Plate Number Recognition Using Segmented Method With Artificial Neural Network

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***Abstract*—This article presents a license plate number recognition system for moving vehicles for Turkish license plates. The proposed system is designed to read information of vehicle plate numbers automatically from digital images for many purposes; such as over-speed control, parking areas, traffic control, and top governmental agencies, etc. The proposed system mainly consists of two stages: the first stages are the recognition process which consists of vehicle detection from license plate number, localizing and plate position estimation, segmentation of words and numbers, and license plate recognition stage. The second one is the use of the neural network; three different types of networks were used. (pattern net, perceptron, and multi-layer neural network). simulation result indicated that pattern net has a very good performance in recognizing the license plate image compared to the other two types of networks. Also, has the advantage of less training time compared to other types of neural networks.**

Keywords— License Plate Recognition (LPR), License Plate Detection, Optical Character Recognition, Neural Network, Image Processing, Machine Learning

I. INTRODUCTION

Plate number recognition is an artificially intelligent and advanced computer vision technology that is used in intelligent transport systems (ITS). Also, License plate number recognition involved image processing techniques that automatically detect the license plate image and recognized its characters on it without human intervention. It's a very important area of research that has a wide range of applications such as; over-speed control, automatic toll collection [1], road traffic control [2], parking areas. It can also be applied in tracing stolen cars among others [3].

The attainment of license plate number recognition varies from the country; in some countries, their license plate is complex while others are simple. Therefore, the success of the license plate number depends on the simplicity and absence of illumination [4]. The use of intelligent systems has brought a tremendous effect on our daily lives. Thus, most of the companies are promoting computer vision research are now embedded into most of the intelligent systems to capture physical images and process them. This work aims to design and implement an efficient plate number recognition system with an intelligent device that operates in real-time[5]. A desired licensed number plate for recognition system used digital image processing techniques for detecting and recognizing characters of the license plate number and produced an output result as characters as a string[3,6].

Plate number recognition consists of three major stages: the first stage consists of vehicle detection from license plate number, edge detection, and extraction techniques were used are among the techniques. the second stage is the segmentation of characters in which Vertical and horizontal projection analysis are the techniques used in the second stage. The last stage is to recognize the characters, the letters and numbers are classified using an artificial neural network (ANN). This recognition of characters is part of the system which is carried out by the ANN network [7]. These processes are quite challenging because some of the images were taken with different backgrounds, angles of illumination, different plate formats during image acquisition [8]. Some of these sample images are shown in Fig. 1. To overcome such problems, this work proposes the application of an image enhancement technique using median filters [9] to remove noise on the images and also make it a clear and readable image. This study aims to design a plate number recognition system capable of identifying and recognizing Turkey vehicle license plates. Fig. 2 shows the description flow of the proposed plate number recognition system.

II. LITERATURE REVIEW

A lot of research work has been done in the field of plate number recognition. The author in [10] Presented a rapid intelligent method based on its connection with optical character recognition, with a multiple layered perception artificial neural networks (MLPNN) models, in which Pakistan vehicles license plate image recognized in conjunction with the color region. The algorithm is based on real-time features for the different font styles and colored license plate localization as well as recognition. Image can be enhanced by detecting its white region by applying an optimal threshold. The performance analysis of the system was configured by the localization method and recognition method

Fig. 1. Standard vehicle license plate used in Turkey (Private)

Fig. 2. Description flow of the License Plate Recognition System (LPR)

by using the proposed algorithms. For the OCR-based system, the overall performance time was 2.44 and for MLPNN based system, it was 2.74. In [11], the neural network-based method perceptron is trained by setting a few intelligent rules with a sample set. One of the problems with neural networks is training a perceptron which is quite difficult and involves massive sample sets to train the network. If the system is not trained in a suitable method, scale and orientation invariance may not be addressed. In [12], clustering methods using fuzzy C-mean and K-mean were presented. The two methods were for both automating Grabcut and improving segmentation accuracy. Besides, a method called "SOFM clustering" was employed for the automation of the Grabcut which is additional to the user interface for the requirement by the old algorithm. This Grabcut is a global optimal result that is performed at the boundary region between the object and background to make Grabcut a globally optimal solution. In [13], an efficient plate number extraction algorithm based on geometric properties and the multi-level threshold is proposed. This type of algorithm can be used to identify, segment the vehicle license plate while capturing the vehicle image. The segmentation algorithm for extraction has 75% localization accuracy. There were some difficulties with license plate detection, with poor image quality.

The author in [5,14] approaches the problem of license plate number recognition by using a group of three multilayer perceptron based on a mixture of expert's architecture for each segmented character. Edge detection was used to detect the license plate, while the character segmentation was obtained through vertical projection. The accuracy for localization is 95.39% and the total accuracy of the system is 92.45%. The author in [15] proposed an algorithm called the low-complexity histogram modification technique. Usually, it does not require any splitting operation, instead, it deals with histogram increments to realize black and white extensions and adjusts the level of enhancement adaptively to the system. Thus, the dynamic range of the system is better utilized while meeting the requirement for noise visibility and natural appearance.

III. Methodology

The developed systems aim to identify and recognize Turkish vehicle license plates. the input to the system is the license plate image captured by the digital camera, and the output of the system is the detected and recognized license plate image. The program developed is implemented on MATLAB 8.2. The implementation of procedures is in three stages:

A. Pre-Processing

The main goal of image preprocessing is to improve the quality of an image that would be suitable for easy recognition [16]. The stages of preprocessing are so important and are commonly obtained in any computer vision application. In this research, processing an image required two methods i.e., adjustment size which is one of the basic stages of image preprocessing is by reducing its size after being taken from the camera into an appropriate aspect ratio, and color transformation ratio, which most of the image captured are encoded in software standards. Therefore, these captured images are of RGB type which has 3 channels as red-green, and blue. These channel values in the captured image indicate the amount of color information that the image has. The image is in RGB form, by converting it to grayscale which offers less information for each pixel of an image.

Another process applied to improve the quality of the image is by reducing its noise. Noise reduction or media filtering is one of the techniques that can be applied in this process. The process is used to take the input image and a mask with dimensions 3 * 3, 5 * 5, or 7 * 7 and find/calculate the median given to the kernel of each pixel of the input image. And lastly, by replacing pixels with a median value that is equivalent to the center of the kernel. Usually, noise reduction is one of the key factors to improve the quality of the image. The median filter would be used to eliminate the noises from the image. This filter is a non-linear digital filtering technique used for data processing such as edge detection of an image, also this filter not only eliminates the noise but makes the frequency of the image high in concentration. This median filter is implemented for removing such a purpose.

B. Plate Localization

There are a few steps required to obtain a reliable localize license plate in real-time. The approach applies to the real-time system at different stages, and these steps have better time complexity reduction. These include edge detection, the intensity of license plate modification, connected component analysis, and objects separation, among others.

C. Edge Detection

In [17], this research, used of canny edge detection method because it is among the easiest and popular for detecting an edge of the license plate number. Also, canny edge detection is one of the robust algorithms for detecting edges compare to other types of detection like Sobel and Prewitt edge detection algorithms [18]. This edge detection technique can also help to reduce the size of images in which computers do not require too much memory. If images are classified based on the number of objects contain, this technique is greatly used in the process of segmenting the images, because edges are in the image, in which boundaries of an object can be seen as shown in Fig. 3.

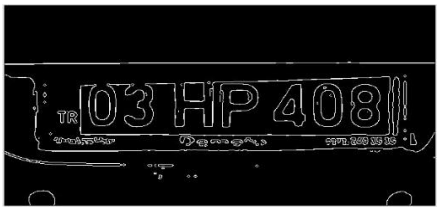

Fig. 3. Result of Canny Edge Detection

D. Object Separation

Separating of objects from the background: In this research, Thresholding is another technique in image processing. The basic idea of thresholding an image is by setting background pixels' values of the image below a threshold value, and the foreground value assigns to another value [40]. This technique is based on converting a grayscale license plate image into a binary image. The conversion is of two types, Global thresholding, and local thresholding. For the benefit of this work, local thresholding was used. Equation (1) is used to arrive at the thresholding technique.

$$f(x) = \begin{cases} 255, if\ f(x,y) > T \\ 0, \quad otherwise \end{cases} \tag{1}$$

E. Character Segmentation

Segmentation of character is an important stage of OCR, also is one of the most important steps in license plate number recognition. Moreover, characters segmentation helps in achieving reliable, accurate character recognition. This process can be achieved by portioning an image into smaller parts. The method used in segmenting the detected license plate is a bounding box. If the segmentation fails, the accuracy of recognition would be delayed as illustrated in Fig. 4.

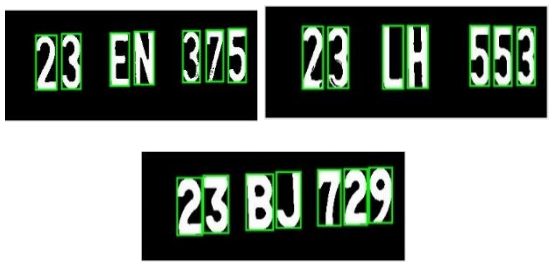

Fig. 4. Some of the segmented license plate images

A lot of researchers working on artificial neural networks (ANN) have gone far in recent years[16,19], defined a neural network as an immensely distributed processor, in which its made of simple processing units, and have expected learning for putting empirical knowledge and formulating. Also [20] describes the neural networks as an imitation of the human brain. The human brain has a lot of ability to adapt and learn new things. The human brain is one of the most amazing abilities in analyzing unclear and incomplete, also fuzzy information, and making its final decision out of it. In this research, MATLAB neural network toolbox was used. By using a neural network in optical character recognition, it smooths the system extensible. In the character recognition algorithm using a neural network, the weights and bias of the ANN can be adjusted by training it using a back propagation algorithm.

[21–23] stated the error backpropagation algorithm as one of the most popular algorithms used in mapping non-linear processes. This algorithm is a feed-forward network that has one or more hidden layers. The fundamental structure of the feedback propagation network consists of three layers. Also, [15,20,24] stated error backpropagation is a technique for training multilayer neural networks, in which the number of hidden layers does not have any constraints, therefore, the mathematical expression is very strong. The neural network must learn all the training data's ranging from (0-9) and (A-Z) that added altogether would be 36 characters. To validate the neural network, the software is proposed that can read the series of characters, and, also identify each character and recognize the identified characters. An artificial neural network (ANN) with a back propagation algorithm was used in recognizing the characters on the license plate image. Fig. 5 shows a sample of extracted characters.

Fig. 5. Some of the recognized characters of license plates.

IV. Results and Discusiion

MATLAB software is used for writing simulation programs related to training and testing for three different types of ANN (perceptron, PatternNet models, and multilayer neural networks). The performances of the three models were evaluated. The performances were observed and the result of the validation of the neural networks for a different type of plate number using each neural network is illustrated in Table 1.

TABLE I. Validation of 5 License Plate Images

Type of Architecture	Type of license plate	True/False
Net1 MLP 123_36 tansig_tansig	23HC353	True
	238J721	False
	238S611	False
	23EN375	True
	73ES352	False
	23K318S	True

Type of Architecture	Type of license plate	True/False
	23LH553	True
Net21 PTRN 63_36 tansig_softmax	23BC353	True
	23BJ729	True
	23BS611	True
	23EN375	True
	23FS352	False
	23K318G	True
	23LH553	True
Net3 MLP 36_36 tansig_tansig	23BC353	True
	23BJ729	True
	23BS611	True
	23EN375	True
	23ES352	True
	23K3184	True
	23LH553	True
Net5 PCRN(hardlim) 36	Z0RL000	False
	ZZ0JTZ0	False
	Z00SSTT	False
	7ZRNJ75	False
	700S007	False
	Z0K0T0G	False
	70LR550	False
Net7 PTRN 123_36 tansig_softmax	23BC353	True
	23BJ729	True
	Z3BS6TJ	False
	23EN375	True
	23ES35Z	False
	23K3184	True
	Z3LH553	False

Some images of characters and numbers were used in training and testing the perceptron model, which indicated the actual output and the desired output of the perceptron network, or by saying the target vectors and the actual vectors of a neural network as illustrated in Fig. 6.

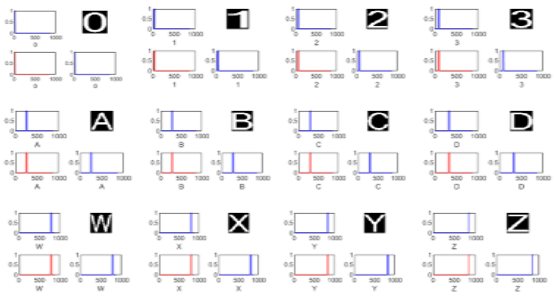

Fig. 6. Illustrated some images of characters and numbers used at training perceptron neural networks, target vectors, and outputs vectors of networks.

Other images of characters and numbers used in training and testing the pattern net model (shown in Figs. 7, 8, and 9), which indicated the actual output and the desired output of the perceptron network, or by saying the target vectors and the actual vectors of neural network.

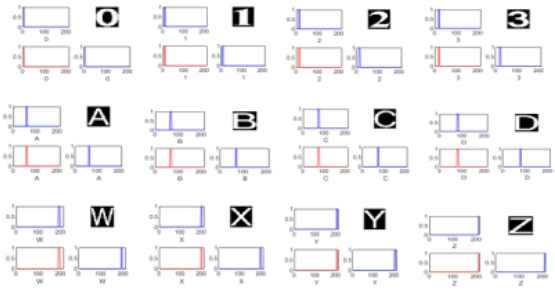

Fig. 7. Illustrated some images of characters and numbers used at testing neural networks, target vectors, and outputs vectors of networks for the Perceptron ANN model.

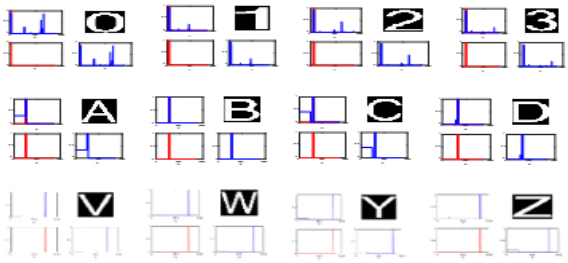

Fig. 8. Illustrated some images of characters and numbers used at training Pattern Net neural networks, target vectors, and outputs vectors of networks.

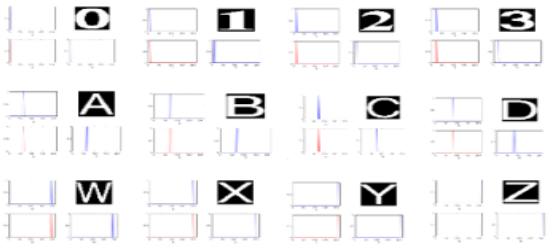

Fig. 9. Illustrated some images of characters and numbers used at testing neural networks, target vectors, and outputs vectors of networks for Pattern Net ANN. Model.

In this study, an experiment was conducted for the evaluation of the performance of recognition of characters. Three models were used to compare the performances of the neural network system, based on time, speed, and accuracy. The three models are pattern net, perceptron, and multilayer neural network. In the training mode, perceptron which is a simple network takes a long time before it converges, unlike the pattern net which has less time. Also, pattern net gives much better accuracy compared to perceptron as shown in Figs. 6, 7, & 8. Moreover, the pattern net model has a percentage error with a smaller number of the epoch when compared with perceptron and multilayer neural network models which are not the same as the pattern net model. For pattern net and MLP, four different types of architectures of the neural network are used to observe the performances of the

network. From the result obtained, both pattern net and MLP has very good performance in recognizing the license plate images compared to the perceptron network. Moreover, pattern net has the advantage of less training time compared to the other two types of neural network (MLP and perceptron network). For perceptron, two different types of the network were used to observe their performance, these are Net2 PCRN (tansig)_36, Net5 PCRN (hardlim) 36. Based on the observation, none of them were able to recognize one license plate recognition, this shows that perceptron has poor recognition performance when compared with MLP and pattern net.

V. CONCLUSIONS

This study aimed at designing a plate number recognition system capable of identifying and recognizing Turkish license plates. the use of backpropagation (BP) in optical character recognition (OCR) give good output results. however, these OCRs can be affected by many factors like brightness, noise, and shadow background. therefore, pre-processing is essential to be used in documented images as an initial step for character recognition, to remove the effects of such factors. to overcome these challenges of occluded images during data acquisition, an image enhancement technique was proposed using median filtering to make the images and characters easily recognizable. also, the pattern net model implemented in this study showed that its performance is better when compared with the perceptron model in terms of its accuracy and error percentage. moreover, it has a small epoch as compared with the perceptron model.

REFERENCES

[1] P. Dhar, S. Guha, T. Biswas, M.Z. Abedin, A System Design for License Plate Recognition by Using Edge Detection and Convolution Neural Network, Int. Conf. Comput. Commun. Chem. Mater. Electron. Eng. IC4ME2 2018. (2018). https://doi.org/10.1109/IC4ME2.2018.8465630.

[2] I. Ullah, H.J. Lee, An Approach of Locating Korean Vehicle License Plate Based on Mathematical Morphology and Geometrical Features, Proc. - 2016 Int. Conf. Comput. Sci. Comput. Intell. CSCI 2016. (2017) 836–840. https://doi.org/10.1109/CSCI.2016.0162.

[3] K. Khorgade, Security for Campus Vehicle by Automatically Recognition of Number Plate with Notification, Int. J. Res. Appl. Sci. Eng. Technol. 7 (2019) 3983–3985. https://doi.org/10.22214/ijraset.2019.5657.

[4] C.N.E. Anagnostopoulos, I.E. Anagnostopoulos, I.D. Psoroulas, V. Loumos, E. Kayafas, License plate recognition from still images and video sequences: A survey, IEEE Trans. Intell. Transp. Syst. 9 (2008) 377–391. https://doi.org/10.1109/TITS.2008.922938.

[5] W. The, W. Academy, Performance Analysis on Automatic Number Plate Recognition System and Methods Performance Analysis on Automatic Number Plate Recognition, (n.d.).

[6] A.O. Agbeyangi, O.A. Alashiri, A.E. Otunuga, Automatic Identification of Vehicle Plate Number using Raspberry Pi, in: 2020: pp. 1–4. https://doi.org/10.1109/icmcecs47690.2020.246983.

[7] J. Jagtap, S. Holambe, Multi-Style License Plate Recognition using Artificial Neural Network for Indian Vehicles, 2018 Int. Conf. Information, Commun. Eng. Technol. ICICET 2018. (2018) 1–4. https://doi.org/10.1109/ICICET.2018.8533707.

[8] M. Nejati, A. Majidi, M. Jalalat, License plate recognition based on edge histogram analysis and classifier ensemble, 2015 Signal Process. Intell. Syst. Conf. Sp. 2015. (2016) 48–52. https://doi.org/10.1109/SPIS.2015.7422310.

[9] I.K. Gunawan, I.P.A. Bayupati, K.S. Wibawa, I.M. Sukarsa, L. Adi, Indonesian Plate Number Identification Using YOLACT and Mobilenetv2 in the Parking Management System, 9 (2021) 69–76.

[10] J. Tarigan, Nadia, R. Diedan, Y. Suryana, Plate Recognition Using Backpropagation Neural Network and Genetic Algorithm, Procedia Comput. Sci. 116 (2017) 365–372. https://doi.org/10.1016/j.procs.2017.10.068.

[11] N.M. Basheer, A.M. Aaref, D.J. Ayyed, International Journal of Advanced Research in Digital Image Sobel Edge Detection Using FPGA, (2018).

[12] S. Norul, K. Omar, K. Omar, A. Salimi, M. Petrou, M. Khalid, Determining adaptive thresholds for image segmentation for a license plate recognition system, Int. J. Adv. Comput. Sci. Appl. 7 (2016). https://doi.org/10.14569/ijacsa.2016.070667.

[13] A. G, H.N. T, J. Kumari, S. M, Analysis of Digital Images Using Morphlogical Operations, Int. J. Comput. Sci. Inf. Technol. 5 (2013) 145–159. https://doi.org/10.5121/ijcsit.2013.5112.

[14] N. Omar, A. Sengur, S. Ganim, S. Al-ali, Cascaded deep learning-based efficient approach for license plate detection and recognition, 149 (2020). https://doi.org/10.1016/j.eswa.2020.113280.

[15] A.A. Universit, MATLAB Code of Artificial Neural Networks Estimation MATLAB Code of Artificial Neural Networks Estimation, (2016).

[16] J.V.C.I. R, S. Montazzolli, C. Rosito, Real-time license plate detection and recognition using deep convolutional neural networks q, J. Vis. Commun. Image Represent. 71 (2020) 102773. https://doi.org/10.1016/j.jvcir.2020.102773.

[17] F. Alim.Ferhat, L. Ait mohamed, O. Kerdjidj, K. Messaoudi, A. Boudjelal, S. Seddiki, Implementation of Sobel, Prewitt, Roberts edge detection on FPGA, Proc. 2013 Int. Conf. Image Process. Comput. Vision, Pattern Recognition, IPCV 2013. 1 (2013) 200–203.

[18] P. Ganesan, G. Sajiv, A comprehensive study of edge detection for image processing applications, Proc. 2017 Int. Conf. Innov. Information, Embed. Commun. Syst. ICIIECS 2017. 2018-Janua (2018) 1–6. https://doi.org/10.1109/ICIIECS.2017.8275968.

[19] I.V. Pustokhina, D.A. Pustokhin, J.J.P.C. Rodrigues, D. Gupta, A. Khanna, Automatic Vehicle License Plate Recognition Using Optimal K-Means With Convolutional Neural Network for Intelligent Transportation Systems, (2020). https://doi.org/10.1109/ACCESS.2020.2993008.

[20] H. Kukreja, An introduction to artificial neural networks, Hardw. Archit. Deep Learn. (2020) 3–26. https://doi.org/10.1049/pbcs055e_ch1.

[21] J. Wang, B. Bacic, W.Q. Yan, An effective method for plate number recognition, Multimed. Tools Appl. 77 (2018) 1679–1692. https://doi.org/10.1007/s11042-017-4356-z.

[22] I. Portugal, P. Alencar, D. Cowan, The use of machine learning algorithms in recommender systems: A systematic review, Expert Syst. Appl. 97 (2018) 205–227. https://doi.org/10.1016/j.eswa.2017.12.020.

[23] S. Bassel, Z. Nizar, Recognition of Vehicle Numberplate Using Matlab, (2016). https://doi.org/10.13140/RG.2.1.1459.8640.

[24] M. Thakur, I. Raj, P. Ganesan, The cooperative approach of genetic algorithm and neural network for the identification of vehicle License Plate number, ICIIECS 2015 - 2015 IEEE Int. Conf. Innov. Information, Embed. Commun. Syst. (2015) 1–6. https://doi.org/10.1109/ICIIECS.2015.7193090.