

License Plate Recognition Based on Edge Detection Algorithm

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Abstract—with the development of vehicles and the increasing number of cars in modern society, people pay more and more attention to the vehicle license plate recognition system. Vehicle license plate recognition is divided into three parts: license positioning, character segmentation and character recognition. This paper proposes a new way of vehicle license plate recognition. In license positioning, the license positioning method is based on median filtering double edge detection; in character segmentation, it adopts a combinative method of locating the original level and improved vertical projection segmentation algorithm; in character recognition, the recognition method is based on classification template matching of font characteristics. The proposed license recognition method focuses on the timeliness of recognition process. Its smaller calculation largely reduces the time of license recognition, with high accuracy and precision rate at the same time.

Keywords—license recognition; edge detection; vertical projection; template matching

I. INTRODUCTION

As an important method of car control, the license recognition system obtains the information of cars through analysis processing of the collected images. Thus, it gives an effective management of cars. It plays a positive role in preventing traffic jams, increasing roads and bridges toll service and easing the traffic tension. Based on the related theory of digital image processing and technology research and analysis, this paper makes research and improvement in license positioning, character segmentation and character recognition, which are the three parts of the license recognition system.

License positioning segments the plate from the complicated scene. By combining the median filtering double edge detection method, on the one hand, it effectively eliminates the unrelated marginal information on the scene with complicated images, and on the other hand, it saves more time compared with other edge detection methods. Segment the plate character into single character zone on the located plate image, and automatically obtain the image of single character for the next step of recognition. This paper adopts a combinative method of locating the original level and improved vertical projection segmentation algorithm, quickly realizes the tilt correction of plate and eliminates the effects of noise on character segmentation accuracy. Character cognition extracts features from the segmented

characters and then recognizes the character. This paper adopts classification template matching of font characteristics, largely reduces the time of template matching and effectively eliminates the misidentification of similar characters.

The proposed license recognition method features high accuracy, speed and timeliness.

II. LICENSE POSITIONING

The objective of license positioning is to segment the plate from complicated background [1] [2]. It is the key component of license recognition. The effectiveness of location will directly affect the following operation of character segmentation and character recognition.

A. Pretreatment of the Image

1) Graying of Original Image

Generally, the data size of original plate image is the larger one: 24 bits true color image, which is mixed with R (red), G (green) and B (blue) [3]. Each color is artificially graded into 256 levels from 0 to 255. The colored images can represent $256 \times 256 \times 256 = 166777216$ kinds of colors according to various combinations of R, G and B. The calculated amount of direct processing these colors is extremely large. It goes against the timeliness and feasibility of plate recognition system. So the first step is to transform the original image into 256-level gray image, convenient for computer processing. Gray-scale image only have brightness information instead of color information. The original image and the histogram of grey-scale image are shown in Figure 1. Its small amount of information is in favor of quick image processing.



(a)

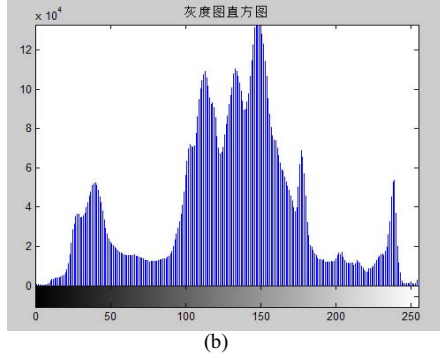


Figure 1. (a)The original image , (b) the histogram of grey-scale image.

B. License positioning based on double edge detection

Edge is one of the most fundamental and important features of image. It represents in sudden change in partial gray scale, and refers to a set of pixels with step change or those with roof change of the surrounding pixel gray. Edges on both sides belong to the two regions respectively. The gray level of each region is uniform, but there are some differences in character between the two regions. License plate location based on double edge detection takes advantage of severe change in license plate character color and background in the gray-scale; detect the edge of license plate character to achieve the license plate location. Double edge detection of license plate location method [4] is a method combining of edge detection and multi-scale mathematical morphology. We can get the result of edge detection, as shown in Figure 2. License plate, with differences in color of text and background color, has rich edge image edge, so the detection can effectively highlight the license plate area.

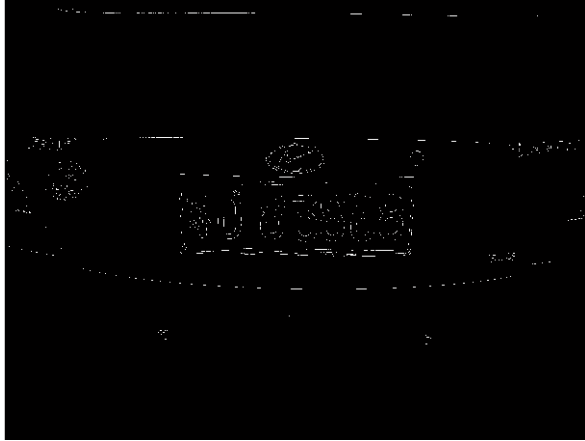


Figure 2. The license plate image of edge detection by Sobel operator

Firstly, make edge extraction of the noise filtered image by longitudinal Sobel operator [5]; Then, use a larger expansion erosion operator [6] in processing image in the first step, to calculate the connected domain for possible license plate area; and then make edge extraction of the processed image by vertical Sobel operator; use a smaller expansion erosion operator in processing image of the

previous step to calculate the connected domain for a more precise plate region. Finally, make use of priori knowledge, such as moderate range of length and width, a certain range of length-width ratio, etc. Reject the dissatisfactory alternate license areas. Figure 3 shows the license plate image of positioning.



Figure 3. The license plate image of positioning

III. CHARACTER SEGMENTATION

Character segmentation is to segment the characters on the plate one by one which involves two important elements: (1) tilt correction of the plate; (2) character segmentation.

A. Correction of Tilt Inclination

This paper proposes a new plate correction method based on positioning the original horizontal line [7]. The purpose of plate correction is to correct the characters to the right horizontal position; determine the inclination based on Hough [8] by finding the license plate upper and underside of the frame. Making a segment that represents for the tilt inclination instead of finding one will greatly reduce the correction time. The plate correction method is proposed on the basis of the method of positioning the original horizontal line.

- Segment the image into 3 equal parts along the vertical direction, select the middle part;
- Make binarization processing on the image by improved Ostu algorithm [9] [10]. Figure 4 shows the comparison between the grey scale image and the image of binaryzation. Make vertical pixel projection segmentation and meet the requirements that there is at least a complete character in two segmentation regions;



Figure 4. The grey scale image and the image of binaryzation

- Select any segmentation region with complete character. And select the highest white pixel position and the lowest white pixel position in this region, and make a detection line across the two points;
- The upper detection line can rotate centering on the highest pixel position of the middle character. The detection line crosses the white region both leftwards and rightwards for three times, and then obtains the successful positioning. The low detection line is similar to it. And the two lines have almost identical slope;
- After positioning the original horizontal line, the tilt declination can be determined according to the current slope of the horizontal line. Then through

rotation, correct the tilt plate. The rotation transformation formula:

$$\begin{pmatrix} x' & y' & 1 \end{pmatrix} = \begin{pmatrix} x & y & 1 \end{pmatrix} \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}.$$

The main calculation amount of license plate tilt correction based on positioning the original horizontal is to make projection of pixel value for partial license plate image. The inward approximation can be used in detection line adjustment. Generally, the tilt angle of the license plate can be obtained through only 4 to 5 times of adjustment. Therefore, the calculation is greatly reduced, saving the time of correction.

B. Characters Segmentation

1) Median Filtering For Noise Reduction

Median filtering [3] is a kind of partial smoothing technique, and also a kind of non-linear filtering. But its calculation is a simple weighted sum. Firstly, it sorts all the pixels of its region according to the gray-level. Then it selects the median of the group of pixels as the output value of processing. If the number of the pixels is even, select the average value of two middle pixels; if the number is odd, select the sorted median.

Generally, the window of median filter selects odd number. Its principle lies in replacing the one point pixel value in the image with the median pixel value of all points in one window region. The median is: a group of numbers X_1, X_2, \dots, X_n (n is an odd), if sorted as $X_{i1} \leq X_{i2} \dots \dots \leq X_{in}$, its median is Med

$X_{i1}, X_{i2}, \dots, X_{in} = X_{i[(1+n)/2]}$. Median filtering largely reduces the noise in the image and improves the quality of image. The result of median filtering is shown in Figure 5. This will help the processing and analysis of image characteristics.



Figure 5. the image of median filtering

2) The Process of Segmentation

Vertical projection [11] refers to the projection of two-dimensional image in the X direction, i.e. the total number of character pixel in the j line. The projection value $v(j)$

$$= \sum_{i=1}^m f(i, j). \text{ The vertical projection of image after}$$

pretreatment will form a valley bottom among adjacent characters. But there may be a valley bottom between Chinese characters or on both sides of the separators. Simply selecting the valley bottom as the basis of character segmentation will lead to errors. This paper proposed a new character segmentation method [3] [12] based on this method.

- Average segmentation projection. Each character on the plate generally takes the same mean width.

Segment the plate into 7 parts on average and the general position of each character is determined.

- Accurately determine segmentation line between adjacent characters. Center on the average segmentation line, and find the minimum projection value within a certain scope on both sides of the projection. The minimum value is the segmentation line of the two characters.
- Determine single character line. Through the above two procedures, the maximum left and right boundaries have been determined. Search rightwards from the left boundary until finding the character region and set it as the accurate left boundary; search leftwards from the right boundary until finding the character region and set it as the accurate right boundary. Finally, we get the characters of segmentation, as shown in Figure 6.

There are left and right frames and dot, so special treatment will be given to determine the left boundary of the first character, the left boundary of the third character and the right boundary of the seventh character.



Figure 6. characters of segmentation.

IV. CHARACTER RECOGNITION

Character recognition [13] is the last important step in the whole license plate recognition system. The classification template matching of font characteristics method [7] is used for character recognition. By detecting whether the characters pass specific detection area and excluding impossible character mode grade by grade in each region according to the results of detection, which largely reduces the amount of calculation and saves a lot of time, eliminating the misrecognition rate on similar characters.

- Detection of specific position window. Select 15 detection areas in the character images. Each area has 4 pixel points.
- Detect the color of each area after determination the position. Specifically: if the white pixel points take larger ratio than the threshold in the total area, this area is white, i.e. there are characters crossing the region.
- Grade it according to the detection areas. There may be 24 English letters and 10 figures on the plate. It could be found out that a certain character always crosses some detection areas, and not crosses some other detection areas according to the features of character.
- Exclude the pixel position. Upon completion of detection area sampling, exclude the recognized characters compared with the classification table. The characters crossing the area and characters without crossing the area are described in TABLE I.

TABLE I. TABLE OF CLASSIFICATION OF CHARACTER FEATURES

Detection area	Characters crossing the area	Characters without crossing the area
1	B, D, E, F, H, K, M, N, L, P, R, T, U, V, W, X, Y, Z, 3, 5, 7	A, C, G, J, Q, S, 2, 4, 6, 8, 9, 0
2	A, B, C, D, E, F, G, P, Q, R, S, T, W, Z, 2, 3, 5, 7, 8, 9, 0	H, J, K, M, N, U, V, X, Y, 6, 4
3	E, F, H, J, K, L, M, N, T, U, V, W, X, Y, Z, 5, 7	A, B, C, D, G, P, Q, R, S, 2, 3, 4, 6, 8, 9, 0
4	B, C, D, E, F, G, H, K, L, M, N, P, Q, R, S, U,	A, J, T, V, W, X, Y, Z, 3, 4, 6, 7
5	A, K, T, W, 3, 4, 6	B, C, D, E, F, G, H, R, J, L, M, N, P, Q, R, S, U, V, X, Y, Z, 2, 5, 7, 8, 9, 0
6	B, C, H, G, J, M, N, P, Q, R, S, U, 2, 8, 9, 0	A, D, E, F, K, L, T, V, W, X, Y, Z, 3, 4, 5, 6, 7
7	B, C, D, E, F, G, H, K, L, M, N, P, Q, R, U, 5, 0	A, J, S, T, V, W, X, Y, Z, 2, 3, 4, 6, 7, 8, 9
8	B, E, F, H, K, N, P, R, S, T, W, X, Y, Z, 2, 5, 6, 7, 8, 9	A, C, D, G, J, L, M, Q, U, V, 3, 4, 0
9	D, E, F, G, H, J, M, N, Q, U, 9, 0	A, B, C, K, L, P, R, S, T, V, W, X, Y, Z, 2, 3, 4, 5, 6, 7, 8
10	B, C, D, E, F, G, H, J, K, L, M, N, P, Q, R, S, U, 3, 4, 6, 8, 0	A, T, V, W, X, Y, Z, 2, 5, 7, 9
11	A, M, K, T, V, Y, 4, 7	B, C, D, E, F, G, H, J, K, L, N, P, R, S, U, W, X, Z, 2, 3, 5, 6, 8, 9, 0
12	B, C, G, H, J, M, N, Q, S, U, 3, 4, 5, 6, 8, 9, 0	A, D, E, F, K, L, P, R, T, V, W, X, Y, Z, 2, 7
13	A, B, D, E, F, H, K, L, M, N, P, R, X, Z, 2	C, G, J, Q, S, T, U, V, W, Y, 3, 4, 5, 6, 7, 8, 9, 0
14	B, C, D, E, G, J, L, M, Q, S, T, U, V, Y, Z, 2, 3, 5, 6, 8, 9, 0	A, F, H, K, N, P, R, W, X, 4
15	A, E, G, H, K, L, M, N, Q, R, X, 2	B, C, D, F, J, P, S, T, U, V, W, Y, Z, 3, 4, 5, 6, 7, 8, 9, 0

- Through the above graded exclusion, the only step is to select the corresponding template to matching algorithm with the recognized character. The final result of recognition is shown in Figure 7. It reduces the amount of calculation and increases the recognition effectiveness.



Figure 7. The result of character recognition

V. CONCLUSION

This paper adopts the method of median filtering double edge detection, effectively excludes the unrelated margin information and suppresses the effect of noise. The combinative method of positioning the original level and improved vertical projection segmentation algorithm speeds up the correction of plate tilt declination and effectively eliminates the noise effect on the accuracy of segmentation. In character recognition, the recognition method, based on classification template matching of font characteristics, reduces the amount of calculation and time-consuming and increase the accuracy of cognition. The experimental results show that this kind of recognition method not only has high recognition rate, but also shows its timeliness, which is the most noticeable feature of this recognition method.

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