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New Morphology-Based Method for Robust Iranian Car Plate Detection and Recognition

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***Abstract*—Persian License Plate Detection and Recognition System is an image-processing technique used to identify a vehicle by its license plate. In fact this system is one kind of automatic inspection of transport, traffic and security systems and is of considerable interest because of its potential applications to areas such as automatic toll collection, traffic law enforcement and security control of restricted areas. License plate location is an important stage in vehicle license plate recognition for automated transport system. This paper presents a real time and robust method of license plate detection and recognition based on the morphology and template matching. In this system main stage is the isolation of the license plate, from the digital image of the car obtained by a digital camera under different circumstances such as illumination, slop, distance, and angle. The algorithm starts with preprocessing and signal conditioning. Next license plate is localized using morphological operators. Then a template matching scheme will be used to recognize the digits and characters within the plate. The system is tested on Iranian car plate images, and the performance was 97.3% of correct plates identification and localization and 92% of correct recognized characters. The results regarding the complexity of the problem and diversity of the test cases show the high accuracy and robustness of the proposed method. The method could also be applicable for other applications in the transport information systems, where automatic recognition of registration plates, shields, signs, and so on is often necessary.**

***Index Terms*—License Plate Recognition, Character Recognition, Object Localization, Transport Information Systems, Segmentation.**

I. Introduction

While the first industrial automatic system for Car License Plate Recognition (LPR) was introduced in the 80's, an outburst of commercial systems occurred in the 90s. Although that a lot of LPR systems are available in the market, the research and development still continues and new sophisticated solutions to plate localization, character segmentation and recognition appear.

This is due to the growing demand for the automatic vehicle identification required for traffic control, border control, access- control, calculation of parking time and payment, search for stolen cars or unpaid fees, and the requirement for reliable identification at different lighting conditions, presence of random or structured noise in the plate, and nationality specific features, concerning plate's size and type of characters [1, 2]. Figure 1 illustrates a typical license plate recognition system.

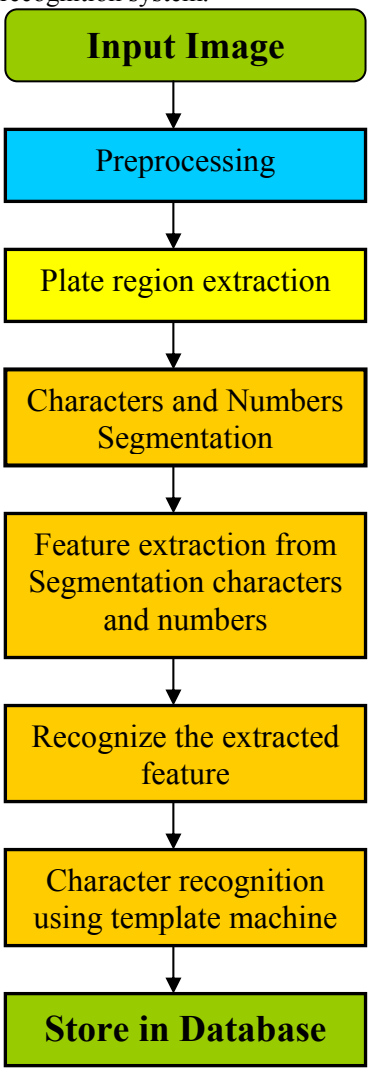

Fig1. An automatic vehicles License Plates Recognition system

Some of the related works in the field of automatic car plate recognition are as follows. Lotufo, Morgan and Johnson [2] proposed automatic number-plate recognition using optical character recognition techniques. Abolghasemi and Ahmadifard [5] proposed an IFT-based fast method for extracting the license plate. Meanwhile Zamani and Movahedi [6] proposed a morphologic method for extracting the license plate using some simple constant templates.

In this paper, we introduce a novel method for license plate

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recognition from a grayscale image of the car. We first use a preprocessing stage that contains a certain number of transforms established heuristically for reduces the extra information of car picture. Input of the car plate detection and recognition system is the binary image that obtains form preprocessing stage. Next, start a process for identifying and isolation of the car's license plate from the image, then the result of this process send to segmentation part. Segmentation part separates the characters individually. Finally recognition part recognizes the characters giving the result as the plate number.

II. The Proposed Method

Based on their technical knowledge, expertise, level of potency and available means educational institutes and organizations, have several solutions to implement an E-learning system. In the following sections, we will pay special attention to these solutions which are one of two kinds: purchasing a software program or designing one.

A. Preprocessing

Preprocessing mostly is necessary to facilitate further high performance recognition. In this study, we firstly convert the RGB color input image to a 256 grayscale image using Equation 1.

$$A_{GL} = \frac{3A_R + 6A_G + A_B}{10} \quad (1)$$

Where AGL is the converted gray level image, and AR, AG, and AB are R, G and B spectrum of the color image respectively.

Next, a vertical and horizontal Sobel operator is applied on the image to amplify the corresponding edges. Then an appropriate threshold T is used to generate the binary images where the edges are highlighted in a black background. (See Equation 2).

$$G(x,y) = \begin{cases} 1 & if A(x,y) \geq T \\ 0 & other\_wise \end{cases} \quad (2)$$

The experiments suggest that the threshold T must be from nearly 0.25 for clear, noise free, bright environments to almost 0.12 for noisy, darker environments. The mean value of the main image is used to determine whether it is bright enough or not, while the difference between the energies of the image and its one octave low pass filtered version determines the level of noise. A dilation operator also is used to generate more continues borders and edges. Equation 3 illustrates the dilation operation, where A and B are the image and the structuring element respectively.

$$A \oplus B = \left\{ d \in R^2 : d = a + b, \forall a \in A, b \in B \right\} \quad (3)$$

B. Plate Region Extraction

After the preprocessing stage, a morphological operator is applied to the image for specifying the plate location. Morphology is a technique in image processing based on shapes. We can build a morphological operator that be sensitive to a specific shape in the input image. In fact we try to create a structural element with special properties. For instance, a horizontal line of length=5 pixels or a rotated one with Θ=45 can be some typical structural elements. In this study, a rectangular box can be employed as a structural element to detect the car plates. (See Figure 2 for details)

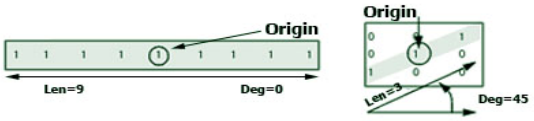

Fig2. Structural element for horizontal and Θ=45 rotated line

Applying the closing operation on edge image in the horizontal direction yields several connected regions which are plate candidates. With respect to a license plate shape, a rectangular structural element (SE) is used. The main motivation to focus on morphology was the rectangle shape of the plates. However, there may be more than one candidate region as plate location in the image after closing. To find the correct region and discard the others, some features such as shape, aspect ratio, and size of the plate are tested for all regions; this filter considerably reduces the Noise. The processed image after these stages is as shown in Figure 3, while Figure 4 illustrates some Iranian care plates.

C. Segmentation

Character segmentation is an important stage in many license plate recognition systems. There are many factors that cause the character segmentation task difficult, such as image noise, plate frame, rivet, and rotation and illumination variance [4, 5]. Preprocessing is very important for the good performance of character segmentation. Firstly, image is filtered for enhancing the image and removing the noises and unwanted spots. During the threshold processing on a gray scale Image, many small objects or points accrue in the threshold image due to the problem of different illumination, low quality cameras and motion effect. This kind of noise gives direct effect on segmentation and recognition process. We have used a morphological process which search the entire image for small connected elements and remove it.Then dilation operator is applied to the image for separating the characters from each other if the characters are close. After this stage, partition scanning is proposed to extract characters from plate. This method is conducted by checking the mean of each partition in image (the size of partition of a character or background. In this process, the background is defined as white (1) and characters are defined as black (0). After some experiments, it is concluded that the optimum threshold value is nearly 0.7-0.8. Partition value larger than 0.7-0.8 is considered as background, otherwise it is considered as character. Then the plate is divided into two blocks. The first block contains digits, and the second block contains the letter (Figure 4).

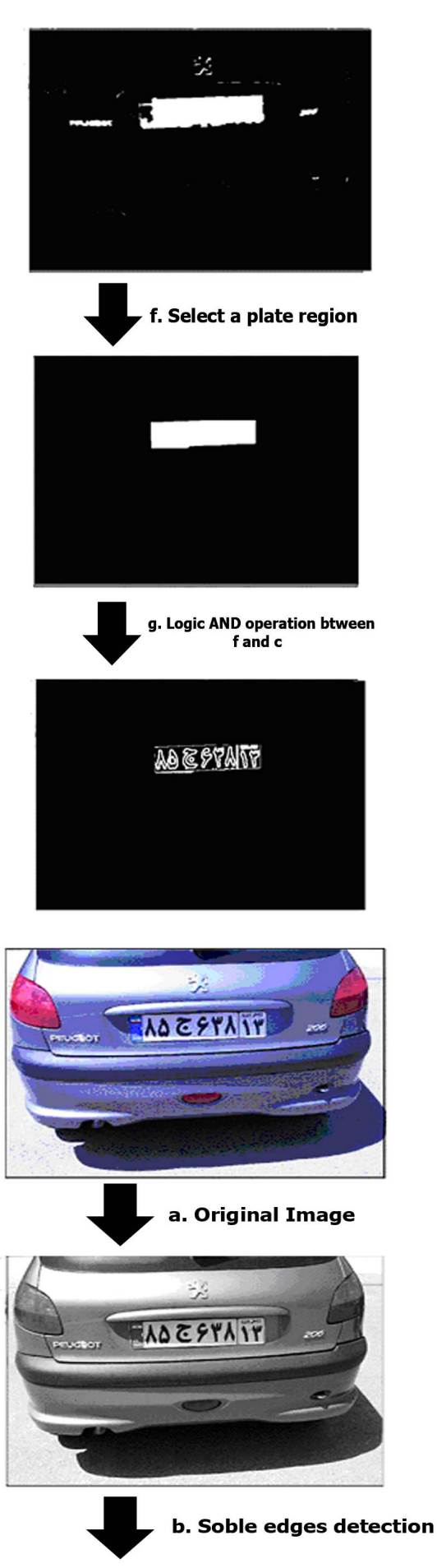

Fig3. Vehicle plate detection procedure

Fig4. Some samples of Iranian plates

D. Character Recognition using Template matching

Before employment of the recognition algorithm, the characters would be normalized. Normalization is to refine the characters into a block containing no extra white spaces (pixels) in all the borders of the characters. Then each character is fit to a 38x20 block as shown in Figure 5. Fitting approach is also necessary for template matching. For matching the characters with the database, input images must be equalizing to a 38 x 20 block with the database characters. In this system the characters are fit to 38x20. The extracted

characters cut from plate and the characters on database are now equalized. The next step is template matching. Template matching is an effective algorithm for recognition of characters. The characters' image is compared to the ones in the database and the best similarity is considered. To measure the similarity and find the best match, a statistical method correlation based is used. Correlation is an effective technique for image recognition. 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. This system used the database as the Iranian license plates characters all 25 alphanumeric characters (16 alphabets and 9 numerals) with the size of 38x20.

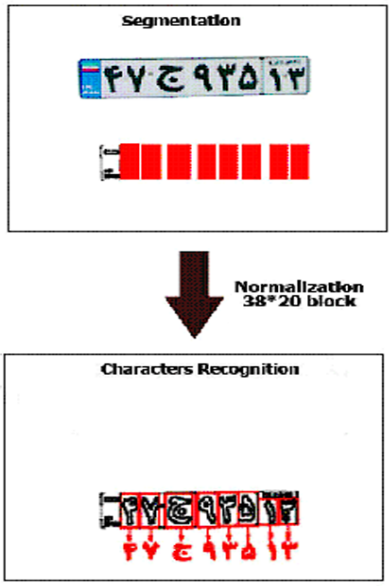

Fig5. Segmentation, Normalization, and the final Character Recognition

Due to the similarities of some characters, there may be some errors during the recognition phase.

The confused characters mainly are "ب" and "ت". To increase the recognition rate, some properties of each character are used in the system for the confused one to define their special feature of vectors. With these feature the applied tests show a serious increase in the correct recognition rate.

III. Results

Experiments have been performed to test the proposed system and to measure the accuracy of the system. The input images are colored images with the size of 640x480. The test images were taken under various illumination conditions and distance. The results of the tests are presented in Table 1.

It is shown that accuracy for the extraction of plate region is %97.3; %94 for the segmentation of the characters and %92 is the percentage of accuracy of the recognition unit. Tested on ten different cars, Figure 6 shows the outcomes of the system.

TABLE1. EXPERIMENTS RESULTS

Applied stages	Number of correct detection	Percentage of Accuracy (%)
Extraction of Plate Region	146/150	97.3%
Segmentation	141/150	94%
Recognition of Characters	138/150	92%

IV. Discussion

The basic elements of a CLPR (Car License Plate Recognition) system are presented in this paper, generally accenting on the problems of LPL (License Plate Localization) instead of the LPCR (License Plate Character Recognition) therein. This reflects the LPL specifics of CLPR application, where the problems of LPCR are usually considered priori resolved by usage of conventional OCR (Optical Character Recognition) software. The goal of the research is to investigate the possibility to create a comprehensive system for multinational vehicle identification based on the license plate recognition. In that case no additional hardware such as transmitters mounted on the vehicle or additional sensors are required. The preliminary results obtained on real data are quite satisfactory. They could be summarized as follows:

- Reliable verification of the plate candidate generated at the phase of localization is achieved
- Accurate plate segmentation under varying illumination and various image distortions is obtained.

In vast majority of classes the plate was contained into one of the detected prospective horizontal strips (plate candidates). Only few images of extremely poor quality (poor contrast and missing part of the plate) attempted more than three prospective strips.

V. Conclusion

In this paper, we presented a novel method of identifying and recognizing of Iranian car license plates. Firstly we extracted the plate location, and then we separated the plate characters by segmentation and applied a correlation based template matching scheme for recognition of plate characters. This system is customized for the identification of Iranian license plates. The system is tested over a large number (more than 150) of images, where this algorithm performs well on different types of vehicles including Iranian car and motorcycle plates as well as diverse circumstances. Finally it is proved to be %97.3 correct in the extraction of plate region and %94 correct in the segmentation of the characters and %92 in the recognition of the characters. We believe that this system can be redesigned and tested for multi national car license plates in the future time regarding their own attributes.

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Fig 6. The outcomes of the LPR system, car images, localized car plate, and recognized characters in different test images