An Efficient and Reliable Automatic License Plate Recognition system for Saudi Cars Plate

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Abstract— **Developing an electronic surveillance system that can automatically identify and read the license plate can be extremely important by providing a cheap and effective method of monitoring all passing vehicle. Such surveillance system would have an important role in minimizing human intervention and reducing the difficulties and challenges we face in our daily lives. In this paper, we propose an efficient and reliable automatic license plate recognition system for Saudi car plates. The proposed system consists of three main processes: plate localization, character segmentation and recognition. The system has been tested on real life capturing images and shows very high segmentation and recognition rate**

Index Terms— **license Plate Recognition, License Plate Detection, License Plate Extraction, Neural Networks, optical character recognition**

I. INTRODUCTION

Nowadays with the huge increase in the number of cars in Saudi Arabia, monitoring of vehicles on the road is considered as an important issue that has to solved. Car plate recognition system becomes the most important application especially for traffic department. Instead of using the human capacity to monitor the roads, boarders and the parking's, car plate recognition (CPR) allows automatic monitoring of car plates to help maintain the traffic laws on vehicles on public roads [1].

One example of monitoring control systems is the border control system. The officer will check many of the car plate every day; this will take the time and effort. In addition, it is not feasible to hire full-time officer just to check on the car plate [2]. A second example of monitoring control systems is smart parking systems which assign each car a dedicated parking space for a fee or as a free service. This system helped regulate traffic in front of buildings and companies and avoided crowds resulting from parking randomly [3]. A third example of monitoring control systems is highway vehicle control systems which are used to monitor speed of cars and report cars which exceed the speed limit [4].

Car Plate Recognition is a mechanism used to automatically identify the contents of a car plate with character and numbers to provide the best services for systems based on real-life analysis and processing of problems [5-6].

A vehicle plate recognition system is an important research area in the literature. It consists of three main phases; first one is image acquisition and License Plate Detection (LPD) [7-8]; Second phase is character segmentation and feature extraction [9]; and the third part is character recognition using Neural Networks (NN) [10-12]. There is a challenging task due to the differences in the license plate format, and the outdoor illumination.

The main contribution in this study is the development an efficient Saudi car plate recognition application system based-on multi-layer perceptron neural network. The system has been implemented and tested successfully and achieves very high segmentation and recognition rate.

This paper is organized as follows. Section II presents the literature review and the related works. The proposed license plate recognition system is provided in Section III. In Section IV and V, we provide the system implementation. Finally, the conclusion and future work is presented in Section VI.

II. RELATED WORKS

Many research studies have been carried out in the field of automatic car plate recognition. According to Sarfraz, M. et al. [13] the license plate extracted from a gray scale image by detecting vertical edges using Sobel edge detector filtering which uses a 3x3 mask, then filtering out unwanted regions by applying seed-filling algorithm in Saudi license plates. they suggested using only the vertical lines in the images to reduce the computation time.

Shanhong, and Tang [14] used gray image texture feature in for detecting the car plate from the entire image. Neeraj et al. [15] presented a car categorization algorithm to track vehicle even in the existence of important perspective changes and severe occlusion. They replaced the blob tracking technique that is not suitable to separate vehicle under occlusion with using vehicle outline patterns, camera adjustment and ground plane information.

Different license plate recognition are used by different researchers, such as the techniques based on edge detection and extraction, morphological operations, and histogram analysis [13, 16]. Also, structural verification and Sobel filter has been used for plate localization and segmentation for most license plate detection and recognition systems.

Chang et al. (2004) [17] they proposed license plate recognition system consists of two main parts: plate localization part and a license digit and character identification part. They extracted the license plate from the image and terms of neural subjects for identifying the digits in the license plate. Their experimental results satisfied 97.9% in localization the license plate, and 95.6 in digit recognition.

Manuscript received January 06, 2020

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Basalamah. [18]. He implemented an automatic Saudi license plate recognition system that locates Saudi license plates in images captured in different orientation time. The proposed system obtained good results in plate localization in the first part. The second part was implemented to classify digits in the located license plate.

Bhushan et al. [19] presented a novel algorithm that enhances the extracting of the license plate from low intensity images. They used Multithresholding and neural pattern recognition. The proposed system satisfies a very high recognition rate of 98.4%. They analyzed certain problems in the previous works such as segmentation, blobs extraction, and character recognition.

III. The Proposed License Plate Recognition System

.The proposed system is developed for real time Saudi license plates recognition. The main process starts after input the image with preprocessing, plate localization, segmentation, and recognition. Fig.1 shows the main phases of whole system.

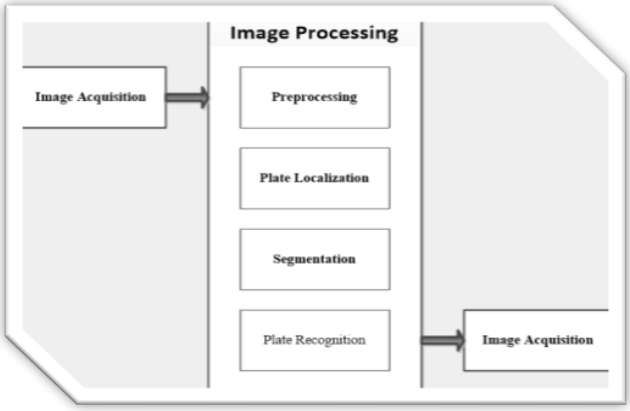

Fig.1 Plate recognition main phases

3.1 The preprocessing Phase

The main reason for doing preprocessing is to enhance and highlight the desired region in the image. The preprocessing phase will be applied on the car plate to be preserved. Preprocessing phase applies many filters on the image to remove the Impurities from the image and to set the plate to be neat as much as possible to be readable. This phase make the plate localization more efficient.

Fig.2 shows the main preprocessing steps.

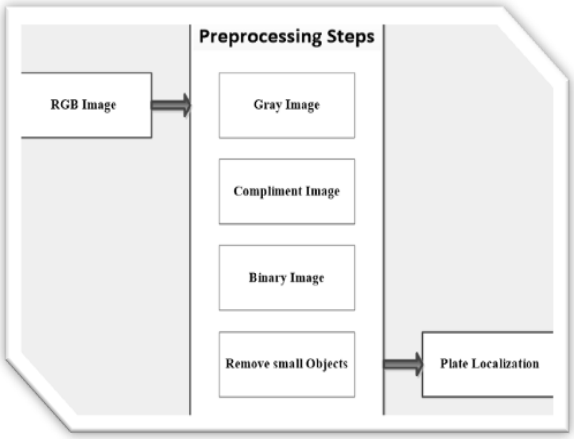

Fig.2 The preprocessing phase

The following steps and filters will be applied:

1. **Gray Image**: Convert the Image into Grayscale.
2. **Compliment Image:** Compliment means reverse each one in the image matrix to zero and each zero to one; so black and white are reversed. In the output image, dark areas become lighter and light areas become darker.
3. **Binary Image:** Convert the gray image to binary image; two colors used for a binary image are black and white. This step makes the segmentation process easier.
4. **Remove small objects**: Removes from a binary image all connected components (objects). This step is applying a morphological erosion operation on the binary image to remove noise.

3.2 Plate Localization

The main goal of plate localization is to identify and extract the car plate from the image. The main idea is to focus on searching in the image to find the rectangle which is the plate of the car.

3.3 Character Segmentation

Character segmentation is the most crucial phase in license plate recognition systems. Character segmentation is the process of extracting characters and digits from the license plate image. To simplify the process of identifying characters and digits, it is desirable to separate the extracted plate image into multiple regions based on thresholding and Connected Component Analysis (CCA). Then each character or digit will be classified as a connected component. There are many factors that cause the character segmentation task difficult, such as image noise, plate frame, rivet, and rotation and illumination variance. Saudi car plates contain both Arabic and English characters. Arabic characters (Arabic letters and Hindi digits) are located in the upper part of the plate whereas English characters (English letters and Arabic digits) are located in the lower part of the plate. Fig.3 shows the two types of Saudi car plates.

Fig.3 Saudi Car Plates.

Pre-segmentation: divide the license plate image into 4 parts as shown in fig.4.

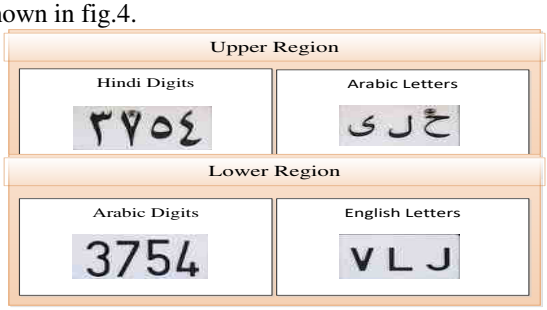

Fig.4 License plate divisions

To extract the Arabic characters or the English characters, there is a horizontal line that splits the image into two regions. The upper part region is the Arabic characters that consist of the Hindi digits and the Arabic letters. The lower part region is the English characters that consist of the Arabic digits and the English letters.
Determining the horizontal line has been implemented by applying an erosion operation to remove all symbols from the plate image. Then the image is divided into two halves according to the horizontal line into upper and lower regions. Then, both the upper or lower parts are further divided into two parts: a left part which contains the digits, and a right part which contains the letters.
The last step of character segmentation phase is the extraction of individual digits and letters from all segments and storing them into separate arrays. The first and second array holds the digits and letters of the upper region. The third and the forth arrays holds the digits and letters of the lower region.

3.4 Character Recognition

Character recognition is the last stage of any car plate recognition system. In this process, each of the segmented regions for the previous process will be recognize using template matching and neural networks.

IV. Implementation and Experimental Results

Our proposed Saudi license plate recognition system has been implemented using MATLAB R2013a (Version 8.1.0.604) environment and MATLAB toolboxes. GUI has been developed as the main panel of the system.

4.1 The preprocessing Phase

After a car plate image is uploaded into the system. The following steps will be applied:

- The image is resized to 640 pixels horizontally and 480 pixels vertically using resize function.
  imresize(Image,[640 480]);
- The resized image is converted into grayscale using rgb2gray function. rgb2gray (Image)
- The Grayscale Image is complemented using imcomplement function. Compliment means reverse each one in the image matrix to zero and each zero to one; so black and white are reversed.
  imcomplement(Image)
- The complemented image is converted into binary image using im2bw function.
  im2bw(IImage,level)
- Applying a morphological erosion operation on the binary image to remove noise using bwareaopen. Removes from a binary image all connected components (objects)thathavefewer than 200pixels.
  bwareaopen(Image,200);

Fig.5 and fig.6 show the car image before and after preprocessing.

Fig.5 the original image

Fig.6 The resulted image after preprocessing

4.2 Plate Localization

The main goal of plate localization is to identify and extract the car plate from the image as shown in fig.7.

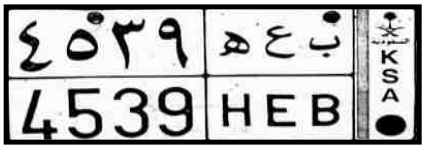

Fig.7 the extracted license plate

The following steps will be applied:

- Label connected components in binary image [L Ne]=bwlabel(imagen);
- Measures a set of properties for each labeled region in the previous step
  propied=regionprops(L,'BoundingBox');
  Where 'BoundingBox' : The smallest rectangle containing the region
- Plot bounding box to cut the car plate and apply OCR to identify the number

4.3 Character Segmentation

Before segmentation the plate, it would be checked to classify it to which its form belong, Classification is based on the ratio between high and width of the plate, after that, the segmentation process will apply on the plate to split each character separately to send it to optical character recognition. The Character are normalized into a size of 42*24, this fixed normalization process is performed to allow the recognition of the segmented characters via artificial neural networks in the character recognition module. Fig.8 shows the character segmentation.

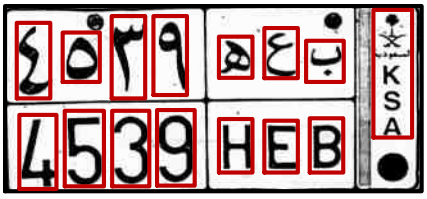

Fig.8 Character Segmentation

In this phase we extracted discriminating features from upper and lower part of the segmented license plate. The extracted features are arranged into arrays called feature vectors which will be used for training the neural network. The last step of feature extraction is storing the feature vectors into 4 matrices (HindiDigits, ArabicLetters, ArabicDigits, EnglishLetters).

4.4 Character Recognition

Artificial Neural Network (ANN) Classifier with Multi-Layer Perceptron (MLP) has been adopted for each matrix resulted from the previous section. MLP are capable of learning non-linear decision boundaries that can increases the versatility of NN for solving real world. The adopted MLP consists of three layers; input layer, hidden layer and output layer. Number of neurons in input layer is varying according to the number of used details coefficient. The experimental results of the MLP NN depend on the number of neurons in the hidden layer and the trained data set.

V. Experimental Results

Fig. 9 shows a real sample of successfully recognized license plate.

Fig. 9 Successfully recognized license plate.

5.1 The data set for training and testing

A sample of 200 images has been taken in a different time of the day. So, the images will have a different illumination. But all images have been captured from the front of the vehicle. the distance between the car image and the camera was between 2 and 4 meters.

5.2 Segmentation Accuracy

The segmentation accuracy for all data sets has been calculated and tested for the digits and the letters separately. The overall segmentation accuracy for the digits and the letters was 100%. No segmentation errors during the process of extracting digits and letters from the car plate images.

5.3 Recognition Accuracy

Four Multi-Layer Perceptron (MLP) Neural Networks has been constructed; two for Hindi and Arabic digits and two for Arabic and English letters. Table 1 shows the parameters used for implementing the NN. Then the constructed Neural Networks has been trained and tested using 75% of the sample images for training and 25% for testing.

Table 1 Neural Network Parameters

Parameter	Hindi Digits	Arabic Digits	Arabic Letters	English Letters
Number of nodes in the input layer	35	35	35	35
Number of nodes in the hidden layer	10	10	28	26
Number of nodes in the output layer	10	10	28	26
Training algorithm	Levenberg - Marquardt	Levenberg - Marquardt	Levenberg - Marquardt	Levenberg - Marquardt
Activation function of hidden layer	Tansig	Tansig	Tansig	Tansig
Activation function of output layer	Logsig	Logsig	Logsig	Logsig

The systems show 100% recognition rate for the Hindi and Arabic digits. The recognition rate for the English letters around 97 % and there is a very low rate for the letters T and D. The recognition rate for the English letters could be increased if we take the corresponding letter in Arabic to make sure from the English letter. We used the upper and lower digits and letters to increase the recognition rate.

The developed system shows very high and acceptable recognition rate in comparison with other Saudi recognition plate existed in the literature [8], [13]. In addition to that, the recognition rate is very high in comparison with other License plate that does not have any letters.

Conclusion

The proposed system detects and recognizes the Saudi license plates under complex scenarios such as variation of illumination, and scales. The developed system shows an efficient technique for localization, segmentation, feature extraction, and character recognition. The system has been developed using matlab and matlab toolboxes. Good results have been obtained. The accurace of the segmentation was 100%. The character recognition part has been implemented using 4 MLP neural networks; two for the Hindi digits and two for. The tested neural network shows very high recognition rate for the digits and the letters in the upper and lower part of the license plate. Further work can be added by using a more robust comparison method in the recognition part of by comparing the digits and the letters in the upper part with the corresponding digits and letters in the lower part to increase the accuracy of the recognition. The accuracy could be increased if we increase the number of training and testing images.

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