Automatic Vehicle Identification by Plate Recognition

Serkan Ozbay, and Ergun Ercelebi

***Abstract*—**Automatic Vehicle Identification (AVI) has many applications in traffic systems (highway electronic toll collection, red light violation enforcement, border and customs checkpoints, etc.). License Plate Recognition is an effective form of AVI systems. In this study, a smart and simple algorithm is presented for vehicle's license plate recognition system. The proposed algorithm consists of three major parts: Extraction of plate region, segmentation of characters and recognition of plate characters. For extracting the plate region, edge detection algorithms and smearing algorithms are used. In segmentation part, smearing algorithms, filtering and some morphological algorithms are used. And finally statistical based template matching is used for recognition of plate characters. The performance of the proposed algorithm has been tested on real images. Based on the experimental results, we noted that our algorithm shows superior performance in car license plate recognition.

***Keywords*—**Character recognizer, license plate recognition, plate region extraction, segmentation, smearing, template matching.

I. Introduction

AUTOMATIC vehicle identification is an essential stage in intelligent traffic systems. Nowadays vehicles play a very big role in transportation. Also the use of vehicles has been increasing because of population growth and human needs in recent years. Therefore, control of vehicles is becoming a big problem and much more difficult to solve. Automatic vehicle identification systems are used for the purpose of effective control.

License plate recognition (LPR) is a form of automatic vehicle identification. It is an image processing technology used to identify vehicles by only their license plates. Real time LPR plays a major role in automatic monitoring of traffic rules and maintaining law enforcement on public roads [1]. Since every vehicle carries a unique license plate, no external cards, tags or transmitters need to be recognizable, only license plate.

So many researches of car identification have been approached by car license plate extracting and recognition, some of the related work is as follows. Lotufo, Morgan and Johnson [2] proposed automatic number-plate recognition using optical character recognition techniques. Johnson and Bird [3] proposed knowledge-guieded boundary following and template matching for automatic vehicle identification. Fahmy [4] proposed bidirectional associative memories (BAM) neural network for number plate reading. It's appropriate for small numbers of patterns. Nijhuis, Ter Brugge, Helmholf J.P.W. Pluim, L. Spaanenburg, R.S. Venema and M.A.Westenberg [5] proposed fuzzy logic and neural networks for car LPR. This method used fuzzy logic for segmentation and discrete-time cellular neural networks (DTCNN'S) for feature extraction. Choi [6] and Kim [7] proposed the method based on vertical edge using Hough transform (HT) for extracting the license plate. E.R. Lee, P.K. Kim and H.J. Kim [8] used neural network for color extraction and a template matching to recognize characters. S.K. Kim, D.W. Kim and H.J. Kim [9] used a genetic algorithm based segmentation to extract the plate region. Tavsanoglu and Saatci [10] proposed an approach to form orientation map as recognition feature using a Gabor filter for recognizing characters. Yoshimura and Etoh [11] used Gabor jets projection to form a feature vector for recognizing low resolution gray-scale character. Hontani et.al. [12] proposed a method for extracting characters without prior knowledge of their position and size in the image. Park et. al. [13] devised a method to extract Korean license plate depending on the color of the plate. H.J. Kim, D.W. Kim, S.K. Kim, J.V. Lee, J.K. Lee [14] proposed a method of extracting plate region based on color image segmentation by distributed genetic.

In this study, the proposed algorithm is based on extraction of plate region, segmentation of plate characters and recognition of characters.

The paper is organized as follows: Section II provides an overview of the overall system. Extracting the plate region is explained in Section III. Section IV gives the segmentation of individual plate characters. Section V deals with recognition of characters based on statistical based template matching algorithm. Section VI discusses experimental results and the paper concludes with Section VII.

II. Structure of the LPR System

The algorithm proposed in this paper is designed to recognize license plates of vehicles automatically. Input of the system is the image of a vehicle captured by a camera. The captured image taken from 4-5 meters away is processed through the license plate extractor with giving its output to segmentation part. Segmentation part separates the characters

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individually. And finally recognition part recognizes the characters giving the result as the plate number.

III. Plate Region Extraction

Plate region extraction is the first stage in this algorithm. Image captured from the camera is first converted to the binary image consisting of only 1's and 0's (only black and white). by thresholding the pixel values of 0 (black) for all pixels in the input image with luminance less than threshold value and 1 (white) for all other pixels. Captured image (original image) and binarized image are shown in Figure 1(a) and 1(b) respectively.

(a) Captured image

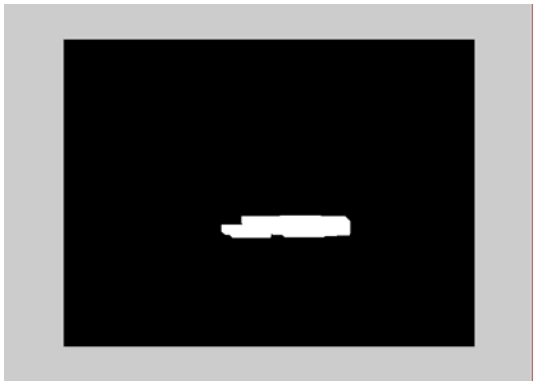
(b) Binarized image

Fig. 1(a) - Original Image, (b) - Binarized Image

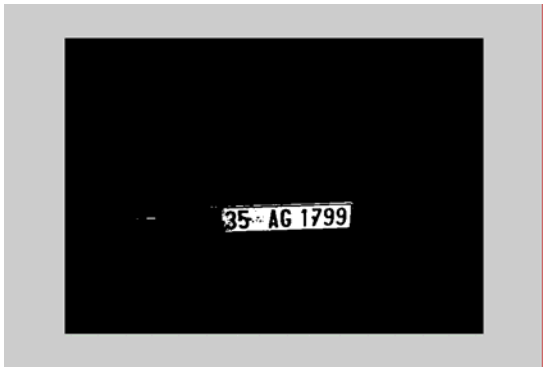
The binarized image is then processed using some methods. To find the plate region, firstly smearing algorithm is used. Smearing is a method for the extraction of text areas on a mixed image. With the smearing algorithm, the image is processed along vertical and horizontal runs (scan-lines). If the number of white pixels is less than a desired threshold or greater than any other desired threshold, white pixels are converted to black. In this system, threshold values are selected as 10 and 100 for both horizontal and vertical smearing.

If number of 'white' pixels < 10 ; pixels become 'black'
Else ; no change
If number of 'white' pixels > 100 ; pixels become 'black'
Else ; no change

After smearing, a morphological operation, dilation, is applied to the image for specifying the plate location. However, there may be more than one candidate region for plate location. To find the exact region and eliminate the other regions, some criteria tests are applied to the image by smearing and filtering operation. The processed image after this stage is as shown in Figure 2(a) and image involving only plate is shown in Figure 2(b).



(a) Plate region



(b) Image involving only plate

Fig. 2 (a) - Plate region, (b) - Image involving only plate

After obtaining plate location, region involving only plate is cut giving the plate as shown in Figure 3.

Fig. 3 Plate Image

IV. Segmentation

In the segmentation of plate characters, license plate is segmented into its constituent parts obtaining the characters individually. Firstly, image is filtered for enhancing the image

and removing the noises and unwanted spots. Then dilation operation is applied to the image for separating the characters from each other if the characters are close to each other. After this operation, horizontal and vertical smearing are applied for finding the character regions. The result of this segmentation is in Figure 4.

Fig. 4 Locations of plate characters

The next step is to cut the plate characters. It is done by finding starting and end points of characters in horizontal direction. The individual characters cut from the plate are as follows in Figure 5.

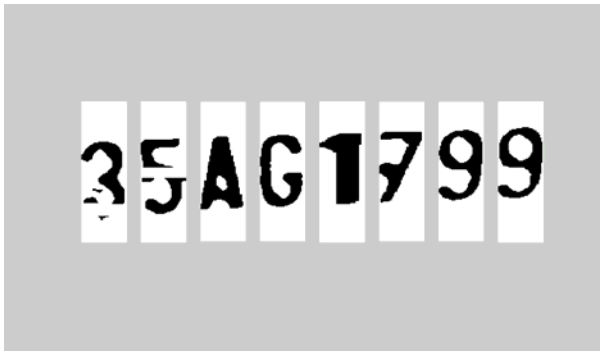


Fig. 5 Individual characters

V. Character Recognition

Before recognition algorithm, the characters are normalized. Normalization is to refine the characters into a block containing no extra white spaces (pixels) in all the four sides of the characters. Then each character is fit to equal size as shown in Figure 6.

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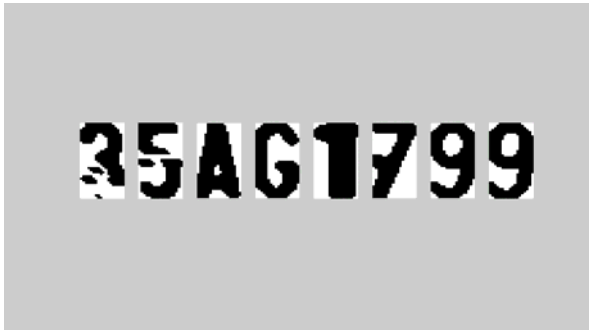

Fig. 6 Equal-sized characters

Fitting approach is necessary for template matching. For matching the characters with the database, input images must be equal-sized with the database characters. Here the characters are fit to 36 × 18. The extracted characters cut from plate and the characters on database are now equal-sized. The next step is template matching. Template matching is an effective algorithm for recognition of characters. The character image is compared with the ones in the database and the best similarity is measured.

To measure the similarity and find the best match, a statistical method correlation is used. Correlation is an effective technique for image recognition which was developed by Horowitz. [15] This method measures the correlation coefficient between a number of known images with the same size unknown images or parts of an image with the highest correlation coefficient between the images producing the best match. There are two forms of correlations: auto-correlation and cross-correlation. Auto-correlation function (ACF) involves only one signal and provides information about the structure of the signal or its behavior in the time domain. Cross-correlation function (CCF) is a measure of the similarities or shared properties between two signals. Since there are two signals as unknown input image and known database image in this system, cross-correlation is used.

Let $F_1(j,k)$ and $F_2(j,k)$ for $1 \le j \le J$ and $1 \le k \le K$ represent two discrete images denoting the image to be searched and the template respectively. The normalized cross-correlation between the image pair is defined as:

$$R(m,n)=\frac{\sum_j \sum_k F_1(j,k)F_2(j-m+(M+1)/2,k-n+(N+1)/2)}{\left[\sum_j \sum_k F_1(j,k)^2\right]^{1/2}\left[\sum_j \sum_k F_2(j-m+(M+1)/2,k-n+(N+1)/2)^2\right]^{1/2}} \quad (1)$$

for m=1,2,….M and n=1,2,….N, where M and N are odd integers.

This system used the database as the Turkish license plates characters all 33 alphanumeric characters (23 alphabets and 10 numerals) with the size of 36×18. The database formed is shown in Figure 7.

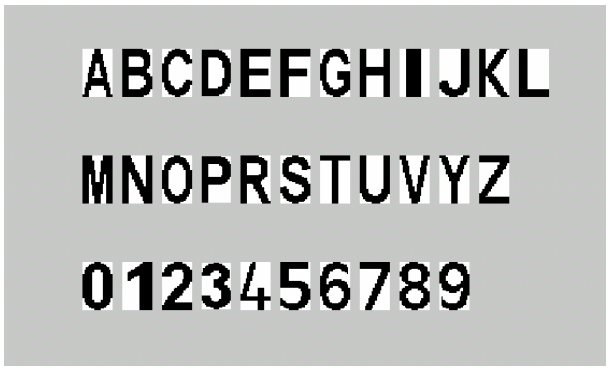

Fig. 7 The database characters

Because of the similarities of some characters, there may be some errors during recognition. The confused characters mainly are B and 8, E and F, D and O, S and 5, Z and 2. To increase the recognition rate, some criteria tests are used in the system for the confused characters defining the special features of the characters. With these features of characters and applied tests during recognition algorithm, recognition rate is increased with the minimum error.

VI. Experimental Results

Experiments have been performed to test the proposed system and to measure the accuracy of the system. The system is designed in Matlab 6.5 for recognition of Turkish license plates. The images for the input to the system are colored images with the size of 1200×1600. The test images were taken under various illumination conditions. The results of the tests are given by Table I.

TABLE I
Results of the Tests

Units of LPR System	Number of Accuracy	Percentage of Accuracy
Extraction of Plate Region	332/340	%97.6
Segmentation	327/340	%96
Recognition of Characters	336/340	%98.8

It is shown that accuracy for the extraction of plate region is %97.6, %96 for the segmentation of the characters and %98.8 is the percentage of accuracy of the recognition unit. The overall system performance can be defined as the product of all units accuracy rates (Extraction of plate region, segmentation of characters and recognition of characters).

Recognition Rate of LPR System =∏(Percentages of Accuracy) (2).

VII. Conclusion

In this paper, we presented application software designed for the recognition of car license plate. Firstly we extracted the plate location, then we separated the plate characters individually by segmentation and finally applied template matching with the use of correlation for recognition of plate characters. This system is designed for the identification Turkish license plates and the system is tested over a large number of images. Finally it is proved to be %97.6 for the extraction of plate region, %96 for the segmentation of the characters and %98.8 for the recognition unit accurate, giving the overall system performance %92.57 recognition rates. This system can be redesigned for multinational car license plates in future studies.

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