FIT5190 Introduction to IT Research Methods

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A Literature Review on License Plate Localization

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Content

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 is about to review four related methods of LPL, including color image processing, edge detection, mathematical morphology and transform analysis. How these methods are applied in the LPL will be described in the body of review. Accordingly, the features and suitable conditions of each method will be discussed follow on. And then the comparison and assessment will be made to analyze the strengths and weaknesses of the methods above. At the end of this review, the tentative idea of three steps of gradual localization of license plate especially for complex backgrounds will be proposed.

Keywords: License Plate Localization, Complex background, Color Image Processing, Edge Detection, Morphology, Wavelet Transform

1. Introduction

With the popularization of motor vehicles, the development of traffic enterprise is so fast that the traditional artificial management cannot satisfy the needs of practical work. For this reason, intelligent transport system (ITS) has been a global research focus in traffic field. 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).

To extract the license plate from a complex background, many researches on different methods have been taken in recent years, such as color image processing (Cheng and Chen, 2009), edge detection (Han and Han, 2012), mathematical morphology (Faradji et al., 2007) and wavelet transform (Rajput et al., 2015). Thus, this review will make critical comments on the existing methods of License Plate Localization (LPL). The objective of this review is to analyze the suitable conditions of each method and make improvements to my LRL system.

This review is constructed in three main parts. Firstly, a discussion on the existing methods will be given to form a way of thinking about license plate localization (LPL). Secondly, an analysis on the weakness and strength of each method under specific condition is conducted to compare the performances of them. Accordingly, is there a combination of methods, which with a high accuracy, can be used cooperatively to locate plate will be taken into consideration. At the end of this review, the tentative idea of an improved license plate localization method especially for complex backgrounds will be proposed driven by this consideration.

2. Scope and Method

Complete LPR process includes three phases: image capture, plate localization and character recognition. The ability to localize the plate effectively determines the success or failure of the entire intelligent system. Thus, I will focus on the methods of license plate localization especially in complex background.

Most of the researches on license plate localization (LPL) only discuss about one or two methods in their paper. However, my research mainly focusses on the LPL in complex background, which is different from the one in flat background. Almost all the existing methods cannot extract the plate alone effectively from an image with much noise (complex background). Thus, an idea of gradual reduction of noise occurred to me. After reading many papers about the methods of dealing with the LPL, I finally chose four existing methods, possibly used in my LPL system, to be discussed in this review.

3. Body of the Review

Existing researches on LPL based on different methods: color image processing, edge detection, mathematical morphology and transformational analysis. According to the paper referenced, a discussion of how each method is applied to LPL will be given in this section. Then, an analysis and a comparison will be made to conclude the advantages and disadvantages of them.

3.1. Four Existing Methods

(1) Color Image Processing based Method

In general, color image processing is used in the image with relatively simple background or the image whose plate makes up a large portion. The two most common plates in China are white/blue and black/yellow. According to these special color-matchings, we can use the extraction of color information to locate the position of the plate.

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

	Blue	**Yellow**	**White**	**Black**
H	[0.53, 0.68]	[0.07, 0.13]	-	-
S	[0.35, 1]	[0.35, 1]	[0, 0.1]	-
I	[0.3, 1]	[0.3, 1]	[0.91,1]	[0, 0.35]

Compared with other color models, HIS is the model which is more similar to human vision (Cheng & Chen, 2009). However, the initial color model of the captured image with license plate is RGB color model. Thus, the image need to be converted from RGB model to HIS model. In HIS model, there are three components: hue, saturation and brightness. The value range of the four colors used on the license plate is shown in Table 1.

Han and Han (2012) use these value range to extract the plate from the background. They use '1' to mark that the value of the pixel is in the range while '0' represents not in the range. Thus, the image in HIS space is converted to the binary image. This progress can be described by the equation (1):

$$p(x,y)=\begin{cases}1 & \left(0.53\le h(x,y)\le 0.68 \; or \; 0.07\le h(x,y)\le 0.13\right) \\ & and \; s(x,y)\ge 0.35 \; and \; v(x,y)\ge 0.3 \\ 0 & else\end{cases} \quad (1)$$

This method can locate the license plate with a high accuracy only when the color of the plate is different from the background. Otherwise, the pixels outside the license plate will also be marked.

(2) Edge Detection based Method

It is easy to find 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). To improve the speed of the edge detection and simplify the process, the color image need to be converted to grayscale image. So, edge detection is executed on the gray image. Generally, Sobel operator is selected to compute the edge lines, which can be seen as the gradient image. The equation (2) of the Sobel operator is as follows:

$$w=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix} \quad (2)$$

$$f*w=\sum_{\substack{(a,b)\in w\\ (x-a,x-b)\in f}} f(x-a,y-b)\bullet w(a,b) \quad (3)$$

Xu et al. (2010) used Sobel operator to convolute with the gray image. This process of convolution, shown in the equation (3), partly loss the details of horizontal edges, but can distinguish the vertical edges with high performance. After edge detection, the high gradient areas will be reserved. However, these areas may not contain license plates.

(3) Mathematical Morphology based Method

Image morphology is a collection of image processing operations based on the shape. Morphology has four basic operations: dilation, erosion, opening and closing. Generally, these morphological operations are used when several candidates of the position of the plate are already found. In other words, they are used to filtrate the candidates according to the features of the plate which is distinguish from the background.

Faradji et al. (2007) proposed a morphological method of license plate location using dilation, closing, erosion and median filter. Firstly, the image is respectively dilated by a horizontal line and a vertical line. Since the plate in their paper is in black/white type (some differences in my research), they use dilation to expand the characters on the plate in order to better distinguish the plate. Secondly, closing operation is taken to fill the holes after dilation. Thirdly, they introduced a structure element, which is a horizontal band (5*40 rectangle). And this structure element is used to do an erosion operation on the binary image. This operation eliminates any regions smaller than the horizontal band. Lastly, they employed a median filter (the size of its neighborhood window: 7*7 pixels) to the image, which can obtain the skeletons of the license plate.

This morphological method can filter the noise effectively based on the requirements of the users. However, it is worth noting that the color-matchings of Chinese license plate, which my research focus on, is different from the one in the paper. Thus, some morphological operations need to be changed. For example, dilation changes to erosion in the first step.

(4) Wavelet Transform based Method

When the image is close to the vehicles (less background noise), wavelet transform based method can be used in license plate location. This transform will get the energy curve of the image. For license plate, its energy is higher than the background since it carries the information of license number. So, this characteristic can be taken to distinguish the plate from relative smooth background. After wavelet Transform of an image, four frequency bands: low, horizontal, vertical and diagonal can be obtained.

In the case of locating the plate area in a whole picture, Rajput et al. (2015) divided localization into horizontal and vertical parts based on its power spectrum. Because these two frequency energies can better identify the location than the other two. They firstly measure the horizontal location by traversing from up to down on the energy curve to seek for the highest frequency representing the plate number. And then they performed the same operation on vertical side (traversing from left to right). These two horizontal and vertical locations work collaboratively to determine the final location of the plate.

3.2. Performances Analysis

Table 2 Comparison of each method of LPL

	Suitable conditions	Advantages	Disadvantages
Color image processing	The color of the license plate is distinct from the background.	simple, easy to understand	low robustness
Edge detection	The vertical edges in the image is less, and the vertical edge of the plate is obvious.	high robustness	require preprocessing
Morphology	Several candidates of the position of the plate are already found. Only need to filtrate out the most possible region of plate.	performs well in noisy condition	time-consuming
Wavelet transform	The background is flat (without information), only high energy (most of the information) on the plate	low computational cost	require preprocessing

Color image processing is the simplest method to distinguish the plate from the background based on HSI color model, similar to human visual system (Cheng & Chen, 2009). Its accuracy is high only when the color of the license plate distinguishes from the background. Even worse, if the dust and stains on the plate change the color of the plate location, it could hardly identify the plate. And this situation occurs frequently in practice application.

Edge detection takes advantage of the design of the vehicle structures that horizontal edges is more than vertical edges (Han & Han, 2012). It is a simple way to find possible contour of the plate. However, it makes no sense unless it combines with other method, since the contours of other objects will also be detected. In addition, complex background containing many vertical edges will reduce the speed of this method. In other words, this approach is not so advantageous when the vertical edges are no longer far more than the horizontal edges.

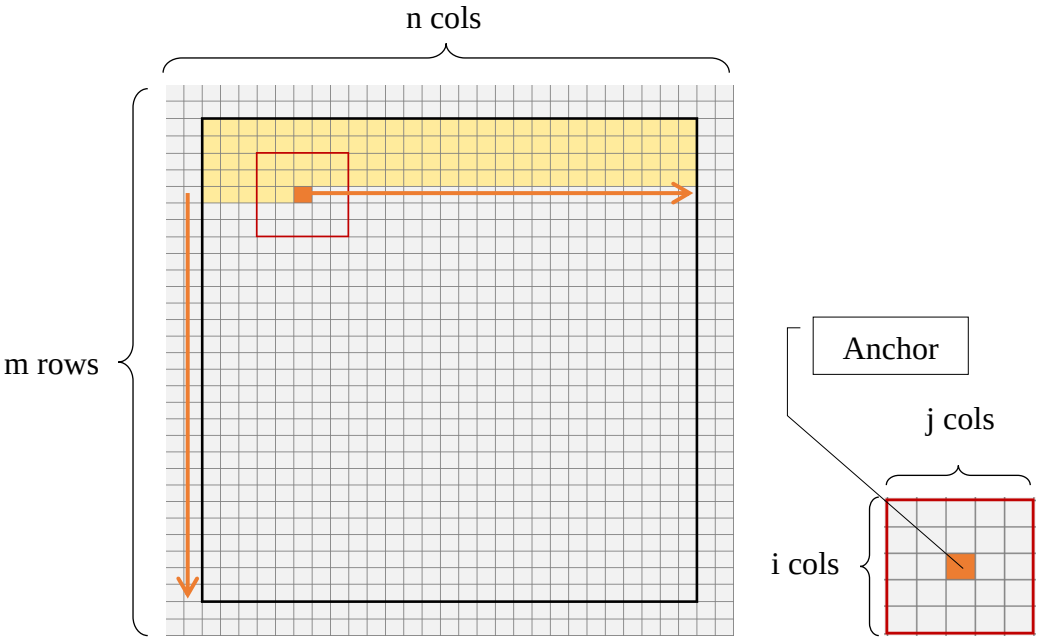

Figure 1 Image convolution process

Mathematical morphology performs well in noisy condition, but it is time-consuming (Faradji et al., 2007). Time-consuming is due to the higher complexity of the calculation (the process is shown in Figure 1). The general implementations of dilation and erosion depend on one-time image convolution. In a convolution process, the structural element, center of which is called anchor, shifts over every pixel on the image (m*n matrix). This process approximately requires m*n additions. Once the anchor points of the structural elements cover a pixel and it requires i*j multiplications. Thus, completing a convolution on a whole image approximately needs (m*n)*(i*j) multiplications and m*n additions. In addition, opening and closing depend on two-times convolution more complex than dilation and erosion. Combined with the application of license plate localization, these morphological operations work cooperatively to achieve the goal. So, the amount of computation will be extremely high.

Wavelet transform is a typical method of transformational analysis. This method locates the plate by the energy curve because high frequency on it (Rajput et al., 2015). The idea of this method is based on information theory. Using wavelet transform is a simple way to localize the plate with relatively low computational complexity compared with morphology method. We only need to go through the horizontal and vertical directions to find the maximum range of energy curve. However, this method will fail when the background is complex, which means that not only the position of the license plate is rich of energy. Therefore, the method of directly using the wavelet transform will encounter the bottleneck in a complex background.

4. Interpretation and Conclusion

Existing methods on the paper referenced includes color image processing, edge detection, mathematical morphology and transformational analysis. However, each of them cannot satisfy the application in a complex background alone. Thus, an idea of gradual reduction of noise occurred to me, which is based on some of these four methods discussed.

Color image processing is based on color discrimination. It causes to the rigid requirement of that the background cannot have a similar color to the plate, which is hard to meet in practice. I decide to expand the range of HSI color model to get preprocessed images which will not remove the valid plate region even it is covered with dust. Mathematical morphology performs well for the enhancement of the object and elimination of the noise, although it is time-consuming. In my study, morphological operations must be taken to reduce the noise. Differently, considering computational complexity, I am going to do morphological operations locally instead of on the whole image.

Edge detection seems to be a simple way to find possible contour of the plate. However, it makes no sense unless it combines with other method. Wavelet transform locates the plate by the energy curve because high frequency on it. However, the noise is high on an image containing complicated background. It also contains high energy which will interrupt the process of localizing the plate. Edge detection and wavelet transform both have low robustness under complex situation with background noise. These two methods can be taken only after the preprocess of the original images. In the case of choosing which method, the method of controlling variable is required in the following experiments, and the method with higher accuracy will be selected according to the result of later experiments.

Although the license plate localization (LPL) in complicated background is the focus of my research, it is obvious that the images closer to the plate will be easier to localize the object. Taking advantage of this, three steps of gradual extraction will be performed to localize the license plate. Firstly, a rough extraction based on the improved detection of color information will be taken to seek all the possible region of plate as candidate regions. Secondly, edge detection or wavelet transform will be selected to further filtrate the candidates. Lastly, more morphological characteristic of the plate will be fully used in the precise extraction determining which candidate is the plate.

References

Cheng, Z., & Chen, R. (2009). License plate location method based on modified HSI model of color image. *The IEEE International Conference on Electronic Measurement & Instruments*, 4, 197-201.

Davis, A. M., Arunvinodh, C., & Arathy Menon, N. P. (2015). Automatic license plate detection using vertical edge detection method. *International Conference on Innovations in Information, embedded and Communication Systems*, 1-6.

Faradji, F., Rezaie, A. H., & Ziaratban, M. (2007). A Morphological-Based License Plate Localization. *The IEEE International Conference on Image Processing*, 1, 57- 60.

Han, H., & Han, R. (2012). Method of license plate localization based on edge detection and color information. *The IEEE International Conference on Transportation, Mechanical, and Electrical Engineering*, 1477-1480.

Rajput, H., Som, T., & Kar, S. (2015). An automated vehicle license plate recognition system. *Computer*, 48(8), 56-61.

Xu, Z., Yang, C., & Yuan, C. (2010). Research on regional edge features license plate location. The, *International Conference on Industrial Mechatronics and Automation*, 2, 397 - 400.