License plate recognition technology based on dual positioning

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Abstract

With the development of society, cars in people's lives have brought great convenience. The position of license plate recognition technology in the field of transportation is gradually improved. Therefore, the research of license plate recognition technology is particularly important. In this dissertation, a dual-positioning license plate recognition technology is proposed, starting with the preprocessing of the image, the edge detection of the Sobel operator and the mathematical morphological processing, locating the position of the license plate in the original image, denoising and morphological processing of the obtained license plate area and the positioning of a single character in the license plate, then a single character is filtered according to the aspect ratio of the character, and finally the characters in the license plate are identified by convolution neural network. Experiments show that the recognition time of this method can reach 0.15s, the recognition rate can reach 98%, the recognition speed is faster than the traditional license plate recognition technology, and the recognition rate is higher.

Keywords

License plate recognition, image processing, convolution neural network.

1. Introduction

With the continuous development of automobile industry, urban traffic has gradually become the focus of people's research. In transportation field, license plate recognition technology is an important means to collect vehicle information in traffic system. License plate recognition plays an important role in road toll management, public car park management, overspeed violations and other fields. The license plate recognition system can be divided into four parts: the acquisition and preprocessing of the original image, the location of the license plate area, the character segmentation of the license plate and the character recognition of the license plate. In this dissertation, a dual-positioning license plate recognition technology is proposed, after locating the position of the license plate, denoising and mathematical morphology of the license plate area, then continue to locate and rectangle the single character in the license plate, and then filter out the characters in the license plate according to the character aspect ratio. Experiments show that this method is better than the traditional method of first positioning and re-projection, and the recognition speed is more effective. The identification process is shown in Figure 1.
2. Image preprocessing

Typically, the vehicle images we collect through the camera and image card which are all color images. The color images are so complicated that they can’t be processed directly. If so, the processing speed of the system will be greatly affected. Image preprocessing is to grayscale and denoise the collected original image, and then carry out binarization processing on the image. In this dissertation, the R, G and B tri-color weighted average method is used to grayscale the image. The formula is as follows:

\[ f(x, y) = w_1 \times R(x, y) + w_2 \times G(x, y) + w_3 \times B(x, y) \]  

(2.1)

Among them, \(w_1\), \(w_2\) and \(w_3\) are the weights of the three-color components of \(R(x, y)\), \(G(x, y)\) and \(B(x, y)\) respectively, and \(w_1 + w_2 + w_3 = 1\). According to the different weight selection can obtain different grayscale images, a large number of experiments found that the sensitivity of the human eye to color, generally take \(w_1 = 0.299\), \(w_2 = 0.587\), \(w_3 = 0.114\), the obtained grayscale image effect is better [1]. In this dissertation, the median filtering method is used to filter the image after grayscale. The basic principle is to replace the value of a point in a digital image or sequence with the median value of the points in a field of that point. This method can protect the edge information of the image while removing the noise. The preprocessed image is shown in Figure 2:

![Image preprocessing](image)

3. License plate positioning

License plate area location mainly uses the method of Sobel operator edge detection and mathematical morphological operation to locate the license plate area, which can locate the position of license plate from the image, which is higher than the traditional single location method[2].
3.1 Sobel operator edge detection

The edge detection of the image is based on the change of the grayscale of the image to accurately locate the desired edge area. The uniform of license which are generally blue and white in our country, which resulted in the existence of abundant edge information to select edge detection operator for license plate area in this dissertation.

The operator is obtained by convolving the original image \( f(x, y) \) with two convolution kernels \( g_1(x, y) \) and \( g_2(x, y) \). Its mathematical expression is:

\[
S(x, y) = \max\{\sum_{m=1}^{M} \sum_{n=1}^{N} f(m,n) g_1(i-m,j-n), \sum_{m=1}^{M} \sum_{n=1}^{N} f(m,n) g_2(i-m,j-n)\}
\] (3.1)

In fact, the algorithm adopted by Sobel edge operator is to carry out by weighted average first and then carry out by differential operation. We can replace the first partial derivative with difference. The calculation method of the operator is as follows:

\[
\begin{align*}
\Delta_x f(x, y) &= [f(x-1, y+1) + 2f(x, y+1) + f(x+1, y+1)] - [f(x-1, y-1) + 2f(x, y-1) + f(x+1, y-1)] \\
\Delta_y f(x, y) &= [f(x-1, y+1) + 2f(x-1, y) + f(x-1, y+1)] - [f(x+1, y-1) + 2f(x+1, y) + f(x+1, y+1)]
\end{align*}
\] (3.2)

The Sobel operator template shown in Figure 3, detects the edges of the horizontal direction in the image, while the latter detects the edges of the vertical direction in the image. Use these two templates to convolution operations on each pixel point in the image, taking its maximum value as output [3]. The image after the Sobel operator is marginalized is shown in Figure 4.

![Sobel operator template](image)

(a) Horizontal orientation templates  
(b) Vertical orientation templates

3.2 Mathematical morphological treatment

Mathematical morphology is a subject of image analysis based on Glenn and topology, and it is the basic theory of mathematical morphological image processing. In Digital image processing,
mathematical morphology is mainly based on the two basic operations of corrosion and expansion, which composed of open operation, closed operation, skeleton extraction, limit corrosion and other operations. Different combinations of these operations can constitute different image analysis and processing methods[4].

(1) Image corrosion
The effect of image erosion is to eliminate the boundary points of the object, to narrow the target, and also to eliminate noise points smaller than the structural elements. Therefore, the size of the structural elements is different, and the noise removed is also different. Corrosion can also separate the characters in the connected area. The mathematical expression of corrosion is as follows:

\[ E = F \ominus S = \{ (x, y) \mid S_{xy} \subseteq F \} \]  
(3.3)

Where F is the original binary image, S structural element and E etched binary image.

(2) Image expansion
Image expansion and image erosion are dual operations. Image expansion can expand the target area, merge the background points touched by the target area into the target, and expand the target boundary to the outside. In the license plate area positioning process, it can be used to fill the gap of the license plate character area, so that the entire license plate area forms a zone together with the area to determine the position of the license plate. The mathematical expression of the expansion operation is as follows:

\[ E = F \oplus S = \{ (x, y) \mid S_{xy} \cap F \neq \emptyset \} \]  
(3.4)

Where F is the original binary image, S structural element and E etched binary image.

(3) Open and close operation
The opening and closing operation are based on corrosion and expansion. The process of first corrosion and then expanding is called the opening operation. The process of first expanding and then corrosion is called closing operation. The open operation removes isolated pixels and eliminates the effects of fine noise to smooth the target area. Closed operations fill small gaps in the target area and connect adjacent targets. The image after the morphological operation of the license plate image is shown in Figure 5:

\text{a) Corroded image} \hspace{1cm} \text{b) Smoothing the image after corrosion} \hspace{1cm} \text{c) Remove small objects from objects} \hspace{1cm} \text{d) Positioned license plate area}

Figure 5 License plate positioning flow chart
4. License plate character segmentation

When segmenting the license plate characters, it is necessary to perform operations such as denoising, binarization, and tilt correction on the image after the license plate is positioned. In order to ensure the accuracy of character segmentation and the accuracy of character recognition in the next stage. There are many traditional license plate character segmentation methods, contour-based character segmentation, projection-based character segmentation, and character matching based on template matching. These methods are more complicated and affect the efficiency of license plate recognition. This dissertation proposes a dual positioning method for license plate character segmentation. Firstly, the license plate character is processed in a morphological manner, each character is separated separately, and then a single character is rectangular. Finally, according to the aspect ratio of the license plate character is 3.14. The rectangular box is filtered to locate a single character [5][6]. The specific operation process is shown in Figure 6:

![Figure 6 Car license plate character segmentation flow chart](image)

5. Character recognition

The traditional license plate character recognition mainly includes recognition methods based on character structure features, recognition methods based on template matching, recognition methods based on neural networks, and classification recognition methods based on support vector machines. In the character recognition part of this dissertation, the convolutional neural network method is used for identification.

Convolutional neural networks are a kind of deep network that uses convolution to extract images, which has strong robustness. Convolutional neural networks are mainly divided into input layer, hidden layer and output layer. The hidden layer can be three-layer convolutional layer for feature extraction, sampling layer for feature optimization and extraction, and fully connected layer. Because China's license plate characters are composed of Chinese characters, letters and numbers. There are 65 categories in total. Considering the difference between Chinese characters and letters and numbers in the license plate, two classifiers can be designed to classify them, one for Chinese characters and one for letters and numbers. Therefore, the convolution model can be roughly divided into 7 input units and 65 output units (including 31 Chinese characters). After the network model is built, the data needs to be trained. The 31 Chinese characters are numbered one by one, from 0 to 30, and the numbers and letters are numbered from 34 characters, from 0 to 33. 1000 Chinese characters should be selected, a total of 31 categories, 1200 numbers and letters, a total of 34 categories, training models on the CPU for i5-3230, and supervised learning [7]. The model training recognition rate is shown in Table 1, and the license plate recognition result is shown in Figure 7:
Table 1 Network model training recognition rate

<table>
<thead>
<tr>
<th>Number of samples</th>
<th>Recognized number</th>
<th>Unrecognized number</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese character(1000)</td>
<td>965</td>
<td>35</td>
<td>96.5%</td>
</tr>
<tr>
<td>Letters and numbers(1200)</td>
<td>1137</td>
<td>27</td>
<td>98%</td>
</tr>
</tbody>
</table>

6. Conclusion

This dissertation uses the dual positioning method to characterize the vehicle license plate. After pre-processing the image, the combination of Sobel operator and morphology is used to locate the license plate area, and the positioned license plate is tilted and corrected, and a single character is positioned and rectangular. A single character is filtered based on the aspect ratio feature of the license plate character. Finally, characters are input into the convolutional neural network to identify the characters. This method not only quickly locates the license plate, but also makes the character segmentation process easier and more precise. Experiments show that the recognition accuracy of this method is about 98%, and the recognition time is about 0.15s.

References