International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Recognition of Arabic Handwritten Characters using Discrete Wavelet Transforms and Neural Network

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Abstract: ***New approach of recognizing Arabic handwritten characters have been proposed, includes two main steps. In the first step, the input image which includes Arabic handwritten characters is acquisitioned using digital scanning, and then the scanned image is transformed using discrete wavelet transform (DWT) to extract a specific vector of features from the transformed image which reflects the texture of the scanned characters. While the second step performs the classification job using neural network based on the extracted features from first step. The classification process using ANN is trained by 208 images and other 70 images for testing. The simulation results of classification prove the capability of the proposed approach to perform significant percent of accuracy especially when Coiflet3 filter is considered for DWT and number of layers in ANN is increased to 6 or layers.***

Keywords: Arabic handwritten character, Image classification, ANN, DWT, Coiflet3

1. Introduction

In general, the process of recognizing handwritten characters is the most significant problem in the field of pattern recognition. At the same, this process is widely used in many applications like: reading the postal codes, recovering printed text, etc [1].

Handwritten characters usually written on the bottom line or in an upright position, therefore, edge detection is an essential feature and contains the necessary information to get the recipe picture, Sobel filter is used to detect the edges [2].

In general, morphology is a mechanism to extract certain components of digital image like boundaries and skeletons which describe the texture of the tested region. Also, the operations of filtering, thinning and pruning are performed by the morphology [3].

In this paper, morphology operations is combined with neural network to recognize input Arabic character based on the selected features that are extracted from the transformed version of input image using DWT. With respect to ANN which performs classification job uses Back propagation as a learning algorithm.

Related Works

Many approaches found in literature deal with handwritten characters using different techniques of pattern recognition. In [4] 2009, a new approach of recognizing Arabic letters was proposed using back propagation ANN based on start/end point and branch of straight piece in character region. Another handwritten letter recognition approach which is proposed by [5] 2011 using ANN based on a set of features that were extracted from Discrete Cosine Transform (DCT) and DWT, the outcome recognition accuracy from this approach exceeds 96 %. In [6] 2014, an algorithm is performed using DCT and DWT for feature extraction and ANN and Hidden Markov Model (HMM)) for recognition, the outcome accuracy exceeds (95.00%). From [7] 2015, preprocessing is(normalize the image, remove the noise, thinning process simplifies), feature extraction is (Curve let transform), algorithm type(back propagation algorithm), Accuracy (90.3%).

2. The Proposed Methodology

The general block diagram of the proposed approach for Arabic handwritten characters is mentioned in Figure (1). The suggested approach contains two stages: first stage performs features extraction using the transformed version using DWT of an input scanned image that contains Arabic character. The second stage performs classification operation using ANN.

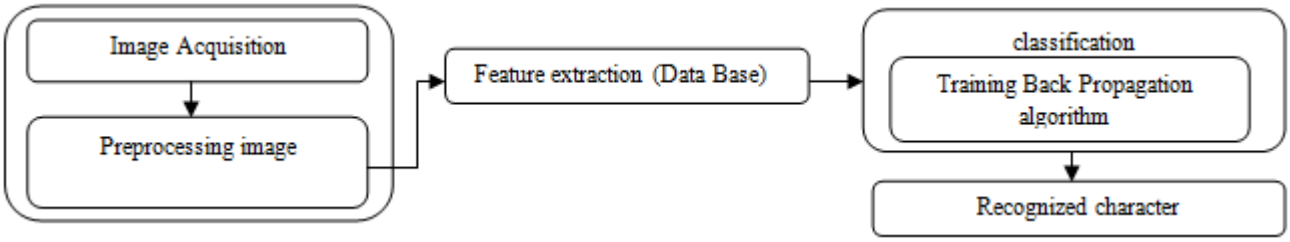


Figure 1: General Block Diagram of the Proposed Approach for Recognizing Arabic Handwritten Character

2.1 Image Acquisition

First step in the proposed recognition approach is image acquisition. In this operation the input image which includes Arabic handwritten character is captured using digital camera or any digitally multimedia devices. The captured image is stored using the standard image format JPEG [8].

2.2 Pre-Processing

The next step in the proposed recognition approach is preprocessing. In this step many operations are implemented sequentially. These operations are implemented to improve the quality of the scanned image. Thus, effective features can be extracted from the improved image. The operations which are performed in this step are explained in Figure (2).

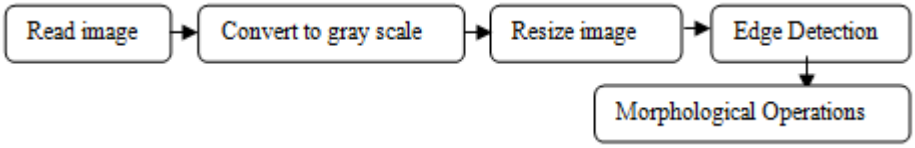


Figure 2: The Sequential Operations in Pre-processing Stage of the Proposed Recognition Approach

In Pre-processing step, the reading of the scanned image is followed by converting it to gray scale color because most existing recognition techniques are implemented on gray image not full color image [1].

The second operation in pre-processing operation is resizing the gray color from the previous operation into standard size. This operation is implanted to make the resultant image for next operation with unique size [9].

In general, the process of edge detection is very important for many applications like recognizing pattern and object and analyzing images, etc. Sobel filter can be applied to edge detection to obtain the basic feature of image. Also, rich information can be explained from the edges of image which is used mainly for obtaining the complete characteristic of the recognized object [3]. In simple meaning, the edges of images represent boundaries which are determined between the detected shape and its background. In addition, Edge are usually used to differentiate the object from another and/or split them from their background [10], Figure (3) explains how to call the image and makes resize to it and implement the edge detection using sobel filter.

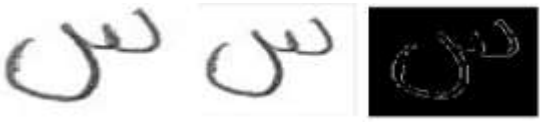


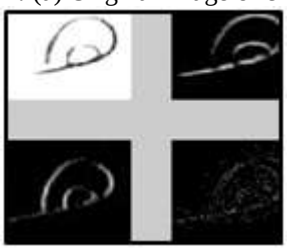
Figure 3: The Resultant Images of Pre-Processing Step, (a) The Original Reading Image, (b) The Unique Sized Image after Re-resizing , (c) The Edge Filtered Image by Sobol Filter.

The morphological depends on set theory of mathematics. This theory deals with the structure information of the tested shape. The famous techniques within this theory are dilation and erosion. The dilation is mostly used to increase outlines of the tested object, while the erosion is used to decrease these outlines [11].

2.3 Features Extraction

The resultant image from the pre-processing step is transformed using DWT, because this transformed convert the input image into multi-resolution segments based on applying low pass and high pass filters in rows and columns in a sequence of four resolutions called LL HL, LH, and HH , respectively as shown in Figure (4). These resolutions include coefficients which represent many information of the input image. Thus, these coefficients can be used to extract effective features for next step of classification.

Figure 4: (a) Original image of character



(b)Wavelet decomposition with one levels

There are many types of filters which can be used in DWT. The type of filter specifies the texture of the resulted coefficients which update the type of the extracted features [12].

3. Classification

In general, the classification process is the final decision step in any recognition system. The classifier is performed to explain the shape of characters based on the database that is calculated by performing DWT, these data base are used for trained classes, explained in Figure (5).

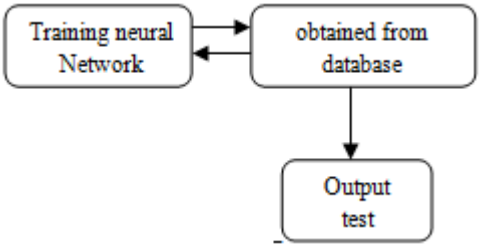


Figure 5: Classification stage

3.1 Back Propagation (N. N) Recognition

Multilayer (BPNNA) used for training and classification of the Arabic handwritten characters [12]. (B.P) algorithm is a gradient descent method for minimizing the (MSE)between the actual and target [2],figure(6)shows the input and three hidden layers and output.

Figure 6: The Distribution of Input, Hidden, and Output Layers in ANN.

Within learning cycle of ANN, the weights of network are updated and error value is decreased. The value of error determined by different between desired output and actual output. Other meaning, it is propagated in backward from (O/P) to (H.L) and to input layer to train network [13].

The weight between input and the (H.L) and between (H) and the (O/P L.) initialized randomly and adjust new weights such that the error decreases with each iteration to reach to desire output, (initially ,Learning rate is 0.5). Network trained (10,000) epoch. Training the network done using (B.P.L.) algo. That minimizes the error also update weights during the learning until calculated output are within margin of known output. Input testing is fed into the (I/P) layer, and feed forward net. will generate results based on its knowledge from network trained. Neural Network is training until at least one of the Termination conditions were satisfied, Maximum Epoch as specified is reached or Given Minimum Gradient reached as shown in figure (7). Figure (8)shown the performance of training .

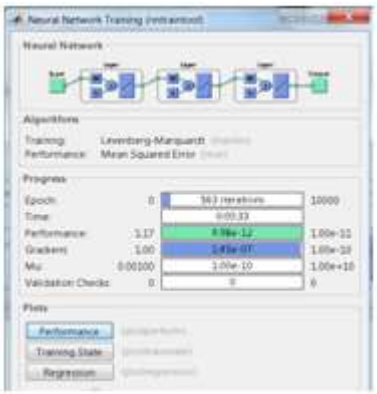


Figure 7: Training of (N.N)

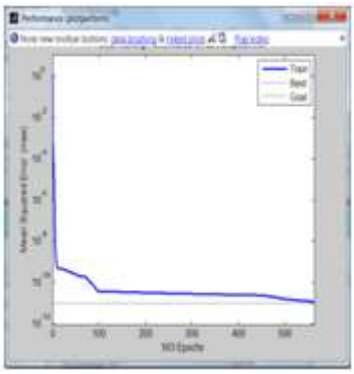


Figure 8: Performance of (N.N)

4. Experimental Results

The software is implemented using MATLAB. In this paper used (JPG) image (256) and various Discrete Wavelet Transforms (db3, db8, db9, coif3 and coif5) have been used to extract features from the character images.

The network is trained using different number of layers (3,6,8), the fit output obtained when number of layer are increasing and the number of epochs are increased, the fit output obtained at layers (6,8),Recognition rate is defined in equation(1) as follows:

$$A = 100\left(\frac{Nc}{Nt}\right)\text{----------(1)}$$

Where :
A rate of recognition.
Nc number of the corrected classified patterns.
Nt number of the tested patterns.

The results of recognition in the proposed approach at level(3) of wavelet transform are viewed in Table(1)

Table 1: Simulation Result of Recognition using the Proposed Approach

Type of Transform	No.of layer	No.of epoch (iteration)	time	Performance	Recognition rate%
db3	3	168	0.00.08	$6.12e^{-10}$	57.142
	6	708	0.00.36	$1.57e^{-10}$	100
	8	10000	0.09.43	$2.24e^{-11}$	100
db8	3	11	0.02.34	$6.12e^{-10}$	57.142
	6	10000	0.08.12	$2.20e^{-10}$	85.71
	8	1750	0.01.45	$9.99e^{-14}$	100
db9	3	10000	0.06.22	$6.12e^{-10}$	57.142
	6	229	0.00.13	$5.34e^{-11}$	100
	8	1007	0.00.59	$9.22e^{-14}$	100
Coif3	3	960	0.00.38	$6.33e^{-10}$	71.428
	6	515	0.00.26	$9.47e^{-11}$	100
	8	1868	0.01.52	$5.28e^{-11}$	100
Coif5	3	10000	0.06.21	$6.12e^{-10}$	57.142
	6	7552	0.06.13	$1.76e^{-11}$	100
	8	5539	0.05.26	$9.99e^{-14}$	100

The best value is obtained at hidden layers (6,8) of (N.N.) for (three-level) wavelet transform. The recognition rate have more accuracy in (Coiflet 3) transform. Therefore, applied the (Coiflet 3) in one-level and six-level wavelet transform, then comparison the result between different levels of wavelet transform as the table(2).

Table 2: Applied (Coiflet 3) on different level of transform

	layer	epoch	time	performance	Recognition rate %
Level (1)	3	359	0.00.10	$6.36e^{-10}$	55.71
	6	10000	0.06.08	$2.59e^{-10}$	90
	8	10000	0.07.14	$8.32e^{-11}$	97.14
Level (3)	3	960	0.00.38	$6.33e^{-10}$	71.428
	6	515	0.0036	$9.47e^{-11}$	100
	8	1868	0.01.50	$5.28e^{-11}$	100
Level (6)	3	1020	0.00.28	$6.26e^{-10}$	57.14
	6	10000	0.06.09	$2.70e^{-10}$	94.28
	8	10000	0.07.19	$2.73e^{-11}$	98.57

Table 3: Comparison with other researches

researches	Preprocessing	Feature Extraction	Algorithm type	Accuracy(%)
[26] 2009	Skeletonization and thinning	Start and end point of character region	Back propagation Neural network	98.7%
[8] 2011		DCT and DWT	Artificial Neural Network	96.56%
[9] 2014		DCT and DWT	ANN and Hidden Markov Model (HMM)	95.00%
[13] 2015	normalize the image, remove the noise, thinning process simplifies	Curve let transform	back propagation algorithm	90.3%
Our method	Convert to gray scale, image resize, edge detection(sobel filter),Morphology	DWT	back propagation algorithm	Layer: (3)=59.999%
				Layer: (6)=97.142 %
				Layer: (8)=100%

5. Conclusion

Through training operations of the network we noted:

1) The use of several types of wavelet transform (db3,db6,db8,coifl3,coifl5) , the results were better when using (coifl 3) where the recognition rate at layer 3 is 59.999%,and recognition rate at layer (6) is 97.142 and recognition rate at layer (8) is 100% .
2) The network was trained on several decomposition of wavelet transform ,the best recognition rate at level three.
3) When trained the network on several layers (3,6,8), observed that increased the number of layers lead to increased the network efficiency and discrimination ,where up to 100%.
4) Increased the number of hidden layers increased the time spent in the training process, as well as increasing performance.
5) Recognition accuracy increases with increasing the number of layers trained, where up to 100% .
6) The network was trained on different value of (MSE) for the same filter , the best recognition rate at value ($1e^{-11}$&$1e^{-13}$).

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