13—29 A Vehicle Identification System by Automated Korean License Plate Reading

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Abstract

This paper introduces a vehicle identification system (VIS) by automated Korean license plate reading. Generally, an automatic violator detection system requires various techniques, including sensing, image acquisition, license plate reading, communication, database, and so on. We developed all of such techniques and integrated into an intelligent law enforcement system against traffic violations such as speeding or illegal lane driving. Our system showed excellent recognition results in the field test in real-world traffic environments.

1 Introduction

The ability to identify and interpret license plates is a powerful tool for enabling three of ITS'(Intelligent Transportation System) major objectives: alleviating congestion, expediting traffic flow, and improving road safety. Thus automatic recognition of car license plates becomes a key technology in various traffic control related applications including road (or parking area) tolling, access control, and law enforcement. There have been several license plate recognition systems developed worldwide, e.g., [1][2][4], but few exist that can read Korean license plates reliably.

This paper introduces a vision-based vehicle identification system (VIS) by automated Korean license plate reading. Generally, an automatic violator detection system (VDS) requires various techniques including sensing, image acquisition, license plate reading, communication, database, and so on. Our system provides a complete solution from tasks in local sites including violation detection, image acquisition, and license plate reading and transmission, to jobs in the information center such as data gathering, driver's information retrieving, penalty notification sheet printing, and traffic information service.

In the following section, we introduce the overall scheme of our law enforcement system. Section 3 deals with the Korean license plate model and some issues on Korean license plate reading including plate type classification. In Section 4, we address our method for Korean license plate reading. Finally, experimental results and conclusions are discussed in Sections 5 and 6, respectively.

2 System Overview

A complete traffic law enforcement system is illustrated in Figure 1 and 2. Figure 1 shows our local system and Figure 2 represents a Law Enforcement Center. It is a typical configuration for a violator detection and law enforcement system in Korea that can be applied for various purposes including prohibited lane driving violation detection, speed violation detection, enforcement system in NTCS (non-stop toll collecting system). In this paper, we are only

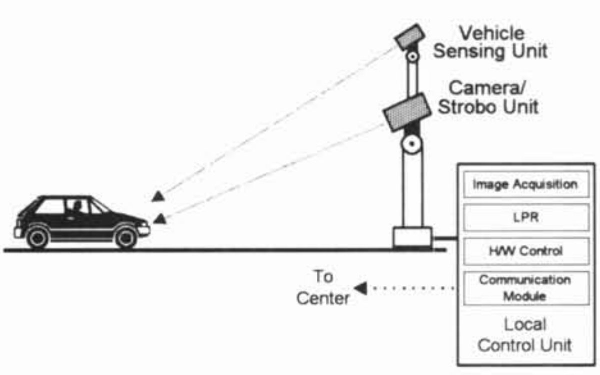

Figure 1. Local system overview

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concerned about the illegal lane driving enforcement system.

Our local system consists of a vehicle sensing unit (VSU), a camera/strobo unit (CSU), and an industrial PC-based local control unit (LCU).

Vehicle Sensing Unit (VSU): We developed a vehicle image sensor to detect the presence of a car on a target region. A camera module and a computing module comprise the VSU. The camera module consists of an analog CCD camera, an auto iris optical lens, and a housing to cover the camera module. A pair of Compact PCI based boards, an analog frame grabber and a CPU board, constitutes the computing module. Physically, the camera module is established at a height of about 9 meters on a roadside pole. On the other hand, we put the computing module in the LCU.

In spite of some performance-related problems, this kind of video sensor has a lot of advantages including non-destructive sensing, lower maintenance and operating cost, and easy installation. Furthermore, it produces various parameters such as queue length and vehicle classification, which cannot be acquired by conventional sensors such as loop detectors and photo sensors. We developed a real-time video sensing algorithm, which can provide accurate vehicle entrance triggering.

Camera/Strobo Unit (CSU): If a violation car comes in, the VSU generates a trigger signal into the LCU. Then the LCU produces trigger signals (in adjusted timing) for a camera and a strobo in the CSU. The CSU, which acquires vehicle images for license plate reading, consists of four major parts: a CCD camera, a motorized zoom lens, a flash lamp set (strobo) with an optical lens, and a pan/tilt system. We adopted a high resolution, 1024 x 1024 in pixel, digital CCD camera to capture vehicle images. Because Korean license plate is quite complicated in structure, and we have to cover a full lane that is about 3.2 meters wide, it becomes popular to use such a camera for reading license plates on the road. A motorized zoom lens with focal length ranging from 16mm to 160mm is attached in front of the CCD camera. It enables us to control image brightness, zoom, and focus in local sites or in the center system. We also developed an infrared flash lamp set (strobo). It is a high voltage type (the peak voltage exceeds 800 DCV) and recharging time is less than 0.5 second. An optical lens set is also used to adjust the flash beam size and focus, and an infrared filter is adopted to reduce visual disturbance to drivers due to the strobo flash. Finally, a pan/tilt unit is used to choose and control the direction of the CSU. It enables the system operator in the center to choose a surveillance lane.

Local Control Unit (LCU): Our computing module in the LCU is made up of Compact PCI based industrial PCs. There are three processors in the LCU: a video sensor processor (VSP), a local slave processor (LSP), and a local master processor (LMP). The VSP, with an analog frame grabber, analyzes the real time video signals to produce accurate vehicle entrance signal and various kind of traffic information.

The LSP performs a lot of tasks including receiving/sending proper trigger signals, speed calculation, vehicle image capture, license plate reading, image compression and so on. One LSP does all jobs for a lane, and in the case of multiple lane monitoring, several LSPs are necessary. If a vehicle image is captured on the camera, a digital frame grabber transfers the image into the system buffer, and the License Plate Reading (LPR) module in the LSP pops the image and reads it. If a non-permitted license plate number is detected, the LSP compresses the vehicle image and sends the violation data (plate number, date, time, violation class, etc.) and the compressed image to the LMP for transmission to the center.

Finally, the LMP receives all violation information from the LSPs and traffic data from the VSP, and sends it to the center system. It also manages the whole local site and monitors local system resources. If some abnormal situation occurs, the LMP reports them to the center system.

The center system is illustrated in Figure 2. Our

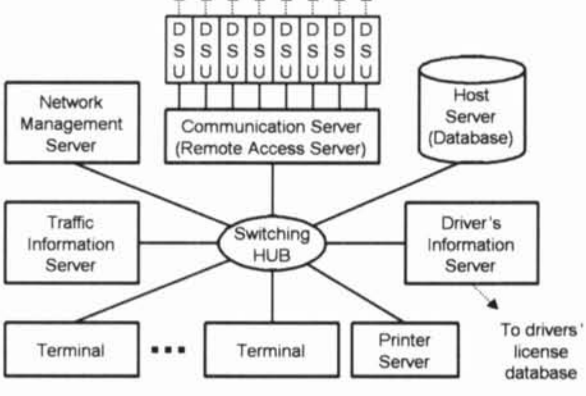

Figure 2. Center system overview

center system consists of several major parts: a communication server (CS), a network management server (NMS), a traffic information server (TIS), a host server (database), a driver's license information server, a printer server, and some operation terminals.

Communication Server (CS): The CS is a set of networking equipments to receive (or send) data from (or to) local sites on the road. It is composed of a set of DSUs (Data Service Units) and a remote access server.

Network Management Server (NMS): The NMS receives the violation data from local sites. It also monitors and controls resources in each local system by sending control messages to the local system via the CS. The violation data are stored temporarily in the NMS.

Traffic Information Server (TIS): This server reports the traffic conditions and yields statistics for each local site using the traffic data.

Driver's Information Server: This server makes inquiry about the vehicle number to the vehicle register database, and retrieves a detailed information about the violation vehicle such as owner's name, address and so on. The resulting data are inserted into the violation database.

Host Server (Database): This is the violation database server and handles queries from the clients. It also contains the vehicle images.

Terminals and Printer Server: Penalty sheets for illegal lane driving are formatted and printed by the printer server. Several terminals provided for operators to do various functions including database reference, permitted vehicle management, manual modification for incorrect data, and system resource control and management.

3 Issues on Korean License Plate Reading

Figure 3 illustrates the structure of Korean license plates, which consists of four fields and Figure 4 shows some real examples. Generally, Korean license plate causes some difficulties in automatic recognition.

First, a Korean license plate has two rows. The upper characters (area code and vehicle classification number) are much smaller than the lower ones (Hangul code and serial number). In

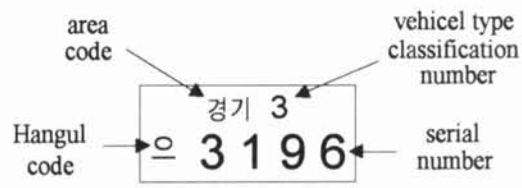

Figure 3 Korean license plate structure

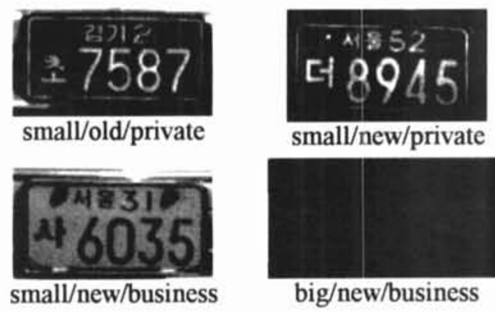

Figure 4 Examples of Korean license plates

the case of dirty or damaged plates, it becomes very hard to read them even by the human eye.

Due to a recent change of the license plate type, there exist two types of license plates, old and new. The old plate has one digit for the vehicle type classification number, but the new plate has two digits for it. In addition, fonts of the plates are different. Since vehicles with both plates types are running on the road, we have to read both of them.

There are some other classification rules of Korean license plate, such as big/small, private/business, special, temporary, heavy equipment car and so on. Figure 4 illustrates several types of Korean license plates.

4 License Plate Reading

Figure 5 shows our software configuration. All of the software was developed in efficient, modular and portable way. Thus although our

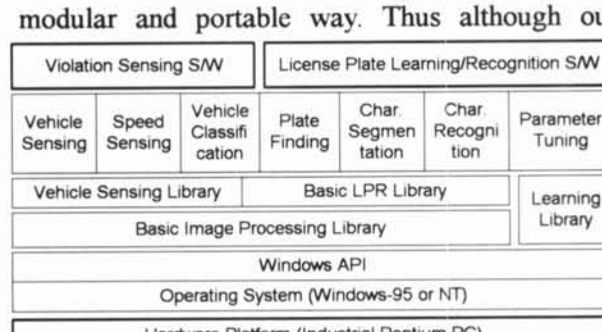

Figure 5 Software configuration

system is based on Pentium industrial PC, all of the recognition software can be easily ported to other systems. In this paper, we only address our LPR algorithm.

Generally, an LPR algorithm consists of three major tasks: finding the plate, separating each field (character segmentation), and recognition. Since there are quite a number of vertical edges near the characters on a license plate, we firstly find the lower region (Hangul code and serial number) of the plate using horizontal gray level change. Next, we threshold the region and process a projection based character segmentation step. During this step we classify the plate. If the background of the region is darker (lighter) than characters, the vehicle is considered as a private (business) one. We also estimate the horizontal scale factor and determine whether the plate is small or big.

Then, the serial number is first segmented into each numeral, which is read by the *mesh analysis* method, where each numeral's region is divided into sub-images. The average gray-level of each sub-image is used as the feature of the sub-image. The feature vector of each numeral's region, consisting of features of all sub-images, is recognized using the training feature vectors of ten numerals (0,1,...9). To read the Hangul code, we first decide the vowel and separate the consonant from the character. Then the consonant is recognized in a similar way as in the case of the serial number. At this stage, we determine whether the plate is old version or new one.

To read the area code and the vehicle type classification number, we used the *normalized template matching* [3]. Because the characters in the upper region are small and easily contaminated by dirt, asphalt, or specular reflection of light, robust binarization of the upper region is nearly impossible. Thus, we adopted a gray-scale searching technique. A set of area code template models is extracted from some typical training samples of the area code. Then, we match all of the template models to the area code region. The best-matched template represents the exact area code for the plate. There are 16 area codes in Korea at this time, and our approach is quite cost effective. Similarly, reading the vehicle type classification number is performed. Compared with the conventional binary image based methods, our algorithm reported excellent results in reading the area code and the vehicle type classification number, especially when plates are very dirty and noisy.

Company	Recognition Rate	Rejection Rate
A	98.4 %	18.7%
B	99.0 %	18.7%
C	98.8 %	18.5%
LGIS	99.5 %	12.7%

Table 1 LPR performance comparison

5 Experimental Results

Our system showed excellent recognition results in all weather conditions, 24 hours a day, 7 days a week in real-world traffic environments. In the official performance test administered by Korea Road Traffic Safety Association (RTSA), our system showed an excellent recognition rate of 99.5 % with reject rate of 12.7 %, which is the best among the license plate recognition systems developed in Korea so far. Table 1 shows the official record provided by RTSA, and there are only four companies passed the RTSA test including LG Industrial Systems. Recently, the reject rate was further reduced to about 9% with the same recognition rate.

6 Conclusion

A complete vehicle identification system (VIS) by automated Korean license plate reading was presented. The system includes sensing, image acquisition, license plate reading, communication, database, etc. We developed all of such components and integrated into an intelligent law enforcement system against traffic violations such as speeding or illegal lane driving. Our system shows excellent recognition results in the real-world traffic environments.

References

[1] M. Tamagawa, et al., "Development of vehicle license plate recognition system," *Proc. World Congress on ITS*, vol. 4, Berlin, 1997.

[2] Perceptics Corp., USA.

[3] A. Rosenfeld and A. Kak, *Digital Picture Processing*, Academic Press, 2nd ed., 1982.

[4] P Comelli, et al, "Optical Recognition of Motor Vehicle License Plates," IEEE Trans. on Vehicular Technology, Vol 44 No. 4 Nov. 1995