

Multi-National Integrated Car-License Plate Recognition System Using Geometrical Feature and Hybrid Pattern Vector

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Abstract: In this paper, we have proposed license plate recognition system for multi-national vehicle license plate using geometric features along with hybrid and seven segment pattern vectors. In the proposed system, we suggested to find horizontal and vertical relation after going through preparation process with inputted real-time license plate image of Korea and Japan, and then to classify license plate with using characteristic and geometric information of license plates. It classifies the extracted license plate images into letters and numbers, such as local name, local number, classification character and license consecutive numbers, and recognize license plate of Korea and Japan by applying hybrid and seven segments pattern vectors to classified letter and number region.

License plate extraction step of the proposed system uses width and length information along with relative rate of Korean and Japanese license plate. Moreover, it exactly segmentation by letters with using each letter and number position information within license plate region, and recognizes Korean and Japanese license plates by applying hybrid and seven segment pattern vectors, containing characteristics related to letter size and movement within segmented letter area.

As the result of testing the proposed system in real experiment, it recognized regardless of external lighting conditions as well as classifying license plates by nations, Korea and Japan. We have developed a system, recognizing regardless of inputted structural character of vehicle licenses and external environment.

1. Introduction

With the increase of vehicles, vehicular crime and traffic jam are being considered as a social problem. Specially, demands for a system, recognizing vehicle license plate regardless of nations and vehicle kinds, are on the rise. The multi-national integrated vehicle license plate recognizing system is an image recognizing system, composed of Korean and Japanese license plate recognition algorithm, computer, infrared camera and image acquisition board. It is a system, eligible to use for automatic toll collection at airport terminal, highway and parking lots,

prevention of crime and vehicle stealing as well as advancement of traffic management.

Related studies published so far have been focusing on local license plate recognition and low-priced system providing real time process was insufficient. There have been various restrictions due to recognition efficiency decrease with external environment in day and night, and limited recognition of local license plate.

For existing studies related to license plate extraction, there are method of recognizing license letters based on predetermined information about certain region of license plate and neural network method[1], recognizing license letters by extracting license plate region with binarization and applying similarity method of letters[2], and recognizing letters with circular pattern vectors regardless to size, movement and rotation of letters[3]. License letter recognition system, using neural network, caused recognition problem in real time processing and noises with learning time and method, as well as time consuming problem[1]. License letter recognition using similarity drawing also requires great processing time [2].

Therefore, we have proposed a multi-national integrated vehicle license plate recognition system, complementing above problems as well as adaptively recognizing vehicle license plate by nations and vehicles.

In this paper, proposed multinational integrated vehicle license plate recognition system is generally divided into classification process of Korean and Japan license plate, segmentation process by license letters and license plate recognition process by nations. As we have applied the proposed system to real license plate, it could recognize license plate regardless of nations, vehicle types, lighting condition and external environment.

2. System Block-diagram and Characteristics of Multi-national Vehicle License Plate

Multi-national Korean and Japanese vehicle license plate recognition system proposed in this paper is designed to get vehicle images from infrared camera as soon as infrared detection sensor detects input object. It recognizes license

plate by discriminating license plate with using certain license plate character information from vehicle images. Namely, it segmenting them into license plate by nations with position information of classified vehicles, and segmentation them into vehicle letters, and then applying proposed pattern vectors to them. For Japanese license plate, it recognizes them by applying proposed hybrid and seven segment pattern vectors. And also, for Korean license plate, it recognizes them by applying proposed hybrid pattern vectors. Proposed Korean and Japan integrated vehicle license plate recognition system diagram is shown in Fig. 1.

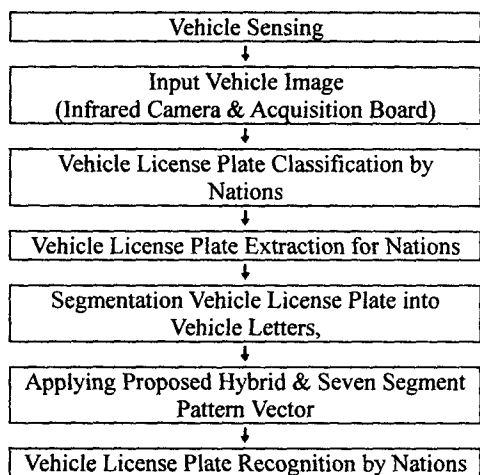


Fig. 1. Block-diagram of Korean and Japan integrated vehicle recognition system.

For exactly recognizing vehicle letters and numbers of license plate from inputted Korean and Japanese vehicle image, image segmentation is required. Moreover, analysis for characteristics of Korean and Japanese vehicle license plate is has to be performed in advance for exact vehicle letter and number segmentation.

As shown in Figure 2, Korean and Japanese vehicle license plates are constituted with local name, local number, classification character and four license consecutive numbers. For Korean passenger cars, license plate is composed of white letters on green background, and green letters on yellow background are used for commercial vehicles. Moreover, white letters on orange color background are used for trucks. In general, they designed to be identified easily.

For Japanese license plates, there are four types of license plates, black letters on yellow background, yellow letters on black background, white letters on green background and green letters on white background.

On the other side, Japanese license plate uses two(Kyoto), three(Nagoya) or four (Owarangomaki) Chinese letters for region name

and one or up to three numbers for region numbers. However, Korean license plate uses two Korean letters for region name and one or two numbers for region numbers.

Size of Korean and Japanese license plate showed the width to length ratio of 2:1, and each letters and numbers are placed at relative and certain position. With using these characteristics, we could extract license plate with using its relative size among characteristics of Korean and Japanese vehicle license plate. Moreover, we could segmentation them by vehicle letters with relative position information of letters and numbers within license plate area. Feature of Korean and Japanese vehicle license plate is shown in Fig. 2 and Fig. 3 shows the types of Korean and Japanese vehicle license plate

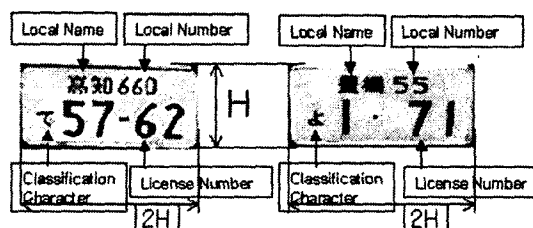


Fig. 2. Feature of Korean and Japanese vehicle license plate.

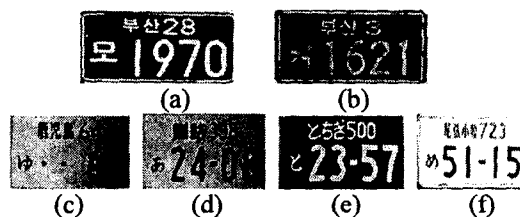


Fig. 3. Types of Korean and Japanese vehicle license plate; (a) local number two(Korean); (b) local number one(Korean); (c) local name three and number two(Japanese); (d) local name two and number three(Japanese); (e) local name three and number three(Japanese); (f) local name four and number three(Japanese).

3. Multi-national Korean and Japanese Vehicle License Plate Extraction Algorithm

Until now, exact vehicle license plate extraction was difficult due to various external aspects, such as lighting conditions, noises and other external environment. In this system, it determines vehicle license plate by finding vertical edge relations of license plates, and then finding horizontal edge relation within vertical edge area. For final verification, if horizontal to vertical ratio is 2:1, it extract the image as vehicle license plate, and then it makes average bright value into binary system. Figure 4 shows the whole license plate extraction process.

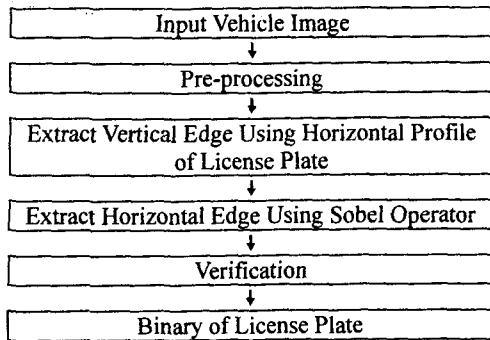


Fig. 4. Block-diagram of vehicle license plate Extraction Algorithm.

Fig. 5 shows the vehicle license plate extraction procedure, in following Fig. 5, you can see vehicle license plate image extracted by using horizontal and vertical relation of license plate. Figure 5(a) shows the result of extraction vertical relation of license plate, and Figure 5(b) shows the result of extracting whole vehicle image with using Sobel operator, and Figure 5(c) shows the result image, dynamically made into binary within license plate area. In the figure, you can see that the noises are removed when vertical relation edge is extracted, and vehicle license plate is extracted after getting vertical relation edge of license plate.

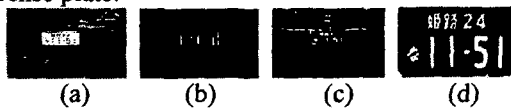


Fig. 5. Extraction result of License Plate; (a) Original image; (b) Vertical area, (c) Horizontal area, (d) Active binary image.

4. Multi-national Korean and Japanese Vehicle License Plate Recognition Algorithm

Within extracted license plate area, it segments image into each letter and number with the relative position information. For Korean license plates, it recognizes them by applying hybrid pattern vectors, and comparing mutual relationship of letters and numbers. For Japanese license plate, it recognizes letters on license plates by applying hybrid and seven segment pattern vectors, and comparing relations about patterns. Block-diagram of vehicle license plate recognition algorithm is shown in Fig. 7.

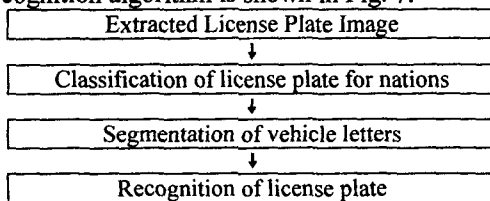


Fig. 7. Block-diagram of license plate recognition.

4.1 Letter Segmentation Within Sampled License Plate Area

It gets horizontal profile by tracing license plate image horizontally. Choose coordinate of where

letters end at upside and downside from the center of horizontal profile as top coordinate of consecutive number and grouping number. Moreover, find left and right coordinate of each letter and number by tracing relative position information of each letter and number from left and right. Segmentation each letter and number by using four candidate letter coordinates, which you calculated before. Fig. 7 shows segmented Korean and Japanese vehicle license plate.



Fig. 7. Segmented Results of Korean and Japanese Vehicle License Plate; (a) Korean License Plate, (b) Japanese License Plate.

4.2 Apply Patten Vectors for Each Vehicle Letter.

Since size of segmented letters and numbers on license plate change according to the size of license plate and distance camera captured the image, it used elliptical characteristics to sample patterns flexibly regardless of letter size. Moreover, geometrical form of each letter is recognized with using other characteristics.

Fig. 8 shows the hybrid and seven segment pattern vector which is applied Korean and Japanese license plate, respectively. We sampled patterns by applying hybrid pattern vector (Fig. 8(a)) to each partitioned letter area within sampled license plate area. Numbers are sampled with applying Seven Segment Pattern vector (Fig. 9(b)). For generating patterns, divided 1/2 height by 3, and determined radius of each circle, and sampled 36, 72, 120 patterns by turning the circle by 10° , 5° , 3° . Moreover, we sampled each pattern with applying horizontal and vertical patterns. Regulate them into 1(255) and 0(0) according to sampled patterns. We have described the circle with radius R in method of calculating from X-Y coordinate and Equation (1), and put it in binary system.

$$Cir(x, y) = (R \times \cos \theta, R \times \sin \theta) \quad (1)$$



Fig. 8. Hybrid and Seven Segment Pattern Vector; (a) Hybrid Pattern Vector, (b) Seven Segment Vector.

It recognizes letters by comparing relations of each existing letter and number patterns with each regulated letter and number patterns. Table 1 at below shows patterns about letters and numbers of Korean license plate. As you can see in Table 1, spots of each letter pattern is the part where letters

are, which illustrates 1 among regulated patterns, and places where there is no spot illustrate 0 among the patterns. Choose these regulated patterns for standard pattern of Korean and Japanese license plate, recognizing license plate.

Table 1. Results of Pattern Vector about letters and numbers of Korean License plate.

Korean License Plate			
Character		Pattern	
가-나	First	Ctr1	Horizontal
		Ctr2	Horizontal
		Ctr3	Horizontal
	Second	Ctr1	Vertical
		Ctr2	Vertical
		Ctr3	Vertical
다-라	First	Ctr1	Horizontal
		Ctr2	Horizontal
		Ctr3	Horizontal
	Second	Ctr1	Vertical
		Ctr2	Vertical
		Ctr3	Vertical
0			
9			

It compares patterns of each letter saved before and recognizes a letter with greatest relation among them for Korean and Japanese vehicle license plate. In addition, we embodied a function that search inputted license plate number from criminal vehicle list, and ring an emergency bell, and then save it on database. It also saves vehicle license plate number with incoming time on database. Table 2 shows pattern vectors related to letters and numbers on Japanese vehicle license plate number. The result and GUI of comparing segmented image by letters with Korean and Japanese license plate recognition algorithm is shown in Fig. 9. Ad also. Table 2. Pattern Vectors related to letters and numbers on Japanese vehicle license plate

Table 2. Results of Pattern Vector about letters and numbers of Japanese License plate.

Japanese License Plate			
Character		Pattern	
A-Z	First	Ctr1	Horizontal
		Ctr2	Horizontal
		Ctr3	Horizontal
	Second	Ctr1	Vertical
		Ctr2	Vertical
		Ctr3	Vertical
0-9	First	Ctr1	Horizontal
		Ctr2	Horizontal
		Ctr3	Horizontal
	Second	Ctr1	Vertical
		Ctr2	Vertical
		Ctr3	Vertical
0			
9			

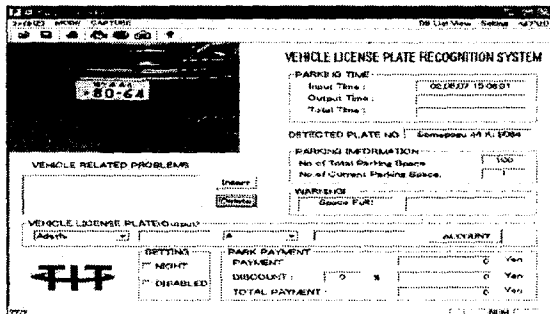


Fig. 10. GUI of license plate recognition system.

5. Experimental Results

We ran an experiment over the proposed system at various time periods (early morning, day and night) and by nations, vehicles and levels. Moreover, we ran experiments with conditions when vehicles enter from forward, left and right.

Table 4. Recognition rate for enter direction.

Enter Direction	Korea(%)	Japan(%)
Forward	96.66	96.0
Right	95.0	93.0
Left	95.0	93.0

As you can see in Table 3, recognition rate with experiment ran during day and experiment by distances was high. Fig. 10 is the image sampled by hours, and Fig. 11 is the image sampled by entering directions.



Fig. 10. Image sampled by hours; (a) Early Morning, (b) Day, (c) Night.



Fig. 11. Image sampled by entering directions; (a) Forward, (b) Right, (c) Left.

6. Conclusion

In this paper, we proposed a Korean and Japanese vehicle license plate recognition system, which extract license plate area from whole vehicle image with using horizontal and vertical relation, and classification them by its nations with segmentation letter position information, and apply pattern vectors after segmentation each letter and number. It recognized license plate regardless of lighting characteristics as well as grouping its nations. Moreover, it also recognized them regardless of distances, entering direction and external environment.

This work was supported by grant No.(R05-2002-000-00115-0) from the Basic Research Program of the Korea Science & Engineering Foundation.

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