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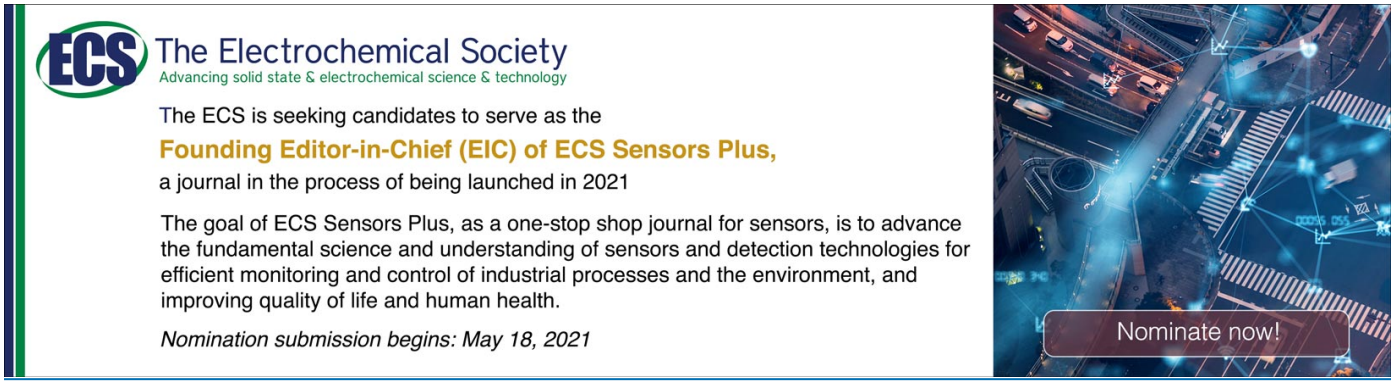

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A Vehicle License Plate Recognition System Using Morphological ROI (Region of Interest) Map Generated from Morphology Operation

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Abstract. In this paper, morphology features are used to improve license plate region and Morphological ROI (MROI) map that consists of a standard deviation map of open and close images is proposed. Unlike conventional morphology techniques, MROI map is used to improve the detection of license plate in a complex background. Furthermore, distribution of the MROI map was analyzed to determine a threshold level, generate binary code images, and finally, determine the vehicle license plate region by using the features of the plate such as aspect ratio and vertical edge intensity. The proposed method could improve the error rate by approximately 4-7% depending on the pattern of the images.

1. Introduction

The vehicle license plate recognition system is one component of the intelligent transportation system and is widely used for the tolling system on the highway and security closed-circuit television (CCTV). Recently, this system is used for autonomous vehicles.

The license plate recognition system (LPRS) consists of two main technologies, which are the license plate positioning technology and the plate number recognition technology. The former technology detects the position of the license plate in a complex background and the latter technology recognizes the plate numbers in the plate region detected from the first technology. To process the LPRS effectively, the accurate position detection method is very important.

Current plate position detecting algorithms use the edges of characters and numbers in plates[1], color feature of plates[2], sliding window technique that scans entire images of plates[3], and morphological operation [4-5].

The method using the edges of characters in plates utilize brightness vector. It uses the fact that the brightness variation of the characters in the plate is clearly distinguished than other regions. Therefore, vertical edge of the image are extracted and analyzed to detect the license plate. However, it can cause errors if there are many vertical edges in other regions than the plate region.

The method using the color feature of plates searches for pixels that are within the color range of the plate and examine them. It performs badly where there are a lot of illuminance variations.

One of the most popular methods to scan and detect number plates is the sliding windows method. It requires very complicated operations because it needs to scan the entire images.

The final method uses erosion and dilation operations through random structure element to improve the license plate region and detect license plate numbers. Most popular algorithms are the top-hat and the bottom-hat method, which are as complicated as the sliding windows method.

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In this paper, we propose a new method to improve the conventional morphological methods for more accurate license plate detection in a complex background.

2. The Proposed License Plate Detection Algorithm

There are two main plate detection methods using morphological operations: top-hat method and bottom-hat method. These operations can effectively find more apparent edge regions. Because these methods are used to detect edges, they can cause errors if there are strong edges in the background.

To solve this problem, we propose the license plate detection method using Morphological ROI(MROI) map as shown in Fig.1. M-ROI map consists of the standard deviation of morphological open and close image. It uses to find to the brightness difference between the characters and the background in the plate. It is important to detect the plate regions that have high standard deviations and are clearly distinguished from the background.

Figure 1. Flow chart of the proposed license plate detection algorithm

2.1. Pre-Processing by Morphological Operation

A color image is first converted to the grayscale image. The morphological operations such as the close and open operations are then performed. The size of the structure element (SE) is 4 x 4. It was determined by considering the sizes of characters and numbers in the plate. If this size is too small, the overall noise level will be larger, and if too large, the entire image will be blurred.

(a) (b) (c)

Figure 2.(a) Original Image, **(b)** Open operated Image, **(c)** Close operated Image

Fig. 2(a) shows an image that contains many strong edges. The images in Fig. 2(b) and Fig. 2(c) show the results after open and close operations, respectively. After the open operation is performed by erosion-dilation operations, black characters and numbers in the plate regions are emphasized. Moreover, through the close operation such as dilation-erosion operations, the characters and numbers in the plate regions are disappear. As shown in Fig.2, the processing results of the open and close operations are discriminated noticeably in the plate region.

2.2. Block Processing of MROI map

The standard deviations of the open-operated image and close-operated image are calculated based on 15x5 rectangular blocks. For the shape and size of the block, considering the blank in the center of the plate, the width was made larger than the height. As shown in Fig.3, a map is then generated by using computed standard deviations of the blocks. An element of map, W(i,j), is a standard deviation of block. If the image size is 720x480, then it is converted to 48x96 map by the block processing.

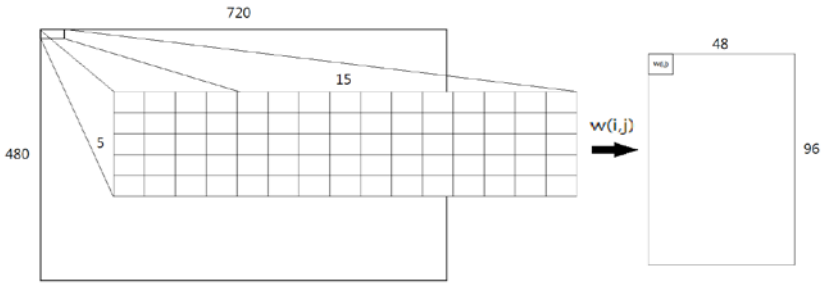


Figure 3. Generation Process of the Standard Deviation Map

(a) **(b)** **(c)**

Figure 4.(a) Open deviation Map, **(b)** Close deviation Map, **(c)** MROI Map

The largest difference between the open deviation map and the close deviation map results can be found on the license plate. Thus, to detect the license plate region, we compute the value as in Equation (1).

$$\text{MROI Map} = \frac{(Open\ Deviation\ Map + 1)}{(Close\ Deviation\ Map + 1)} \quad (1)$$

Fig. 4(c) shows the result after Equation (1) was applied and this result has the large value of ROI map of in the plate region. The values of ROI map are very low in other regions such as backgrounds and smooth regions.

2.3. Histogram Analysis

To convert the MROI map shown in Fig. 4(c) to a binary image, a threshold value should be determined. Fig. 5 shows a histogram of the MROI map. The histogram is normalized. It shows that they are concentrated in the lower values and less concentrated in the higher values.

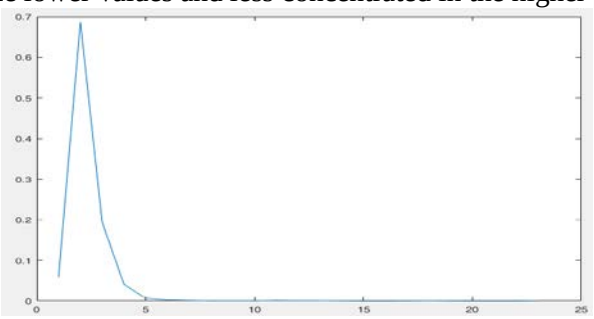
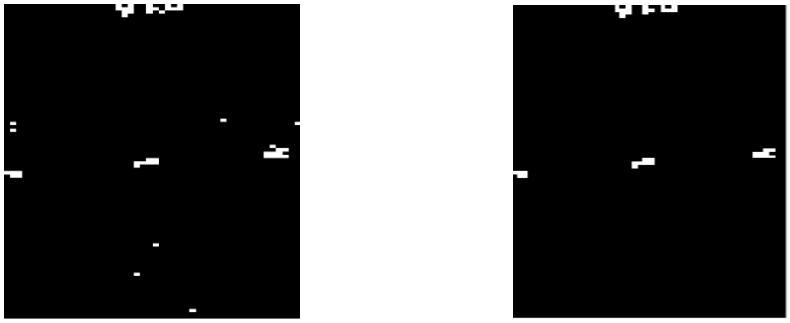


Figure 5. Typical Histogram of ROI MAP

The higher values of ROI map include high texture region such as the license plate region. In order to find the candidate of license plate, the binarization of map in performed by Thresholding. Fig. 6(a) shows the binary image of the ROI map after exclusion 99% of histogram, in which a small amount of noise is included.

To eliminate the noise, we used a simple mask. If the neighbouring standard deviation data is not connected to any of four directions, up, down, left, and right, then it is considered as a noise region.

The results are shown in Fig. 6(b).



(a) **(b)**

Figure 6.(a) Binary ROI Map, **(b)** Noise Removal Mask Image

3. ROI Verification Process

The plate region verification is processed by two methods. The first method uses the aspect ratios of the possible plate regions. The second method uses the vertical edge distribution of the possible plate regions.

3.1. Determination by Aspect Ratio

The real size of the plate is fixed. It is always either 520mm x 110mm or 335mm x 155mm. The aspect ratios for plates are 520/110=4.73, 335/155=2.16 and the range of suitable ratio is $2 \leq$ Real Aspect Ratio ≤ 5 in real image. In the case of the aspect ratio in binary ROI map, it ranges from 0.66 to 1.66, approximately 1 to 2. Then, it is available to determine whether these regions are the plate regions or not.

3.2. Determination by Vertical Edge

After the candidate region of Fig6.(b) is determined by the aspect ratio feature, those regions are selected from the original image. The characters and numbers in the real plates usually have strong vertical edges. Therefore, the vertical edges using vertical Sobel mask are calculated. Those vertical edges are projected on the vertical plane to compute the edge distribution. The vertical edges in the plate regions are concentrated in the center of the vertical plane, while the vertical edges in other regions are existed randomly. To find the higher edge value in the center, the license plate region can be determined by sum of multiplying the normalized edge histogram value with weighting coefficient value. Coefficient value is expressed as Equation (2).

4. The Experimental Result

$$coefficient : f(x) \begin{cases} x \div \dfrac{\mathrm{row_{total}}}{2} & \left(\text{if} \quad x \leq \dfrac{row_{total}}{2}\right) \\ (\mathrm{row_{total}} - x) \div \dfrac{\mathrm{row_{total}}}{2} & \left(\text{if} \quad x > \dfrac{row_{total}}{2}\right) \end{cases} \tag{2}$$

where x is row number of selected candidate region and $\mathrm{row_{total}}$ is max of row number.

In the simulation, various 720x480 real images are used as shown in Fig 7, in which some have a very simple background such as a tollgate and the other images have a relatively more complicated background such as a parking lot and multiple cars on the road.

The accuracy of the experiment is determined by implementing algorithms and indicating the plate regions with the bounding boxes. If the bounding box includes a plate region, the system determines that it worked successfully. Otherwise, the system determines that it detected a wrong region.

Figure 7. Examples of Test Data Samples

Fig.8 is the results of the proposed method in various environments. As shown in Table 1, when 30 tollgate images were tested, the plate regions were successfully detected without any errors due to the simple background. The accuracy of the proposed method is 90%, 40% in the complicated parking lot and cars on the road, respectively.

The proposed method has the better performance than the conventional method in the situation that the edges of background are complicated shown in Fig.9. The conventional method has an error to detect the vertical edges in the background and cars as well as the edges in the plate region. The proposed method detects the exact plate region even if the edges of background are strong.

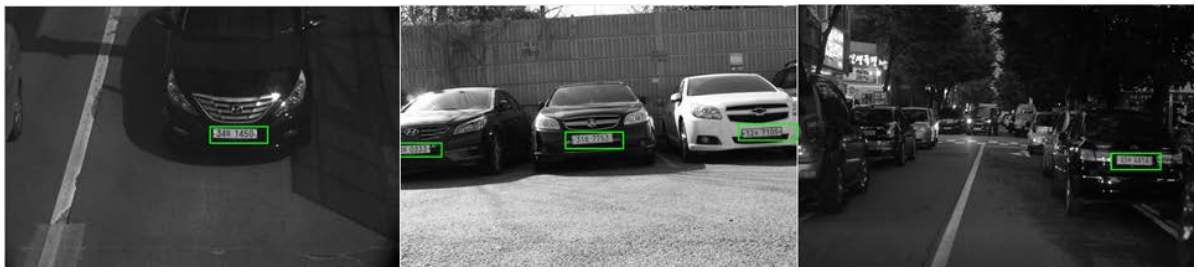


Figure 8. Results Images of proposed method

Table 1. Results of the experiment

	Tollgate	Parking garage	On the Road
Number of Images	30	30	30
Conventional method Accuracy [1]	100%	86%	33%
Propose method Accuracy	100%	90%	40%

5. Conclusion

In this paper, vehicle license plate detection using Morphological ROI map was proposed in the complex vehicle images. The MROI map is made by using the standard deviation of morphological open and close images, and the threshold value is calculated using the distribution of the MROI map to effectively detect the candidate region. After detecting candidate regions, those are verified using the features of the license plate. Experimental results show that the proposed method has the higher detection rate then to conventional method by 4-7% in the complex environments.

Figure 9. Comparison between the conventional method (Left) and the proposed method (Right)

Acknowledgement
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