ISSN: 2454-4248
315 – 318

An Innovative Solution of Prolonged Part Problem in Skew Correction Process for Online Handwritten Words

Gouranga Mandal
Department of Computer Science & Engineering, FST
The ICFAI University Tripura
Agartala, India
E-mail: gourangamandal@yahoo.com

Tamal Biswas
Department of Computer Science & Engineering
National Institute of Technology Agartala
Agartala, India
E-mail: tamal.cse01@gmail.com

***Abstract*—**Handwriting is one of the easiest ways to save any record offline and also online without making use of keyboard. People can write any text using his/her own handwriting with own language, own style or font. Analysis and recognition of handwriting especially online handwriting is one of the most interesting research areas nowadays. Online handwriting recognition process contains many pre-processing steps. Skew detection correction is one of the most important pre-processing step by which a handwritten word can be skew corrected. There are few existing algorithms of skew detection and correction for offline and online handwritten word but most of them face problem while a word consist some prolonged part in it. Here we have proposed a new technique by which any handwritten can be skew corrected with a great solution of prolonged part of words. This process works based on the total height and total width of the word. The particular angle where the height of a word becomes minimum and width becomes maximum, we can consider that particular angle as an approximate skew angle but not exact skew angle. After finding the approximate skew angle we consider only busy zone of the word, where maximum number of pixels are available so that prolonged part can be avoided. After considering only busy zone of the word we have calculated the skew angle using same process which is based on height and width of the handwritten word. The skew value is considered as zero on that particular angle, where the height is minimum and width is maximum at second iteration. We have tested this proposed technique on 4000 Bengali handwritten word and have achieved an outstanding result of 97 percentage of accuracy.

Keywords- *Online Handwriting; Pre-Processing Steps; Skew Detection; Height; Width; Busy Zone*

*****

I. INTRODUCTION

Handwriting is one of the most important ways to give instruction and save records of the language and font style used by the people. Offline handwriting is a very easy procedure to record information by using plain paper and pen, without any costly digital device and any keyboard. Whereas online handwriting is a procedure to record information using touch sensitive surface or stylus pen tablet. Online handwriting document consists of collection of many co-ordinate values of all the pixels. Recognition of people's online handwriting contains many pre-processing steps like noise detection and correction, smoothing, skew detection and correction, normalization, segmentation etc., out of them skew detection and correction is the most important pre-processing step by which a handwritten word can be skew corrected. If there is a skew or tilt in handwritten word then it is very difficult to perform next pre-processing steps and recognition will also be difficult. There are few existing algorithms of skew detection and correction for offline and online handwritten word but most of them face problem while a word consists of some prolonged part in it. Here an attempt is made to explore a new technique by which any handwritten can be skew corrected with a great solution of prolonged part of words. This algorithm can be applied for any Indian as well as foreign languages. Here several tests are done on the algorithm of Bengali handwritten words. The paper is organized as follows-

Section II contains Bengali script and online data collection, Section III deals with the related work of Skew Detection and Correction process, Section IV explains the proposed methodology, Section V describes results and discussion, Section VI concludes the research work with future directions.

II. BENGALI SCRIPT AND ONLINE DATA COLLECTION

The Bengali alphabet or Bengali script is the writing system for the Bengali language and, together with the Assamese alphabet, is the fifth most widely used writing system in the world. The script is used for other languages like Meithei and Bishnupriya Manipuri, and is also used to write Sanskrit within Bengal. Besides, Bengali is the national language of Bangladesh. From a classificatory point of view, the Bengali script is an abugida, i.e. its vowel graphemes are mainly realized not as independent letters, but as diacritics attached to its consonant letters. It is written from left to right and lacks distinct letter cases. It is recognizable, as are other Brahmic scripts, by a distinctive horizontal line running along the tops of the letters that links them together which is known as matra. From a statistical analysis we notice that the probability that a Bengali word will have horizontal line is 0.994.The Bengali script is however less blocky and presents a more sinuous shape [1].

The alphabet of the modern Bengali script consists of 11 vowels and 40 consonants. These characters are called as basic characters. In Bengali 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 Bengali. There are about 280 compound characters in Bengali. In this work the recognition of Bengali basic characters are considered.

ISSN: 2454-4248
315 – 318

The 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. That kind of data is known as digital ink and can be regarded as a dynamic representation of handwriting "Fig. 1". 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 are 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 axis and y axis and a point of origin.

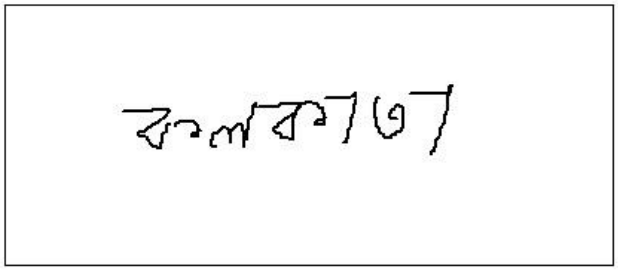

Figure 1. Example of a online bengali handwritten word

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.

III. Related Work

There are two types of handwritten document images are available. One is the offline handwriting another 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. As stated earlier, several research works are available on skew detection and skew correction of handwritten document image, but most of those are applicable for offline handwritten document. In online handwritten document few works are there, especially in Bengali. Most of the existing algorithms faces problem while a word contains some prolonged part in it. Some of the works on offline handwriting are discussed as follows:–

A. Baseline skew correction

This approach works with the baseline of Bengali handwriting. First it detects the baseline of the word then calculates the angle of the baseline with horizontal line and then rotates all the pixels with that angle in opposite direction [2].

B. 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. This approach initially used for skew correction on offline data. In this approach the system was tested on 713 offline images of Brazilian bank checks and among those 70% was correctly processed [3].

C. 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. In this approach 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 [4].

D. Hough Transform Method

Hough transform technique may be applied on the upper envelopes for skew estimation, but this is a 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. This 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 center for a further Hough transform analysis at plus or minus one degree with a resolution of 0.1 degrees. [5].

E. Morphological Approach

The Mathematical Morphology consists in comparing an unknown picture X with a pattern B, perfectly defined in terms of shape, size and gray scale, named structuring element. In this approach the illustration was done with real examples of handwritten dates on bank checks. [6].

F. 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. In this approach the projection profiles are calculated at different angles directly from image data. Some methods using this approach calculate projection profiles from image features also. This approach also has been applied on algorithms that use the Hough transform for skew detection and correction. Another class of technique extracted features with local is directionally sensitive masks. The performance of most of the methods using projection profile approach reported in the literature range up to 0.1 degree accuracy. While it is arguable whether

ISSN: 2454-4248
315 – 318

this fine resolution is needed in a digital copier application, at least a resolution of 0.2 to 0.3 degrees should be achieved [7].

G. 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. Each pixel is applied with a nonlinear quadratic filter to fine tune all the pixels according to the local information available. This technique 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 [8].

H. Skew Correction based on gravity center balancing

This approach works based on center of gravity of left part and right part of a handwritten word. After finding the center of gravity, the angle θ of the line, which connects the two gravity centers in relation to horizontal line, is calculated. Then the word is rotated clockwise by the angle θ if θ<90º, or anti-clockwise by the angle (180º-θ) if θ>90º. All the pixels move to the particular angle to correct the skew. 3000 Bengali words have been tested and obtained around 92.22% accuracy on word data from the proposed system [9].

I. Overlapping Regions

In this approach skew detection and correction is done over the words that are separated from text lines. For skew detection, two equal overlapping portions including the whole word. The angle made by the line joining the two centers of mass with the horizontal is considered as the skew angle. The word is skew corrected on rotating pixels by the detected skew angle in the opposite direction [10].

J. Skew Between Two Successive Characters

In order to correct the skew between two successive characters the angle between them is calculated first. This is obviously the angle between the two successive points i p and j p corresponding the two characters. Let this angle be denoted as θ, then we can find tanθ = l / b. The base b gives the horizontal distance between two points and the perpendicular l gives the amount of skewness. Thus in the next step the image component between the two segmenting points is rotated upwards or downwards properly to make the skew angle zero. This process is continued for all points in the set C_p. Proper padding ensures that we don't lose any vital object information when we rotate the image word in concerned [11].

IV. SKEW DETECTIONN AND CORRECTION

The algorithm implemented here is very simple, innovative and its time complexity is very low and at the same it can provide outstanding result of accuracy. Maximum existing algorithm creates problem to the words which contains prolonged part in it. Because of few prolonged part, exact busy zone of a word cannot be determined and exact skew angle also cannot be determined "Fig. 2". This algorithm is based on height and width of the whole handwritten word. As a general point of view height of any word should have minimum value and width of any word should have maximum value if there is no skew.

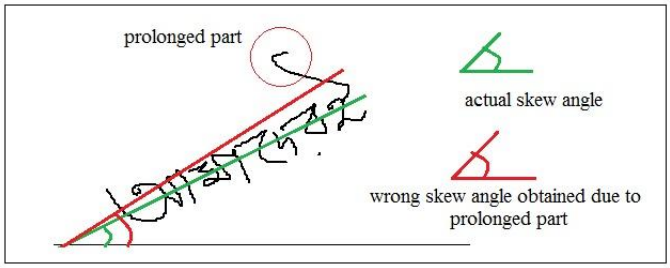

Figure 2. Wrong skew angle obtained due to prolonged part of word

After skew correction with approximate skew angle repetition of the same process, considering only busy zone is done to do the exact skew correction "Fig. 3". The algorithm of Skew Detection and Correction is as follows-

Algorithm: Skew Detection and Correction

step 1: Consider co-ordinates (x,y) of all the pixels of handwritten word and find minimum value of y axis (min_y) and maximum value of y axis (max_y).

step 2: Calculate the height of the word, i.e.- height = (max_y - min_y)

step 3: Rotate all the pixels of the word in anticlockwise direction by 1 degree. i.e.-
Rotation of any point (x,y) by certion angle θ with respect to the point:-
$x' = xr+(x-xr)\cos\theta-(y-yr)\sin\theta$ and
$y' = yr+(x-xr)\sin\theta+(y-yr)\cos\theta$
(where x' and y' are new generated co-ordinate value, x and y are old co-ordinate value, xr and yr are co-ordinate of centroid of the word.)

step 4: Now calculate the height of the word again and again for each 1 degree of rotation (up to 45 degree anticlockwise and 45 degree clockwise).

step 5: Find the particular angle where the height of the handwritten word is minimum value and stop the rotation.

step 6: If it is observed that height is minimum for more than one angle then, consider co-ordinates (x,y) of all the pixels of handwritten word and find minimum value of x axis (min_x) and maximum value of x axis (max_x)

step 7: Calculate the width of the word, i.e.- width = (max_x - min_x)

step 8: Now check width of the word for the entire angle where same minimum height exists.

step 9: Consider the angle where the width value is maximum for the minimum height and stop the rotation.

step 10: Now the skew correction is almost done but not exactly, so calculate busy zone of the word by

ISSN: 2454-4248
315 – 318

checking number of pixels available in each y co-ordinate to remove unwanted prolonged part.

step 11: Now consider only the busy zone of the handwritten word (don't consider those pixels which are outside of the busy zone) and repeat step 1 to step 9 once again.

step 12: The handwritten word will be skew corrected.

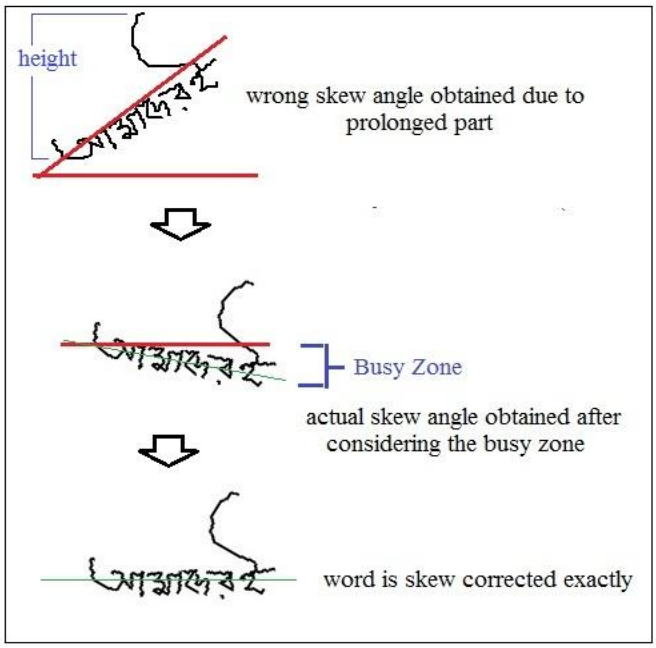

Figure 3. Process of Skew Detection and Correction

V. Result And Discussion

The experimental evaluation of the above algorithm is carried out using online Bengali handwritten words. The handwritten data is collected from the people with different backgrounds. Total of 5,800 Bengali handwritten words are collected as samples for the experiment. Out of them 42% of the words are used for the training of the classifier for the present work and rest is used for the testing purpose. 3364 Bengali skew words with prolonged part have been tested in our system and around 97.05% accuracy is obtained "Table 1". The skew correction accuracy obtained from the classifier is shown in Table:

TABLE 1: RESULT OF SKEW DETECTION AND CORRECTION ALGORITHM

Total Words	*Skewed Word with Prolonged Part*	*Corrected*	*Incorrected*	*Skew Correction Accuracy In %*
5800	3364	3265	99	97.05%

VI. Conclusion

This paper represents an innovative technique of skew detection and correction of online handwritten word based on height and width of the word by ignoring the prolonged part of the words. By this algorithm any online handwritten word can be made skewless even if there are many prolonged parts in a word. The major drawback of skew correction algorithm (i.e. - proper angle not determined because of prolonged part) is solved here. If a handwritten word is skewed correctly this algorithm can be applied for Bengali and other Indian script. We tested the proposed system on 5800 data out of them 3364 are words with skew and got the encouraging result. Not much work has been done towards the online recognition of Indian scripts in general and Bengali in particular. So this work will be helpful for the research towards online recognition of other Indian scripts as well as for Bengali in the level of word, text and so on. In fact the work for online recognition of Bengali handwritten word can be done smoothly by taking the help of the current proposed work

VII. References

[1] Mazumdar, Bijaychandra,"*The history of the Bengali language*" (Repr. [d. Ausg.] Calcutta, 1920. ed.). New Delhi: Asian Educational Services. p. **57**. ISBN **8120614526**, **2000**.

[2] Bharath A. and Sriganesh Madhvanath, "*online handwriting recognition for indic scripts*", hp laboratories, india, hpl-**2008-45**, may **5, 2008**.

[3] marisa e. morita, jacques facon, fl´avio bortolozzi, a. silvio j.a. garn´es, Robert sabourin, "*mathematical morphology and weighted least squares to correct handwriting baseline skew*", document analysis and recognition, 1999. icdar '**99**. proceedings of the fifth int. conf., pp. **430 – 433, 1999**.

[4] kai ding, lianwen jin and xue gao, "*a new method for rotation free online unconstrained handwritten chinese word recognition: a holistic approach*", college of electronic and information, south china university of technology, guangzhou, prc. document analysis and recognition, 2009. icdar '**09**. 10th int. conf., pp-**1131 - 1135** , **2009**.

[5] farjana yeasmin omee, shiam shabbir himel and md. abu naser bikas, "*a complete workflow for development of bangla ocr*", int. journal of computer applications by foundation of computer science, **21(9):1-6**, may **2011**.

[6] marisa e. morita, fl avio bortolozzi, jacques facon, robert sabourin, "*morphological approach of handwritten word skew correction*", anais do xi sibgrapi, outubro de **1998**.

[7] jonathan j. hull, "*document image skew detection: survey and annotated bibliography*",document analysis systems ii ,pp **40-64, 1998**.

[8] u. pal, s. sinha and b. b. chaudhuri, "*multi-oriented text lines detection and their skew estimation*", proc. in indian conference on computer vision, graphics and image processing, pp. **270-275**, **2002**.

[9] Rajib Ghosh, Gouranga Mandal, "*A Novel Approach of Skew Correction for Online Handwritten Words*", International Journal of Computer Applications (**0975 – 888**), Volume **48**–No.**9**, June **2012**.

[10] Shahnaz Abubakker, Bapputty Hajia, Ajay Jamesa, Dr.Saravanan Chandranb, "*A Novel Segmentation and Skew Correction Approach for Handwritten Malayalam Documents*", International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST- 2015), Procedia Technology **24 (2016) 1341** – **1348**.

[11] A.Roy, T.K.Bhowmik, S.K.Parui, U.Roy "A Novel Approach to Skew Detection and Character Segmentation for Handwritten Bangla Words", Proceedings of the Digital Imaging Computing: Techniques and Applications (DICTA 2005) **0-7695-2467-2/05 2005** IEEE