License Plate Location Algorithm Based on Edge Detection and Morphology

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Abstract—**Vehicle license plate recognition has complex characteristics due to diverse effects as the fog, rain, shadows, irregular illumination conditions, partial occlusion, variable distances, cars' velocity, scene's angle and others. License-plate location in sensor images plays an important role in vehicle identification for automated transport systems. For the extraction of positioning in license plate recognition system, traditional Roberts operator and morphological edge detection algorithm exist the interference of image noise and low edge resolution. This paper proposes a new algorithm for vehicle license plate location based on edge detection and mathematical morphology. Roberts operator added two direction template can compensate the breaks of the edge and make it fully connected together. Then detect edge by selecting the appropriate threshold for Roberts operator and utilize morphological analysis to obtain candidate regions of license plate, analyze candidate regions by connected component, finally position plate region. The experimental results show that the algorithm can well suppress the impact of noise on the identification of the target area in the image, but also shorten the time of license plate location, valid license plate positioning.**

Keywords-Roberts operator; edge detection; morphology; license plate location

I. INTRODUCTION

With the coming of 21st century, people's standard of living and demand of consuming is being improved step by step. This prompts the gradually increasing in transportation demand of the whole society. License plate recognition system (LPRS) has played a more and more important role in electronic toll collection (ETC), highway traffic monitoring and check access control applications. License plate location is a critical step in the LPRS, whose accuracy directly influences the following license plate segmentation and recognition.

Many papers have been published on license plate location during last 30 years, such as color segmentation, mathematical morphological, multi-color model, wavelet transform, neural network and texture feature analysis of gray-scale images. The method of license plate location which is based on color segmentation, the accuracy will decline when the quality of color image which gained is high, especially the difference between the color of the plate region and the color of nearby is huge. The method of license plate location which is based on mathematical morphological, it has less influence of license plate size, location and the background of image, it can restrain noise well, it is easy to form blocks because of interference edge which is not easy to remove in the process of inflation. The method of license plate location which is based on multi-color mode can keep the information of plate region, so it can extract the license plates accurately, but the efficiency of segmentation is low and the speed of extraction is slow. The method of license plate location which is based on wavelet transform, it can locate well and segment accurately when the noise is small, the percent of location error will increase and the speed will become slowly when the noise is large. The method of license plate location which is based on neural network, it can improve the speed of license plate localization processing and gain a high accuracy, but it also has many shortcomings, such as, it needs great work, it is not ideal to deal with fracture and broken image. The method of license plate location which is based on texture feature analysis of gray-scale images is sensitive to noise, the percent of location error will increase dramatically for the image of complicated background. Although these algorithms are available to extract the license plate under certain conditions, there are some limitations that lead to the failure in most practical applications due to the diversity of the license plate characteristics (such as the wear and tear, the crease, or the fracture) and the complexity of the natural environment (such as rain, snow, fog)[1-2].

In this paper, the method we proposed is mainly based on improved Roberts edge detection and morphology. First of all, we conduct the gray-scale transformation and edge detection preprocessing on the collected image, and then take the morphology operation to find the boundaries of license plate, and thus license plate location is attained.

II. THE ROBERTS OPERATOR DESCRIPTION

The Roberts operator, a 2×2 operator template, is a partial differential operator to find the edge operator. It is the convolution of the original image and operator $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$ or $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ [3]. The template operator is as follows:

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1	0		0	1
0	-1		-1	0
(a)			(b)	

Figure 1. Roberts template. (a) 0° operator. (b) 90° operator.

III. IMPROVE ROBERTS EDGE DETECTION

The Roberts edge detector is a simple and fast partial differential operator, and effectively detects the steep edge in the image with low-noise. However, the edge is not very smooth, and usually generates a wide response in the neighboring regions. Considering the low position precision, the refinement is needed.

To improve the performance of Roberts algorithm, here we make some improvements as follows:

A. Pretreatment of the vehicle image

First, we take the gray-scale transformation on collected original color image. Taking the influence of the noise, uneven illumination into account, some preprocessing steps such as mean filtering, binarization are needed.

1) The Gray-scale transformation

The Gray-scale transformation can not only speed up the subsequent steps, but also transform the various kinds of images to gray image to simplify the process. Here we choose weighted average method which takes the sensitivity of the human eye into consideration, i.e. the green highest, the red high, to the blue lowest. Thus we let $W_R = 0.9$, $W_G = 1.77$, $W_B = 0.33$ namely:

$$g = 0.299R + 0.587G + 0.114B \quad (1)$$

Where W_R is the weight of R, W_G is the weight of G, W_B is the weight of B.

2) The Mean filter

The edge image without the mean filtering may exists a large number of false fringes, and the image with other forms of filtering, such as the Gaussian low-pass filtering, a circular filtering, Laplace filtering may lead to similar results. The experiment proved that taking mean filtering using the selected template with a size 3×3 will greatly reduce the false fringes and finally get shape edges.

3) The Binarization

The key of image binarization is threshold selection. A appropriate threshold can not only greatly suppress the noise, but can clearly divided the image into the target and background, leading to the reduce the computational time. Traditional thresholding methods for the binarization are global thresholding and local thresholding. The thresholding method in this paper is an improvement based on the global thresholding method. Here we set the pixels with a gray value less than the threshold to 0, pixels with gray value greater than the threshold to 255. The selection method for the initial threshold value T is as the formulation:

$$T = g_{\max} - \frac{g_{\max} - g_{\min}}{3} \quad (2)$$

Where $g_{\max}$ is the maximum gray value, $g_{\min}$ is the minimum gray value. Experiments show that the selected threshold has some good adaptability to different images, and can ensure that the basic background to be set to 0 to highlight the region which includs the whole license plate.

The original image of acquisition to finish the effect after pretreatment shown below:

(a) (b) (c) (d)

Figure 2. The results of image preprocessing. (a) The original image. (b) The gray image. (c) The mean image. (d) The binary image.

B. Edge detection with the template with additional directions

The Roberts operator is not isotropic, and the edge image we get is not completely connected, leading to some disconnection which will greatly affect the accuracy of the license plate extraction. Here we add the two other directions 180^{0} and 270^{0} (show as in Figure 3) to the original template, that is:

-1	0		0	-1
0	1		1	0
(a)			(b)	

Figure 3. The two new Roberts operator detection template. (a) 180^{0} operator. (b) 270^{0} operator.

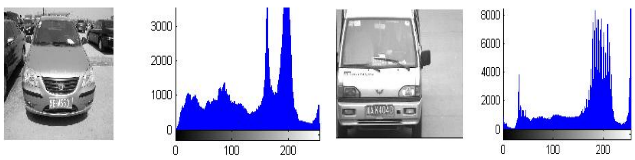
C. The threshold selection of the Roberts detector

As an important key in image segmentation, threshold selection directly affects the accuracy of image segmentation.Given the binary image we attain, the range for threshold value $\tau \in [0,1]$, the binary image $f(x, y)$ is:

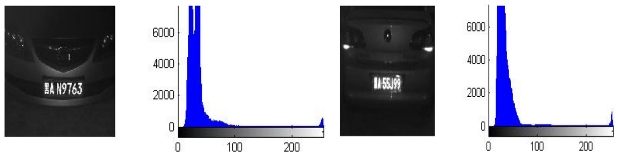
$$g(x, y) = \begin{cases} 1 & if\ f(x, y) \geq \tau \\ 0 & if\ f(x, y) < \tau \end{cases} \quad (3)$$

Where $g(x, y)$ is the image after threshoding process.

The threshold can be determined by the analysis of gradient histogram and the gray-scale histogram. A typical histogram distribution of the image can be as follows:



(a) (b)

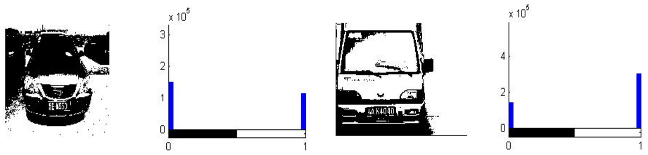


(c) (d)

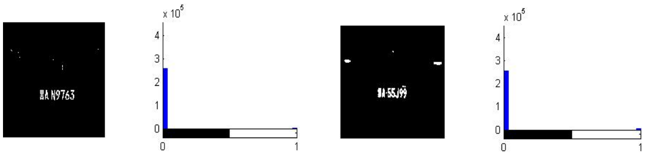
Figure 4. The gray-scale histogram of the image.

From the histogram Figure 4 (a) and (b), we can be see, the gray value can satisfy $T \in (180,220)$. With the formula $\tau = T/256$ and the range for binary image (0,1), we can convert the selection of the threshold into the range $\tau \in (0.7, 0.86)$. Similarily, the gray value in the image (c) and (d) $T \in (10,40)$ can be converted into the range $\tau \in (0.04, 0.16)$.

The histogram distribution of the image after the preprocessing can be shown as follows:



(a) (b)



(c) (d)

Figure 5. The histogram distribution of the image.

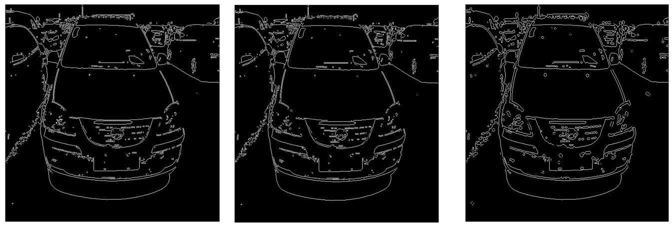
Similar results can be concluded from Figure 5. The gray-scale values for the image 5 (a) and (b) are close to 1, so the threshold should be favor of a number close to 1; the threshold for the image (c) and (d) should be close to 0.

The experiment results show that the threshold τ is related with the information from collected images. For the image with rich license plate information and less false edges, the threshold must satisfie $\tau \in (0, 0.3)$. Otherwise, for the image with less license plate information and too much false edges, the threshold must satisfie $\tau \in (0.7, 1)$.

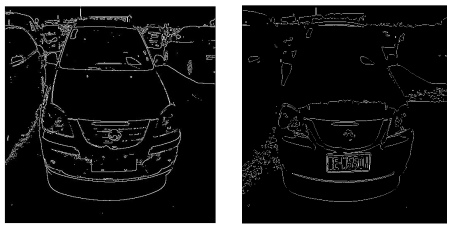
Making a further analyze about the selection of the threshold τ , the thought of adaptive dynamic threshold determined based on literature [4], if we adopt the fixed threshold, it is easy to produce much interference edge; if the threshold which we adopt is too large, it is easy to lead much fracture of edge .Because of the resolution of the human's eye is insensitive toward the grey of image, and much sensitive to the noise of the image smooth part. Therefore, according to the characteristics of human vision, we can set the threshold smaller in the area of higher visual resolution, and set the threshold bigger in the area of lower visual resolution. By practical experience and experimental results, the resolution of human's eye (sensitive degree) is least sensitive toward the area of white, the second is the area of black, the third is the gray level about 127, the resolution of human's eye is sensitive toward the area of gray level about 48, 206. The sensitivity of the human's eye on the gray-scale is not linear variation with the gray value, according to the past experience, adopting the parabola is more reasonable to calculate the threshold[4], combination with Figure 4, we can divided the gray-scale into several regions, including [0,10], (10,40), [40,180], (180,220), [220,255], we can make a analysis, the parabolic which is adopt to set the threshold, the formula is as follows: $T(x) = ax^2 + bx + c$, combined with the convert of $\tau = T/255$, we can confirm the threshold which is selected τ . In this paper the selection of the threshold is based on the characteristics of human visual, it is generality, so it is suitable for all gray-level images, combined with the literature [4], we can deduce the formula of initial threshold:

$$T(X) = \begin{cases} -0.05x^2 + 15 & 0 \le x \le 10 \\ -0.133x^2 + 6.667x - 43.37 & 10 < x < 40 \\ 0.023x^2 - 3.826 + 126.246 & 40 \le x \le 180 \\ -0.1x^2 + 40x - 3780 & 180 < x < 220 \\ 0.106x^2 - 54.122x + 6956.539 & 220 \le x \le 255 \end{cases} \tag{4}$$

We conduct the simulation with MATLAB software[4], and the edge detection results is shown as below:



(a) (b) (c)



(d) (e)

Figure 6. Edge detection results. (a) The Sobel edge detection. (b) The Prewitt edge detection. (c) The Log edge detection. (d) The Roberts edge detection. (e) Improvement of the Roberts edge detection.

IV. THE MORPHOLOGY PROCESSING

The mathematical morphology is to extract the specified structure which is the same as the structure element for the following image analysis and recognition. It consists of a team of the morphology of the algebra operator, of which the basic two operation are imerode, imdilate. The operation of the commonly used morphology are as follows:

(a) Imerode

As a morphology basic operation, imerode is based on the concept of filling structural elements, and the filling process depends on the operation translation.

$$A \Theta B = \bigcap \{ A - b \mid b \in B \} \tag{5}$$

(b) Imdilate

Imdilate is the imerode of the dual operation. Imdilate is to combine the points adject to the object with the object, leading to the increase of the area of the object.

$$A \oplus B = \bigcup \{ A + b \mid b \subset B \} \tag{6}$$

(c) Opening operation and closing operation

The operation imerode on a imdilated image is called the opening operation.

$$A \circ B = (A \Theta B) \oplus B \tag{7}$$

The operatoin imdilate on a imeroded image is called the closeing operation.

$$A \bullet B = (A \oplus B) \Theta B \tag{8}$$

In the morphological processing, we first conduct the operation imerode, and then fill the holes and take the filter on the image, the results would be favorable[5-6]. Results are shown as follows:

(a) (b) (c)

Figure 7. The mage after morphological processing. (a) The imeroded image. (b) The image after filling. (c) The image after morphological filtering.

V. EXPERIMENTAL RESULTS

We output the four vertex coordinates of he last selected region after morphological filtering and extract the license plate, the results shown in Figure 8:

Figure 8. The final license plate after the positioning.

In the experiments, we test the proposed method on the collection of 120 images (including rain, snow, fog and other environment). The results show that, 109 images can be located accurately, 11 cannot be recongnized, and the positioning rate is 90.833%. Thus vehicle plate extraction with this method can achieve a relatively high positioning rate.

Figure 9. A series of license plate results after positioning.

VI. CONCLUSION

This paper presents a vehicle license plate extraction algorithm base on improved Roberts detector and morphology operation. Experiments have proved the proposed method has high positioning rate and fast processing speed. Compared with the traditional edge segmentation, it serves as a better solution to the loss of edge features. By the combining morphological processing with the edge segmaentation, the positioning accuracy of the license plate is increased, and the robustness of the positioning is improved, and thus the algorithm has good prospects for real-time processing applications. Meanwhile, for some license plate with more serious defect or the image under poor illumination, the results for the license plate extraction is not very satisfactory, which deserve us for further study.

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