Bengali Handwritten Character Recognition Using Artificial Neural Network

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***Abstract*— The constant development of computer tools leads to a requirement of easier interfaces between the man and the computer one of the example is handwritten character recognition. Handwritten character recognition is the ability of computer to receive and interpret the handwritten input images from sources such as document, photograph or touch-screen and transform it to machine readable and editable format. In this project we have developed an Artificial Neural Network for recognizing handwritten character. There are several steps we followed in this project. At first we went to the local school and collect handwritten character from the student of different classes for collecting the data. Then we preprocess the data. The input image which consists of the handwritten text will be loaded and will go through some process. The processing of the documents on which the characters to be interpreted reside, starts with making electronic images of them. At the end of the process, the information read from the forms is present in a database. Finally, the classification process will take place and the extracted character will be classified by using the Artificial Neural Network.**

***Keywords*— Character Recognition, Handwritten Character Recogniton, Bengali Character Recognition, Artificial Neural Network, Neural Network, OCR, ANN, NN.**

I. Introduction

The purpose of this paper is to take handwritten Bengali characters as input, process the character, train the neural network algorithm, to recognize the pattern and modify the character to a beautified version of the input. This project is aimed at developing software which will be helpful in recognizing characters of Bengali language. This project is restricted to Bengali characters only. It can be further developed to recognize the characters of different languages. This paper is already developed in English language. It engulfs the concept of neural network. One of the primary reason by which computers are possessed with humanlike abilities is through the use of a neural network[1]. Neural networks are particularly effective for solving problems that cannot be expressed as a series of steps, such as recognizing patterns, classifying them into groups, series prediction and data mining.

Pattern recognition is possibly the most common use of neural networks. The neural network is submitted with a target vector and also a vector which contains the pattern information, this could be an image and hand written data. The neural network then endeavors to determine if the input data matches a pattern that the neural network has memorized. A neural network trained for classification is designed to take input samples and sorting them into groups. These groups may be fuzzy, without clearly defined boundaries. This project concerns finding out free handwritten characters[2].

II. Background Study

Handwritten Character Recognition has been one of the most fascinating and challenging research areas of image processing and pattern recognition in the recent years. Handwritten Character Recognition is the competency of a computer to be given and explain intelligible handwritten input for example digital cameras as well as other devices. Handwritten Character Recognition system requires a number of phases that are pre-processing, feature extraction, and classification. Handwritten Character Recognition can be categorized into two elements which are on-line and off-line character recognition.

Off-line character recognition includes the automatic conversion of text in an image into letter codes which can be feasible within computer and text-processing applications. The data acquired by this form is considered a static representation of handwriting. Off-line character recognition is somewhat challenging, as different people have different handwriting patterns. On-line character recognition comprises of the automatic conversion of text as it is written on a particular digitizer or Personal Digital Assistant, in which a sensor senses the pen-tip movements and also pen-up/pen-down switching. This type of data is familiar as digital ink and can be regarded as a digital outline of handwriting. The obtained signal is transformed into letter codes which are workable within computer and text-processing applications[3][4].

This study launches the principle stages of Handwritten Character Recognition system and the classification process for recognizing a handwritten character. That process will be analyzing Using Artificial Neural Network. The objectives of this project is to take handwritten Bengali characters as input, process the character, and then train the proposed algorithm, to recognize the character.

III. The Dataset

We collect some of the data from different school from different ages of student. And we collect some of the data from the CMATERdb pattern recognition database repository. It consists of a Train folder and a Test folder, containing 12,000 and 3,000 images respectively. Also we collect some data from Banglalekha Isolated. BanglaLekha-Isolated, a Bangla handwritten isolated character dataset contains 84 different characters comprising of 50 Bangla basic characters, 10 Bangla numerals and 24 selected compound characters. 2000 handwriting samples for each of the 84 characters were collected, digitized and pre-processed. After discarding mistakes and scribbles, 1,66,105 handwritten character images were included in the final dataset. The dataset also includes labels indicating the age and the gender of the subjects from whom the samples were collected. This dataset could be used not only for optical handwriting recognition research but also to explore the influence of gender and age on handwriting. Our network is trained on slightly distorted images, continually caused in on-line fashion; hence we may use the whole un-deformed training set for validation, without worsening training images. Pixel intensities of the original gray scale images range from 0 (background) to 255 (max foreground intensity). 28*28 = 784 pixels per image get mapped to real values pixel intensity $\frac{image\ intensity}{127.5}$ -1.0 in [-1.0; 1.0], and are fed into the NN input layer[4].

IV. Materials and Methods

A. Related Work

1. Banglalekha isolated designed a system that is applied to their own handwritten Dataset for classification aim. The systems made us of Artificial Neural Network for classification.
2. *Chirag I Patel, Ripal Patel, Palak Patel* create a model to recognize the characters in a given scanned documents and study the possessions of changing the Models of ANN.

B. Neural Network

Neural network provides the best solutions to many problems in image recognition, natural language processing, and speech recognition. The basic idea of neural network is to simulate interconnected brain cells inside a computer so it can learn things all by itself, recognize patterns, and make decisions just like human way.

V. Data Preprocessing

We take pictures to preserve great moments in time. Pickled memories ready to be "opened" in the future at will. Similar to pickling things, we have to pay attention to the right preservatives. Of course, mobile phone also provide us with a range of image processing software, but as soon as we need to manipulate a huge quantity of photographs we need other tools. This is when programming and Python comes into play. Python and its modules like Numpy, Scipy, Matplotlib and other special elements provide the optimal functionality to be able to cope with the flood of pictures.

VI. Neural Network Design

In this paper, an Artificial Neural Network (ANNs) form the basis of an OCR which is trained using the Back Propagation algorithm. After converting the handwritten Bengali characters into 5×7 or 6×8 matrices as explained earlier, these matrices can be fed to the ANN as input. After the Feed Forward Algorithm which gives workings of a neural network, the Back Propagation Algorithm performs Training, Calculating Error, and Modifying Weights. The Back Propagation algorithm starts with computing the output layer, which is the only one where desired outputs are available. The error rate in the output layer is calculated based on the difference between the desired output and the actual output. In this project, the result of Back Propagating ANN is a matrix of 1×52. The output being obtained from the Back Propagation ANN can be used to obtain one of the alphabets of the Bengali language. The Back Propagation Neural Network implemented for the purpose of this project is composed of 3 layers, one input, one hidden and one output. For the 5×7 (6×8) matrices, the input layer has 35 (48) neurons, the hidden layer has 100 neurons, (the number of neurons in the hidden layer has been determined by trial and error) and the output layer has 52 neurons. The output layer is in fact a competitive layer (only one bit of the output becomes 1 for each class). For this project, the sigmoid function has been used as a non-linear neuron activation function:

$$y = \frac{1}{1+\exp(-z)}$$

Bias terms (equal to 1) with trainable weights were also included in the network structure.

VII. Training and Testing

In this paper, we train the network to recognize the Bengali Alphabet characters, the corresponding 5×7 (6×8) grids are applied in the form of 1×35 (1×48) vectors to the input of the network. The initial learning rate was experimentally set to 1.5 which is divided by a factor of 2 every 100 iterations and is reset to its initial value after every 400 iterations and the momentum rate is set to 0.95. For testing, the weights that were calculated during the training are used. The testing inputs are given in the form of a 1×35 (1×48) vectors for the corresponding 5×7 (6×8) grids. Character are considered recognized if all the outputs of the network were no more than 0.01 off their respective desired values. Now that we’ve trained the network, at least on a small subset of 100 records, we want to test how well that worked.

VIII. Performance And Evaluation

In order to train the network to recognize the Bengali Alphabet characters, we applied the corresponding 5×7 or 6×8 grids in the form of 1×35(1×48) vectors to the input of the network. We had initially tested the network only for the 5×7 grids (which are obtained by running a 10×10 window on the 50 pixel ×70 pixel resized sub-image of a character) but then We also tested the network for a larger matrix, so We resized each sub-image to a 90 pixel ×120 pixel image and then ran a 15×15 window on it this time. As it is obvious the resolution of the second approach is much higher, so our results got improved. The Error goal is set to 0.01 for all the 52 outputs, which means a character can be recognized only if all the fifty two outputs of the network were no more than 0.01 off their respective desired values. The initial learning rate was experimentally set to 1.5 and the momentum was set to 0.95.

TABLE I

COMPARISON OF RECOGNITION RATE RESULTS OBTAINED USING DIFFERENT ORIENTATION WITH 35 FEATURES:

Networks	**1**	**2**	**3**
Feature Extraction Type	**Vertical**	**Horizontal**	**Diagonal**
Number of Nodes in Input Layer	35	35	35
Number of Nodes in Hidden Layer	100	100	100
Number of Nodes in Output Layer	52	52	52
Recognition Rate Percentage	88.56	89.37	86.69

TABLE II

COMPARISON OF RECOGNITION RATE RESULTS OBTAINED USING DIFFERENT ORIENTATION WITH 48 FEATURES:

Networks	**1**	**2**	**3**
Feature Extraction Type	**Vertical**	**Horizontal**	**Diagonal**
Number of Nodes in Input Layer	48	48	48
Number of Nodes in Hidden Layer	100	100	100
Number of Nodes in Output Layer	52	52	52
Recognition Rate Percentage	90.47	86.76	87.39

Conclusion and Future works

An off-line handwritten character recognition using Artificial Neural Network has been described in this paper. We follow this procedure in this paper: First scanning the paper page with the handwritten characters on it then extracting sub-images of individual characters form the scanned image using the image processing. Resizing the sub-images either to a 50 pixel ×70 pixel image or a 90 pixel×120 pixel image (Since the cropped sub-images of characters from the last step can have different sizes, they have to be resized to a same standard size to be given as the input to the classifiers). Creating a 50×70 or a 90×120 matrix of Boolean values from each sub-image by assigning ‘0’s to white pixels and ‘1’ to black pixels. Resizing the original large matrix to a smaller matrix (by running a 10×10/15×15 window on the 50×70/90×120 original matrix and finding the average of the values in the window). Feeding the 5×7/6×8 matrix in the form of a 1×35/1×48 matrix to the input of the Back Propagation Neural Network. Finally, we can get the results of the classification As the results from the previous section suggests NN is the most efficient and the fastest classifier for solving this problem that have been examined in this paper. Moreover, for the BP NN we mentioned earlier we have considered an input matrix and we got higher accuracy for the input that had higher resolution. So performances of our technique were measured by highest Accuracy: 89.16%. Besides these information analysis results can be utilized for further research as a part of upgrading the accuracy of the Handwritten Character Recognition system in future. Our future goal is to find out the real accuracy using neural network. And also we want to complete this with a full featured Android Application and implement this in a real world.

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