***ABSTRACT***

An off-line handwritten alphabetical character recognition system using multilayer feed forward neural network is described in the paper. A new method, called, diagonal based feature extraction is introduced for extracting the features of the handwritten alphabets. Fifty data sets, each containing 26 alphabets written by various people, are used for training the neural network and 570 different handwritten alphabetical characters are used for testing. The proposed recognition system performs quite well yielding higher levels of recognition accuracy compared to the systems employing the conventional horizontal and vertical methods of feature extraction. This system will be suitable for converting handwritten documents into structural text form and recognizing handwritten names.

***KEYWORDS***

Handwritten character recognition, Image processing, Feature extraction, feed forward neural networks.

***INTRODUCTION***

Handwriting recognition has been one of the most fascinating and challenging research areas in field of image processing and pattern recognition in the recent years. It contributes

immensely to the advancement of an automation process and can improve the interface between man and machine in numerous applications. Several research works have been focusing on new techniques and methods that would reduce the processing time while providing higher recognition accuracy.

In general, handwriting recognition is classified into two types as off-line and on-line

handwriting recognition methods. In the off-line recognition, the writing is usually captured

optically by a scanner and the completed writing is available as an image. But, in the on-line

system the two dimensional coordinates of successive points are represented as a function of

time and the order of strokes made by the writer are also available. The on-line methods have

been shown to be superior to their off-line counterparts in recognizing handwritten characters

due to the temporal information available with the former. However, in the off-line systems, the neural networks have been successfully used to yield comparably high recognition accuracy levels. Several applications including mail sorting, bank processing, document reading and postal address recognition require off-line handwriting recognition systems. As a result, the off-line handwriting recognition continues to be an active area for research towards exploring the newer techniques that would improve recognition accuracy.

***THE PROPOSED RECOGNITION SYSTEM***

In this section, the proposed recognition system is described. A typical handwriting recognition system consists of pre-processing, segmentation, feature extraction, classification and recognition, and post processing stages.

***Image Acquisition***

In Image acquisition, the recognition system acquires a scanned image as an input image. The

image should have a specific format such as JPEG, JPG etc. This image is acquired through a

scanner, digital camera or any other suitable digital input device.

***Pre-processing***

The pre-processing is a series of operations performed on the scanned input image. It essentially enhances the image rendering it suitable for segmentation. The various tasks performed on the image in pre-processing stage are shown in Fig. Binarization process converts a gray scale image into a binary image using global thresholding technique. Detection of edges in the binarized image using sobel technique, dilation the image and filling the holes present in it are the operations performed in the last two stages to produce the pre-processed image suitable for segmentation.

***Segmentation***

In the segmentation stage, an image of sequence of characters is decomposed into sub-images of individual character. In the proposed system, the pre-processed input image is segmented into isolated characters by assigning a number to each character using a labelling process. This labelling provides information about number of characters in the image. Each individual

character is uniformly resized into 90X60 pixels for classification and recognition stage.

***PROPOSED FEATURE EXTRACTION METHOD***

In this stage, the features of the characters that are crucial for classifying them at recognition

stage are extracted. This is an important stage as its effective functioning improves the

recognition rate and reduces the misclassification. Diagonal feature extraction scheme for

recognizing off-line handwritten characters is proposed in this work. Every character image of size 90x 60 pixels is divided into 54 equal zones, each of size 10x10 pixels. The

features are extracted from each zone pixels by moving along the diagonals of its respective

10X10 pixels. Each zone has19 diagonal lines and the foreground pixels present long each

diagonal line is summed to get a single sub-feature, thus 19 sub-features are obtained from the each zone. These 19 sub-features values are averaged to form a single feature value and placed in the corresponding zone. This procedure is sequentially repeated for the all the

zones. There could be some zones whose diagonals are empty of foreground pixels. The feature values corresponding to these zones are zero. Finally, 54 features are extracted for each character. In addition, 9 and 6 features are obtained by averaging the values placed in zones row wise and column wise, respectively. As result, every character is represented by 69, that is, 54 +15 features.

**Procedure for extracting feature from the characters**



***CLASSIFICATION AND RECOGNITION***

The classification stage is the decision making part of a recognition system and it uses the

features extracted in the previous stage. A feed forward back propagation neural network having two hidden layers with architecture of 54-100-100-38 is used to perform the classification. The hidden layers use log sigmoid activation function, and the output layer is a competitive layer, as one of the characters is to be identified. The feature vector is denoted as X where X = (*f*1, *f*2,…,*fd*) where *f* denotes features and *d* is the number of zones into which each character is divided. The number of input neurons is determined by length of the feature vector d. The total numbers of characters n determines the number of neurons in the output layer. The number of neurons in the hidden layers is obtained by trial and error. The most compact network is chosen and presented.

The network training parameters are:

* Input nodes: 54/69
* Hidden nodes: 100 each
* Output nodes: 38 (26 alphabets, 10 numerals and 2 special symbols)
* Training algorithm: Gradient descent with momentum training and adaptive learning
* Perform function: Mean Square Error
* Training goal achieved: 0.000001
* Training epochs :1000000
* Training momentum constant: 0.9.

***RESULTS AND DISCUSSION***

The recognition system has been implemented using Python.The scanned image is taken as dataset/ input and feed forward architecture is used. The structure of neural network includes an input layer with 54/69 inputs, two hidden layers each with 100 neurons and an output layer with 26 neurons. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions is used for neural network training. Neural network has been trained using known dataset. A recognition system using two different feature lengths is built. The number of input nodes is chosen based on the number of features. After training the network, the recognition system was tested using several unknown dataset and the results obtained are presented in this section.

Two approaches with three different ways of feature extraction are used for character

recognition in the proposed system. The three different ways of feature extraction are horizontal direction, vertical direction and diagonal direction**.**

In the first approach, the feature vector size is chosen as 54, i.e. without row wise and

Column wise features. The results obtained using three different types of feature extraction are summarized in Table. The criteria for choosing the type of feature extraction are:

i.The speed of convergence, i.e. number of epochs required to achieve the training goal.

ii. Training stability. However, the most important parameter of interest is the accuracy of the recognition system. The results presented in Table show that the diagonal feature extraction yields good recognition accuracy compared to the others types of feature extraction.

