License Plate Location using Feedback Control Technology in Complex Environment

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***Abstract*---License plate can be distinguished from other areas of a vehicle by Edge detection, because the information at the edge area of the license plate is richer and more concentrated than the information at other areas of the vehicle. Comparing with other edge detection methods, we adopted Robert edge operator. It was manifested robust in a complex background. Besides, a feedback control technology is presented in this paper. According to the results from morphological processing of automatic parameter *adjustment*, it shows our method is efficient and effective in license plate recognition system.**

Keywords---license plate; Robert operator; complex background; automatic adjustment

Ⅰ. INTRODUCTION

License plate recognition (LPR) system, which is widely used in vehicle video monitoring, intelligent parking management, electronic police and other occasions, is the principal part in the application of intelligent transport system (ITS)[1-2] in computer vision and pattern recognition. The number of motor vehicles has increased quickly in recent years. According to the incomplete data, the market's holding quantities of motor vehicles in China increase from 85 million in 2000 to 250 million in 2014. The future average annual growth rate of the national motor vehicle will be greater than the current average annual growth rate (more than 15%)[3]. Therefore, it is theoretically and economically to establish, improve and develop an efficient LPR system.

It is very difficult to recognize the license plate because of the complexity of vehicle license plate background and the diversity of license plate characters, such as license plate tilt, light interference, etc. Digital image processing, pattern recognition and artificial intelligence are mainly used in license plate location technology to position the license plate image from the vehicle image. It means that the input is a vehicle image, while the output is the license plate board. Nowadays, there are three common location methods to deal with PLR .The first method[4-6] is the location method based on edge detection. The values of pixel are processed to locate the license plate. The typical algorithms in this method are Robert operator, Sobel operator, Prewitt operator and Canny operator. The second method[7-9] is using the properties of color feature, mainly using the color edge or the gray edge with the color features to locate the license plate. The third method[10] is machine learning where the characteristics and excellent training methods are needed. Using the ADABOOST feature in License plate detection, the detection rate can reach more than 98%. But there is a large amount of computation and complex algorithm in machine learning, resulting in high false alarm rate and a lot of error detection.

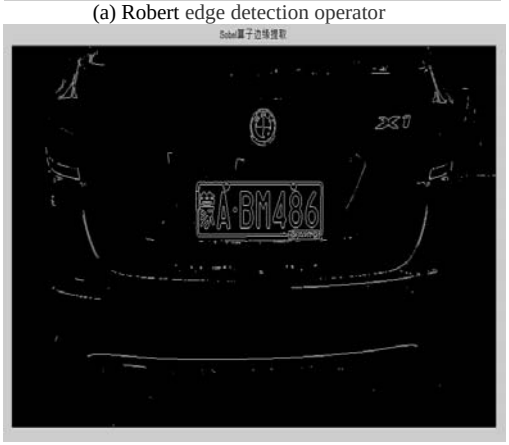
Four commonly-used edge detection algorithms are compared in this paper. We choose Robert operator as our edge detection method. Then we locate our plate following the routine image processing diagram and introduce feedback control technology before final location. Experimental results show the effectiveness of this method.

Ⅱ.EDGE DETECTION OPERATORS

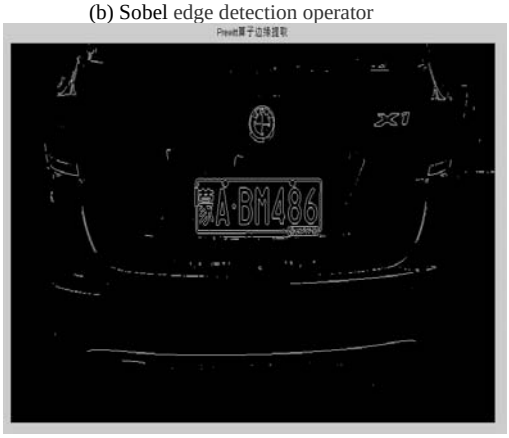
The edge detection operators including Robert operator, Sobel operator, Prewitt operator and Canny operator are widely used in LPR system. Even if the background is complex ,edge information can be distinguished from other parts of the license plate region as the information of license plate edge is generally richer and more concentrative than the information of other regions. The core of these operators is the mathematical module with the change of gradient direction. In the

implementing process of the algorithm, convolution summation is computed with each pixel through the 2 x 2 (Roberts operator) or 3 x 3 (Sobel, Prewitt, Canny operator) template in the image.

(a) Robert edge detection operator



(b) Sobel edge detection operator



(c) Prewitt edge detection operator

(d) Canny edge detection operator

Fig.1. Different edge detection operators in the same license plate

As we can see from Fig.1, Canny operator(Fig.1(d)) is much more sensitive to noise than other operators .Comparing with Fig.1(a) and Fig. 1(b),we found the Sobel operator suppresses noise more than Robert. However, the Sobel operator is not as accurate as Robert operator for edge location. Prewitt operator, shown in Fig. 1(c), resists noise through the pixel average, like a low-pass filter. Through the comparison with different operators, we selected Robert operator as the license plate detection algorithm. If we choose Robert edge detection operator using local difference method, any mutual vertical direction difference can be used to estimate the gradient. Robert operator using diagonal directions of adjacent pixel difference, that is

$$\triangle_x = f(x,y) - f(x-1,y-1) \quad (1)$$

$$\triangle_y = f(x-1,y) - f(x,y-1) \quad (2)$$

The amplitude is $G(x,y) = (\triangle_x f^2 + \triangle_y f^2)^{1/2}$

and $f(x,y)$ is the image gray-scale distribution function. Robert gradient taking(x-1/2,y-1/2) as the center, it measures the gray change on coordinate axis at 45^0 and 135^0 orientations. Taken the threshold T, if $G(x,y)>T$, then $(x,y)$is the edge step point. The operator is expressed as the form of template, shown in Fig.2. In the practical application, each pixel in the image makes convolution with the two templates. In order to avoid the negative values, the edge detection uses the absolute value.

0	1
-1	0

1	0
0	-1

Fig. 2. Robert operator templates

Ⅲ.PLATE LOCATION METHOD

License plate location is the first step of LPR system. LPR system generally consists of three parts: license plate location，characters segmentation and characters recognition. The location performance affects the PLR system directly. Our aim is to locate the right position of the license plate swiftly and automatically. The flow chart of the algorithm is shown in Fig. 3.

The difference between other location methods is that we introduce a module to deal with license plate in complex environment. After morphological filtering in plate processing, it still contains a lot of noise and we may get an inaccurate position of the plate. The module here is to judge whether we need another filtering through the comparison between the Robert operator threshold T with an empirical one. If we fail to locate the license plate, our system is able to response quickly and make the parameter adapted to the location again.

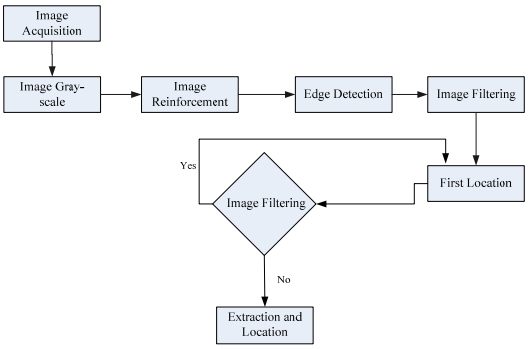


Fig.3. License plate location diagram

Ⅳ. EXPERIMENT RESULTS AND ANALYSIS

As our aim is to locate the license plate in complex background ,we choose two ‘canonical’ pictures from internet. Both the vehicle bodies can reflect light. Both the license plates are blurry, especially the dense reticulate perforation structure in the upper part and the lower part of the license plate shown in Fig. 5(a). Additionally, the date at the lower right corner of the license plate also makes the license plate extraction and location very difficult. All of these characteristics make the license plate difficult to locate. Through a set of image processing technology, such as gray-scale, binarization, median filtering, we get Fig.4 (b) and Fig.5 (b), respectively.

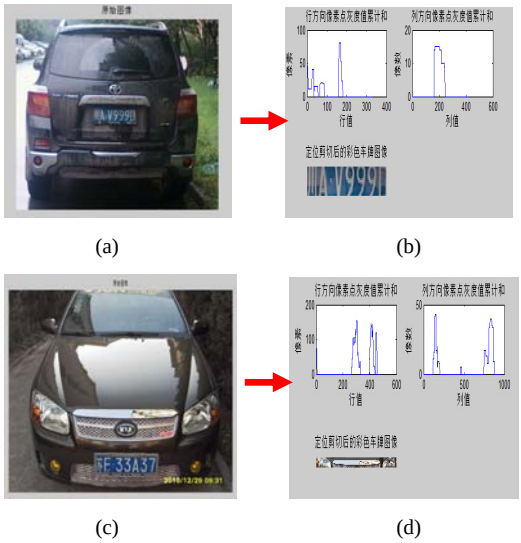


Fig.4.Two different cars with license plates under complex background and the correspondence results of license plate location

We can analyze the results from Fig. 4(a) to 4(b). It was shown that the plate was located in the first process although the cumulative of pixel value in the column direction were fluctuant. Inappropriate parameter of extraction leads to some missing edge feature, but that doesn’t affect the result. In Fig. 4(c) and 4(d),we didn’t get good result. There was a big noise in both the column direction and row direction. The cumulative of pixel value in the column direction peaked the high wave twice and the row direction produced very obvious interference noise. This resulted in a bad location as shown on Fig. 4(d) .

We can see from Fig.4(c) that the dense reticulate perforation structure in upper part and lower part of the license plate and the date on the picture make lots of noise and lead to a very bad result. In order to get the right position of license plate, we use a different way from the above traditional method. We set the threshold T with an empirical number 0.5, and then filter the image again. According to the threshold of the location, the positioning algorithm adjusted the open and close operation parameters again to eliminate the noise. The processing results are followed. We get the license plate as we want.

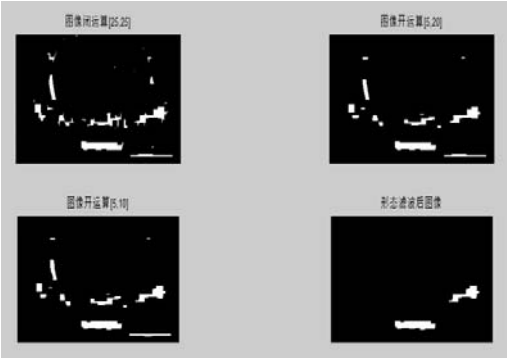


Fig. 5. Morphological computation in second filtering

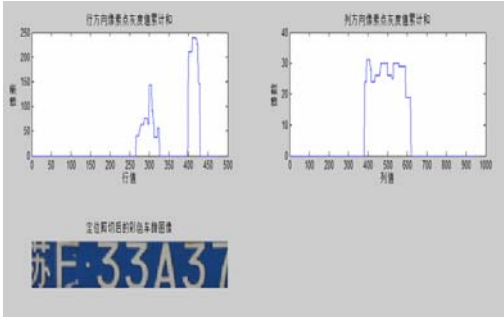


Fig.6. The plate get located in second filtering

We can see that our proposed method can resist noise effectively and be applied in the license location with complex background from Fig. 5 and Fig.6.

Ⅴ. CONCLUSION

License plate location is the key module of LPR system. The performance of the four operators is compared and the Robert edge detection operator is selected to do the computation. Depending on the characteristics of the operator, we proposed an algorithm to accomplish the location goal. The plate location system could adjust parameters automatically and process morphological computation again on the blurry image to reduce noise interference. Experimental results show this method is suitable to deal with the license plate location problems with complex background.

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