Vehicle License Plate location Based on Histogramming and Mathematical Morphology

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Abstract

In a vehicle license plate identification system, plate region detection is the key step before the final recognition. This paper presents a license plate detection algorithm from complex background based on histogramming and mathematical morphology. The proposed algorithm consists of two main modules: license plate region’s rough detection and license plate exactly location. The former characterized by vertical gradients detection extracts candidate regions from an input image, while the latter conceptualized in terms of mathematical morphology aims to locate the license plate fast and accurately. Experiments have been conducted for this algorithm, and 360 images taken from various scenes were employed, including diverse angles, different lightening conditions and the dynamic conditions. The algorithm can quickly and correctly detect the region of license plate and the license plate detecting rate of success is 97.78%.

1. Introduction

With the development of Intelligent Transport Systems (ITS), automatic license plate recognition (LPR) plays an important role in numerous applications in reality. And how to find the license plate region from complex scenes is the key component of LPR, for which directly affects the system’s overall performance. A large number of scholars have carried on the research and development of this technology recently, and a number of techniques have been proposed, such as the methods base on edge extraction [1], Hough transform [2], color feature [3], and histogram analysis [4]. But most previous works have in some way restricted their working conditions, such as limiting them to indoor scenes, stationary backgrounds, fixed illumination, prescribed driveways or limited vehicle speeds [5-8]. In this paper, as few constraints as possible on the working environment are considered.

This article put forward a method about the automobile license plate automatic detecting that based on histogramming and mathematical morphology. For the bigger intense of gradient variations in a vehicle image represents the position of license plate region and mathematical morphology is very effective in searching black pixels in white background or white pixels in black background which is a main characteristic of the license plate in whole image, license plate region can be roughly located by analyzing histogram of gradient variations and exactly detected by using mathematical morphology.

There are four stages in this algorithm: rough detection of license plate region based on histogramming; extracting candidate regions; defining the vertical position of license plate using mathematical morphology and exactly locating the license plate using the feature of license plate.

The rest of the paper is organized as follows: section 2 introduces the algorithm in detail, section 3 shows the experimental results and finally section 4 concludes the paper with references.

2. The algorithm of license plate detection

There are many characters which we can used to detect the region of automobile license plate, and this paper chiefly uses histogramming and mathematical
The flowchart of the algorithm is shown in Figure 1.

2.1. Rough detection

For the images of license plate are acquired from real environments, such as the corrupted and stained license plate, different distance from the CCD, uncontrolled illumination and moving vehicle, they are often with thick shades and in low contrast. So before license plate detection, a pre-processing should be done to the images. The operation is shown in Eq.1.

\[ f( x ) = \tanh\left( \frac{c}{\sigma} x \right) \]  

(1)

In this equation, \( x \) represents the intensity value of the input image and \( \sigma \) is the variance of the image, and \( c \) is a constant.

2.1.1 Step 1: Get the gradient variance. As one of the features of license plate, most license plates are composed of two colors. So gray of the character pixel and the background pixel are different. We can make use of this feature of the license plate to detect its region. We can calculate the average gradient variance and compare with each other. The bigger intense of variations represents the position of license plate region. So we can roughly locate the candidate of license plate from the gradient value. We can calculate vertical gradient using Eq.2, and Figure 2 shows the result of image vertical gradient.

\[ g_x(i, j) = |f(i, j + 1) - f(i, j)| \]  

(2)

Figure 2. The vertical gradient of image

2.1.2 Step 2: Horizontal projection of gradient variance. From step 1, we can see that the region with bigger value of vertical gradient can roughly represent the region of license plate. So the license plate region tends to have a big value for horizontal projection of vertical gradient variance. According to this feature of license plate, we calculate the horizontal projection of...
gradient variance using Eq.3, and the result of this horizontal projection is shown in Figure 3.

$$T_H(i) = \sum_{j=1}^{n} g_v(i, j) \quad (3)$$

**Figure 3. The horizontal projection of vertical gradient**

From Figure 3, the horizontal position of license plate must be a wave crest of the projection. So we should search the crest to get the possible horizontal position of license plate. But as we can see in Figure 3, there are many burrs in the horizontal projection. In order to get rid of these burrs, we introduce Gauss filter. The Gauss filter is shown in Eq.4.

$$G(x, \sigma) = e^{-x^2/2\sigma^2} \quad (4)$$

But in practice, because the curve is discrete, we often use Eq.5 to filter the image.

$$T'_H(i) = \frac{1}{k} \left\{ T_H(i) + \sum_{j=1}^{w} \left[ T_H(i-j)h(j, \sigma) + T_H(i+j)h(j, \sigma) \right] \right\} \quad (5)$$

where $$h(j, \sigma) = e^{-(j\sigma)^2/2}$$

$$k = 2 \sum_{j=1}^{w} h(j, \sigma) + 1$$

In Eq.5, $$T_H(i)$$ represents the original projection value, $$T'_H(i)$$ shows the filtered projection value, and i changes from 1 to m. w is the width of the smoothness region, h(j,σ) is the Gauss filter and σ represents the parameter of Gauss filter. After many experiments, the practicable values of Gauss filter parameters have been concluded. In our algorithm after many experiments, w = 8 and σ =0.05. The result of horizontal projection after Gauss filter is shown in Figure 4.

**Figure 4. The horizontal projection after Gauss filter**

As shown in Figure 4, one of wave crests must represent the horizontal position of license plate. So the apices and vales should be checked and chosen. The regions can be gotten from the position of apices and vales in the next step.

### 2.1.3 Step 3: Getting candidates

In order to find the position of license plate, we make use of two known features of license plate: firstly, the license plate usually lies on the bottom of the image; secondly, the several maximal integrals of all apices denote the possible horizontal position of license plate.

Therefore, with the purpose of find the real apices and vales of the curve, we examine those apices and vales carefully in order to get rid of the false ones. Then we calculate the integral around the remained apexes and compare them to get the most possible horizontal position of license plate. If there are still several positions, some more strict inspections will be applied to ensure the horizontal position of license plate. If there aren’t any candidates, we must adjust the parameters and re-perform step 1 to step 3 orderly until we can get some candidates.

After that, we duplicate the regions of license plate from original image as candidates of license plate. For many vehicles may have poster signs in the back window or other parts of the vehicle that would fool the algorithm, the candidate regions obtained in this step may more than one in some images. The result of above algorithm is shown in Figure 5.

**Figure 5. The candidates of the original image**

### 2.2 Accurate location

From rough detection, one or more candidates have been taken from original image. Then these candidates will be processed one by one using mathematical morphology.

#### 2.2.1 Step 1: Horizontal gradient and vertical projection of gradient variance

Just as 2.1.1 get the vertical gradient and 2.1.2 get horizontal projection of gradient variance, we can define horizontal gradient as Eq.6 and get vertical projection as Eq.7. The results of the vertical projection are shown in Figure 6.
2.2.2 2.2.2 Step 2: mathematical morphology deal. Mathematical morphology \[1\][9] is an non-linear filter, with the function of restraining noises, extracting features and segmenting images etc. Its characteristic is that it can decompose complex figure and extract the meaning figures. Mathematical morphology’s basic arithmetic are erosion and dilation.

Erosion: Aggregate A is eroded by structure B
\[
X = A \Theta B = \{ X \in B \mid X \subseteq A \}
\]

Dilation: Aggregate A is dilated by structure B
\[
X = A \oplus B = \{ X \in B \mid X \cap A \neq \emptyset \}
\]

The erosion arithmetic and dilation arithmetic could not be resumed. The two operations can conform the open and close arithmetic.

Open : structure B open Aggregate A
\[
A \cdot B = (A \in B) \Theta B
\]

Close : structure B close Aggregate A
\[
A \bullet B = (A \Theta B) \in B
\]

Open arithmetic can eliminate little objects, and separate objects at fine places, smooth boundary of big objects.

Close arithmetic can fill in little holes of objects, and connect two neighborhood objects, smooth boundary of objects.

In the algorithm of this paper, we use close arithmetic to deal with the vertical projection. Suppose the vertical projection of gradient variance to be aggregate A and we use a one dimension structure element B to execute dilation to the aggregate A. And the result is aggregate C. Then we use a one dimension structure element D to execute erosion operation to aggregate C and the result is aggregate E.

In order to draw the region of automobile license plate further, and accelerate processing speed and enhance precision, we select structure element according to the geometry size of the automobile license plate. Suppose the maximum intervals between characters to be a and the height of the character to be 4b, the length of structure element B should be (2a+1), and structure element D should be (2b+1). In our algorithm after many experiments, a=15, b=10. The result after close operation is shown in Figure 7.

2.2.3 Step3: Calculate threshold and binarization. In order to locate the right and left edges of license plate from candidate region, the vertical projection after mathematical morphology deal should be changed into binary image. The arithmetic is:
\[
f_T(i,j) = f(i+1,j) - f(i,j)
\]

\[
T(i,j) = \sum_{i=1}^{m} g_H(i,j)
\]

where \( f_T (i,i) \) is the vertical projection after mathematical morphology, \( T \) is the threshold. Obviously, the key problem of getting binary image is how to choose the threshold. In the algorithm proposed in this paper, the threshold is calculated by Eq.8
\[
T = t * \text{aver}
\]

where aver is the average value of \( f_T (i,i) \) and \( t \) is weight parameter. In our algorithm, after experiments, \( t = 1.23 \).

Then scan the function of \( f_T (i,i) \) and register the potions where values change from 0 to 1 and from 1 to 0 in stack1 and stack2 respectively. So the candidate position of the left and right edge of the license plate are in stack1(1,i) and stack2(1,i) respectively, and the candidate’s width of the license plate is calculated by Eq.9 and the binary images are shown in Figure 8.

\[
\text{width}(1,i) = \text{stack2}(1,i) - \text{stack1}(1,i)
\]

![Figure 6. The vertical projection of horizontal gradient](image1)

![Figure 7. The vertical projection after close](image2)

![Figure 8. The binary image](image3)
with too small or too big width-to-height ratio. If there are still several regions, some more strict inspections should be applied to ensure the region of license plate. And if we can’t get any regions from candidates, we should go back to step 3 and adjust the parameters. Then rerun step 3. From section 2.1.3 we have the acknowledge that there may be more than one candidate region obtained from rough location, each of the candidate regions will be processed one by one from section 2.2.1 to 2.2.3 and finally the left and right edge of the license plate are detected.

2.2.4 Step 4: Extract license plate. From above steps, we can get the row and column position of the license plate. In order to make the location more accurately, we use some rules to adjust the row and column position and then we extract the accurate license plate image from original image. The extracted license plate image is shown in Figure 9.

![Figure 9. The accurate license plate region](image)

3. Experimental result

360 images taken by CCD camera from various scenes and under different conditions of the real world, including diverse angles, different lighting conditions and the dynamic conditions, were employed in the experiment, most of which are with license plate as a frontal view in the image. The size of the images is 600*450. The result of the experiment is shown in table 2. And some extracted license plates on which the method is worked are shown in Figure 10.

<table>
<thead>
<tr>
<th>Total images</th>
<th>horizontal position detecting</th>
<th>vertical position locating</th>
<th>failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>360</td>
<td>355</td>
<td>352</td>
<td>8</td>
</tr>
<tr>
<td>Percent (%)</td>
<td>98.61%</td>
<td>97.78%</td>
<td>2.22%</td>
</tr>
</tbody>
</table>

![Figure 10. Some extracted license plates](image)

Because of the existence of too many other text blocks and weak gradient information from the plate area of some license plates, 8 images in our experiment failed. The success rate is 97.78%.

4. Conclusion

A method is proposed that extracts license plate based on histogramming and mathematical morphology. A two-stage approach is designed to deal with images taken from various conditions. In the first stage, the whole image is searched, and the candidate areas are roughly located based on the gradient feature. In the second stage, the exactly position of license plate is detected by mathematical morphology and the license plate is extracted from the original image.

From the result of the experiment, we can see the proposed approach is robust. But for there are still some images failed in the experiment, our algorithm still needs further research.

References


