A license plate recognition algorithm based on image processing technology

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Abstract
With the development of society, license plate recognition systems had become an important part of intelligent transportation systems, and had been widely used. In this paper, the existing license plate recognition algorithm was optimized by the image processing technology.Firstly, by means of the collected original gray-scale image processing,three methods of color-to-gray image were proposed. Then the edge detection was carried out, and the Sobel operator was chose as the optimal edge detection method by using four kinds of edge detection operators. Finally,according to the genetic algorithm construct the method of boundary location,the license plate was located on the basis of the column scan, and accuracy rate was up to 97%.
Key words: LICENSE PLATE RECOGNITION, GRAY SCALE, EDGE DETECTION, GENETIC ALGORITHMS, BOUNDARY LOCATION.

1. Introduction

With the improvement of people's living standard, the cars had become the part of family life.However the rapid increase of the number of cars had more and more negative affects and road usage had improved at the same time,so intelligent transportation system was very important on facilitating vehicle management[1].

The essence of the intelligent transportation system was the use of various high-tech means, information technology, electronic control technology and computer processing technology, and the traditional transportation system was transformed into a new modern traffic system on road traffic flow information of a comprehensive real-time monitoring in order to effectively solve the traffic accidents, such as traffic congestion and so on. In order to establish and improve the intelligent transportation system, different vehicles needed to be identified,so the license plate recognition technology was crucial. The license plate recognition algorithm was mainly studied in this paper ,which was designed to contribute to the development of intelligent transportation system.

In view of the research of the license plate recognition system, many predecessors had made a lot of contributions.Tongyan Liu and Zhou Liang had further studies on the license plate recognition algorithm in the use of computer vision and pattern recognition technology, which put forward the improved algorithm and the ultimate development of license plate recognition system[2-3].Li Chi and Sixing Zhang improved the adaptive PCNN neural network on image pre-processing and the edge of the complete binary image. Then A new form of learning method improved the speed of recognition algorithm by lots of candidate regions of license plate and the effect was relative ideal[4-5].Chen K and Jun Xiong studied the license plate recognition system on the edge degree analysis algorithm of license plate location and license plate character segmentation algorithm and culminated in the character recognition based on hog features.And then selecting 500 license plate image experiments which was proved that the character recognition algorithm of high accuracy had made a significant contribution to license plate recognition technology [6-7].

Combined with image processing technology ,the existing license plate recognition algorithm was optimized based on previous studies. Firstly, by means of the collected original gray-scale image processing,-three methods of color-to-gray image were proposed. . Then, the edge detection was carried out and the Sobel operator was the most optimal edge detection method by using four kinds of edge detection operators. Finally, the license plate was located on the basis of the column scan, according to the genetic algorithm construct the method of boundary location.

2. Image preprocessing

the original image collected by the camera often was affect by the surrounding environment, light illumination and camera angle. Such images would cause serious difficulties for the follow-up work about license plate recognition. Therefore it was necessary to preprocess the image including image gray transformation, image value and image edge detection[8].

2.1. Gray invert of image

Commonly used vehicle license plate image acquisition equipment is a digital camera, video camera, which is the original image of the original image into a color image, it is known as the RGB image. RGB is a kind of model, color from red, green, blue superposed. RGB color image contains the amount of color information is too large, the need to take up large memory, which will reduce the system running speed.This problem could be solved by the formation of gray images. Gray level images only contain intensity information, which greatly reduces the amount of information and improves the operating speed of the system[9]. The principle and method of color image was through the following algorithm to RGB equal, is $R = G = B$.

If selecting R, G, B value of the largest one, and then adjust the other two, is equal to the maximum value of three,

$$R = G = B = \frac{R + G + B}{3} \tag{1}$$

If the mean value of the gray level is equal to the color, as shown in the formula (2),

$$R = G = B = \frac{R + G + B}{3} \tag{2}$$

According to other indicators to the three color to give different weights, so that the gray value is equal to the weighted average value of the three color, as shown in the formula (3),

$$R = G = B = \frac{W_R R + W_G G + W_B B}{3} \tag{3}$$

The gray image is represented by the Y component in the YUV color space, which contains all the information of the gray image, and the calculation method is shown in the formula (4),

$$Y = 0.3R + 0.59G + 0.11B \tag{4}$$

2.2. Two value of the image

Binary image is the image into an image by a black and white composition. According to the license plate recognition system[10], the value of the two images is the key to find the proper threshold, distinct object and background. A variety of methods to binary image, this paper for the license plate recognition sys-

tem, proposed the Bimodal law to carry out the two value of the image, speed and easy to achieve. Bimodal law to draw the histogram of the input image, if the image target object and background contrast, in the histogram appear two valley, a valley values in the target region, another valley value in regional background, two valley value intersection where trough, wave valley was chosen as a threshold as shown in Figure 1, you can target and background can be separated, complete the image binarization.

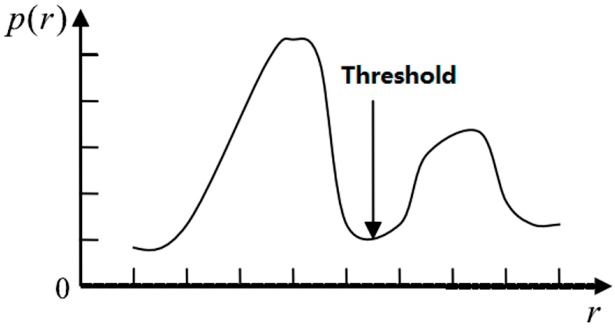

Figure 1. Bimodal law histogram

2.3. Edge detection

Edge detection is on at the final step of the above image preprocessing and segmentation of license plate based, is the key technology of a connecting link between the preceding and the following, in view of the above, the gray image, the edge is often to gray level jump form. In this paper, we use differential operation to represent the change of the function, so we can draw the edge of the image. The edge extraction can be used for the first order differential and the second order derivative in differential operation. Image $f(x,y)$ at the point (x,y) of the first order differential definition, as shown in the formula (5),

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial x} \end{bmatrix} \quad (5)$$

Formula (5) in the gradient intensity by formula (6) said

$$|\nabla f| = \sqrt{G_x^2 + G_Y^2} \quad (6)$$

Laplace operator is the two order differential, which can be used to solve the edge strength, the formula is

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \quad (7)$$

In view of the actual title of license plate recognition system, to simplify the calculation, the first-order derivative, second-order differential expressed in the form of differential operator, this paper selects four differential operators for edge detection: Roberts operator, Sobel operator, Prewitt operator, LOG operator, and compare the effect of detection results.

As the Roberts operator, when the image edge is detected, on a per pixel computing the gradient and seeking the absolute value, the threshold operation. Its approximate differential expression is

$$G_R = |f(x,y) - f(x+1,y+1)| + |f(x+1,y) - f(x,y+1)| \quad (8)$$

Template of Roberts operator [4],

$$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \qquad \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \quad (9)$$

As the Sobel operator, the Sobel operator is not a simple mean difference, but a weighted average of the difference, which is shown as follows

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad (10)$$

As the Prewitt operator, Prewitt operator has the effect of suppressing the noise, the principle is the pixel average. Template for

$$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \quad (11)$$

As the LOG operator, it was the two order reciprocal operator, also need to use the template to achieve. The common two kinds of templates are

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \qquad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \quad (12)$$

LOG operator could not detect the direction of edges, so it was not used for edge detection in its original form. Before the LOG operator was performed, it was required to make a smooth. The concrete method is to make the image and the Gauss function for convolution calculation, and then carry out the LOG operator, and the calculation process is shown in the formula (13)

$$g(x,y) = \nabla^2 (G(x,y) \otimes f(x,y) = (\nabla^2 G(x,y) \otimes f(x,y) \quad (13)$$

Where the $G(x, y)$ in the Formula (13) is the Gauss function.

Through the above four kinds of operator principle and template, combined with the MATLAB software for image edge detection, edge detection results are shown in Figure 2.

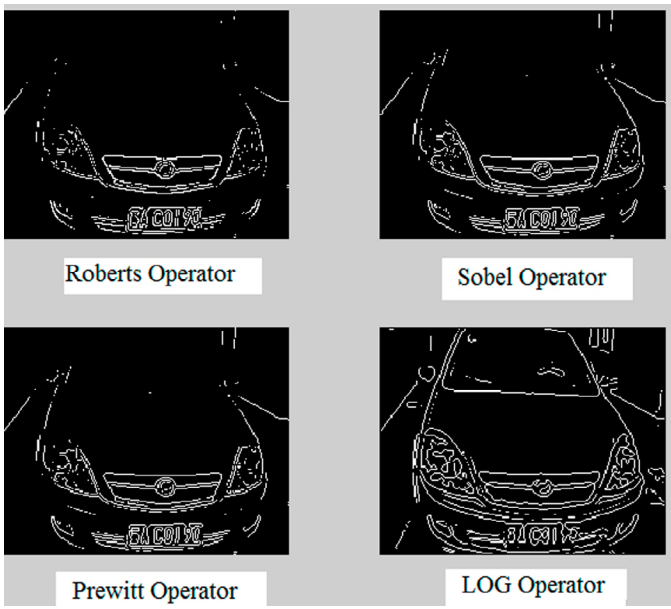

Figure 2. four operator edge detection effect

Through the experimental process and results the Figure 2 showed that a lot of information was lost in use of Roberts operator while those weak edge information was not reflected. Instead of the Roberts operator the edge information was retained too much using LOG operator.The edge detection effect in use of Prewitt operator and Sobel operator were between Roberts operator and LOG operator. Sobel operator was a better choice with noise inhibition ability for the license plate recognition, so Sobel operator was selected as optimal edge detection method, which was beneficial to the following license plate location.

3.Vehicle license plate locating method

3.1. The license plate location based on column scan

The input image was expressed in the form of matrix which was regarded as a $i \times j$ matrix F , and the value of the element $F(i, j)$ indicated the gray value of the pixel of the point located in line j and column j . So the license plate region pixel gray value would be greater than the surrounding with a row of pixel gray value accumulation of the longitudinal coordinate, and each column of the matrix elements could form one-dimensional matrix, using a formula (14)

$$G(j) = \sum_{k=round(i/3)}^{i} F(k, j) \qquad (14)$$

The column scanning image could be draw for G index as abscissa and the elements of G value as the ordinate.Because of the symmetry of the car the scanning image showed certain symmetry, and the image was shown in Figure 3.

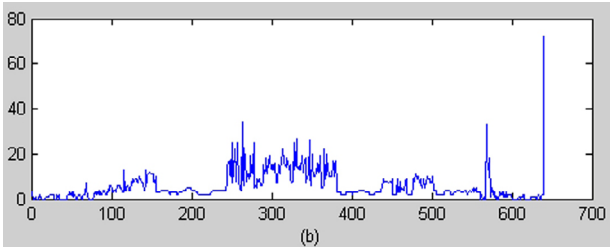

Figure 3. The column scan imaging of certain symmetry

For ease of handling calculated average value of all the elements in the matrix,the column scan imaging of certain symmetry could be seen from the Figure 3, while below average values of elements G' were used instead of zero and redraw column scan was shown in Figure 4.

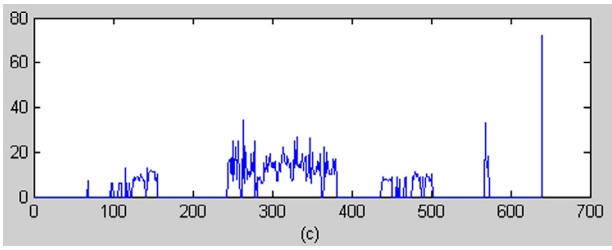

Figure 4. Processing of scanned images

According to the Figure 4 the algorithm of the left and right of the license plate was as follows.The zero area was found in the continuous length of G that was greater than twenty, and the central position of the region was marked.The gray value changes of the two markers were recorded, and the change of each gray level was recorded as a jump.Comparing jump times the jump with the largest number of regions was the

license plate area, so this area from the first nonzero position to the last nonzero position was the plate boundary. In MATLAB software the license plate location effect was shown in Figure 5.

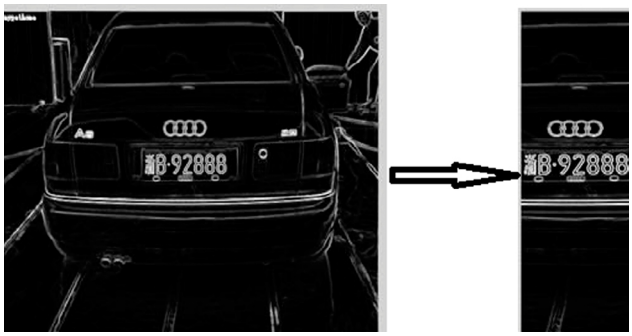

Figure 5. The effect of vehicle license plate boundary location

Through the license plate location process, a large number of more information were removed and the operating speed was improved , so the search range would be greatly reduced in the next upper and lower boundary positioning process.

3.2. Boundary location of license plate based on genetic algorithm

The genetic algorithm was selected as license plate boundary location method due to the principle of genetic algorithm. The design of fitness function was based on the key point of genetic algorithm and remarkable characteristic on boundary location of license plate image was rich texture features in the area of license plate while other areas of basic were not changed. Therefore, the adaptation degree functions were designed according to texture feature. In the process of positioning, the image of the isolated points and lines must be first filter out by two kinds of operators, as shown below:

The threshold is 6 for the T_1 operator detection width of a pixel,and the threshold is 8 for operator T_2 outlier detection.When the calculated values was greater than or equal to the threshold, the operator superimposed and moved the image and the detection and removal of target were completed.

$$T_1 = \begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix} \tag{15}$$

$$T_2 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \tag{16}$$

A license plate image shown in Figure 6 was selected, and its size was $m \times n$, which corresponded to a $m \times n$ matrix W . The length of the license plate was $n/3$ and the license plate length and width ratio was about 3, so the license plate width was $n/3$.

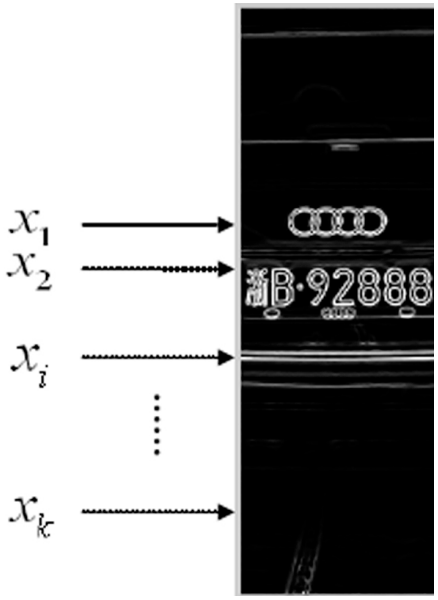

Figure 6. The license plate image after the left and right locations

The symbol $x_1, x_2, \cdots x_k$ was used to represent the number of points corresponding to the matrix W in the interval $[1, \ m]$. Assuming that the symbol x_i was the point of the upper left corner of the rectangle, the symbol n was the rectangle length, and the $n/3$ formed a rectangle region. Then the rectangle area was as an area to be searched, and the T value of the region was calculated and recorded as T_i. Each point corresponds to a rectangular area, so the T value of each region was calculated and recorded as $T_1, T_2, \cdots, T_K$ .Symbol $[1, \ m]$ was the range of the population and symbol $x_1, x_2, \cdots x_k$ was the individual of the population and symbol k represented the number of individuals, so symbol $T_1, T_2, \cdots, T_K$ was the target function value for each individual. Finding out the individual maximum of the objective function value, then the rectangular region of the corresponding certain was the license plate region usually located in the middle and lower part of the image, so individual range began to search for $[m/3, m]$ from one-third of the image, as shown in Figure 6.

4. Comprehensive experimental test

From one hundred captured digital camera image test samples,a total of 97 pieces could accurately identify the license plate,and positioning renderings were shown in Figure 7.

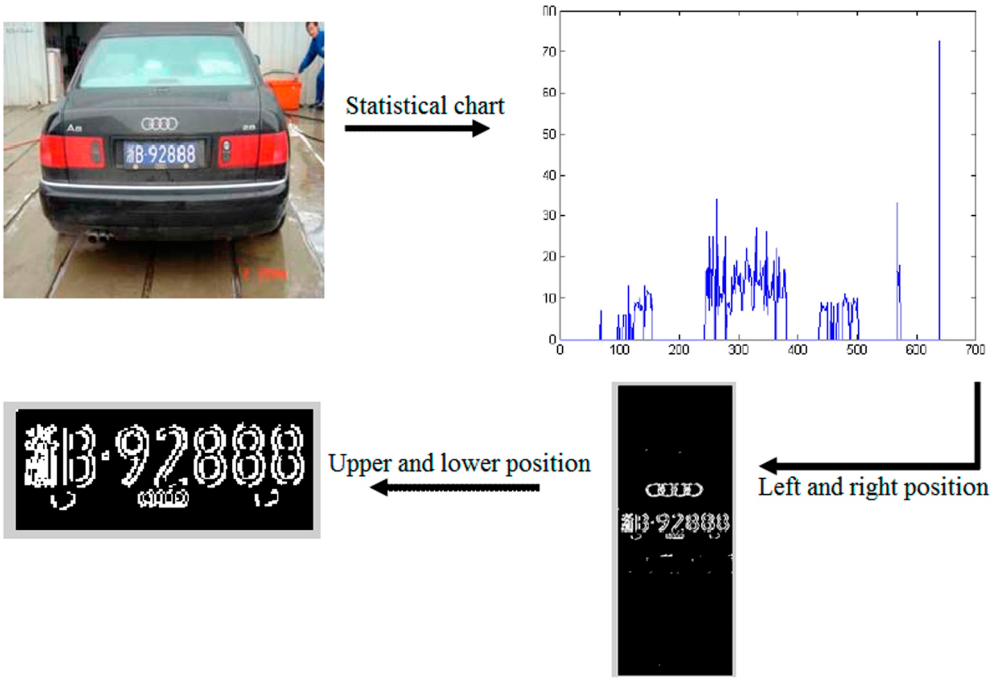

Figure 7. The effect of a license plate location map

Through 100 pieces of sample image test, it showed that because of the car image symmetry the plate boundary could still locate in the case of more complex and interference, which can largely eliminate the interference so as to greatly reduce the number of iterations in the subsequent genetic algorithm. Recognition method of license plate location made full use of the left and right and the efficient genetic algorithm on localization and simplicity based on the image processing technology ,and the picture of the complex had a good positioning effect so that accuracy rate was up to 97%..

5. Conclusion

The existing license plate recognition algorithm had been optimized based on previous studies combined with image processing technology. By means of collected original gray-scale image processing, three methods of color-to-gray image were proposed. Among four differential operators for edge detection,that is, Roberts operator, Sobel operator, Prewitt operator, LOG operator, Sobel operator was the best optimal edge detection method for the license plate recognition by comparing the effect of detection results, which was beneficial to the following license plate location.

The license plate boundary location method was construct taking advantage of genetic algorithm.The genetic algorithm on efficient localization was simple and produced a good positioning effect for the complex picture.

The image processing technology was applied to license plate recognition, which had made important contributions in optimizing the license plate recognition system, and expands the application of image processing technology. The image processing technology can be not only applied to license plate recognition, but also more picture processing work, so as to promote the development of all related technologies.

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Prediction of the trend of network attacks based on mechanism analysis method

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Abstract
With the development of Internet, network attacks are more and more.Network attacks have jeopardized all sectors, and even national security.The development trend of network attacks could be predicted through the mechanism of analysis.The model of network attacks was briefly built by principle analysis. Some experiment simulation were made by dealing with the data collected from the Internet,and the