Real-time License plate number detection based on image contour

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Abstract. The license plate number detection technology is an application of computer video image recognition technology in vehicle license plate recognition. In this paper, an image processing technology is used to extract and detect a license plate in motion from a complex background to a license plate recognition system. The method in this paper is mainly divided into four steps. First, the original image is preprocessed, the color image is converted into a grayscale image, and the gradient edge features are extracted by Sobel operator. Secondly, after the image is binarized, the image generated through the morphological operation of the image to highlight the image outline. Then detect the contour of the entire image and label the contour. Finally, the RGB space is converted into the HSV color space through color space conversion, and the color of the license plate is used to find the area where the license plate is located in the image.

Keywords: License plate detection, Sobel operator, image morphology, image contour.

1. Introduction
The license plate recognition system is a technology that can detect vehicles on the monitored road surface and automatically extract vehicle license plate information (including Chinese characters, English letters, Arabic numerals, and license plate colors) for processing. License plate recognition is one of the important components in modern intelligent transportation systems and is widely used. Based on digital image processing, pattern recognition, computer vision and other technologies, it analyzes the vehicle images or video sequences captured by the camera to obtain the unique license plate number of each car, thereby completing the recognition process. It is of practical significance for maintaining traffic safety and urban law and order, preventing traffic jams, and realizing automatic traffic management [1].

Some license plate recognition systems also have the function of judging whether there is a car through video images, which is called video vehicle detection [2]. A complete license plate recognition system should include vehicle detection, image acquisition, and license plate recognition. When the vehicle detection section detects the arrival of the vehicle, the image acquisition unit is triggered to collect the current video image. The license plate recognition unit processes the image, locates the position of the license plate, divides the characters in the license plate for recognition, and then forms the license plate number for output. Taking into account the actual situation, license plate images obtained on the road often face various problems, such as light, weather, noise interference or license plate tilt, etc., which will lead to poor picture quality, which will increase the difficulty of license plate
recognition. Therefore, it is necessary to preprocess the image before license plate localization to reduce these interferences. The commonly used license plate positioning methods are mainly as follows [3].

1. License plate positioning method based on edge detection:
   The edges in the image usually appear in the place where the grayscale of the image suddenly changes drastically. The license plate hanging in the center of the car and the surrounding color have a huge difference. Therefore, the edge characteristics of the license plate can be used to determine the upper and lower left and right boundaries of the license plate to complete the license plate number positioning. One of the methods of horizontal and vertical structural elements, which uses edge detection and mathematical morphology to process the license plate image, can be used to eliminate the interference caused by the license plate border and rivets; there are methods based on edge detection to calculate the grayscale jump change the number to determine the license plate area.

2. License plate positioning method based on mathematical morphology:
   The basic operations of mathematical morphology include expansion, erosion, open operations and closed operations. In license plate localization, the local maximum is processed by expansion to process the outside of the image, and the local minimum is processed by erosion to process the interior of the image. This technology can connect the character areas in the license plate image into one piece, but it is difficult to solve the problem of interference noise. Intelligently processing images with relatively simple backgrounds, it is often combined with other methods to achieve license plate positioning.

3. License plate location method based on color features
   Most of the pictures collected by the camera are color images, which contain a lot of color information. The technology for locating license plates based on this information is color positioning. Even under this complex background, the preparation rate of license plate positioning is still high. However, the disadvantages are also obvious. The amount of calculation on the host is relatively large. Results shows: license plate position is not fast enough.

This article combines the three methods mentioned above. First, the input image is preprocessed, the color image is converted into a grayscale image, and then the edge feature map of the entire image is obtained using sobel edge feature extraction. The expansion, erosion, open operation and closed operation in processing the edge feature image, it can connect the character area in the license plate image into one piece. Then, the processed entire image is subjected to contour detection, and the contour area in each image is then judged whether it belongs to the license plate area based on the color characteristics of the license plate. Finally, determine the outline area of the license plate and frame it with a rectangular frame.

2. Principle
   License plate detection process architecture. The license plate detection process architecture is mainly composed of the following 4 parts, as shown in Figure 1:

   ![Figure 1. License plate detection flowchart.](image)

   In Figure 1, after the pre-processing of the input original image, the gradient edges of the entire image can be obtained through Sobel edge feature extraction, and then the digits of the license plate are closed by morphological operations, and the open operation will not be blocky or The smaller part is removed, and the contour edges obtained for part of the image are not uniform. Therefore, performing another expansion operation can make the license plate in the image form a connected area. Then, contour detection is performed on the image, and the results of the detected contour regions are judged one by one on the color features, and finally the bounding box where the license plate number is located is obtained.
**Image preprocessing.** An image containing a license plate number needs to be grayed out from three-dimensional space to two-dimensional space, and then Gaussian blurring is performed on the basis of the grayscale image. The so-called "blur" can be understood as each pixel is averaged from surrounding pixels. As shown in Figure 2, 2 is the middle point, and the surrounding points are all 1. Take the average of the surrounding points at the middle point and it will become 1. Numerically, this is a "smoothing". On the graphics, it is equivalent to produce a "blur" effect, and the "middle point" loses details. Obviously, when calculating the average value, the larger the value range, the stronger the "blurring effect".

![Figure 2](image2.png)

**Figure 2.** Relationship between a pixel and the surrounding 8 pixels.

If you use simple averaging, it is obviously not very reasonable, because the images are continuous, the closer the points are, the closer the relationship is, and the further away the points are, the more distant the relationship is. Therefore, the weighted average is more reasonable, the closer the point is, the greater the weight is, and the farther the point is, the smaller the weight is. Gaussian blur determines the weight of surrounding points according to the normal distribution. The one-dimensional formula of the normal distribution is:

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma}e^{-(x-\mu)^2/2\sigma^2}$$  \hspace{1cm} (1)

The image transformation of the original image after preprocessing is shown in Figure 3:

![Figure 3](image3.png)

**Figure 3.** Image graying and Gaussian blur.

However, for the sake of code efficiency, the calculation method of two-dimensional normal distribution will not be adopted, but the Gaussian blur of the X-axis and Y-axis will be achieved twice, which can also achieve the effect (that is, the weight is calculated by the one-dimensional normal distribution).

**Sobel edge detection.** This article uses Sobel operator for edge feature extraction. It can extract different gradients in the x and y directions. It is a discrete differentiation operator, which is used to calculate the approximate gradient of image gray. The larger the gradient, the more probably the edge [4].

The function of the Sobel operator combines Gaussian smoothing and differential differentiation. It is also called a first-order differential operator. The derivative operator differentiates in the horizontal and vertical directions. The obtained image is in the x and y directions. Gradient image. The
disadvantage of this method is that it is more sensitive to noise and the edges are easily affected. It is necessary to reduce the noise by Gaussian blur (smoothing). The operator expands the difference through different weights.

The Sobel gradient is calculated as follows:

Horizontal change: Convolve I with an odd-sized kernel $G_x$. For example, when the kernel size is 3, $G_x$ is calculated as:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \ast I$$

Vertical change: Convolve I with an odd-sized kernel $G_y$. For example, when the kernel size is 3, $G_y$ is calculated as:

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} \ast I$$

At each pixel of the image, combine the above two results to find an approximate gradient:

$$G = \sqrt{G_x^2 + G_y^2}$$

Sometimes it is replaced by a simpler formula, which is fast:

$$G = |G_x| + |G_y|$$

The effect of binarizing the image after the edge is calculated by the Sobel operator is shown in Figure 4:

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Image morphology processing. The binary edge image obtained in this paper is further processed. The closed operation first connects the digital parts of the license plate, and then the open operation will remove the non-blocky or smaller parts. For the closed operation: the contour of the image is also smoothed, but in contrast to the open operation, it can bridge narrow discontinuities and slender furrows, eliminate small holes, and fill cracks in the contour lines. Use structure element B to close the set A, which is defined as:

$$A \cdot B = (A \oplus B) \ominus B$$

This means that A is first expanded with B and then the result is etched with B. For the open operation, it smooths the outline of the image, breaking narrow necks and eliminating thin protrusions.

Make structure element B operate on set A, which is defined as:
\[ A \circ B = (A \ominus B) \bigoplus B \]  

This means that A is etched with B and then the result is expanded with B. After image morphology processing, because the contour edges of part of the image are not uniform, another expansion operation is performed.

**Figure 5.** Effect of image morphology processing.

**Image contour detection.** Image contour detection is a curve connecting all consecutive points (along the boundary), with the same color or intensity. The borders in the image are connected by curves, and the effect is shown in Figure 6:

**Figure 6.** Image outline detection effect contour.

3. **Experiment**

In this paper, the contour areas detected in the image are quickly converted from RGB space to HSV space, respectively, and the high and low thresholds of blue in HSV space are set to extract the blue features in the area and retain the largest blue area. Contour, and at the same time rectangularize the contour to get the final license plate detection result as shown in Figure 7:

**Figure 7.** License Plate Detection Effect

At the same time, the algorithm of this paper also has the same detection effect on vehicles with background and other color features as shown in Figure 8:
Figure 8. License plate detection effect of other background vehicles.

4. Summary
Modern license plate detection and recognition technology is becoming more and more mature, and this technology realizes automatic traffic management. This article combines the license plate location method based on edge detection, the license plate location method based on mathematical morphology, and the license plate location method based on color features to realize the license plate The automatic positioning of the position reduces interference from environmental changes such as background and vehicle color in actual application scenarios.

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References
[1] Yule Yuan, Wenbin Zou, Yong Zhao. A Robust and Efficient Approach to License Plate Detection [J]. IEEE Transactions on Image Processing, 2017, 26 (3): 1102-1114.
[2] Roy A C, Hossen M K, Nag D. License plate detection and character recognition system for commercial vehicles based on morphological approach and template matching [C] // 2017.
[3] Yuxin Shi, Youguang Chen. License Plate Detection Based on Convolutional Neural Network and Visual Feature [C] // 2018 3rd International Conference on Mechanical, Control and Computer Engineering (ICMCCE). 2018.
[4] Gabriela E. Martínez, Patricia Melin, Olivia D. Mendoza. Face Recognition with a Sobel Edge Detector and the Choquet Integral as Integration Method in a Modular Neural Networks [J]. Studies in Computational Intelligence, 2015, 601: 59-70.