ISSN No. 2278-3091
Volume 2, No.3, May - June 2013
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://warse.org/pdfs/2013/ijatcse07232013.pdf

Character Recognition using Neural Network

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ABSTRACT

Handwritten characters recognition (HCR) presents a great challenge in the field of image processing and pattern recognition. This paper presents handwritten English characters recognised using shape based zoning features with the help of neural network (NN) as a classifier. The neural network used is pattern-net. The recognition rate is observed almost 96%.

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Key words:HCR, NN, Zoning, Pattern-net, Classifier.

1. INTRODUCTION

Handwritten characters recognition has been one of the most captivating and challenging research areas in field of image processing and pattern recognition in the recent years [1]. Several researchers have been focusing on new techniques and ideas that would reduce the processing time as well as providing higher recognition accuracy [2]-[3]. In general, handwritten characters recognition is classified into two types as off-line and on-line. In the off-line recognition, the handwritten characters are usually digitizedusing an optical scanner and the completed writing is available as an image. But, in the on-line system the successive touch points by a pen or device are represented on a two dimensional coordinates as a function of time and the order of strokes written on the special screen by the writer are also available. The on-line methods are superior to their off-line counter parts in recognizing handwritten characters due to the availability of temporal data in case on-line methods [4]. Yet, in the off-line systems neural networks are successfully used to achieve comparably high recognition accuracy levels [5]-[6]. Different applications like mail sorting, bank check processing, document reading and postal address recognition require offline handwriting recognition methods. Thus, the off-line handwriting recognition continues to be an active and challenging area for researcher and necessitates the exploration of the newer techniques that would improve recognition accuracy of the characters [7]-[8]. In this paper a neural network based off-line handwritten character recognition system is presented for the recognition of handwritten characters. The pre-processed image is segmented into individual isolated characters. Every character is resized into 32x32 pixels and these pixels information are used to train a Pattern-net neural network, especially for performing classification and recognition taskswhen number of outputs is large. The rest of the paper is organized as follows. In section II, the different feature extraction methods are described. Section III describes the methodologyused. Section IV discusses the various performance analysis parameters. Section V presents the experimental results and comparative analysis and finally, the paper is concluded in section VI.

2. FEATURE EXTRACTION

Feature extraction is still one of the basic building blocks of off line handwritten character recognition system. The performance of character recognition system is primarily depends on effective feature extraction and suitable classifier selection.The feature extraction stage analyzes a text segment unit and selects a set of features that can be used to uniquely identify the unit. The derived features are then used as input to the script classifier. These features are a reduced representation of the contents of the image which focus on preserving the characteristics that are most relevant to the task of identification. The aim of feature extraction is to identify patterns by means of minimum number of features that are effective in discriminating pattern classes. In HCR different feature of the texts may be important depending on the tasks and the approach of the process. The different feature extraction methods are elaborated in terms of their invariance properties, robustness and distortions and variability of the characters sets.Feature extraction methods are mainly classified into three major categories [21].

1. Statistical
2. Structural
3. Global Transformation

1. Statistical

Representation of a document image by statistical distribution of points takes care of style variations up to some extent. It is usually preferred for easy extraction and fast computation and also when reconstruction of image is not required. These features are found very low invariant to distortion, deformation and writing style of the character data set.

1.1 Zone

Image of the character is subdivided into blocks known as zone. Where horizontal plane is divided into m lines and vertical plane in n lines then number of zone formed will be (m x n). Then for particular region of a zone the average gray evel intensity is calculated. Zone intensity of a block is

restricted to a particular region instead on the whole image. Shape of a character will uniquely define each character set and hence used as feature. However these features are not illumination invariant. For example an image of 30x30 pixels if divided into 3x3 blocks then 9 features will be extracted from it as shown in figure 1.

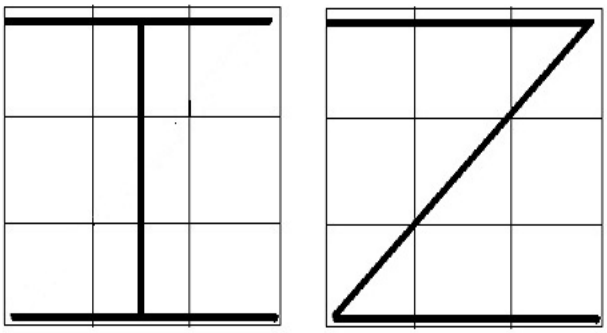

Figure 1: Showing two characters I and Z and zoning of image into 9 zone and each region area is independent on the whole image and hence can be extracted as feature.

1.2 Crossing and Distance

Another popular statistical feature is a number of crossings by a line segment of a contour. Number of transaction from background to foreground along the horizontal direction is horizontal crossing and along vertical direction will give vertical crossing [9].

1.3 Projection

Character image is divided into k regions as shown in figure 2 and then projection is taken in horizontal direction will give horizontal projection and similarly in vertical direction and diagonal will give vertical projection and diagonal projection respectively as shown in figure 2 [10].

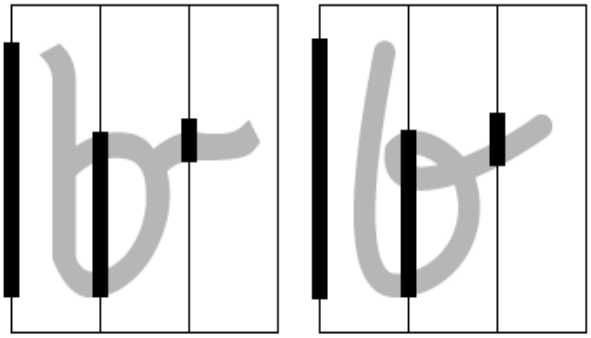

Figure 2: Shows an example of the celled projection. The geometric shapes on the figure represent Bangla numeral eight in standard form (on left) and handwritten distorted form (on right). It is noticeable that even with those distortions the celled projection of both character are quite similar.

2. Structural

Structural feature find high efficiency in on line character recognition [11]. Different local and global properties of the set of character image can be represented by geometrical and topological feature having high immunity to the handwriting style and distortion.

2.1 Topological structure

In this a predefined shape/structure is searched for mapping the character. It includes line (L) and arc (C) that constitute the main constituent of character. Character are represented by extracting and counting different topological feature like maxima, minima and extreme points, below and above threshold, number of loops, number of horizontal and vertical line segment and end points[12].

2.2 Geometrical Properties

Character are represented by geometrical properties such as width to height ratio, relative distance from first pixel to last from top to bottom and may include pixels distance from leftmost to rightmost.

2.3 Tree and Graph

Characters are converted into a set of topological primitives, which include strokes, loops, cross points, end points, etc. Then, these primitives are embodied using attributed or relational graphs [14]. The representation of graphs is done by two methods. The first method uses the coordinates of the shape of the character. The second is an abstract representation of the nodes corresponding to the strokes and edges according to the relationships between the strokes [15]. Trees are used to represent the characters with a set of features, having a hierarchical relation [16].

3. Global Transform

Global transform techniques transform the image into a compact form which reduces the dimensionality of the feature. Transform of the image can be represented by linear combination of a series of general well defined sine and cosine function. First N coefficients of the Fourier transform are taken as feature vector of a particular character. Since inverse transform is available so image can be reconstructed.

3.1 Fourier Transform

The magnitude spectrum of the feature vector as Euclidean space can be used as a feature. It also recognizes the pattern shifted character.

Fourier Angle: if moduli alone will not classify then efficiency can be increased with Fourier angle [17].

Fourier Magnitude: fast Fourier transform is not fully successful in case of rotation and shifted invariant descriptor. Hence use of Fourier descriptor has to be use to remain invariant to rotation and shift in character image.

3.2 Gabor Transform

It is best suited for rotation invariant and size invariant character set. Research has led to provides good tolerance with noise background or shape distortion and deformation [18].

3.3 Wavelet

Wavelet transformation is a series expansion technique that allows us to represent the signal at different levels of resolution. The segments of document image, which may correspond to letters or words, are characterized by wavelet coefficients, equivalent to various levels of resolution. These coefficients are then fed to a classifier for recognition [19].

3. METHODOLOGY

In this section, the methodology of recognition system is discussed. A simple handwriting recognition system consists of character Image acquisition, pre-processingwhich includes binarization and thinning, feature extraction and classification. The general schematic diagram of the recognition system is shown in Figure1.

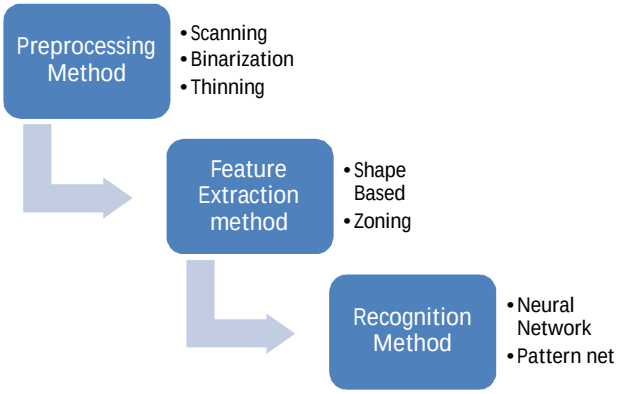

Figure 3: Shows a block diagram of recognition system

Character Image Acquisition: It is a process of obtaining a digital image of character and it is done with the help of scanner. The samples were taken on white paper having character set of 26 English uppercase characters of different 25 people and then with the help of scanner a digital image obtained of character sets and JPEG format is used for the assembly of characters sets.

Preprocessing of characters Images: In this process some operations areapplied before extraction of feature. Like segmentation is applied to isolate each character from each other. Manual segmentation is used to avoid error occurred during the segmentation process. After manual segmentation the image is enclosed by a minimum rectangle box which is defined as the shortest matrix that fits the entire character images and is selected because the features extracted from the character image include the positions of different line segments in the character image. So every character image should be independent of its image size.

Binarization: Binarization process converts agray-level image into a black-white image and is used to extract the object information from background.

Normalization and thinning: In this process image enclosed of minimum rectangle box is resized into 32x32 pixel images,because for zoning feature extraction every image should be invariant to size. After resized into 32x32 size image becomes gray scale and need to be converted to binary image. Hence the gray scale image (0 to 255 pixel values) is converted into binary image (0 and 1 pixel values) by selecting a threshold value in between 0 to 255. However for some low quality thresholding value is changed for getting better result depending on the value of intensity of the image. After *binarization,thinning* is applied on image so that image black pixel should be of only 1 width and be ready for next feature extraction process.

Feature extraction: Zoning is one of the most effective methods for extracting distinctive characteristics from patterns. In particular, zoning is very widely used in the field of handwritten pattern recognition, since different writing styles and changeable writing conditions make handwritten patterns extremely variable. The image is divided into windows of equal size, and the features are calculated on individual windows. Let A'be a pattern image and a zoning $ZM = \{z1, z2, \ldots, zM\}$ of image A'is a partition of A'into *M(16)* sub images, named zones, each one providing information related to a specific part of the pattern. The image was zoned into 16 equal sized windows. Feature extraction was applied to individual zones with also on the whole image. This gives more information about fine information of character skeleton. Also the locations of different line segments in a character image become a feature if zoning is used. Thus a particular line segment of a character image occurs in a particular zone in nearly all cases. For instance, the horizontal line segment in center of image of character 'A' almost occurs in the central zone of the entire character zone. For all 16 zones the averages of number of black and white pixel is calculated and cascaded along with whole image and used as 17 feature vectors (16+1).

Classification and Recognition: The classification stage is the decision making part of the recognition system. A feed forward back propagation based Pattern-net neural network is used in this work for classifying and recognizing the handwritten characters. The 32x32 pixels derived from the resized character in the segmentation stage form the input to the classifier. The hidden layer uses log sigmoid activation function and the output layer is a competitive layer as one of the characters is required to be identified at any point in time. The 26 total neurons are selected in the output layer [12].

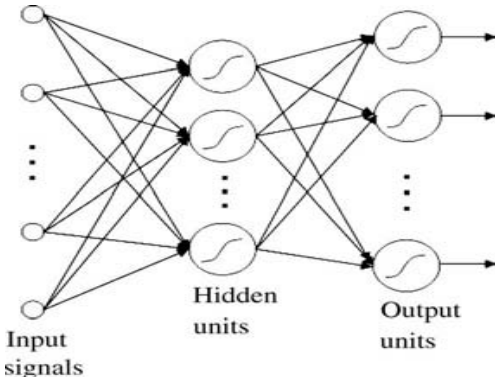

Figure 4 : Patternnet: A two-layer feed-forward network [20]

4. PERFORMANCE ANALYSES

MSE

MSE is the average squared difference between outputs and targets.Lower values are treated as better and zero value means no error and is defined by:

$$mse = \frac{\sum_{i=1}^{N}(e_i)^2}{N} = \sum_{i=1}^{N}(t_i - a_i)^2$$

Where t_i is the target and a_i is the output of the output neuron i.In each step the weight of the connections are justified by using the formula:

$$x_{k+1} = x_k - a_k g_k$$

Where a_k is learning factor, g_k is the gradient and x_{k+1} and x_k are new and previous weights.

Recognition rate

The recognition rate (RR) is defined as:

$$RR = \frac{Numbers\ of\ correctly\ recognized\ chracters}{Total\ number\ of\ testing\ characters}$$

Confusion Matrix

The element I (p, q) represents the number of elements with target class p and outputs as q. Thus the diagonal elements signify the correctly recognized character and other block shows the misclassified ones to other characters. The overall accuracy can be calculated by dividing the sum of the diagonal elements with the total number samples taken.

5. RESULTS AND SIMULATION

Database

Database is formed by taking samples from 25 different people. After scanning the characters samples were segmented and 25x26(650) total isolated samples were collected. From 650 samples, 520 were used for training purpose and rest 130 was used for testing.

Training

For the training purpose MATLAB Neural Network Toolbox has been used.

Size of the Neural Layers:

Input Layer: Since there are 17 feature, size of the input layers has been taken as 17.

Output Layer: The output layer size is the number of classes to be classified into as each output bit is allocated to a corresponding output class. For 26 characters there has to be output layer of size 26.

Hidden Layer: Ideally the number of hidden layer should lie in between N and 2N, where N is number of output layers but it has to be studied practically at what number system is providing better efficiency.

Classification: Classification is the process of classifying a given image unit into one of the predefined categories based on different feature analysis of the image. Once the image features are extracted the next task in character recognition is to group each image unit to their proper label based on their feature magnitude.

Table 1: Parameter values of different network

Number of Neuron	Time	Recognition Rate	Performance	Epoch
Neuron33	15	93	0.002937	149
Neuron40	17	91.64	0.002691	217
Neuron52	19	95.385	0.000259	138
Neuron80	22	96.154	0.001023	238
Neuron 104	25	93.85	0.001759	243

Characters recognition is observed with varying number of hidden neuron and various parameters are observed during the recognition process. From the table 1 it is clear 'training time' increases with the number of hidden layer neurons increases. Performance of the network is defined as 'MSE' i.e mean square error between targets and outputs.

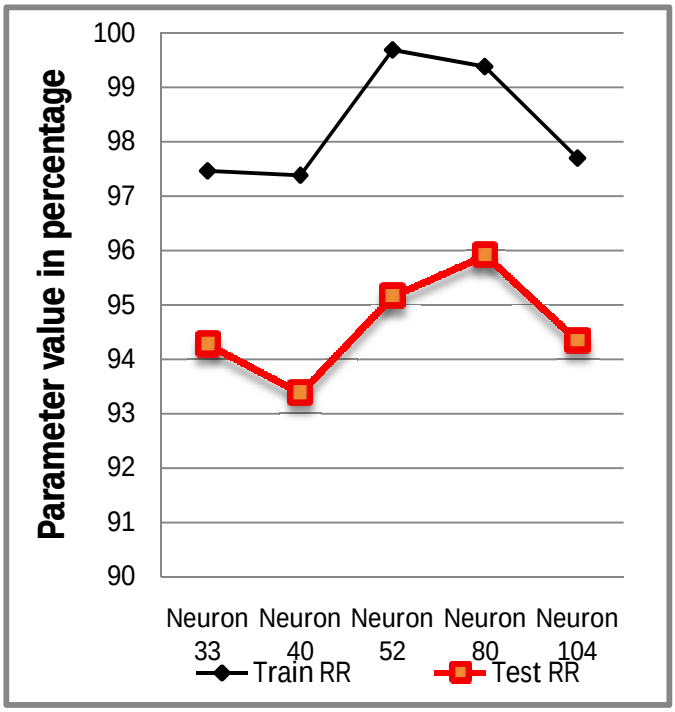

Figure 5 : Shows a line graph showing the recognition rate of training and testing respectively

Best recognition rate is observed by the network having neurons 80 and various parameter of network are given by:

- Name='Pattern Recognition Neural Network'
- Train Function: 'trainscg'
- Number of Hidden Neuron 80
- Computation Time (Train) =22 second
- Minimum MSE = .001023
- Epoch = 238

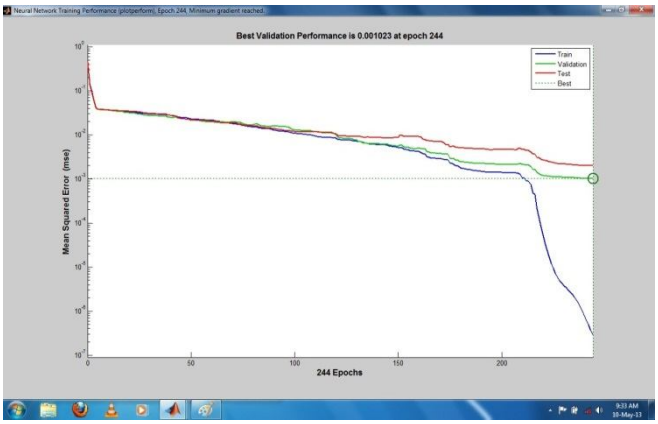

Figure 6 : Shows a MSE graph variation with respect to the epochs during training of the network

6. CONCLUSION

Offline handwriting recognition is a difficult problem, not only because of the great quantity of variations in human handwriting style, but also, because of the overlapping of the neighbor characters. Recognition strategies heavily depend on the nature of the data to be recognized. Since handwritten characters could be of carious shapes and size, the recognition process needs to be much efficient and accurate to recognize the characters drawn by different offline users. In pursuit of the highest recognition accuracy and the lowest misrecognition rate, the shape based feature extraction strategy for feature dimensionality reduction.There are different network in neural network for the classification purpose and pattern net network is used for classification and observed almost 96 recognition rate.

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