A MORPHOLOGICAL-BASED LICENSE PLATE LOCATION

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ABSTRACT

License plate location is an important phase in vehicle license plate recognition for intelligent transport systems. This paper presents a robust and real time method of license plate location. The proposed algorithm consists of some stages. In the first stage, we extract vertical edges of the input image using Sobel mask. In the next stage, histogram analysis is used for finding the candidate regions of license plate. Candidate regions are also verified by defined compact factor. In the last stage, we locate the license plate exactly with some morphological operators. Experiments have been conducted for this algorithm. 400 images taken from various scenes were employed, including diverse angles, different lightening conditions. The algorithm can quickly and correctly detect the region of license plate. The license plate detecting rate of success is 83.50%.

***Index Terms*—** License plate location, compact factor, morphology

1. INTRODUCTION

Nowadays one of the problems which appears in the Intelligent Transport Systems (ITS) is License Plate Recognition (LPR). LPR is used in different applications such as parking lots [1], automatic toll collection [2], traffic law enforcement [3] and many others. The first stage of LPR is License Plate Location (LPL), which means locating the region of the license plate in an image. After extracting the license plate, system must recognize the number of it.

In different applications, various restrictions are applied. Limited vehicle speed [4], fixed illumination [5], designated ranges of distance between vehicle and camera [6], prescribed driveways [7], stationary backgrounds [8] are some of these restrictions. The less the restrictions are, the better the recognition system is. In this paper, we have used a database, which contains complex images. Images are different in background, illumination, distance between the vehicle and camera. In addition, drivers are not obliged to drive at a limited speed or follow a prescribed driveway.

In this paper, we focus on the LPL. Since recognition of digits and characters of a license plate is based on the output of this stage, the importance of LPL becomes obvious to everyone.

Numerous methods exist in License Plate Location. Edge detection [9], Hough transform [10], histogram analysis [11] and morphological operations [12] are some of these methods.

Edge detection is not useful with itself, since many other points, which are not in the license plate, will be considered as edges. However, it is a fast and simple way.

Hough transform is good when we want to locate the license plate using its borderlines. The disadvantage of this method is the high amount of memory and time devoted to it.

Histogram analysis is good for noiseless images without any tilt, but it does not work properly on the images with noises and the images with tilted plates.

Morphological operations work well in the presence of noise but because of their slowness, they are not used in real time systems.

In the method proposed in [13], the approach consists of some steps. First the vertical edges of the car image is extracted using image enhancement and Sobel operator, then most of the background and noise edges is removed by an effective algorithm, and finally the plate region is searched by a rectangle window in the residual edge image and the plate is segmented out from the original car image.

There are also some color-based methods. In these methods, the system makes use of color information of the plate [14].

What proposed here is a method combined of edge detection, histogram analysis and some morphological operations. We will define a compact factor to develop the performance of our system.

This paper is organized as follows. Section 2 describes our proposed LPL system. In Section 3, we will discuss experimental results and some probable faults of the system. We also make a comparison between our proposed system and the one of [13] in this section. Section 4 gives conclusion remarks and suggestions for future works.

2. PROPOSED LPL SYSTEM

Since our approach does not need color information, the system is able to locate license plates with different colors. The overview of the algorithm is shown in figure 1. Figure 2 depicts a sample of input image, which is gray-scale.

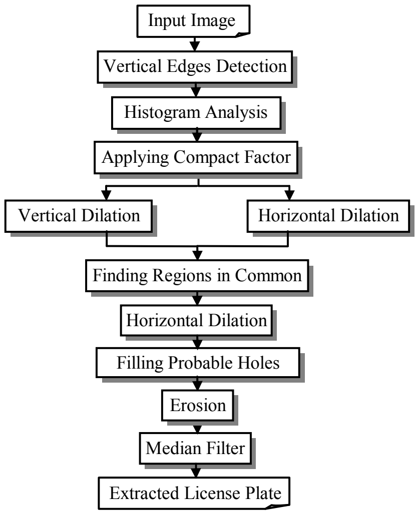

Figure 1. Overview of the proposed algorithm

2.1. Vertical edges detection

Due to digits and characters, a license plate contains many vertical edges. This feature is employed for locating the plate in an image. Many approaches has been proposed for edge detection. Sobel mask has a good performance compared with others; indeed, it is fast and simple. In general, there are two masks for Sobel, horizontal mask and vertical one. Figure 3 shows these masks. We just use the vertical mask of Sobel. Supposing that the input image is not highly tilted, vertical edge detecting plays its role well enough. The result of edge detection is depicted in figure 4.

2.2. Histogram Analysis

Now we employ histogram analysis and find vertical projection of the edge image. To do this, we calculate the number of "ones" for each row of the image. Vertical projection is a diagram with two axes; vertical axis is the rows of the image, and horizontal axis shows the number of white pixels in each row. Figure 4 shows the vertical projection of the edge image too.
The rows corresponding to the license plate usually have the highest values in the vertical projection. For this reason, the next step is finding the rows with the *c%* highest values in the projection. These are candidates for license plate.
For reducing noise effects, a row is considered as a candidate, not only when its value is *c%* above, but also when the value of the next row is *d%* the value of the row. Simulations find values for *c* and *d*. We consider *f* rows before and after each candidate row as candidates too, and we continue processing on the regions determined by them. Figure 5 is the resulted candidate image, and Figure 6 is for comparison with the input image.

Figure 2. A sample of database, input image

-1	0	1
-1	0	2
-1	0	1

(a)

1	2	1
0	0	0
-1	-2	-1

(b)

Figure 3. Sobel masks; (a)Vertical mask, (b)Horizontal mask

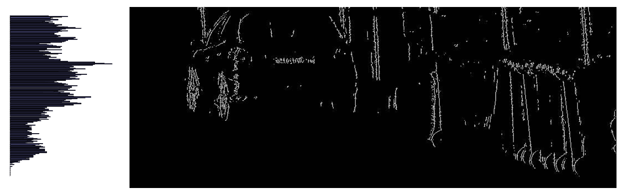

Figure 4. Vertical edge detection result

2.3. Definition of Compact factor

Due to vertical edges of structures such as fences or some parts of the vehicles, they can be selected as candidate regions. To prevent this, we propose the compact factor. A License plate has vertical edges in a narrow range, but those structures have vertical edges in a wide range. This feature is used in compact factor. This means that if we can calculate the quantity of compactness of the vertical edges, we can easily classify them. A simple criterion for this purpose is the number of deviations between "ones" and "zeros" and vice versa for each candidate row. The rows with *e%* minimum values belong to plate, so we omit the other rows from candidate regions. Vertical edges of the plate are close to each other, so for a row in the plate region, there so many cases in which consequent points are totally "ones" or "zeros" and this makes the deviations minimum. Simulations find the acceptable value of *e*.
For evaluating the performance of compact factor, refer to figure 7. As it is shown in its vertical projection, fence structure of the vehicle is also considered as a candidate region. Local maximum in the row 116 is due to this fence structure, as maximum in the row 325 is because of the plate. These two rows are shown in figure 8 and 9. Figure 10 illustrates candidate regions without considering compact factor. The above region is omitted if we consider this criterion.

2.4. Dilations

Now we use a morphological operator. The image of figure 5 is once dilated horizontally and the other time vertically. Another horizontal dilation is employed on the common bright pixels of these two dilated images. The structuring elements of dilations are 6-pixel horizontal or vertical lines.

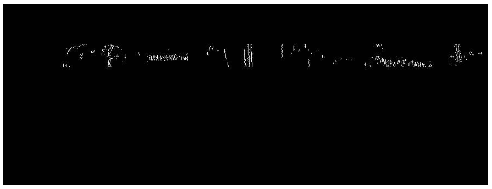

Figure 5. Candidate regions in vertical edge image

Figure 6. Candidate regions in input image

Figure 7. Another sample image of database

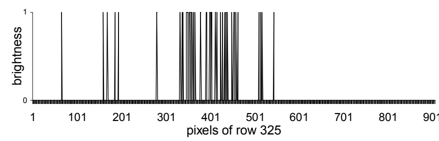

Figure 8. Brightness of pixels ofrow 325

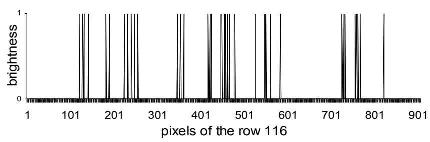

Figure 9. Brightness of pixels of row 116

Figure 10. Candidate regions without considering compactness

Figure 11. Resulted image after filling holes

2.5. Filling the probable holes

As we want to obtain a continuous region as the plate location, in this part of algorithm, the probable holes are filled. Figure 11 illustrates the filling operator result.

2.6. Erosion and Median Filter

Erosion operator excludes any extra regions, which do not belong to the plate. We erode the image with a horizontal band (a 5*40 rectangle). Any regions smaller than this band are totally omitted from the candidate regions.

By employing median filter to the image, the skeleton of the license plate is obtained. The neighborhood window of the median filter is a 7*7 rectangle.

In the next step, we use this skeleton to find the surrounding rectangle of the plate. The resulting image up to now is shown in figure 12.

2.7. License plate extraction

In this step, we find the surrounding rectangle of the filtered image. By enlarging this rectangle, the plate is located in the image.

Experimentally, we decrease x_{min} by $0.5*f$ and increase x_{max} by $1.5*f$; also we decrease and increase y_{min} and y_{max} respectively by $1.1*f$.

Figure 13 depicts the output of the proposed system. Once the plate is located in the image, it can be saved as a different image. Figure 14 is the extracted license plate of figure 2.

3. EXPERIMENTAL RESULTS

3.1. Probable faults of the system

The proposed method in the case of very low resolution and contrast is unable to perform its task well.

There are some probable faults listed here:

- Fault No. 1: Extracting a region larger than the plate
- Fault No. 2: Extracting a region smaller than the plate
- Fault No. 3: Extracting a wrong region as the plate
- Fault No. 4: Being unable to extract any region

3.2. Results

The Database contains 400 images different in size, background, camera angle, distance, and illumination conditions.

The performance of the system for $c=15$, $d=70$, $f=20$ and $e=10$ are shown in table 1. The performance of the method of [13] with our database is also illustrated in this table. Table 1 also shows the computational time needed by these methods for a typical 384*288 image [13]. We use a personal computer, Pentium-4 2.4 GHz, 256 MB RAM, for implementation.

As it is shown, the proposed method is not only faster than the method of [13], but also it has a better performance on our database.

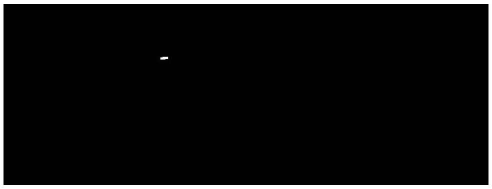

Figure 12. Resulted image after employing median filter

Figure 13. License plate is located in this image

Figure 14. The extracted license plate of figure 2

Table 1. Comparison of the performance of two methods

		Correct location	Fault No. 1	Fault No. 2	Fault No. 3	Fault No. 4
No. of samples	Proposed method	334	31	17	11	7
	Method of [13]	307	23	61	9	0
Rate of correct location (%)	Proposed method	83.50	7.75	4.25	2.75	1.75
	Method of [13]	76.75	5.75	15.25	2.25	0.00
Computational time (ms)	Proposed method	32.4				
	Method of [13]	47.9				

4. CONCLUSION

In this paper, we proposed a real time and robust method for license plate location. Images of our database are complex and different in size, background, camera angle, distance etc. Considering all of these, the proposed method has the correct location rate of 83.50%.

Preparing and introducing a standard database for making comparisons between proposed methods in this field is an essential work for future.

Relating to the proposed method, finding some ways to calculate the optimum values for parameters such as c, d, e and f can be another future work.

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