A Novel Approach of Skew Correction for Online Handwritten Words

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ABSTRACT
Segmentation of a word into basic characters or strokes is an essential and necessary step for character recognition in many handwritten word recognition systems. The one of the major difficulties in character segmentation is the existence of the skew in the handwritten word. But skew detection in the bangla handwritten word is difficult because of its shape variability of the characters as well as larger number of character classes. If the skew correction is done successfully then the character segmentation of the word will be more perfect and as a consequence the percentage of the correct word recognition will be higher. In this paper, we propose a novel method for skew detection and skew correction of online Bengali handwritten word through holistic approach. This approach works based on center of gravity of left part and right part of a handwritten word. After finding the center of gravity it calculates the angle of the line which connected the two gravity centers in relation to horizontal line. Then Rotates the word clockwise by the angle θ if θ<90º, or anti-clockwise by the angle (180º-θ) if θ>90º. All the pixel moves to the particular angle to correct the skew. The algorithm has been verified on a database of 3000 Bengali word data collected from different people of different age group and it gives 92.22% accuracy on word data from the proposed system.

General Terms
Pattern Recognition.

Keywords
Online, Handwriting, Bangla, Skew, Recognition

1. INTRODUCTION
With the development of digitizing tablets and microcomputers, online handwriting recognition has become an area of active research since the This became a need because machines are getting smaller in size and keyboards are becoming more difficult to use in these smaller device. Moreover, online handwriting recognition provides a dynamic means of communication with computers through a pen like stylus, as it is natural writing instrument and this seems to be an easier way of entering data into computers. Work on online character recognition started gaining momentum about forty years ago. But work on online word recognition is in its nascent stage. For online word recognition there are some pre-processing steps. The most important pre-processing step is Skew detection and correction. Some work is already there on skew correction for online handwriting. Here a new algorithm is proposed for skew detection and correction of online Bengali handwriting based on Holistic Approach. The rest of the paper is organized as follows. In Section 2 we discuss about the Bengali language and data collection. Section 3 deals with the related works. Section 4 details the Skew detection and correction method. Section 5 details about experimental comparisons with related work. The experimental results are discussed in Section 6. Finally, conclusion of the paper is given in Section 7.

2. BANGLA SCRIPT AND ONLINE DATA COLLECTION
Bangla, the second most popular language in India and the fifth most popular language in the world, is an ancient Indo-Aryans language. About 200 million people in the eastern part of Indian subcontinent speak in this language. Bangla script alphabets are used in texts of Bangla, Assamese and Manipuri languages. Also, Bangla is the national language of Bangladesh. The alphabet of the modern Bangla script consists of 11 vowels and 40 consonants. These characters are called as basic characters. Writing style in Bangla is from left to right and the concept of upper/lower case is absent in this script. It can be seen that most of the characters of Bangla have a horizontal line (Matra) at the upper part. From a statistical analysis we notice that the probability that a Bangla word will have horizontal line is 0.994.

In Bangla script a vowel following a consonant takes a modified shape. Depending on the vowel, its modified shape is placed at the left, right, both left and right, or bottom of the consonant. These modified shapes are called modified characters. A consonant or a vowel following a consonant sometimes takes a compound orthographic shape, which is called as compound character. Compound characters can be combinations of two consonants as well as a consonant and a vowel. Compounding of three or four characters also exists in Bangla. There are about 280 compound characters in Bangla. In this work the recognition of Bangla basic characters are considered.

For online data collection, involves the automatic conversion of text as it is written on a special digitizer or PDA, where a sensor picks up the pen-tip movements X(t),Y(t) as well as pen-up/pen-down switching (see Figure 1 and Figure 2). That kind of data is known as digital ink and can be regarded as a dynamic representation of handwriting. The ink signal is captured by either:

A paper-based capture device

A digital pen on patterned paper

A pen-sensitive surface such as a touch screen

The information on strokes and trajectories is mathematically represented in an ink signal composed of a sequence of 2D points ordered by time. No matter what the handwriting surface may be, the digital ink is always plotted according to a

matrix with x and y axes and a point of origin. Online data acquisition captures just the information needed, which is

trajectory and strokes, to obtain a clear signal. This effective information makes the data easier to process.

3. RELATED WORK

There are two types of handwritten document images are available. One is offline handwriting another one is online handwriting. Offline printed word recognition is comparatively easier than online handwriting recognition because it comes in printed form, so like handwritten word there are not so much variations there in writing styles. Printed word has not that much skew like online and offline handwriting. Before recognition of any handwritten word we need to do some sort of preprocessing. There are so many preprocessing steps like smoothing, dehooking, skew detection, skew correction etc. Already there are many research works are available on skew detection and skew correction of handwritten document image, but most of those are in offline handwritten document. In online handwritten document very few works are there, especially in Bengali. Some of the works on offline handwriting are discussed as follows:–

3.1 Baseline skew correction:

This approach works with the baseline of Bengali handwriting [1].

3.2 Convex Hull:

The main objective of employing the pseudo-convex hull is to decrease the use of empirical thresholds in developing this approach. This technique is being used in a way that reduces the minima in a word so that, when filtering undesirable minima, few empirical thresholds will have to be defined [2].

3.3 Holistic Approach:

This approach works based on center of gravity of left part and right part of a handwritten word. After finding the center of gravity all the pixel moves to the particular angle to correct the skew [3].

3.4 Hough Transform Method:

Hough transform technique may be applied on the upper envelopes for skew estimation, but this is slow process. Sometimes digitized image may be skewed and for this situation skew correction is necessary to make text lines horizontal. Skew correction can be achieved in two steps. First, estimate the skew angle θt and second, rotate the image by θt, in the opposite direction and detect the skew angle is using Matra [4].

3.5 Morphological Approach:

The Mathematical Morphology consists in comparing an unknown picture X with a pattern B, perfectly defined in terms of shape, size and grayscale, named structuring element [5].

3.6 Projection Profile:

A straightforward solution to determining the skew angle of a document image uses a horizontal projection profile. This is a one-dimensional array with a number of locations equal to the number of rows in an image. Each location in the projection profile stores a count of the number of black pixels in the corresponding row of the image. This histogram has the maximum amplitude and frequency when the text in the image is skewed at zero degrees since the number of co-linear black pixels is maximized in this condition [6].

3.7 Robust Solution:

The first step of this method is to divide images into NxN blocks, and then Otsu's method is applied straightaway in each of the blocks. Then each and every pixel is applied with a nonlinear quadratic filter to fine tune all the pixels according to the local information available [7].

4. SKEW DETECTION AND CORRECTION

The algorithm we have implemented is very interesting one and it is based on Rotation correction method by gravity center balancing. Rotation correction is important in unconstrained handwritten word recognition because most character based recognition methods are not designed for rotation free.The algorithm for Skew Detection and correction is as follows:

Algorithm: *Skew Detection and Correction:*

Step 1: Calculate number of pixel of each Y co-ordinate.

Step 2: Consider the busy zone of the whole word.

Step 3: Find the minimum x-co-ordinate and maximum x-co-ordinate.

Step 4: Calculate the average point of the min and max x-coordinate.

Step 5: Draw a line through the average point and divide the whole words into two parts one is left part another is right part.

Step 6: Calculate the gravity centers for each part.

Step 7: Draw a line to connect the two centers of gravity.

Step 8: Calculate the angle θ of the line which connected the two gravity centers in relation to horizontal line.

Step 9: Rotate the word clockwise by the angle θ if $\theta<90^{\circ}$, or anti-clockwise by the angle $(180^{\circ}-\theta)$ if $\theta>90^{\circ}$ (see Figure 3).

Step 10: Partition the word into left and right parts by the vertical line through the gravity center of whole word. If the starting point of the handwriting falls in the right part, rotate the word 180° clockwise.

Step 11: Correct up-down reversed word (see Figure 4).

5. EXPERIMENTAL COMPARISONS WITH RELATED WORK

Most of the approaches that have been used till now for skew detection and skew correction of handwritten words were in offline handwriting recognition. Experimental comparisons of some of those approaches are discussed below:

One approach initially used for skew correction on offline data known as convex-hull approach [2]. In this approach the system was tested on 713 offline images of Brazilian bank checks and among those 70% was correctly processed.

In another approach known as Holistic approach [3] the system was tested on 8888 categories of 1,137,664 unconstrained online handwritten Chinese word samples. Experimental results for randomly rotated unconstrained cursive online handwritten Chinese word data demonstrated

that the proposed method can achieve about 96.58% recognition accuracy.

Hough transform approach [4] was another approach applied on offline data with an accuracy of 0.1 degrees. A page image is first divided into 20x30 rectangular blocks and the percentage of black pixels in each block is determined. If that percentage is between 5% and 25%, the block is considered to be non-noise and the Hough transform is calculated from it with a resolution of one degree over the range plus or minus five degrees. The angle with the maximum response in the transform space is used as the centre for a further Hough transform analysis at plus or minus one degree with a resolution of 0.1 degrees.

In the Morphological approach [5] the illustration was done with real examples of handwritten dates on bank checks.

In the projection profile approach [6] the projection profiles are calculated at different angles directly from image data. Some methods using this approach calculated projection profiles from image features also. This approach also has been applied on algorithms that used the Hough transform for skew detection and correction. Another class of technique extracted features with local, directionally sensitive masks. The performance of most of the methods using projection profile approach reported in the literature range up to a 0.1 degree accuracy. While it is arguable whether this fine a resolution is needed in a digital copier application, at least a resolution of 0.2 to 0.3 degrees should be achieved.

The Robust Solution [6] is another skew correction technique for offline handwritten data. An accuracy of 97.7% has been obtained by this method after testing the system on 3045 text lines.

There is no such Skew Correction algorithm which has a great accuracy for online Bengali handwritten word. In our algorithm we obtained around 92.22% accuracy on word data from the proposed system.

6. RESULTS AND DISCUSSION

The experimental evaluation of the above techniques was carried out using online handwritten words. The data was collected from people of different background. Total of 6,000 words are collected for the experiment. Out of them 50% of the words are used for the training of the classifier for the present work and rest will be used for the testing purpose. We tested my system on 3000 Bengali word data and obtained around 92.22% accuracy on word data from the proposed system.

The skew correction accuracy obtained from the classifier is shown in Table:

Table 1: Result of Skew Correction

TOTAL WORDS	SKEWED WORDS	CORRECTED	INCORRECTED	SKEW CORRECTION ACCURACY IN %
3839	1660	1531	129	92.22%

7. CONCLUSION

This paper presents a scheme for the Skew correction of Bengali online handwritten word. Using this technique different Bengali online handwritten word can be Skew corrected. This result will be helpful for recognizing Bengali words.

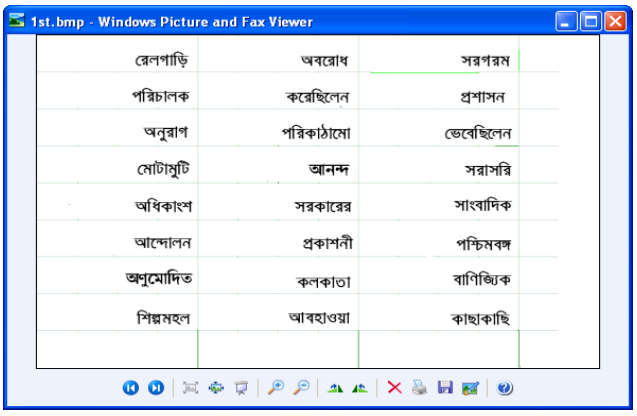

Figure 1: Datasheet used for word collection

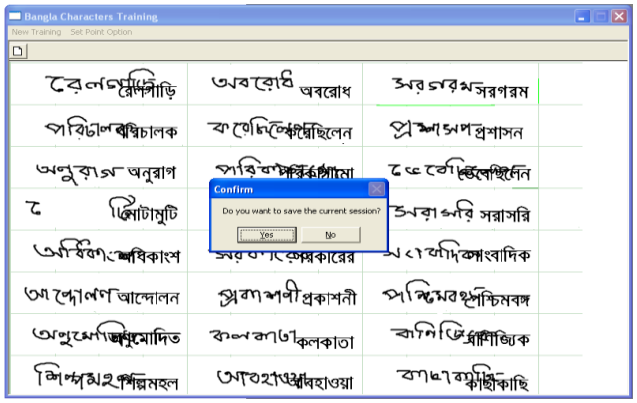

Figure 2: Datasheet after collecting handwriting

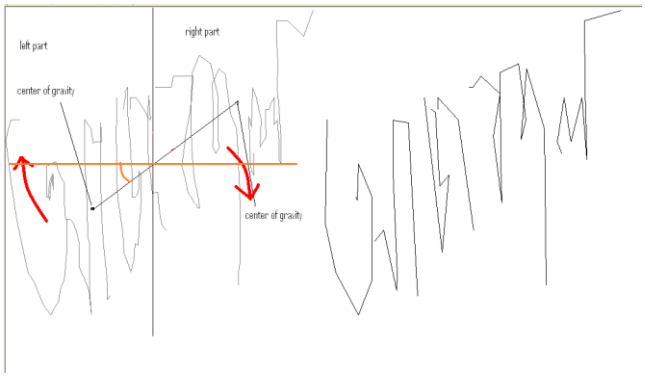

Figure 3: Process of Skew Detection and Correction

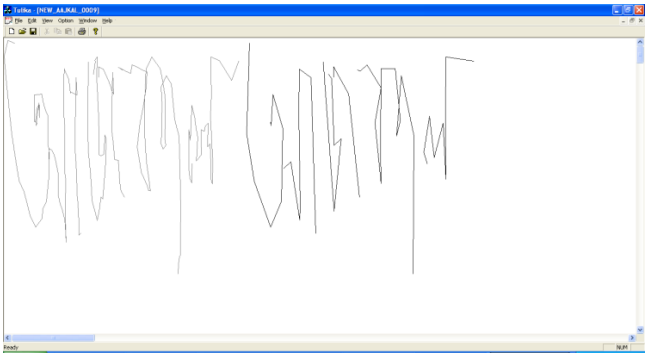

Figure 4: Word after Skew Correction

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