License Plate Recognition- A Template Matching Method

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ABSTRACT

License Plate Recognition (LPR) has a lot of applications in various fields. It is a mass surveillance method that uses an optical character recognition method to read vehicle registration plates. LPR system is mainly used in parking lots, tolling booths and nowadays in the signal system in order to identify the vehicle that crosses the line before the indication of green signal. This paper presents an efficient method for LPR. This method utilizes a template matching technique. This LPR system can only be practical on the front view and rear view orientation of the license plates. The methodology is suitable for both Indian license plates and foreign license plates. The algorithm was tested with 10 images such as images taken from parking lots and roadside. The license plates that was successfully located and segmented as 80% and 87.5% respectively. The recognition rate of character using template matching method is 97%. Overall performance of the system is 88.16%. The total processing time of the system is 298ms.

I. INTRODUCTION

License plate numbers are being used to uniquely identify a vehicle. LPR system plays an important role in many applications like electronic payment system (toll payment [3] and parking fee payment), to find stolen cars [1], traffic surveillance. For example in parking, number plates are used to calculate duration of the parking. When a vehicle enters the gate, license plate is automatically recognized and stored in database. When a vehicle later leaves the parking area through the gate, license plate is recognized again and compared with the first-one stored in the database. The time difference is used for calculating the parking fee. The LPR system is convenient and automated. In addition it is cost efficient because only less human resources are needed. Fig. 1 shows the block diagram of LPR system. Images are collected from the parking lots and roadside. Pre-processing step is to convert the grayscale image into binary image. License Plate Detection (LPD) is to locate the license plate in the image after converting the image to binary image. Character segmentation is used to perform the segmentation of characters for further processing in the Character Recognition (CR). CR is to recognize the segmented characters.

Fig.1. LPR System

LPR system for Indian license plate is difficult compared to the foreign license plate as there is no standard followed for the aspect ratio (length to width ratio) of license plate. Fig. 2(a) shows the foreign license plates and Fig. 2(b) shows the Indian license plate.

Table 1 presents different LPR systems implemented in recent research works. Second and third column of the table represents the methods used for the LPD and CR. Researchers have proposed several methods for locating license plate such as edge detection method, morphological operations etc. There are a large number of CR techniques reported such as support vector machine, artificial neural networks etc. Template matching method is the easiest and simplest technique. It is also a less time consuming technique. Most of the system process the English and numeral characters. Environmental conditions play an important role in the LPR system. Some of the LPR system needs proper illumination conditions in order to properly detect the license plate. [1],[2],[3],[4],[6] has performed tilt correction. Tilt correction is the process of correcting the slant in the plate. It may be horizontal or vertical correction or both. Fig.3 shows some sample images used by those systems. Some works have been reported to handle Indian license plates [18]. However, due to varying aspect ratio, they have proposed only LPD and not LPR system. The main focus of this paper is to select the appropriate methods and implement LPR system for Indian license plates.

(a) (b)

Fig.2. (a) Foreign License Plates (b) Indian License Plates

Table 1 Comparison of different LPR systems

Ref: No	LPD (Success Rate %)	CR Method (Success Rate %)	Environment Conditions	Tilt Correction	Recognized Character	Rate (%)
[1]	Search Window Method (96.7)	Artificial Neural Network (97.1)	Controlled	No	English Numerals	93.9
[2]	Edge Analysis (95.9)	Artificial Neural Network (92.3)	Controlled	Yes	Chinese English Numeral	90.1
[3]	CCA (91.7)	Neural Network (87.16)	Controlled	No	English Numeral	90.93
[4]	SCW (96.5)	PNN (89.1)	Controlled	No	English Numeral	86.0
[5]	Fuzzy Discipline (97.9)	Neural Network (95.6)	Less Controlled	No	English Numeral	93.7
[10]	Improved Bernsen (97.16)	SVM (97.8)	Uncontrolled	Yes	Chinese English Kana, Numeral	93.54
[8]	Vertical Edge Detection (92.5)	Template matching (91.1)	Controlled	No	English Numerals	92.1
[9]	Hough Transform + Counter algorithm (98.76)	Hidden Markov Model	Controlled	No	English Numerals	92.85

In section II, license plate pre-processing is presented where the Otsu method is explained. Otsu method is the simplest algorithm. It can easily remove the dirt, shadows in an image and convert the particular image to binary image by exposing the essential part. Connected Component Analysis (CCA) for LPD is explained in the section III. Character recognition algorithms are elaborately explained in the section IV. Experimental results are shown in the section V and finally discussion and future works are presented in section VI.

Fig.3. Sample License Plate Images

II. LICENSE PLATE PREPROCESSING

It is an essential part of the LPR system. This phase is used to remove the shadows or dirt in the license plate region and convert the grey scale image to a binary image. In this paper a binary method called Otsu algorithm is used for binarization.

1) OTSU [12] method

The Otsu's method is used to convert each block to binary form. Otsu's method searches for the threshold that minimizes the intra-class variance which is defined as the weighted sum of variances of the two classes [10].

$$\sigma_{\omega}^{2}(t) = \omega_1(t)\,\sigma_1^2(t) + \omega_2(t)\,\sigma_2^2(t) \qquad (1)$$

where ω_i denotes the probabilities of the two classes separated by a threshold t, and σ_i denotes the variances of these classes. Otsu has proven that minimizing the intraclass variance is the same as maximizing interclass variance.

$$\sigma_h^2(t) = \sigma_2 - \sigma_{\omega}^2(t) = \omega_1(t)\,\omega_2(t)[\mu_1(t) - \mu_2(t)]^2 \qquad (2)$$

which is expressed in terms of class probabilities ω_i and class means μ_i, which in turn can be updated iteratively. The procedure for OTSU method can be depicted as follows:-

Step 1.Compute histogram and probabilities of each intensity value;
Step 2.Set the initial value of $\omega_i(0)$ and $\mu_i(0)$;
Step 3.Loop for all possible thresholds t
Step 3.1. Update $\omega_i(t)$ and $\mu_i(t)$;
Step 3.2. Compute $\sigma_b^2(t)$;
Step 4.Choose the threshold t*corresponding to the maximum of $\sigma_b^2(t)$.
Step 5.The image binarization can be expressed as follows:-

$$I_B(x,y) = \begin{cases} 0 & I(x,y) < t^* \\ 1 & I(x,y) \geq t^* \end{cases} \qquad (3)$$

Here 0 denotes black representing the text, and 1 denotes white representing the background.

Fig.4. shows the result of OTSU method. This method gives a good binary result.

Fig.4. OTSU Method Result

III. LICENSE PLATE DETECTION

`After the license plate is processed with the binary method, the system steps into detection part. The result of the detection is the key to the following work and directly affects the performance of the entire system. This phase marks the license plate in the image and helps to extract the license plate for the later part of the recognition system. Connected component analysis (CCA) is a well-known technique in image processing that scans an image and labels its pixels into components based on pixel connectivity (i.e., all pixels in a connected component share similar pixel intensity values) and are, in some way, connected with each other (either four-connected or eight-connected). Once all groups have been determined, each pixel is labeled with a value according to the component to which it was assigned. CCA works on binary or gray-level images, and different measures of connectivity are possible. For the present application, CCA with eight connectivity has been applied to binary images.

Connected Component Analysis

Connected component labelling [13] works on binary or gray level images and different measures of connectivity are possible. The connected component labelling operator scans the image by moving along a row until it comes to a point *p* (where *p* denotes the pixel to be labelled at any stage in the scanning process) for which intensity value *V={1}*. When this is true, it examines the four neighbours of *p* which have already been encountered in the scan (*i.e.* the neighbours (i) to the left of *p*, (ii) above it, and (iii and iv) the two upper diagonal terms). Based on this information, the labelling of *p* occurs as follows:

- If all four neighbours are 0, assign a new label to *p*, else
- If only one neighbour has *V={1}*, assign its label to *p*, else
- If more than one of the neighbours have *V= {1}*, assign one of the labels to *p* and make a note of the equivalences.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0

Fig. 5. Digitized Image [3]

After completing the scan, the equivalent label pairs are sorted into equivalence classes and a unique label is assigned to each class. As a final step, a second scan is made through the image, during which each label is replaced by the label assigned to its equivalence classes.CCA process the pre-processed binary image. In raster scan mode, the binary image (Fig. 5) is searched, and a unique ID is labelled to the group of the pixels that neighbour each other (Fig. 6). It is possible to neighbour one or more pixels.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	0
0	0	0	0	0	0	7	7	7	7	7	7	7	7	7	0
0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
0	0	0	0	0	0	7	7	7	7	0	0	0	0	0	0
0	7	7	7	7	7	7	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	8	8	8	8	0
0	0	0	0	0	0	0	0	0	0	8	8	8	8	0	0

Fig.6.First Pass of CCA on Digitized Image [3]

A pixel is assigned an ID by first referring to the upper and then to the left side pixel ID. As a result, an equality table is formed, as shown in Table 2. Multiple stages are required to resolve all labels. This is required due to the limitations on the hardware resources. Using this table, the integration table is filled out, as shown in Table 3.

Table 2 Equality table of the first pass [3]

1	=	2
3	=	2
4	=	3
5	=	6

Table 4 Integrity Table of First Pass [3]

1	=	7
2	=	7
3	=	7
4	=	7
5	=	8
6	=	8

As seen in the first pass in Fig. 6, IDs 1, 2, 3, and 4 are in the same cluster, and IDs 5 and 6 are in another cluster. After the final pass over the image, IDs 1, 2, 3, and 4 are labelled as 7, and IDs 5 and 6 are labelled as 8 (Fig. 7).

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
0	0	0	0	0	0	2	2	2	2	1	1	1	1	1	0
0	3	3	3	3	3	3	2	2	2	1	1	1	1	1	0
0	0	0	0	0	0	3	2	2	2	0	0	0	0	0	0
0	4	4	4	4	4	3	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	0
0	0	0	0	0	0	0	0	0	0	6	5	5	5	0	0

Fig.7. Final Pass of CCA on Digitized Image [3]

This paper mainly focuses on the license plate with white background and black characters. In order to extract the license plate, the aspect ratio and area of license plate is necessary. Aspect ratio is the proportion of length to width. It changes as the distance between the car and camera varies. First all the bounding boxes are made visible which corresponds to the similar properties in the image. Then filter the bounding boxes as per the requirements. Eliminate the bounding box which is less than 4 and greater than 5. Then extract the plate with area between 10000 and 100000. Fig.8. shows the result of LPD phase.

Fig.8. Result of LPD phase

IV. CHARACTER SEGMENTATION

Fig. 9. shows the result of character segmentation. This is an important phase in LPR system to perform the character recognition. The same method used for license plate detection is used in this phase. Bounding boxes are placed on the characters to extract the bounded characters.

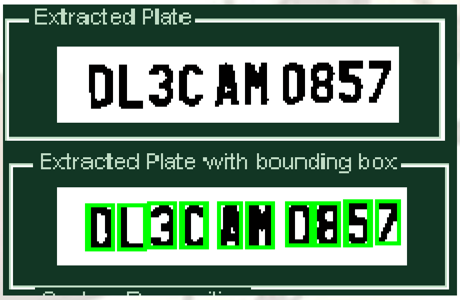

Fig.9. Segmented Character

V. CHARACTER RECOGNITION

Template Matching [14] is a technique that compares portions of images against one another. It can be used in manufacturing as a part of quality control [15], a way to navigate a mobile robot [16], or as a way to detect edges in images [17]. Sample of image may be used to recognize similar objects in the source image. If a standard deviation of the template image in comparison to source image is small enough, template matching may be used. The matching process moves the template image to all possible positions in a larger source image and computes a numerical index that indicates how well the template matches the image in that position. Matching is done on a pixel by pixel basis. The template is of size 42 × 24 as depicted in Fig.10. Since the template size is fixed, it leads to inaccurate recognition.

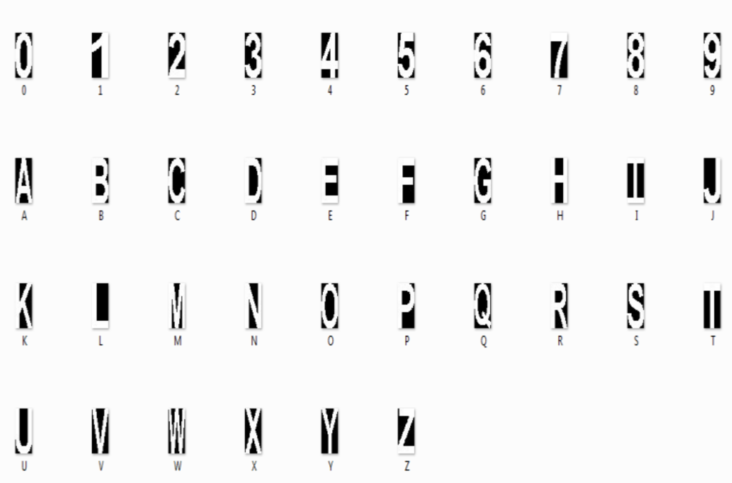

Fig.10. Templates Used for Template Matching

Template matching method is mainly used for classifying objects. Templates are most often used to identify printed characters, numbers and small other objects. In template matching method templates are correlated with the source image. Correlation is a measure of degree to which two variables agree. The variables are the corresponding pixel values in two images, template and source. The correlation value is between -1 and +1. Higher the correlation value means strong relationship between the template and source image. Fig 11 shows the result of character recognition.

Fig.11 Result of Character Recognition

VI. PERFORMANCE OF THE SYSTEM AND PROBLEM ANALYSIS

In this paper, the LPR system was tested on a Microsoft Windows 7 operating system, Inter core i5 processing unit and 4 GB RAM. The software implementation was realized using MATLAB R2009a environment.

Table 5 shows the performance result. The system was tested with 10 images. Image database consists of both Indian license plate and foreign license plate. It is difficult to locate the Indian license plate compared to the foreign license plate. Because the aspect ratio and area of Indian license plates are different.

Table 5 Performance Analysis of the System

Criteria	LPD	Character Segmentation
Number of tested images	10	8
Number of succeeded images	8	7

This paper focused on both Indian plates and foreign license plate with an aspect ratio between 4 and 5. This is one of the limitations of the system. Another limitation is in the template matching method. Plates should have same format that of the template otherwise it doesn't recognize.

VII. CONCLUSIONS AND FUTURE WORKS

LPR system mainly consists of three phases 1) plate detection 2) character segmentation 3) character recognition. The paper mainly focuses on the Indian and Foreign license plates. Pre-Processing was tested with 10 images taken from different location in different environmental conditions. The license plates those were properly visible after the pre-processing is 8. So percentage of successfully visible license plate is 80%. The success rate of LPD is 80% and the success rate of character segmentation is 87.5%. The success rate of CR is 97%. LPD phase can be implemented using some other methods so that better results can be achieved. The main advantage of the paper is that it can process both the Indian plates and foreign plate but all the plates have to maintain a specific aspect ratio range. Template matching method can be replaced with Support Vector Machine (SVM) or Artificial Neural Networks (ANN). As an enhancement work, LPR system can be applied to video sequences.

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