Invention Journal of Research Technology in Engineering & Management (IJRTEM)
ISSN: 2455-3689
www.ijrtem.com Volume 2 Issue 1 ǁ January. 2018 ǁ PP 11-16

A Study on Single Camera Based ANPR System for Improvement of Vehicle Number Plate Recognition on Multi-lane Roads

[1]Seong-In Kang, [2]Sang-cheol Byun, [3]Yeo-Han Yoon, [4]Youn Sub Park

[1]*Senior Researcher, Korea Institute of Civil Engineering and Building Technology, Korea*
[2]*Research Fellow, Korea Institute of Civil Engineering and Building Technology, Korea*
[3]*Senior Research Fellow, Korea Institute of Civil Engineering and Building Technology, Korea*
[4]*Hanilstm Corporation*

ABSTRACT *:* In this paper, we introduce the single camera-based number recognition system used for this system recognizes vehicle number plates on one lane by using a single camera. Intelligent transport system (ITS) has been constructed because there is a limit in solving traffic problems in a physical manner such as construction of roads and subways. The single camera-based number recognition system used for this system recognizes vehicle number plates on one lane by using a single camera. Due to the increased cost of the installation and maintenance thereof, there is a growing need for a multi-lane-based number recognition system. When the single camera-based number recognition system is used for multi-lane recognition, the recognition rate is lowered due to a difference in vehicle image size among lanes and a low-resolution problem. Therefore, in this study, we applied a character extraction algorithm using connected vertical and horizontal edge segments-based labeling to improve multi-lane vehicle number recognition rate and thereby to allow application of the single camera-based system to multi-lane roads.

KEYWORDS: *Automatic Number Plate Recognition, Multi-lane Detection, Vehicle Image Processing, Real-Time Traffic Information*

I. INTRODUCTION

Since 1990, Intelligent Transport System (ITS) has been built as a solution to solve traffic congestion. It collects and processes basic traffic data such as traffic volume, speed, occupancy, etc. to be used for traffic management and traffic information [1]. In particular, studies are being actively conducted on automatic number plate recognition (ANPR) technology, which is a key technology of intelligent traffic system [2-10]. At present, single lane ANPR allows to detect only one lane per camera. Thus, it is installed at intervals of 4-10km considering the construction and maintenance costs. It employs a bridge-shaped structure with one camera per lane. The installation interval of the device is long due to the installation cost, resulting in a large time lag in section traffic information. Also, it has a low vehicle number matching rate, which reduces the accuracy of the traffic information. when a multi-lane vehicle number plate recognition method is applied using a single camera, the recognition rate is low due to a difference in vehicle image size among lanes and a low-resolution problem.

In this study, we propose a single camera based ANPR system based on a character extraction algorithm using connected vertical and horizontal edge segments-based labeling to allow recognition of multi-lane vehicle number plates based on a single camera. The algorithm for automatic recognition of multi-lane vehicle number plates detects the coordinates of the edge patterns of characters repeated at regular intervals, calculates the edges from the differentiated images, and then cumulatively labels the individual edges for each scan line to extract character components. The candidate area of a number is enlarged so that the size of the character is equal to or larger than 40 pixels and the characteristic feature of the characters is extracted from the enlarged image. We created a single camera based ANPR system in accordance with the proposed method, constructed a test bed on actual roads and analyzed the results.

II. MULTI-LANE ANPR ALGORITHM

Unlike the conventional method of detecting one lane with one camera as shown in Fig.1, the multi-lane ANPR system recognizes vehicle plates on multi-lane roads.

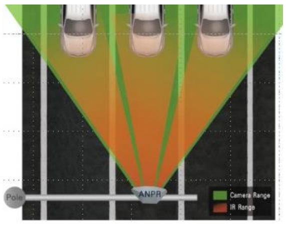

Fig. 1: Multi-lane ANPR System

The multi-lane vehicle number plate recognition system can be divided into a camera unit and an enclosure unit. The camera unit is composed of a housing, a camera, a lens, an IR LED controller, and an IR LED board. The enclosure unit includes an enclosure, a controller and an SMPS The camera is a device for acquiring images, and the IR LED controller and the IR LED board are devices for lighting at night or in the rain. The controller is a device for driving a three-lane vehicle number plate recognition algorithm, and the SMPS is a device for supplying power to the camera and the lighting controller. In particular, the camera specifications are as follows: The number of pixels of the image to be photographed is proportional to the square of the number of lanes. A camera of 2.8 megapixels was used for two-lane ANPR, and in order to obtain the same level of image quality, a camera and lens of 6.3 megapixels was used for three lanes and 11.2 megapixels for four lanes. The installation diagram of the system installed and `operated outdoors is shown in Fig. 2.

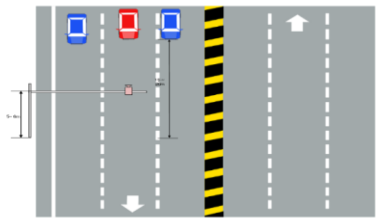

Fig. 2: Installation of ANPR System

The multi-lane ANPR algorithm employs connected vertical and horizontal edge segments-based labeling for character extraction and an image enhancement process without damage to the invariant features of characters. The overall process for implementing the ANPR system is shown in Fig. 3.

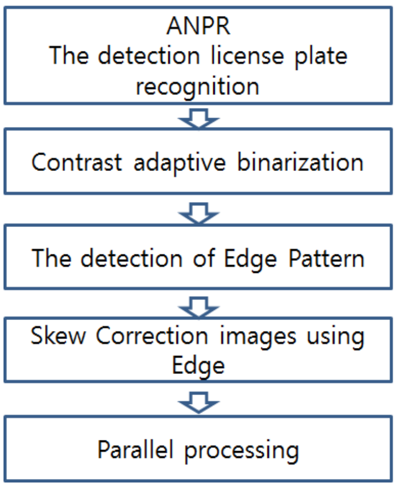

Fig. 3: The Block Diagram for ANPR recognition

The first step of vehicle number recognition is an algorithm for detecting the candidate area of a vehicle number plate. As shown in Fig. 4, each number includes edge patterns of characters which appear repeatedly at regular intervals. We detected the coordinates of these repeated patterns.

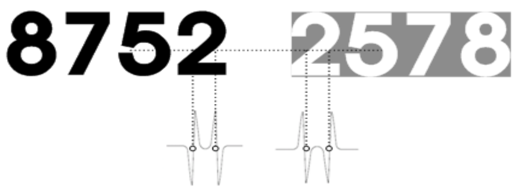

Fig. 4: The Edge Pattern Using the Quadratic Differential Equation

The foreground and background of the characters were estimated and the edges were calculated, from the second order derivative of the edge patterns of the characters. Then, as shown in Fig. 5, each edge was cumulatively labeled for each scan line to extract character components.

Fig. 5: The Regulation of Segmented Characters by Labeling

In order to recognize the character size of the captured vehicle number, the interval of the scan line is defined as 5 pixels as shown in Fig 6. Then, when the same edge is repeated at row_i as shown in equation (1) below, the features of the section where the edge occurs repeatedly are analyzed.

$$\sum_{k=0}^{n} edge_k \; (n \geq 4) \qquad (1)$$

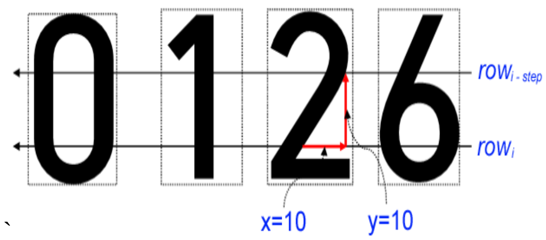

Fig. 6: The Labeling Algorithm Structure

The size of the mask convolution for edge detection is defined as 2 pixels given the narrow spacing between adjacent characters. If n in equation (1) is 4 or more, the vehicle plate number is estimated based on repeated calculation of the edges that may occur in four-digit numbers. When a valid edge pattern is detected in row_i, the same process is repeated on the scan lines of row_{i-5} and row_{i+5}, and when a repetitive feature similar to the detected edge pattern is detected, the edges detected in row_{i-5} and row_{i+5} are cumulately labeled as the $edge_i$ detected in row_i to separate a character. In the cumulative labeling algorithm as shown in Fig. 7, when the x-axis displacement Δx = 10 pixels in the edgei detected in row_i, the y-axis displacement Δy = 10 pixels at the maximum. $Edge_j$ of the same pattern is searched from the range of $edge_i$-Δx ~ $edge_i$+Δx in row_i-step, and the connectivity thereof is calculated.

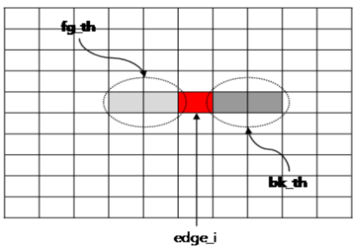

Fig. 7: The Mask Definition for Edge Recognition

In this study, we enlarged the candidate area of a vehicle plate number so that the size of the characters is equal to or larger than 40 pixels, applied an image enhancement algorithm to the enlarged image, and then applied an algorithm for recognizing unique features of characters. Fig. 8 shows the process of vehicle plate number recognition, which is performed together with the image enhancement algorithm

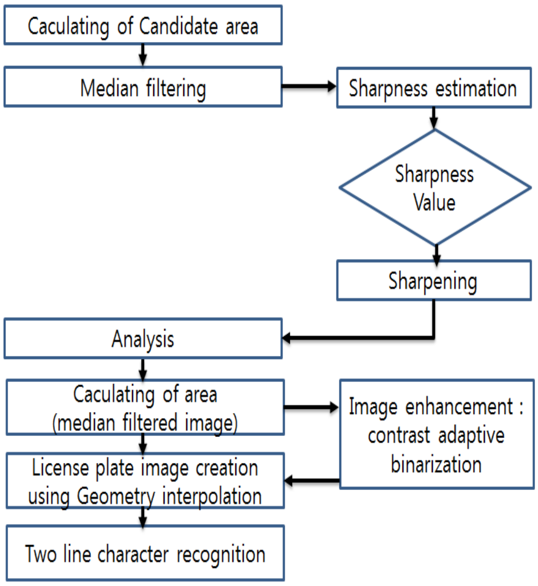

Fig. 8: The Process of Recognition of Number Plate

Sharpness estimation and sharpening processes estimate the blurred value of the current image by using the gradient of the edge pattern in the vehicle number's candidate area calculated from the input image. If the blurred value is lower than the threshold value, a sharpening algorithm is used to make the boundary area clear. The image enhancement process enhances the images of the image area calculated as the candidate area, through binarization using adaptive contrast.

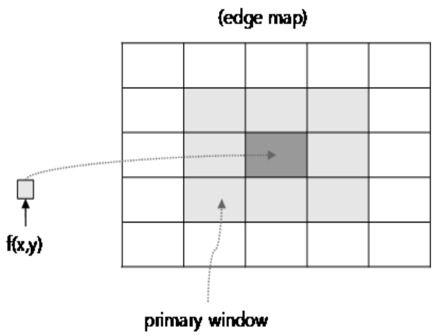

Fig. 9: The Edgemap and Primary Window

As shown in Fig. 9, the contrast adaptive binarization defines a 3 × 3 primary window after constructing an edgemap for the candidate area. Then, the following calculation for binarization is performed on the primary window:

$$T =$$
$$(1-\alpha_1)\times m + \alpha_2 \times \left(\frac{s}{R_s}\right) \times (m - M) + \alpha_3 \times M$$
$$where\ \alpha_2 = k_1\left(\frac{s}{R_s}\right)^{\gamma},$$
$$\alpha_3 = k_2\left(\frac{s}{R_s}\right)^{\gamma},$$
and α_1, γ_1, k_1 and k_2 *are positive constants.*

Table. 1: The Segment Contrast Adaptive Binarization

parameter	range	value at paper
γ	2	2
α_1	0.1 – 0.2	0.12
k_1	0.15 – 0.25	0.25
k_2	0.01 – 0.05	0.04

The contrast adaptive binarization algorithm effectively enhances outdoor shot or scanned images. In multi-lane ANPR systems, which are operated in an outdoor environment, there are many cases where a vehicle plate number needs to be recognized from the rear of the vehicle. In this case, consideration should be given to the fact that a shadow may occur on a vehicle number plate due to geographical factors or vehicle type. For a vehicle plate number with a shadow as shown in Fig. 10 the contrast adaptive binarization algorithm is separately applied to the first line and the second line because the window for threshold calculation has a high fluctuation in brightness.

Fig. 10: The Image Enhancement by Contrast Adaptive Binarization

III. CONCLUSION

The multi-lane automatic number plate recognition (ANPR) system was installed on a test bed on three-lane roads as shown in Fig. 11 and the daytime recognition performance was analyzed.

Fig. 11: ANPR System Test Bed Area

Mobile reference equipment used by the dedicated ITS performance evaluation organization was used and the performance evaluation method provided by the ITS project implementation guide (Ministry of Land , Infrastructure and Transport, October 2010). The performance was compared with the data collected for 1 hour from the mobile reference equipment as shown in Fig. 12.

Fig. 12: Test Reference Equipment

Table, 4 shows the number extraction results. The total number of the passing vehicles was 199, including 4 vehicles with damaged vehicle number plate or abnormal driving state. Thus, the total number of the passing vehicles was regarded as 195. According to the evaluation results, 166 vehicles were detected among the 195 passing vehicles, thus achieving the detection rate of 84.6%.

Table 4: The Detection Result of Number Plates

	lane 1	lane 2	lane 3	Total
Passing vehicle	50	109	36	195
Detected vehicle	43	91	31	165
Detection Rate (%)	86.0%	83.5%	86.1%	84.6%

According to the results, there was almost no error in detecting and recognizing the numbers of relatively good vehicle images. However, there was a problem of not being able to recognize a specific vehicle model, “Damas” of GM Korea, and there was an error in detection and recognition of a difference between consonants or vowels such as [ha] vs. [hə], [do] vs. [nə] and [ə] vs. [a]. Further researches are necessary to develop an algorithm that can accurately detect vehicle numbers by studying the patterns of specific vehicle models and differences between consonants or vowels. In this paper, we proposed a character extraction algorithm using connected vertical and horizontal edge segments–based labeling and analyzed its performance through test bed demonstration. Although there are constraints for detecting multiple lanes with one camera, it achieved the detection rate of over 85%. Studies have been conducted on multi-lane ANPR technology. However, it is expected that the accuracy of detection results will be improved by introducing the concept of ROI (region of interest) and the concept of high resolution image implementation. A future challenge is to further improve the detection rate through further development to overcome environmental conditions with low visibility such as nighttime and fog.

ACKNOWLEDGEMENTS

This research was supported by a grant(16CTAP-C078470-03) from Technology Advancement Research Program (TARP) funded by Ministry of Land, Infrastructure and Transport of Korean government

REFERENCES

1. Byun Wan Hee, Road traffic ITS handbook and design, cheong moon gak, p.27
2. M. Y. Kim and Y. D. Kim, “An Approach to Korean License Plate Recognition Based on Vertical Edge Matching,” System Man and cybernetics, IEEE International Conference Vol.4. pp8-11, 2000.
3. National Transportation information center, http://www.its.go.kr, 2016.05.01
4. Kim jin ho, “Vehicle License Plate Recognition for Smart Tolling by Selective Sharpening”, The korea contents association, Vol. 14, No. 12, 2014.
5. Moon Yong Jin, “Real-Time Vehicle number Plate Recognition System Using Adaptive Heuristic Segmentation Algorithm”, KIPS, Vol 3, No 9, 2014.
6. Kim jin ho, “Vehicle License Plate Recognition System By Edge-based Segment Image Generation”, The korea contents association, pp.9-16, 2014.
7. Shin, Wook-Jin, “Improved license plate recognition for degraded vehicle imags in CCTV surveillance systems ”, KAIST, 2013.
8. Vicky Ambula, “Adaptive Median Filter for Image Enhancement”, IJESIT, Vol.2, Issue 1, 2013.
9. Sin Hyub Hak, “Local Block Learning based Super resolution for license plate”, The Korean Society Of Computer And Information , Vol 16, No 1, 2011.
10. Meng-Ling Feng, “Contrast adaptive binarization of low quality document images”, IEICE Electronics Express, Vol.1, No.16, pp.501-506, 2004Note that the journal title, volume number and issue number are set in italics.