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Artificial Intelligent System for Character Recognition using Levenberg-Marquardt Algorithm

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***Abstract*— In this paper, character recognition system is implemented using artificial neural networks. A database of printed English alphabet characters is prepared. The characters are scanned and pre-processed to remove noise and enhance the quality of images. The enhanced character images are thresholded, skeletonized and pruned so as to get final segmented characters of just one pixel lines. Suitable features based on geometry of characters are extracted from the segmented character images. These features are used to train the multilayer backpropagation neural network classifier. The network is trained with the help of Levenberg-Marquardt algorithm. The proposed character recognition system is then tested on new unknown samples of printed characters. The system performed well and achieved 93% accuracy rate.**

***Keywords*— ANN, database, enhancement, thresholding, skeletonization, pruning, backpropagation, neurons, epochs**

I. INTRODUCTION

Computers have become an integral part of human life. The ease with which we can exchange information between user and computer is of immense importance today. With the growth of internet, the demand for online information has led to the need of what was once on paper is now desired in digital form e.g. old books, manuscripts, typewritten material, printed research work etc. This has led to the development of many methods for recognition of text documents.

Character Recognition is the process of identification of characters in which a scanned character image is converted into machine-editable format. It is an important field of image processing, pattern recognition and artificial intelligence [2]. Classical methods in pattern recognition were not sufficient for recognition of text characters due to varying shape, size and style of characters. So, intelligent systems are designed which are capable of recognizing characters of changing fonts. But still it is the case of less efficiency and accuracy.

II. ARTIFICIAL INTELLIGENCE

Artificial intelligent system is the information processing system that mimics the intelligent behaviours of human nervous system. An Artificial Neural Network (ANN) is composed of many neurons or processing units that co-operate to perform the desired function. It generally consists of input layer, hidden layer and output layer. There may be varying number of neurons in these layers. The output of a neuron is a function of the weighted sum of the inputs plus a bias. The function of the entire neural network is simply to compute the resultant output of all the neurons [4]. The basic architecture of an artificial neural network is shown below:

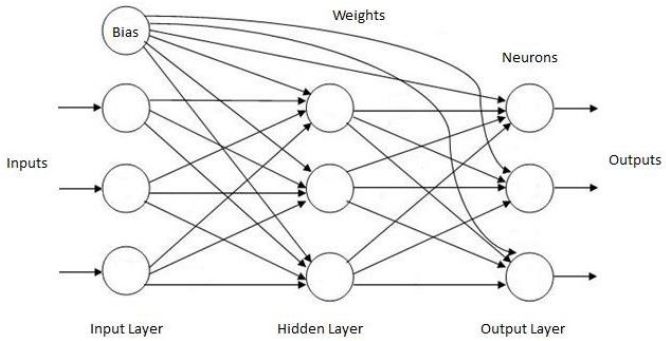

Fig. 1 Basic architecture of artificial neural network

An artificial neural network can be trained with known examples of a problem before it is tested for its inference capability on unknown instances of the problem. ANNs possess the capability to generalize, thus they can predict new outcomes from past trends. A very important feature of these networks is their adaptive nature, where programming is replaced by learning in solving problems. They are robust, fault tolerant and can recall full patterns from incomplete, partial or noisy patterns. [4], [6]

III. METHODOLOGY

The main objective of the proposed work is to carry out research contribution leading to the development of an

artificial intelligent system for character recognition. Levenberg-Marquardt algorithm is used here for the training of artificial neural network. Character Recognition process goes through 5 basic stages- Data Collection, Pre-processing, Segmentation, Feature Extraction and Classification. [8], [9]

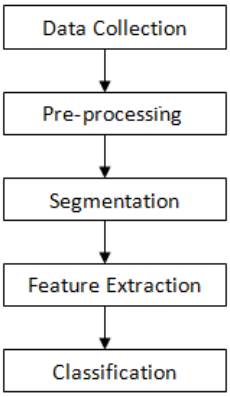

Fig. 2 Stages involved in Character Recognition

A. Data Collection

Raw data is collected in the form of printed English alphabet characters from A to Z of various fonts. The printed characters are then scanned at a resolution of 300 dpi. We have prepared database of characters having 15 samples of each alphabet. These character images are used for training and testing of the artificial character recognition system. Some samples of the character images are shown below:

Fig.3 Samples of character images

B. Pre-processing

Pre-processing is basically done to remove noise or any unwanted information present in the character image [5]. Noise may arise due to number of factors like dust, ink or pencil marks present on the text paper. Noise may also get added during transfer of digital images through electronic devices e.g. digital camera, scanner etc.

In pre-processing, all the character images are firstly resized to 100*100 pixels because of their varying shape and size. The resized character images are passed through median filter to reduce the noise elements [10]. After filtering, the images are enhanced using enhancement techniques to improve their black and white contrast. Enhanced character images are further used in the later stages of character recognition process. The images obtained after pre-processing are shown in the figure below:

Fig. 4 Original character image, Filtered image, Enhanced image

C. Segmentation

Segmentation means the separation of clear character area from non-character area in the given image. The first step to segment out the character part is 'thresholding' which means to create a binary version of the image [3]. After this two 'morphological operations' are performed on the thresholded image- skeletonization and pruning. [11]

Skeletonization is done to reduce the character area to just one pixel line, known as skeleton. Due to skeletonization some spurs (unwanted branches) may develop on the output skeletons. So in the final step of segmentation, these spurs are removed with the help of pruning and we get the final segmented image as shown below:

Fig. 5 Thresholded image, Skeletonized image, Segmented image

D. Feature Extraction

The segmented images are used here to find out the specific characteristics i.e. features of the characters. Features are extracted to define each character uniquely and to increase the recognition rate [2]. This is called heart of the system because accuracy of the entire recognition system lies in the selection of features which distinguish all the characters from each other.

For this research work we have selected 7 features which give distinguishing feature values for different characters and similar feature values for the same set of characters. Each character is represented as a feature vector, which becomes its identity. The features used in this stage are- Number of boundaries, Extent, Filled area, Major axis length, Minor axis length, Orientation and Solidity. [11]

The first feature gives total number of boundaries of the character e.g. if an outline of character 'A' is drawn, we can see that 'A' has two boundaries (in figure 6) and similarly character 'B' has three boundaries and character 'C' has only

one boundary. This feature differentiates the characters in terms of their boundaries.

Fig. 6 Boundaries of character 'A', 'B' and 'C'

The second feature extent is obtained by dividing the area of character to the area of its bounding box. Bounding box is the smallest rectangle that covers the character region. Filled area is defined as the number of pixels in the filled image of the character. Filled image is obtained by filling the holes in the character with white pixels. Major axis length and Minor axis length are the lengths of major axis and minor axis of the best fit ellipse, respectively. Best fit ellipse is the smallest oval surrounding the character. Orientation is defined as the angle between horizontal axis and major axis of the best fit ellipse. Solidity is calculated by dividing the area of character to its convex area. [11], [12]

Bounding box, filled image and best fit ellipse are shown in figure 7. Bounding box and best fit ellipse are marked by red rectangle and blue oval, respectively.

Fig. 7 Bounding box, Filled image, Best fit ellipse

E. Classification`

Classification is the main decision making stage of character recognition system. This stage uses the features extracted in the previous stage to train the system. For this, an artificial neural classifier is designed using backpropagation algorithm [1]. Backpropagation is a supervised feedforward multilayer neural network which back propagates errors in order to minimize them.

Different backpropagation training algorithms are studied and it has been found that Levenberg-Marquardt algorithm works best in this research work. The training function used here is 'trainlm' that updates weights and bias values according to Levenberg-Marquardt optimization [7] and the transfer functions used for activation of neural network are 'tansig' and 'purelin'. Tansig is hyperbolic tangent sigmoid transfer function and purelin is linear transfer function.

After completion of training, new feature inputs from testing set are fed to the classifier to test the efficiency and accuracy of the character recognition system. The input layer of neural network has 7 neurons in it, consisting of feature inputs whereas output layer has 26 neurons, one neuron for each character. The hidden layer neurons are varied until the system gives out recognized characters with minimum mean squared error.

IV. RESULTS & DISCUSSIONS

The proposed artificial intelligent system for character recognition is implemented with the help of MATLAB [12]. The system is trained using 10 samples of each alphabet character and then tested with 5 new samples of each character. It can be observed (in table I) that error keeps on reducing with increase in number of hidden layer neurons but along with that time required also gets increased. Thus, moderate number of neurons should be selected which give more accuracy and minimum error in less time.

TABLE I
PERFORMANCE ANALYSIS OF PROPOSED SYSTEM WITH VARYING HIDDEN LAYER NEURONS

S.No.	Hidden Layer Neurons (n)	Epochs (e)	Time Elapsed (in mins.)	Mean Squared Error (mse)	Samples Tested	Samples Recognized	Percentage Accuracy
1.	10	500	4.48	0.093081	130	27	20.8
2.	20	500	13.06	0.049602	130	76	58.5
3.	30	500	19.05	0.027491	130	111	85.4
4.	40	500	28.17	0.023853	130	115	88.5
5.	**50**	**500**	**40.33**	**0.01683**	**130**	**121**	**93**
6.	60	500	1.00.45	0.0081525	130	113	87
7.	70	500	1.22.58	0.0094834	130	113	87
8.	80	500	1.45.24	0.0018358	130	97	74.6
9.	90	500	2.16.02	0.014275	130	120	92.3
10.	100	500	2.43.21	0.00904	130	113	87

It has been found that the system best converges when hidden layer neurons, n=50 in approximately 40 minutes with mean squared error, mse=0.01683. Accuracy of the system is obtained by dividing the total number of samples recognized by the total number of samples tested. The proposed system has recognized 121 samples accurately out of 130 tested samples giving overall accuracy rate of 93%.

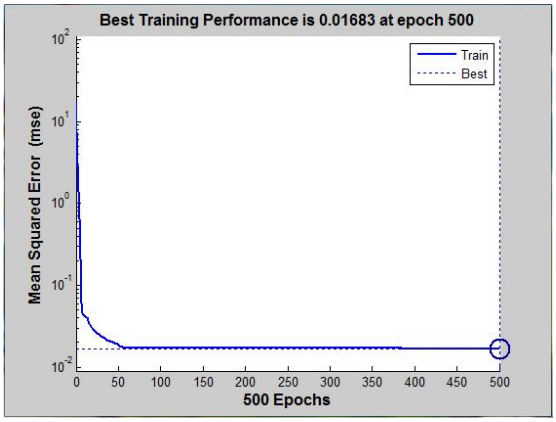

Fig. 8 Performance achieved when hidden layer neurons, n=50

TABLE II
INDIVIDUAL RECOGNITION RATE OF EACH CHARACTER

Character	No. of Samples Tested	No. of Samples Recognized	Percentage Recognition
A	5	5	100
B	5	5	100
C	5	5	100
D	5	5	100
E	5	5	100
F	5	5	100
G	5	5	100
H	5	5	100
I	5	3	60
J	5	5	100
K	5	5	100
L	5	5	100
M	5	5	100
N	5	4	80
O	5	5	100
P	5	5	100
Q	5	5	100
R	5	4	80
S	5	4	80
T	5	5	100
U	5	4	80
V	5	4	80
W	5	5	100
X	5	5	100
Y	5	3	60
Z	5	5	100

V. CONCLUSION & FUTURE SCOPE

In the proposed research work an attempt was made to develop an artificial intelligent system for character recognition. Levenberg-Marquardt algorithm was used to train feedforward multilayer backpropagation neural network. The system gave good performance with 93% accuracy rate.

Current work was carried out for recognition of printed English alphabet characters. In future we plan to explore in the field of recognition of handwritten characters and textured characters in different languages.

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