An Efficient Method For Dark License Plate Detection

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Abstract
License plate detection from images is an important step in vehicle license plate recognition for automated transport system. Dark images and complex background make license plate detection problems challenging. In this paper, a novel method of based on rectangle window was proposed to resolve license plate detection problems. The proposed method firstly enhances images using traditional method. Secondly input enhanced images are converted from RGB color space to HSI color space, then we extract I component from HSI color space and get vertical edge images using Sobel operator. Thirdly a novel method was proposed to remove most of the background curves and noise edges. Fourthly, we propose an effective algorithm search the license plate region by a rectangle window in the residual edge. Finally segment the license plate detection from the original dark license plate images. Experimental results show that the license plate detection by our method is better than other conventional methods. The proposed method also shows the effectiveness and robustness.

Keywords: License Plate Detection, HSI, Image Enhancement, Rectangle Window

1. Introduction

With number of moving vehicles in highway or downtown has been considerably increased. License plate recognition (LPR) is one of the most important aspects of applying to intelligent transportation systems. These applications including: road traffic surveillance, parking lots access control, control of restricted areas, etc [1, 2].

In general the LPR system is composed of the following three processing components: (1) license plate detection, (2) segmentation of the license plate characters, and (3) license plate recognition. License plate detection is an essential and key component in the LPR system, which influences the overall accuracy and processing speed of the whole system significantly [3]. However, the license plate detection is a challenging problem because of the following reasons: (1) poor image quality with complex background, (2) the color similarity between the license plate and background vehicle body, (3) different imaging conditions such as blurring, viewpoint changes, and bad weather. Especially dark scene, the license plate is difficult to be located accurately and efficiently [1, 4]. In recent years, many researches on license plate detection have been reported. In this paper, license plate detection algorithms can be mainly classified into four classes, namely edge-based algorithms, geometrical-based feature algorithms, color-based algorithms, and fuzzy logic algorithms.

An edge-based algorithm is the most commonly used method for license plate detection, which often is the combination of edge detection and mathematical morphology [2, 4-7]. In these methods, edge is first extracted from the image and then a spatial analysis by morphology. [2] firstly extract out the vertical edges of the vehicle image using image enhancement and Sobel operator, then remove most of the background and noise edges by an effective algorithm. Due to license plate area contains rich edge and texture information, [4] develops a method for detection of the license plate in gray images. The method first estimate the density of vertical edges in the images, then applying the filter on the edge density image followed by a threshold procedure. [5] proposes a method for multi-style license plate detection with quantitative parameters, such as plate rotation angle, plate line number, character type and format. To detect various style characters, user can configure the method by defining corresponding parameter values on edge information. [6] proposes edge-based detection method, which is detected in the gray scale image using Canny edge detector, and output is a binary image containing the edges. Output of this operation is sent for contour finding and these contours are stored in a sequence. Due to edge density can be used to successfully detect a number plate location, [7] developed a method to improve the edge image by eliminating the highest and lowest portions of the
edge density to simplify the whole image. Edge-based algorithm have one limitation is that will be lost some of the plate region identity.

Geometrical-based feature algorithms are other traditional method of license plate detection [3,8-9]. [3] proposes a region-based license plate detection method, which is consisted of two steps. (1) A color vehicle image is filtered using mean shift, and (2) these candidate regions are analyzed and classified in order to decide whether a candidate region contains a license plate. [8] proposes a method named sliding concentric windows used for faster detection of regions of interest. The method was developed implementing the following steps: (1) creation of two concentric windows \( A \) and \( B \) size \( (2X_Y) \times (2Y_Y) \) pixels and \( (2X_Y) \times (2Y_Y) \) respectively for the first pixel of the image. (2) calculation of statistical measurements in windows \( A \) and \( B \). [9] use pre-defined property to make region of interests as the license plate detections. This method can be affected a lot by non-uniform illumination and low image contrast. Geometrical-based feature algorithms have the good performance in accurately, however, these methods the computation complexity will limit their usability.

Compared with edge-based algorithms and geometrical-based feature algorithms, color-based algorithms depend more on the application conditions [10-12]. [10] proposes a color-based method to extract license plate appearance in each language. The method is consisted steps as follows: (1) an edge detector sensitive to only three kinds of edges, black–white, red–white, and green–white, as this research focuses on Korean LPs. (2) the method creates an initial edge image in which all other color tones beside white, black, red, and green are eliminated. (3) the RGB model of the input color image is transformed. (4) use fuzzy maps represent the degrees of belonging to a license plate. However, if color of license plate is similar with complex background, the method doesn’t perform well. In order to win high recall and low false positive rates, [11] uses a support vector machine (SVM) to train texture classifiers to detect image block that contains license plate pixels. This method may be affected by multi-lingual factors. [12] uses color features to locate license plate, the method is sensitive to the license plate color and brightness and needs much processing time. And these methods also are not robust enough to the different environments.

Fuzzy logic has been applied to the problem of license plate detection [13]. In generally, membership functions are given for the fuzzy sets “bright,” “dark,” to get the horizontal and vertical plate positions. The work [11] also introduces fuzziness’s into the entries of the characteristic map and refers to the result as the fuzzy map. There are several ways to realize fuzziness. The authors define a generalized fuzzy set, termed “like a license plate,” on the respective sets of hue, saturation, intensity, and edge magnitude [14].

Even though many researches have been done in license plate detection, however, these methods are far from a solved problem of license plate detection.

In this paper, we propose a novel method of based on rectangle window to resolve license plate detection problems. The proposed method is composed of the following steps. (1) Enhances images using traditional method. (2) Input enhanced images are converted from RGB color space to HSI color space, (3) Extract I component from HSI color space and get vertical edge images using Sobel operator, (4) remove most of the background curves and noise edges. (5) Search the license plate region by a rectangle window in the residual edge. Experimental results show that the effectiveness and robustness of the proposed method.

The remainder of the paper is organized as follows. Section 2 describes our method. Experimental results are presented in Section 3. Finally, the conclusion is given in Section 4.

2. Methodology

In this section, we will firstly descript our method, and then these steps of our method will be illuminated in detail. The input to this module is an RGB color image. However, our method is the intensity-based strategy to detect license plate location in dark images. The proposed method is composed of the following four components: (1) Pre-processing using image enhancement, (2) Conversion of RGB to HSI color space, (3) Extract edge image information, (4) Extract license plate using proposed method. The flowchart of the proposed method is shown in Figure 1. These steps are described the detail in the following.
2.1 Dark image enhancement

Due to dark images and complex background make license plate detection problems challenging, we can not clearly extract license plate from the dark background. In order to accurate extract license plate, we do pre-processing to enhance dark images. The tone-mapping approach is used to enhance the dark image and to separate an image into details and large scale features. In this paper, the nonlinear tone mapping function is used to attenuate image details and to adjust the contrast of large scale features [15]. Tone mapping function is used as follows.

$$m(x, \psi) = \frac{\log\left(\frac{x}{x_{Max}} + 1\right)}{\log(\psi)}$$  \hspace{1cm} (1)

The white level of the input illumination is set by $x_{Max}$ and $\psi$ controls the attenuation profile. This mapping function exhibits a similar characteristic as the traditional Gamma correction. Some examples of using tone mapping function to enhance dark images are shown in Figure 2.

![Figure 1. A block diagram of the proposed method.](image)

![Figure 2. (a) original dark image, (b) enhanced image using tone mapping function.](image)

2.2 Conversion of RGB to HSI color space

In this paper, our method is based on intensity component of the images. So we have to convert the input RGB to other color space. A proper color space for license plate detection should decouple the achromatic and chromatic information and should be close to the color perceiving properties of the
human visual system. HSI (hue, saturation, intensity) color model is an ideal tool for developing image processing algorithms based on color descriptions that. HSI color model decouples the intensity component from the color-carrying information (hue and saturation) in a color image. Intensity is a subjective descriptor that is practically impossible to measure [16,17].

The RGB space of the input color image is transformed into the HSI space. Let \((R, G, B)\) and \((H, S, I)\) denote the (red, green, blue) and (hue, saturation, intensity) values of an image pixel, respectively. The transform from \((R, G, B)\) to \((H, S, I)\) is shown as follows. Firstly, the \(H\) component of each RGB pixel is obtained using the equation [15],

\[
H = \begin{cases} 
\theta & \text{if } B \leq G \\
360 - \theta & \text{if } B > G 
\end{cases} 
\]  

with

\[
\theta = \cos^{-1} \left\{ \frac{(R-G) + (R-B)}{2[(R-G)^2 + (R-B)(G-B)]^{1/2}} \right\}
\]

The saturation component is given by,

\[
S = 1 - \frac{3}{R + G + B} \min(R, G, B) 
\]  

Finally, the intensity component is given by,

\[
I = \frac{1}{3}(R + G + B) 
\]

It is assumed that the RGB values have been normalized to the range \([0, 1]\), and that angle \(\theta\) is measured with respect to the red axis of the HIS space. Hue can be normalized to the range \([0, 1]\) by dividing by \(360^\circ\) all values resulting from Eq. (2). The other two HSI components already are in this range if the given RGB values are in the interval \([0, 1]\). Some examples of the RGB components and their converted HSI component are shown in Figure 3.
2.2 Extract vertical edge and remove noise

By observing license plates in images, we can find some features of license plate. Such as: (1) shape of license plate, (2) region density of license plate, (3) horizontal edges around a license plate are relatively strong and dominant, (4) density of vertical edges across a license plate are significant, while background edges are usually either long curves or very short. Various features have been utilized to detect license plate. We consider features (3) and (4) of license plate. In this step, we focus on address as follows two problems: (1) we first estimate the locations with significant density of vertical edges. (2) in order to filter out false candidates, background curve, and strong noise, we also use a match filter and design a efficient algorithm.

The selection of a proper threshold to extract strong edges and prevent to miss important edge information is relatively difficult. In this work, we select the vertical Sobel operator to detect the vertical edges, because the simple operator costs us a little computational time. Convolve the vehicle image with this Sobel operator to get the vertical image. We use Sobel to obtain the edge information of the input image in vertical direction. In this work, Sobel is given as follows.

$$
\begin{bmatrix}
-1 & 0 & 1 \\
-2 & 0 & 2 \\
-1 & 0 & 1
\end{bmatrix}
$$

We get the vertical Sobel edge image shown in Figure 4 (a). From Figure 4 (a), we find some problems including: the background curve is longer than license plate region, false candidates, and strong noise. So we have to resolve these problems. In this work, we design a match filter, which use similar match filter with work [4], to filter out false candidates and strong noise. We construct match filters using Gaussian functions, the mathematical equation of this filter is:

$$
I(x, y) = \begin{cases} 
A_1 \exp\left(-x^2 / 0.3\sigma^2\right) & \text{for } 0 \leq x < \frac{m}{2}, 0 \leq y < n \\
A_2 \exp\left(-x^2 / 3\sigma^2\right) & \text{for } \frac{m}{2} \leq x < m, 0 \leq y < n
\end{cases}
$$
The match filter had shown a rectangular \( m \times n \) mask. The filter varies only in vertical direction. \( \sigma_x \) is the variance of the main lob toward \( x \) direction. It should be that variance of the side lobs is 0.1 of main lob variance.

We use proposed match filter to remove strong noise and false candidates, however, background curves still is a difficulty problem. These background curves may interfere in the license plate location. We also propose a simple algorithm to remove them from the edge image. This algorithm only requires us to scan the edge image and record the edge lengths \( L_{\text{length}} \). We scan the edge image from top (or left) start points to bottom (or right) only one. If the record lengths \( L_{\text{length}} \geq T_h \), we will delete these curves in edge image. Note that, threshold \( T_h \) is high of license plate. We discuss this threshold next sub-section.

Figure 4 (b) shows that most of the background curves and noise edges have been eliminated, but the license plate edges are almost fully saved.

**Figure 4.** (a) the vertical edge image, (b) the edge image after removing background curves and noise edges.

### 2.4 License plate search

By estimating the locations with significant density of vertical edges and filtering out false candidates, background curves, and strong noise etc, we can get edge image with license plate. In this section, in order to search license plate region, we use two features of license plate, namely: shape of license plate and region density of license plate. We can shift a rectangle window whose size is just bigger than that of the license plate from left-to-right and top-to-bottom in the edge image. Rectangle window set size \( T_h \times T_h \). According to empirical value, size \( 110 \times 25 \) is set in this paper. (Note that, setting this value must be according to camera distance to vehicles.). In order to expedite the search process, we let the window shifted by pixels. The steps of proposed method are shown as follows:

**Step 1:** Input edge image after removing background curves and noise edges;
**Step 2:** Use rectangle window \( (T_h \times T_h) \) to scan input edge image;
**Step 3:** If region edge density is biggest than the other areas in edge image, it present license plate candidate. Note that, it only one candidate will be searched in general.
**Step 4:** Input edge image is transformed binary image. Search all the candidates in their local regions, sort them by region density of license plate. If region density ratio is smaller, it means that rectangle window should be shrinking, if region density ration is bigger, it means that rectangle window should be enlarging.
**Step 5:** The license plate segment from the vehicle images in Figure 2 is shown in Figure 5(d).

As LPR system, the rest tasks are plate distortion correction, characters segmentation and recognition, but these methods are not discussed in this paper.

### 3. Experimental results

In this section, in order to demonstrate the performance of the proposed method, we performed experiments on 400 various vehicle images captured from a highway intersection, campus, community,
etc. These images have been taken natural scenes mainly with complex background and under different illumination and weather conditions. Some other related methods have been implemented and their results are compared with proposed method. Figure 5 and 6 shows the results of the proposed method in this paper, the proposed algorithm in [3], and the proposed algorithm in [4]. From Figures 5 and 6, we find that the conventional based on region in [3] often causes miss characters, such as Figure 5 (c). If it is the daytime license plate image, more border of license plate is present, such as Figure 6 (c). In [4] also propose a method for detection of the vehicle license plates in 2D gray images. A match filter, which models the license plate pattern, is designed. However, due to the proposed filter on the edge density image followed by a threshold procedure, accuracy rate of license plate is low than others traditional methods of license plate. Compared to these methods, Figures 5(d) and 6(d) show that the proposed method produce high accuracy rate of license plate and it is clear from figure that proposed method achieves the detail content of license plate and it doesn’t lost characters.

Figure 5. (a) original dark license plate image, (b) the proposed algorithm in [4], (c) the proposed algorithm in [3], (d) the proposed method in this paper.

Figure 6. (a) original daytime license plate image, (b) the proposed algorithm in [4], (c) the proposed algorithm in [3], (d) the proposed method in this paper.

In order to demonstrate that the proposed method performs well and valuate objective contrast methods. Experiments are performed to test the accuracy of the proposed method, the method in [3], and the method in [4]. Total 400 different license plate images are included in the experiment. All these methods are implemented using MATLAB. Table 1 shows the datum values of accuracy rate of license plate. From Table 1, it shows the proposed method outperforms other methods in most cases, and our method has high accuracy rate of license plate detection than the other two methods.

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<td>480X640</td>
<td>80%</td>
<td>82%</td>
<td>90%</td>
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Meanwhile the performance of the method is promising when it is applied on dark license plate images. We also compare the computational times of the proposed method and the other two methods. In this work, all these methods are implemented using MATLAB [Version R2010a] on PC computer with Intel Core (i5), Duo CPU 2.8 GHZ and 4 GB RAM. Table 2 shows that the proposed method spent the less processing time than other two methods. It is shown that the proposed method is simple and efficient.

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<th>Table 2. Comparison of processing time (unit: ms)</th>
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<td>Input images</td>
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4. Conclusions

In this paper, a novel method of based on rectangle window was proposed for accurate license plate detection. The method works based on presence of vertical edges in plate region and address dark license plate detection problems. The proposed method can be comparable with the results of the state-of-the-art algorithm both in accuracy, robustness, and computational efficiency. Experimental results show that the proposed method is simple and efficient.

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References


