License Plate Extraction in Low Resolution Video

Hsien-Huang P. Wu, Hung-Hsiang Chen, Ruei-Jan Wu, Day-Fann Shen
Department of Electrical Engineering
National Yunlin University of Science and Technology
#123 University Road, Section 3, Douliou, 640 Taiwan, ROC
wuhp@yuntech.edu.tw

Abstract

Extensive study has been conducted in the detection of license plate for the applications in intelligent transportation system (ITS). However, these results are all based on images acquired at a resolution of $640 \times 480$. In this paper, a new method is proposed to extract license plate from the surveillance video which is shot at lower resolution ($320 \times 240$) as well as degraded by video compression. Morphological operations of bottom-hat and morphology gradient are utilized to detect the LP candidates, and effective schemes are applied to select the correct one. The average rates of correct extraction and false alarms are 96.62% and 1.77%, respectively, based on the experiments using more than four hours of video. The experimental results demonstrate the effectiveness and robustness of the proposed method.

1 Introduction

The deterioration of social order, which causes vandalism and terrorism around the world, has increased the importance of security and raised the demand on surveillance plans. Among all the possible schemes, installation of video surveillance systems at intersections of streets to record suspected vehicles has become an important tool for investigation by the police. Whenever criminals committed a crime, it is very possible that they would use vehicle for transportation. Hence, the police can retrieve all the videos recorded around the crime scene at a certain period of time to find the possible suspects for further investigation by following the vehicle to track the owner. However, the huge volume of video needed to be checked visually can easily wear down the spirit and efficiency of the pursuit. Therefore, methods which combine image processing and computer vision to automatically extract the vehicles and recognize their license plates for identification would be a great help for the police to solve the case more efficiently and quickly.

Many researches have been done in the license plate recognition (LPR) for the intelligent transportation systems (ITS), such as parking, access control, border control, tolling, and law enforcement. A typical LPR system can be roughly divided into three modules, they are: license plate detection, character segmentation, and character recognition. Among these three modules, the license plate detection is the most critical one and several approaches have been developed to date. For example, edge-based methods are based on the observation that characters embossed on LPs usually show high contrast with respect to the background (plate region); therefore, regions with a high edge magnitude and high edge variance are identified as LP regions [1][2][3]. Morphology-based approaches [4][5] are also based on this high contrast feature. Texture and color information have also been used in neural network for detection of LPs [6].

While many methods have been proposed in various ITS applications, the detection and recognition of license plate is usually based on image acquired at $640 \times 480$ resolution. In contrast, most of the surveillance videos used by the criminal police team for identifying suspected vehicles are recorded at a resolution of $320 \times 240$ with compression in order to save storage space under continuous recording. The image quality caused by the difference of resolution can be observed in Figure 1. Although the low resolution combined with degradation of quality due to compression is acceptable for visual recognition, it makes automatic extraction of license plate very difficult and renders most of the available methods useless. In order to equip all the currently available DVR systems used in the road surveillance with the capability of automatic license plate extraction, techniques designed specifically for low resolution video are necessary, and this is the goal of the system described in this paper.

The organization of this paper is as follows. Method proposed for detection of possible LP blocks is described in the section 2. In section 3, simple approaches will be used to verify the detected blocks based on the characteristics of the LP. The proposed method will then be evaluated and
2 License Plate Detection

Given a DVR system for road surveillance, the video camera usually remains stationary and aims at the center of the road with an FOV larger than the width of one lane. Assuming that a preprocessing module exists to detect the region of a moving vehicle, we then only need to search the possible blocks of LP in a limited area. The proposed method of generating LP candidates is summarized in Figure 2, and the details will be described in the following subsections.

2.1 Enhancement and Bottom-Hat

Qualities of the Images taken outdoors are usually influenced by the weather and the environment. For example, the position of the sun can generate images with widely variant brightness. Moreover, the roadside buildings and trees might cast the shadow on the vehicle and further reduce the contrast of the input image. Hence, contrast enhancement is needed to increase the image quality and improve the result of LP detection.

Mathematical morphology (dilation, erosion, opening, and closing) has proven to be a powerful tool for image analysis, particularly the analysis of shapes in images. Originally developed for the binary image, it was later modified by Sternberg for the grayscale image. The ‘bottom-hat’ operator, which can enhance the edge and suppress the homogeneous region, is defined as the difference between a ‘closed’ grayscale image and the original image, that is

\[ I_{BH} = I \bullet B_{n \times m} - I \] (1)

where \( I \) is the original image, \( B_{n \times m} \) is the structural element with size \( n \times m \), and symbol ‘\( \bullet \)’ represents ‘closing’ operation. After morphological operation by ‘bottom-hat’, details of the region formed by alphanumeric data of the LP, as well as other highly textured area, will be greatly enhanced, as shown in Figure 3 (\( n = m = 7 \)).

2.2 Morphology Gradient and Candidates

Since the ‘bottom-hat’ operation can enhance various kinds of texture, many non-LP regions also show up significantly; for example, the frames of the vehicle and its windows. However, region of the LP usually contains denser structure than those of others due to the close arrangement of the alphanumeric data. Fortunately, morphology gradient can be used to distinguish a denser region from a looser one. The morphology gradient is defined as

\[ I_{MG} = I_{BH} \bullet B_{n \times m} - I_{BH} \circ B_{n \times m} \] (2)

where \( I_{BH} \) is image after ‘bottom-hat’ operation, and symbol ‘\( \circ \)’ represents the ‘opening’ operation. Output of the morphology gradient is further ‘closed’ (by \( B_{1 \times 7} \)) to connect the texture and form a mass in the LP region for easier identification. The closed image is then binarized by Otsu’s algorithm and all connected components are labeled as LP candidates.

3 Plate Candidate Verification

After the detection process, the system generated binary image with labeled LP candidates. Each one of the candidates must be checked by certain criteria to see if it satisfies the requirements of a LP. Two criteria are adopted sequentially, the geometric properties of the LP is utilized first, and then characteristics of the alpha-numerals in the LP are employed in the process of verification.

3.1 Criterion 1: Geometric Properties

The LPs have uniform size and shape, and the distance between the video camera and the observed vehicle usually
falls within a known range. Therefore, the width, height and aspect ratio of the LP image can be estimated and used as a good criterion for selection. Assuming the bounding box of a given labeled component is $C_W \times C_H$, we demand that this component needs to satisfy the following five constraints in order to become a candidate of the LP:

1. $20 \leq C_W \leq 65$
2. $C_H \geq 20$
3. $1.5 < AR < 4$
4. $A > 450$
5. $\frac{4}{C_W \times C_H} > 0.5$, where $AR = \frac{C_W}{C_H}$, and $A$ is the number of active pixel inside the bounding box.

One example of this verification process is presented in Figure 4, where (a) is the input image, (b) is the image of labeled candidates produced by the module of License Plate Detection, and (c) contains the refined candidates of LP after screening by the above five constraints. Apparently, many labeled candidates which do not satisfy the geometric criterion were removed, as illustrated in Figure 4(c). However, one extra component which is not a LP also passed the verification (candidate 1 in Figure 4(c)(d)). Hence, application of extra criterion described in the next subsection is needed to further improve the results.

3.2 Criterion 2: Frequency of Zero Crossing

In the input image, there are many other scenes contain texture similar to that of the LP block. For example, the enlarged phone number or plate number printed on the back of the vehicle, the advertisements imprinted on the windows of the bus, and etc. Although they might be indistinguishable in the detection module, the alphanumeric feature of the LP actually exhibits regular and higher variation due to its smaller size. A comparison can be seen in Figure 4(d) and (e). Interestingly, a simple check by traversing the center of the LP candidates can easily reveal this information, as will be described below.

The image block of the LP candidate is first high-boosted and binzarized (bright pixels as 1s and dark pixels as 0s) to separate the alphanumeric contents from the background, as depicted in Figure 5(a) and (b). Then, three rows traversing the center part of the binarized image are selected and their values are inspected for examination of the zero crossings (Figure 5(c)). Starting from the leftmost nonzero value, we calculate the space between two ‘1’ pulses ($W_{zc}$ in Figure 5(d)). As we mentioned in section 3.1, the size of the LP is limited to a certain range and so is the value of $W_{zc}$. In our installation, if the value of $W_{zc}$ falls within 2 to 10 pixels, it will be counted as a successful zero-crossing. Since the LP must contain 4-6 alpha-numerals in our application, LP candidate consists of less than 4 zero-crossings will be removed from the list. This simple and fast postprocessing will eliminate most of the non-LP candidates, like candidate 1 in Figure 4(c).

4 Experimental Results and Discussion

Twenty low resolution (320 × 240) surveillance video clips with 17.15 hours in length, which were taken from different cameras installed at various intersections, are used to evaluate the performance of our proposed LP detection method. Given 474 vehicles in a four hours video, LP of 458 vehicles are successfully detected, 16 of them are missed, and eight textured non-LP regions were also detected. These results correspond to 96.62%, 3.38%, and 1.77% for correct extraction rate (CER), missed detection rate (MDR) and false alarm rate (FAR), respectively.
program was written in C++ and can process up to 30 images per second in a Pentium4-based PC with 3.2GHz clock.

Several successful extractions are illustrated in Figure 6, and robustness of the proposed method can be demonstrated by successful extraction of the low contrast image in Figure 6(a). Two examples of missed detection of LP are also presented in Figure 7, where the vehicles have been identified (as number 60 and 22). The failure is due to the saturation caused by reflection of the bright sunlight. As can be observed from the images in Figure 7, strong illumination has destroyed the texture inside the LP and made the detection unsuccessful.

5 Conclusions

A fast and effective license plate extraction method is proposed in this paper. The main purpose of this new method is to successfully extract the LP in low resolution surveillance video. It has been implemented in PC environment and is currently under intensive field tests. Preliminary results based on four hours of video shot in Jia-Yi county of Taiwan by a networked DVR system have proved the robustness and effectiveness of the method. With an average extraction rate of 96.6%, we believe that this automatic LP extraction system would help the police in searching the suspected vehicle. Since the detection process uses a general approach, the proposed method can also be used to extract the license plates of other countries.

References


