Vehicle License Plate Detection and Recognition Based on Contour Extraction in Various Environments

Sung-Kook Pyo, Sang-Hun Lee, Gang-Seong Lee, Young-Soo Park

Abstract ***In this paper, we have tried to detect the area of the license plate in the environment of the vehicle and recognize the characters in the detected license plate area. We propose a method to detect the license plate based on contour extraction that adapts to the surrounding environment and a method of recognizing characters by template matching in detected license plate area. The proposed method is divided into the detection of license plate area and the character recognition in the license plate area. DoG(Difference of Gaussian) and Morphology operation were used to emphasize the character part outline, and the license plate was detected by determining the aspect ratio of the characters. And the character recognition process was performed with the detected license plate area. Through noise remove and normalization, characters were segmented by vertical histogram. The template was matched with the divided characters to recognize the characters. In this study, we used 130 different vehicle image data such as vehicle license plates, which are inclined in front of the vehicle, and license plates with changes in the environment around the vehicle. In the detection plate area, the character recognition rate was 96% in the case of the slanted plate, 93% in the various background environment, and 97% in the plate image of the front face.***

Keywords: License plate detection, Character recognition, Normalization, Vertical histogram, Template matching

I. INTRODUCTION

Modern society has become an integral part of automobile transportation and logistics. However, as the number of vehicles increases, license plate identification technology, which is a vehicle identification number, is indispensable for the management of violation of traffic regulations, parking management, and toll collection. The surveillance camera installed on the traffic light is progressing gradually as a measure against signal violation and overspeed, and is now entering the stage of automatically recognizing the vehicle. In addition, the parking management system and the intermittent system, which are currently being commercialized, are performing vehicle detection and vehicle recognition by applying image processing techniques. Vehicle recognition systems are classified into two categories: vehicle license plate area detection[1] and character recognition[2]. The detection of the license plate area has a great influence on the recognition performance by preprocessing the license plate character recognition. Current vehicle license plate detection has been studied using a combination of edge component[3] of a license plate or neural network[4] and fuzzy[5]. Character recognition is a process of extracting characters from the detected license plate area. To recognize each character, characters are segmented[6,7] and machine learning and template matching[8,9] are used to recognize the character. In this study, we propose a method to detect car license plate area based on contour detection and to recognize characters in detected license plate area. DoG and morphology operations in the vehicle image remove noise and emphasize the character part of the license plate. The extracted contour lines are connected in the horizontal direction, and the longest selected contour line is recognized as the plate plate area, and the plate area is detected.Noise removal and normalization process were performed to increase the recognition rate in the detected plate area. Then, the characters were segmented using a vertical histogram, and characters were recognized through template matching.

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II. RELATED WORK

2.1. Features and specifications of domestic license plate

It is important to know the characteristics of license plate and utilize it properly. The license plates of domestic vehicles generally have the characteristics shown in figure 1.

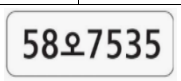
	Before change plate number	Changed license plate	
		Original car	New cars
Car (normal)	 335 x170mm	 335 x155mm	 520 x110mm
Business (normal)	 335 x170mm	 335 x170mm	 520 x110mm
Car (large)	 440 x220mm	 440 x 200mm	

Figure 1. Features of license plate

New license plates were issued from November 1, 2006, and new license plates are standard. The letters,

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shapes, and colors have been replaced. The European version (520 x 110 mm), which is 20 cm wider than the previous version, is 5 cm shorter than the previous one. Actual license plates vary in color depending on the vehicle application, but in contrast, black and white images have contrast values that are contrasted with dark letters on a light background or bright letters on a dark background. With this contrasting contrast value, binarization[10] can be used to distinguish the license plate part and character part, and the license plate area can be extracted using the distinguished character part.

2.2 Edge Detection

Edge Detection is widely used in image processing because it reduces the size of data and minimizes meaningless information. In the image, the vertical component and the horizontal component are separated and the candidate region of the plate is detected using the coordinate information of the connected edge [11, 12]. If the threshold value processing is performed on the edge image, it can be confirmed that the accumulation value of the projection data is concentrated in the license plate area.

2.3 Detection of license plate area using color information

The car license plate is divided into white letters on a green background and black letters on a white background. In order to set the plate candidate region, the RGB image is converted into the YCbCr color coordinate system in which the contrast and color difference are separated, and only the Cr component for green is used. The green part of the car license plate can be classified into binary images according to the threshold value of Cr component.

2.4 Global Binarization

It is a simple and fast binary method applied to real-time character recognition. This method uses the same value for the entire image as the threshold value. Assuming that the brightness distribution of the image is usually divided into background pixels and letter pixels in the preprocessing process, the middle part is used as a threshold value. Therefore, global binarization is the simplest way of recognizing characters using the minimum brightness and average brightness of the image.

2.5 Template Matching

A template is a sample image of a character to be recognized. The characters of the license plate are designated as template images, and the template image and the input data are compared to define the number of pixels matched with each other as a score, and then consideration thereof is made. There is also a method of normalizing by adding the number of matched pixels and the number of matched pixels. This method is a method of normalizing considering a case in which a white pixel corresponding to a background is matched and a case in which it is not, rather than considering a case in which a black pixel is matched with a case in which a template and a character image are not matched.

III. PROPOSED METHOD

The proposed method is divided into a plate detection process and a character recognition process in the detected license plate area. First, in the license plate detection process, noise-removed outlines are extracted through DoG and binary images are obtained. Then, the preprocessing process was performed to emphasize the character part while removing the noise of the binary image by using the erosion and expansion operations, which are morphological operations. In the image with the contour emphasized, the contours which are judged as the character area are extracted through the ratio of the width and the width. Then, an image including the contours of the character part was acquired, and an area including many of the contours was judged to be the plate area and detected. Next, the process of recognizing the characters in the license plate area detected was proceeded. Normalization process was performed to remove noise in the detected plate region and to increase template matching probability. Then, the characters were divided by vertical histogram and labeling, and the divided characters were recognized using template matching. In figure 2 is a flowchart of the license plate detection and character recognition method of the proposed method.

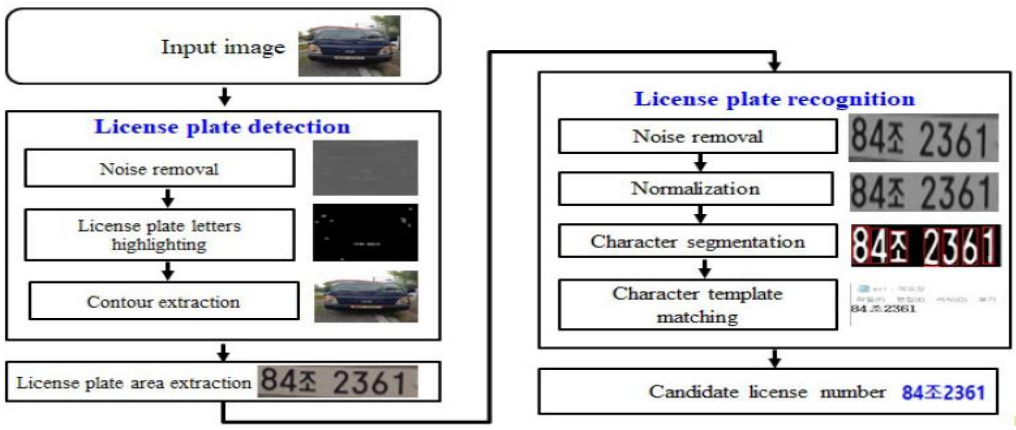


Figure 2. The algorithm of the proposed method

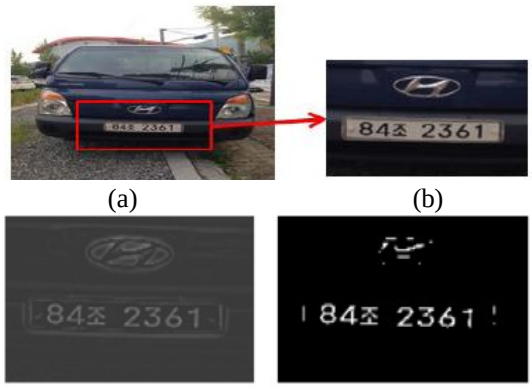
3.1 Detection of license plate area

Difference of Gaussian is first applied to the gray image to remove the noise of

the image and extract only the necessary contours.

$$DoG(x,y) = \frac{1}{2\pi\sigma_1^2} e^{-\frac{x^2+y^2}{2\sigma_1^2}} + \frac{1}{2\pi\sigma_2^2} e^{-\frac{x^2+y^2}{2\sigma_2^2}} \quad (1)$$

By using the DoG of Eq.(1), which is often used for edge extraction, it is possible to convert a vehicle image with low contrast or lighting effects into a binary image with a contour emphasis.



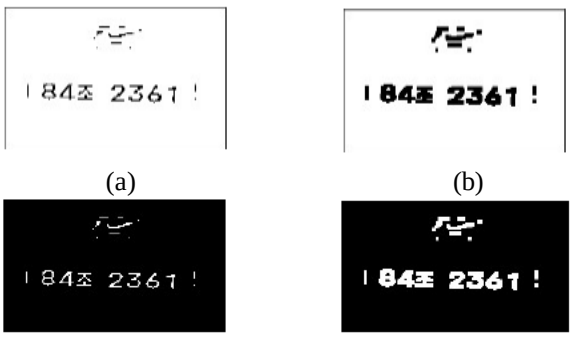
(a) (b)

(c) (d)

Figure 3. An example of obtaining a binary image using DoG filtered results for a vehicle image
(a) Original image, (b) Expanded area of interest
(c) DoG filter applied image (d) Binary image

The edge image obtained by DoG filtering the vehicle image is shown in Figure 3(c). When scanning from left to right of the image and connecting the points where the sign changes as an end point, we could obtain a binary image emphasizing character strokes as shown in Figure 3(d). Through the equations (3) and (4), images were obtained in which the character strokes were emphasized in the binarized image of the license plate, which is a white character on the license plates and the black license plate, on each white license plate. Figure 4 shows an image with erosion and expansion applied to the binarized image.

$$A \ominus B = z|(B)_z| \subseteq A(2)$$
$$A \oplus B = z|(\hat{B})_z \cap A \neq \phi \quad (3)$$



(a) (b)

(c) (d)

Figure 4. Examples of application of erosion and expansion to binary images
(a) Binary image with black character (b) Image applied with erosion operation (c) Binary image with white character (d) Image applied with expansion operation

Figure 5 shows the process of acquiring a character part containing a distinct outline by morphological operation and then capturing the outline of each character. Each individual outline is accessed by an array and a rectangle is placed on each outline. The number of the license plate is judged through the process of exclusion of unnecessary contours through the upper and lower limit of the size and the aspect ratio of the found outline.

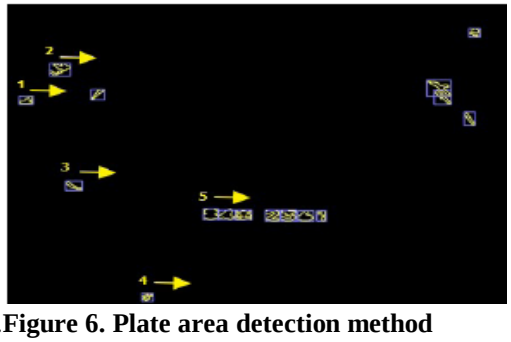
(a) (b)

Figure 5. License plate-like contour extraction image
(a) Original image (b) Outline extraction image

After excluding unnecessary contour lines, outline of the license plate area and the surrounding background are distinguished from those of the remaining license plate line outline. The outline, which is supposed to be a license plate, appears in a straight line from a minimum of four to a maximum of seven. Therefore, the search is performed from the position of the left edge OC(i) to the right direction to judge whether or not the outline exists and estimate the longest outlines as the plate region. In order to discriminate the characters of the license plate, the aspect ratio of the contour line was analyzed using Eq.(4), and valid characters were selected to primarily select the characters existing on the license plate.

$$OC(i) = \begin{cases} 1, & r_{min} \le R_i \le r_{max} \\ 0, & otherwise \end{cases} \quad (4)$$

In this paper, the aspect ratios of letter size in the general plate area were determined and the experiment was conducted with r_{min} set to 0.5 and r_{max} *set* to 2.5. We took the upper left corner of the distinct outline as a reference point and detected it in the right direction. In the detection process, the distances and slopes between the contours existing on the same line are judged and unnecessary contours are excluded. The longest connected outline was determined as the license plate area. Figure 6 shows how to detect the license plate area



.Figure 6. Plate area detection method

If the slope between the outlines is too large, it is difficult to judge the area of the plate. Also, if the difference of the X coordinate is too long, it is difficult to judge this outline as a license plate. Based on the equation (5) and (6), the slope (G) of the next outline is calculated based on the left top (tl) of the outline of the rectangle. If the slope is less

than 0.45, We also excluded contours with a size of d of 200 or more because it is difficult to judge the contours that are too far away from the characters of the license plate.

$$\mathcal{G} = \frac{tl_{y_{n+1}} - tl_{y_n}}{tl_{x_{n+1}} - tl_{x_n}} \quad (5)$$

$$\mathrm{PC}(i) = \begin{cases} 1, & \mathcal{G} < a \text{ and } d < \beta \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

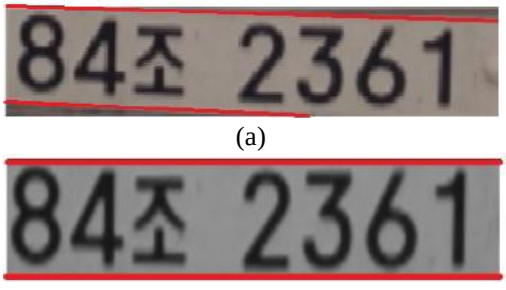
Using the crying and distance, the set of contours estimated to be the plate area is displayed as shown in Figure7(a). Finally, the plate area is extracted as shown in (b).

(a) (b)

Figure 7. Final license plate area detection image
(a) Final license plate candidate area
(b) License plate detection image

3.2 License plate recognition

Character recognition was performed with the detected license plate area. The recognition process is divided into noise elimination, normalization, character segmentation, and template matching. First, the noise was removed using a median filter. The median filter is a filter that aligns the values of neighboring pixels in the input image in ascending or descending order, and replaces the pixel value with the value in the center. The Median filter has the advantage of effectively removing salt and pepper noise, thus facilitating character recognition. And normalized the plates detected using Huffman transforms to recognize slanted characters. Figure 8 is the license plate normalization process.



(a)

(b)

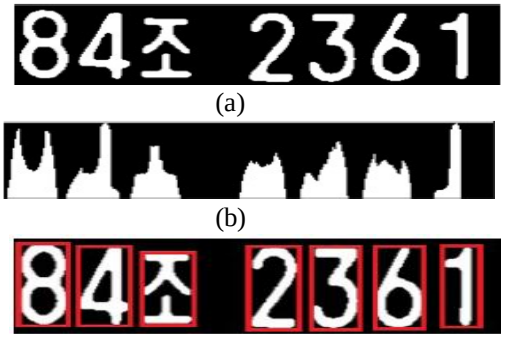
Figure8. Normalization process
(a) Input image (b) Normalized image

After the normalization process, character segmentation was performed using a vertical histogram to match the template. N in equation (7) represents the number of observations and represents a histogram. H_kin equation (8) represents the cumulative histogram. The vertical histogram is a method of accumulating and accumulating all the observations existing in the region in the vertical direction. Vertical histograms allow you to easily separate characters in a license plate.

$$\mathrm{N} = \sum_{K=1}^{n} h_k \quad (7)$$

$$H_k = \sum_{k=1}^{k} h_k \quad (8)$$

The separated characters were recognized as one object through labeling. Fig. 9 (b) shows the image of the license plate area using the vertical cumulative histogram. Each histogram is labeled and characters are separated as shown in (c).



(a)

(b)

(c)

Figure 9.Character segmentation process image
(a) Binarized image (b) Vertical histogram image
(c) Character labeling image

Finally, character recognition was performed using template matching. Through the comparison of the image used as the template sample and the character to be recognized through the equation (9), it was recognized as the corresponding character when the matching rate of 50% or more was shown. Fig. 10 shows sample images used for template matching and

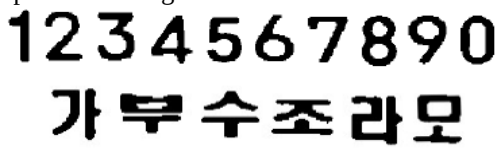


Figure 10. Template sample image

$$compore \begin{cases} equalcount + 1 \\ else \end{cases} \quad 0 \quad (9)$$

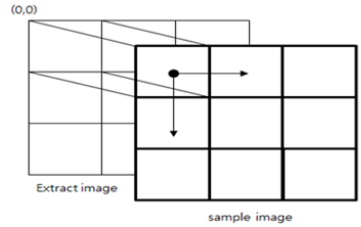


Figure 11. Template matching method

IV. EXPERIMENTS AND CONSIDERATIONS

In this paper, we experimented with images provided by Google Images and vehicle images parked at a distance. Each image was experimented with an image in which the license plate was in front, an image in which the license plate area was inclined, and an image in which the background or vehicle was complex. It was possible to detect not only the image of a general license plate in front but also the license plate in an image with a slanted license plate and images of various backgrounds. Then, normalization process and template matching were

performed with the detected plates, and character recognition was performed. The experiment was carried out with 30 images with 60 oblique images on the front of the license plate, and 30 images with complex images on the surrounding environment. Figure 12 shows some of the various vehicle images used in the experiment.

Figure 12. Experimental image

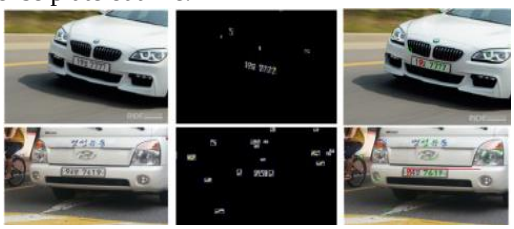
(a) (b) (c)

Figure 13. Front image of the vehicle
(a) Original image(b) Outline extraction image
(c) License plate area estimation result image

(a) (b) (c)

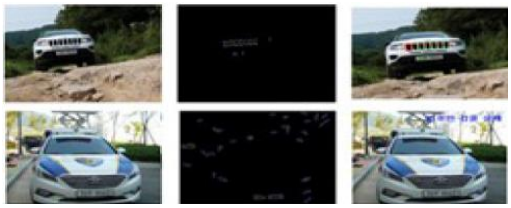
Figure 14.Vehicle image with complex background
(a) Original image (b) Outline extraction image
(c) License plate area estimation result image

Figure 13 is an image of the front of the vehicle, which is generally not complicated. As shown in the image of (b), there is not much noise around the vehicle and the characters in the license plate area are well detected. Based on the outline on the left side, the presence or absence of the outline is judged in the right direction. The longest continuing contours are estimated as plates, and the plate area is detected as shown in (c). In Figure 14, the experiment was carried out with an image with a stone floor or a somewhat complicated background. In the image with this complicated background, the license plate area is detected because DoG removes the noise and excludes the meaningless outlines and extracts the license plate outline.



(a) (b) (c)

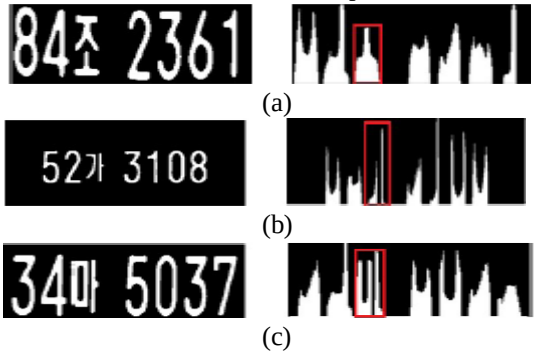
Fig.15 Vehicle images where there are differentcharacters from images with slanted plates
(a) Original image (b) Outline extraction image
(c) License plate area estimation result image



(a) (b) (c)

Fig.16icense plate detection failure image
(a) Original image (b) Outline extraction image
(c) License plate area estimation result image

The images in Figure 15 are images in which the license plate is not a front but an image that is tilted and acharacter exists outside the license plate.Although the plate contours are not straight lines, we can extract the plates through tilt correction. Even if there are other characters, the plate area is detected by determining the distance between the characters and the aspect ratio.Figure 16 shows the failed plate detection image. Because of the similar pattern of repetition on the front part where the plate exists, the other area is recognized as alicense plate, so that the failed image and surrounding noise are too severe to recognize the license plate area character, but the license plate area is not detected.



(a)
(b)
(c)

Fig.17 Hangeul labeling Course
(a) Korean with consonant and vowel position vertical
(b),(c) Korean consonant and vowel position are horizontal

Figure 17 shows the characters with vertical consonants and vowels as in Hangul '조', and the character divisions that exist horizontally like '가' and '마'. In case of '조', there is no problem in segmentation, but in case of '가' and'마', consonants and vowels can be separated and recognized.

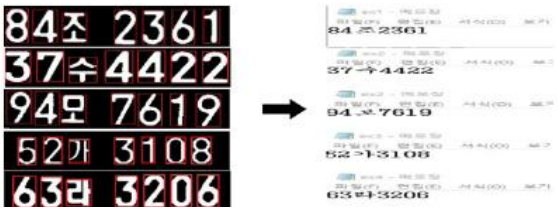


Fig.18 Template matching result image

Figure 18 shows the template matching result image. Each character was divided and labeled, and the sample image and license plate letters were compared and analyzed through template matching. Because it has undergone the normalization process, both numbers and letters were easy to recognize even in sloping license plates.

Table.1 Comparison table of other algorithms

	Canny edge	HSI color	LPD rate	Proposed method (LPR rate)
Front image	83%	86%	98%	97%
Tilted image	76%	70%	93%	93%
Various background	73%	70%	90%	96%

Table 1 shows the method of detecting the license plate area using the method of detecting license plate area using Canny edge [14] and the HSI color information [15] using the limiting algorithm as the front image, the slanted image, And the result of the recognition on the detected license plate. Canny edge and HSI color were detected in 83% and 86% of the images, respectively, and the proposed method showed a high detection rate of 98%. In addition to the frontal image, the proposed method also showed a higher detection rate than the other methods. Also, the recognition rate of the detected license plates is 95%, which is high.

V. CONCLUSION

In this paper, we have studied the recognition of characters in license plate area and detecting the characters in the area of the license plate in the environment of vehicle environment. We used DoG and morphology operations to emphasize noise elimination and character outline and extract the character part of the license plate through contour extraction to detect license plate area. Normalization process was performed on the detected plate area and characters were segmented by vertical histogram. The final character recognition was performed by template matching with the sample image having the divided characters. In this paper, we show not only the frontal image of license plate, but also the sloped license plate and the high license plate area detection rate and license plate character recognition rate in various background situations.In future research, it is necessary to study the detection of plate area in a plate image with a high slope or an image with noises and to improve the recognition rate of the plate on the plate.

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