: the license plate location, character segmentation and character recognition. The task of license plate location is to determine plate position from the picture. The task of character segmentation is to cut out one by one after the positioning of characters in license plate images. The task of character recognition is to identify characters by segmentation.

2. Image Preprocessing

Due to many factors, the quality of images is poor in the process of signal collection and importation. It usually contains different degrees of noise, blurred, tilted and defected. The pretreatment will have a direct impact on the ease of recognition and identification of results. Pretreatment can not only remove the image noise, improve image quality and reduce the negative impact, but also effectively reduce the required storage space of the system and improve the recognition speed. Image preprocessing usually includes gray-scale transformation, noise reduction, and image enhancement processing.

2.1. Image gray processing

As the camera used to capture images of the car are 24-bit true color image, while the majority of image processing techniques are directed at the 256 grayscale image, so it is necessary to convert the color image into the grayscale image. The RGB color of grayscale and color image in grayscale image correspondence transformation relations are

$$g(i, j) = 0.11 \times R(i, j) + 0.59 \times G(i, j) + 0.3 \times B(i, j) \qquad (1)$$

And g is gray value of (i, j), R, G, B represent three primary color value of this spot.

2.2. Image noise removal and edge enhancement

The method of noise removal has airspace law (such as median filtering, k average neighbor, etc.) and frequency-domain method (low-pass filter and high-pass filter). Based on the vehicle license plate identification, the edge definition of objects is higher. Therefore, we select the value filtering to carry on the image smoothing.

In order to enhance the contrast of images, make license plate and the background contrast stretching, to enhance image processing is necessary. In fact, image enhancement is an amendment to grayscale image. The main objective is to improve the definition of contour lines of license plate number. While the balance of technology of the straight side chart is the best and the algorithm is simple. In this paper, we use the gray histogram balanced method to the image enhancement. Suppose having n levels grayscale image, and the probability of i level grayscale appearance is p_i, so it contains the information content is

$$I(i) = p_i \log \frac{1}{p_i} = -p_i \log p_i$$

The entire image which contains the information is

$$H = \sum_{i=0}^{n-1} I(i) p_i \log p_i$$

With uniform distribution of the image histogram, the information content H is the biggest and $p_0 = p_1 = \ldots\ldots = p_{n-1} = \dfrac{1}{n}$. As mentioned above, the primitive histogram of image transformation for the close histogram of uniform distribution is the histogram equalizing.

3. License plate location

The license plate localization is the region which extract license plate from the plate image containing the license plate. In this paper, we use a weighted statistical method to make plate position to be prominent in the image. It is the concrete principle as follows.

The object of weighted statistical method is the image which is composed of the element 0 and 1, carries on the line-by-line scanning to 2 value image, and adds a positive integer m to the weight value of a specific rectangle domain around the pixel that the value is 1. For example, the original image matrix as shown in table 1. The specific rectangle domain is 3×3, and m values is 1. After carring on the weighting operation, we obtained matrix as shown in table 2.

Table1. The original image matrix

0	0	0	0	0	0
0	0	1	1	1	0
1	0	0	0	0	0
0	0	1	0	0	0
0	0	1	0	1	0
0	0	0	0	1	0
1	0	0	0	0	0
0	0	0	0	0	0

Table2. The image matrix after weighting

0	1	2	3	2	1
1	2	2	3	2	1
1	3	3	4	2	1
1	3	2	3	1	1
0	2	2	4	2	2
1	2	1	3	2	2
1	1	0	1	1	1
1	1	0	0	0	0

The length and breadth proportion of specific rectangle domain is 3.14:1(standard car license proportion of length and breadth). We carry on the weighting statistics operation to three kinds of graph as shown in figure 1 (a), and get the result as shown in figure 1 (b).

Figure1.(a)The original image (b) The image after weighting

4. Feature Extraction

According to statistics of China's motor vehicle licensing standards[3], China has three types of standard license plate to identify different objects at present. They are Chinese character, English character and digital & English, including 51 Chinese characters, 25 capital letters except I and 10 digitals. A total of more than 80 license plate characters have the same size and uniform.

The thick grid feature named as local gray feature is a part of Statistical characteristics. First, the thick grid feature extraction method is made the size and position of recognized characters normalized. Second, divide grid into $N \times N$ part and count the number of pixels of each grid. Each of the grid reflects a particular character. In the identification stage, the grid is combined as statistical characteristics to identify the characters.

4.1. Image gray processing

In order to eliminate bias on the lattice position, we need to move the whole lattice images of characters to the stipulation position, this process is known as the location of the normalized[4]. This paper uses the method based on the center of mass position normalization. First, calculate the outside frame of characters, and discover the center, then move the characters center to the position which assigned. The anti-jamming ability of this method is strong. Calculate character center (x_c, y_c)

$$x_c = \sum_{x=L}^{R}\sum_{y=B}^{T} x \cdot f(x,y) \bigg/ \sum_{x=L}^{R}\sum_{y=B}^{T} f(x,y), \quad y_c = \sum_{x=L}^{R}\sum_{y=B}^{T} y \cdot f(x,y) \bigg/ \sum_{x=L}^{R}\sum_{y=B}^{T} f(x,y)$$

where $f(x, y)$ is two value matrices of characters, and x, y are respectively abscissa direction and longitudinal direction. Moreover T, B, L, R express the character's top, bottom, left and right boundary separately.

The process that makes the transformation to the characters of different size, and cause them to become the identical size is called the size normalization. There are commonly has two kinds of size normalization methods.

One kind is that to reduce or enlarge the character outside frame to proportionate unification size. The other kind is to carry on the size normalization according to the distribution of black picture element on horizontal and the vertical direction (goal picture element).

4.2. Character feature extraction

For reserved character overall construction and detail characteristic, after normalization, each pixel as a grid point input to neural network sorter. The car license character 5(e.g. Figure 2(a)) is normalized the proportion size of 4×4 (e.g. Figure 2 (b)). The black picture element is 1, and the white picture element is 0.

Transform each line of elements to 16×1 matrix as the neural network the data.

(a)   (b)

Figure2.(a) Wait recognition character (b) 4×4 grid characteristic chart

5. Character recognition algorithm based on BP neural network

5.1. Technology of BP neural network

BP neural network is essentially a set of samples of the input and output that is transformed into a nonlinear optimization problem. It is a learning algorithm through the gradient algorithm for solving the question of the weight (e.g. Figure 3).

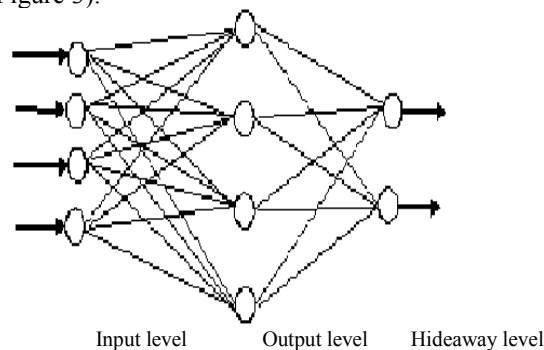Input level   Output level   Hideaway level

Figure3. BP neural network model

The BP algorithm has not only the input spot, the output spot, but also one or many concealed spots. Regarding the input signal, firstly, it should disseminate the concealed stratification spot forward. After action function, BP disseminates the implicit strata point's output signal to the output spot. Finally network gives the output result. Excitation function usually selects the function:

$$f(x) = \frac{1}{1 + e^{-\frac{x}{e}}}$$

where Q is Sigmoid parameter of adjustment form.

Suppose n points that of characters are Sigmoid in a random network. For simplicity, assign the network have an output y, and the output of any point i is o_i, and equipped with N samples $(x_k, y_k)(k = 1, 2, 3 \cdots, N)$.

To the input x_k, the output is y_k. The output of point i is o_{ik}. The output of point j is $net_{jk} = \sum_i w_{ij} o_{ik}$, and defines the error function as

$$E = \frac{1}{2}\sum_{k=1}^{N}\left(y_k - \widehat{y}_k\right)^2$$

where $\widehat{y}_k$ is network actual output.

Define

$$E_K = \left(y_k - \widehat{y}_k\right)^2, \delta_{jk} = \frac{\partial E_k}{\partial net_{jk}},$$

$$o_{jk} = f(net_{jk}),$$

so

$$\frac{\partial E_k}{\partial w_{ij}} = \frac{\partial E_k}{\partial net_{jk}} \cdot \frac{\partial net_{jk}}{\partial w_{ij}} = \frac{\partial E_k}{\partial net_{jk}} \cdot o_{ik} = \delta_{jk} o_{ik}.$$

When j is output,

$$o_{jk} = \widehat{y}_k, \quad \delta_{jk} = \frac{\partial E_k}{\partial \widehat{y}_k} \cdot \frac{\partial \widehat{y}_k}{\partial net_{jk}} = -(y_k - \widehat{y}_k)f'(net_{jk}) \tag{2}$$

When j isn't output,

$$\delta_{jk} = \frac{\partial E_k}{\partial net_{jk}} = \frac{\partial E_k}{\partial o_{jk}} \cdot \frac{\partial o_{jk}}{\partial net_{jk}} = \frac{\partial E_k}{\partial o_{jk}} f'(net_{jk}), \quad \frac{\partial E_k}{\partial o_{jk}} = \sum_m \delta_{mk} w_{mj}. \tag{3}$$

So,

$$\delta_{jk} = \sum_m \delta_{mk} w_{mj} f'(net_{jk})$$

$$\frac{\partial E_k}{\partial w_{jk}} = \delta_{mk} o_{ik} \tag{4}$$

If there are M levels in network, the level of M only contains outputs, and the first level is input point, the step of BP algorithm is:

One step is to select the initial weight;

Another step is to redundant the following process until restraining.

1) Count o_{ik}, net_{jk} and $\widehat{y}_k$ when $k = 1, \ldots N$ forward process). To each level reverse count from M to 2 (reverse process).

2) Regarding identical point $j \in M$, calculate δ_{jk} based on formula (2)-(4).

3) Revise weight,

$$w_{ij} = w_{ij} - \mu \frac{\partial E}{\partial w_{ij}}, \mu > 0, \text{ where } \frac{\partial E}{\partial w_{ij}} = \sum_{k=1}^{N} \frac{\partial E}{\partial w_{ij}}.$$

When revising the weight gradient descent law, before considering the gradient direction, we frequently defer to the negative gradient direction on k times, thus causes the shake of learning process, and the convergence rate is slow. For this reason propose the law that has the momentum gradient descent.

$$w_{ij}(k+1) = w_{ij}(k) + \eta[(1-\alpha)d(k) + \alpha d(k-1)]$$

where $d(k)$ is the negative gradient on k times, η is learning speed, and $\alpha \in [0,1]$ is momentum factor. When $\alpha = 0$, The correction of weight is only related with the current negative gradient. The weight revision was decided by the negative gradient which previous time circulated.

5.2. Design BP network

(1) Input level's number: To be normalized the grid of 4×4, take each picture element spot as a network, and the input level neuron number takes 16.

(2) Output level's number: 51 Chinese characters, 25 capital letters except I and 10 digitals.

(3) Concealed level's number: This article uses three BP neural network that only has a concealed level. Concealed level's number is calculated by the formula[6]:

$$s = \sqrt{m+n} + c,$$

where n is input number, m is output number, s is concealed number, and c is integer between 1~10. So, there have 18 Chinese characters, 16 English character and 15 digitals in concealed level. The initial weight of BP network is defined in $[0,1]$. The initial value of learning factor and the momentum factor is respectively 0.1 and 0.9.

5.3. The result of experiment

Through the recognition to nearly 100 vehicles license plates, we compared the momentum gradient descent law with the steepest descent law, and obtained error curves about the digital recognition (e.g. Figure 4, Figure 5).
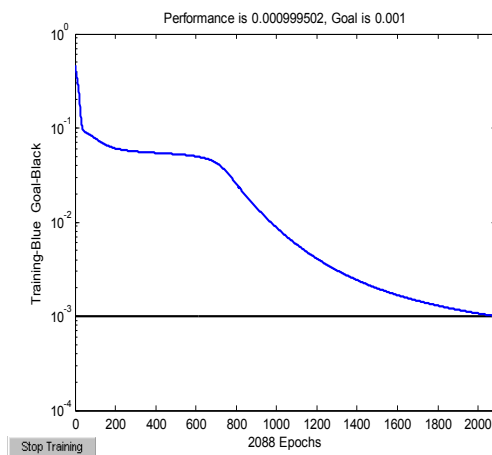

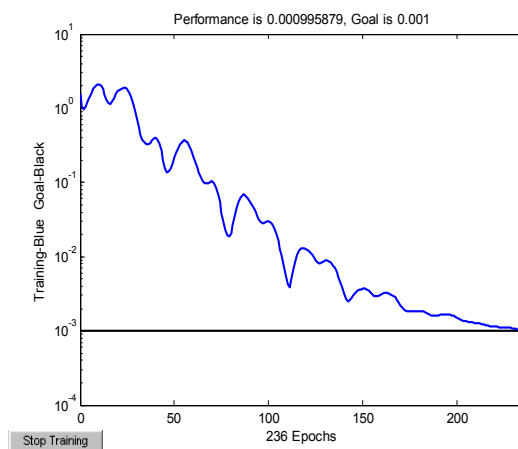Figure4. Error curves of the momentum gradient descent method   Figure5. Error curves of the steepest descent method

After analyze the experiment, we obtain that the momentum gradient descent law restrain quickly comparing with the steepest descent law. The momentum BP law needs to iterate 236 times to make error reach restraining, but the steepest descent method needs to iterate 2088 times.

Table3. Erroneous recognition rate

network type	Sample number	Recognition rate

Chinese character network	100	91.2%
English character	100	93.5%
Letter and digital network	100	94%
digital network	100	96.1%

We can see digital and the letter recognition rate is high by Table 3, but the Chinese character recognition rate isn't ideal. The reason is that on the one hand, English letter and digital quantity are few, but the Chinese characters are many. On the other hand, the structure of Chinese character is complex. In addition, in the actual operation light, weather, photography and other reasons also affect the recognition rate of Chinese characters.

6. Conclusions

In this paper we use weighted statistics to make plate in the image in a more prominent position. At the same time, we combine the thick grid feature extraction and momentum BP algorithm to distinguish license. The momentum gradient descent law restrains quickly comparing with the steepest descent law by experiment.

As there are so many kinds of plates, the paper only studies the common background of the blue license, thus the license for the other background is left for us to study in the future.

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