# Multiple License Plate Detection for Complex Background

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## Abstract

*This paper presents a wavelet transform based method for extracting license plates from cluttered images. The proposed system consists of three major stages. First, a wavelet transform based method is used for extracting important contrast features as guides to search for desired license plates. Then, finding a reference line in HL subimage plays an important role to locate the desired license plate region roughly. According to the reference line we can decrease the searching region of license plate and speed up the execution time. The last stage of the method is to locate the license plate accurately by license plate adjustment. More importantly, the proposed detection method can locate multiple plates with different orientations in one image. Since the feature extracted is robust to complex backgrounds, the proposed method works well in extracting differently illuminated and oriented license plates. The average accuracy of detection is 92.4%.*

*Keywords: -Wavelets transform, license plate detection, candidate region verification, character segmentation, k-mean*

## 1. Introduction

With the rapid development of public transportation system, automatic identification of vehicles become more and more practical in many applications during the past two decades. [1-3] Automatic license plate recognition (LPR) has turned out to be an important research issue. The license plate detection method might be applied for electronic tolls to help identify violating vehicles. A LPR system is mainly composed of three processing modules, that is, license plate detection, character segmentation, and character recognition. Among them, license plate detection is considered the most crucial stage in the whole LPR system. [4] In the past, a number of techniques have been proposed for locating the desired plate through visual image processing. Now there are some algorithms about the locating of license plate, such us the methods based on color feature [5], edge extracting [6-7], histogram analysis [8], symmetry [9], morphological operators [10], and so on. A color-based approach is normally useful and fast. However, color is not stable when the lighting conditions change. This paper proposes a method of extracting license plate from cluttered scenes based on wavelet transform. In this approach, we consider the vertical edges of image between a license plate and its backgrounds are obvious. The proposed system consists of three main stages, wavelet transform, roughly extracting candidate regions based on high frequency features, and locating the exact license plate. In addition, the proposed detection technique can locate multiple plates with different orientations in one image. The rest of the paper is organized as follows. Details of wavelet transform based for license plate detection are described in Sec 2. Then, the experiment results are presents in Sec 3. Finally, a conclusion will be summarized in Sec 4.

## 2. License Plate Detection

It is known that a license plate is a pattern composed of several characters that have high distinctive intensities in their background. The high contrast area can be used as a key feature to detect the desired license plates. In the following, we will describe a wavelet transform based method to extract the high contrast area and detect the desired license plates. Flowchart of the proposed license plate detection algorithm is shown in Fig.1.

A three-stage process is proposed in the approach, wavelet transform, the rough location, and the accurately location. The rough location in which candidates of license plate region are found using wavelet transform based method. And the accurate location where the exact plate region is extracted from candidates.

### 2.1 Wavelet Transform

In this paper, we use Haar scaling function for wavelet transform. In order to give prominence to the trait of license plate region, the pixel value of every bands of gray-level image is binarized by a predefined threshold. There are four sub-images, and they separately represent LL, LH, HL and HH. The lowpass-filtered original image is shown as LL. HL expresses characteristics contained in vertical direction. LH contains horizontal directional characteristics. And HH shows cater-corner characteristics. As shown in Fig.2, obviously, these four sub-images represent the features of license plate region.

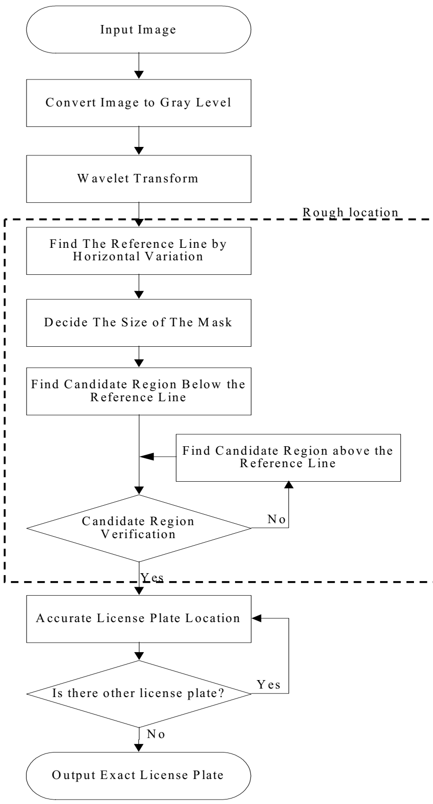


**Fig.1. The overview of the proposed license plate detection algorithm**


**(a) (b)**

**Fig.2 (a) original input image (b) result of Haar wavelet transform and the reference line in LH subimage**

## 2.2 Searching License Plate Location

After wavelet transform, we first locate the license plate roughly, the detail procedure is described as follows:

**Step 1: Find the reference line by horizontal variation in LH sub-image**

After wavelet transform processing, we can see the region with high horizontal variation in LH subimage. We find a reference line with maximum horizontal variation. So we calculate the horizontal projection of horizontal edge using Eq.1.

$$T_H(j) = \sum_j e_H(i,j) \qquad (1)$$

Where $T_H(j)$ represents the projection value of the $j$ th line and $e_H(i,j)$ are the pixels in HL sub-image. Then we search the maxima peak on the horizontal projection of LH subimage to get the reference line. Using the reference line, we can decrease the searching region of license plate, and speed up the execution time. The result is shown in Fig.2(b).

**Step 2: Decide the size of the mask**

Because the size of license plate may change by the distance between camera and car we must decide the size of searching mask before finding the candidate region. We note that the vertical edge in HL subimage shows the plate size information and unusual vertical edge. Calculate the horizontal projection of vertical edge in HL subimage. The curve of horizontal projection can be gotten and we examine the curve carefully to get the peaks. Then, the several maximal sets of all peaks denote the possible width of the license plate. Hence, we can decide the proper size of the searching mask according to the width of maxima set.

**Fig.3 The unusual vertical edge**

**Step 3: Find the candidate regions below the reference line**

For extracting the candidate region, we use the proper mask to search the image below the reference line. Calculate the value of total pixels for each mask and find the maximum. Then, the corresponding mask with maxima value is the possible license plate region.

**Step 4: Candidate region verification**

Once a candidate region has been selected, the confidence degree of candidate region for being a license

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plate is verified according to the geometrical properties. The geometrical criteria include the density and the ratio of length and width. In our experiment, the normal ratio of length and width is 3. If the feature of candidate region doesn't match the feature of license plate, we will search another candidate region above the reference line. If the feature of candidate region matches the feature of license plate, the accurately license plate region can be gotten in the following step. Furthermore, if there were more than one car in one image, we consider that there are multiple plates with different orientations in one image. Go back to Step 3 search the image besides extracted license plate region again and verify the features of candidate regions.

From the rough location, one or more candidates have been extracted from original image. These license plates will be processed one by one by the following method.

**Step 5: Searching the complete license plate region**

Because the size of the license plate region changes by the distance between camera and vehicle the extracted region must be modulated. In the beginning, we magnify the extracted region to make sure that all the characters are included. Then, we carry out a column search for the magnified region and two columns is a checking unit. We calculate the value of total pixels in the checking unit and if the value is smaller than the threshold, we consider the column may not be the part of license plate region, and exclude the checking region. Using the column search method, we can find the left and right boundary of license plate region. The same as column search method, we can find the top and bottom boundary of license plate region by row search method. We abbreviate the checking region progressively until the boundary of the license plate region.

## 3. Experimental Results

The proposed method was implemented on a personal computer with an Intel Pentium 4- 1.6GHz CPU/256M RAM using Borland C++ Builder 6. Many images with various types of license plate are collected from several outdoor parking places with different angles and different lightening conditions. In order to analyze the performance of the proposed approach, 315 images are used for evaluation. The size of each image is $600 \times 450$. We get accurate license plate from 291images and 24 images failed. The rate of success is 92.4%. As shown in Fig.4, the vehicle licenses are detected in every condition. The reasons of the failure can be classified into two major categories:

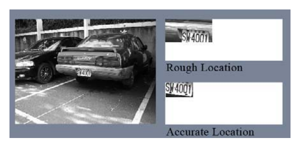
1. The contrast between the license plates and background is not clear enough.
2. The distance is far from the vehicle and the angle of viewpoint is large so that the license plate distort seriously.

Fig.5 shows the failure of license plate detection. Nevertheless, the algorithm gives good results on our database, and it is relatively robust to variations of the lighting conditions and different orientations. From the results of experiment, the scheme is satisfying.

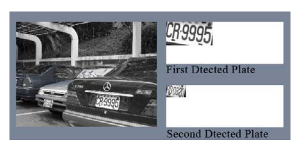
## 4. Conclusion

The mean idea of the thesis is to realize a system of license plate detection which is effective and fast-calculating. A novel approach for extracting license plate from cluttered scene is presented in this paper. The proposed system consists of three main stages, wavelet transform, roughly extracting candidate regions based on high frequency feature, and locating the exact license plate. The average accuracy of license plate detection is 92.4%. The experimental results show that our method has great effect in application. Therefore, no matter how the captured environment is changed, the desired license plate can be correctly located.


**(a) Result of license plate detection in the night**



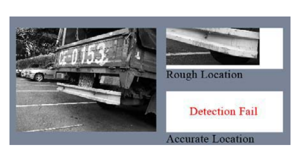

**(b) Result of license plate detection when the plate is inclined and smaller**




**(c) Result of multiple plates in one image**

**Fig.4 The license plates detection result in every condition (a)~(c)**


**(a) The contrast between the license plates and background is not clear enough**



**(b) The distance is far from the vehicle and the angle of viewpoint is large**

**Fig.5 The fail detection result**

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