# Local Enhancement of Car Image for License Plate Detection

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**ABSTRACT**

*In this paper we address the problem of car plate detection. In the first part of algorithm we propose a method for enhancing car plate regions. We estimate the local density of vertical edges in the image as a criterion for local enhancement. In the second part, the vertical edges from the enhanced image is then extracted and feed to a morphological filter to constitute candidate regions for the place of car plate. This filter aims to connect vertical edges closer than the size of a defined structuring element. The output of this process is a number of connected components among which the plate region is. We use some geometrical features of car plate such as shape and aspect ratio to filter out non-plate regions from the candidate list. Using the correlation between the candidate regions and the model of car plate, the most probable region is found. The result of enhancement on car images shows the ability of the proposed method for improving the contrast of plate region(s) in the image. The experimental results on out-door car images confirms the robustness of the proposed method against the severe imaging condition.*

## 1. INTRODUCTION

Intelligent transportation systems (ITSs) are powerful tools for traffic control and its related applications. License Plate Recognition (LPR) is one of the most important requirements of an ITS. A LPR system aims to detect car plate from the input image and read the license plate. Such system has to be robust to illumination changes and other environmental conditions. Security control of restricted areas, traffic law enforcements, surveillance systems, toll collection and parking management systems are some other applications of this field [1][2].

In general a LPR system consists of three major parts [3]: License plate detection, Character segmentation and Character recognition. A desired LPR system has to work in various situations, such as low contrast, blurring, dirty plates, and different weather conditions. Hence car plate detection is the most difficult and crucial task among these steps [3].

During many years different approaches for car plate detection have been proposed, including edge analysis [4][5], neural networks [6][7][8][9], color and fuzzy [10][11] wavelet and Gabor analysis [12][13], etc. Various features of a license plate including text features, rectangular shape, aspect ratio, color, variance, edge density are typically used to locate the license plate(s).

High discrimination of intensity between characters and background of a license plate is a strong feature which is considered in edge analysis [14]. In order to strengthen this attribute in poor quality images, we may add a pre-processing enhancement stage to the system. This stage aims to enhance plate-like regions. Zheng et al [4] used local variance of each pixel to decide on pixels whose contrasts have to be enhanced. By applying their algorithm on various images, we observed that this criterion (variance) is not robust in different illumination conditions and fails in situations such as low or high illuminated images.

In this paper another feature is used for the enhancement stage. We use vertical edge density regardless of variance as a robust feature for enhancing the plate-like regions. We compute edge density of pixels in a neighbourhood. If they are in a specific range there may be a license plate. So we enhance the corresponding pixels in the grey scale image. After image enhancement step, vertical edges are constructed. Then some of non-plate edges are eliminated. By applying closing morphological operator, several separated connected regions which are plate candidates are achieved. Finally, by putting on some distinctive features of license plate such as aspect ratio and edge density, most probable region(s) for license plate is offered. This algorithm has been tested on new Iranian license plates. The promising results confirms that the edge density feature is more robust that variance for image enhancement stage. The proposed algorithm can also work for other types of license plates.

The rest of the paper is organized as follows. Section 2 explains the proposed method on license plate detection. Then experimental results are presented in section 3. At last the paper is concluded in section 4.

## 2. DEFINITION OF THE ALGORITHM

One of the distinctive features for a car plate is the strong edges associated to dark characters on bright background. This attribute can be very useful for finding the plate location in images. Furthermore, the vertical edges on a license plate are dominant and can be observed as a homogenous texture. This property is especially important for Persian characters on license plate. On the other hand, the surrounding edges for a plate are mainly horizontal. These features are the key motivation for license plate detection in the proposed algorithm. In order to enhance edges in the plate region, we set a pre-processing step to enhance plate regions in images. The detection algorithm is introduced in following subsections.

### 2.1 Pre-Processing Stage

In order to alleviate the problem of low quality and low contrast in car images first we pass images from a pre-processing stage to enhance car plate region(s). This step aims to enhance contrast for the plate regions in intensity images. Although the exact location of license plate is unknown at this stage, we locally enhance image at regions with similar characteristic of a license plate.

#### *2.1.1 Edge Density Estimation*

Measuring the edge density in a local neighbourhood is a reasonable criterion to decide on locations which have to be enhanced. In order to avoid increasing computational time, we use a simple 2D Gaussian estimator on the edge image. This is reasonable to avoid complex processing in this stage.

In order to estimate the density of vertical edges in the image, first we obtain the gradient image. A proper candidate is Sobel operator Figure 1.

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

Figure 1 Vertical Sobel operator

This operator is convolved with the input image to yield the gradient image. Comparing the gradient image against a proper threshold results the vertical binary edge map. Preferably we select a relatively low threshold to preserve even poor edges on a licence plate image. The result has been shown in Figure 2.

In the next step we estimate edge density using a 2D Gaussian estimator. The 2D estimator used in this paper has been plotted in Figure 3(a). The size of the estimator has been selected from average size of license plates in the database (30*80).

(a) (b)

Figure2 (a) Sample car image (b) Vertical edge map

After convolving the binary edge map with this Gaussian kernel, a blurred version of Figure 2 (b) is produced. The result has been shown in Figure 3 (b).

In [4] Zheng et al used local variance of image as a criterion for local enhancement of plate region. The idea is based on the fact that local variances for complex background are much higher than that of license plate region. In contrast the variance of smooth regions is considerably low. Using this fact Zheng [4] proposed an enhancement algorithm which boosts image contrast in plate-like regions. Through experiments we observed that this method of enhancement is sensitive to illumination condition. Therefore we suggest using edge density as a criterion instead of local variance.

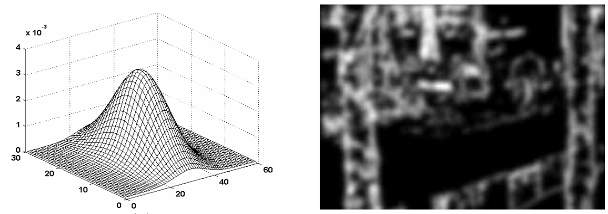
#### *2.1.2 Image Enhancement*

We aim to increase image contrast in plate-like regions using the local density of edges in the image (Figure 3 (b)). The algorithm is as follows.

Consider $I$ , $I'$ denote the input and the enhanced images respectively. The size of images are $m \times n$ . Let $I_{ij}$ , $I'_{ij}$ be intensity levels at pixel $P_{ij}$ in the relevant image. In order to enhance the input image, regarding the edge density, we define an enhancement function similar to the proposed function in [4] as follows:

$$I'_{ij} = f(\rho_{Wg_{ij}})(I_{ij} - \bar{I}_{W_{ij}}) + \bar{I}_{W_{ij}} \qquad (1)$$

The $\bar{I}_{W_{ij}}$ presented in the equation, is local mean of pixel $P_{ij}$ in a small neighbourhood regarding a $p \times q$ rectangular window (smaller than default plate size). $f(\rho_{Wg_{ij}})$ is the weighting function which assigns appropriate weights for pixels intensity, with respect to the Gaussian kernel shown in Figure 3(a). A plot of this function has been depicted in Figure 4.



(a) (b)

Figure 3 (a) The 2D Gaussian kernel $Wg$ (b) Result after convolving Figure 2 (b) and Figure 3 (a)

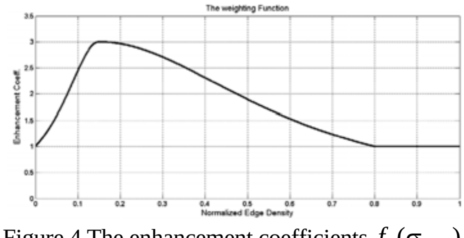



Figure 4 The enhancement coefficients $f(\sigma_{W_{ij}})$

As can be seen from Figure 4, the regions with the edge density around 0.15 are significantly enhanced. These regions are likely to be license plate. The intensity of pixels with edge density more than 0.8 remains unchanged. We tuned these parameters experimentally.

We defined the weighting function in Figure 4 based on Zheng‘s method [4] as follows:

$$f(\rho_{Wg_{i,j}})=\begin{cases}\dfrac{3}{A\cdot(\rho_{Wg_{i,j}}-0.15)^2+1} & \text{if } 0\le\sigma_{W_{i,j}}<0.15\\[2ex] \dfrac{3}{B\cdot(\rho_{Wg_{i,j}}-0.15)^2+1} & \text{if } 0.15\le\sigma_{W_{i,j}}<1\\[2ex] 1 & \text{if } \sigma_{W_{i,j}}\ge 1\end{cases}\quad . \qquad (2)$$

Where A and B are adjusting factors:
( $A=\frac{2}{(0.15)^2}$, $B=\frac{2}{(0.8-0.15)^2}$ ).

For computing $\bar{I}_{W_{ij}}$ (Eq. 1) we used the algorithm in [4] to reduce the computational complexity. Figure 5 shows the result of image enhancement using the proposed method. As seen from this figure the image contrast at the plate region has been considerably increased.

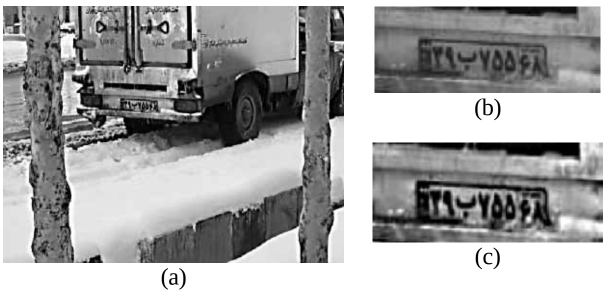


Figure 5 (a) Input car image. The plate (b) before and (c) after image enhancement algorithm

## 2.2 Vertical Edge Detection

To detect plate region(s) in image, first we use sobel operator to extract vertical edge from the enhanced image. The local enhancement of image let us to select a high value as threshold for extraction of strong edges from plate region. This filters out a large amount of trivial edges at background. The vertical edges of the car image in Figure 5 (a) have been shown in Figure 6.

One can see that the amounts of background edges are considerably low in compare with Figure 2 while the plate edges are preserved.

## 2.3 Filtering The Plate Edges

Although selecting a high value as threshold in the edge extraction removes a lots of background edges, for fine detection of plate region more filtering is needed. The clutter edges are mainly related to car body, trees and road in the scene. These edges are mainly either long curves or noise like dots which are not comparable with plate edges. In order to filter out these edges, we compute the length of all strings in edge image, very long and short strings are removed from this image [4]. The result image after rejection has been shown in Figure 7. This procedure reduces the computational time in the next step.

Figure 6 The edge image obtained from Figure 5(a)

## 2.4 Morphological filtering to extract license plate

Morphology is a technique of image processing based on shapes. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. By choosing the size and shape of the neighbourhood, we can construct a morphological operation that is sensitive to specific shapes in the input image [10][15].

Figure 7 Edge image after rejection of trivial edges

Iranian license plates include eight characters. The vertical edges related to them are extremely dense in comparison with most part of background (Figure 8). Applying the closing operation on edge image (Figure 6) in the horizontal direction yields several connected regions which are plate candidates. With respect to a license plate shape, a rectangular structuring element (SE) is used. This SE has the height of 2 to 3 pixels and its horizontal length is more than pixels between two characters. As can be seen from Figure 9 (a) which is output of this stage, there are some clutter regions which have to be removed.

Figure 8 Some samples of Iranian plates

Several useful features such as shape, aspect ratio and plate size are used as geometrical criterions to remove clutter regions. The number of edges, height, width and aspect ratio of each connected component is computed. Then each of these features is compared to its corresponding threshold to decide whether it can be a plate or not. The value of threshold for each property of plate can be selected through predefined plate size and training of car images. Regions which do not follow one of these criteria will be removed from the final image. Figure 9 (b) shows the result of applying this filtering stage.

(a) (b)

Figure 9 (a) Regions obtained after closing of edge image
(b) Result after Filtering non-plate regions

The remaining region(s) is marked as the probable region for license plate. However in some images there may be still a few regions left as plate candidates. Hence to make the final decision on plate region, we convolve remaining binary edge image with a plate model. We defines a plate model as a rectangular window with pixel value one. The size of the model is the average of plate regions in the database. The location with maximum intensity in the image is declared as the license plate.

## 3. EXPERIMENTAL RESULTS

We tested the proposed algorithm on a database including 400 car images taken from outdoor scenes. The image size in this database is 240x320 and the plates are viewed from different angles and distance. The scenes are mostly complex (Figure. 9).The experiments have been conducted on the intensity images. In the first part of experiments we applied the proposed method on the database. In this part a fixed size structuring element has been used for the morphological stage of method. The recognition rate of 92.3% was obtained. Considering the complexity of scenes, the result is very promising.

TABLE 1
Applying rectangular SEs with different sizes

| SEs (number of repetitions) | 3 | 5 | 7 |
|---|---|---|---|
| Detection Rate | 89.3 % | 93.5 % | 97.1 % |
| Spent time (second) | ~5 | ~8 | ~11 |

We need to emphasis that with a wide range of plate sizes in the images (as a result of imaging from different distances), using a fixed-size structuring element (SE) for constituting a plate region is inadequate. If we choose SE size adaptively proportional to the plate size in the image, the performance of plate detection would improve. As we do not have enough information for estimating the plate size in the image, we suggest using a number of SEs with different sizes. After applying the proposed algorithm on an image using different SEs, we compared the candidate regions. The most consistent region with the plate is declared as the license plate. Table 1 demonstrates the result of this experiment. It can be seen by increasing the number of SEs (with different sizes) the performance improves. However the complexity of process also increases (the second row in Table 1).

In the third part of experiments we compare the performance of the proposed method against the Zheng's method. The comparison result has been presented in Table 2. As can be found from the table the proposed method has better performance over Zheng's method [4]. The complexity of Zheng's method is slightly less than the proposed method. Moreover another method [16] presented in the table which is based on mathematical morphology is less complex, while the detection rate of the proposed method is much better.

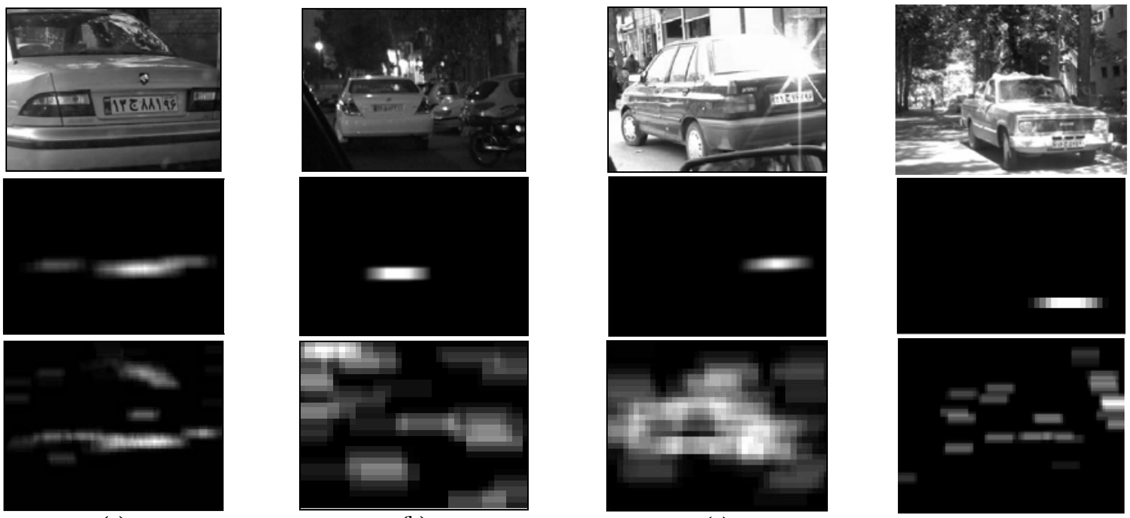
The experiments shows the algorithm well performs for car plates viewed within $\pm 20$ degrees. The experiments also show an acceptable robustness to the illumination changes (Figure. 10).

## 4. CONCLUSION

A car license plate detection algorithm has been proposed. In the fist stage of the algorithm we locally enhance image at the plate region. From the enhanced image we extract vertical edges and attempts to extract license plate using morphological operations from the background. Using geometrical features of the plate region we filter out clutter regions from the candidates. Final extraction of the plate region is performed using the correlation between candidate regions and a plate model. The experiments showed promising results under sever illumination condition when the plate viewed from different viewing angles and distances. No doubt the enhancement stage has a key role in this regard.

TABLE 2
A Comparison of Some Methods

| Ref. | Processor | Detection Rate (%) | Time (sec) | License plate Detection Method |
|---|---|---|---|---|
| The Proposed | Matlab 6.0, P IV 3.0GHz | 92.3 | ~5 | Edge statistic and Morphology |
| [4] | Matlab 6.0, P IV 3.0GHz | 82.7 | ~3 | Edge statistic and Morphology |
| [16] | AMD K6, 350MHz | 80.4 | ~4 | Mathematical Morphology |



(a) (b) (c) (d)

Figure 10 some sample images from the database
First row: input images. Second row: proposed result image. Third row: Zheng's result method

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