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Cursive Handwriting Recognition System Using Feature Extraction and Artificial Neural Network

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Abstract – Cursive *Handwriting recognition is a very challenging area due to the unique styles of writing from one person to another. Various researches have been conducted in this field since around four decades. In this paper, an offline cursive writing character recognition system is described using an Artificial Neural Network. The features of each character written in the input are extracted and then passed to the neural network. Data sets, containing texts written by different people are used to train the system. The proposed recognition system gives high levels of accuracy as compared to the conventional approaches in this field. This system can efficiently recognise cursive texts and convert them into structural form .*

Key Words **:** Image Processing, Feature extraction, Neural networks, Cursive handwriting, Classification.

1. INTRODUCTION

Cursive writing recognition is one of the most challenging research areas in the field of image processing and pattern recognition. Each person has a different style of writing the same alphabet. There are also variations in the text written by the same person time to time. The development of cursive writing recognition systems has led to an improved interaction between man and machine. Various research works have been conducted focusing on new techniques that aim at reducing the processing time while providing higher accuracy.

Handwriting recognition can be of two types, off-line and on-line recognition methods. In the off-line approach, the input is obtained by scanning the text written on the paper using a pen/pencil in the form of an image. In the on-line system the two dimensional coordinates of successive points are represented as a function of time. The input is hence obtained by transducer devices like electronic tablets or digitizers. The online system works in real time but the offline approach can provide higher levels of accuracy in recognising the characters. There are a number of applications where these systems can be used effectively like mail sorting, bank processing, document reading and postal address recognition.

The first step in any handwritten recognition system is pre-processing followed by segmentation and feature extraction. Pre-processing is mainly essential to shape the input image into a form suitable for segmentation. In the segmentation, individual characters are separated and then, each character is resized into m x n pixels towards the training network. The most critical factor in achieving high recognition performance is the selection of appropriate feature extraction method. The methods like Template matching, Graph description, Projection Histograms, Zoning are widely used.

An Artificial Neural Network is used in the back end for performing classification and recognition operation. In the off-line recognition system, the neural networks have emerged as the fast and reliable tools for classification towards achieving high efficiency. Some major classification techniques include statistical methods based on Bayes decision rule, Artificial Neural Networks (ANNs), Support Vector Machines (SVM) etc.

This paper is organized into various sections. The Section 2 gives a brief overview of the existing methods that have been proposed in this area. The next, Section 3 describes the proposed approach based on multilayer feed forward neural network. Towards the last sections of this paper, we analyse the results of the proposed approach under various conditions and conclude the paper.

2. EXISTING METHODOLOGY

Cursive handwriting recognition has been an area of interest of various researchers due to its applicability in easing a number of tasks of the real world. Notable contributions have led to development of systems which are extremely fast and efficient in recognizing the input texts.

The recognition of cursive texts based on division of continuous characters in triplets was proposed in 1999. A word was segmented into triplets an subsequent triplets contained two common letters [11]. This concept of overlapping the characters was used to achieve higher recognition rates. A cross correlation matrix was maintained to track the connectivity between the symbols. A modified quadratic classifier based scheme [9] to recognize texts in six

different Indian scripts was proposed in 2007. In the same year Horizontal/Vertical strokes along with Zoning techniques were proposed which have reported high efficiency [8]. But the feature extraction process in this approach is complex and time consuming. The method also uses thinning process on the characters which leads to the loss of certain features.

Neural Networks have proved to be an efficient tool for recognizing handwritten texts. In 2011, an approach based on the above was proposed but the characters had to be of a fixed size [5]. Feature extraction module was missing from this system rendering a low recognition accuracy. Another system based on hybrid Hidden Markov Model (HMM) was proposed in 2011 to recognize unconstrained offline texts[11]. The structural part of the optical model was modified and a Multilayer Perceptron was used to recognize the characters.

An approach to recognize English characters was proposed in 2012. It was based on Fuzzy classification theory [1] where a membership function was used. This function was based on the coordinates (x,y) and the length of the character. The degree of similarity between the character and trained image was used to recognize the alphabet. A Back Propagation algorithm [4] using momentum item and role function was proposed in 2013 for cursive writing recognition. The approach had advantages like quick speed and higher recognition effect.

3. PROPOSED SYSTEM

In this paper, a diagonal feature extraction scheme for the recognition of handwritten characters is proposed. An overview of the system can be taken from the block diagram in Figure 1.

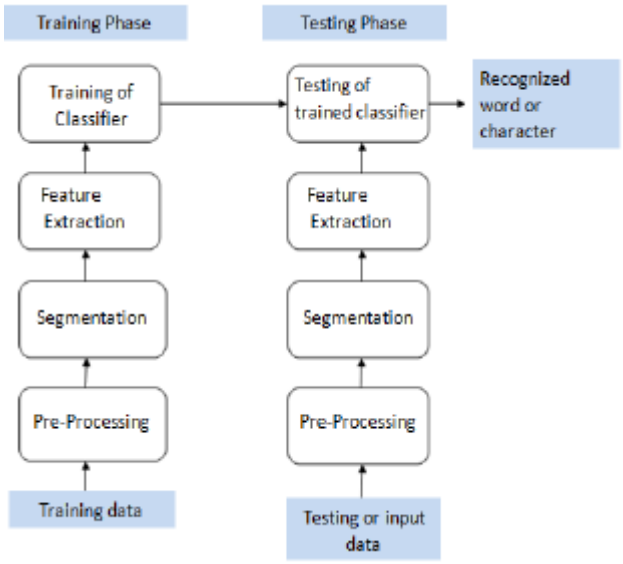

Fig - 1 : Block Diagram of Cursive Writing Recognition System

In the feature extraction process, resized individual character of size 90x 60 pixels is further divided into 54 equal zones, each of size 10x10 pixels. The features are extracted from the pixels of each zone by moving along their diagonals. This procedure is repeated for all the zones leading to extraction of 54 features for each character. These extracted features are used to train a feed forward back propagation neural network employed for performing classification and recognition tasks. The advantage of the above technique is that it requires lesser time to train the neural network.

3.1 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, BMT etc. The image is obtained through a scanner, digital camera or any other suitable digital input device.

3.2 Pre – Processing

A series of operations are 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 Figure 2. Binarization process converts a gray scale image into a binary image using a threshold method. Detection of edges in the binarized image using sobel operator, dilating 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. Slant correction is also done in this phase to correct the angle of the text.

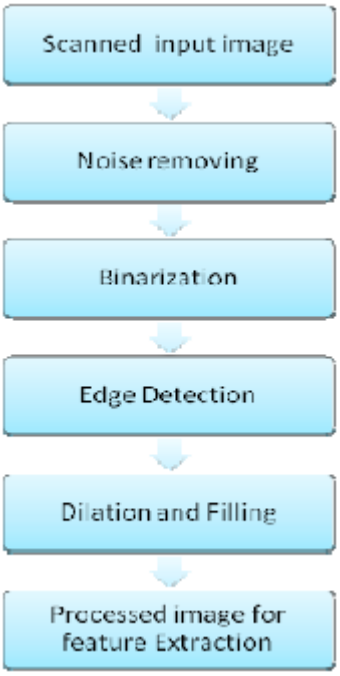

Fig – 2 : Stages of Pre - Processing

3.3 Segmentation

In this 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.

3.4 Feature Extraction

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 chain codes are used to detect the directions as shown in Figure 3 in order to extract the features of a character.

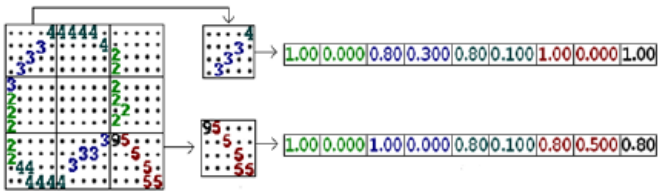

Fig – 3 : Directional features of a character

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 rowwise and columnwise, respectively. As result, every character is represented by 69,
features.

3.5 Classification and Recognition

This 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 as shown in Figure 4, having two hidden layers 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 = ($f1, f2,...,fd$) where f denotes features and d is the number of zones into which each character is divided.

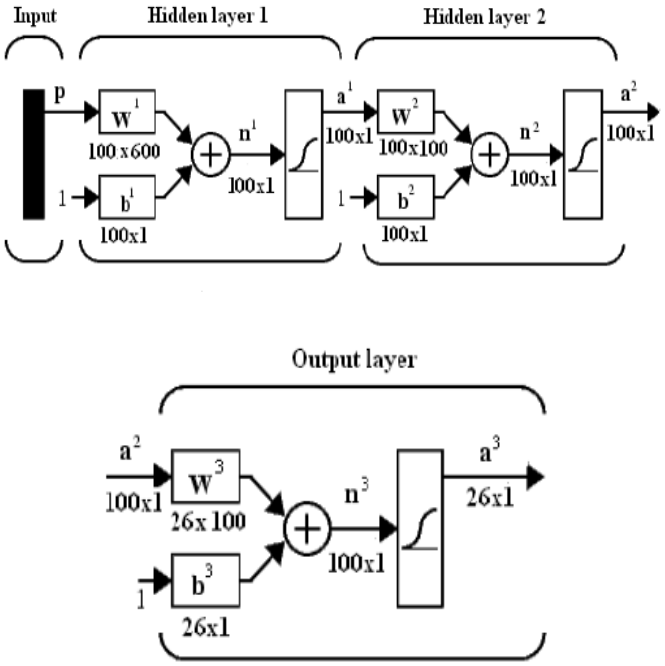

Fig – 4 : Architecture of the Neural Network

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.

4. EXPERIMENT AND RESULTS

The proposed system has been implemented using Matlab. 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 inputs, two hidden layers each with 100 neurons and an output layer with 26 neurons. The network is trained using the gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer function. 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 analysed here. Three different ways of feature extraction are used for character recognition in the proposed system ie. horizontal direction, vertical direction and diagonal direction. The feature vector size is chosen as 54,

i.e. without rowwise and columnwise features. The results obtained using three different types of feature extraction are summarized in Table 1.

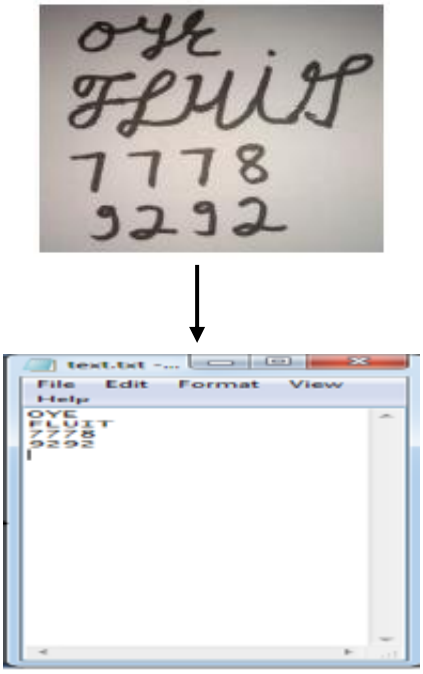

Fig – 5 : Input Text and Final Result

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 and (ii) training stability. However, the most important parameter of interest is the accuracy of the recognition system. A sample input image being converted into the desired result ie. recognised characters has been shown in Figure 5.

The results presented in Table 1 show that the diagonal feature extraction yields good recognition accuracy compared to the others types of feature extraction. The desired performance goal has been achieved in 923 epochs.

Table – 1 : Comparison of Recognition Rates obtained with Different Orientations

Networks	1	2	3
Feature Extraction type	Vertical	Horizontal	Diagonal
Number of nodes in input layer	54	54	54
Number of nodes in 1st hidden layer	100	100	100
Number of nodes in 2st hidden layer	100	100	100
Number of nodes in output layer	26	26	26
Recognition rate percentage	92.69	93.68	97.80

5. CONCLUSION

A simple off-line cursive character recognition system using a new type of feature extraction, namely, diagonal feature extraction is proposed. The Neural Network used to recognise the characters is built using 54 features. To compare the recognition efficiency of the proposed diagonal method of feature extraction, the neural network recognition system is trained using the horizontal and vertical feature extraction methods, six different recognition networks are built.

From the test results it is identified that the diagonal method of feature extraction yields the highest recognition accuracy of upto 97%. The diagonal method of feature extraction is verified using a number of test images. The proposed off-line hand written character recognition system with better quality recognition rates will be eminently suitable for several applications including postal/parcel address recognition, bank processing, document reading and conversion of any handwritten document into structural text form.

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