An Efficient Method of License Plate Location in Natural-scene Image

Haiqi Huang[1] , Ming Gu[2] ,Hongyang Chao [2]
[1] *Department of Computer Science, Sun Yat-Sen University, 510275, P.R. China*
[2] *School of Software, Sun Yat-Sen University, 510275, P.R. China*
Email: isschhy@mail.sysu.edu.cn

Abstract

License plate recognition (LPR) plays an important role in the application of intelligent transportation system (ITS), while the license plate (LP) location is the most crucial step in it. In this paper, a new and efficient algorithm for vehicle license plate location is proposed. The purpose of this approach is to locate license plate efficiently regardless of the limitation of LP distance, angle of view, illumination conditions as well as background complexity. The contribution of this method is that we combine sliding concentric windows (SCWs) method and mathematical morphology method so as to gain a more fast and robust one. Moreover color information of LP is also employed to locate LP accurately. Compared with other LP location methods, our method is not restricted by many preconditions and can locate more than one LP in an image. Moreover, the processing time is acceptable in real time (only 0.1 second). The algorithm was tested with 200 natural-scene vehicle images of different backgrounds and ambient illumination. Experimental results lend strong support for the robustness and efficiency of the method presented in this paper.

1. Introduction

License plate recognition (LPR) system can be applied to many applications, such as electronic toll payment, traffic surveillance and security control of restricted areas. Of all these application areas, license plate location (LPL) plays an important role, and also it is the most difficult step [1]. Therefore, any improvement of license plate location algorithm is very helpful in all related applications.

Typically, for all license plate (LP) location methods, LP in an image is determined in an image by its features which include LP color [2], shape [3], symmetry [4], texture of grayness [1], spatial frequency [5], and variance of intensity values [6]. All of the LPL methods can be divided into two categories which are shown in fig.1: the grey-scale-based method and the color-scale-based method. Nowadays most LPL algorithms are based on grey-scale images [1], for its simplicity and the maturity of related technology. Meanwhile, the difficulty of determining color in a color-scale image also hinders the development of color-scale-based methods. However, as color-scale image contains rich information of LP, it attracts some academic attention recently and the experiments showed that it is feasible as well [1].

Analyzing texture or frequency of image is the mainstream in grey-scale-based method. Furthermore, we can divide texture-based method into three kinds: edge analysis [7], region analysis [1], and template matching methods [8]. In the grey projection map of an image, the horizontal lines that cross the LP always show continuous peak-valley-peak distribution, which provide the basis for edge analysis methods. Sometimes these methods are too simple to locate LP when the background of the image is complex and many horizontal lines that cross the background may have similar peak-valley-peak distribution as the horizontal lines that cross the LP. Methods based on region analysis are the most popular and efficient ways to locate LP. Because LP contains same number of characters which have rich edge texture, region-analysis methods use algorithms like edge detective to extract the textures of the images, and connect these textures into regions from which license plates are determined by the features of them. Unlike above, template matching methods require a priori knowledge of the size of a LP and use a rectangle of the same size as template to locate the LP. The template that contains the most amount of LP feature is likely to be the area which LP locates.

Though there are already many successful implementations of license plate recognition system in reality, the recognition rate is still not satisfied. Most of these systems can only be applied to simple scenes in which the camera focus on the license plate. In a natural-scene image, illumination may vary significantly; the background could be rather complex and even there may be more than one LP in one image. The traditional license plate location methods perform poorly in these situations. The aim of this study is to improve the performance of LPL in these cases and lower the processing time. Compared with other license plate location methods, our

978-0-7695-3305-6/08 $25.00 © 2008 IEEE
DOI 10.1109/FSKD.2008.230

method is not restricted by many preconditions and can locate more than one LP in the image. Moreover, the processing time is acceptable in real time (only 0.1 second).

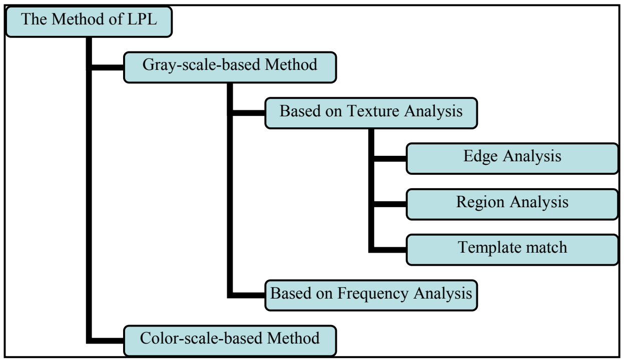

Figure 1. The categories of license plate location methods.

2. The Proposed Method for License Plate Location

The typical license plate in China is composed of letters and digits, as is shown in Table 1. There are two kinds of plates according to the number of rows. The one-row license plate has three color schemes: white characters in blue background, white characters in black background, and black characters in white background. The size of all one-row LP in China is 440×140 (mm), and each character is 45mm wide and 90mm high. The size of two-row license plate is 440×220 (mm) (standard of GA36-92). All these information can help us to find license plates in an image.

Table 1. The classification of LP.

One-row LP	Blue background White characters	
	Black background White characters	
	White background Black characters	
Tow-row LP	Yellow background Black characters	

Fig. 2 shows the flow chart of our proposed method. The novel contribution of our method is that we proposed a more fast and robust method which combines SCWs method [1] and mathematical morphology method [9], as it is listed on 2.2 and 2.3. Furthermore, color information of LP is also employed in our method to locate LP accurately.

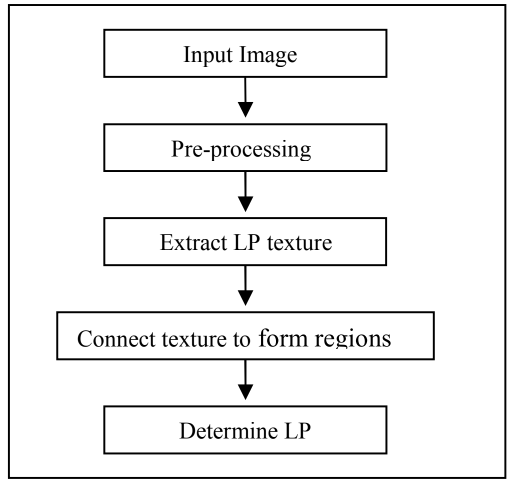

Figure 2. The flow chart of our proposed method.

As shown in Fig 2, our algorithm can be divided into four steps: pre-processing, extract LP texture with OSCW method, connect texture to form regions with mathematical morphology and determine the LP. We explain these steps in details in the following subsections.

2.1 Pre-processing

In the first step of our algorithm, we scale down the input image into a resolution of 484×324, and convert the color-scale image into grey scale. A low resolution picture can greatly speed up the LPL process and a certain decline of resolution has little effect on our method. Our algorithm performs only on binary or grey-scale image, but the original high resolution color-scale picture is retained. The color information is needed to further locate LP. A high resolution picture is also preferable in the character segmentation and character recognition process.

2.2 Optimized sliding concentric windows (OSCWs)

The algorithm of sliding concentric windows (SCWs) is proposed by Christos. N. E. A et al [1]. The main idea of this algorithm is as follows. Two concentric windows A and B scan through the image from left to right, top to bottom (Fig.3). The statistical measurement (mean value or standard deviation) in the two boxes is calculated at the same time. If the ratio of the statistical measurements in the two windows exceeds a threshold, the central pixel of the windows is considered to belong to region of interest (RoI). The pixel value in the perspective coordinate (x, y) of the image is set either 0 (not in RoI) or 1 (in RoI) according to Equation (1).

$$in \quad I(x,y) \Rightarrow \begin{cases} I(x,y) = 0, if \ \dfrac{M_B}{M_A} \le T \\ I(x,y) = 1, if \ \dfrac{M_B}{M_A} > T \end{cases} \quad (1)$$

Here M is the statistical measurement.

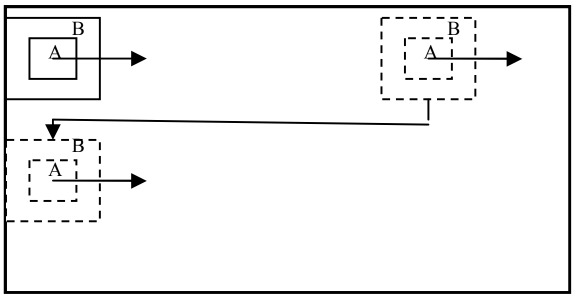

Figure 3. The process of SCWs.

The SCWs algorithm can outline the area which has abrupt changes in the image (Fig. 5 (b)). Based on experiments, we find that small size of those two windows is preferable, because large size of them is time consuming and not robust. As a result, we set the size of inner window to 2×2, and the outer window to 4×4. Though we can't form a region of license plate in the image directly, we use mathematical morphology for supplement and gain a faster and more robust method.

2.3 Mathematical morphology

There are two basic operations in mathematical morphology: erosion and dilation. Each of these operators takes two pieces of data as input: an image to be processed, and a structuring element (SE). Erosion of object A by the SE B is defined by Equation (2). Similarly, dilation is defined by Equation (3).

$$A \otimes B = \{z \mid (B)_z \subset A\} \quad (2)$$

$$A \oplus B = \{z \mid (B)_z \cap A \neq \varnothing\} \quad (3)$$

After OSCWs process, we can see that most pixels in the license plate area belong to RoI, though they may not be connected as a region (Fig.5 (b)). Here, we use Fig.4 (a) as SE for erosion so as to eliminate small islands and horizontal lines (Fig.5 (c)). After that we use Fig.4 (b) as dilation's SE to connect the isolated parts in the image (Fig.5 (d)).

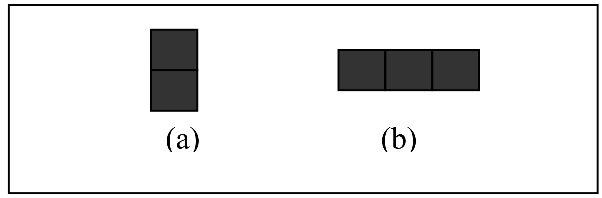

Figure 4. (a) SE for erosion, (b) SE for dilation.

2.4 Determine the license plate

After all of the above processes, we can see that there are many connected regions in the image among which license plate area exists. We need to sift through all these candidates with the width, height and width-to-height ratio of LP to determine the location of LP. If we set the filter conditions too strict, the region containing LP may be missed. However, if we set the filter conditions too soft, other regions may be included. After trial-and-error experiments, we find that width between 20 and 50, height between 10 and 40, width-to-height ratio between 2 and 5 are suitable to determine license plate region.

With the raw location of LP we get, to further locate LP accurately, color information is needed. Because of varied illumination, it is difficult to determine color in the image. We define blue color if (B-1.5*R>0&&B>G) and the yellow color is defined if (R+G-2*B>60), here B is the blue value of the pixel, R is the red value of the pixel and G is the green value of the pixel [4].

In the raw location area of LP, we extract the blue or yellow color and get the result area like Fig.6. At the same time, according to the blue or yellow color for LP background, the kind (private car or bus) and the layout of LP are determined. For example, it is one-row LP if the background color is blue and it is two-row LP if the background color is yellow.

3. Experimental results

We take 200 pictures for experiments. Some of these pictures are collected from the Internet; others are takenby camera in natural scene. All these images may have different resolution, various illumination conditions and even varied view points.

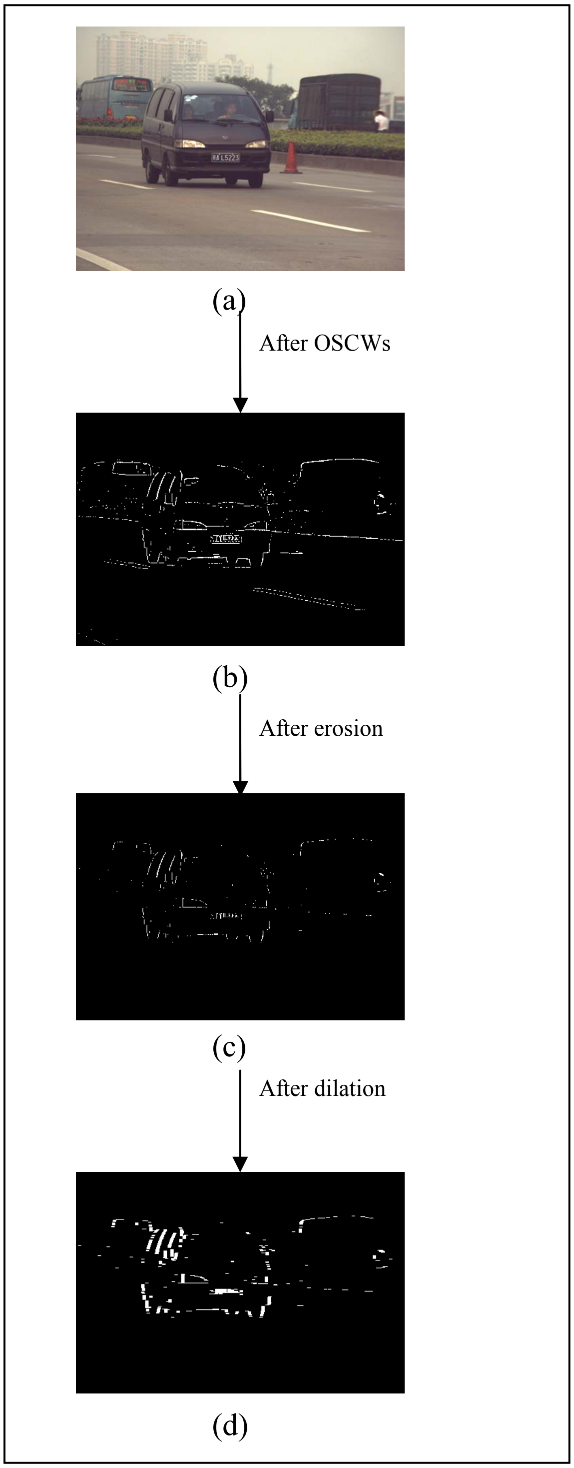

Figure 5. The process of mathematical morphology.

Figure 6 shows the experiments on two pictures of different illumination conditions and Figure 6 shows the experiments on two pictures of different illumination conditions and varied view points. The experimental result is presented in Table 2. This method is success over 90% cases and the images that we fail to locate LP are mostly because the illumination is dark or the LP is blurred.

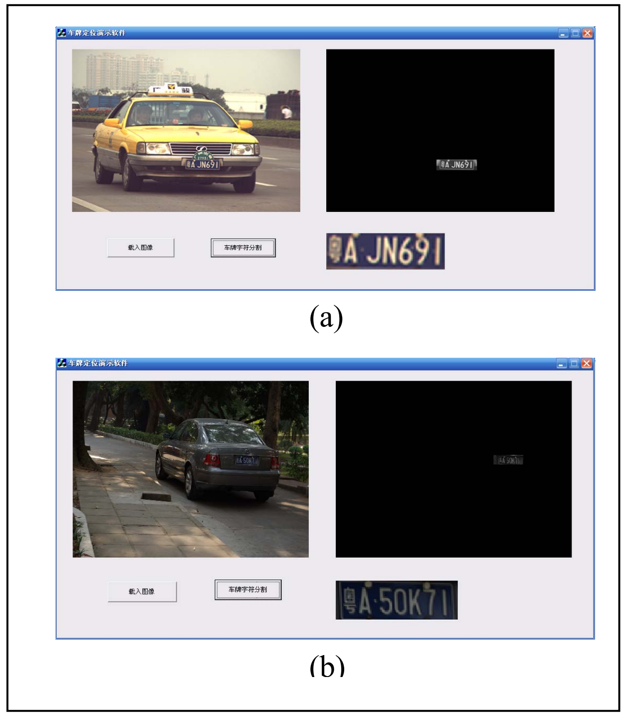

Figure 6. Experiments on different conditions.

Table 2. Success rate.

Total Image	Success	fail
200	192	8
(%)	96%	4%

Another advantage of our algorithm is that it can locate more than one LP in an image, as it is shown in Fig.7. Moreover, as color information is employed in our method, we can determine the background color of LP at the same time, which is very helpful for later processes.

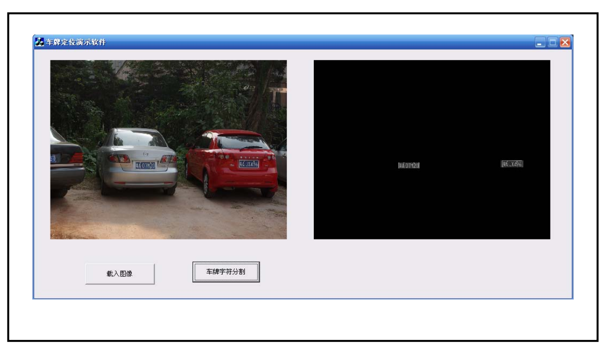

Figure 7. Successful location of two LP in an image.

Because the method of this paper is an improvement of the method proposed in [1], a comparison is made between these two methods with the same testing set. The result is shown in table 3.

Table 3. Comparison between our method and the method proposed in [1].

	Ratio of Success	Time Required
Method in [1]	160/200	642ms
Our Method	192/200	140ms

Experiment shows that our method outperforms the original method both in ratio of success and in processing time.

4. Conclusions

In this paper, we present a new LPL algorithm which is based upon SCWs and mathematical morphology methods. Experimental results show that our method is efficient to locate LPs from an image regardless of LP distance, angle of view, illumination conditions as well as background complexity. Though we target on Chinese LP in this paper, our method can be applied to other LPs as well if we do a little changes.

LPL is just the first step in LPR system. We will concentrate our work on character segmentation and character recognition later. We hope that our effort can be applied to real practice in future.

5. References

[1] Christos Nikolaos E. Anagnostopoulos, I.E.A. and V.L.a.E. Kayafas, “A license plate recognition algorithm for intelligent transportation system applications”, IEEE Transactions on Intelligent Transportation Systems, 2006, 7(3), pp. 377-392.

[2] Zhu Wei-gang, H.G.-j., Jia Xing, “A study of locating vehicle license plate based on color feature and mathematical morphology”, In the 6th International Conference on Signal Processing, Beijing, 2002, vol.1, pp. 748–751.

[3] M. J. Ahmed, M. Sarfaz, A. Zidouri, and K. G. AI-Khatib, “License plate recognition system”, In the 10th IEEE International Conference on Electronics, Circuits and Systems, 2003, pp. 898-901.

[4] D. S. Kim and S. I. Chien, “Automatic car license plate extraction using modified generalized symmetry transform and image warping”, In the IEEE Symposium on Industrial Electronics, 2001, vol. 3, pp. 2022–2027.

[5] C.-T. Hsieh, Y.-S. Juan, and K.-M. Hung, “Multiple license plate detection for complex background”, In the 19th IEEE International Conference on Advanced Information Networking and Applications, 2005, vol. 2, pp. 389–392.

[6] D. S. Gao and J. Zhou, “Car license plates detection from complex scene”, In the 5th International Conference on Signal Processing, 2000, vol. 2, pp. 1409–1414.

[7] Shyang-Lih Chang, L.-S.C., Yun-Chung Chung, and Sei-Wan Chen, “Automatic license plate recognition. IEEE Transactions on Intelligent Transportation Systems”, 2004, 5(1), pp. 42-53.

[8] Danian Zheng, Y.Z., Jiaxin Wang, “An efficient method of license plate location”, Pattern Recognition Letters, 2005, 26, pp. 2431-2438.

[9] J. Serra, “Image Analysis and Mathematical Morphology”, Academic Press, USA, 1982