

# Character Segmentation Method for a License Plate with Topological Transform

Jaedo Kim, Youngjoon Han, and Hernsoo Hahn

**Abstract**—This paper propose the robust character segmentation method for license plate with topological transform such as twist, rotation. The first step of the proposed method is to find a candidate region for character and license plate. The character or license plate must be appeared as closed loop in the edge image. In the case of detecting candidate for character region, the evaluation of detected region is using topological relationship between each character. When this method decides license plate candidate region, character features in the region with binarization are used. After binarization for the detected candidate region, each character region is decided again. In this step, each character region is fitted more than previous step. In the next step, the method checks other character regions with different scale near the detected character regions, because most license plates have license numbers with some meaningful characters around them. The method uses perspective projection for geometrical normalization. If there is topological distortion in the character region, the method projects the region on a template which is defined as standard license plate using perspective projection. In this step, the method is able to separate each number region and small meaningful characters. The evaluation results are tested with a number of test images.

**Keywords**—License Plate Detection, Character Segmentation, Perspective Projection, Topological Transform.

## I. INTRODUCTION

THE computer vision is perhaps the most important areas of research in recent years. During the past decade, computer vision has grown from a research area to a widely accepted technology, capable of providing a dramatic increase in productivity and improving living standards. It belongs to the broader field of image-related computation and relates to areas such as image processing, robot vision, medical imaging, image databases, pattern recognition, computer graphics, and virtual reality. Especially, these systems are useful for a real-time surveillance system or the traffic control center. There are a number of specific circumstances which causes or aggravate congestion. Most of them reduce the capacity of a road at a given point or over a certain length, or increase the number of vehicles required for a given throughput of people or goods.

To solve these problems, many researchers concern license plate detection techniques for surveillance system of illegal roadside parking, or unmanned parking control system. There

are three steps to detect a license plate on the vehicle. In the first step, the method has to decide a license plate region in an arbitrary image with a vehicle. The character recognition step is done in the car license plate region. Since there are many characters in the license plate, they are separated each other in the next step. The most important techniques in this system are extracting license plate region and separating each character.

There are lots of methods to detect a license plate region in the color or gray image. The first method is a vertical or a horizontal edge based method [1, 2]. This method is intuitively adopted in the computer vision industry. In this method, there are a number of edges in the image, so it's very difficult to extract license plate region. The second method is to use the brightness pattern of the license plate region [3]. If it finds nothing similar patterns, wrong regions could be detected. The motivation of this method is to detect intensity features in the license plate. The final method is based on the color information [4-6]. Most methods using color information are sensitive to intensity change. As we can see from these research results, the characteristic features for the license plate are not useful. So this paper proposes the method assuming a license plate region using finding characters in the license plate.

There are two kinds of methods in the character separation from the license plate method. The first one is to extract characters from arbitrary plate image, which are compared with registered one in the database [7]. Before adopting it, the method has to find outer line of the plate, and to recover topological distortion using the projection matrix. Another process is to find blanks between characters [8]. The detected license plate image data is projected to the x and y-axes, and then the height and width of them is extracted. The numbers in the plate should be projected on the x-axis, so this method easily can find blanks on the axis.

In this paper, we present the robust license plate detection method using character separation technique with topological transform. The method is starting with closed loops in an acquired image for characters. It has stable results under the various illuminations due to using bright changing rate method. And the skew features in extracted region are corrected by the perspective projection matrix. After this step, each character regions are easily separated through the projection method. The results are useful to recognize each character. The block diagram of the proposed method is shown in Fig. 1.

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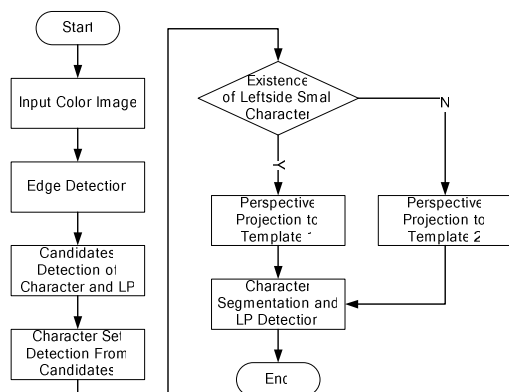


Fig. 1 Block diagram of the proposed method

In the first step on the block diagram, edge image is extracted from the input image, and the method finds closed loops. Car plate and character candidates are acquired from above closed loops. After binarization of candidate regions, character regions are distinguished each other. The twist parameter is calculated from detected characters set. The parameter is used in the perspective projection matrix, and recovered characters are compared with registered standard car plate template. In this step, every character in the plate is separated coincidentally. The proposed method is able to detect partial feature of a character.

The rest of the paper is organized as follows. In the Section II, the technique to detect candidate regions for license plate and character is illustrated. The twist compensation method for the candidate regions, separating each character and the license plate is described in the Section III. The evaluation results are shown in the Section IV. In the final Section V, conclusion and future works are mentioned.

## II. CHARACTER DETECTION METHOD

### A. Candidate Detection of Character and License Plate

In the preprocessing step in a general computer vision module, color input images are converted to gray images through the edge detection. The canny edge detection module is widely used in the computer vision field. The result of them is shown in Fig. 2.



Fig. 2 Preprocessing, (a) Gray image from color input image, (b) Edge image from (a)

After this step, the candidates of plate and characters are found; the detailed procedure is described below.

#### Step 1: Find closed loop edge point

As the high contrast value between the characters and the background of the license plate, a number of the edge points of characters are detected. Hence, the probability values that the

edge points make a closed loop are high. The closed loop is made by eliminating the end points that have no connectivity in the edge image, as shown in Fig. 3.

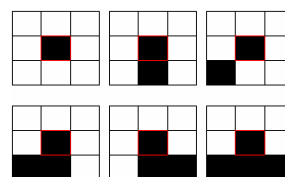


Fig. 3 The example of end points

The end point is decided according to the number of neighbors. Points having one or no neighbors are considered as end points. Points having two neighbors are considered as end points if the Euclidian distance between the two neighbors is one pixel. Finally, if the center point has three neighbor pixels, the abscissa and the ordinate of each neighbor are checked. And if all the abscissa or the ordinates are same, the center point is eliminated as an end point. Fig. 4 shows the result of closed loop detection. If having four or more neighbors, the center point always has connectivity.



Fig. 4 Detected closed loop

#### Step 2: Filling closed loop

After the closed loop detection, the closed loop is filled to get each region information of character or plate. From seed point (0,0), the closed loop edge point is searched for in all direction. If the current point is not a closed loop point, it is set to 'FALSE' value. If the current point is a closed loop point, stop searching in that direction. And then set 'TRUE' value for points that are not searched. Fig. 5 shows a filled region.

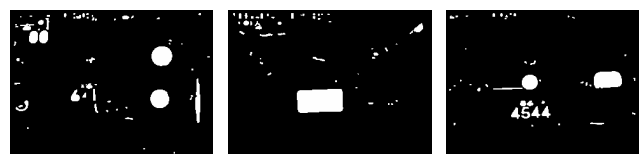


Fig. 5 Filled region

#### Step 3: Detect Candidates of character and plate.

By putting some limits, candidates of character and plate can be found from the previously obtained region. Firstly, by restricting the aspect ratio of each region, candidates of character and plate can be approximated. And then by applying the following conditions, the correct region can be found reliably. Let  $R$  denote the filled region with size  $w \times h$  where  $w$  and  $h$  are the width and height of  $R$ , the ratio  $r$  between the width and height of  $R$ ; that is,  $r = w/h$ , the density of  $R$ ;  $den = A/hw$ , where  $A$  is the number of plate candidate pixels as real area of  $R$ .

#### Plate Case

1.  $h > 38$ .
2. The density  $den$  should be larger than 0.7.
3. The ratio  $r$  between  $w$  and  $h$  should be larger than 1.6 and less than 2.3.

#### Character Case

1. The width is less than the height of character region in each case.
2. The character region has other neighbor character regions nearby.

Fig. 6 shows segmented candidates of character and plate. Sometimes all the characters are not detected, but still the desired license plate can be detected without problems.

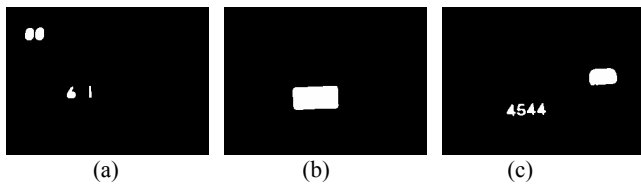


Fig. 6 Detected candidates, (a) includes a part of whole characters, (b) includes plate, (c) includes plate and characters

#### B. Character Set Detection from Candidates

To detect character set, gray image is converted to a binary image by changing the threshold value for expanded character candidate region and plate candidate region until string of license plate is detected completely from binary image, adding to search for the existence of the left-side small character of a license plate. Fig. 7 shows the character set detection results of several cases.

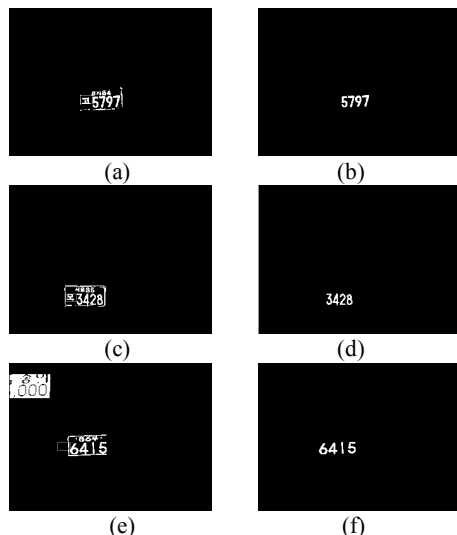


Fig. 7 The character set detection in binary image, (a) is binary image of plate candidate region, (b) is detected whole characters for (a), (c) is binary image of character candidate region with left side small character, (d) is detected whole characters for (c), (e) is binary image of character candidate region without left side small character, (f) is detected whole characters for (e)

#### III. WARP CORRECTION AND CHARACTER SEGMENTATION

There are often appeared topological distortions at a license plate region in the arbitrary image. These unexpected distortions should affect deciding certain character region. In this section, we will discuss the technique to remove the distortion. To use the perspective projection method, 4 corner points of the region is required. They are able to be extracted from above results such as Fig. 7 (b),(d),(f). The basic equation for the perspective projection is shown in (1).

$$\begin{bmatrix} wx' \\ wy' \\ w \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad (1)$$

This matrix equation is rearranged about  $x'$  and  $y'$  axes as shown (2).

$$x' = \frac{ax + by + c}{gx + hy + 1}, \quad y' = \frac{dx + ey + f}{gx + hy + 1} \quad (2)$$

Above equations are able to be expressed based on the  $x'$  and  $y'$ . They illustrated in (3).

$$\begin{aligned} x' &= ax + by + c - gxx' - hxy' \\ y' &= dx + ey + f - gxy' - hyy' \end{aligned} \quad (3)$$

There are 8 unknown parameters ( $a \sim h$ ) in the equations. When the method extracts at least 4 correspondence points from an image, they could give 8 formulas for the  $x$  and  $y$  axes. Each point on the corner of candidate region for character set is used to the calculation module about twist parameter. First of all, angles for upper ( $L_{top}$ ) and lower ( $L_{bottom}$ ) lines with the  $x$ -axis are extracted using 4 correspondence points. To extract vertical angle, mean angle about center points for each character is required. A left side point for the region on the  $x$ -axis with normal direction for the vertical angle is defined as left line ( $L_{left}$ ). The right line ( $L_{right}$ ) could be extracted with same manner. Extracted 4 lines make 4 cross points in the image space. They are shown in the Fig. 8 (a), and the perspective projected result is also shown in Fig. 8 (b).

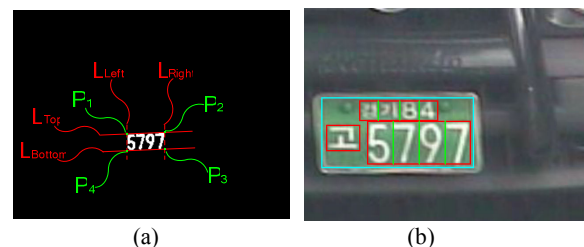


Fig. 8 Perspective projection points and result of template with small character

However, this method makes wrong decision in the case of the number '1'. In this case, since the occupied area of the number '1' is narrower than other numbers, the mentioned problems are occurred as shown in Fig. 9 (b).

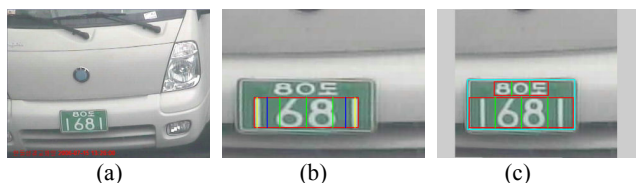


Fig. 9 Result of template without small character, (a) is original image, (b) is wrong projective projection, (c) is corrected projective projection

As in the Fig. 9 (b), other numbers except the number '1' exceed their own specific region, and the number '1' is not positioned on the center of the region. From these problems, the final result should be got fault. To solve them, the perspective projection to move the center points in the outer number region is done again. In the Fig. 9 (c), center position of outer numbers are moved into the center of each number area. Using this method, each number is clearly separated, so the algorithm easily divides each number for recognizing character set.

#### IV. EXPERIMENT RESULTS

To evaluate the proposed algorithm, 500 sequential images are taken with a CCD camera are  $640 \times 480$  for testing. They are divided into two groups. One of them is including small characters near the number; another one is without the small characters. The number of each group is 250. Some of them in each group are with topological distortion such as rotation or skew.

TABLE I  
ACCURACY OF CHARACTER SEGMENTATION

ACCURACY OF CHARACTER SEGMENTATION				
	Test Set 1	Test Set 2	Total	
# of images	250	250	500	
Success	232	233	465	
Fail	Step1	4	3	7
	Step2	11	9	20
	Step3	3	5	8
Accuracy			93%	

Test Set 1 = Image set including small characters

Test Set 2 = Image set without small characters

Step1 = Detecting Candidate Regions of Character and License Plate

Step2 = Detecting Character Set in the Candidate region

Step3 = Perspective Projection

The evaluated results are shown as Table I. As we can see, 93% of image set are in the success. Each the numbers of successive images are 232 and 233. Therefore, it is shown that that the type of license plate doesn't affect to the results. Error rate of them is 7%. 20% (7 images) of errors are failed to find a closed loop feature in the candidate region detection module. The reason of failures is occurred due to strong illumination. High intensity value affects to reduce edge components for the input image. 57 % (20 images) of errors are failed in the module of character set detection. This problem is caused by the shadow effect. Shadow region in the image gives unclear boundary condition. Finally, the rest of the error is due to perspective projection module. Because these images suffer the large geometric distortion, the algorithm cannot detect certain 4

points and, then perspective projection module makes wrong image. Each character is broken by the module.

#### V. CONCLUSION

In this paper, we propose the robust license plate detection method. The proposed method serves simple and robust method to recognize each number in the license plate. In the candidate region detection module, partial information of the number is enough to detect. Though the character undergoes any geometric distortion, it also can be detected by the proposed method. As a result, the recognition module is simpler than other previous system. It only uses the template matching method without any processing. However, this system is also weak in the serious illumination and shadow problem likes other system. These problems are commonly appeared in the computer vision field. To solve these problems, contrast enhancement technique should be considered in this method. Furthermore, we will have to deal with large skew or rotated distortion in the image.

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