Offline Handwritten Character Recognition Using Neural Network

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Abstract **-** This paper is aimed at recognition of offline handwritten characters in a given scanned text document with the help of neural networks. Image preprocessing, segmentation and feature extraction are various phases involved in character recognition. The first step is image acquisition followed by noise filtering, smoothing and image normalization of scanned image. Segmentation decomposes image into sub images and feature extraction extracts features from input image. Neural Network is created and trained to classify and recognize handwritten characters.

Keywords **-** *Offline Handwritten Character, Image Preprocessing, Segmentation, Feature Extraction, Image Normalization, Classification.*

I. INTRODUCTION

Character Recognition is one of the most successful applications of neural network technology. Character recognition is classified into two categories as:

- Offline character recognition
- Online character recognition

Offline character recognition deals with set which is obtained from scanned handwritten document. Online character recognition deals with automatic conversion of characters that may be written using a special digitizer [1]. There are two main areas in Character Recognition:

- Printed Character Recognition
- Handwritten Character Recognition

Printed Character Recognition includes all printed texts of newspaper, magazines, books and outputs of typewriters, printers or plotters. Handwritten Character Recognition includes handwritten texts [2].

This paper presents system for recognition of offline handwritten characters using Neural Network Toolbox in MATLAB. The paper is organized as follows: The recent work is presented in section II. Section III describes problem formulation. The proposed recognition system is presented in Section IV. The Feature Extraction Methods are described in section V. Section VI describes about classification and recognition. The results are presented in section VII. Finally, the conclusion is given in section VIII.

II. RELATED WORKS

This section is a literature review in published studies about recognition of characters and neural networks. In 1991, C.C. Chiang et.al [3] designed handwritten character recognition system implemented by a stochastic neural Net (SNN) and achieved recognition rate of 90-94%.In 1996, Gabriela Castellano et.al [4] developed a system for handwritten digits recognition using the Hough transform and a neural network. In this system the Hough transform is responsible for the feature extraction process from the input image and Neural network performs the recognition task. In this system two types of neural networks perform recognition. These are: The multilayer perceptron trained with the back error propagation algorithm and Kohonen's self organized feature map. Recognition rate of 80% was obtained using a Kohonen's self organized feature map testing 720 samples of digits written by 18 different persons. In 1998, Samuel et.al [5] developed a system for handwritten character recognition using a steerable filter and a neural network where the steerable filter yields the local direction of dominant orientation while the neural network recognizes the character. Two different models of neural networks have been tested: (i) The single layer Perceptron with error correction and (ii) Multilayer Perceptron with back propagation algorithm. The recognition rate is 54% without using any filtering and 80% using both filtering. Using only steerable filters, the recognition rate obtained is 74% and it is 72% when only low-pass filtering is used. In 2001, Yong Haw et.al [6] described an approach to combine neural network (NN) and Hidden Markov models (HMM) for solving handwritten word recognition problem. In this NN-HMM hybrid recognition system, the NN functions as the character recognizer that is not only able to recognize character in probability value, but also able to reject the letter hypotheses that do not look like any letter that it learned during the training process. The NN estimates character recognition probabilities for each letter hypothesis, while the HMM computes the best segmentation among all possible letter hypothesis, using dynamic programming approach. Dynamic programming (forward-backward) in the HMM select the most probable recognition result given a word image. In 2009, S. Arora et.al [7] proposed a scheme for offline Handwritten Devnagari Character recognition. The character is pre-processed and features namely: Chain code histogram, four side views, shadow based are extracted and fed to Multilayer Perceptrons.

Each MLP is trained with Backpropagation learning algorithm with momentum. It minimizes the sum of squared errors for the training samples by conducting a gradient descent search in the weight space. The proposed system achieved 98.16% recognition. In 2011, Salvador Espana-Boqurae et.al [8] proposed the use of hybrid Hidden Markov Model (HMM)/Artificial Neural Network (ANN) models for recognizing unconstrained offline handwritten texts. The model present new techniques to remove slope and slant from handwritten text and to normalize the size of text images with supervised learning methods. Slope correction and size normalization are achieved by classifying local extreme of text contours with Multilayer Perceptrons. Slant is also removed in a non uniform way by using Artificial Neural Networks. Recognition rate of 95% is obtained with HMM/ANN. In 2013, Rajneesh et.al [9] proposed a technique for script identification at character level that consist of English and Gurumukhi characters and digits. English character set of 52 characters (26 uppercase letters and 26 Lowercase letters), Gurumukhi character set of characters and 10 digits of each script. Experiments were performed on multifont and multisized characters with Gabor features based on directional frequency and Gradient features based on gradient information of an individual character. Multi-class Support Vector Machine has been used for classification. Average identification rates obtained with Gabor and Gradient features are 98.9% and 99.45% respectively.

III. PROBLEM FORMULATION

Recognition of isolated handwritten characters is process of identifying individual characters. Offline handwritten character recognition has wide range of applications areas like bank cheque reading, postal address interpretation, signature verification, document processing and many others. The problem is to recognize handwritten characters. This problem is divided into two phases:

- Reading a windows image format
- Development of Artificial Neural Network.

Second phase is further divided into two sub-phases:

- Training phase of neural network
- Testing phase of neural network.

The major difficulties in recognizing handwritten characters are:

- Variation in writing styles by different writers.
- Presence of noise and various kinds of distortions such as poorly written, degraded or overlapping characters.

IV. PROPOSED METHODOLOGY

The proposed method has four major steps:

- Image Acquisition and Preprocessing
- Segmentation
- Feature Extraction
- Classification and Recognition

A. Image Acquisition and Preprocessing

Image acquisition is the process of getting scanned image as input image. The image is acquired through a scanner, digital camera or any other digital input device. The image should have specific format such as JPG, PNG, JPEG, etc [2].

The preprocessing is series of operations performed on scanned input image to easily extract relevant features. Operations performed are binarization, noise removal, dilation, smoothing, skew detection, slant correction, normalization**,** contour making and skeletonization [2, 10]. The computation code for preprocessing of image using MATLAB software is as below

1. Binarization of image using function

```
bw = im2bw(im);
```

2. Edge detection of image using function

```
Iedge = edge(bw, 'sobel'); or

Iedge = edge(bw, 'canny');
```

3. Dilation of image using function

```
Se = strel('square',2);
```

4. Region filling of image using function

```
Ifill = imfill(bw, 'holes');
```

B. Segmentation

Segmentation is process of decomposing an image of sequence of characters into sub-images of individual character [2]. Segmentation is performed by using Matlab's function regionprops, bwlabel, rectangle and imcrop[11]. Segmentation of image is performed using function

```
[Ilabelnum] = bwlabel(Ifill);

Iprops = regionprops(Ilabel);

Ibox = [Iprops.BoundingBox];

Ibox = reshape(Ibox,[4,num]);

for cnt = 1:length(Ibox)

rectangle('position',Ibox(:,cnt),'edgecolor','r');

end
```

C. Feature Extraction

Feature extraction is used to extract relevant features for recognition of characters**.** Features may include height, width, density, loops, lines, stems and other character traits [8, 11].

D. Classification and Recognition

Classification is the decision making part of recognition system. Each pattern having feature vector is classified in predefined classes using classifiers. Classifiers are first trained by a training set of pattern samples to prepare a model which is then used to recognize the test samples. In paper, Neural network is used for classifying and recognizing handwritten characters.

V. FEATURE EXTRACTION METHODS

Feature extraction methods analyzes handwritten character image and selects a set of features that can be used for uniquely classifying character. Firstly features are computed and extracted and then most relevant features are selected to construct feature vector which is used for recognition [12].

A. Zoning Density Features

The character image is divided into overlapping or non-overlapping zones and densities of object pixels in each zone are calculated. From each zone features are extracted to form feature vector. Density of each zone is calculated by finding number of pixels in each zone and dividing it by total no of pixels [12, 13].

B. Diagonal Feature Extraction

In Diagonal Feature extraction technique features are extracted from pixels of each zone by moving along its diagonals. Diagonal features help to achieve better recognition accuracy [13].

C. Projection Histogram Features

Projection Histogram count number of pixels in particular direction. Projection Histogram types are: horizontal, vertical, left diagonal, right diagonal [13].

D. Distance Profile Features

Distance profile computes distance from bounding box of character image to outer edges of character. Profiles of four sides left, right, top, bottom are used.

Left and right profiles are traced by horizontal tracking of distance from left bounding box in forward direction and from right bounding box in backward direction respectively to outer edges of character. Similarly top and bottom profiles are traced by vertical tracking of distance from top bounding box in downward direction and from bottom bounding box in upward direction respectively to outer edges of character [7, 13].

E. Background Directional Distribution Features

Directional distribution values of background pixels for each foreground pixel are calculated by using masks as for each direction. The pixel 'X' is foreground pixel under consideration to calculate directional distribution values of background. The weight of each direction is calculated by using specific mask in particular direction [13].

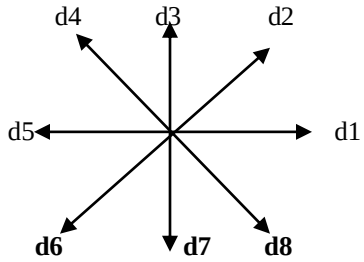

Fig.1 (a) 8 Directions

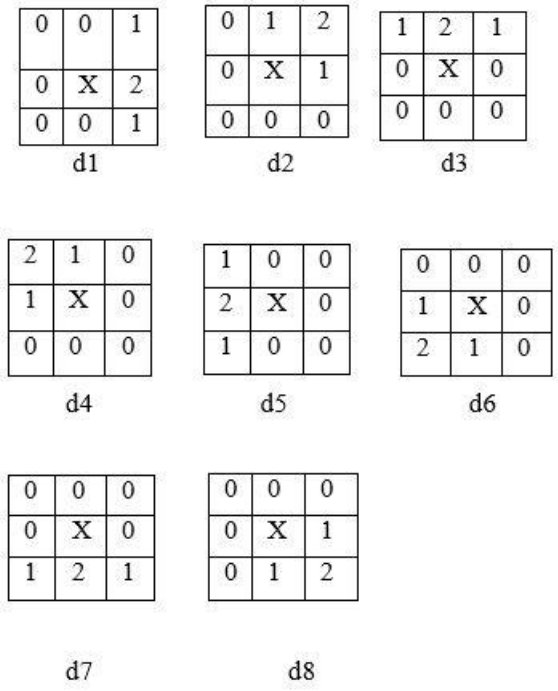

Fig.1 (b) Masks used to compute different directional distributions

VI. CLASSIFIACTION

The feature vector obtained from feature extraction is given as input to classifier for recognition of character. Neural network is used as classification tool. Classification step involves two phases: training phase and testing phase.

A. Creating neural network

A feed forward back propagation neural network is created by using MATLAB inbuilt function (newff). The network has one input layer, one output layer and two hidden layers. The command used to create three layer neural network is:

Net= newff(input-range, [H1 H2 O], {'logsig' 'logsig' 'logsig'}, 'traindx')

H1, H2, O represents number of neurons in first hidden layer, second hidden layer and output layer. Training function used is Log-Sigmoid ('logsig'). After execution of above command, network is created. Weights and bias of network are initialized and network is ready for training [14]. A network can be initialized using command:

Net = init(net);

An input vector is created by placing first 264 values out of 330 of segmented character i.e. out of 10 similar samples of same character, 8 values are taken and input vector is created. The other two values of character sample are saved in another file for testing. Target vector is 33x264 identity matrix.

The following parameters are used for creating network for training:

No. of neurons in input layer: 33
No. of layers: 2
No. of epochs: 1000
Learning rate parameter: 0.01
Network training parameter goal: 0.1
Transfer Function used for layer 1: "Logsig"
Transfer Function used for layer 2: "Logsig"
Adaptive Learning Function: "Traingdx"
Performance Function: "MSE"

B. Training Network

The training process begins by set of examples of proper network inputs and target outputs. During training phase, weights and biases of network are adjusted to minimize network performance. Performance function is mean square error (MSE), Sum Squared error (SSE). The adaptive learning function is "Traingdx". The network trains its weight array to minimize the error using back propagation algorithm. The image used for training comprises of samples of handwritten characters which is collection of 10 samples of each character making total of 330 samples. The training image is shown in Figure 2.

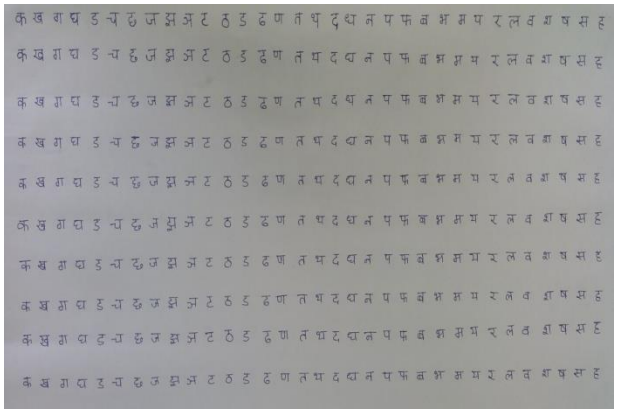

Fig.2. Training sample image

C. Testing and simulating Network

After training the network, recognition system was tested with untrained images. The MATLAB inbuilt function (sim) simulates the network.

VII. EXPERIMENTAL RESULTS

The recognition system has been implemented using MATLAB. The scanned image is taken as dataset input and feed forward architecture is used. Firstly neural network has been trained using known dataset of different handwriting styles. After training, system is tested using several unknown dataset and result is obtained. The desired performance goal has been achieved in 130 epochs.

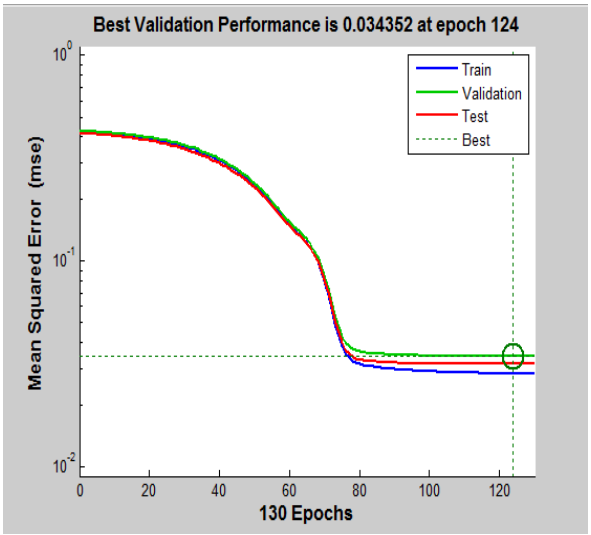

Fig.3. Neural Network performance state

Figure 4 shows neural network training state. It specifies the gradient at epoch 130, validation checks and also learning rate.

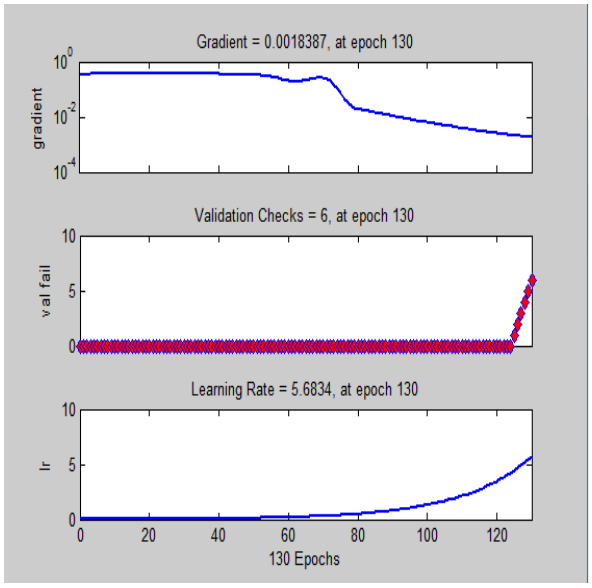

Fig.4. Neural network training state

Neural network regression state is shown in figure 5.

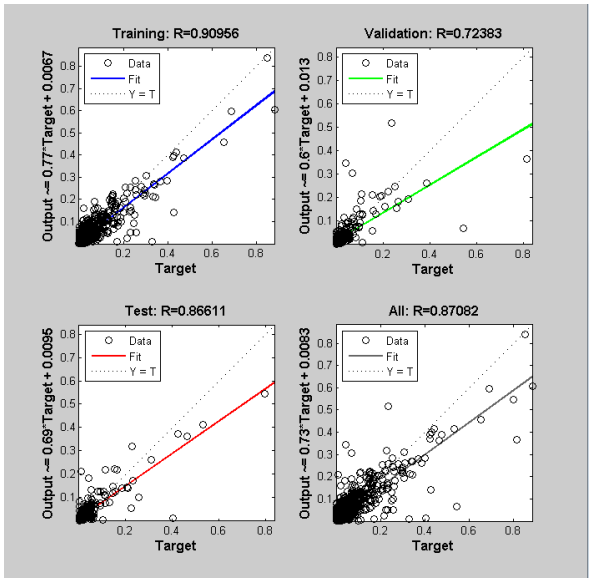

Fig.5. Neural network regression state

The recognition rate is defined as ratio of number of characters identified correctly to total number of characters, i.e.

$$\text{Recognition rate} = \frac{\text{number of characters identified correctly}}{\text{Total number of characters}} * 100$$

The proposed system has an average recognition rate of 94.70%.

VIII. CONCLUSION

In this paper, a system is developed for recognition of handwritten devnagari characters using feed forward back propagation algorithm. The system has two phases: the feature extraction phase and classification phase. The features obtained from feature extraction are fed as input for training neural network and then testing is performed. The proposed system has recognition rate of 94.70%.

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