FIT5190 Introduction to IT Research Methods

An Efficient Method of License Plate Localization under Complex Background

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28 May 2017

Contents

Abstract

License plate localization (LPL) is the core issue in the intelligent transport system (ITS). The ability to localize the plate effectively determines the success or failure of the entire intelligent system. This paper proposes a three-phase system of gradual localization of license plate in a complex background. Firstly, preprocessing is taken for better recognition. Secondly, a rough localization based on the improved detection of color information and simplified morphological operations are taken to seek all the possible regions of plate as candidate regions. Lastly, wavelet transform is selected to further filtrate the candidates in the phase of accurate localization. My system chooses the optimal approach for each phase according to the current characteristic of the image. It performs well especially for complex background, helping for further realizing the intelligence and digitization of traffic management.

Keywords: LPL, complex background, color detection, morphology, wavelet transform

1. Introduction

To identify motor vehicles in different applications, such as traffic surveillance and parking lot management, localizing the license plate is a greatest challenge in the license plate recognition (LPR) system (Faradji et al., 2007). Many researches on methods of LPL have been taken in recent years, such as color detection, mathematical morphology, edge detection and wavelet transform. Color detection is based on color discrimination in HIS color model (Cheng & Chen, 2009). Although it is simple to realize and easy to understand, it requires that the background cannot have a similar color to the plate. Morphology performs well in noisy condition based on the extraction of the graphic feature of the plate, but it is time-consuming (Faradji et al., 2007). Edge detection is a simple way to find possible contour of the plate. However, it makes no sense unless it combines with other methods, since the contours of other objects will also be detected (Han & Han, 2012). Wavelet transform locates the plate by the distinguishing high frequency on the energy curve because (Rajput et al., 2015).

LPL in a complex background is the goal of this research. However, the methods above cannot satisfy the requirements in a complex background alone. Some improvements and modifications are made in my system of LPL. For color detection, the range of HSI color model will be expanded to get preprocessed images reserving the valid plate region even covered with dust. For morphology, I will operate it on binary image instead of gray image to simplify computational complexity. For edge detection and wavelet transform, they both have low robustness under complex situations with background noise. Thus, these two methods will be taken only after the preprocessing.

In the case of choosing which method, practical experiments are required to compare the performance of them.

2. Objectives

My research focus on the LPL in complex background, different from the one in flat. This paper proposes a method and realize a complete system of LPL. This hybrid method of LPL helps for further realizing the intelligence and digitization of traffic management.

3. Methodology

This system takes a strategy of gradual localization of license plate with three phases.

3.1. Image capture and preprocessing

The captured images of vehicles are the input of the system. Before entering the localization process, normalization uses to get a standard input in the form of 400*300 pixels. In addition, the obstacles of low contract, blurring and noises (Faradji et al., 2007) also need to overcome (Wen et.al, 2009). Figure 1(a) shows the captured image with different conditions of night. We need to improve the brightness and contrast for recognition. The conversion formula (1) is as follows:

$$g(i,j) = \alpha f(i,j) + \beta \quad where\ \alpha = 1.5 \tag{1}$$

$$\beta = \frac{\sum_{c=1}^{3}\sum_{i=1}^{300}\sum_{j=1}^{400} f_c(i,j)}{3*300*400} \tag{2}$$

where c is the channels (RGB) of the color image, $f(i,j)$ is the input image and $g(i,j)$ is the enhanced image. α is an empirical value. The value of β is changed related to the average lightness of the input. If the image is dark (light), this value will be high (low). We will get Gigure 1(b) through this conversion.

(a)

(b)

Figure 1. Image capture and enhancement:
(a) standard image and (b) enhanced image.

3.2. Rough localization

3.2.1. Color Detection

The two most common plates in China are in white/blue and black/yellow form. Accordingly, we can use the color information to locate the plate. In this paper, we will take white/blue as the experimental subject.

Table 1. the value range of four colors of the license plates in HSL space

	Blue	**Yellow**	**White**	**Black**
H	[100, 124]	[26, 34]	[0, 180]	[0, 180]
S	[43, 255]	[43, 255]	[0, 30]	[0, 255]
L	[46, 255]	[46, 255]	[221, 255]	[0, 46]

Different from others, the range of attributes in HSL color model in Table 1 will be expanded in this paper to get an output image with the valid plate region even it is covered with dust. In addition, considering white is very common in the image, it performs not well in distinguishing the plate. Thus, only blue will be used to detect:

$$m(x,y)=\begin{cases}1 & 100<h(x,y)<124,\ 43<s(x,y)<255,\ 46<l(x,y)<255 \\ 0 & else\end{cases} \quad (3)$$

where $h(x, y)$, $s(x, y)$ and $l(x, y)$ means the hue, saturation and lightness of each pixel in the image. $m(x, y)$ is the output image.

The process of color detection is shown in Figure 2. The background with blue regions will also be detected. So, further works are necessary to filter the noise from the background. The output of this phase is the binary image of marked blue region, also known as candidates of the license plate, shown in Figure 2(c).

Figure 2. color detection process:
(a) enhanced image, (b) HSL image and (c) blue region marked image

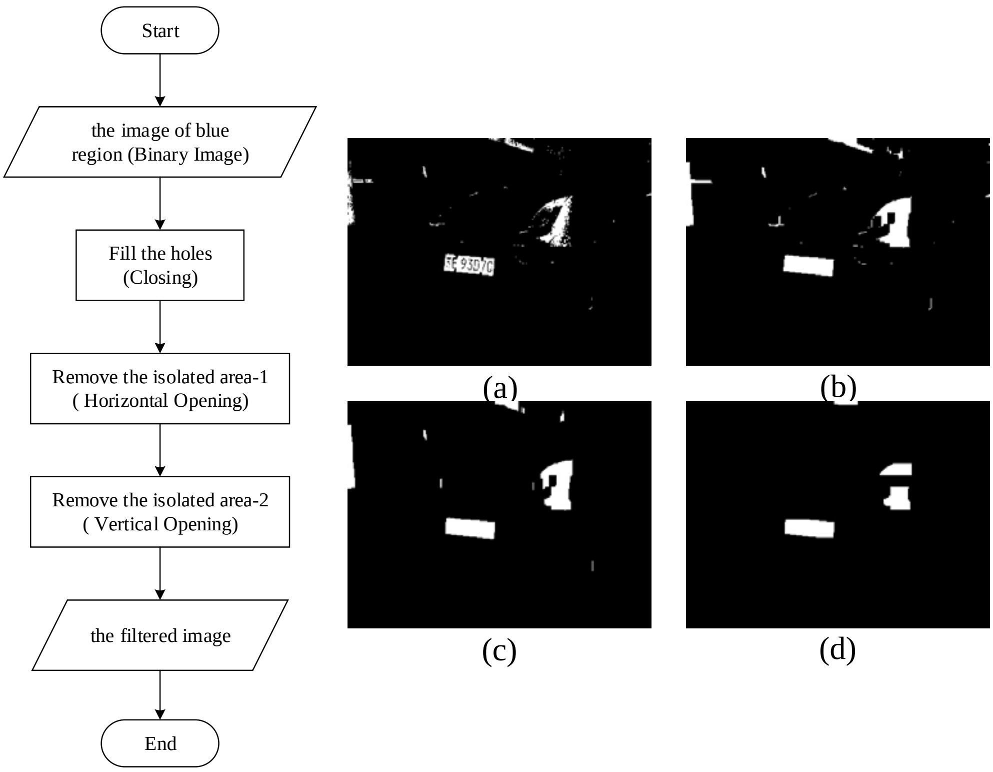


Figure 3. Morphological progress:
(a) input image, (b) image filled holes,
images after (c) horizontal opening and (d) vertical opening

3.2.2. Morphological Operation

To remove some of the impurities around the blue regions, some morphological operations are required. Morphological operation is comparatively time-consuming.

Thus, instead of gray images, the binary images of the candidate regions are used as the input of this phase for simplified calculation. Before the filter of the candidates, closing operation is conducted to fill the holes on the candidates. Then, horizontal and vertical opening operations can be adopted to filter the shape that could not be the plate. An example result after these operations is shown in Figure 3(d). Then we can map this figure to the original binary image and get Figure 4.

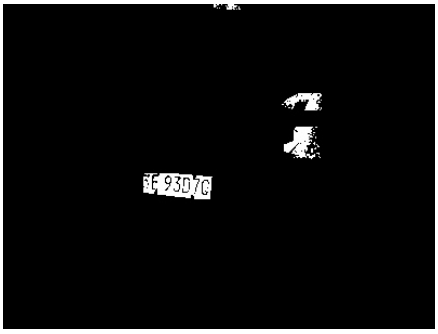


Figure 4. Example output of the rough localization

3.3. Accurate localization

After the rough localization, we have got a result image with finite candidates as the input of this phase. For accurate localization, edge detection and wavelet transform will be compared to select an appropriate method.

3.3.1. Edge Detection

Generally, vertical Sobel operator is used to compute the edge lines, seen as the gradient image. The expressions of the Sobel operator (4) is as follow:

$$Sobel\_h = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}, \quad Sobel\_v = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{4}$$

Sobel operator is used to convolute with the binary input image. The result is shown in Figure 5. However, neither horizontal nor vertical operator is suitable in my system. Considering the reason of the result, it is worth noting that the idea of this method is that most of vehicles have more horizontal lines than vertical ones. Thus, vertical edges have a better effect than horizontal ones on distinguishing the plate from the background (Davis et al., 2015). Since we have already distinguished the plate from motor vehicle structure by its color, this method has no effect on my system.

Figure 5. Edge detection comparison: (a) horizontal edge and (b) vertical edge

3.3.2. Wavelet Transform

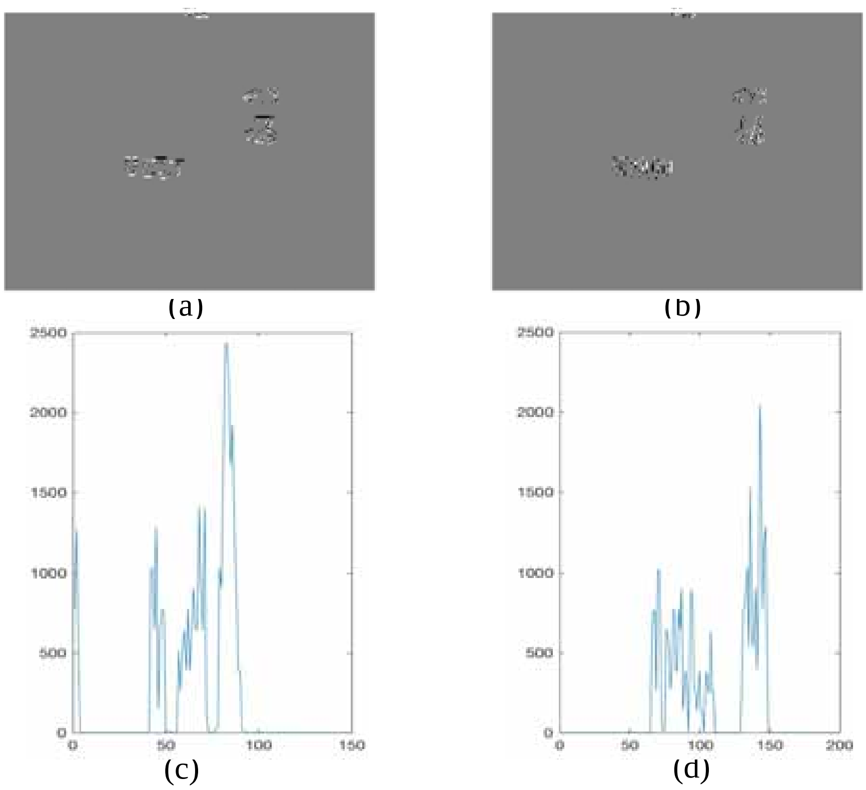
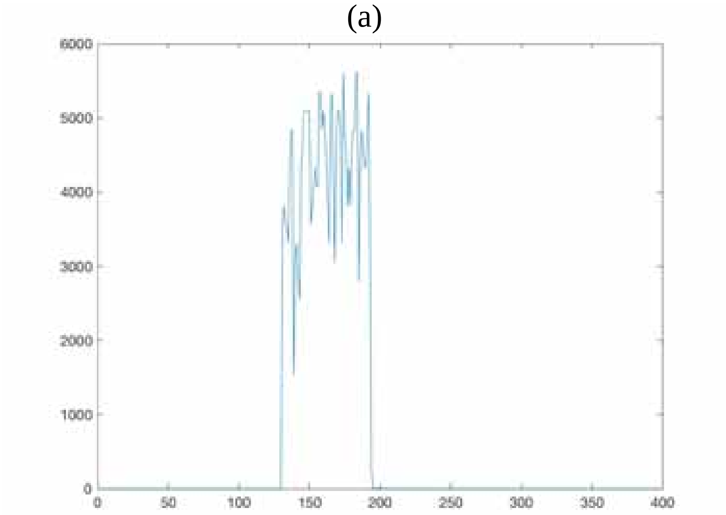


Figure 6. Horizontal (a) and vertical (b) frequency band of wavelet transform, Horizontal and vertical frequency energy curves: summing up pixel intensities of (c) each row in horizontal band and (d) each column in vertical band

In wavelet transform, locating the plate area in a whole picture is divided into horizontal and vertical parts based on its power spectrum. Figure 6(a) and 6(b) show the horizontal and vertical frequency band of the image after wavelet transform. The energy curve of the horizontal band can localize the desired region of the plate, but vertical one cannot. Accordingly, only the horizontal band will be used, and the localized result is shown in Figure 7(a). Then, vertical localization based on the horizontal result, the energy curve of which is in figure 7b, is taken to further localize the plate. After all the process, we can finally localize the license plate in the complex background. An example result is shown in Figure 8 in both binary and color forms.

(a)



(b)

Figure 7. Horizontal localization (a) and its energy curve (b)

(a)

(b)

Figure 8. Plate Localization: (a) binary form and (b) color form

4. Novelty

Differ from previous related research, my research can solve the LPL even in a complex background. Not only the structure of the motor vehicles but also the interferences from the roadside can be filtered in this method. Although the basic techniques remain the same, some adjustments have been taken on each of them. For color detection, the range of attributes in HSL color model will be expanded in this paper to get a better performance, where accuracy changed from 76.2% to 90.5%. For morphological operation, instead of inputting the gray image, binary image is used to simplify the calculation. For wavelet transform, this method first take the energy curve of horizontal band to analyze the position of the plate with high frequency. And then it will use the result of the horizontal localization and do vertical localization directly on the horizontal result (95.2% accuracy), quite different from the other’s operation (71.4%).

5. Conclusion and Significance

This paper proposed a three-phase LPL method and divided localization into rough and accurate localizations. The first phase captures and normalizes the images to a standard dimension. And it improves the brightness and contrast of the image for better recognition. The second phase use color detection and morphological operations to roughly extract the possible regions of the plate. In the third phase, wavelet transform is taken to accurately localize the plate with high energy on it.

The traffic management department prohibits cars from parking along the road with large traffic. The layout of streets with large traffic is so complex that can consider as a complex background. Nowadays, the treatment of illegal parking is still handled manually. This method performs especially well in LPL under complex situations. Through the adoption of it, the traffic management department is expected to further realize the intelligence and digitization of traffic management.

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