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Handwritten Assamese Character Recognition using Texture and Diagonal Orientation features with Artificial Neural Network

Rubul Kumar Bania

Assistant Professor, Department of Computer Applications,
North-Eastern Hill University, Tura Campus, Meghalaya-794002, India.
Email: rubul.bania@gmail.com

RuhUllah khan

Former Post Graduate Student, Department of Computer Applications,
North-Eastern Hill University, Tura Campus, Meghalaya-794002, India.

Abstract

Handwritten word recognition (HWR) is a kind of optical character recognition (OCR) system. Text segmentation and feature extraction are the essential parts of a HWR system. In the text segmentation phase generally lines of text, words then characters are segmented from a given text image document. In this paper, a computational model is proposed for handwritten Assamese text to perform the preprocessing, text segmentation and then extraction of different features from individual characters for further classification task. To segment, a document image into various parts, global projection profile approach is used with some modifications. For character segmentation, zone-segmentation approach of a word is used to identify the upper, lower and middle area of a word. An amalgamation of diagonal features using zoning concept and texture features via GLCM (Gray Level Co-occurrence Matrix) are computed for extracting various features of individual characters. A feed-forward back propagation neural network having two hidden layers is used to recognize the characters**.** Two categories of data for Assamese scripts were collected from different persons with a constraint of less cursive nature of writing style. One category belongs to isolated characters and another category belongs to sentences. The proposed model achieves maximum accuracy in segmenting the text images and for classifying the characters successfully.

Keywords: Assamese, Segmentation, Feature extraction, Diagonal, GLCM, Neural network.

INTRODUCTION

We human being can recognize printed or handwritten characters easily but to make a computer system to recognize these characters becomes a difficult and challenging task due to random variation of noise, varying styles, cursive nature, unvarying fonts and size. Optical character recognition or Optical Character Reader (OCR) describes a system that performs the mechanical or electronic conversion of images. They are capable of converting typed and handwritten texts into "machine-encoded text". Identification of handwritten characters is an important step in the process of Optical Character Recognition (OCR) of handwritten document images, which is a vital perspective for various document retrieval purposes [1][2]. OCR finds a variety of applications and is a widely used form of information entry owing to its ability to digitize printed documents. The problem of handwritten recognition which comes under OCR has been studied for decades and many methods have been developed. Handwriting word recognition (HWR) is one kind of OCR system which mainly focuses on handwritten documents. HWR is categorized into either online or offline model [1]. In Online HWR, the trajectories of pen tip movements are recorded and analyzed to identify intended information. It uses temporal information, such as the position and velocity of the pen along its trajectory, is available to the recognition algorithm. Since most algorithms for online HWR attempt to recognize the writing as it is being written, sometimes it is also referred to as "real-time" HWR. On the other hand, off-line HWR deals with the recognition of handwritten words after it was written[2]. Moreover, there is little or no control in most offline scenarios of the type of medium and instrument used. In practice, however, handwritten words may be cursive, purely discrete, touching discrete, or a mixture of these styles. These different styles of writing, creates the research challenge to the research community. Many methods and approaches on handwritten character segmentation and recognition are published in the literature for different Indian scripts but at the best of our knowledge only very few reports are available for Assamese scripts. Even very less effort has been put to develop HWR system for the North-Eastern languages of India, particularly the Assamese language. The lack of effective research work in Assamese language motivated us to develop a handwritten character segmentation and recognition model.

In this paper we proposed a model for text segmentation, feature extraction and for classification/recognition of Assamese offline handwritten characters using scanned text document. Methods which we have designed and implemented are evaluated by handwritten characters collected from different writers with various writing styles.

We have considered both isolated characters and sentences for this study. Diagonal orientation features using different zones and texture features with the help of Grey level co-occurrence matrix (GLCM) are applied on the segmented isolated characters. An artificial neural network as a backend is used for fast and reliable classification towards achieving high recognition accuracy.

RELATED WORK

In the literature for recognizing offline handwritten scripts for Indian languages, some of the works already have been done which can be found in [8, 11, 12, 13, 14]. Assamese and Bangla both these scripts are syllabic in nature. It means that text is written using consonants and vowels that together form syllables. Assamese script is somehow quite similar with the Bangla script. In recent years, the recognition of Bangla characters has been explored by many researchers. The first complete system capable of doing OCR from printed Bangla documents is done in [12]. In this system pre-processing involves skew correction, followed by noise removal, and preliminary segmentation of the input image into lines, zones and characters. A hand written recognition system for Bangla characters is proposed by using Self organizing Map (SOM) [5]. To take care of touching character in the recognition system for Bangle and Devnagri script, authors has proposed a novel technique in [20]. In the late 1970s, for the recognition of handwritten and machine printed Devnagari characters, presented a syntactic pattern analysis system with an embedded picture language [13].

Similarly authors in [10] have described both stroke based and character based methods for Assamese handwritten character recognition using HMM classifier. Artificial neural network (ANN) based Assamese handwritten text segmentation approach can be found in [6]. This work explored the performance differences obtained by applying an ANN-based dynamic segmentation algorithm compared to projection-based static segmentation. In [7] authors have proposed a method for recognizing Assamese handwritten numerals using mathematical morphology. The digits are classified into two groups. One group contains digits which contains one or more blobs or/and stems in its structure. The other group does not contain any blobs. An extensive survey report on various methods which can be applied for extracting important features from handwritten text characters is reported in [8]. Use of global projection profile for segmentation and geometric features for the Assamese characters with artificial neural network can be seen in [18] for character recognition system. For handling Kannada handwritten documents authors have developed a system to perform skew detection, correction and segmentation documents [22]. In skew detection and correction, bounding box technique is used. Line segmentation is carried out by using Hough transform and word segmentation part is done by the help of contour detection technique. Authors in [23] have proposed a method by applying statistical texture features for handwritten and printed text classification in south Indian scripts. Authors have primarily aimed for word level classification. Words are first extracted from the scanned document. For each extracted word, different statistical texture features are computed for generating feature vectors. Then those feature vectors are used to classify words using K-nearest neighbor (K-NN) classifier.

Assamese Scripts and properties

Assamese is one of the principle languages of North-eastern region, especially in Assam [3]. Assamese has derived its phonetic character set and its behavior from Sanskrit. There are 11 vowels, 41 consonants, 10 digits and over 300 compound characters in the Assamese language and a sample is shown in (Figure 1). A large number of ligatures are possible since potentially all the consonants can be combined with one another [3, 6]. Vowels can either be independent or dependent upon a consonant. Assamese script is written from left to right with no upper and lower case property. Assamese characters can be divided into three parts horizontally upper, middle and lower parts. Every individual has a unique style of writing and this style varies from person to person and their different state of mind. Assamese characters line is ended with a vertical line called as "dari" and also the upper

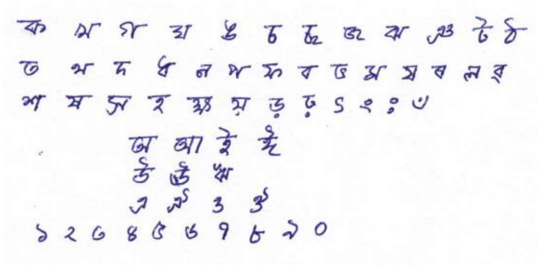

Figure 1. Assamese handwritten characters and digits

and middle portion of the divided by continuous line called as "matra". A typical Assamese word can be classified into three Zones [11] and it shown in (Figure 2). Upper zone: area above the head line. It is characterized by the presence of extensions of the modifiers. Middle zone: area where the main body of the character lies. Lower zone: area where some of the modifiers exists.

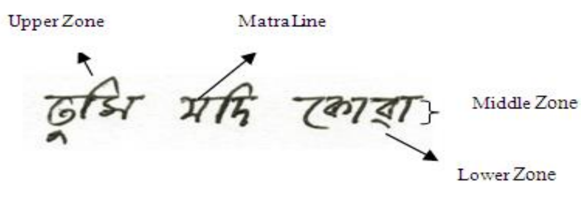

Figure 2. Different zones of Assamese word.

OBJECTIVES

The main objectives of this work are summarized below:

i. To collect different handwritten text samples from different persons and to digitize them.

ii. To remove noise, binarization and to detect and correct skew-ness in an input image document by applying standard methods.

iii. To segment a document image into:

- Line segment, word segment and character segment.

iv. To extract different features of individual character with the help of statistical texture and diagonal orientation feature approach for the task of classification.

METHODOLOGY

The very primary task of HWR system is to collect the dataset of the handwritten character images. Images can be collected or obtained by scanning text document as well as from various standard datasets. For this work handwritten characters are collected from different writers, to ensure various writing styles. The written document is scanned (300dpi) and the scanned image is used for further pre-processing and analysis. The schematic block diagram of the proposed work is shown in (Figure 3). In the following subsections details of the different stages of the methodology, which are followed for this research work, are discussed. The pre-processing step is included in this section itself, which defines a set of operations that are performed on an input document. If the input document image is in RGB format then for further analysis we have first convert the image into a gray-scale image [9].

Noise Removal

Digital images are affected by several types of noise, which occurs during acquisition process due to printer, print quality, scanner's or camera's sensor heat, age of the document, etc. So, noise is the result of error in the image acquisition process that results in pixel values that don't reflects the true intensities of the real scene. Two types of noises are very common. They are background noise and salt & pepper noise. The mean and standard median filters (SMF) [9] are kind of spatial digital filtering technique, frequently used to clean Gaussian and salt-pepper noises from an input image. Median and mean filters are based upon moving a window or mask over an image (as in a convolution) and computing the output pixel as the median/mean value of the brightness within a stipulated input window. These two approaches are initially applied to an image document in our model, with a constraint of a less amount of salt-pepper noise, as literature reveals SMF can handle less noise density only.

Binarization

Binarization is the method via which gray scale document image is converted in to binary images based on the pixel value. It is used to extract text from low quality background [9]. The pixel that make up characters only require one bit of data each. Based on the pixel value black or white image will be replaced by either with 0 or 1 respectively. Threshold based approach is applied here. Thresholding is an important technique in image segmentation applications. The basic idea of thresholding is to select an optimal gray-level threshold value for separating objects of interest in an image from the background based on their gray-level distribution. So, in this work all the pixels which threshold value is greater than a threshold value are set to one (1) otherwise as zero (0). For binarization in the literature various methods are available like Ostu's global thresholding algorithm, local thresholding algorithm [18] etc. So, each point (x, y) of the image which have value f(x, y) > T is called the foreground object, and each point which have value f(x, y) < T is called background object. A thresholded image g(x, y) is defined as,

$$g(x,y) = \begin{cases} 1; & if\ f(x,y) > T \\ 0; & if\ f(x,y) < T \end{cases}$$

In (Figure 4) screenshot image of one input document as an example, for binarization process is shown.

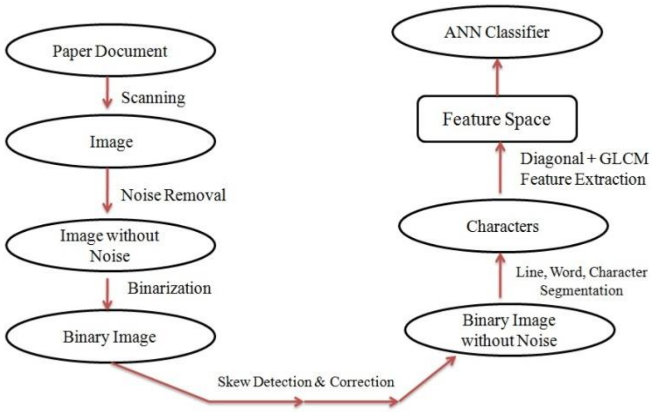

Figure 3. Schematic block diagram of the work

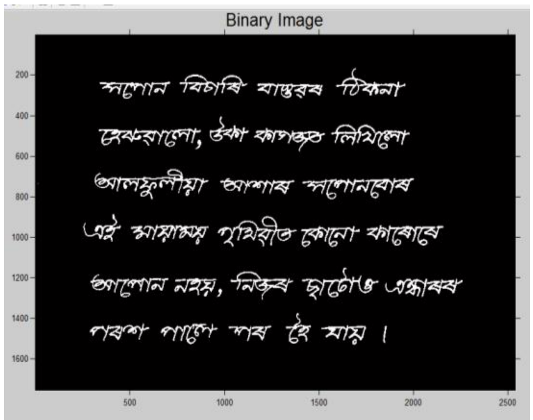

Figure 4. Binary image

Skew Detection

When a document is fed in to the scanner either by man or machine, a few degrees of tilt (skew) is unavoidable [12] [20]. Skew angle is the angle between the lines of text in the digital image and the horizontal direction. Moreover, the hand written text is generally not in the straight line, so it is extremely important to straighten the written word. This skew has a negative effect on document analysis, character segmentation and recognition. In [20] authors have proposed two algorithms which make use of the Radon transform based projection profile technique for skew detection and correction. In this work we have used the radon transform based techniques for skew detection and correction. After applying this method to our input image, the results which we have observed and got is satisfactory. In (Figure 5) one screenshot image as an example is presented.

SEGMENTATION

After the document image is pre-processed using the methods discussed above image is ready for the segmentation phase. Segmentation of hand written text document image into individual character is an important phase in document analysis, character recognition and many other areas. In this stage we subdivide an image into different logical segment, viz., lines of words, individual words from lines, and individual characters from words [16].

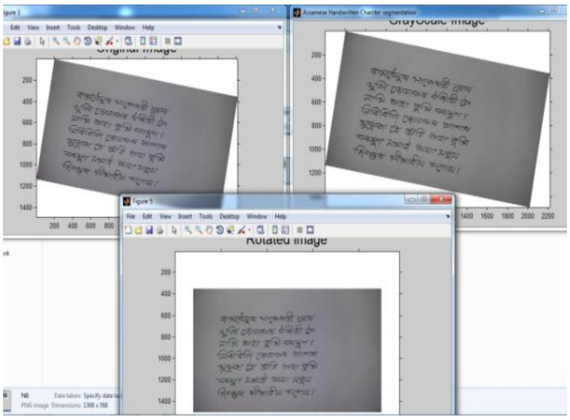

Figure 5. Skew detection and correction

A. Line Segmentation

In order to extract individual text line, a technique based on global horizontal projection method is used. The global horizontal projection profile (HPP) method computes sum of all black pixels on every row and constructs corresponding histogram [9]. Equation-1 represents the HPP. Then we have find out the top or upper position and bottom or lower position of lines. After that the portion between top and bottom are extracted. The row with the highest frequency of 1 (one) is detected as *matraline* or headline.

$$HPP(x) = \sum_{1\leq x\leq m} f(x,y) \quad (1)$$

The various steps which are applied for extracting lines are given below:

Step 1: Summing up the image horizontally i.e., row wise summation of black pixel.

Step2: Create a logical vector *R*, which includes the rows which have text and which don't have text.

Step3: Calculate a difference logical vector *D* from *R.*

Step 4: Find the top line and bottom lines from *D.*

Step 5: Perform a loop for extracting the texts between top and bottom position from the binary image.

B. Word Segmentation

In order to extract individual words from the segmented lines, a technique based on global vertical projection method is used. Vertical projection profile (VPP) is similar to the HPP, but it gives the column wise sum [9]. After detecting a line, the system scans the image vertically from the left to the right of a line text image. This method computes sum of all black pixels on every column and constructs corresponding histogram. Equation-2 represents the VPP.

$$VPP(y) = \sum_{1\leq x\leq m} f(x, y) \quad (2)$$

The various steps which are applied for extracting words are given below:

Step1: Summing up the image vertically i.e., column wise summation of black pixel.

Step2 :Create a logical vector *R*, which includes the columns which have text and which don't have text.

Step 3: Calculate a difference logical vector *D* from *R.*

Step 4: Find the left position and right position from *D.*

Step 5: Perform a loop for extracting the texts between left and right position from the binary image.

C. Charcter Segmentation

After the words are segmented from individual lines, segmentation of the isolated character is one of the toughest jobs. The challenges occur if the word suffers from slant, cursive, uneven sized characters or of any other irregular shapes. In general a word in Assamese language is formed using characters and modifiers. To segment the character properly, the modifiers need to be detected. Depending on the uses there are mainly four kinds of modifiers: middle zone, lower zone, upper-middle and upper zone modifiers. In (Figure 6), different type's modifiers are shown respectively. Here we have first segment a word into the upper-zone, middle-zone, and lower-zone part of a word, as it is shown in (Figure 2).

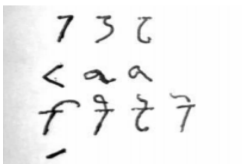

Figure 6. Different types of modifiers

By using zone segmentation we can detect the upper and lower zone modifiers. Busy-zone of a word is the region of the word where a maximum portion of its characters lie. Busy-zone of word is used for identifying the upper, lower and middle area of any word. By adopting the zone segmentation and busy zone approaches [15] segmentation of the three parts of a word is done. After these three parts segmentation of a word, character segmentation of the base characters from a particular word is important. For this reason the middle part characters of the word are also segmented to get isolated characters. For segmentation of middle part characters at first, the inter space between two characters are identified, then the segmentation lines are determined using the VPP model which is discussed above. After identifying the segmentation lines the characters of the middle part are segmented properly using those segmentation lines. Then all the segmented characters are uniformly resized to 90 × 60 for the future extraction process.

FEATURE EXTRACTION

Selection of a feature extraction method is almost certainly the single most important thing in achieving high recognition rate. This leads us to the question which available feature extraction method is the best for Assamese characters or alphabets [8]. Recognizing the handwritten document character re-lies on the competent use of the extracted features that provide discriminating information. The following subsection presents the description of the feature extraction methods which are used in this study.

A. Diagonal orientation Features

Diagonal feature extraction scheme for recognizing off-line handwritten characters was proposed in [16]. For our work every character image of size 90x60 pixels is divided into 54 equal zones, each of size 10x10 pixels. The features are extracted from each zone pixels by moving along the diagonals of its respective 10x10 pixels. Each zone has 19 diagonal lines and the foreground pixels present along each diagonal line is summed to get a single sub-feature and 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 value corresponding to these zones are zero. Finally, 54 features are extracted for each character.

B. Texture Features

Texture features are first reported in [4] for image classification. For better understanding, texture can also be defined as a property, which contains important information about structural arrangement of surfaces and their relationship with surrounding environment. Approaches to texture feature analysis are grouped into four categories structural based, statistical based, model-based and transform based. In statistical texture analysis, texture features are computed from the statistical distribution of observed combinations of intensities at specified positions relative to each other in the image. According to the number of intensity points (pixels) in each combination, statistics are classified into first-order, second-order and higher-order statistics. The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second order statistical texture features [4]. In this paper, we use simple statistical measure of texture from image, which observe texture as quantitative measure of arrangement of intensity level in image region.

C. Gray Level Co-Occurence Matrix(GLCM)

A GLCM is a matrix where the number of rows and columns are equal to the number of gray levels, G, in the image. GLCM texture considers the relation between two pixels at a time, called the reference and the neighbor pixel. The matrix element P (i, j | Δx, Δy) is the relative frequency with which two pixels, separated by a pixel distance (Δx, Δy), occur within a given neighborhood, one with intensity 'i' and the other with intensity 'j'. The theory and techniques behind the Gray Level Co-occurrence Matrix (GLCM) method is thoroughly presented in [4, 23].Statistical properties of the intensity histogram such as mean (f1), contrast (f2), absolute value (f3) , entropy (f4), variance(f5), sum average (f6), sum variance (f7), sum entropy (f8), Difference Variance (f9), Difference entropy(f10). These set of ten statistical texture features collectively used to generate a feature vector. Random variable r indicate pixel intensity of i, p(r) is the histogram of the intensity levels in a region, N is the number of possible gray level intensity.

(1) f1 is a measure of average intensity

$$Mean(\mu) = \sum_{i=0}^{N-1} r_i p(r_i)$$

(2) f2 is a measure of Contrast :

$$Contrast = \sum_{i,j=0}^{N-1} (i-j)^2 p(i,j)$$

(3) f3 is a measure of dissimilarity or absolute value:

$$Diss = \sum_{i,j=0}^{N-1} |i-j| p(i,j)$$

(4) f4 is a measure of Entropy:

$$Entropy = -\sum_{i,j=0}^{N-1} p(i,j) \log[p(i,j)])$$

(5) f5 is a measure of Sum of square Variance:

$$Varience = \sum_{i=0,j=0}^{N-1} (i-\mu)^2 p(i,j)$$

(6) f6 is a measure of Sum Average:

$$AVG = \sum_{i=0}^{2N-2} i p_{x+y}(i)$$

(7) f7 is a measure of Sum Variance

$$SumV = \sum_{i=0}^{2N-2} (i - AVG)^2 p_{x+y}(i)$$

(8) f8 is a measure of Sum Entropy:

$$SENT = -\sum_{i=0}^{2N-2} p_{x+y}(i)(\log(p_{x+y}(i))$$

(9) f9 is a measure of Difference Variance:

$$DV = \sum_{i=0}^{N-1} (i - AVG)^2 p_{x+y}(i)$$

(10) f10 is a measure of Difference Entropy :

$$DENT = -\sum_{i=0}^{N-1} P_{x+y}(i)(\log p_{x+y}(i))$$

CLASSIFICATION WITH NEURAL NETWORK

The classification stage is the decision making part of a recognition system and it uses the features extracted in the previous stage. An artificial neural Network as the backend is used for performing classification and recognition tasks. In the off-line recognition system, the neural networks have emerged as the fast and reliable tools for classification towards achieving high recognition accuracy. We have extracted total 64 features, including diagonal orientation and statistical texture features. A feed forward neural network with back propagation having two hidden layers with architecture of 64-100-100-52 is used to perform the classification. 64 neurons as input layer, two hidden layers with 100 neuron size and 52 (41 consonant + 11 vowels) neurons for the output layer. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions are used for trained the neural network.

The output of i^{th} layer can be given by:

$$a^i = logsig\,(w^i a^{i-1} + b^i)$$

Where, $i = [1,2,3]$ and a^0 = P

w^i = Weight vector of i^{th} layer

a^i = output of i^{th} layer

b^i = bias vector for i^{th} layer

EXPERIMENTAL RESULTS & DISCUSSION

In this section, we are presenting the major experimental results and associated observations that we have made after the experiments. Due to the unavailability of proper data set, we have collected samples of Assamese handwritten text documents from 40 persons with their different handwriting styles in A4 size pages. Some isolated character pages related to consonants and vowels were collected from the students of a Lower primary school of Darrang disctrict, Assam. All the A4 size pages were digitized by scanning at 300 dpi. We have avoided those pages of sentences where very much cursive style of writing present and overall 2200 isolated characters got extracted. For many of the frequently used characters, minimum 30 numbers of sample extracted for this study. For simple isolated character segmentation from the digitized images only line and word segmentation process were applied. Those images where lines of sentences present, all the three steps of segmentation process were applied for extracting individual characters. We have manually counted the number of lines, words and characters present in the digitized documents for analysis purpose. Implementations of different methods and functions were designed in Matlab R2012a which runs on a computer with following configuration: Processor: Intel® Corei3 2.4 GHz, Operating System: Microsoft® Windows 7 Ultimate, RAM: 4GB.

In (Figure 7) an example of segmentation of individual lines of text is shown with references to the image shown in (Figure 4). We can observed that in that image there are total six(6) lines of text presents and the line segmentation method which we have modified can segment it properly without any error. In line1 there are four words present. Similarly from line no. 2 to line no. 6, there are total four, three, five, five and four words are presents respectively. In (Figure 10) segmentation of individual words are shown. Here also we can observed that word segmentation method which we have proposed can segment the words properly from individual lines of text without any inaccuracy. Total twenty six (26) numbers of words are segmented. An example of line segmentation and character segmentation of isolated characters for vowels is shown in (Figure 8) and (Figure 9). One sample of GLCM based feature vectors for five different characters with 10 numbers of feature values are tabulated in (Table 1). Similarly (Table 2) gives the details of the number of lines and words

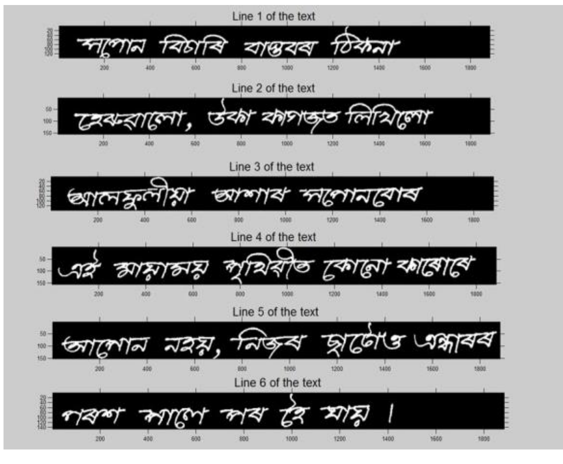

Figure 7.An example of line segmentation

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segmented by the horizontal and vertical projection profile methods from the images which are used for the experimental purpose. It achieved almost 98% of accuracy.

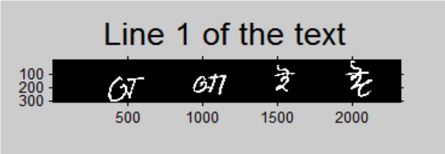


Figure 8. An example of Line segmentation for segmenting isolated characters for vowels.

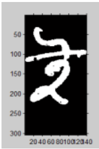


Figure 9. An example of segmented isolated character

Then character segmentation method is applied for extracting individual characters from individual words. For each character feature vectors are extracted using the diagonal and GLCM approach.

Table 1.A Sample of feature value extracted using GLCM

Character	**Gray Level Co-occurrence Matrix**									
	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10
	2.12	1.52	1.48	8.92	1.11	2.44	3.16	8.03	1.22	3.71
	1.82	1.87	1.18	7.76	1.54	3.14	3.54	9.11	1.42	3.01
	2.01	1.57	1.98	8.12	1.32	2.49	3.13	8.93	1.27	2.98
	2.31	1.88	1.44	8.33	1.06	2.33	3.77	7.25	1.87	3.15
	2.44	1.77	1.32	8.64	1.09	2.32	3.13	8.03	1.77	3.23

On the segmented word images, character segmentation approach is applied. On Seventy (50 images contains full sentences and 20 images contains only collection of single-single individual characters) word images experiments were performed successfully. In manual counting total 2700 numbers of characters were found and after executing all the processes it turns out to 2200 numbers. It can be observed from the experiment that the character segmentation method performance is not up-to that level for the words which are more cursive in nature. It acquires overall 81.48% of segmentation accuracy. In (Table 3) the details of the number of character segmented from the images for experimental purpose is shown.

Figure 10: Word segmentation

Table 2: Results of Line and Word segmentation

Total no. of lines	Total no. of words	Lines segmented accurately	Words segmented accurately
280	1160	268	1146

Table 3: Results of character segmentation

Total no. of characters	Numbers of characters segmented accurately
2700	2200

Above mentioned neural network has been trained using the dataset which is generated after the character segmentation process. For each frequently used individual character, minimum 30 samples were generated. The numbers of input nodes are chosen based on the number of features. After adequately training the network, the recognition system was tested using several unknown train datasets and an illustration of results obtained by the network is presented in the (Table 4). Here recognition accuracy results for five characters are shown only, with two different samples.

The hidden layers use *log sigmoid* activation function, and the output layer is a competitive layer as one of the characters have to be identified.

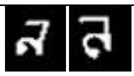
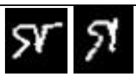
The network training parameters are:

- Input nodes : 64, Hidden nodes : 100 each, Output nodes : 52 (41 consonants, 11 vowels)

- Training algorithm: Gradient descent with momentum training and adaptive learning
- Perform function: Mean Square Error
- Training goal achieved: 0.001
- Training epochs: 2000,
- Training momentum constant: 0.95

On an average the proposed system has achieved a maximum recognition accuracy of 90.34%.

Table 4: Results of character segmentation

Characters	Number of samples in Training phase	Number of samples in Testing phase	Percentage of Accuracy
	25	10	85.33%
	25	8	88.09%
	28	10	91.22%
	20	10	89.76%
	25	10	87.34%

CONCLUSION & FUTURE WORK

This paper presents an approach for Assamese handwritten character recognition by combining the statistical texture features with diagonal orientation features. Feed forward neural network with the help of 64 numbers of extracted features obtain suitable and acceptable classification accuracy for maximum number of characters. The performances of line and word segmentation approaches are very well, almost 98% segmentation accuracy achieved. When a word is more cursive in nature, accuracy of character segmentation is bit poor. Overall accuracy of the proposed system for recognizing character is 90.34%. In future some post-processing like lexicon can be incorporated after the character recognition output so as to accelerate the word recognition. Also the proposed model can be also compared and analyzed with various methods and other classification methods.

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