Design of Intelligent Parking Management System Based on License Plate Recognition

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Abstract—License Plate Recognition (LPR) which has been extensively studied recently is becoming one important part of Intelligent Transportation Systems (ITS). It is not only applied to public security monitoring, but also applied to a red light shot, speeding violation paparazzi, parking system and so on. The present paper introduces an intelligent parking management system based on LPR, recognizing license plate automatically at the parking lot access and realizing vehicle information integrated management conveniently. The software part is developed with VC++, QT and Microsoft Office Access Database. In the system, LPR is carried out through video streaming frame by frame to choose the best result with a high speed. After accurate LPR, the vehicle information, such as LP number, LP color, car type and access time, will be stored in system database. In addition, the system interface is designed very friendly and simple for administrators to operate, which can largely improve the whole performance of LPR system. Experimental results show that this parking management system can achieve high correct rate at 95%, and can be applied to real-time implementation.

Index Terms—Intelligent Parking; LPR; VC++; QT; Access

I. INTRODUCTION

With the rapid development of highway and mechanization, vehicle ownership has been increasing quickly. Problems generated by the lack of parking spaces have become more urgent in many towns and cities, particularly in more densely populated areas. As a result, vehicle users are not serviced conveniently during their driving trips. Increased traffic congestion, longer travel times, more difficult in finding parking spaces, in parallel with a poorer quality of life and lower levels of accessibility [1] are prominent. All of these aspects confirm the importance of promoting intelligent parking management.

Intelligent Transportation Systems (ITS) include a group of technologies as well as individual decisions surrounding many aspects of travel, which can improve management of transportation system and public transit. Recently, ITS study has already been the main direction of present traffic administration. Although some novel techniques, for example RFID (radio frequency identification), WSN (wireless sensor network), etc., have been proposed for vehicle ID recognition, LPR on image data is still an indispensable technique in current ITS for its convenience and low cost [2]. Because License Plate (LP) is with unique information for each vehicle, License Plate Recognition has been applied in many fields, such as in traffic flow control, automatic parking systems, radar based speed control [3] and so on. The advantage of LPR system is that it can be carried out without vehicle stop and the needlessness to install any equipment on the car, conveniently and efficiently. So as for intelligent parking lot, LPR can be used for identifying vehicles at the parking lot entrance and exit easily. License Plate Recognition (LPR) therefore plays a very important role in ITS. So we propose a complete set of intelligent parking system based on LPR, which can recognize LP number and LP color from video-streaming frame by frame, choose the best recognition result among images of one car, and then stores vehicle information in system database for further processing.

In previous work, researchers had come up with lots of solutions for LPR with varying levels and complexities. As license plate location is the first step of LPR method, the location performance is directly related to the LPR system accuracy rate. Because of the different LP color and format, the light and environmental factors and so on, there are many difficulties in the process of LP location. Yan Qing [4] presented a new method for LP location based on license plate texture and HSV color space. This method can meet with real-time request and has high robustness. The experiment proves that it has obvious superiority in terms of speed, algorithm complexity and precision. Rami Al-Hmouz and Khalid Aboura [5] introduced a new approach of LP localization using a statistical analysis of Discrete Fourier Transform (DFT) of the plate signal, combined with color-based histogram thresholding. In the article, the LP signal was represented by five statistics: the signal strength, normalized maximum amplitude, frequency of maximum amplitude,
frequency center and frequency spread, the method achieved 97.27% accuracy using plate signals from binary images. Further more, LP characters segmentation is also a very crucial step of LPR algorithm. However, most of the various LP segmentation methods suffer from sensitivity to non-uniform illumination distribution, existence of shade in LP region, etc. Franc and Hlava [6] had used Hidden Markov chain to formulate the dynamic segmentation of characters in license plate. This method has been reported to be robust to noise but a precise format definition is needed as well. Zhang Wenjuan [7] in 2012 proposed a license plate segmentation method realizing by FCM clustering algorithm with spatial information, which is quite effective and efficient. While a LPR system usually includes two major components, which are license plate detection and character recognition. Choi and Kim [8] [9] proposed a method based on vertical edge, using Hough Transform (HT) to detecting vertical lines, selecting each character individually, and extracting the integrated license plate at last. But this method is too sensitive to deformation of plate boundaries and is time consuming. Jianfeng, Shaofa and Zhbin [10] have worked on Chinese car plate system. They have employed a Neural Network for color analysis for correct plate extraction. Their success rate was 95.7%. Lotufo, Morgan and Johnson [11] proposed automatic number plate recognition using optical character recognition techniques. Lihong Zheng, Xiangjian He et al [12] presented an algorithm for detection and recognition of license plates in traffic video datasets. They applied both global edge features and local Haar-like features to construct a cascaded classifier consisting of six layers with 160 features. For LPR, an open source OCR is modified and used. Besides, there are plenty of methods, such as using neural network for color extraction, using template matching for characters recognition or using color information for vehicle license plate location and so on.

Here we use VC++ and Qt programming patterns which have a wonderful and friendly interface. After LPR, vehicle information is handled and stored in Microsoft Office Access Database. The proposed system offers administrators with all kinds of report analysis service. In the next section, we introduce features of LPR system. Section 3 presents system framework and LPR module analysis. In Section 4, an experimental platform is built up. Results show that the proposed system has good robustness, high identification and it does best in real-time performance. Finally, the paper is concluded in Section 5.

II. FEATURES OF LICENSE PLATE RECOGNITION SYSTEM

Compared with parking management systems using other methods, such as manual record, RFID card and radar installations, LPR system has its unique advantages and also technical difficulties.

Firstly, one of the advantages of LPR is that only some specific characters and ten Arabic numerals are needed to recognize. In other words, LPR system has fewer recognition categories to handle.

Secondly, the LP region is so small in a car image that the characters are more difficult to locate, segment and detect. And there are similar characters in LP, such as number ‘2’ and letter ‘S’, number ‘8’ and letter ‘B’, number ‘0’ and letters ‘O’, ‘Q’, and ‘D’.

Thirdly, the task of vehicle license plate recognition is quite a challenging work from vehicle images, due to the viewpoint changes and tilted situations. In addition, vehicle bodies and LP region have similar color, multi-style plate formats and the non-uniform illumination conditions during image acquisition, especially in the situation of detecting high-speed cars.

Considering several facts above, general design of the proposed LPR system follows such principles as reliability, high-efficiency, energy-saving, environment protecting, integrity and humanity. That is, the system can run steadily, recognize LP quite fast and accurate, and need no cards which may be destroyed in use. Integrity and humanity of the management system interface makes it easy to operate, charge parking fee and generate monthly or annual report.

Therefore, the system has basically three essential modules as LP location using image of the vehicle, LP characters extraction and segmentation using a proper algorithm, and LP characters recognition using a suitable algorithm. Facts proved that method using video streaming to implement frame-by-frame recognition to achieve the best result is quite effective.

III. SYSTEM FRAMEWORK AND MODULE ANALYSIS

The framework of the proposed intelligent parking system includes vehicle detection module, access control module, and system management software module.

A. Hardware Architecture

Figure 1 shows the system hardware architecture, consisting of induction coil, automatic barriers, surveillance cameras, video capture card and personal computer terminal. When a car is entering, the camera automatically captures car picture which is transferred to the computer terminal in real time. After license plate recognition and verification, the automatic barrier is opened at the entrance to allow vehicles parking. While the induction coil at the entrance sends a closed signal to
automatic barrier to make it drop down. Also, the barriers can be opened and closed both by controllers and software buttons on the operator interface. Similarly, when a car is leaving, the camera will take the car picture, which will be compared with its photo at the entrance. Cameras are HD video cameras, which can meet with complex environment, for example various weather, light conditions and car running. The install angle and height of cameras should be accurately (see data in Fig. 1). The computer terminal is installed with video capture cards, which deal with tasks of real-time video detection, capture and transformation.

B. Implementation of System Management Software

The basic structure and flowchart of the proposed system are as follows (see Figure 2). This paper focuses on the overall efficiency of the parking management system, including effectiveness of LPR algorithm and system interface operating conveniently and quickly in case of wrong recognition results.

In Fig. 2, vehicles data is collected and transferred through video capture card to the control computer. After a series of image detection and pre-processes, LPR module will play a key role in the proposed system. At last, the recognized LP is confirmed by the administrator and stored in system database.

C. Vehicles Data Collection

Function of this module is to achieve front, clear vehicle images in good condition of contrast and brightness. However, for obtaining an appropriate car image and LP region confronting with a non-uniform illumination, the image must be divided into many blocks for filtering and processing [13]. So the installation of cameras position and angle is critical. In this module, vehicle video is transferred to the control terminal in real-time. The car image information can be used at the parking entrance and exit, showed clearly to the current administrator to check up the recognized LP and to assure parking payment.

D. LPR Algorithm

Actually, the LPR system comprises of three crucial processing stages. First of all, the system processes the incoming video streaming and roughly locates the potential LP regions. In this step, it will detect and correct the skew LP to make location and verification accurately. In the second stage, LP characters and numbers are segmented [14], the LP characters and numbers are extracted, especially from the complex circumstance with various noise sources. Finally, and the recognition is carried out. Software flow chart in LPR module can be described in Fig. 3.

![Flowchart of data processing](image)

Figure 2. Flowchart of data processing

Locating the LP quickly and accurately is a very critical step in the technology of automatic LPR in real-time. It is also a typical problem of image segmentation, which is a tough job to carve out the LP region quickly and accurately from a complex background. This requires the location algorithm to be insensitive to noise, illumination changes, LP defects, skew, deformation and other adverse conditions. Here we study, discuss and compare with several LP location algorithms as follows: method based on linear detection, method based on gray-scale edge detection, method based on morphology, method based on texture feature [15], and method based on color feature [16]. Table 1 shows the different performances of these LP location algorithms.

<table>
<thead>
<tr>
<th>LP location algorithms</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Method based on linear detection [3]</td>
<td>Simple in principle</td>
<td>Heavy computation and do not apply to the de-normalization LP</td>
</tr>
<tr>
<td>Method based on gray-scale edge detection</td>
<td>Be well used for images of high-contrast and clear edge feature</td>
<td>Be susceptible to interference by the environment</td>
</tr>
<tr>
<td>Method based on morphology [21]</td>
<td>Parallel implementation, high-speed of image analysis and process</td>
<td>Vulnerable to noise and heavy computation</td>
</tr>
<tr>
<td>Method based on texture feature [22]</td>
<td>Low requirement for image quality and LP region size</td>
<td>Sensitive to interference in complex environment</td>
</tr>
<tr>
<td>Method based on color feature [23]</td>
<td>Precise LP location in high-contrast conditions</td>
<td>Computation is triple of method based on gray-scale edge detection, requiring high-contrast</td>
</tr>
</tbody>
</table>

In this paper, we consider all the above affecting factors, take the image characteristic in high vertical edges into account and correct the skew LP with horizontal edge detection method. After two-step process, the LP region can be located accurately.
Once a LP region has been identified and verified, it continues with the segmentation step, isolating characters accurately in the LP image and then to forward them to recognize. There are kinds of methods for segmentation, such as segmentation using mean space and distance between characters [17], segmentation by projection in horizontal and vertical directions [18], and segmentation through the recognition reliability [17,19]. All these segmentation method can be combined to some extent to extract LP characters more accurately from complex backgrounds.

In the recognition process, we need to extract specific information from each separate character and number, which is known as feature extraction. Because the rate and the efficiency of the LP recognition is the key of a LPR based intelligent parking system, a simple feature extraction method should be used. In [17], LP recognition by template matching is discussed. This method can be fast but too sensitive to noise. Algorithm using support vector machine (SVM) is popular recently. It is flexible and time saving. Methods based on statistical characteristic and neural network are all mature technology, however, any individual algorithm is considered to be reliable. Table 2 shows the difference of several license plate recognition algorithms, which are the most common methods at present.

<table>
<thead>
<tr>
<th>LP algorithms</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method based on template matching</td>
<td>Recognize fast and quite accurate</td>
<td>Too sensitive to noise and characters skew</td>
</tr>
<tr>
<td>Method based on statistical characteristic matching</td>
<td>Flexible, not be affected by color</td>
<td>Plenty of training samples and distribution unpredictable</td>
</tr>
<tr>
<td>Method based on neural network</td>
<td>High fault tolerance, learning ability and good adaptability</td>
<td>Network too huge and complex, recognition slow</td>
</tr>
</tbody>
</table>

E. Database Management

The system database is realized by Microsoft Office Access Database technology, providing the administrator with friendly interface for vehicle information management. Information concludes license plate number, license plate color, car style, arrival time, leave time, parking duration, parking fee and system operator (see Fig. 4). Fig. 4 a) is the video and picture at the entrance, when the car leaves, the system database is called and cars information is shown in details in Fig. 4 b).

Also, the database includes administrator management, offering different levels of operation authority (see Fig. 5). For example, super administrator can set parking fee standard and manage the system report, while general user can only deal with vehicle access and parking charge.
The system temporary database CarPark.mdb contains four main tables. Vehicle information in real time is processed in temporary database. Table of car styles includes fields of parking fee per hour, parking fee cap every day, time interval of charging, and so on. For this table, system offers the administrator an intelligent interface to set charge standard. Table of administrators includes information of all operators, such as the employee number, the name and the password of their own. Table of vehicles information in the parking lot includes fields of LP number, LP color, car style, arrival time, leave time, parking duration, parking fee, operator name when entering and operator name when leaving, and so on. Table of parking lot information includes fields of total parking number and parking manager.

Interior vehicle information and a full record of vehicle access information is stored in system historical database. The principal role of system historical database CarParkHis.mdb is to provide query services and statistic report, which is convenient and important for the parking lot management. System interface can be seen in Fig. 7.

where “Management of Cars In” can add, modify and delete interior vehicles information, which can enter the parking lot without payment [19]. In addition, “Report Management” provides super administrator with functions that all of the vehicle parking information can be print out in report table. It is very useful for a parking to make some statistical analysis.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed system is developed using VC++ and QT [16, 20]. QT is a comprehensive C++ application development framework for creating cross-platform GUI applications. It lets programmers use a single source tree for applications running on Windows, Mac OS X, Linux and many other versions of UNIX.

We install a set of the system at a school gate, with cameras in appropriate position and angle. In the experiments, the program is done with Dell Vostro Desktops with Intel(R) Core(TM) E7200, 4GB memory.

Fig. 8 shows the system performance when LPR works right. At this time what the operator on duty need to do is just pushing the button “Confirm & Open”. However, LPR will not work properly due to the complicated circumstances outside, such as the sunlight, the stained car license plate, the tilted path and the high speedy car, etc. In Fig. 9, head of the car license plate number is recognized wrong. At this time what the operator on duty
need to do is just pushing the button “Head”, choosing correct head of LP, and pushing the button “Confirm & Open”. Indeed, series of the above operations may consume some time, but the system accuracy is greatly increased.

Taking ten days of vehicle records both at the entrance and the exit for statistics, the system performance can be seen in Table 3.

<table>
<thead>
<tr>
<th>Number of records each day</th>
<th>System Accuracy</th>
<th>False positive rate</th>
<th>Missing recognition rate</th>
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<tbody>
<tr>
<td>394</td>
<td>91.88%</td>
<td>7.11%</td>
<td>1.01%</td>
</tr>
<tr>
<td>301</td>
<td>93.69%</td>
<td>5.65%</td>
<td>0.66%</td>
</tr>
<tr>
<td>421</td>
<td>93.82%</td>
<td>5.94%</td>
<td>0.24%</td>
</tr>
<tr>
<td>337</td>
<td>95.85%</td>
<td>3.72%</td>
<td>0.43%</td>
</tr>
<tr>
<td>363</td>
<td>95.04%</td>
<td>4.41%</td>
<td>0.55%</td>
</tr>
<tr>
<td>368</td>
<td>95.92%</td>
<td>3.81%</td>
<td>0.27%</td>
</tr>
<tr>
<td>356</td>
<td>96.09%</td>
<td>3.52%</td>
<td>0.39%</td>
</tr>
<tr>
<td>285</td>
<td>96.44%</td>
<td>3.16%</td>
<td>0.40%</td>
</tr>
<tr>
<td>253</td>
<td>96.47%</td>
<td>2.83%</td>
<td>0.7%</td>
</tr>
<tr>
<td>251</td>
<td>94.82%</td>
<td>4.78%</td>
<td>0.40%</td>
</tr>
</tbody>
</table>

In Table 3, the number of records each day can be got from system database, which contains a complete record of each car. Based on these experimental results, accuracy of the overall proposed system can be obtained at 95%. Moreover, the system can achieve almost real-time recognition.

Certainly, due to the effects of light and environmental conditions, the system recognition rate at night is slightly lower compared with that during the daytime. That can be seen in Figure 8. In Fig. 10 a) and b), the videos are captured at 6 o’clock in the early morning.

However, it cannot be expected 100% accuracy in each real-time application. For recognition failure, the barrier will not open and the proposed system also allows manual action, making a picture of the vehicle, recording vehicle information and saving them in system database.

V. CONCLUSION

In this paper, a real-time and intelligent parking system based on LPR has been presented. The significance of the proposed algorithm is that it can recognize vehicle LP and store its information in system database, almost in real time. And the results prove that the average processing time for a vehicle is between 30ms and 100ms, without stopping the vehicle. Compared with parking by card or manual, it is very convenient and efficient. This system also provides the administrator with friendly Graphical User Interface (GUI) to help manage a parking lot and vehicles.

As future improvement, to further reduce error rate in similar character recognition and LP patterns, we recommend developing a more reliable LP location algorithm to improve overall performance of the system.

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