A New Algorithm Research of License Plate Tilt Correction

Zhoujuan Guan, Limin Song and Xiaorui Song
Dalian maritime university, Liaoning Dalian 116026, China

***Abstract*—in the parking system, the inclination of the plate image is relatively large, which creates the recognition rate of license plate is lower than the positive imaging, based on the color information and the corner feature, this paper presents a fast correction algorithm , The license plate area separated by color , then the area is processed by using mathematical morphology to extract the border and eventually locate the position of the corner, Tilt correction can be completed by using the minimum moment of inertia of the plate, experiments show that the algorithm is practical, can improve recognition rate of license plate.**

Keywords-correction; color information; corner feature; moment of inertia

I. INTRODUCTION

License Plate Recognition is an important part in Intelligent Transportation System, it is widely used in traffic monitoring and control, property management and many other areas, road pricing [1] and parking systems, the license plate recognition system consists of image acquisition, image preprocessing, license plate location, character recognition and inclination correction [2], but the camera is placed in the parking system and terrain and other reasons, the image always exists certain angle, which adversely affect the subsequent character segmentation and recognition .

The common tilt correction algorithms include nearest neighbor interpolation [3], bilinear interpolation rotation [4] and the projector rotation correction [5], although the above-described methods may be implemented for license plate tilt correction, but in fine weather ,the recognition rate close to 95% ,for the requirements of parking license plate recognition, we propose a correction algorithm, which is based on color information and corner feature (CICD), the algorithm uses color information to isolate license plate and use mathematical morphology to process the information of license plate, The mathematical morphology mainly have erosion, dilation, opening and closing operation, then can get four corner points by fitting extracted plate, by using minimum moment of inertia can complete tilt correction. The algorithm based on VS2010, And collected 1000 car license plate from a car park in Dalian, which have 750 pictures during the day, at night have 250 pictures, the image resolution is 320*302, after a large number of repeated Experimental, Results show that the correction rate is up to 99%, by using the algorithm of CICD.

II. CICD THEORETICAL DESCRIPTION AND IMAGE PROCESSING

A. The Method of Color Space Conversion

The color of the license plate can be divided into 10 categories, More common color of license plate is blue and white, yellow white, black and yellow and so on ,The color of license plate carry a lot of information, color space is a method of color encoding, commonly used RGB, HSV, CMYK and other color space. RGB includes red, green, and blue color channels, and changes in their mutual superposition to obtain a variety of colors; compared with RGB color space, CMYK model requires four components, it includes Y, M, C and represent respectively the color of yellow, magenta, cyan, In addition to this, it's necessary to add black to improve the CMY color model [6].

Extract the target region of the license plate, it's necessary to use distinct color space, CMYK is color space of color printing, RGB is related to brightness and light intensity, This paper selects CMYK color mode, Color space can be converted to each other, the following is conversion formula between the model of RGB and CMYK.

$$\begin{aligned} R &= (255 - C) * ((255 - K) / 255) \\ G &= (255 - M) * ((255 - K) / 255) \\ B &= (255 - Y) * ((255 - K) / 255) \end{aligned} \tag{1}$$

Based on the concept of color space, convert RGB to CMYK color space, The input image is obtained after pre-treatment license plate image, most of the selected image has redundancy of edge information after positioning. Conversion results are shown in figure 1

(a)

(b)

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(c)

FIGURE I. COLOR MODE CONVERSION

Figure 1 shows the separation results by using CMYK color space, it can be seen, The test image that randomly selected filter out noise in the body and other parts, it contains all the useful information.

B. Contour Extraction Method Based on Morphology

Mathematical Morphology is the use of a certain form of structural elements to measure and extract the image corresponding to the shape and image analysis in order to achieve the purpose of identification. The basic operations have expansion, corrosion, etc., Flood Fill is one type of Seed Filling, from a certain point within a given external point color painting from the inside, by-pixel processing until it reaches the border color [7], then using the morphological to process image of license plate after color space conversion, as shown in Figure 2:

(a)

(b)

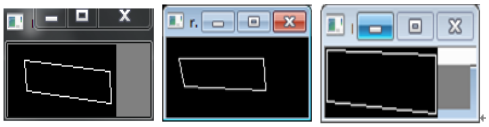
(c)

FIGURE II. MORPHOLOGY OPERATION

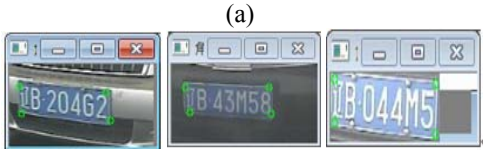
a ~ c in the Figure 2 is respectively image after using Flood Fill, expansion and corrosion, The outline of the license plate is more clear After morphological processing, with a strong anti-noise ability, should be noted that it needs the Flood Fill before the expansion, otherwise can lead to corrosion failure for the edge.

C. Corner Extraction and Rotation Algorithm

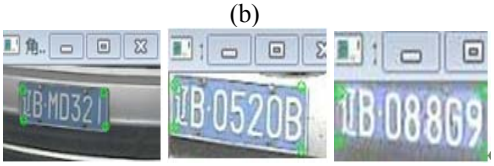
In the image of license plate, the angular point contains a great deal of using information, such as rotation invariant features, etc. fitting a straight line for the license plate After the mathematical morphology processing, and extract the four angular point , as shown in figure 3



(a)



(b)



(c)

FIGURE III. CORNER FEATURE EXTRACTION

Figure 3 (a) is The license plate images after fitting a straight line, the four corner points detected in Figure 3 (b) and (c).

After extracting the corner feature, according to the definition of the principal axes of inertia and correcting the rectangle of being determined by Corner, which can draw the centroid point, if the moment of inertia is the smallest angle of inclination of a straight line, That is the inclination plate.

Specific implementation steps:

Calculate a target corner centroid and moment of inertia, as a calibration standard.

If the angular coordinate is (x_i, y_i), i=1、2、3、4，, corner centroid can be expressed as:

$$\bar{x} = \frac{1}{4}\sum_{i=1}^{4} x_i \quad \bar{y} = \frac{1}{4}\sum_{i=1}^{4} y_i \qquad (2)$$

Make $(\bar{x}, \bar{y})$ as the origin of coordinates, there is $\bar{x} = 0$, $\bar{y} = 0$, Angular point related to the moment of inertia of the origin can be expressed as:

$$d = \sum_{i=1}^{4} (x_i^2 + y_i^2) \qquad (3)$$

Assuming that a line named l passing through the origin of the inclination, Assuming that the inclination is α, there is a straight line corresponding to the moment of inertia is:

$$d_l = \sum_{i=1}^{4} (x_i \sin\alpha - y_i \cos\alpha)^2 \qquad (4)$$

Extended to the general case, the equation can be expressed as:

$$d_l = \sum_{i=1}^{n} (x_i \sin\alpha - y_i \cos\alpha)^2$$
$$= (\sum_{i=1}^{n} x_i^2)\sin^2\alpha - 2(\sum_{i=1}^{n} x_i y_i)\sin\alpha\cos\alpha + (\sum_{i=1}^{n} y_i^2)\cos^2\alpha \quad (5)$$

Obtaining the minimum value of d_l corresponding to the α_0 in the formula, That is the tilt angle of license plate.

Since corner positioning is accuracy in this paper, the number of defined target angle have four points.

Make $m_1 = \sum_{i=1}^{n} x_i^2$, $m_2 = \sum_{i=1}^{n} x_i y_i$, $m_3 = \sum_{i=1}^{n} y_i^2$, The inertial principal axis is $y_i = x_i \cos\alpha_0$, To find α_0 in the minimum of d_l , The d_l derivative of α_0 , So the result is zero can be obtained:

$$m_2 \tan 2\alpha_0 + (m_1 - m_3)\tan\alpha_0 - m_2 = 0 \quad (6)$$

Thereby can get the formula:

$$\tan\alpha_0 = \frac{-(m_1 - m_3) \pm \sqrt{(m_1 - m_3)^2 + 4m_2^2}}{2m_2} \quad (7)$$

III. EXPERIMENTAL RESULTS AND ANALYSIS

The below shows the picture after tilt correction by using minimum moment of inertia.

FIGURE IV. CORRECTION RESULT

As it can be seen from Figure 4 that the algorithm simultaneously have horizontal and vertical correction, The correction accuracy and real-time significantly better than conventional calibration algorithm.

This paper collected 1000 car license plate from a car park in Dalian, which have 750 pictures during the day, at night there are 250 pictures, the image resolution is 320 * 302, This paper using the above three kinds of algorithms and license plate tilt correction algorithm described in this article. After a large number of test results, the experimental results were counted, statistical results in Table 1.

Nearest neighbor interpolation rotation correction, Bilinear interpolation rotation correction and the projected rotation correction algorithm is a common tilting correction algorithm, CICD is proposed in this paper. Statistics show that CICD is higher in recognition rate. Tilt correction algorithm of this paper has been applied in the license plate recognition system in the Dalian airport and teaching, can achieve horizontal and vertical tilt correction, the correction of high accuracy, Calibration accuracy is relatively high. The average error of correction is small.

TABLE I. STATISTICAL RESULTS

	Nearest neighbor interpolation rotation correction	**Bilinear interpolation rotation correction**	**Rotating projection**	**CICD**
The average error correction	0.348°	0.323°	0.318°	0.315°
Recognition rate	89.9%	96.8%	93.4%	99.5%

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