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Handwritten Urdu Characters Recognition Using Multilayer Perceptron

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Abstract

In recent years, Artificial Neural Networks are found to have a wide range of applications in many fields and Character recognition is one among them. In this paper, we intend to make use of artificial neural network in recognition of handwritten Urdu characters in isolated form with an aim of improving efficiency. The proposed method is based on the use of feed forward back propagation method to classify the Urdu characters. The Multilayer Perceptron neural network is trained using the Back Propagation algorithm in which handwritten Urdu letters represented in binary form are made ready as input to the neural network. An optimal architecture of the network with the limited sized training data is developed by balancing between model performance and training costs.

Keywords: Character Recognition, Urdu, Neural Network, Multilayer, perceptron, Handwritten

INTRODUCTION

Handwriting recognition is indeed one of the most attractive areas of pattern recognition [3]. It is applicable in a variety of real world problems like document analysis, mail address interpretation, cheque processing, signature verification, verification purposes and others [6**].**Various pattern recognition approaches have been tried in both online and off-line domain of handwriting recognition such as statistical, structural and syntactic techniques and also the neural networks. In case of online recognition, the system identifies strokes whereas the offline system tries to recognize Characters, groups of characters, or complete words **.**Inspired by biological nervous systems, neural networks are composed of simple units called neurons which operate in parallel. As in natural neural system, the network function is decided with the management of connections between units. A neural network is prepared to train itself to perform a specific function by altering the values of the weights between nodes. The neural networks are trained in such a way that a particular input leads to a specific output and the weights are altered until the network output is matched with the target output as shown in fig.1 below. There are various approaches for addressing the problem of character recognition and they vary on the basis of the features extracted from the graphical representation of the Characters.

Researchers have already paid attention towards the development of hand written character recognition system as discussed in [3-8] because of vital applications in several fields. Although a considerable performance has been achieved for handwritten recognition of many scripts, the problems still exist in developing a perfect system and the magnitude of the problem in recognizing Urdu script is very large owing to its cursive and variable characters. To make a distinction between the similar Urdu characters, their minor differences have to be identified with regard to the extent in which the characters are written by various writers and also by the same writer at different times. In this work, the objective of Urdu character recognition system is to transfigure a hand written character of Urdu text on the paper to a digital shape that can be manipulated by a Wordprocessor. In this system, a given input Urdu letter is mapped onto a single character of the Urdu character set. The final output is integrated through a lookup table. Neural network architecture is designed for diverse values of the network parameters such as like the number of layers, number of neurons in every layer, the values of weights, the training coefficient and the tolerance of the accuracy. Depending upon the complexity of the character, an optimum selection of the network parameters is made to achieve the desired result.

PROPOSED HANDWRITTEN CHARACTERS RECOGNITION SYSTEM

The Urdu character set inherits the properties of several other languages such as Persian, Arabic and Sanskrit. Handwritten Urdu characters are more cursive and complex in nature and hence more difficult to be recognized. The Urdu script contains 38 letters and ten numerals, some of them are similar in shape which makes them harder to be classified. Some characters are looped, some are open and some consist of rhombus shaped dots ranging from single to triple [1,3]. Most of the characters are differentiated with respect to the position of dots as well as their own position in the word. The absence of baseline and direction of writing of Urdu language makes it further distinguishable. The Urdu character changes its shape upto a maximum of four with the change in its context. These exclusive characteristics of Urdu characters make their classification and recognition more open and challenging to the researchers. The ongoing work involves two main phases for recognition of handwritten Urdu characters. In first phase,

the characters of Urdu script are preprocessed, skeletonized and then modelled as B-Spline curves whose dominant points can be computed from the control points of the curve as described in our previous part of this work [1, 3]. The characters are split into 48 blocks which are scaled to a standard size and then thinned so as to obtain the skeletal patterns of the characters to be recognized. The second phase consists of neural network architecture to which the characters to be classified are fed as shown in figure.1.

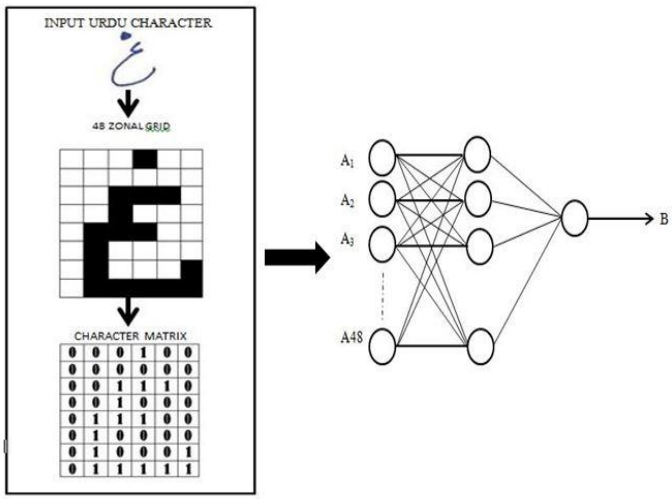

Figure 1. Urdu characters Recognition System

During the process, blocks of the Urdu characters to be recognized are arranged in the form of pixel matrix in such a manner that "1" shows the presence of block and "0" represents blank space. Each of 48 elements of this matrix serves as the input to each node of the neural network with different parameters for the training. The results are very satisfactory particularly when handwritten characters are more resembling with the printed ones.

Image acquisition

The Image acquisition is the first stage at which the system receives a scanned image of characters to be recognized in a particular format like JPEG or Bitmap through a scanner, digital camera or any other digital input device.

Preprocessing

The preprocessing step consists of several operations performed on the input image of the character the scanned input image. The preprocessing boosts the quality of image thereby making it ready for segmentation. Important operations in this step are binarization and dilation. Binarization is the process of transforming an image from gray scale to the binary form with the help of thresholding method. Dilation of edges is done after binarization using Sobel technique.

Segmentation

The segmentation stage is the significant step in the character recognition process in which a series of Characters is decomposed into sub-parts of individual character [9]. In the proposed work, the preprocessed input image is segmented into isolated characters and numbering each of them by making use of labeling method which helps in providing information about all characters in the input image. These individual handwritten characters are by assigning a number to each character using a labeling process. This labeling provides information about number of characters in the image. Each individual character is homogenously resized into 30X30 pixels.

Classification and Recognition

The classification and recognition stage is the most imperative part of any recognition system and is also called the decision making part of the recognition system [10]. In this work, a feed forward back propagation neural network is employed for classification and recognition of the handwritten Urdu characters as described below.

A. Multilayer Perceptron Network

An artificial neural network which makes use of more than one layer to accomplish the job of mapping the input neurons to the target output are known as multi-layer neural networks. The design of multi-layer ANN showing two layers has been presented in figure.3 as under:

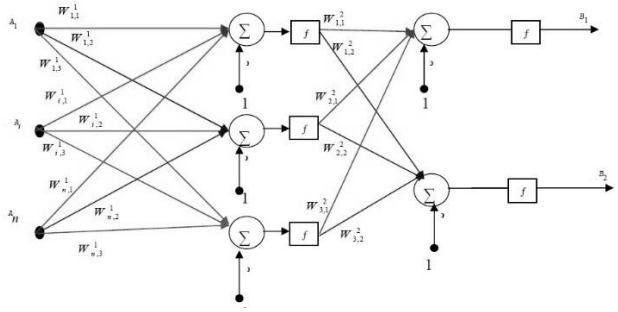

Figure 3. A multilayer Perceptron Network

An Artificial neural network which employs the Widrow-Hoff learning rule and nonlinear transfer functions is called the Backpropagation neural network and it estimates nearly any function with a finite number of cutoffs. The back propagation network when accurately trained produces better results for the inputs which have never been seen before. The multilayer perceptron networks are made to train in supervised way with the help of error back-propagation algorithm which works on the basis of error correction learning rule [11].This paper presents the application of feed forward MLP with Error-back propagation algorithm for training. Error back-propagation learning has two passes:-

a. Forward Pass: The input vector is fed to the nodes of the network and results are propagated from previous layer to the next one so as to get the final output of the

network. During this pass, the weights are kept constant.

b. Backward Pass: During this pass, the weights are altered as per error correction rule and the true output of the network is subtracted from desired output to produce the error signal which is propagated backward along the network nodes.

B. Multi-Layer Perceptron Algorithm

1. The network is initialized and the weights are randomly set to the numbers in the range [-1, +1].
2. Feed the network with first training data and get its output.
3. Make the comparison between actual output and desired output.
4. Propagate the Error in backward direction.
5. Adjust the weights of the output layer with the following expression:

$$W_{yz} = W_{yz} + (\eta \delta_z O_z)$$

Where x, y, z are input, hidden, output layers respectively; η = learning rate;

$$\delta_z = O_z(1 - O_z)(1 - O_z)$$

And adjust input weights as: $W_{xy} = W_{xy} + (\alpha \delta_y O_y)$

Where $\delta_y = O_y(1 - O_y)\sum(\delta_z W_{yz})$

6. Calculate the Error using following formula $E = \frac{\sqrt{\sum_{m-1}^{n}(t_z - O_z)^2}}{n}$
7. Repeat the step 2 to 6 for the training data to obtain one epoch.
8. Reshuffle the training data randomly.
9. Repeat the 2 to 6 for desired number of epochs or until error becomes constant.

In respect of Back-propagation training algorithm, the necessary calculations are as under:

$F_y = \frac{1}{(1+e^{-n})}$; Where N= $\sum W_{ij}O_i$

The error can be minimized by adjusting weights of the network with the help of following algorithm [9]:

$$E = \frac{\sum(T_{si} - A_{si})^2}{2}$$

And the weights can be updated by following formula so as to get the convergence:

$$W_{ij}(n + l) = W_{ij}(n) + \Delta W_{ij}(n)$$

$$\Delta W_{ij}(n) = \eta \delta X_j + \alpha(W_{ij}(N) - W_{ij}(n - 1))$$

EXPERIMENTAL RESULTS

The whole description in respect of the proposed system of recognition of handwritten Urdu characters is given in this paper. As mentioned above, the characters are sub-divided into 48 blocks for which the neural network is designed in a way that it takes 48 bits of the matrix as input and 38 outputs each representing an Urdu character. The data set of the Urdu Characters collected from different writers was arranged in such a manner that 150 samples for training and 150 for testing were stored make a total of 300 samples from 15 writers. The experimental results generated by the proposed method are depicted in Table.1 below. The individual blocks of the character cannot be input while creating the training patterns as the shape of blocks is mostly dependent on writing style. So, it was automated in such a way that whole character is fed to the system and then the particular block is extracted. The whole mechanism of training patterns is shown in figure.4 as under:

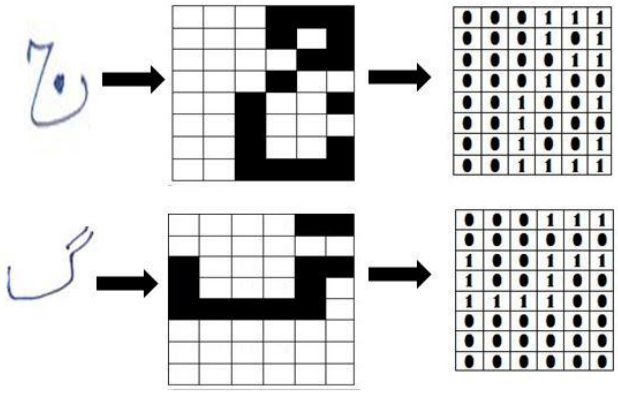

Figure.4. Training Samples of Handwritten Urdu Characters

The binary input of every Urdu character as shown in the matrix above is fed to all the input units of the neural network simultaneously which are processed through the hidden layers [12] and Backpropagation algorithm to train the network for all these characters thus enabling the trained network to recognize handwritten Urdu characters of different writing styles. The testing samples are indicated in figure.5 below:

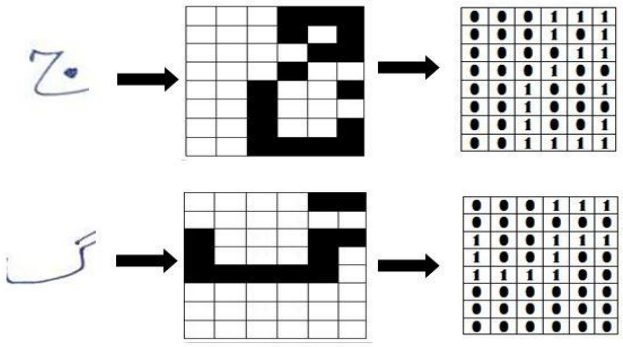

Figure.5. Testing Samples of Handwritten Urdu Characters

The network was trained for different samples of handwritten Urdu characters collected from different writers and also from same writer at different times and results obtained are tabulated as mentioned in Table.1

Table.1. Results of recognition of handwritten Urdu characters alongwith accuracy

URDU CHARACTERS	NO.OF TRAINING SAMPLES	NO.OF TESTING SAMPLES	EPOCHS	ACCURACY (%)
ا	25	08	297	93
ب	25	08	325	84
پ	25	08	592	73
ت	25	08	590	75
ٹ	25	08	548	88
ث	25	08	251	78
ج	25	08	250	86
چ	25	08	255	71
ح	25	08	260	74
خ	25	08	665	70
د	25	08	597	72
ڈ	25	08	298	89
ذ	25	08	645	87
ر	25	08	461	76
ڑ	25	08	395	73
ز	25	08	360	77
ژ	25	08	270	79
س	25	08	285	82
ش	25	08	660	88
ص	25	08	205	82
ض	25	08	255	92
ط	25	08	460	83
ظ	25	08	493	71
ع	25	08	515	90
غ	25	08	335	94
ف	25	08	255	81
ق	25	08	291	96
ک	25	08	645	74
گ	25	08	461	91
ل	25	08	395	77
م	25	08	490	96
ن	25	08	202	92
و	25	08	548	76
ہ	25	08	263	75
ھ	25	08	587	93
ء	25	08	285	88
ی	25	08	252	72
ے	25	08	669	95

CONCLUSION AND FUTURE SCOPE

In this paper, a method for recognition of Handwritten Urdu characters has been developed which makes use of Backpropagation neural network having two hidden layers. After testing the method for all 38 Urdu characters with different writing styles and also of the same writer a different moments of time, It has been observed that it has successfully recognized the handwritten Urdu alphabets having an average accuracy of 87% except some characters having similar shapes which have shown low recognition rate ranging from 73-80% . The method needs further improvement by increasing the size of data set and extension to include Urdu numerals which is left as future work.

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