American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-6, pp-86-92
www.ajer.org
Research Paper Open Access

Multi-Layer Perceptron Network For English Character Recognition

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ABSTRACT: *The recognition of English language character is an interesting area in recognition of pattern. Within this article, effort has been made to design a program that will recognize English characters with a multilayer perceptron having only a single hidden layer. Fourier descriptors and boundary trace are features extracted off the English characters. The shape of each character is analyzed and used to identify and compare its features that differentiates each character. Determining numerals of hidden layer neurons was analyzed in other to attain great back propagation performance in English language character recognition. Training of the network was done with 78 samples collection of English characters and was tested on 78 samples different from the training samples which indicated that Fourier description together with back propagation provides decent accuracy of recognition at 95% for characters having a smaller amount of classification and training period.*

Index Terms: *Feature Extraction, English Character Recognition, Multilayer Perceptron Network, Boundary Tracing.*

I. INTRODUCTION

In recent times, neural networking are utilized through numerous manners for the recognition of patterns. Neural network plays a significant function in English language character recognition. The recognition of English character is amongst the emerging, challenging and fascinating areas of research in the recognition of pattern study. Generally, for recognition of English characters, there are 2 classification categories; these are Offline and Online methodologies of recognizing characters. For the offline, a scanner is used to optically capture the writing and it appears as an image on completion. Then, for online system, there is a representation of consecutive points of 2 dimensional coordinates. The first as a time function and the next, a stroke function. There is more superiority in the online method in comparison to offline in recognition of written characters. This is as a result of availability of temporal material present to online method. Nevertheless, in offline structures, neural networking have been productively presented to produce comparably great levels of accuracy for character recognition, the time required for character classification and training. Numerous areas of application that require an offline setup for recognition of characters include; reading of document, sorting of mails, bank processes and recognition of postal addresses [3]. In this project report, efforts have been made to design a neural network with multilayer perceptron network algorithm for English character recognition having a great accuracy of recognition and minimal period of training and also classification time.

1.1 PROBLEM STATEMENT

Using artificial neural network in English language character recognition has pose to be an open issue. English language character of every individual is different for instance, the handwriting of each individual, or different font type in characters using Microsoft office, and as such it is difficult to recognize some English characters. However, since neural network plays an essential role in the recognition of English characters, an automatic English language character recognition system will be designed to recognize these characters with high performance accuracy and reduced training time as well as minimum classification time.

1.2 OBJECTIVE

The main purpose of this research is to design an artificial neural network that will identify different English language characters, the methodology and making use of a multilayer perceptron network algorithm to achieve the project objective.

II. MODELLING OF CHARACTERS

There are 26 characters that make up the English language linguistic characters. We have as consonants, 21 characters and 5 characters as vowels. These characters are written in other from left hand side to the right hand side. An English character set is presented in the figure below [5].

Fig. 1 English Characters Set [5].

2.1 CHARACTER SCANNING AND THE SKELETONIZATION

Scanning process is used to input the characters. With binary pixels conversions into 1024 (32x32). The process of skeletonization is employed to image binary pixel and also the additional pixel that may not fit in with the mainstay of the characters has been erased and the extensive strokes abridged to tinny lines. An illustration of Skeletonization shown in Fig. 2.

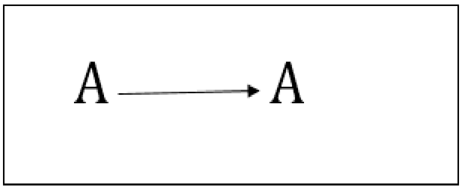

Fig. 2: English Character Skeletonization [3].

2.2 NORMALIZING

There exists several variants in different kinds of writings. For that reason, after the process of skeletonization, the normalizing of characters is done to ensure that all characters become equal in matrix dimensions. Within this article, there are normalization of characters into pixel letters of 30x30 and moved to top leftmost corner of the pixel frame.

III. CHARACTER SYSTEM RECOGNITION

A block illustration of character system recognition is presented in Fig. 3 below.

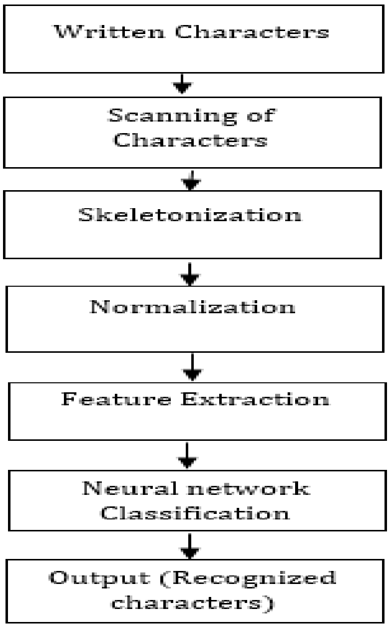

Fig. 3: System Recognition Diagram Block [7].

The process of writing English characters recognition is broken down below as:

- Sample is acquired by process of scanning.
- Operations of Skeletonization and normalizing are carried out.
- Boundary recognition feature removal technique.
- Classification of neural network.
- Recognized Letter.

IV. EXTRACTION OF FEATURE

Inside this article, for boundary information extraction of a written character, we employed the method of eight neighbor adjacent. With this method, the image of the binary is scanned up until the boundary is found. The search process follows in pattern to direction of clockwise. In a case of any focal point pixel (P), all the focal point pixels set that are linked to it, is known as linked component comprising P. The P pixel together with its eight neighbors are presented in Fig. 4 below. As soon as there is a detection of a white pixel, another newfangled white pixel is checked in that order. The character tracing automatically follows the boundary. However, if the foremost pixel is located, coordinates of that location is assigned to the program to specify the boundary origin. The newly located pixel is used as a fresh point of reference and initiates the eight neighbor search. With this manner, the early point coordinates will vary depending on pixel positioning. As the tracer travels alongside the boundary image, the matching coordinates are stored in arrays and used for calculating the Fourier Descriptors. Throughout the process of boundary trace, the program frequently checks the state whether the foremost boundary coordinates equals the coordinates of the last. As soon as it is acquired, means all the boundary are traced and that completes the process.

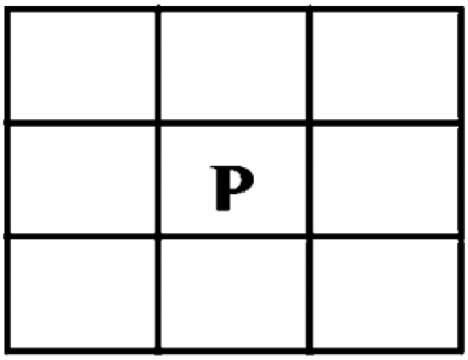

Fig. 4: A depiction of P pixel with its 8-neighbours [3].

Fig. 5: Tracing of Character Boundary

4.1 THE FOURIER DESCRIPTORS

It's used to compute the distinct coefficients of a Fourier descriptors where a and b are coefficient of [k] with condition k between 0 and L value as shown below.

$$a[k] = 1/L \sum x[m] e^{-jk(2\pi/L)m} \quad \text{.....(1)}$$

$$b[k] = 1/L \sum y[m] e^{-jk(2\pi/L)m} \quad \text{.....(2)}$$

The Fourier coefficients obtained from equation (1) and equation (2) which are non-rotational nor shift invariant rather than the Fourier Descriptors which possesses invariant characteristics with veneration to shift and rotation, the succeeding tasks are being defined. Aimed at each (n) calculate an invariant descriptors set r(n)

$R(n) = [\,|a(n)|^2 + |b(n)|^2\,]^{1/2}$ ……(3)

Calculating a fresh descriptors set s(n) by the elimination of the letter size from r(n)

$S(n) = r(n) / r(1)$ ……(4)

a (n), b (n) and invariant descriptors

s (n), n = 1,2…….(L – 1) are derived on behalf of every letter.

V. NEURAL NETWORK

Neural network is a machine designed in such a way as to perform a particular task based on the model of human brain. The network consist of a number of simple interconnected processing elements. The implementation of neural network is by some useful software programs executed on a computer. Example of these software are; Matlab, Neuroph, and GNU Octave etc. In this paper the algorithm used for the processing of the English characters in the neural network is the multilayer perceptron algorithm.

5.1 CHARACTER RECOGNITION

The recognition of the English language characters as inputs in a feed-forward multilayer perceptron network with a hidden layer was used. Twenty-six (26) English language characters were used to train the network with the implementation of a back propagation algorithm. Recognizing these characters may be complex but with repeated adjustments of their weights the performance and recognition accuracy of the network increases.

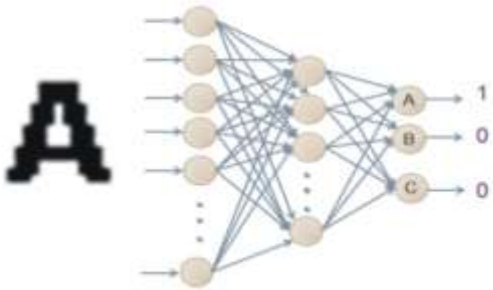

Fig. 6: Multilayer pattern presentation [1]

The Figure 6 present a first pattern of English language character presented to the network. There are 26 characters / clases and so each target vector could be a 1-in-26 vector. The target value for the first pattern (A) could be [1,0,0,0,0…] which means that first output unit should be on (1) as shown in Figure. Each character is defined in terms of binary value (Pixels) on a grid of size 32x32 Pixels.

5.2 A MULTILAYER FEED-FORWARD PERCEPTRON NETWORK

The feed-forward multilayer perceptron is considered as the most recognized and widely used neural network. In a multilayer perceptron the signals are transmitted in a feed-forward way. This means that the transmitted signals through the network is one way, without loops so the output of that neuron is not affected by the individual neurons in the network. The hidden layers are regions that are not connected directly to the environment. In this paper, a two layer perceptron has been used. A two layer perceptron is one which has one hidden layer and one output layer. The figure below shows the structure of a two layer perceptron for English character recognition network.

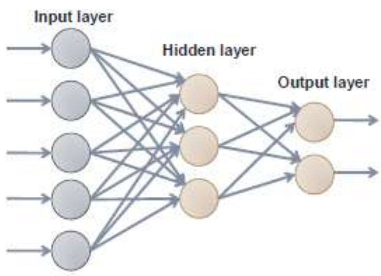

Fig. 7: Multilayer Perceptron Network (Two-Layer) [1]

In a multilayer perceptron network with a training algorithm that includes a back propagation, the formulas below applies to such network conditions.
Assuming the actual output of the system differs from the target output, this shows that there is error in the network which has to be reduced to an acceptable level or eliminated totally by updating the weights and re-train the network. [1] The Activation Function (Sigmoid Function)

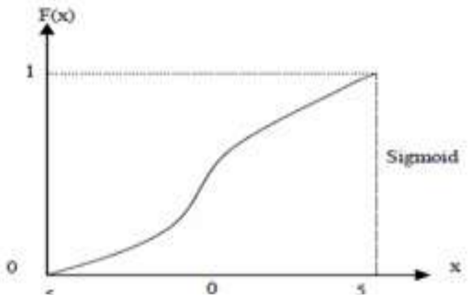

Fig. 8: Sigmoid graphical function [3]

A Sigmoid function transition between 0s and 1s when x is approximately between -3 and positive 3 ($-3 < x < 3$) as shown in table **X**. while in Figure **X2** the Sigmoid performance is rounded to the soft threshold shows below.

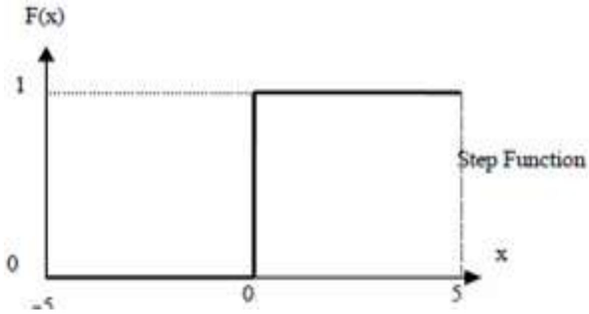

Fig. 9: Sigmoid Function Graph [6]

$$f(x) = \frac{1}{1 + e^{\sum_{i=1} oi\, wi}}$$

[2] The Error signal: the backward propagation error signal is computed by deducting the network output from the expected (Desired) value as shown below.
Error (e) = d (Desired output) – y (Network output)
[3] Delta Rule: a Back-propagation it's a learning rule in which weights and biases are adjusted by error-derivation known as Delta rule used to compute the desired output of any given output using the equations shown below;

$\delta_j = y_j(1- y_j)e_j$ Delta rule
$e_j = w_{i,j}\delta_j$ Backward Error

[3] Adjusted Weight: When the error signals of each neuron is computed, the weight coefficient might be computed and modified using the weight update function below

□$W(n) = \eta\delta x_j$ Adjusted Weight
$W(n+1) = w_{old} +$ □$W(n)$ New Weight

VI. RESULTS OF EXPERIMENT

6.1 DATABASE OF CHARACTERS

There were 78 sample of collection from 3 different set. 26 samples for each set ranging from the first English character to the last character, A to Z. First 52 sample are used to store in the database while the 26 other set are used to test the network reliability. The function below is used to compute the total number of characters (patterns) the network can store successfully.

$$P_{max} = \frac{N}{2 \ln N}$$

6.2 FLOWCHART AND PROCEDURE

A procedure of recognizing written English character is provided below:

- Scanned characters capturing.
- Normalizing process performance.
- Binarization done.
- Application of feature extraction methodologies.
- Implementation of Neural network classification.
- Obtain the character recognized.

A comprehensive flowchart of recognition of written English character is illustrated in Fig. 7 below.

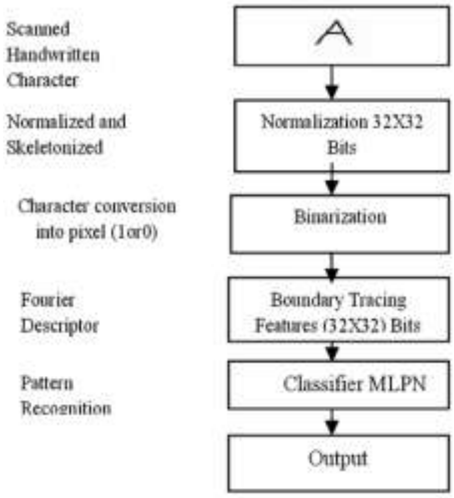

Fig. 10: A structure for the recognition of English Characters [9].

6.3 EXPERIMENTAL ANALYSIS

Table 1: An experimental analysis and result

No. of Hidden Neurons	Learning rate	Epoch No	Recognition %	
			Training Sets	Test Set
80	0.05	152	2	26
80	0.05	450	26	26
80	0.05	600	52	26

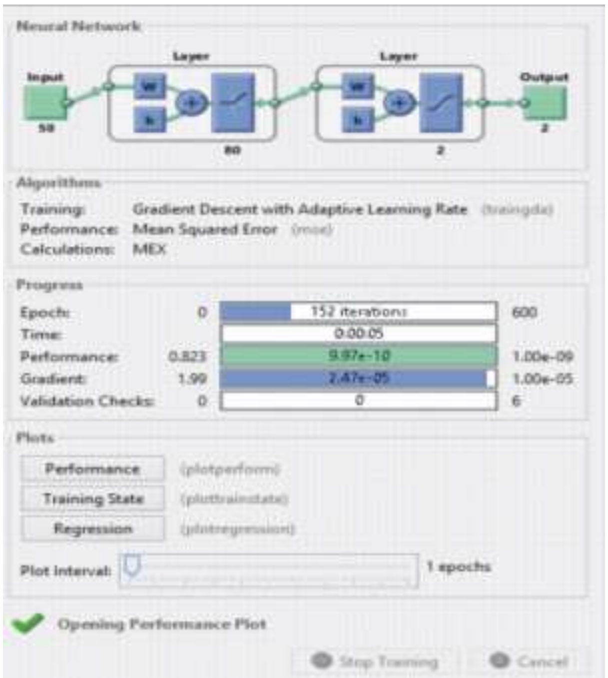

Fig 11: Epoch and Performance result

The Optical Character Recognition (OCR) program shows in Figure 11 above breaks the function of character recognition into three different stages.

[1] Neural Network: the neural network section present the input, number of layers and it corresponding layers used in OCR. The network is presented with 50 input patterns, the network layers are divided into two different hidden layers with 80 and 2 hidden layers, while the network present two output patterns.

[2] Algorithm: the algorithm section present the network algorithm used in computing and recognizing characters. The network performance in Figure 11 is 9.97 (97%) after 152 iteration (Epoch).

[3] Plots; The plots section present the provision for plotting network performance, training state and regression in a form of a graph as shown in Figure 12. Below.

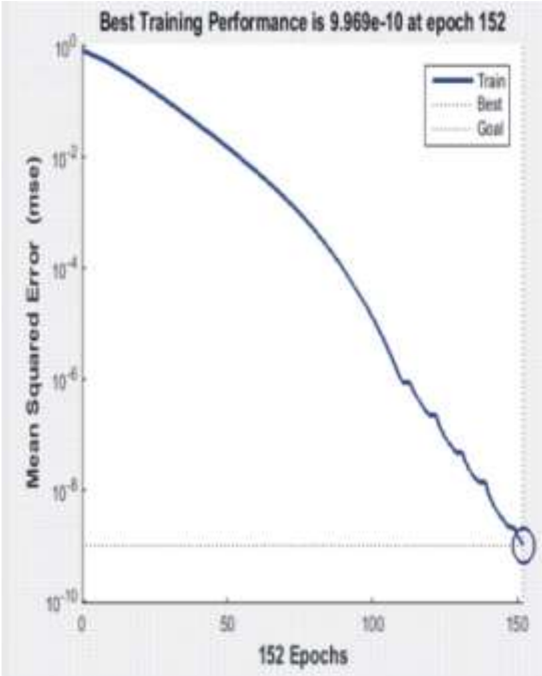

Fig 12: Error against Epoch graph

VII. Conclusions

Within this article, a written English characters recognition system were developed. The result of the experiment demonstrates that Fourier descriptors using back-propagation yields decent accuracy of recognition at 95%. Skeletonization and normalization of binary pixels of English characters are used as input to MLPN. The structure study of results indicate that epoch numbers taken for written character recognition increased with increase in hidden neurons numbers. A great deal of hard work have been employed to obtain greater accuracy, there still remain remarkable opportunity of increasing the accuracy of recognition by the development of fresh feature extraction methodologies or the modification of current feature extraction methodologies.

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