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Character Recognition using Artificial Neural Network

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Abstract **– A neural network is a machine designed to model the way in which the brain performs a particular task. Character recognition techniques help in recognizing the characters written on paper documents and converting it in digital form. Handwritten character recognition is a very difficult problem due to great variation of writing style, different size and shape of the character. Neural network is a technique used to improve the accuracy and efficiency of the handwritten character recognition system. The error back propagation algorithm is used to train the *MLP* networks. The main advantage of back propagation neural network (BPN) method is that it can fairly approximate a large class of functions. The aim of the paper is to use the improved neural network technique to recognize the offline handwritten characters.**

Keywords **– Offline Handwritten Character, Neural Network, Distance Feature, Back Propagation Algorithm.**

I. INTRODUCTION

Handwriting recognition has been one of the most fascinating and challenging research areas in the field of image processing and pattern recognition. With increasing the interest of computer applications, modern society needs the input text into computer readable form. In recent years, Character Recognition has been applied throughout the entire spectrum of industries, revolutionizing the document management process. Character recognition has enabled scanned documents to become more than just image files, turning into fully searchable documents with text content that is recognized by computers. Based upon the technique how the input data is obtained handwritten character recognition can be classified into two categories: Offline Handwritten character recognition and Online Handwritten character recognition. Recognizing handwriting recorded with a digitizer as a time sequence of pen coordinates is known as online character reorganization. Off-line handwritten character recognition deals with the scanned handwritten document.

A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships[1]. Neural network resembles the human brain in acquiring the knowledge and storing it within interneuron connection strengths. A neural network model is a structure that can be adjusted to produce a mapping from a given set of data to features of relationships among the data.

A back propagation network consists of at least three layers: an input layer, at least one hidden layer and output layer. Input units are connected to in a feed forward fashion with input units fully connected to the units in the hidden layer and hidden units fully connected to the units in the output layer. As the name suggested, the errors propagate backwards from the output nodes to the inner nodes. This method can be effectively used for the feature matching.

II. RELATED WORK

There is a worldwide interest in the development of handwritten character applications and the tremendous advances in the computational intelligence algorithms have provided new tools for the development of intelligent character recognition.

There are various types of classification of feature extraction methods like statistical feature based methods, structural feature based methods and global transformation techniques[2]. It can be mainly classified in three categories:

1) Partitioning in regions 2) Profile generation and projections 3) Distances and crossing. Statistical method uses the information of statistical distribution of pixels in image. Structural features are extracted from stricter and geometry of character. Global transformation features are calculated by converting image in frequency domain. Handwritten character recognition can be done by using associative memory net (AMN)[3]. It directly works at pixel level. Dataset designed in MS Paint 6.1 with normal Arial font of size 28 and keeping the dimension of image as 31 X 39. Once characters are extracted, their binary pixel values are directly used to train AMN.

Binary features can be used to train neural network [4]. Each individual character is resized to 30 X 20 pixels for processing. In post processing stage, recognized characters are converted to ASCII format. Another method for character recognition is the fuzzy membership function based approach [5]. In this method the images are normalized to 20 X 10 pixels. Average image (fused image) is formed from 10 images of each character. Bonding box around character is determined by using vertical and horizontal projection of character. After cropping image to bounding box, it is resized to 10 X 10 pixels size. After that, thing is performed and thinned image is placed in one by one raw of 100 X 100 canvas.

Similarity score of test image is matched with fusion image and characters are classified. Single layer neural network based approach for HCR to reduce training time [6]. Characters are written on A4 size paper in uniform box. Segmented characters are scaled to 80 X80 pixels. Wavelet transform based handwritten character and numeral recognition is also a method for pattern recognition [7]. Color images are converted in gray scale and median filter is applied to remove noise. Binarized image is then normalized to 32 X 64 pixels size.

III. System Design

The overall method of the implemented system is illustrated in Fig.1:

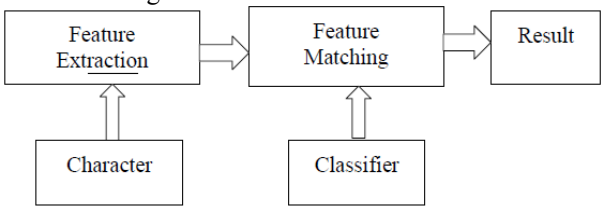

Fig.1.Block Diagram

- *Input Image:* The input character to the recognition system is given through the database.
- *Preprocessing and Feature Extraction:* Preprocessing step involves noise removal generated during document generation. Median filter is applied to remove noise from document. Binarization process converts gray scale or colored image to black and white image. Feature Extraction is the process used for extracting essential features from input.
- *Classification:* When input image is presented to HCR system, its features are extracted and given as an input to the trained artificial neural network classifier. It will compare the input feature with stored pattern and find out the best matching class for input.

IV. Proposed Feature Extraction Method

For extracting the feature, the zone based hybrid approach is proposed. The major advantage of this approach stems from its robustness to small variation, ease of implementation and provides good recognition rate. The character centroid is computed and the image is further divided in to fifty equal parts. Average distance from the character centroid to the each pixel present in the zone is to be computed. Similarly zone centroid is computed and average distance from the zone centroid to each pixel present in the zone is to be computed. We repeated this procedure for all the zones/grids present in the numeral image. Finally 100 such features are used for feature extraction. For classification and recognition nearest neighbor classifier and feed forward back propagation neural network classifiers are used. Following algorithm provides the proposed hybrid feature extraction system. (ICZ +ZCZ).

Proposed Algorithm: ICZ + ZCZ based Distance metric feature extraction system.
Input: Preprocessed numeral image
Output: Features for Classification and Recognition
Method Begins
Step 1: Compute the input image centroid
Step 2: Divide the input image into **n** equal zones.
Step 3: Compute the distance between the image centroid to each pixel present in the zone.
Step 4: Repeat step 3 for the entire pixel present in the zone.
Step 5: Compute average distance between these points.
Step 6: Compute the zone centroid
Step 7: Compute the distance between the zone centroid to each pixel present in the zone.
Step 8: Repeat step 7 for the entire pixel presentin the zone
Step 9: Compute average distance betweenthese points.
Step 10: Repeat the steps 3-9 sequentially for the entire zone.
Step 11: Finally, **2*n** such features will beobtained for classification and recognition.
Method Ends

V. ANN Approach

The recognition of characters from scanned images of documents has been a problem that has received much attention in the fields of image processing, pattern recognition and artificial intelligence. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain.

Phases in Back Propagation Technique

Back propagation learning algorithm can be divided into two phases: propagation and weight update.

Phase 1: Propagation

1. Forward propagation of the training input is given through the neural network in order to generate the propagation's output activations.
2. Back propagation of the output activations propagations through the neural network using the training patter's target in order to generate the deltas of all output and hidden neurons.

Phase 2: Weight Update

For each weight synapse:

1. Multiply its input activation and output delta to get the gradient of the weight.
2. Bring the weight in the direction of the gradient by adding a ratio of it from the weight.

This ratio is called as the learning rate which impacts on the speed and quality of learning.

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Back Propagation in Neural Network

In fig.2,

1. The output of a neuron in a layer moves to all neurons in the following layer.
2. Each neuron has its own input weights.
3. The weights for the input layer are assumed to be 1 for each input.
4. The output of the NN is obtained by applying input values to the input layer, passing the output of each neuron to the following layer as input.

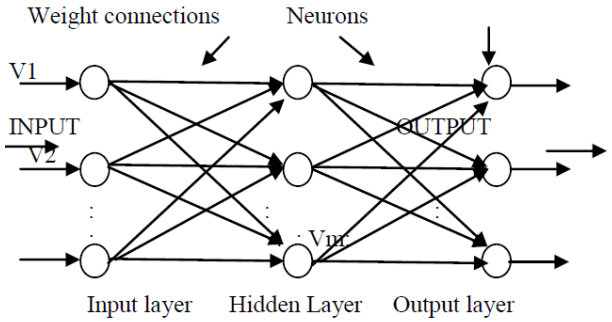

Fig.2. Architecture of the network

Back propagation is an iterative process which starts with the last layer and moves backwards through the layers until first layer is reached. If the error of the output is known, it is easy to calculate changes for the weights for reducing that error. The back propagation equations are given below [8]. For an artificial neural network,

$$y = \sum_{i=1}^{n} w_i x_i$$

where Xi are the inputs and Wi are the weights.

Assume that for each layer, the error in the output of the layer is known. If the error of the output is known, then it is not hard to calculate changes for the weights, so as to reduce that error. The error E is calculated as,

$$E=\sum_{P=1}^{N}(y_p^d - y_p)^2 \ldots\ldots\ldots (1)$$

Where y_p^d is actual system output and y_p is neural network output. The process starts by computing the partial derivative of the error because of a single input pattern with respect to the outputs of the neurons on the last layer.

E is the cost function and it should be minimum. To minimize E we take the partial derivative of the given equation (1) which is known as the Gradient descent rule.

$$\frac{\partial E}{\partial W_i} = \sum_{p=1}^{N} \frac{\partial E}{\partial y_p}\cdot\frac{\partial y_p}{\partial W_i}$$
$$= x_i.(-(y_p^d - y_p)) \ldots\ldots (2)$$

Using the numeric values of the derivative, the changes in weights are calculated using following equations:

If we update weight

$$W^{new} = W^{old} - \eta\frac{\sigma E}{\sigma W} \ldots\ldots (3)$$

$$V_j = \frac{1}{1+e^{-hj}} \qquad h_j = \sum W_{jk}\, y_k$$
$$y_i = \frac{1}{1+e^{-si}} \qquad s_i = \sum W_{ij}\, V_j$$

Weight update rule for weights between hidden layer & output layer

$$W_{ij}(t+1) = W_{ij}(t) - \eta\frac{\partial E}{\partial W_{ij}} \ldots\ldots (4)$$
$$W_{jk}(t+1) = W_{jk}(t) - \eta\frac{\partial E}{\partial W_{jk}}$$

Where,

Wij is weight connecting j^{th} hidden neuron and i^{th} output neuron.

Wjk is weight connecting jth hidden neuron and kth input neuron.

Therefore,

$$\frac{\partial E}{\partial W_{ij}} = -(y_i^d - y_i)\frac{\partial y_i}{\partial W_{ij}} = -(y_i^d - y_i)y_i(1-y_i)V_j$$

Substitute this value in equation (4) then we get,

$$W_{ij}(t+1) = W_{ij}(t) + \eta(y_i^d - y_i)\;\; y_i(1-y_i)V_j$$
$$\delta_i = (y_i^d - y_i)y_i(1-y_i)$$

Similarly

$$W_{jk}(t+1) = W_{jk}(t) + \eta\delta_j x_k$$

Where,

$$\delta_j = V_j(1-V_j)\sum_i \delta_i W_{ij}$$

Where,

δi is the error back propagated from the hidden layer.

δj is the error back propagated from the hidden layer.

VI. Experimental Results

Proposed system is simulated in the MATLAB platform. There are 2600 character images of 26 characters are used in this experiment, of which 50 are alternately selected for training for each character and other 50 as testing samples. The testing database is passed through the various blocks of the proposed system and finally compared with the recognition details from classifier. The test results of 100 test samples show that the whole recognition rate of the character recognition system is 84%.

Table I: Result Table

INPUT TO THE NETWORK	NO. OF HIDDEN NEURONS	PERFORMANCE ON TRAINING SET	PERFORMANCE ON TESTING SET
256X256 pixel input image	32	100%	83.61%
	38	100%	81.15%
	40	100%	83.15%

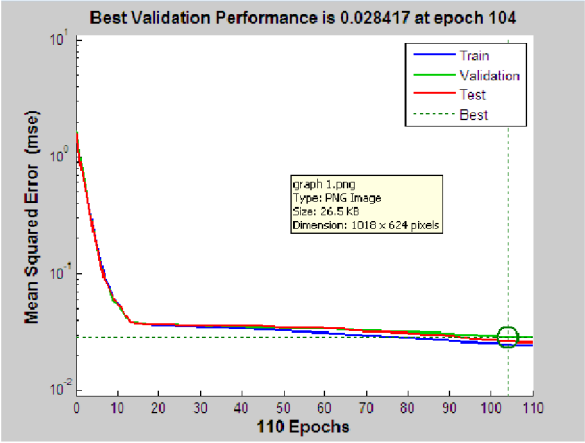

Fig.3.Comparison between mean squared error and no. of epochs

The validation performance of system is shown in Fig. 3 and it is observed that the best validation performance is 0.028417 at epoch 104.

VII. Conclusion

In this paper we have shown that how a simple character recognition program can be designed. The algorithm used is Back propagation which works on gradient decent rule. The project is implemented using the above algorithm in which a database of weights is created from the input patterns and then these weights are matched with the input patterns, which are given as output with some errors. The complexity of the problem is greatly increased by noise in data and by an almost infinite variability of hand writing as a result of the writer and the nature of the writing. Sometimes humans can't even recognize their own handwritings and the handwritten character varies from man to man and depends on many factors i.e. emotion, pen pressure, and environment. This is why; it is too difficult to get accurate efficiency. Though it is problematic if a man follows standard writing rules, the filtering and feature extraction is done more accurately, and then it is possible to recognize the handwritten text into computer readable form in more precise manner.

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