2021 21st ACIS International Winter Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD-Winter) | 978-1-6654-1843-0/20/$31.00 ©2021 IEEE | DOI: 10.1109/SNPDWinter52325.2021.00012

License Plate Detection Methods Based on OpenCV

1st Lin Xu
School of Computer Science and Cybersecurity. Communication University of China
Beijing,China
896991374@qq.com

2nd Wenqian Shang
School of Computer Science and Cybersecurity Communication University of China
Beijing,China
shangwenqian@163.com
* corresponding author

3rd Weiguo Lin
School of Computer Science and Cybersecurity Communication University of China
Beijing,China
linwei@cuc.edu.cn

4th Wei Huang
School of Computer Science and Cybersecurity Communication University of China
Beijing,China
huangwei_910@cuc.edu.cn

***Abstract*—With the popularization of automobile and the progress of computer vision detection technology, intelligent license plate detection technology has gradually become an important part of intelligent traffic management.License plate detection is used to segment vehicle image and obtain license plate area for follow-up recognition system to screen. It is widely used in intelligent traffic management, vehicle video monitoring and other fields.In this paper, two license plate detection methods are studied, one is based on Sobel edge detection and the other is based on morphological gradient detection.Basing on OpenCV and visual studio 2012 under Windows system, two methods of license plate detection are implemented, and the two algorithms are compared in detail from the aspects of license plate detection accuracy.These methods have high efficiency and good interactivity, which provide a reference for later license plate recognition.**

Keywords—Intelligent Transportation System, License Plate Detection, Edge Detection, Morphological Gradient Detection

I. INTRODUCTION

In recent years, with the continuous improvement of China's social and economic level, the popularization rate of China's automobile has greatly increased, and the status of China's automobile industry in the world is also rising.However, due to the rapid development of modern transportation industry and urban construction industry,there is a significant increase in the number of motor vehicles, more and more traffic safety accidents have occurred in China, especially with the development of expressway, the injury and fatality rate of traffic accidents are greatly increased.At present, the main solutions to traffic problems are as follows:controlling the traffic demand, such as taking measures to reduce the number of motor vehicles, but this method is not conducive to long-term development;building more transportation infrastructure, but this way is limited by financial shortage, unreasonable road design and other factors;adopting intelligent transportation system,which is a ground transportation system based on computer technology, artificial intelligence technology and information technology.

The license plate recognition system, which uses digital image processing, computer graphics, computer vision, character recognition and other technologies, is an important exploration in modern intelligent transportation. For examples, the recognition system can be utilized for managing park facilities,monitoring unauthorized vehicles entering private areas,detecting stolen vehicles, controlling traffic volume, ticketing speeding vehicles, and so on.[1]In license plate recognition technology, detection is the key.

Foreign research and development of license plate recognition system is early, and the recognition technology has been very mature,and it has been widely used, their years of experience has also developed a variety of license plate recognition relating to products.[2] Because the products developed by western companies are basically aimed at local license plate recognition, and most of them can only recognize foreign language characters, China can not fully adopt foreign license plate recognition technology, but can learn from its advantages.

Compared with foreign countries, the research on license plate recognition technology in China is relatively late,Chinese companies developing license plate recognition system include:Chengdu Zhenzhi Technology Development Co., Ltd., which has developed Huoyan Zhenjing license plate recognition system; Beijing Wentong Technology Co., Ltd., which has developed Wentong automobile license plate recognition system; Beijing Zhitong Video Technology Development Co., Ltd., which has developed license plate recognition integrated machine, etc. Many Chinese researchers have carried out in-depth research in the field of license plate recognition, developed a wealth of related algorithms, and achieved useful progress.However, in China, the background color of license plate and the color of character bar frame are different. In addition, due to the interference of complex environment and the inability to obtain clear pictures, there is no general open algorithm for license plate recognition in arbitrary environment in China.

II. RELATED PROCESS

Generally, the process of a license plate recognition system includes:(1) Image detection is used to locate the license plate position in the image;(2)License plate correction;(3)Symbol segmentation to divide the symbols or characters in the license plate image into independent parts;(4) Identify characters,

978-1-6654-1843-0/21/$31.00 ©2021 IEEE
DOI 10.1109/SNPDWinter52325.2021.00012

identify the divided part one by one, and finally combine the results to form a complete license plate number.

In this paper, the license plate detection module in license plate recognition is studied. The two algorithms are license plate detection algorithm based on Sobel edge detection and license plate detection algorithm based on morphological gradient detection. It includes the following processing methods and detection: HSV color model processing, edge detection, thresholding processing, morphological processing and rectangular region search.By examining a variety of image types, the license plate detection results are analyzed, and the advantages and disadvantages of the two algorithms are compared and summarized.

III. License plate detection based on Sobel edge detection

A. Algorithm Design

Among the common license plate detection methods based on color image, I selected the license plate detection method based on Sobel edge detection. The process includes:(1)Image preprocessing;(2)Sobel edge extraction;(3)Point extraction of suspected area of license plate;(4)License plate region extraction.

B. Image Preprocessing

It is an important way to distinguish different types of motor vehicles by recognizing the color of license plates.

The color pattern in computer vision is represented by RGB model. The range of R, G and B components is 0 to 255. The colors in RGB color space can be divided into three independent primary colors: red, green and blue.At present, one way of license plate location is to convert RGB image into chroma image.The process includes inputting image, strengthening chroma component, performing binary operation with threshold of th on chroma enhancement map, eliminating unqualified image and determining license plate area .RGB color model has clear physical meaning and is suitable for color display system, but it is easy to be affected by light intensity. When the environment of vehicle is complex, it is not suitable for color segmentation. Therefore, license plate location method based on RGB color model can not obtain good performance.

HSI color space is mainly composed of three basic properties of color, namely hue, saturation and illumination.Hue (H) describes the property of a pure color, which is the feeling of color produced by different wavelengths of light, and reflects the types of colors;Saturation (S) refers to the brightness of pure color after being diluted by white. S value is directly proportional to the color purity, that is, the greater the value, the higher the purity, which reflects the depth of color;Illumination (I) describes the intensity of light. The stronger the luminous intensity of an object, the higher the brightness.For an image with RGB (red, green and blue) resolution as the recognition mode, the HSI component can be obtained for each RGB resolution pixel in the picture according to the following formula.

$$H=\begin{Bmatrix}\theta & B\le G\\ 360-\theta & B>G\end{Bmatrix} \tag{1}$$

$$\theta=\arccos\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-G)(G-B)]^{\frac{1}{2}}}\right\} \tag{2}$$

$$S=1-\frac{3}{(R+G+B)}[\min(R,G,B)] \tag{3}$$

$$I=\frac{1}{3}(R+G+B) \tag{4}$$

Through image analysis, compared with the original RGB image, HSV image has a higher utilization rate of color information, and is closer to people's perception of color, so it is more suitable for target analysis and target cutting scenes .[3]Therefore, we can use cvtcolor statement in OpenCV to convert the original image srcimage to HSI color space to get the license plate of HSV image.

C. Sobel Edge Extraction

In image processing and computer vision processing, edge detection, as one of its main technologies, is mainly used to detect and recognize the set of pixels in the image, which are generated by the drastic change of brightness.The correct use of edge detection method can effectively analyze target detection, target location and content recognition.

Sobel operator, as one of the widely used discrete micromolecule operators, is often used for edge detection in image processing, and is often used to calculate the approximate gradient in the gray function of the image.Sobel operator firstly appeared in 1986, which can be used to calculate the gradient value of image.This operator calculates the vector and corresponding function of image gradient based on pixel points, and detects image edge based on image convolution. Compared with Laplacian operator and Canny operator, Sobel operator is better for image processing with gray gradient and more noise.According to the characteristics of most vehicle license plates, this paper uses the vertical Sobel operator to extract the edge, that is to find the thinning vertical edge of the image.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig. 1. The Sobel convolution factor

The Sobel convolution factor consists of two groups of 3x3 matrices, which are horizontal and vertical. By convoluting them with the image, we can get the approximate values of brightness difference in horizontal and vertical directions respectively.If A represents the original image, GX and Gy represent the gray value of the image detected by horizontal and vertical edge respectively,[4] the formula is as follows:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A \quad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A \tag{5}$$

The horizontal and vertical gray values of each pixel in the image are calculated by combining the following formulas:

$$G = \sqrt{G_x^2 + G_y^2} \tag{6}$$

If the gradient G is greater than a certain threshold, the point (x, y) is considered as the edge point.

As a common edge detection algorithm, Sobel operator has high efficiency in edge detection, but its accuracy is not enough. [5]When the x-axis and y-axis are arranged, the efficiency is better, and the arrangement accuracy of other angles is not enough.The saturation of color is the best way to judge the color (blue and yellow) and non color (white and black), that is, the white characters on the blue background and the black characters on the yellow background can not only strengthen the edge response, but also suppress other interferences in the detection process.The specific implementation of Sobel edge extraction in this paper is mainly through non maximum suppression and thresholding operation. The vertical edge of vehicle HSV image obtained in the above steps is calculated on the saturation channel, and as many pseudo edge areas as possible are eliminated to obtain binary edge image.

If the element value is larger in the gradient matrix of the image, it means that the gradient value of the point in the image is larger, but this can not be used as the basis for judging that it is the edge of the point.Non maximum suppression can eliminate the pseudo edge information in the image during the operation.[6]This advantage is widely used in image edge detection. Its operation principle is to optimize the local neighborhood of the pixel to achieve the optimal value, and then set the gray value corresponding to the non maximum value as the background pixel.In this process, if the neighborhood of a pixel reaches the local optimal value in the gradient value, it can be determined as the edge of the pixel, and the relevant information in the non maximum value can be suppressed. Using this rule, most of the non edge points in the edge pixels can be removed.

The non maximum suppression method based on Sobel edge detection is as follows: firstly, the vertical direction of Sobel operator is defined, and the image is converted into 32-bit floating-point data;Then the gradient amplitude of convolution results is obtained, and the image and operator are convoluted by filter2d;When calculating the gradient amplitude, based on the comparison between the threshold and the vertical neighborhood gradient, if the threshold value is not greater than the amplitude, then * 4 operation is performed;Finally, the gradient of the two regions is determined, and the edge detection of the binary image is carried out after adaptive.

D. Point Extraction of Suspected Area of License Plate

By presupposing the H , S and I of the HSI color space, we can obtain the license plate background color regions which meet the relevant colors such as blue, yellow, black, white, and so on, so as to obtain the HSV license plate extraction image.

According to the constraints of HSI color channel, the corresponding binary color space extraction graph is obtained. For the obtained binary color image and binary edge image, the target image is traversed with a 3 * 3 window. If it is found that there are at least two edge points and there are blue pixels in the 8 neighborhood around the pixel (the same is true for other color pixels), then the pixel can be judged as the interior point of the license plate area in the image, and all the pixels in the image can be screened by this method.Finally, the image of license plate suspected area extraction can be obtained.

E. License Plate Region Extraction

Closed operation and connected region detection are the methods used in the final image extraction.The closed operation can analyze the filling target area, get the discrete small space and scattered parts, fill them, and use the original structure to expand and re corrode the missing part.This method can clear the small black hole (black area) in the image pixels, and the isolated points lower than the adjacent points will also be eliminated in the process. In a sense, it can remove the noise and make the shape contour smooth. The narrow breakpoints and slender cracks will be filled, and the small holes in the contour will be eliminated to fill the cracks in the contour line.[7]Morphologyex function is provided in opencv for open and close operations.

Through the previous steps, the suspected points in the license plate area have been obtained, and the above suspected points are closed to connect the point sets of each region. The closed operator in this paper is 2 * 25.Based on the image obtained in the above steps, the connected region is detected and determined, and then the contour is filtered. According to the basic characteristics of the license plate, the pixel ratio, width height and width height ratio of non-zero area are screened. The pixel ratio parameter is set to 0.5, the width and height are 60 and 12 respectively, and the width height ratio is greater than 2 and less than 5.

IV. License Plate Detection Based on Morphological Gradient Detection

A. Algorithm Design

In the common license plate detection methods based on gray image, I selected the license plate detection method based on morphological gradient detection, and analyze the implementation process of this algorithm into the following steps.(1)Gradient morphology edge detection;(2)Closed operation in horizontal and vertical directions;(3)License plate region extraction.

B. Gradient Morphology Edge Detection

In image processing, because of the characteristics of digital image, differential operation is often replaced by differential method.Because of the disadvantage of fixed direction, simple first-order differential operation can only detect the edge of fixed direction, so it is not widely used.However, if the image gradient can be defined as an operator, it can make up for this shortcoming and is also a commonly used method.Image gradient is a vector with direction and size. The gradient direction is just at the maximum change rate of image gray level,

which is also its biggest advantage. It skillfully reflects the gray transformation on the image edge. The gradient vector is always orthogonal to the edge in the image processing process.

In order to detect and characterize the edge of an image, morphological gradient can be used to enhance the pixel strength of the image edge.[8] The difference between the original image and the image can be formed by expanding or corroding, and then the neighborhood is strengthened to highlight the periphery of the highlighted area.Among the morphological gradients, calculating the arithmetic difference between dilation and corrosion is the most commonly used method. In addition, there are two methods to calculate the morphological gradient, which are the arithmetic difference of the expansion result based on the original image and the arithmetic difference of the corrosion result based on the original image.The output image pixel value of morphological gradient operation is the maximum value of intensity change of gray level in the neighborhood defined by corresponding structural elements rather than local transition region.

The image obtained by the above method is thresholded again for subsequent work.

C. Closed Operation in Horizontal and Vertical Directions

In the last step, according to the principle of morphological gradient detection, the vertical component is used to detect the vertical edge of the license plate area, and then the image obtained by thresholding is operated.The vertical edge is connected by the closed operator in the horizontal and vertical directions of morphology, and the closed operator matrix is adaptively changed according to the target size of the detected vehicle,[9]follow these rules:

(1)Using closed operation unit operators of 1 * 25 and 8 * 1 matrices, the target condition is that the height width is between 400-600 pixels.

(2)Using closed operation unit operators of 1 * 20 and 6 * 1 matrices, the target condition is that the height width is between 200-300 pixels.

(3)Using closed operation unit operators of 1 * 28 and 6 * 1 matrices, the target condition is that the height width is between 200-300 pixels.

(4)The closed operator of 1 * 15 matrix and 4 * 1 matrix can be used to exclude the above situation.

D. License Plate Region Extraction

Firstly, the image is obtained from the above method, and then the connected region is obtained, and then the minimum circumscribed rectangle is obtained,Then, the real license plate size in the minimum circumscribed rectangle is determined. In this process, the rectangle whose proportion and size or image shape are not required are removed. Finally, the connected area of the external rectangle reserved can be determined as the suspected license plate area.

V. Experiment and Analysis

A. Detection Result

Taking two common types of pictures as examples, the output results of the two methods are analyzed.

The first type of picture: the license plate position is positive, the proportion is large, and the background interference is less.

Fig. 2. The first type of picture

Fig. 3. The outputs of the first method and the second method

The second type of picture: the license plate position is tilted.

Fig. 4. The second type of picture

The first method failed.

Fig. 5. The output of the second method

Through the preliminary analysis of the above detection results, it can be speculated that the first method and the second method can successfully detect the license plate area of the vehicle image with positive license plate position, large proportion and less background interference, and the first detection method has higher accuracy and more accurate positioning area.The second method has a higher success rate for vehicle images with inclined license plate position.

B. Comparative Analysis

In order to verify the previous analysis and conjecture of the detection results, in this paper, 65 car photos with license plates are selected randomly,advantages and disadvantages of the two license plate detection methods as well as the application occasions.

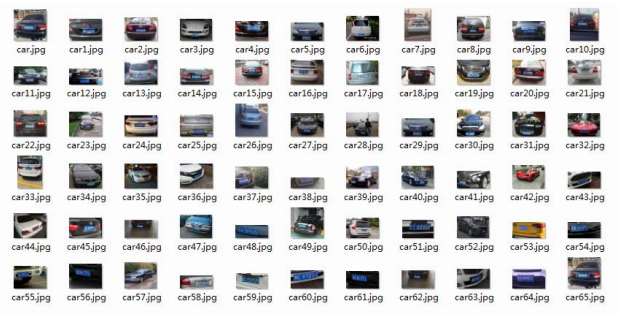

Fig. 6. The data of images

TABLE I. COMPARISON OF TEST RESULTS

Test method / Picture type	License plate detection algorithm based on Sobel edge detection	License plate detection algorithm based on morphological gradient detection
The license plate position is positive, the proportion is large, and the background interference is less(33)	The positioning accuracy is 100% The more accurate rate is 90.91%	The positioning accuracy is 72.73%
The license plate is tilted(32)	The positioning accuracy is 40.63%	The positioning accuracy is 50% The more accurate rate is 70%

Through the comparison of the above detection results, the advantages of license plate detection algorithm based on Sobel edge detection are as follows:When the license plate position is positive, the proportion is large, and the background interference is less,the algorithm can detect the license plate area successfully and the accuracy rate is higher; The disadvantage is:When the license plate is tilted, the positioning accuracy of the algorithm is low. Therefore, the algorithm is suitable for the vehicle images whose camera shooting direction is parallel to the license plate area and has less noise interference.The advantages of the algorithm based on morphological gradient detection are: When the license plate is tilted, the algorithm can detect the license plate area with high accuracy;The disadvantage is: compared with the first method, this method is not accurate enough to locate the license plate of the vehicle image with positive license plate position. The reason for the decline of positioning accuracy is that it is easy to fail to detect vehicle images with multiple noises.Therefore, the algorithm is suitable for detecting the vehicle image with a certain tilt in the license plate position.

C. Improvement Method and Others

In the actual application situation, when a camera shoots the image of a vehicle, there must be a certain angle between the shooting direction and the license plate area, and the license plate image often has a certain tilt. The inclined license plate image will have a great impact on later license plate location and character segmentation,it could reduce the recognition rate, and even make the later character recognition process fail.Therefore, the skew part in the image must be corrected in order to locate accurately. At present, there are mainly three methods for image skew correction:

In image analysis and computer vision, Hough Transformm as feature detection is often used to process tilt correction.This method mainly distinguishes and transforms the features in the image, then classifies the shapes, projects the same shape straight line or curve to another space to form the peak point, thus the detected shape is converted into the problem of statistical peak value.In fact, the algorithm calculates the peak value of the tilt angle, and then corrects it according to the actual situation.[10]

Principal Components Analysis is mainly used for data reduction and signal denoising. Firstly, the principal component is calculated, and then the transformation matrix is obtained. Finally, the original image is corrected by analysis.[11]

The Least Square method is used to correct the skew of the image first, and then the slant correction method is used for other steps.

The corrected license plate image can meet the basic requirements of character segmentation and can be used for later operations.

For license plate recognition, OpenCv provides a neural network like CvANN_ MLP. This multilayer sensing network has one input layer, one output layer and one or more hidden layers. The advantage of deep neural network recognition is that once the network is trained well, the data file needed for recognition is very small and fast.

VI. CONCLUSION

This paper implemented two methods of license plate detection,one is based on Sobel edge detection and the other is based on morphological gradient detection.Through the comparison of the aspects of license plate detection accuracy and license plate tilt detection rate,we can conclude that the license plate detection based on Sobel edge detection is suitable for the vehicle images whose camera shooting direction is parallel to the license plate area and the license plate detection based on morphological gradient detectionis is suitable for detecting the vehicle image with a certain tilt in the license plate position. Therefore, for different types of vehicle images, we can use different license plate detection methods to improve the detection accuracy.

ACKNOWLEDGEMENT

This work was supported by National Key R&D Program of China (2018YFB0803701-1) and Fundamental Research Funds for the Central Universities.

REFERENCES

[1] Hsieh, Jun-Wei, Shih-Hao Yu, and Yung-Sheng Chen. "Morphology-based license plate detection from complex scenes." Object recognition supported by user interaction for service robots . Vol. 3. IEEE, 2002.

[2] Jin, Lisheng, et al. "License plate recognition algorithm for passenger cars in Chinese residential areas." Sensors 12.6 (2012): 8355-8370.

[3] Yan, Qing. "Method of license plate location based on license plate texture and HSV color space." Information Engineering and Applications. Springer, London, 2012. 962-970.

[4] Gao, Wenshuo, et al. "An improved Sobel edge detection." 2010 3rd International conference on computer science and information technology. Vol. 5. IEEE, 2010.

[5] Deng, Caixia, Weifeng Ma, and Yin Yin. "An edge detection approach of image fusion based on improved Sobel operator." 2011 4th International Congress on Image and Signal Processing. Vol. 3. IEEE, 2011.

[6] Neubeck, Alexander, and Luc Van Gool. "Efficient non-maximum suppression." 18th International Conference on Pattern Recognition (ICPR'06). Vol. 3. IEEE, 2006.

[7] Chaudhuri, D., and Ashok Samal. "A simple method for fitting of bounding rectangle to closed regions." Pattern recognition 40.7 (2007): 1981-1989.

[8] Rivest, Jean-Francois, Pierre Soille, and Serge Beucher. "Morphological gradients." Journal of Electronic Imaging 2.4 (1993): 326-337.

[9] Evans, Adrian N., and Xin U. Liu. "A morphological gradient approach to color edge detection." IEEE Transactions on Image Processing 15.6 (2006): 1454-1463.

[10] Leavers, V. F. "Which hough transform?." CVGIP: Image understanding 58.2 (1993): 250-264.

[11] Dunteman, George H. Principal components analysis. No. 69. Sage, 1989.

[12] Axelsson, Owe. "A generalized conjugate gradient, least square method." Numerische Mathematik 51.2 (1987): 209-227.

[13] Anagnostopoulos, Christos Nikolaos E., et al. "A license plate-recognition algorithm for intelligent transportation system applications." IEEE Transactions on Intelligent transportation systems 7.3 (2006): 377-392.

[14] Du, Shan, et al. "Automatic license plate recognition (ALPR): A state-of-the-art review." IEEE Transactions on circuits and systems for video technology 23.2 (2012): 311-325.