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RESEARCH ARTICLE

LICENSE PLATE CHARACTER SEGMENTATION USING CLAHE ENHANCEMENT AND CONNECTED EDGE COMPONENTS

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ABSTRACT

License plate images usually suffers from low illumination and poor contrast due to motion of vehicles and large depth of fields. Therefore, license plate image segmentation and number extraction is a challenging task. This paper proposed an fast and efficient license plate character segmentation method using CLAHE pre-enhancement and by finding the morphologically connected region. CLAHE method is used as pre-enhancement stage to improve the contrast and illumination of number plate images. This helps to improve the performance of character segmentation. In the second stage the wiener filter is used to remove the noise and blur present in the image. The proposed method uses the label connected neighbourhood with 8-conect mask to segment the desired characters form the edge image. The shift invariant edge detector mask is used for detecting the edges. Using the combination of pre enhancement and filtering improves the convergence rate of the standard segmentation method. The proposed character segmentation method is tested on the various kinds of licence plate images. It is found that entropy of segmented object is improved with the proposed method.

INTRODUCTION

There is an significant growth of the vehicle surveillance systems is observed over the last few decades. Therefore, vehicles number plate identification for the traffic management and secularity has become a demanding field of research. This is commonly achieved either manually by automatic segmentation systems which identifies the vehicles number plates in real time (Sarmad Majeed Malik, and Rehan Hafiz, 2014). Therefore, researchers have developed various techniques for number plate recognition and character segmentation. Basically segmentation is considered as a middle stage of license plate identification system as shown in Figure.1.Ttherefore efficient segmentation is the key of success for license plate identification.

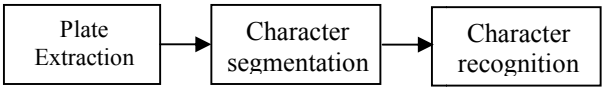

Figure 1. Basic license plate identification system

The thresholding based methods are commonly used for objects defection (Rajesh Kumar Rai *et al.,* 2012) automatic targets detection (Mohammad Ghazal and Hassan Hajjdiab, 2013), and for character segmentation (Sarmad Majeed Malik, and Rehan Hafiz, 2014) applications.

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Thresholding based segmentation is effective for segmenting the clearly defined regions. Otsu's adaptive thresholding method is another widely used segmentation method (Jun Zhang and Jinglu Hu, 2008). Although these methods work well for dark noticeable objects on intense backgrounds however, method is in-efficient for segmenting the blurred license plate images. It may generate visual artifacts in the segmented plate image, mainly because it is pixel oriented. Also since license plates are required to identify in real time for surveillance applications Therefore, new methods are needed to solve segmentation issues.

The label connected components have become increasingly popular image processing technique for segmentation. An object in the image consists of pixels. Individual labels are essentially regions of pixels in closed contact with each another. By identifying the connected components the characters in the license plates may be identified and separated efficiently. The edge detection methods are widely used to improve the robustness of the license plate segmentation techniques. In this paper a robust method is proposed using a Laplacian of Gaussian edge detection (Neetu Sharma and Paresh Rawat, 2011). This improves the performance under large motion conditions by improving the connectivity.

Paper proposed an efficient method for license plate character segmentation. The proposed method uses the combination of pre-enhancement and method of finding the morphologically

connected edge components. To improve the convergence rate Wiener filter is used in place of median filter. In addition, for improving the segmentation efficiency of the proposed images are enhanced before segmenting the objects, using method of Contrast Limited Adaptive Histogram Equalization abbreviated as (CLAHE) (Etta *et al.,* 1998). A Laplacian of Gaussian edge detector mask is used in place of conventional edge detectors and morphological thinning is introduced for improving the performance. Paper also compares the performance of existing edge based methods with the proposed method.

Literature review

Segmentation techniques for license plate images can be distinguished by methods used at enhancement and character segmentation stages. Therefore literature of existing license plate segmentation methods is also reviewed in two stages.

A. Review of contrast enhancement methods

License plate images are usually of low contrast due to vehicle motion. Thus enhancement methods are widely used for these images. Researchers have explained various contrast enhancement techniques including edge based methods (Muhammad Suzuri Hitam ?), Histogram based methods (13), Jyoti *et al.* (2007) have proposed using brightness preserving histogram equalization with maximum entropy (BPHEME) method for enhancing the underwater images. Method was based on the histogram processing.

Etaa D. Pisano *et al.* (1998) have proposed a method named Contrast Limited Adaptive Histogram Equalization (CLAHE) for enhancing the image quality. Letter on many researchers used CLAHE as tool for contrast enhancement as (Jun Zhang and Jinglu Hu, 2008; Etta *et al.,* 1998; Rajesh *et al.,* 2012). Antonis Daskalakis *et al.* (Daskalakis *et al.,* 2007) under their research has investigate on an efficient CLAHE based, spot adaptive image segmentation method improuve on microarray gènes quantification. There team found that this method improved the display of spots and emphasized on the spots depiction.

B. Review of segmentation methods

Various algorithms have been developed for license plate identification. Every algorithm uses diffrent features of the license plates. Smearing Algorithm for license plate extraction is proposed in (Sarmad Majeed Malik and Rehan Hafiz, 2014). Rahesh *et al.* (2008) have used CLAHE enhancement and histogram based global thresholding methods for image segmentation. The CLAHE method is implemented on gray images in spatial domain. The efficiency of the method depends upon the manual selection of global threshold. Sarmad *et al.* (2014) have proposed using connected component analysis method. Paper used optical character recognition (OCR) method for recognition of green plates.

Proposed methodo

An efficient License plate character segmentation method is proposed which is implemented in two pass. In fist stage the CLAHE enhancement method (Etta *et al.,* 1998) is used with wiener filtering for improving the contrast and to remove noise. This improves the performance of the character segmentation for the blurred noisy and non uniform illuminations images. In the second step combination of Laplacian edge detection (Pandya and Sing, 2011) and label connect method (Sarmad Majeed Malik and Rehan Hafiz, 2014) is used to segment the characters. Usually using wiener filtering reduces the blurring effects thus improves efficiency of segmentation method. Block diagram of proposed segmentation method is given in Figure 2.

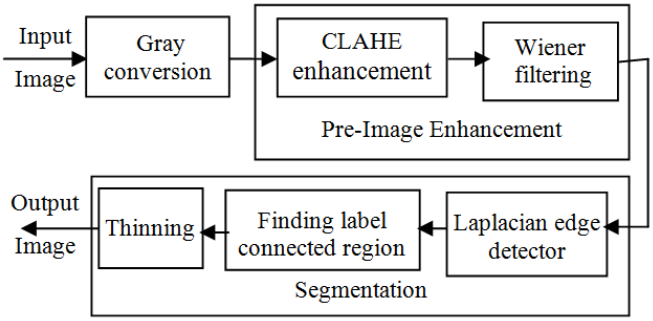


Figure 2. Block diagram of proposed method

Each of these block are sequentially explained in the rest of this paper

CLAHE enhancement algorithm

The input images are converted to gray images and then equalized using spatial domain CLAHE method. Basic algorithm for enhancing the contextual image regions by using the CLAHE technique (Etta *et al.,* 1998) is sequentially given below;

Step 1: Input color image is changed to gray image using Rgb2gray function.
Step 2: Sub divide gray image is into small tiles of 8X8.
Step 3: Clip limit is selected to default value
Step 4: Histogram is calculated for each individual tiles.
Step 5: Histogram of each region is transformed so that its height do not exceed the default clip limit

Since segmentation requires the flat histogram distribution thus CLAHE with uniform distribution is used for enhancement in this paper. The transformed gray levels for CLAHE method with uniform distribution can be mathematical expressed as;

$$g = [g_{\max} - g_{\min}] * P(f) + g_{\min} \quad ...(1)$$

Where $g_{max}$is maximum pixel value, $g_{min}$is the minimum pixel value. Where, g is computed pixel value and $P(f)$ is the Cumulative probability distribution.

Since CLAHE method is basically designed for maximum entropy as shown in the Figure 3. Therefore, it is used for enhancement in proposed algorithm.

a) Gray leve License plate image

b) CLAHE Enhanced image

Figure 3. Example of CLAHE enhanced license plate WIENER FILTERING

In the previous methods in order to filter the noise 2-D median filters are used. But the performance of these filter degrades under the presence of blur or large vehicle motion. Therefore in this paper for noise removal 2-D Wiener filter is proposed to use. Which also reduces the blur present in the image. The Weiner filter is an inverse filter that employs a linear de-convolution method. Because the Weiner filter is, a linear filter it is computationally less intensive. In order to design the filter an license plate image and noise are, consider as random variables. The prime goal of the filter is to minimize the mean square error between the uncorrupted image $f(x,y)$ and its estimate $f\hat{}(x,y)$**.** The mean square error can define by

$$e^2 = E\{(f(x,y) - f\hat{}(x,y))^2\} \quad \text{.....(2)}$$

Based on the assumption that among noise and license plate image one or the other has zero mean. Also assume that the gray levels in the wiener estimate are a linear function of the levels in the blurred-noisy image. On the basis of above mentioned assumptions, the minimum of the error function in equation (2) can be given as inverse filter in the frequency domain as ;

$$\hat{F}(-u,v) = \left[\frac{H^*(u,v)}{[H(u,v)]^2 + S_\eta(u,v)/S_f(u,v)}\right] G(u,v) \quad \text{..... (3)}$$

Where,

$H(u,v)$ = Is Point spread function or degradation function
$H^*(u,v)$ = is the complex conjugate of $H(u,v)$
$G(u,v)$ = is frequency transform of the plate image and
$S\eta(u,v) = |N(u,v)|^2$ = is power spectrum of the noise
$S_f(u,v) = |F(u,v)|^2$ = Power spectrum of plate image

Using this standard wiener filter formulation enhanced license plate image is filtered. An example of the filtered image is given in the Figure 4.

a) Enhanced license plate image

b) filtered image

Figure 4. Wiener filtered image

Laplacian of gaussian edge detector

In this paper a Laplacian of Gaussian high pass filter (Neetu Sharma and Paresh Rawat, 2011) is used to find the edges instead of Sobel mask. This method specifies the sensitivity threshold. The method ignores all edges that are not stronger than the threshold Th. Method adaptively chose the value of threshold Th automatically. This cab be implemented using the following Laplacian mask.

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

a) b)

Figure 5. Two kind of 3×3 Laplacian mask

The Laplacian is usually combined with smoothing as a precursor to finding edges via zero-crossings. The 2-D Gaussian function

$$h(x,y) = -e^{\frac{x^2+y^2}{2\sigma^2}} \quad \text{.....(4)}$$

where σ is the standard deviation, blurs the image with the degree of blurring being determined by the value of σ. The Laplacian of h is

$$\nabla^2 h(x,y) = -\left[\frac{x^2+y^2-2\sigma^2}{\sigma^4}\right] e^{\frac{r^2}{2\sigma^2}} \quad \text{..... (5)}$$

Finding label connected regions

It is observed that edge image results in number of connected components such as characters of the plate, some noise or other bright components. Each connected component is represented by an individual label using morphological label connect operation. These label connected components are candidate regions for each characters of the plate image. In order to find the label connected components in the edge image first image is smoothen for reducing the number of connected components. The smoothening mask used for this purpose is given as;

$$msk = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad \text{.....(19)}$$

Now morphologically 8 connected components are determined using 8x8 standard Sedgewick Roberts algorithms (Rajesh *et al.,* 2012). The required connected component containing the desired character is carefully selected by observing the all labels of the image.

Now the pixels contained by selected label are find which are corresponding to the desired character. To improve the efficiency the connected image is thinned using morphological thinning operation.

Experimental results

In this paper an simple and efficient method of segmenting the characters of the License plate images is presented using the pre enhancement and identifying the label connected components. The image database used for this paper is shown in the Figure 5.

a) Plate image 2

b) Plate image 3

c) Plate image 4

Figure 5. Database of input License plates used

The performance of the proposed method is compared to the existing methods of the license plate characters segmentation. It is found that the previous methods uses the median filter and the Sobel edge detectors for character identification. But this method is unable to efficiently identify the characters of many license plates as clearly seen from Figure 6 b). Thus in this paper first the license plates are enhance and de-blurred and then Laplacian of Gaussian edge detector Figure 6 c) is used for efficient edge detection. This improves the quality of edge detection as well as the quality of the connected components in the edge image as clearly seen from the Figure 6 d) and Figure 6 e).

The comparison of the existing method of median filtered image and our proposed wiener filtered image along with CLAHE enhancement is given in the Figure 7.

The quality of these two methods can be clearly observed form the comparison of the entropy of the filtered images as given in the Table 1. It is clear that wiener filter works better.

Table 1. Comparison of the Entropy for filtered images

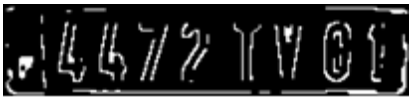
S. No.	Image	Entropy with Median filter	With proposed Wiener filter
1	Plate_image2	5.49279	5.634403
2	Plate_image_3	6.76491	6.86917
3	Plate_image_4	6.50177	6.70948

Sequential results of the proposed method including the per enhancement and segmentation are presented in the Figure 8. It can be seen that character is clearly segmented.

a) Original image

b) Sobel edge image

c) Laplacian of Gaussian edge image



d) Connected regions with sobel edge image

e) Connected regions with Laplacian of Gaussian edge image

Figure 6. Comparison of the Edge detectors performance

a) Median filtered image

b) Wiener filtered image

Figure 7. Comparison of the filtering methods

a) Original Plate image 4

b) Gray level image

c) CLAHE enhanced image

d) Wiener Filter image

e) Laplacian Edge image

f) Label Connected component image

g) Segmented character with L=6

Figure 8. Sequential results of the proposed method

Conclusion

An efficient License plate character segmentation method is proposed to use in this paper. The CLAHE enhancement method is used with wiener filtering for improving the contrast and to remove noise at the pre enhancement stage. This inturn improves the performance of license plate character segmentation. Laplacian of Gaussian edge detection is used which improves the quality of edge detection and also the connected components in the edge image. The modified enhancement method improves the information and entropy of the license plate image thus the efficiency of the segmentation. The proposed method is efficient even for the large motion of vehicles and also computationally less complex.

The proper selection of the connected components may efficiently segmented the desired characters from plate image. In future the performance of the method can be improved by adaptively opting the edge detection method and also by setting the threshold for edge detection.

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