A hybrid License Plate Extraction Method Based On Edge Statistics and Morphology

Bai Hongliang and Liu Changping

***Abstract*—This paper presents a hybrid license plate extraction algorithm based on the edge statistics and morphology for monitoring the highway ticketing systems. The method can improve the location rate only by the edge statistics. The proposed approach can be divided into four sections, which are, vertical edge detection, edge statistical analysis, hierarchical-based license plate location, and morphology-based license plate extraction. The algorithm can quickly and correctly detect the region of vehicle license plates. Under the experiment databases, which were taken from real scene, 9786 from 9825 images are successfully detected. The average accuracy of locating vehicle license plate is 99.6％.**

***Index Terms*—edge Detection, hierarchical-based license plate location, morphology**

I. INTRODUCTION

IN the modern society, the highway plays a more and more important role in the whole industry of transportation. The Intelligent Transport System (ITS) technology has gotten so much attention that many systems are being developed and applied all over the world. Vehicle license plate recognition (LPR) has turned out to be an important research issue. LPR has many applications in traffic monitoring system, including controlling the traffic volume, ticketing vehicle without the human interruption, and so on.

Usually, a LPR system consists of three parts, that is the license plate detection, the character segmentation, and the character recognition. Among these, the most important and basic is to correctly extract the position of the vehicle license plate, which directly affects system's overall accuracy. To make the extraction process successful and fast, many difficulties must be settled, such as the poor image quality from the uneven lighting condition and various observation angles from the vehicles and cameras..

To detect the region of car license plate, in the past, many techniques have been used, for example the morphological operations[1] [2][10], edge extraction [3][5][7][9], combination of gradient features [4], a neural network for color classification [6], vector quantization [8]. Eun Ryung Lee et al used a standard back-propagation neural network (BPNN) to extract the Korean license plate region under the HLS color space. However, the result maybe bad because for the native shortcoming of BPNN and the unstable properties of color. The result of the vector quantization depends on the uneven lighting and some spots on plates.

Fig. 1 shows the overview of the proposed system, which consists of four sections. After the images are grabbed though the Hanwang Eye ™, the vertical edges are detected, and then edge statistical analysis, such as density of points and lines is calculated. Considering the Chinese license plate layout, the hierarchical-based method is used to extract the license plate. Finally the morphology-based license plate extraction is used to deal with the license plates abraded. In experiments, 9825 real scene images including different orientation variations and lighting are used to test the effectiveness and speed of the algorithm. 9786 plates are accurately located and the localization rate is above 99.6%. It has a notable improvement than before.

In the next section, we describe the algorithm in detail. The experiment results are shown in section 3. In section 4, we summarize the paper.

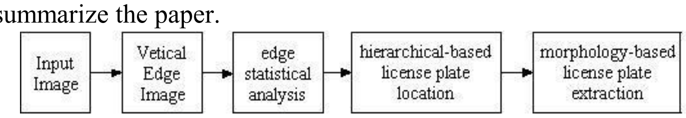

Fig.1. The sytem chart

II. LISENCE PLATE LOCATION

As shown in Fig. 1, the technique for automatically detecting license plate consists of four steps, including the vertical edge detection, edge statistical analysis, hierarchical-based license plate location, morphology-based license plate extraction, which will be described in detail in this section according to the processing order.

A. Vertical Edge Detection

If an image consists of regions of interest (ROI) on a contrasting background, an edge is a transition from background to object or vice versa. There are many methods of performing edge detection. Some of the common ones are Kirsh, Laplacian, Robert, Canny and Susan operators. But for the image that containing license plate may also including the dynamo and fore-baffle etc, which have very strong horizontal edges. These edges have great effect on the LP localization. Fig 2 shows the horizontal edge map by Eq. 1 and vertical edge map

H.L. Bai is with Institute of Automation, Chinese Academy of Sciences, No.95 East of Zhongguan Road, Haidian District, Beijing 100080, P.R.China E-mail: baihl@hanwang.com.cn

C.P. Liu is with Institute of Automation, Chinese Academy of Sciences, No.95 East of Zhongguan Road, Haidian District, Beijing 100080, P.R.China E-mail: lcp@hanwang.com.cn

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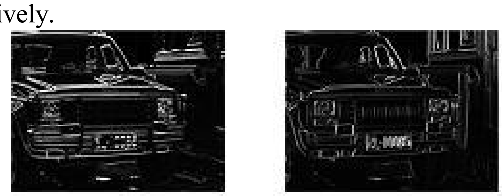
Eq. 2. We can see that vertical edge detector is better than horizontal edge detector in suppressing horizontal noise. Before vertical edge detection, a linear filter is used to smooth the image and apply the illuminance normalization to reduce the influence of light.

$$\begin{aligned} g_H(i,j) = |&[f(i-1,j-1)+2f(i-1,j)+f(i-1,j+1)] \\ &-[f(i+1,j-1)+2f(i+1,j)+f(i+1,j+1)]| \end{aligned} \quad (1)$$

$$\begin{aligned} g_V(i,j) = |&[f(i-1,j-1)+2f(i,j-1)+f(i+1,j-1)] \\ &-[f(i-1,j+1)+2f(i,j+1)+f(i+1,j+1)]| \end{aligned} \quad (2)$$

Where $f(i,j)$ represents the gray image of the input image after smoothing and normalization, $g_H(i,j)$ and $g_V(i,j)$ represents the horizontal edge map and vertical edge map respectively.



(a) (b)

Fig. 2. (a)Horizontal edge (b) Vertical edge

B. *Edge Statistical Analysis*

The change of images is very great on the highway, which include the lighting change, surrounding change, license plate surface change, and so on. So choosing the threshold of edge is not random. It is difficult to distinguish the license plate from the fore lamps. After analysising the character of license plate, we choose four different thresholds.

The process of determining the candidate regions is step by step. First, points are combined to lines. Then lines are combined to rectangles. Finally, the rectangles are combined or deleted. So there are three steps to need.

1) *Forming the lines*

The edge points are named as feature points (FP). The FPs are scanned in the horizontal direction. If the distance of neighbor FPs is less than MAXLENGTH, then the two points form a line. If the distance from the following horizontal point to nearest point of above line is also satisfied the above condition, and then it is combined to the line. By analogy, a group of lines are gotten. The density of points is calculated according to Eq.3. If the point density in the line is between the MINPOINTDEN and MAXPOINTDEN, then the line is reserved, otherwise is deleted. The MINPOINTDEN and MAXPOINTDEN are chosen according to the number of character on the license plate.

$$PointDen = \frac{LineLength}{SumPoint} \quad (3)$$

Where $PointDen$, $LineLength$, and $SumPoint$ represent the density of points in the line, the length of the line, and the number of total points in the line respectively. The remaining lines are called the feature lines (FL).

2) *Forming the Rectangles*

The process of forming the rectangles is like the step 1. First, the lowest line is found in the input image. Based on the line, the above line will be added to it if the vertical distance of the line is less than the MAXDISTANCE. Then, another line is judged whether it belong the rectangle or not. By analogue, a serial of rectangles are gotten. If the line density in the rectangle is greater the MINLINETDEN, then the rectangle is reserved, otherwise is deleted.

$$LineDen = \frac{RectArea}{SumLine} \quad (4)$$

Where $LineDen$, $RectArea$, and $SumLine$ represent the density of lines in the rectangle, the area of the rectangle, and the number of total lines in the rectangle respectively. The remaining lines are called the feature rectangles (FR).

3) *Combining the rectangle*

After getting the rectangles, they are combined because of the unevenness. For the rectangle, R1 and R2, there are four-position relations, shown in Fig.3. (a)-(d) represent the intersecting relation, vertical relation, horizontal relation, diagonal relation.

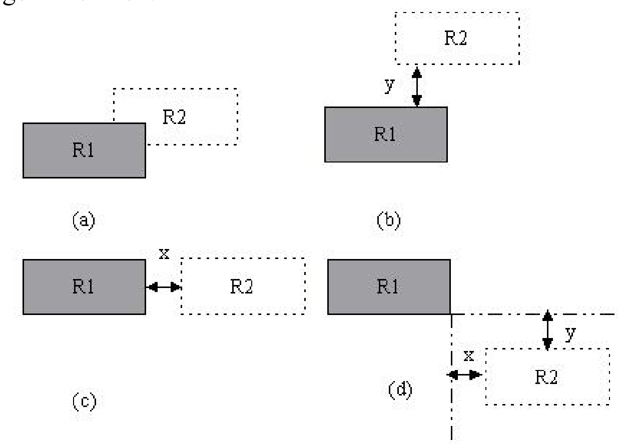


Fig.3. the combination of the rectangle

The candidate regions are combined if they are almost the same width and y-direction position and small distance between them. It can be formulated by the following Eq.5 and named the connected density.

$$D = \frac{overlap_V}{\min(h_1, h_2)} - \frac{dis_H}{\sqrt{w_1 \times w_2}} \quad (5)$$

Where $overlap_V$ denotes the overlapped length of two rectangles in the vertical direction, and dis_H denotes the distance of horizontal direction, and the h_1, h_2, w_1, w_2 denote the height and width of rectangles respectively. If the connected density is greater than some threshold, the two rectangles are combined.

C. *Hierarchical-based license plate location*

In the system, the different threshold of the license plate location is regarded as the different scale, shown in Fig.4. The thresholds are 64, 32, 16, 8, which are the first, the second, the third, the forth scale. In the big scale, the number of the FPs is small, the run time of system is little, but the license plate is detected hard. In the low scale, the more FPs, long time, more regions are gotten, but maybe some fake license plates are also detected.

If the switch pattern is adopted, that is to say, if some candidates are detected, the single word cutting and recognition are done in the region, the abraded license plate is hard to find. To resolve the problem, we use the hierarchical-based location method. Concretely, the results of the first, second, and the third scale are fused. Normally, if the plate is detected in the first scale, it is also detected in the second scale and the third scale. After this fusion section, the 7-8 candidate regions are gotten, and only 3 regions are remained at most by the following rules.

(1) Priority is given to the rectangles gotten from the first scale.

(2) Priority is given to the rectangles in the bottom of the images.

(3) Priority is given to the rectangles, which correspond to the dimension and the ratio of the standard license plate.

(4) The intersecting regions can be referred to the section B. After the three scales, if there are no yet detected candidate regions, the hierarchical method will enter the forth-scale section. Because of more FPs, more candidates will be produced.

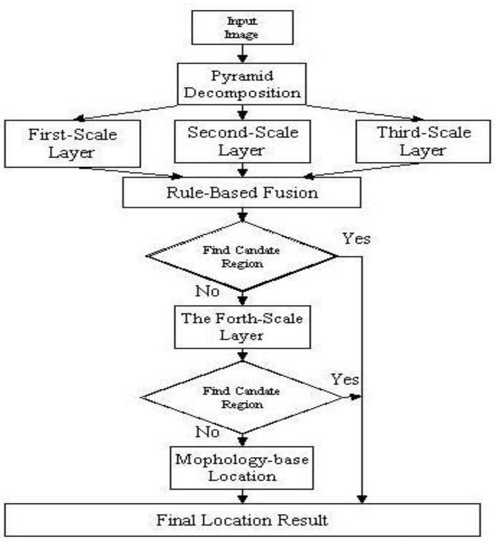


Fig.4. Hierachical char for license plate location

As shown in Fig.5, (a)-(c) represent the candidate region under the first, the second, the third scale. The final fusion result is shown in Fig. 5 (d).

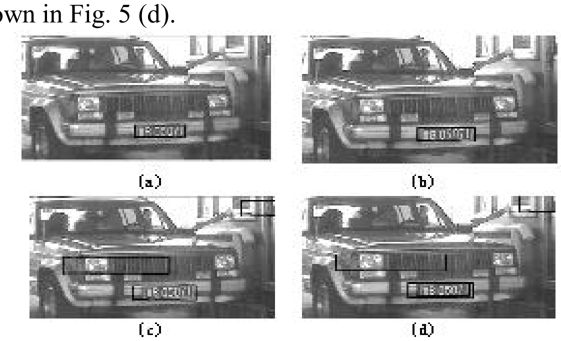


Fig.5. The result of hierarchical fusion

In the practical use, some license plates are so abrasive that it is difficult to detect them with the edge statistics. So from Fig.4, morphology-based license plate location is adopted to resolve the problem.

D. Morphology-based license plate location

Plate regions tend to have a high density of edges. So we can measure the edge density by summing all edge pixels using Eq. 6 in 3×15 block, which is center at $g(i, j)$. Fig.6 a. shows the density of the Fig. 2 a.

$$d(i,j)=\frac{1}{45}\sum_{x=-1}^{x=1}\sum_{y=-7}^{y=7}g_v(i+x,j+y)Mask(i+x,j+y) \qquad (6)$$

Where $d(i,j)$ represents the edge density map.

Before dilation, Binarization and nonlinear filter are used to remove the narrow horizontal lines, which are too strong to be suppressed by vertical edge detector. The Otsu method is used to thresholding the density map that we get at previous step, shown Fig. 6b. For each white (object) pixel, we detected its top edge and bottom edge. If the height between the top edge and the bottom edge is smaller than a certain thresholding T, we turn the pixels from top edge to bottom edge to black (background). We can see the result from Fig. 6 c.

Then we dilate the image use a horizontal mask. The size of the mask is 1×9. This step can join the small closed blocks to a larger one, which will be helpful to the next step. Fig. 3 d. shows the dilation result.

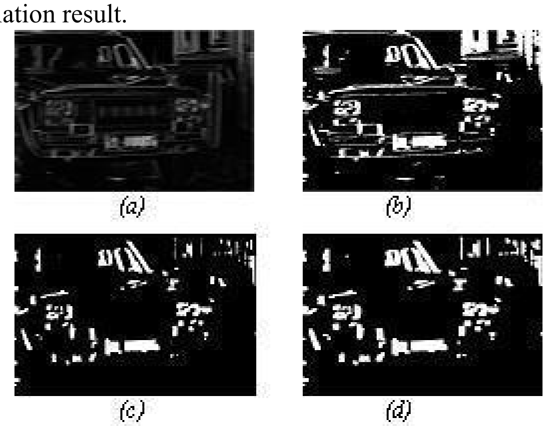


Fig. 6. (a)Edge density map (b)Binarization (c)Nonlinear Filter (d) Dilation

After the preprocessing, following steps gets the candidate regions of morphology-based license plate location:

1) Connected Component Analysis

The connected component analysis algorithm is applied to the processed images. So we get the bounding rectangle of the object and the number of the object pixels in these rectangles.

2) Feature Extraction

With the important information from the CCA, some features of region, such as the aspect ratio (R), the area (A) and the density (D) of region are applied. Let Re denote the region of rectangles with width W and height H, then $R = W/H$ and $A = W\times H$. Let N denote of the number of the object pixels in the rectangles, then $D = N/(W\times H)$. The result by using these features is that most of components are deleted, and 1-5 candidate region(s) will be gotten.

3) Combination of candidate regions

The step can refer to the section B.

4) Getting Final Candidate regions

Some more strict conditions will be applied, and then we can get the final position of license plate, the number of candidate is less than 3. In general, the number is only 1.

III. EXPERIMENTS

Experiments have been implemented to test the efficiency of the proposed system. 9825 color or gray images are been used for testing. The size of them is 768×534. For improving the complexity and universality of the test databases, the images are acquired from the real highway ticketing stations at different lighting condition (cloudy, sunny, daytime, night time) and different kinds of vehicle (van, truck, car). Performance is carried out on PIV 1700MHz/256RAM.

The result of experiment shows that the proposed algorithm can detect the region of the license plate above 99.6%. From the accuracy, we can see the system is robust. The processing time of one color image is about 100ms, which is faster than the algorithm mentioned above. As shown in Fig. 7, the regions of the vehicle license plates are detected. Fig.8 shows the detection result of some deficient images.

IV. CONCLUSION

A hybrid license plate localization scheme is presented in the paper, which is based on the edge statistic and morphology. The proposed approach can be divided into four sections, which are, the vertical edge detection, the edge statistical analysis, the hierarchical-based license plate location, and the morphology-based license plate extraction. The algorithm gives good results on our database, and it is relatively robust to variations of the lighting conditions and different kinds of vehicle. From the result of experiment, the scheme is satisfying.

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Fig.7. the experiment result

Fig.8. The detection result of the deficient license plate