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Car Plate Recognition Using the Template Matching Method

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***Abstract*— One of the most important topics of intelligent transportation system (ITS) is the License Plate Recognition (LPR). LPR systems have many potential applications in intelligent traffic systems, such as the payment of parking fee, highway toll fee, traffic data collection, traffic monitoring systems, traffic law enforcement, security control of restricted areas and so on. Generally, LPR was developed to identify vehicles by the contents of their license plates. The LPR system consists of four major modules: image acquisition, license plate extraction, segmentation and recognition of individual characters. This paper presents a study of applying the template matching approach for character image recognition. The new approach can be applied equally to Egyptian and Saudi Arabian cases and can be extended to cover more countries. It is based on keeping the names of these countries along with a list of Arabic characters as entries in a table and then matching these entries one by one with the car plate. The new approach is tested on 400 samples of extracted license plate images captured in outdoor environment. The result yield 90% recognition accuracy, the method takes 1.6 seconds to perform the car plate recognition.**

***Index Terms*—license plate recognition, template matching, moving window.**

I. Introduction

License Plate Recognition (LPR) is one kind of intelligent transport systems and is of considerable interest because of its potential applications to areas such as highway electronic toll collection, traffic monitoring systems and so on. It can be considered as a logical complement for automatic radar and red-light running systems. Such systems are developed to identify vehicles by the contents of their license plates. The fundamental issues in number plate recognition are high accuracy and high recognition speed [1-5]. Due to the rapidly increase in number of vehicles across the world's big cities and one of them is Cairo, license plate recognition system has become one of the most important digital image processing systems to be used. The field of LPR and its application has attracted many researchers to search and develop systems which can process images and get useful information from them. Most previous researches and applications have faced some kind of poor performance due to the diversity of plate formats, the non uniform outdoor illumination conditions during image acquisition, noisy patterns connecting characters and poor edge enhancement. Accordingly, these researches and applications have in some way restricted their working conditions, such as limiting them to indoor scenes, stationary backgrounds, fixed illumination, fixed type of license plate, limited vehicle speeds and designated ranges of the distance between camera and vehicle. Several techniques have been developed to achieve this job. The artificial neural network method has shown good accuracy but long processing time and a need for periodical training for better accuracy. Template matching theorem has been used widely for recognizing the segmented characters and numbers. Template matching method has shown high accuracy but requires efficient searching method and needs a large storage to save all the numbers and character templates. Fuzzy logic technique has been used to recognize the plate's segmented elements showing high performance, accuracy and short processing time. However, it is sensitive to the noise and distortion. Generally, the LPR system consists of four modules: image acquisition, license plate extraction, segmentation and recognition of individual characters. The structure of such systems is shown in Fig.1.

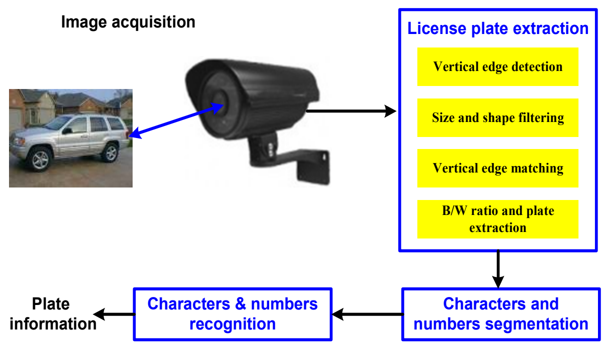

Fig.1 License plate recognition system

The image acquisition is the first phase in the LPR system where the image is acquired through digital camera, video camera or analog camera and scanner. The acquired image may be converted to a grayscale image to facilitate the extraction of the license plate. The first step of license plate extraction process is locating the plate within the car image. This step is achieved through four steps: vertical edge detection, size and shape filtering, vertical edge matching and B/W ratio and plate extraction. For the transformed grayscale image, its corresponding vertical edges are detected using Sobel or Prewitt edge detectors. Sobel edge detector shows better results. The threshold used by the edge detector is dynamic because the system takes an automatic value from the algorithm. The Sobel edge detector uses a 3×3 mask, which is applied on the input image to give the resultant edged image. It is observed that most of the vehicles usually have more horizontal lines than vertical lines. To reduce the complexity of the algorithm, the vertical edges are detected. If two of the vertical edges are detected correctly, the four

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corners of the license plate can then be located. This helps in extracting the license plate exactly from the input image, even if it is out of shape. After the extraction phase, the license plate is segmented into individual characters according to the plate types used in the country. The last phase is character recognition and it is divided into two stages: Normalization of individual characters and recognition using template matching. Normalization is to refine the characters into a block containing no extra white spaces (pixels) in all the four sides of the characters.

II. The Suggested Approach

Unlike the traditional methods for number plate recognition, the proposed algorithm does not need the segmentation process of the input image of number plate. The new approach begins directly after the license plate extraction phase; and will be called herby as information recognition phase (IRP). Usually, the number plate consists of two main sections. The upper section contains the name of the country and the lower part is for the number plate which consists of three or four alphabetic characters and three or four numbers. The recognized information should include the name of the country to which the car belongs and the characters and numbers of this car's plate. The suggested database of the new approach includes an image set for names of the countries included in this system. Currently, there are only two countries: Egypt and Saudi Arabia (Fig.2a). The set can be extended to include more Arabic countries. In addition to the countries names set, the database includes two character image sets. The first set includes all the 38 Arabic alphanumeric characters used in the Egyptian license plates (28 alphabets and 10 numerals) (Fig.3a). The second set is similar to the first one except that it matches the font used in the Saudi Arabian license plates (Fig.3b). The text names of the countries and the alphanumeric characters corresponding to these images are listed in two separate tables (Fig.2b and Fig.3c respectively). Fitting approach is necessary for template matching. The characters included in the database are equal-sized and are fitted to 36 x 18 pixels. The images of the license plates are also equal-sized and are fitted to 240 x 100 pixels. Accordingly, the size of each character in the license plate image is 36 x 18 pixels.

a)

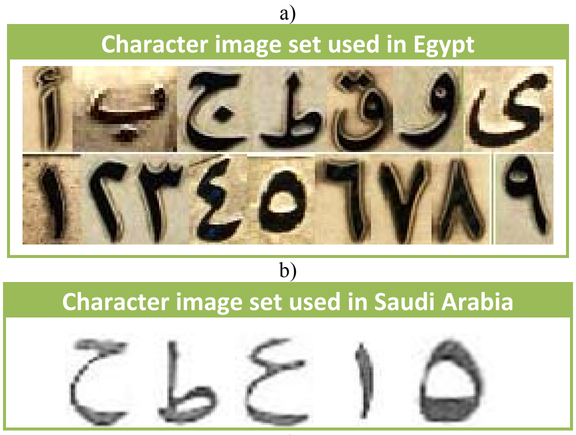
b)

مصر	السعوديه

Fig.2 a) countries images b) countries names

The next step is template matching. Template matching is an effective algorithm for recognition of characters [6]. IRP has been designed and implemented using Microsoft Visual Studio C# software. To recognize the country name, the license plate image is loaded as the main image then the first image entry of the countries images set is loaded as an object. The moving window with template matching method is applied to detect that object within the image. If the answer is "yes" then the name of the country corresponding to the country name image is retrieved from the countries names table. If the answer is "no" the next country name image is loaded as the object and this procedure is repeated. To recognize the characters and numbers of the license plate, the same procedure is performed loading the characters images, one by one, as objects to find out which of them are matching with characters and numbers included in the license plate. The text characters corresponding to those objects are then retrieved from the characters and numbers table. The flowchart of the proposed algorithm is illustrated in Fig.4.

a)



c)

ا	ب	ت	ث	ج	ح	خ	د	..	ي	0	1	2	3	4	5	6	7	8	9

Fig.3 a) A sample of characters images (Egypt)
b) A sample of characters images (Saudi Arabia)
c) The corresponding character set

III. Moving Window With Template Matching Method

Moving window using the template matching method (sum of squared differences) is a common and practical technique utilized in many pattern recognition applications [7,8]. The template matching method gives high recognition accuracy and reduces the processing time compared to other methods such as cross-correlation. The applied method computes the sum of squared differences in each position while the word image we want to recognize moves over the background template. The point where the sum of squared difference is less than a preset threshold will be considered as the point of matching. The proposed moving window template matching scheme is illustrated in Fig.5. First a window containing an object with size smaller than that of the main image is defined. Only a portion of the image is visible through this window. The template matching function is performed between the object in the window and the corresponding area of the image. Then the window is shifted and the template matching function is carried out between the object in the window and the new part of the image visible through the window. Thus, the window is moved left to right and top to bottom in single pixel displacement steps until the entire image is covered and template matching is carried out for all different window positions. Mathematically, distance measure is a measure of the similarities or shared properties between two signals. The distance metric commonly used is the Minkowski metric $d(x,y)$ [9]:

$$\boldsymbol{d(x,y)} = \left(\sum_{i=1}^{N} |\boldsymbol{x_i} - \boldsymbol{y_i}|^r\right)^{1/r}$$

where ***X, Y*** are two ***N*** dimensional feature vectors, and r is a Minkowski factor. And when r is 2, it is actually Euclidean distance.

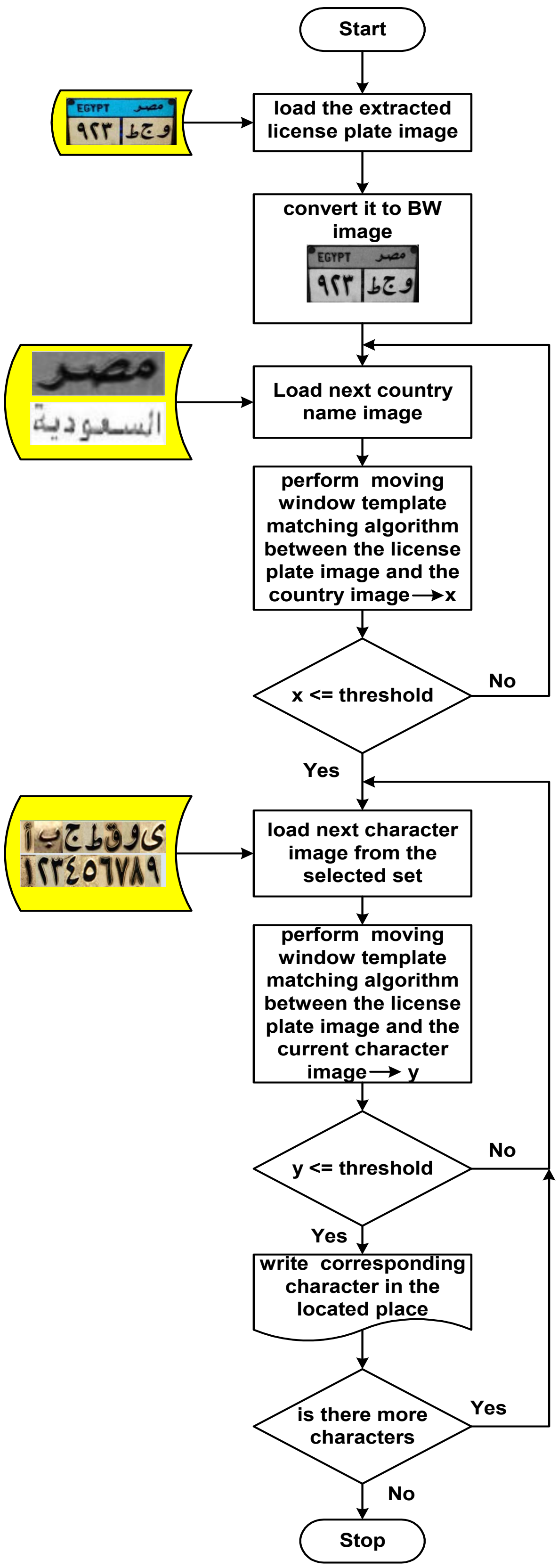


Fig.4 Flow chart to illustrate the suggested approach

In our case there are two discrete signals ***f, t*** represent two images denoting the object to be searched and the template respectively. The object is of dimension ***I x J*** pixels and the template is of dimension ***M x N*** (Fig.5).

$$\boldsymbol{d^2(x,y)} = \sum_{i=0}^{I-1}\sum_{j=0}^{J-1}[\boldsymbol{f(i,j)} - \boldsymbol{t(x+i, y+j)}]^2$$

$$x = 0,1,\ldots M-I, \quad y = 0,1,\ldots,N-J$$

where the sum is over ***i, j*** under the window containing the feature positioned at ***x, y***.

To reduce the computing time, the above equation can be simplified to Manhattan distance:

$$\boldsymbol{d(x,y)} = \sum_{i=0}^{I-1}\sum_{j=0}^{J-1}|\boldsymbol{f(i,j)} - \boldsymbol{t(x+i, y+j)}|$$

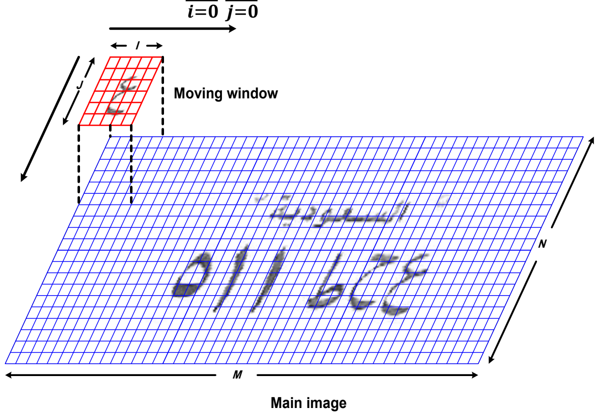


Fig.5. Moving window template matching scheme

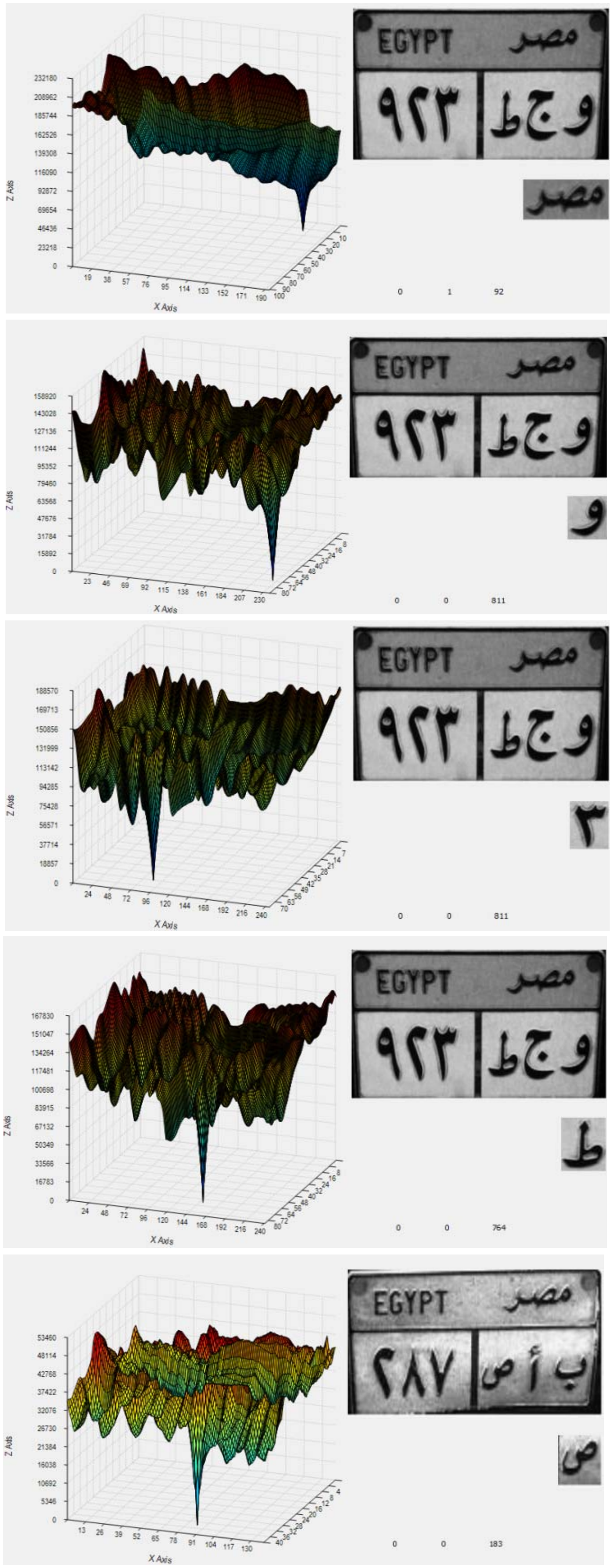
IV. Experimental Measurements

The prescribed moving window template matching algorithm has been implemented in C#, and compiled on a Windows-based PC using Microsoft Visual Studio. A variety of country names, characters and numbers are used through this primary test. Fig.3 shows some of the characters and numbers images included in the database with two different fonts to match the fonts used in Egypt and Saudi Arabia license plates. The software program has been improved several times to reduce the processing time to the minimum value. A large number of Egyptian license plates acquired in different environments have been used in the test phase to determine the most suitable threshold for similarity as shown in Fig.6-a. Another number of Saudi license plates have been acquired and processed in the test phase (Fig.6-b). It can be easily noted that the distance measures for the Saudi plates have higher peaks than that for Egyptian ones. It can be referred to the fact that the Egyptian plates have colored background while the Saudi plates have white background. The size of the moving window is an important criterion in determining the system performance. The threshold corresponding to minimal error has been determined. The relation between the minimum error (minimum distance between the object in the moving window and corresponding area in plat's image) and the standard deviation of the distance measure is control factor for determining the threshold. It has been found that ***R = 0.4*** is safe threshold.

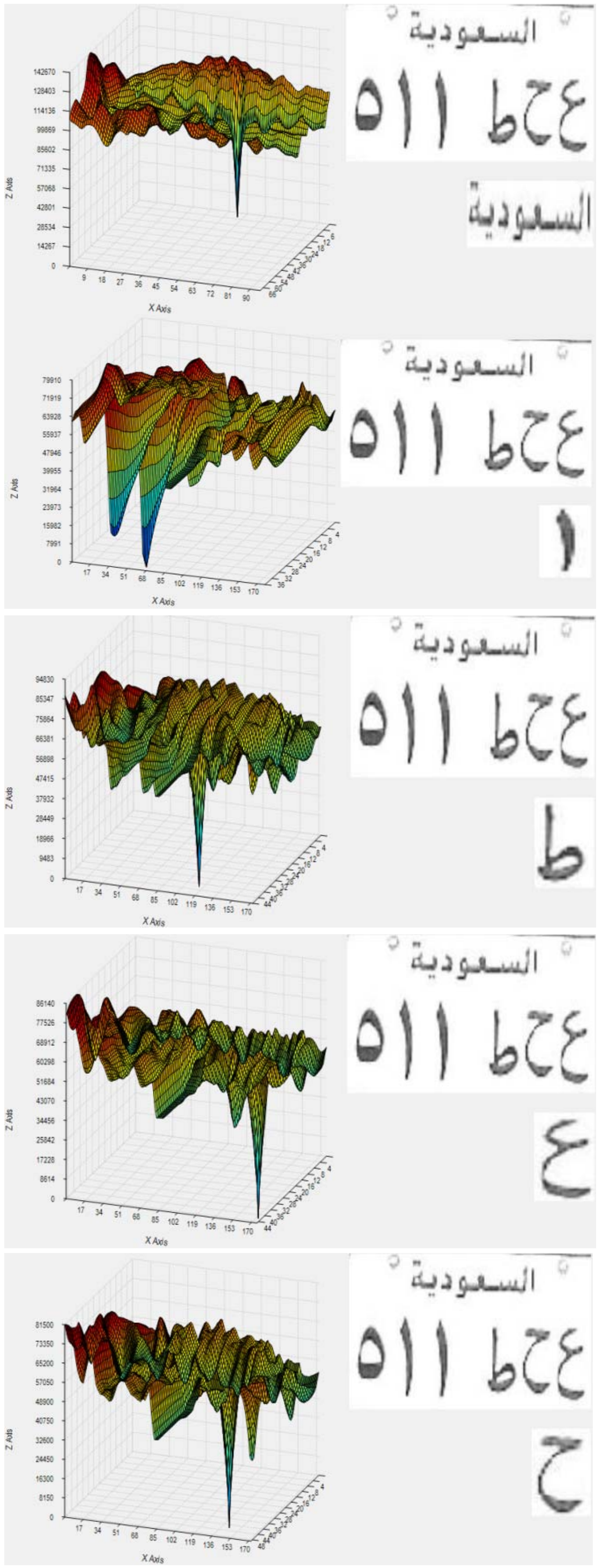
$$R = \frac{d_{min}}{standard\_deviation}$$

$$= d_{min} \Big/ \sqrt{\left(\sum_{x=0}^{M-I}\sum_{y=0}^{N-J}\left(d(x,y) - \tilde{d}\right)^2\right) \Big/ \left((M-I)(N-J)-1\right)}$$

a)



(b)



a: Egyptian case b: Saudi case

Fig.6: Illustration of the threshold determination:

Where d_{min}, $\tilde{d}$ are the minimal error and the average error respectively.

The time required for recognizing one plate is another important criterion in determining the system performance. It has been found that the average time required for detecting one character is 150 ms, and for detecting the country name is

280 ms. The overall time is 1.6 ms. The graphic user interface used in the test phase is shown in Fig.7.

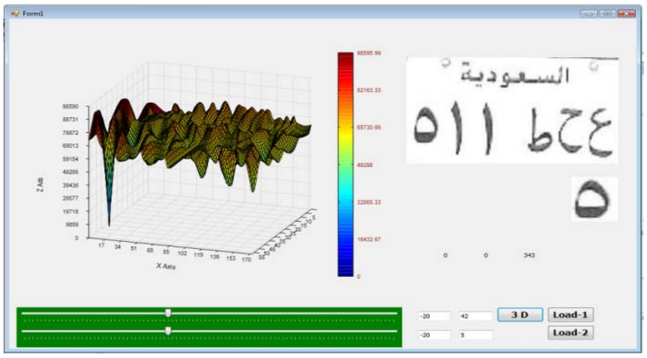


Fig.7: The Graphic user interface used in the test phase

V. CONCLUSION

A new license plate recognition system based on moving window matching algorithm has been implemented. The distance measure (squared Euclidean distance) technique has been used for measuring the similarities between the moving window and the plate image. The new approach has been applied equally for Egyptian and Saudi Arabian cases and it can be extended to cover more countries. The method is applied on a test database of 400 samples of extracted license plate images captured in outdoor environment. The result yield 90% recognition accuracy, the method takes 1.6 seconds to recognize plate information. This time can be reduced if the system is dedicated for one country only using one font style character images.

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