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Handwritten Character Recognition System Using Neural Network

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Abstract: ***Character recognition system provides an efficient way to translate human readable characters to machine readable characters. Handwritten character recognition is an active and interesting area of research. An off-line handwritten character recognition system using multilayer feed forward neural network is described in the paper. We are using a method, called, diagonal based feature extraction for extracting the features of the handwritten alphabets. Twenty data sets, each containing 26 alphabets and 4 numerals written by different people, are used for training the neural network and 300 different handwritten alphabetical characters are used for testing. This paper describes the method for developing handwritten character recognition system for English alphabets and numerals with high recognition accuracy.***

Keywords: Handwritten character recognition; Feature extraction; Diagonal features; Feed forward neural networks.

I. INTRODUCTION

Handwriting character recognition is always a frontier area of research in the field of image processing and pattern recognition and it has been extensively studied in the last half century. Handwritings of different person are different; therefore it is very difficult to recognize the handwritten characters. It contributes immensely to the advancement of an automation process and can improve the interface between man and machine in numerous applications [1]. Handwritten recognition can be categorized into off-line and on-line handwriting recognition methods. Handwritten character and numeral recognition has a great potential in data and word processing for instance, automated postal address and PIN code reading, data acquisition in bank checks, processing of archived institutional records etc. Several studies have been carried out on recognition of characters in the languages like English, Chinese, Japanese and Arabic. Some studies are reported on the recognition of other languages like Tamil, Telugu, Oriya, Kannada, Panjabi, and Guajarati [2].

Reduction in processing time and higher recognition are the two major factors that motivate the researchers to focus on new techniques and methods for character recognition. The selection of appropriate feature extraction method is probably the single most important factor in achieving high recognition performance [1]. There are many feature extraction methods are available such as Projection Histograms, Contour profiles, Zoning, Geometric moment invariants, Zernike Moments, Spline curve approximation, Fourier descriptors, Gradient feature and Gabor features Template matching, Deformable templates, Unitary Image transforms, Graph description.

Dayashankar Singh, Sanjay Kr. Singh and Dr. (Mrs.) Maitreyee Dutta [4], have proposed feature extraction technique to calculate only twelve directional feature inputs depending upon the gradients. Features extracted from handwritten characters are directions of pixels with respect to their neighboring pixels.

Dinesh Acharya U, N V Subba Reddy and Krishnamurthy [7], have used horizontal/vertical strokes, and end points as the potential features for recognition and reported a recognition accuracy of 90.50% for handwritten Kannada numerals. However, this method uses the thinning process which results in the loss of features.

Shubhangi D. C. and Prof. P.S. Hiremath [5], describes the Multi Class SVM classifier and a novel feature set for English handwritten character and digit recognition. In this method structural micro feature set is proposed for handwritten data. Distinctive features for each character are extracted. Those features are passed to multiclass svm classifier which generates the hyperplane. Multiclass hyperplane plots the values of test images in the classified class.

S.V. Rajashekararadhya and Dr P. Vanaja Ranjan [6], have proposed Zone centroid and Image centroid based Distance metric feature extraction system handwritten numeral recognition for four popular South Indian Scripts. The character centroid is computed and the image (character/numeral) is further divided in to n equal zones. Average distance from the character centroid to the each pixel present in the zone is computed. Similarly zone centroid is computed and average distance from the zone centroid to each pixel present in the zone is computed. This procedure is repeated for all the zones/grids/boxes present in the numeral image. Feed forward back propagation neural network classifiers are used for subsequent classification and recognition purpose.

Dinesh Acharya U., N. V. Subbareddy & Krishnamoorthi [2], have proposed an automatic recognition of handwritten Kannada numerals using both unsupervised and supervised classifiers. Four different types of structural features, namely, direction frequency code, water reservoir, end points and average boundary length from the minimal bounding box are used in the recognition of numeral. The effect of each feature and their combination in the numeral classification is analyzed. The final classification is done based on the classification result vector by combing the fuzzy membership values of the base classifiers.

U. Pal, T. Wakabayashi, N. Sharma and F. Kimura [8], describes a modified quadratic classifier based scheme towards the recognition of off-line handwritten numerals of six popular Indian scripts. The features used in the classifier are obtained from the directional information of the numerals. For feature computation, the bounding box of a numeral is segmented into blocks and the directional features are computed in each of the blocks. These blocks are then down sampled by a Gaussian filter and the features obtained from the down sampled blocks are fed to a modified quadratic classifier for recognition.

M. Hanmandlu, K.R.Murali Mohan and Harish Kumar [9], describes the ring based and the sector based method for the recognition of handwritten English capital letters. It seeks to incorporate the variations in the representation of handwritten characters by enclosing characters in circles partitioned into either rings or sectors or both and extract the local features. The characters are pre-classified using the structural features.

Hadar I. Avi-Itzhak, Thanh A. Diep, and Harry Garland [10], describes the centroid-dithering training process with a low noise-sensitivity normalization procedure for optical character recognition. This method uses feedforward neural network scheme to recognize multi-size and multi-font character images.

II. PROPOSED RECOGNITION SYSTEM

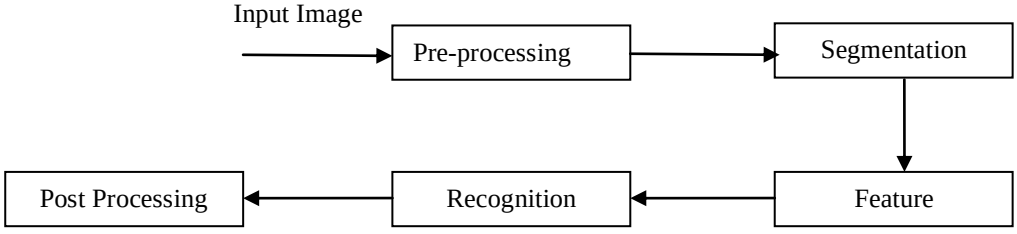

Fig. 1 Proposed Recognition System

The handwritten character recognition system includes image acquisition, pre-processing, segmentation, feature extraction, recognition and post processing stages.

A. Image Acquisition

Input image can be acquired using scanner, digital camera or by using any other digital input device. The input image should in JPEG or BMT format.

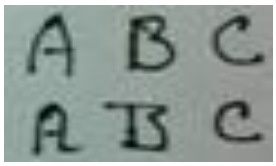

Fig. 2 Sample Image

B. Pre-processing

In pre-processing there are some operations such as noise removing, binarization, edge detection, dilation and filling.

Noise Reduction: Noise reduction is very necessary in order to improve the quality of image. noise can be removed by filtering, morphological operations.

Binarization: In binarization process the gray scale image is converted into binary image. Thresholding is a technique that is used for binarization. In thresholding, pixels that are alike in grayscale (or some other feature) are grouped together. A thresholded image is defined as

$$g(x,y) = \begin{cases} 1, \text{if } f(x,y) > T \\ 0, \text{ otherwise} \end{cases}$$

Where f(x,y) is the gray level at the point (x,y). The pixels labelled1 correspond to objects, and pixels labeled 0 correspond to the background.

Edge Detection: Edge detection refers to the process of identifying and locating sharp discontinuities in an image. There are many methods to perform edge detection some of them are canny method, sobel method, prewitt and roberts method etc.

Dilation and Filling: Dilation transforms an image in different size (but the same shape as the original). Dilation is the process of stretching or shrinking the original figure. The description of dilation includes the scale factor or ratio and the center of the dilation. Filling means filling the holes present in the image.

C. Segmentation

Segmentation includes the decomposition of image 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 labeling process. This labeling provides information about number of characters in the image [1]. Each individual character is uniformly resized into 70x50 pixels for extracting its features.

D. Feature Extraction

The major goal of feature extraction is to extract a set of features in order to maximize the recognition rate with the least amount of elements.

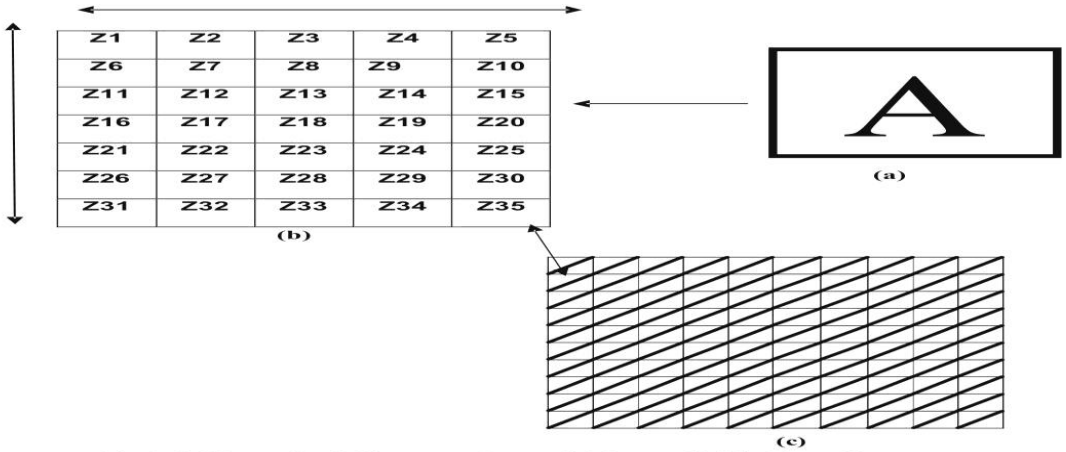

Fig 3. (a)Normalized Character Image (b) Image divided into 35 zones
(c) Diagonal Feature Extraction in a zone each of size 10*10 pixels

These features are extracted from the pixels of each zone by moving along its diagonals as shown in Fig 3. Following algorithm describes the computation of Diagonal Features for each character image of size 70*50 pixels having 10*10 zones and thus each zone having 10*10 pixel sizes. Each of these zones is having 19 diagonals. The number of foreground pixels along each diagonal are summed up to get 19 features from each zone, then these features for each zone are averaged to extract a single feature from each zone [11].

Computation of Diagonal Features

Step I: Divide the input image into n number of zones, each of size 10×10 pixels.

Step II: The features are extracted from the pixels of each zone by moving along its diagonals.

Step III: Each zone has 19 diagonals; foreground pixels present along each diagonal is summed up in order to get a single sub feature.

Step IV: These 19 sub-features values are averaged to form a single value and placed in corresponding zone as its feature.

Step V: Corresponding to the zones whose diagonals do not have a foreground pixel, the feature value is taken as zero.

Using this algorithm, we will obtain 35 features corresponding to every zone.

E. Classification and Recognition

There are many classification methods and they can be categorized as statistical methods, artificial neural networks (ANNs), kernel methods, and multiple classifier combination. Character classifier can be Baye's classifier, nearest neighbor classifier, Radial basis function, Support Vector Machine, Neural Network etc. We are using a feed forward back propagation neural network with two hidden layer architecture of 35-100-100-30 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 = (f1, f2,…,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 [1].

The used network training parameters are:

- Input nodes: 35
- Hidden nodes: 100 each
- Output nodes: 30 (26 alphabets, 4 numerals)

- Training algorithm: Gradient descent back-propagation with adaptive learning rate
- Perform function: Sum Square Error
- Training goal achieved: 0.000001
- Training epochs: 5000
- Training momentum constant: 0.95

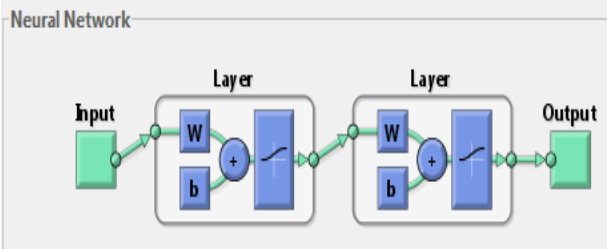

Fig. 4 Three layer neural network for handwritten character recognition

III. Result and Discussion

The recognition system has been implemented using MatlabR2010a.The scanned image is taken as dataset/ input and feed forward architecture is used. The structure of neural network includes an input layer with 35 inputs, two hidden layers each with 100 neurons and an output layer with 30 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. In our recognition system the desired performance goal has been achieved in 563 epochs.

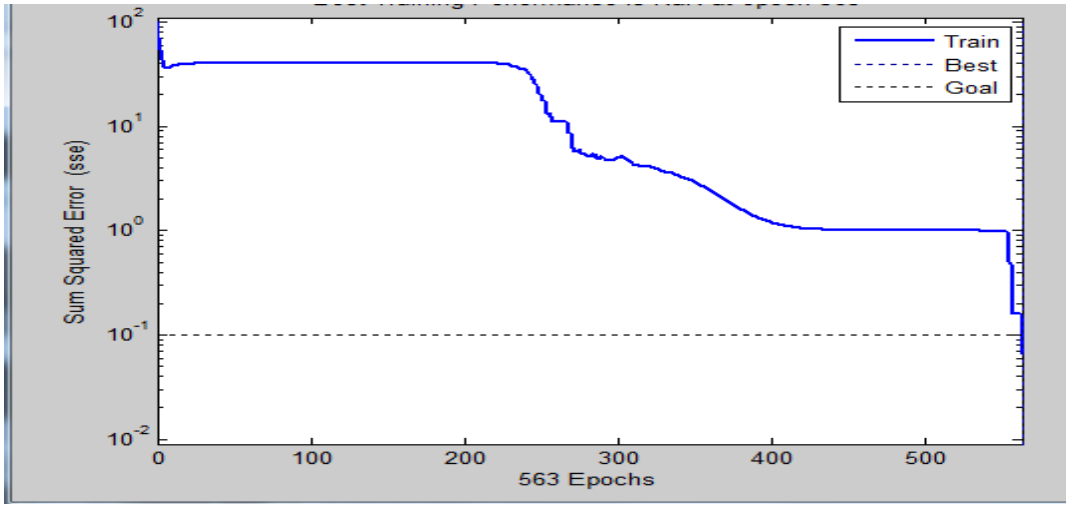

Fig. 5 The variation of SSE with training Epochs for 35 features

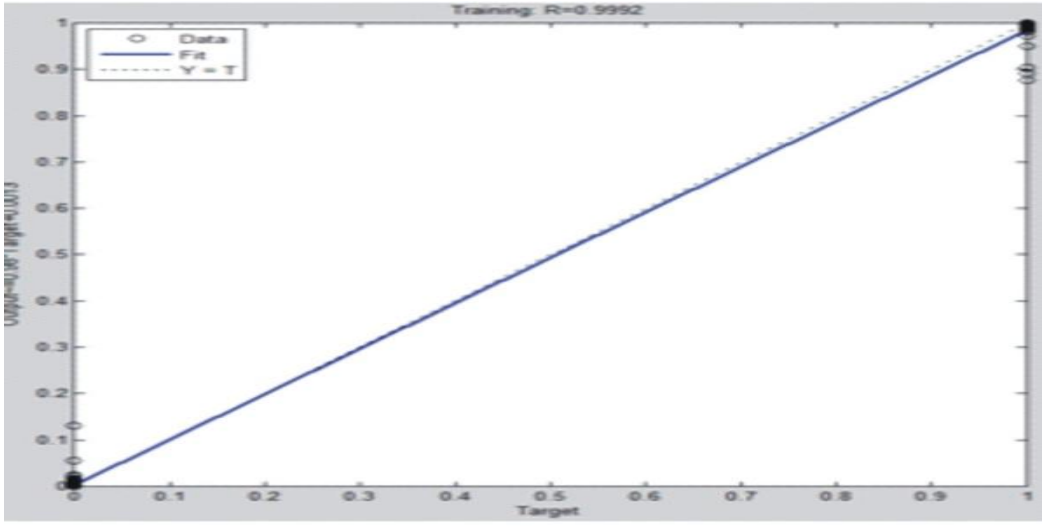

Fig 6. Performance with 563 epochs for 35 features

IV. CONCLUSION

A simple off-line handwritten English alphabet characters recognition system using diagonal feature extraction is proposed. In this approach 35 features chosen to build the Neural Network recognition system. Experimental results show that 35 features gives better recognition accuracy. From the test results it is identified that the diagonal method of feature extraction yields the highest recognition accuracy of 99.8 % for 35 features. The diagonal method of feature extraction is verified using a number of test images.

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