

Handwritten Bangla Character Recognition Using Artificial Neural Network

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Abstract: *This paper presents a system for recognizing Bangla handwritten characters using Artificial Neural Network based on Multi Layer Perceptron classifier. The Bangla alphabets Sorborno and Banjonborno have been chosen to test the recognition System. Character is recognized by analyzing its shape and comparing its features that differentiates each character. The required images are acquired using a digital camera. The color images are then cropped, resized, and converted to binary images. Finally, Multi Layer Perceptron (MLP) based classifier is used for recognition of candidate regions. Experimental results show the relatively high accuracy of the developed method on training and the test sets respectively.*

Keywords: *Artificial Neural Network, Multi Layer Perceptron classifier, OCR, Feature Extraction.*

I. Introduction

Character recognition is an art of detecting segmenting and identifying characters from image [1]. Optical Character Recognition (OCR) is a process of converting printed or handwritten scanned documents into ASCII characters that a computer can recognize. It contributes immensely to the advancement of automation process and improving the interface between man and machine in many applications. Character recognition is one of the most interesting and fascinating areas of pattern recognition and artificial intelligence [2]. Character recognition is getting more and more attention since last decade due to its wide range of application.

This is an efficient way to turn hard-copy materials into data files that can be edited and otherwise manipulated on a computer. This is the technology used for data entry for business documents, e.g. check clearing, automatic number plate recognition, importing business card information into a contact list, more quickly make textual versions of printed documents, e.g. book scanning for Project Gutenberg, make electronic images of printed documents searchable, e.g. Google Books, converting handwriting in real time to control a computer.

Character recognition process can be categorized in two types. One is Offline character recognition and another one is online character recognition. In offline character recognition system, document is first generated, digitized, stored in computer and then it is processed. While in case of online character recognition system, character is processed while it was under creation. External factors like pressure speed of writing, stroke making etc. does not have any influence in case of offline system but they have great impact on online system.

H. Izakian et. al. [3] used a chain code based algorithm to identify isolated Farsi/Arabic characters. Their method extracts a feature vector of each Farsi characters and computes a chain code for each feature vector using a neighborhood function and a series of normalization. S. A. Husain et al. [4] presented a method for recognition of online Cursive Urdu hand written Nastaliq Script. The system was currently trained for 250 ligatures. The Recognition rate of base ligatures was 93%. M Abdul Rahiman et al. [5] has also proposed a Malayalam OCR system. The proposed system has used Daubechies wavelet for feature extraction and neural networks for recognition. The system has been given an accuracy of 92%. Md. Alamgir Badsha et al. [6] has also proposed a system for recognizing bangla handwritten character. The proposed system has used neural network for recognition. The system has been given an accuracy of 84%.

This system can recognize 50 letters with average accuracy of 91.62% and 82.33% for training and test samples respectively. The paper is organized as follows. Section 2 illustrates objective. Section 3 briefly explains Artificial Neural Network and Multi Layer Perceptron (MLP) based classifier. Proposed framework is described in section 4. Section 5 presents results Evaluation and Discussion. Finally Conclusion is given in section 6.

II. Objective

To presents a simple and novel method for handwritten Bangla character recognition system. Also decrease the recognition problem and the computational time. The goal of Bangla character recognition is to provide an efficient and accurate mechanism to recognize the handwritten bangle character. My goal is to recognize 50 basic Bangla characters using Multi Layer Perceptron (MLP) based classifier.

III. Artificial Neural Network

Artificial neural networks (ANNs) are computational models inspired by humans' central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition. They are usually presented as systems of interconnected "neurons" that can compute values from inputs by feeding information through the network. In a neural network for handwriting recognition, a set of input neurons may be activated by the pixels of an input image representing a letter or digit. The activations of these neurons are then passed on, weighted and transformed by some function determined by the network's designer, to other neurons, etc., until finally an output neuron is activated that determines which character was read.

It can be used in function approximation, or regression analysis, including time series prediction, fitness approximation and modeling, classification, including pattern and sequence recognition, novelty detection and sequential decision making, data processing, including filtering, clustering, blind source separation and compression, robotics, including directing manipulators, prosthesis, control including computer numerical control.

3.1 Multi Layer Perceptron classifier

A Multi Layer Perceptron (MLP) is a feedforward artificial neural network model that maps sets of input data onto a set of appropriate outputs. A MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called backpropagation for training the network [7]. MLP is a modification of the standard linear perceptron and can distinguish data that are not linearly separable.

IV. Proposed Framework

I have used MATLAB tools to implement the algorithm. The block diagram in figure 2 shows the working approach towards the solution of the stated problem. In this recognition system, I have used multilayer perceptron classifier. For recognizing the input character by neural network, processed candidate character images must be resized.

4.1 Capture Image

The handwritten bangla character is first captured using digital camera and stored in .jpg format. The characters were written by 100 different peoples. The size of the input images is 480×320 pixels.

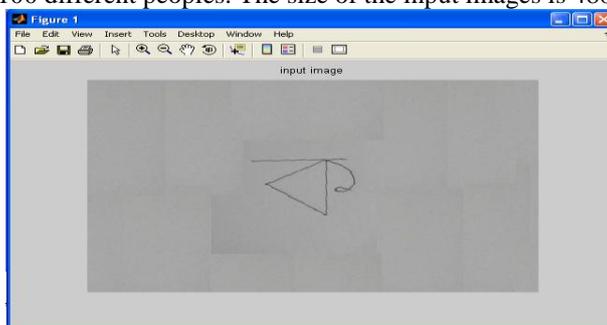


Fig-1: Capture Image

4.2 RGB to Gray scale converter

It is the process that converts the RGB image into Gray scale image. I need to do this conversion because I need binary image for operation. The RGB image is a combination of RED, BLUE AND GREEN colors. The RGB image is 3 dimensional. In an image, at a particular position say (i,j). Image(i,j,1) gives the value of RED pixel, Image(i,j,2) gives the value of BLUE pixel and Image(i,j,3) gives the value of GREEN pixel. The combinations of these primary colors are normalized with $R+G+B=1$; This gives the neutral white color. The grayscale image is obtained from the RGB image by combining 30% of RED, 60% of GREEN and 11% of BLUE. This gives the brightness information of the image. The resulting image will be two dimensional. The value 0 represents black and the value 255 represents white. The range will be between black and white values.

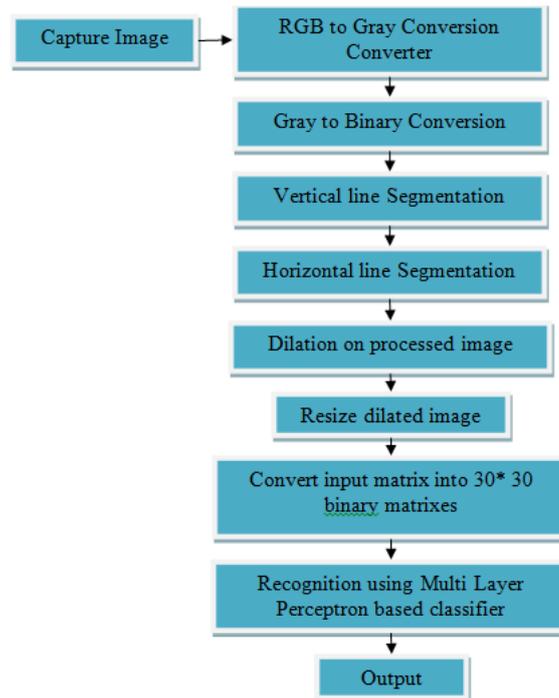


Fig-2: The proposed framework for Handwritten Bangla character recognition.

4.3 Gray scale to Binary image converter

A binary image is a digital image that has only two possible values for each pixel. Naturally the two colors used for a binary image are black and white though any two colors can be used. The color used for the object(s) in the image is the foreground color while the rest of the image is the background color. Thresholding is the simplest method of image segmentation. Thresholding can be used to create binary images from a grayscale image. Thresholding creates binary images from grey-level images by turning all pixels below some threshold to zero and all pixels about that threshold to one. If $g(x, y)$ is a thresholded version of $f(x, y)$ at some global threshold T ,

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

Pixel which have value 1 correspond the object and pixel which have value 0 correspond background. T is a constants, this approach is called global thresholding. Figure 3 shows the result of conversion from gray scale image to binary image.

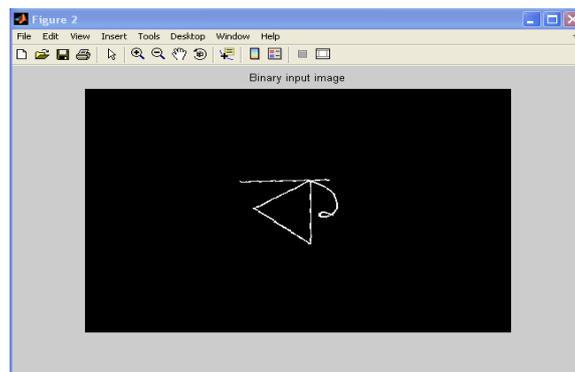


Fig-3: Gray scale image to Binary image

4.4 Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [8] [9]. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

4.4.1 Vertical line Segmentation

image. It scans through y-axis of the region. Fig-4 shows the result of vertical segmentation of binary image.

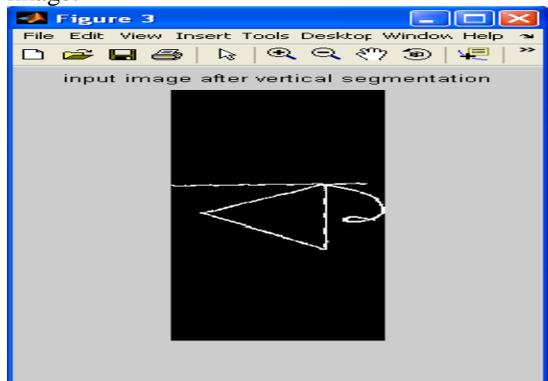


Fig-4: Input image after vertical segmentation

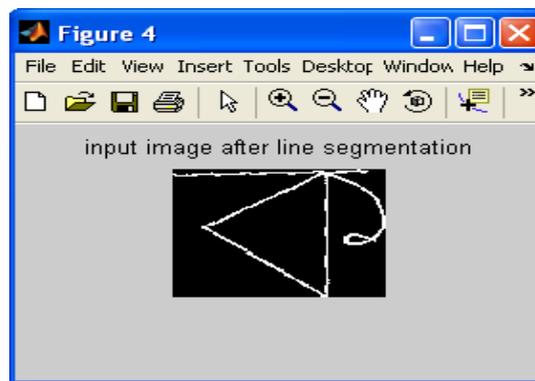


Fig-5: Image after horizontal segmentation

4.4.2 Horizontal line Segmentation

Then horizontal line segmentation is done on the image that is acquired after vertical line segmentation. It scans through x-axis of the region. When scanning discovers any white pixel, it assumes it to be the beginning of any character. And when gets any all-black column in the way of scanning it thinks it to be the end of that digit. Using this handwritten region separated from unwanted area.

4.5 Dilation

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Dilation is one of the basic operations in mathematical morphology. Originally developed for binary images, it has been expanded first to grayscale images, and then to complete lattices. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image. Dilation adds pixels to the boundaries of objects in an image. The number of pixels added to the objects in an image depends on the size and shape of the structuring element used to process the image.

To compute the dilation of the processed binary input image by structuring element, I consider each of the background pixels in the input image in turn. For each background pixel I superimpose the structuring element on top of the input image so that the origin of the structuring element coincides with the input pixel position. If at least one pixel in the structuring element coincides with a foreground pixel in the image underneath, then the input pixel is set to the foreground value. If all the corresponding pixels in the image are background, however, the input pixel is left at the background value. Figure 6 shows the dilation result on processed image.

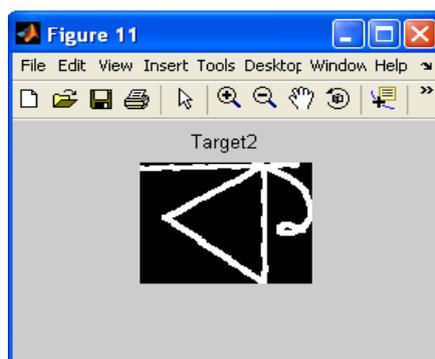


Fig-6: Processed image after dilation

4.6 Target matrix generation

After Dilation on processed image I resized the image and then sample the entire image into a specified portion so that I can get the vector easily. For this I need to convert the 480 X 320 image into the 30 X 30 area by horizontal and vertical segmentation and resize operation. I can easily produce the target matrix for multi layer perceptron network. It is 60 X 60 identity matrixes. The diagonal values are 1 and the value of remaining elements is 0. For each column there is only one element where the value is 1 represents the output neuron is on and other neurons are off. One output column is for input row.



Fig-7: Resized image

4.7 Recognition using Multi Layer Perceptron classifier

Multi Layer perceptron (MLP) is a feed-forward neural network with one or more layers between input and output layer. Feed-forward means that data flows in one direction from input to output layer (forward). This type of network is trained with the back-propagation learning algorithm. Each artificial neuron in the Multi Layer perceptron computes a sigmoid function of the weighted sum of all its inputs. The output from every neuron in a layer of the MLP is connected to all inputs of each neuron in the immediate next layer of the same. Neurons in the input layer of the MLP are all basically dummy neurons as they are used simply to pass on the input to the next layer just by computing an identity function each. The numbers of neurons in the input and the output layers of an MLP are chosen depending on the problem to be solved.

I have used multi layer perceptron network for my proposed system. The network has three layers. The first layer takes input as 30 X 30 matrixes shown in figure 8. The second layer is hidden layer. It consists of 10 neurons. The third layer is output layer. It consists of 60 neurons. The number of neuron in the hidden is chosen carefully to improve the performance of the neural network. Then the output of MLP classifier is converted into human understandable form. For this it uses a thresholding process. It takes 0.5 as threshold value and converts the processed matrix into 1 0 binary matrix. If the value of processed matrix is greater than 0.5 it is set to 1, otherwise the value is set to 0.

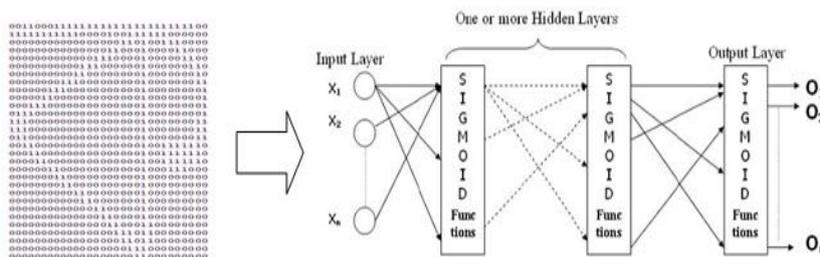


Fig-8: Multi Layer Perceptron classifier

V. Result Evaluation And Discussion

For preparation of the training and the test sets of samples, a database of 5,000 bangla character samples is formed. 50 Bangla characters are collected from 100 peoples of different age groups. A training set of 3500 samples and a test set of 1500 samples are then formed through random selection of character samples of each class from the initial database in equal numbers. An MLP with one hidden layer is chosen for my proposed system. All experiments were done on dual-core 3.00 GHz with 2 GB RAM under MATLAB environment. Recognition rate is calculated as

$$\text{Recognition Rate} = \left(\frac{\text{No. of recognized letters}}{\text{No. of total samples of that letters}} \right) \times 100\%$$

For example, recognition rate of 'ফ' = (95/100)*100 = 95%.

For training samples, recognition rate = (3207/3500)*100 = 91.62%.

For testing data, recognition rate = (1235/1500)*100 = 82.33%.

VI. Conclusion

In this paper I present a simple model of handwritten Bangla character recognition system using Artificial Neural Network based on Multi Layer Perceptron classifier. The recognition rate of my method is remarkable. The software is implemented by using MATLAB. The input images are taken by a camera and it must be in .jpg format. This system can recognize handwritten bangla character with an average accuracy of

91.62% and 82.33% for training and test samples respectively. In the future work, I will try to improve the recognition rate and will also try to do handwritten bangla character recognition from a Bangla text line.

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