

License plate location method based on edge detection and mathematical morphology

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Abstract—The license plate location plays a key role in the license plate recognition system. The quality of the positioning result determines the subsequent license plate character recognition. For the image based on edge detection, it is difficult to detect the license plate area for the discoloration or serious pollution of the license plate. Therefore, a license plate location method based on edge detection and mathematical morphology is proposed. Firstly, the image preprocessing of the license plate includes graying and binarization. Then, the Sobel operator edge detection is performed according to the binarized license plate image. The Sobel operator has moderate sensitivity to the edge and is suitable for the extraction of the license plate edge. Finally, On the result of Sobel operator processing, the mathematical morphology of corrosion, expansion, opening and closing operations are performed to obtain the final license plate location.

keywords—Sobel operator; edge detection; mathematical morphology; license plate location

I. INTRODUCTION

The license plate location is to separate the license plate area from the vehicle picture. At present, the more mature license plate location methods are [1]: texture analysis based methods, edge detection based methods, image based color information methods, mathematical morphology based methods [2], neural network based positioning, genetic based Algorithm positioning, etc.

Based on the texture analysis method, it is necessary to preprocess the image before positioning to increase the contrast of the image. Due to the variety of license plates in China and the influence of illumination, it is necessary to convert the color image into a gray image first, and then use the two-dimensional characteristics of the license plate area to divide the image into small pieces and calculate the feature values of each small piece. , to determine which small pieces belong to the license plate area, thus positioning the license plate. However, when the method deals with an image with a complicated background, it is easy to locate the rich portion of the texture, so the method needs to be improved.

The edge detection method [4] is based on the frequent changes of the grayscale of the license plate character area. First, the image is edge-enhanced, and then the image is binarized, and the license plate area is positioned by the projection method. However, this method is difficult to detect the license plate area for pictures with faded or heavily polluted license plates, so this method needs to be improved.

Image-based color information method [6], using this method for vehicle license plate location, generally uses the image space to determine the color of the license plate. The color space begins with human vision and describes color with hue, color saturation, and brightness. The method firstly finds the license plate background area from the image to determine the threshold value of each relevant component of the card bottom color in the space, and then uses the color space distance and the similarity calculation to perform image color segmentation. However, this method may cause incorrect positioning of the license plate area when the color of the license plate area is close to the color of the nearby area.

Based on the mathematical morphology method, this method is used to locate the license plate. First, the license plate image is converted into a format, then grayscale, and then filtered. Finally, mathematical morphology expansion, decay, opening and closing operations are used. The image is analyzed and processed, and the license plate is located from several candidate areas by using the area, the length and width of the license plate, and the like. However, this method has a poor positioning effect when there is a pseudo license plate in the image.

In order to solve these problems, a method of license plate location based on edge detection and mathematical morphology is proposed. Firstly, the image preprocessing of the license plate includes graying and binarization. Then, the Sobel operator edge detection is performed according to the binarized license plate image. The Sobel operator [3] has moderate sensitivity to the edge and is suitable for the extraction of the license plate edge. Finally, the mathematical morphology of the corrosion, expansion, opening and closing operations on the results of the Sobel operator processing, to obtain the final license plate positioning.

II. IMPROVED K-MEANS CLUSTERING ALGORITHM

A. Binary processing of license plate images

Commonly used binarization algorithms are based on binarization of color images and binarization based on grayscale images [5]. Among them, binarization based on color images is generally applied to select specific color information, but in this paper The processed license plate image will contain information of various colors, and the difference of the color information is not conducive to directly binarizing the image. Therefore, this paper uses a binarization processing method based on gray image.

B. Grayscale image

The color mode used in color images is based on red (R), green (G), and blue (B) colors, and is formulated in different proportions, also called RGB images [5]. The color digital image is composed of pixel points (grid dots), and the brightness or color value of each point is recorded separately. Since the pixel points in the image are mapped by the raster data points, the bitmap is also named, and the data points in the bitmap area. The position is the position of the corresponding pixel. In this article, the bitmap in RGB format is processed. In the RGB color space, the color matching equation of any color light F is:

$$F = r[R] + g[G] + b[B] \quad (1)$$

Where r, g, and b are three-color coefficients, and r[R], g[G], and b[B] are three-color components. The color image is converted into a grayscale image, that is, a grayscale of the color image. Generally, there are three main methods for grayscale processing:

1. Maximum method: make the value of R, G, and B equal to the largest of the three values, that is,

$$Gray = \max(R, G, B) \quad (2)$$

2. Average method: make the values of R, G, and B equal to the average of three values, that is,

$$Gray = (R + G + B)/3 \quad (3)$$

3. Weighted average method: assign different weights w_R, w_G, w_B , to R, G, B according to importance or other indicators, and make Gray equal to the weighted sum of their values,

$$Gray = (w_R \cdot R + w_G \cdot G + w_B \cdot B)/3 \quad (4)$$

Because the human eye has the lowest sensitivity to blue, the sensitivity to red is higher, and the sensitivity to green is the highest. Generally, when $w_R=0.3$, $w_G = 0.59$, and $w_B = 0.11$, a more reasonable grayscale image can be obtained. In order to achieve a better visual effect, the weighted average method is used in this paper to grayscale the image.

After the color image is grayed out, the three-dimensional color image can be converted into a two-dimensional image [8], and each pixel in the image has only one value, that is, the gray value of the pixel, and the gray value is saved in two. In the dimension matrix. After the image is grayed out, there is no color difference in the color image, but the brightness is different, and the range of the gray value is 0 to 255, wherein the gray value 255 represents white, and the gray value value is 0 represents black.



(a) The original image



(b) Grayscale image

Fig. 1. Convert raw RGB image to grayscale image

C. Image binarization

The process of converting a grayscale image into a binary image is called binarization of the image [7], that is, dividing 256 grayscales into two levels, respectively representing white or black. After the image is binarized, not only the background pixel interference and the hopping of the statistical image in a certain direction can be reduced, but also the requirements for storage and processing are reduced. Binarization has an important position in license plate recognition because of its unique advantages. The effect of binarization will directly affect the subsequent character recognition and other operations.

The binarization operation of the image requires dividing the image into two levels [10]. The two levels are represented by 1 and 0 respectively. 1 represents white and 0 represents black. The key to the classification here is to look at the gray threshold selection. Threshold T to distinguish between interference and features. If the gray level range of the original image $f(x, y)$ is (Z_1, Z_k) T is a value between Z_1 and Z_k , then the binarized image is $g(x, y)$ which can be expressed as:

$$g(x, y) = \begin{cases} 0, & f(x, y) \leq T \\ 1, & f(x, y) > T \end{cases} \quad (5)$$



(a) Grayscale image



(b) Binarized image

Fig. 2. Grayscale image is converted to binarized image

III. IMPROVED LICENSE PLATE LOCATION METHOD

A. Improved license plate location method

Based on the edge feature algorithm [3], the edge information in the image is extracted by the brightness change of the local area in the image. Therefore, the algorithm preprocesses the license plate image and converts the original color image into a grayscale image by grayscale operation. Through the scanning operation, the license plate edge information of each row and each column in the image is extracted, and their starting point coordinates, end point coordinates, and line segment length are marked. Its purpose is to find a collection of pixels with sharp changes in brightness in the image, often showing contour information.

The Sobel edge detection operator is usually used to detect the edge of the grayscale image. It is the approximation of the gradient function of the brightness in the image by the split operator in discrete mathematics. For good processing or even noise elimination, it is necessary to introduce a local area to perform the mean operation in the operator. Compared to other operators, the Sobel operator sits on each pixel with a weighting process, so it works better on the detection edge.

$$g(x, y) = [\sqrt{f(x, y) - \sqrt{f(x+1, y+1)}}]^2 + [\sqrt{f(x, y+1) - \sqrt{f(x+1, y)}}]^2 \quad (6)$$

The above formula, where $f(x, y)$, $f(x+1, y+1)$, $f(x, y+1)$, $f(x+1, y)$ are the coordinate values of the four regions, respectively, through the square root of the arithmetic. The operation can be made similar to the human visual system during processing. As shown below [2], the Sobel operator contains two sets of 3x3 operator templates, G_x means to detect the horizontal edge horizontal template, and G_y means to detect the horizontal edge horizontal template.

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad G_y = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & -2 \\ -1 & 0 & -1 \end{bmatrix} \quad (7)$$

Calculate the magnitude of the gradient by finding the horizontal and vertical gradient approximation for each pixel, using the following formula:

$$G = \sqrt{G_x^2 + G_y^2} \quad (8)$$

Then use the following formula to calculate the gradient direction:

$$\Theta = \arctan\left(\frac{G_y}{G_x}\right) \quad (9)$$

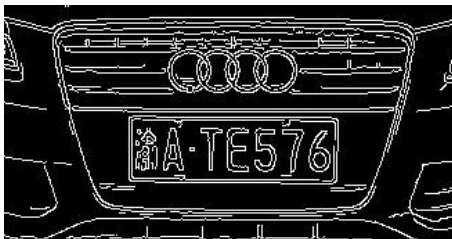


Fig. 3. License plate location image for Sobel edge detection

B. License plate location based on mathematical morphology

The edge accuracy extracted by the Sobel edge detection operator is not high enough to meet the requirements, so further precise positioning is required. The mathematical morphology method is more resistant to tilting and can be accurately positioned. In this paper, the mathematical morphology correlation operation is used to accurately locate the rough-positioned license plate area. Mathematical morphology is a mathematical method for analyzing geometric shapes and structures [6], which uses the set theory method to quantitatively describe the science of geometric structures. Mathematical morphology consists of a set of morphological algebraic operators. These operators and their combinations are used to analyze the image shape and structure. The basic operations include: binary corrosion and expansion, binary opening and closing operations, etc. [1].

1. The image is corroded, the operator of corrosion is Θ , and A is etched with S as:

$$A\Theta S = \{(x, y) | (x, y) \in A, S(x, y)/A = \emptyset\} \quad (10)$$

Corrosion is mainly used to eliminate the boundary points of objects. Corrosion removes small, meaningless objects from the image.

2. Image expansion:

$$A \oplus S = \{(x, y) | (x, y) \in A, S(x, y) \cap A = \emptyset\} \quad (11)$$

The expansion is mainly used to extend the boundary points of the object, and the background points around the image can be merged into the object together. Expansion can fill the voids in the segmented object.

3. Open operation:

$$A \circ S = (A\Theta B) \oplus S \quad (12)$$

The opening operation is performed after first etching and then expanding. The open operation eliminates small objects on the image, smooth the outline of the image, weakens the narrow portion, and removes fine protrusions.

4. Closed operation:

$$A \cdot S = (A \oplus S) \Theta S \quad (13)$$

The closed operation performs first expansion and then corrosion. It can fill small spaces in the image of the object, and it can also connect adjacent objects and smooth the boundary.

C. Mathematical morphology license plate positioning process

After a lot of experiments, this paper is based on the license plate image detected by Sobel operator edge [3]. Firstly, the 1x1 square structure element is selected to perform the corrosion operation on the edge-detected image, two expansion operations, and then 2x2 square structure elements perform closed operation and open operation, and the closed operation first swells and erodes, which not only helps the fusion of the license plate area and the formation of the connected area, but also filters out some smaller areas. The expansion is performed once using a 3x3 square structure element, and finally, an opening operation is

performed to form a series of block-shaped connected regions. In the processing of this paper, only the morphological transformation of the coarsely positioned strip region can save the computation time and save the memory, so that the algorithm is simple. The license plate image obtained according to the mathematical morphology method designed in this paper is shown in Fig. 4. It can be seen from the figure that after a series of mathematical morphology processing, the outline information of the license plate is more obvious, the image is smoothed, and the effective information of the license plate is retained.

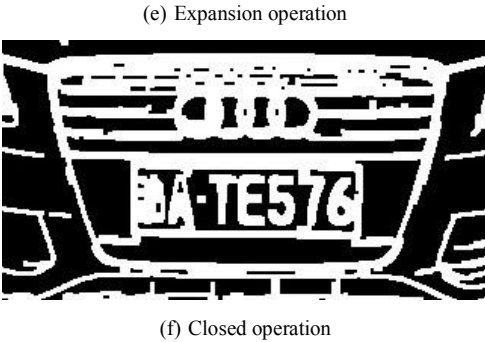
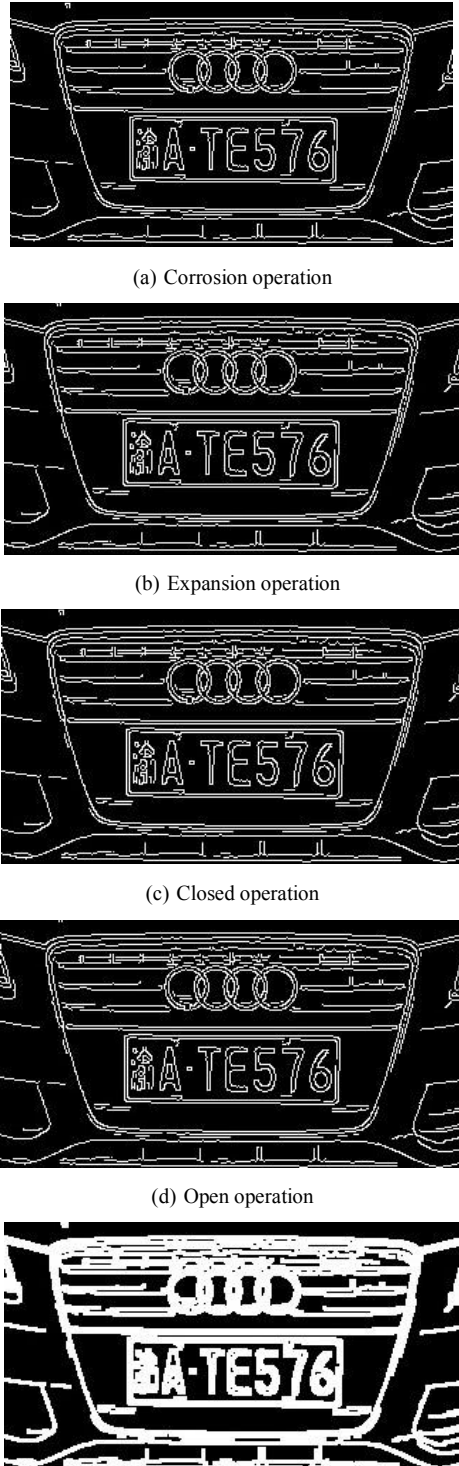
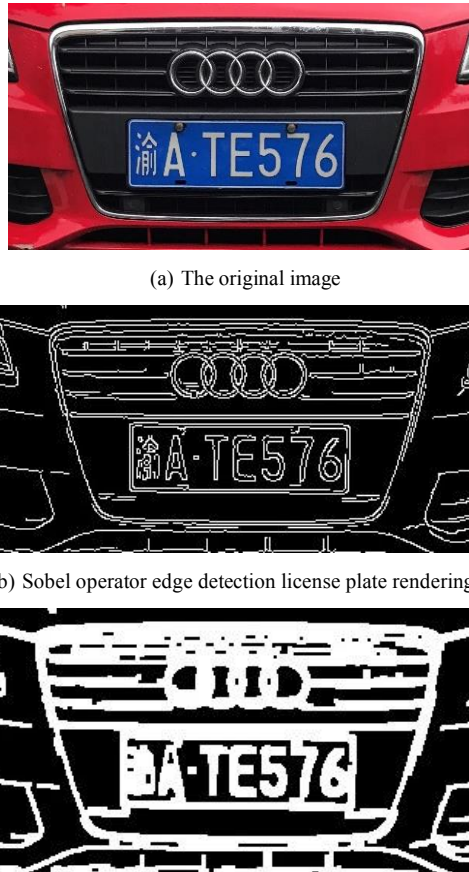


Fig. 4. Mathematical morphology license plate positioning processing effect chart

IV. ANALYSIS OF RESULTS

In order to prove the effectiveness of the license plate location method based on edge detection and mathematical morphology, the two algorithms are tested separately and the positioning results are compared. The results are shown in Figure 5. Through the positioning results, we can see that the effect of image recognition based on edge detection and mathematical morphology on image localization is better than that of traditional edge-based license plate location algorithm. Figure 5(b) has obvious advantages. The former avoids noise interference. And the outline information of the license plate area is more obvious, the picture is smooth and full, and the positioning of the license plate area is more accurate.



(c) Mathematical morphology license plate positioning processing effect chart

Fig. 5. Comparison of experimental results

V. CONCLUSIONS

At present, there are many algorithms for license plate location. Each method has its scope of application. Using a single algorithm often fails to achieve the desired positioning effect. In this paper, a method based on edge detection for rough positioning of license plate and precise positioning of license plate based on mathematical morphology is adopted. This method combines the filtering function of edge detection and mathematical morphology to quickly reduce the interference of noise on images. Quick positioning of the license plate area. The algorithm has good real-time and accuracy, and is simple, fast and robust.

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