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Car license plate segmentation and recognition system based on deep learning

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ABSTRACT

Artificial intelligence techniques and computer vision techniques dealt with the issue of automatic license plate recognition (ALPR) that has many applications in important research field. In this paper, the method of recognizing the license plates of Iraqi cars was applied based on deep learning techniques convolutional neural network (CNN). The two database built to identifying Iraqi car plates. First database includes 2000 images of Arabic numbers and Arabic letters. Second database conations 1200 images of the Arabic names for Iraqi governorates. This paper used image-processing techniques to segmenting the numbers, letters and words from the car license plate images and then convert them into two databases that used to train the two CNN. These training CNN used to recognizing the vocabulary of the car license plate. The success rate of the numbers, letters and words recognition was 98%. The overall rate of success of this proposed system in all stages was 97%.

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1. INTRODUCTION

The vehicle license plate detection (VLPD) technology used in smart cities and electronic garages of many countries around the world and it most used on the roads to record information about speeding cars or to know the location of stolen cars [1], [2]. Each country has its own license plate style that is designed by the government of that country [3], [4]. LP form consist of numbers, letters and words written in the language of that country [5]. For example, the structure of the Iraqi license plate consists of several sections and each section needs own processing to recognize its contents [6]. Therefore, to recognize Iraqi license plates need a smart system, which is effective, fast, works automatically, and its design reduce human interference in the work of the system [7]. The Iraqi car license plate written in Arabic language that carries some complexity in the process of recognizing its words. This complexity represented by dividing each word separately and then dividing the words into letters [8], [9]. Deep learning techniques are the best method to recognizing Arabic numbers, letters and words [10], [11].

The VLPD is the topic that has attracted many researchers and publish many papers on it as [12], [13]. Quiros *et al.* [14] used K-Nearest Neighbors (KNN) algorithm for segmenting the contours inside the plate that computed and evaluated after obtaining the image of plate. Whereas Tarigan *et al.* [15] used the genetic algorithm to improve "backpropagation neural network" that applied on the license plate of the car to get the slicing of numbers and letters correctly. Also before everything, they applied some preprocessing to improve the image. While Kyaw *et al.* [16] worked on the identification of car plates in Myanmar by doing

some preprocessing and noise removal to extract the license plate from the image of the car. In this context, they applied the K-means algorithm to extract the exact license plate vocabulary. As for Saif *et al.* [17] used YOLO to segment the license plate image into characters and words and then classified these characters and words. While Choong *et al.* [18] provided a system to segment characters of the cropped license plate from a digital image that has a white color background and black color characters, also they used "connected component analysis" (CCA) method in that system to separate the black pixel.

Masood *et al.* [19] treated the system's technology that based on a series of deep "convolutional neural networks" (CNNs) to work with a variety of LP templates. Whereas Menon, and Omman [20] utilized plate recognition method for Spanish number plates. In addition, they detecting the LP segmented the character's plate and using a machine-learning method to predict the character. While Lin *et al.* [21] proposed an efficient hierarchical LP recognition system by the combination of the YOLOv2 model with SVM, which allows for high-accuracy license plate acquisition. Whereas Hendry and Chen [22] worked on car plates in Taiwan that generally, consist of six elements. In addition, they used the sliding window single class detection (SWSCD) method to build a neural network consisting of 36 classes that work in different conditions. As for Henry *et al.* [23] presented a high accurate deep ALPR system, which is applicable to deferent LP from seventeen countries and they using tiny YOLOv3 network to detect the LP region. Moreover, they used YOLOv3-SPP to recognition the character. This paper, divided into for section. The proposed method in section two and the result in section three. The last section is the conclusion.

2. THE PROPOSED METHOD

In this paper, a smart system was presented to recognize the license plates of Iraqi cars of the model that appeared in 2012 (the German model). It is a continuation of the previously published paper [24] in which a method for the detection of Iraqi car license plates was presented with a method for splitting the LP and recognizing the color of the left side of the LP.

Here, the process of segmenting numbers and letters are doing by using image-processing techniques (edge detection and find contours). While, the recognition of numbers, letters and words are doing by using deep learning techniques. CNN is the deep learning technology that has been used. CNN is very successful in the field of computer vision and image processing because it has better feature extraction than other techniques [25], [26].

This paper is divided into four stages. The first is segmenting the license plate into sections. The second is separating the license plate numbers and letters. The third is recognizing the numbers and letters of the license plate resulting from the second stage using a CNN. The fourth is recognizing the image of the province resulting from segmenting it in the first stage using a CNN.

2.1. License plate segmentation

When the Iraqi car license plate entered this stage, some image processing operations were performed on it to cut the plate vertically and horizontally to obtain four parts (the left side part, the upper part - the number part-, the lower part and the lower right part - the governorate part -) [24] as show in Figure 1.

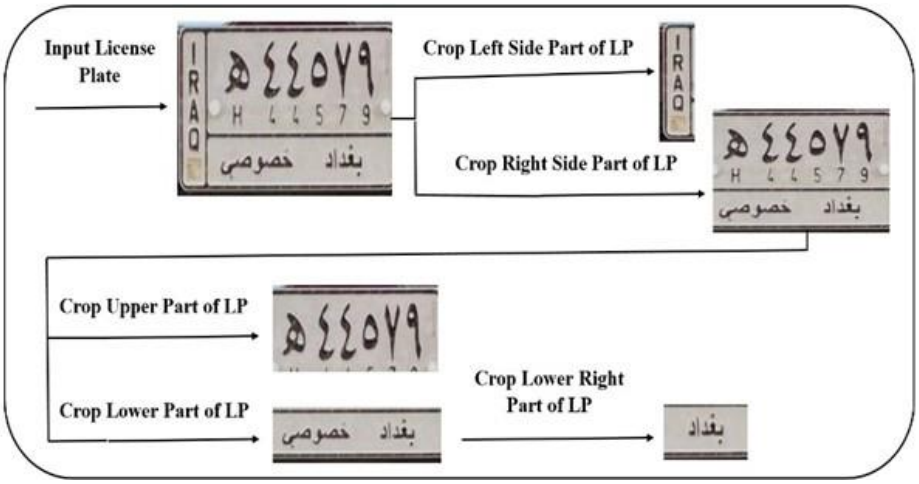

Figure 1. License plate division

2.2. Character separate

Figure 2 represents the workflow of segmenting the number area of a license plate (LP). The following algorithm is represent the method to segmenting the number area of a license plate.

Algorithm: character separation

Input: The image of the upper part of LP

Output: The letter and numbers of LP.

Step 1: Enter an image of the license plate part that contains the LP numbers and letters.

Step 2: Preprocessing the input image (resize LP, gray scale LP, bitateral filter, canny edge) to extract features from it.

Step 3: Remove some unwanted vertical and horizontal lines from the image.

Step 4: Use the morphology technique to find contours.

Step 5: Draw a rectangle surrounding the detected object.

Step 6: Test the area, perimeter and Aspect Ratio of the detected object. If they attain the conditions specified in Table 1, then complete the next step and not go to step 4 (find contours).

Step 7: Cropped the characters, perform background removal, and padding on it.

Step 8: Store the letters and numbers as inputs the numbers and letters recognition stage.

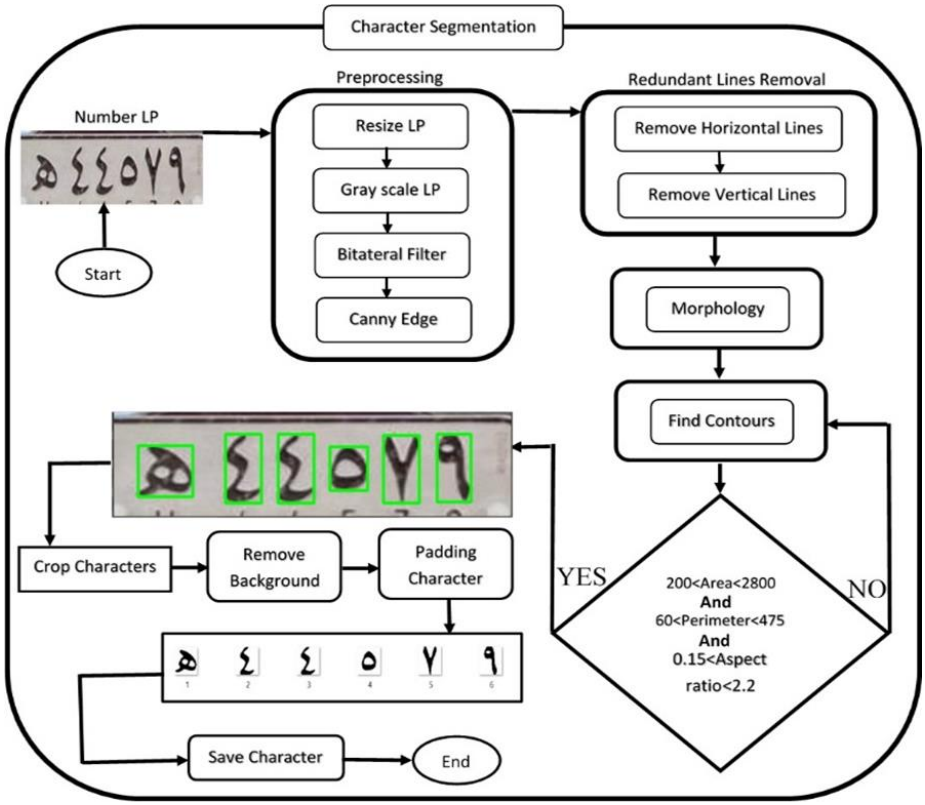

Figure 2. The steps of character segmentation

The values in Table 1 were determined and approved after noting the features of the numbers on the Iraqi license plate (Arabic numerals). It is noted that the area values start from (200 pixels) to match the area of the number zero, which occupies a small area compared to the rest of the numbers while ending with the number (2800 pixel) to match the area of the number seven and eight of the largest width.

Table 1. The conditions for character segmentation

Parameter	The equation	Minimum	Maximum
Area	Width*Height	200 pixel	2800 pixel
Perimeter	2* (Width + Height)	60 pixel	475 pixel
Aspect ratio	Width/ Height	0.15 pixel	2.2 pixel

2.3. Character recognition

This is the stage of training and recognizing the numbers and letters resulting from the previous stage: the segmenting stage.

2.3.1. Data collection

The dataset consists of 2000 images of numbers and letters extracted from the segmentation character of LP stage. These images were divided into 22 classes represented by numbers from 0 to 9 and some Arabic letters that are very repetitive in Iraqi car license plates. In addition, the dataset was divided into the train set and the test set with a ratio of 0.7 for the train set and 0.3 for the test set.

2.3.2. CNN architecture

The neural network used in this work consists of an **Input** layer, six **Convolution** layers, three **Maxpooling** layers, a **Flaten** layer, and two **Dense** layers, as well as using **Relu** and **Softmax** for activation function [27] as shown in Figure 3.

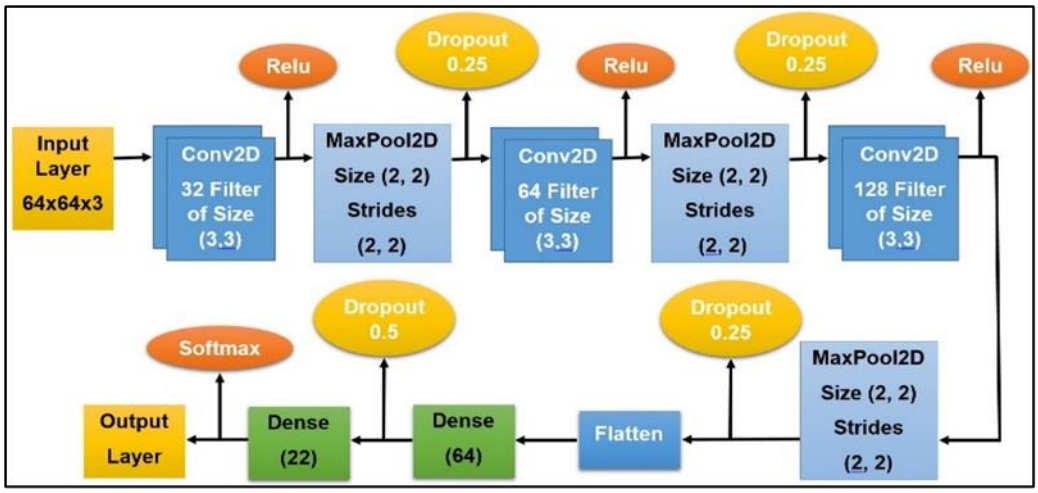

Figure 3. CNN architecture

2.3.3. Model training

After building the CNN, work continues to train the network. To achieve this, the following parameters in Table 2 need to be used. After training the data and after epochs=20 the results for the training data and testing data were in Table 3, Figure 4, and Figure 5.

Table 2. The parameters for training CNN

Function	Value
Optimizer	Adam
Loss	Categorical_Crossentropy
Metrics	accuracy
Batch size	32
Epochs	20

Table 3. The results for training CNN

	Function	Value
training	Accuracy	0.9883
	Loss	0.0392
testing	Accuracy	0.9799
	Loss	0.0705

2.4. Governorate recognition

To recognize which province the car belongs to, the results of the first stage (the license plate division stage) were used. The lower right part of the car license plate shown in Figure 6 was used to create a

dataset that includes 1200 images of the names of the provinces distributed into two groups (training, testing) and each group contains 15 classes from each category. Each group represents one of the governorates of Iraq (Baghdad, Al Basra, Al Muthanna, Dhi Qar, Wasit, Nineveh, Al Anbar, Kirkuk, Maysan, Al Najaf, Karbala, Salah al-Din, Al Qadisiyah, Diyala, Babil). The same deep learning model that was used to recognize numbers and letters was also used here, but the input layer was with dimensions (64, 128, 3) and the number of the class was 15 with Epochs=50. After 50 Epochs, the results of the training data and testing data were in Table 4 and Figure 7, and Figure 8.

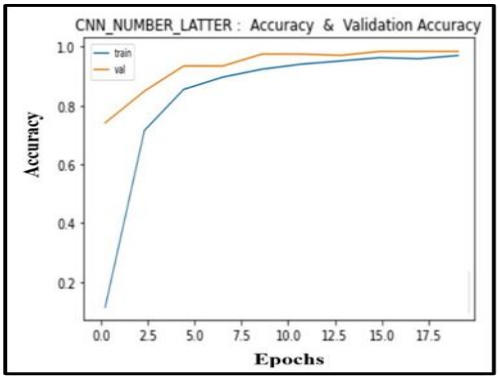

Figure 4. Accuracy function for character recognition

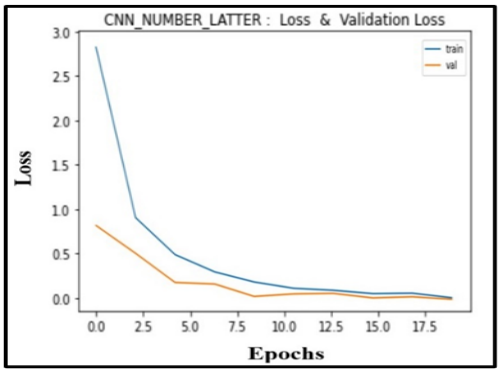

Figure 5. Loss function for character recognition

Figure 6. The lower right part of the car license plate samples

Table 4. The results for training CNN

	Function	Value
training	Accuracy	0.9824
	Loss	0.0177
testing	Accuracy	0.9722
	Loss	0.0332

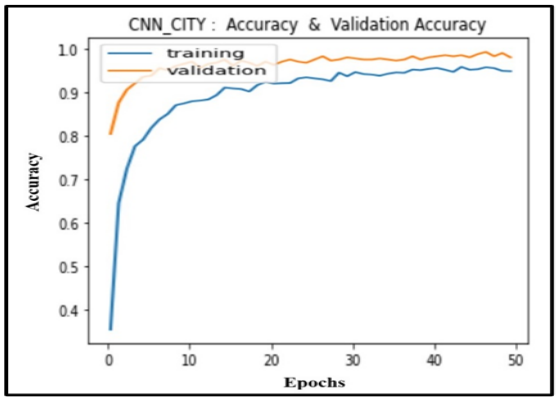

Figure 7. Accuracy function for governorate recognition

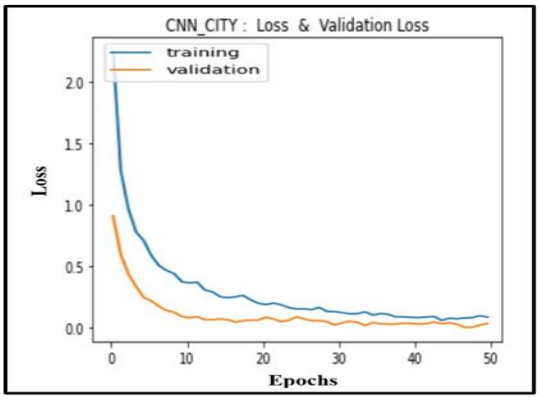

Figure 8. Loss function for governorate recognition

3. THE RESULTS

This work was tested on 500 images of cars bearing Iraqi license plates (the German model) and the results were good in terms of accuracy of identification and efficiency of division to extract the words, letters, and numbers found in the license plate. In addition, there were several images of the cars on which they were tested tilted at an angle; however, good results were obtained. Figure 9 represents one of the worst cases dealt with by the system. In addition, there are many bad cases that the system has been tested on, and the efficiency rate of the system was in the lagging stage, starting from discovering the license plate until giving the results of recognition up to 98%.

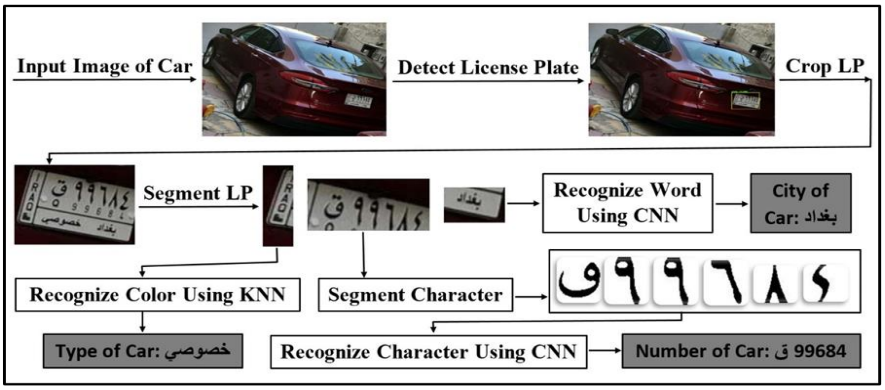

Figure 9. The results of the proposed work

4. CONCLUSION

In this paper, a successful algorithm for car license plate recognition based on image processing techniques and deep learning techniques presented. This research focused on Iraqi car license plates, which consist of more than one line, more than one region and contain much vocabulary. The side part of the license plate is multi-colored, depending on the type of car (government, private, taxi, and carry car). The upper part of LP includes the number of the car and the letter accompanying it, while the lower part contains the name of the governorate to which that car belongs, in addition to car type.

The deep learning technology used to detect the location of the license plate in the input image by the single shot detector (SSD). Then the detected license plate was entered to the partition algorithm based on the techniques (the vertical projection and the horizontal projection). So, the other processing operations will be facilitated. As for the process of segmenting license plate numbers and letters, image-processing techniques (edge detection and find contours) were used to divide them into small images that are easy to recognize by using the CNN.

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