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Slant Estimation and Correction for Online Handwritten Bengali Words

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***Abstract*—**Slant is a common artefact inwhich handwritten word takes the form of slope and handwriting recognition system becomes less accurate. For this reason slant estimation and correction is a standard step in handwriting recognition systems for processing written text after skew detection and correction. If Skew correction and Slant correction are done successfully then recognition part will be more prominent. Handwritten characters of natural handwriting are usually italicized due to mechanism of handwriting and personality. In this paper the slant of the Bengali online handwritten words has been estimated and has been corrected. In slant estimation and correction, we have used Projection profile histogram method to detect core region or busy zone of the handwritten words and we defined the estimated head line (matra) and estimated base line of the words. Then we have detected almost vertical (considering a threshold value of angle 45 degree) straight lines which meet or closer to meet the head line (matra) and baseline of the core region present inside the words. After detecting those vertical straight lines we have calculated angle of slant of each vertical straight lines separately and calculated average slant angle. Then rotate all the pixels into the particular slant angle to do slant correction considering the base as fixed point. We have tested this proposed technique on 2655 Bengali handwritten words and have achieved an outstanding result of 96 percentage of accuracy.

***Keywords*—**Online Handwriting, Head Line, Base Line, Core Region, Virtical Lines, Slant.

I. INTRODUCTION

It is a challenging task for a researcher to make handwriting recognition with a great accuracy now a day. 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, Slant correction, normalization, segmentation etc., out of them slant correction is one of the most important pre-processing step by which a handwritten word can be slant corrected. If there is a slant or slope in handwritten character or word then it is very difficult to perform next pre-processing steps and recognition will also be difficult. There are few existing algorithms of slant correction for offline and online handwritten word. Here an attempt is made to explore a new technique by which any handwritten can be slant corrected. This algorithm can be applied tomany Indian as well as foreign languages. Here several tests are done on the algorithm of Bengali handwritten cursive words. Rest of the paper is organized as follows- Section II contains Bengali script and online data collection, Section III deals with the Related Work of Slant Estimation 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.

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 (e.g., Figure 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.

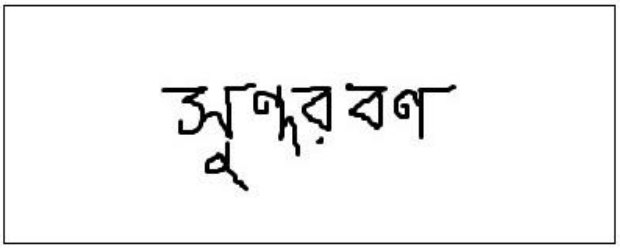

Figure 1. Example of a online bengali handwritten word

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 slant like online and offline handwriting. Before recognition of any handwritten word we need to do some sort of pre-processing. There are so many pre-processing steps like smoothing, de-hooking, skew detection, segmentation, skew correction slant correction etc. As stated earlier, few research works are available on slant estimation and slant 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. Some of the works discussed as follows:–

A. Slant Correction using 2D Affine Transform

In this study a slant handwriting method to detect geometry distorted images of handwriting is being proposed. The shifting processes of continued handwriting are carried out by defining the matrix of the letter through 2D affine transformation function. The image of the letter is shifted based on the slope of the words in the direction of the x or y axis. The shifting process are used a certain scaling factor. The experiments are tested using 40 continued offline handwriting. The data are obtained from IAM Database with image slope of - 45 to + 45 degrees. The results showed that 2D affine transformation methods are successfully detect and correct the slope of the letter and as a result avoid the over-segmentation of the image candidate. It able to improve the accuracy of continued offline handwriting recognition. The experiment in this study utilized the letters with varied slant angles (source database IAM). Affine 2D transformation was performed to detect and to repair the slant's angle of offline cursive handwriting. [2].

B. Slant Estimation based on Core Regionforand Height of each Boxof letter for Latin words

In this approach the Word slant is estimated taking into consideration the orientation and the height of each fragment while an additional weight is applied if a fragment is partially outside the core-region of the word which indicates that this fragment corresponds to a part of the character stroke that has a significant contribution to the overall word slant and should by definition be vertical to the orientation of the word. Extensive experimental results prove the efficiency of the proposed slant estimation method compared to current state-of-the-art algorithms. Portions of each strip separable by vertical lines are isolated in boxes. For each box, the centres of gravity for its upper and lower halves are computed and connected. In case of an empty half, with no foreground pixels, the whole box is disregarded. A box is also disregarded if its height is less than 3 pixels. The slant of the connecting line defined by the centres of gravity for upper and lower halves of box i corresponds to the slant of this box. The rationale behind this parameter is that character parts outside the core-region have a significant contribution to the overall word slant. As we observe in the boxes that

bound the largest fragments and are outside the core region contain the strokes that should be vertical to the orientation of the word and consequently our algorithm considers such strokes as dominant. The height of the box that bounds each fragment indicates important information about its contribution to the overall word slant whereas the location of each fragment is important since if a fragment is outside the core-region of the word most of the times should be vertical to the orientation of the word. Extensive testing based on various test-sets has demonstrated that both of the proposed methods outperform the state of art algorithms concerning slant estimation and core-region detection. Moreover, it is demonstrated that the more accurate the core-region detection algorithm is, the better the proposed slant estimation methodology performs. It is a point of discussion though whether the slant should be locally estimated in order to improve the OCR result of globally estimated in order to in order to be used as a salient feature of writer identification. Consequently as future work we should consider adapting the proposed method to work better for non-uniformly slanted words as much as try to test and adapt it in non-Latin alphabet languages [3].

C. Slant Correction using horizontal and vertical projection profiles

The proposed method deals with offline handwritten Telugu isolated characters and cursive words. The cursive and non-cursive Telugu words that differ with the writing style of people. Some people wrote the characters cursively, segmentation of which is the toughest task because the cursive words comprise slant errors whereas, the non-cursive Telugu words comprise non uniform slant errors for each character. In this paper, we corrected the non-uniform slanted isolated characters and cursive words. We proposed a novel approach for estimating and correcting the slant of offline handwritten Telugu isolated characters and cursive words. This method is a very efficient for correcting slant of offline handwritten Telugu isolated characters and cursive words. A proper slant corrected cursive words can easily segment and a proper slant corrected isolated characters increases the recognition accuracy. Therefore, slant correction is required for Telugu isolated characters and cursive words. This method is motivated from the chain code of the word contour slant correction method but this proposed method does not identify the chain code of the word or character contour. This method uses the vertical starting and ending co-ordinates for estimating the slant. It estimates the slant direction using the maximum vertical projection profile and corrects the slant of offline handwritten Telugu isolated characters and cursive words using shear transformation. The experimental results demonstrate comparative analysis of the efficiency of the proposed method compared with that of the existing method. The proposed method efficiently reduced the processing time compared with the existing methods. [4].

D. KSC Method

Alceu de S. Britto Jr. et. al. implemented a modified KSC method to correct slant of the numeral strings. This method deals with overlapped numerals. [5].

E. Weiner-Ville Distribution Approach

Ali and Jumari detected slant angle by weiner-ville distribution. The authors calculate all histograms by WVD. The highest intensity of histograms is taken as non-slanted word [6].

IV. PROPOSED METHODOLOGY

The algorithm implemented here is very simple, innovative and it can provide outstanding result with perfect accuracy. In case of Bengali words there are many vertical lines available. For printed word all the vertical lines should be perfect vertical i.e.- 90 degree with horizontal line, whereas in case of handwriting , people write in casual way so that the vertical lines not becomes proper 90 degree and this is called as slant. Skew and Slant are not same at all (e.g., Figure 2). Skew is the tilde of the whole word or whole line, happens during fast writing but slant is the slop of every character of words where baseline may be not skew or in a straight line.

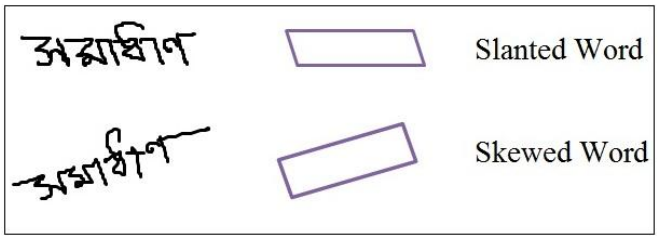

Figure 2. Diffrence between Skewed word and Slanted word

Our proposed technique is based on finding busy zone or core region of the word and identifying almost vertical straight lines which meet head line (matra) and base line of the busy zone (e.g., Figure 3). Slant estimation and correction is generally done after skew correction to get good result.

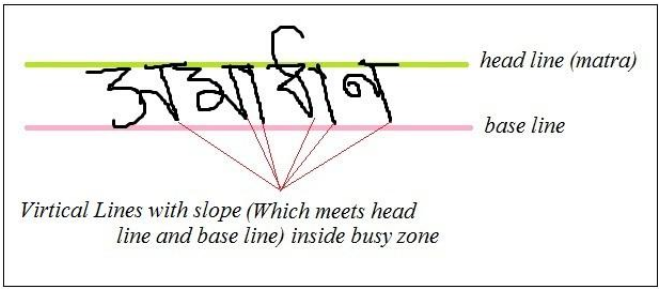

Figure 3. Vertical straight lines which meets head line (matra) and base line of the busy zone

The algorithm of Slant Estimation and Correction is as follows-

Algorithm: Slant Estimation and Correction

step 1: Consider co-ordinates (x,y) of all the pixels of handwritten word and find the histogram of no of occurrences of pixels in each y position.

step 2: Calculate the difference of occurrences for each y position.

step 3: Indicate the busy zone or core region where difference is maximum in upper portion (for matra) and lower portion (for base line).

step 4: Find out the strokes which start from matra (or nearest to matra) and ends to base line (or closer to base line).

step 5: Calculate all the angles among three adjacent pixels. i.e.-

$$\Theta = \cos^{-1}\left|\frac{\{(x2-x1)\times(x3-x2)\}+\{(y2-y1)\times(y3-y2)\}}{\sqrt{(x2-x1)^2+(y2-y1)^2}+\sqrt{(x3-x2)^2+(y3-y2)^2}}\right|$$

(Where θ is the angle, (x1, y1), (x2, y2) and (x3, y3) are the coordinate of three adjacent pixels)

step 6: Find the exterior angle for each θ, i.e.
Exterior angle = 180- θ.

step 7: Calculate sum of exterior angle for all the adjacent pixels, if the sum is lesser that 30 degree then we indicate the line as a straight line or almost a straight line.

step 8: Calculate the slant angle. i.e. - average of angle between all the identified straight line and horizontal line.

step 9: Find out all the lower pick points of the whole world.

step 10: Chose the nearest lower pick point as fixed base point of all the pixels for rotation.

step 11: Rotate all the pixels of the word by certain angle θ degree with respect to the point which meet the baseline for a particular stroke:-

Rotation of pixel segment around one of the end points:-

If x_1, y_1, x_2, y_2 and θ are given then we can find out x_3 and y_3(e.g., Figure 4) like-

$$\begin{bmatrix} x3 \\ y3 \end{bmatrix} = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \begin{bmatrix} x2 & -x1 \\ y2 & -y1 \end{bmatrix} + \begin{bmatrix} x1 \\ y1 \end{bmatrix}$$

step 12: The handwritten word will be slant corrected.

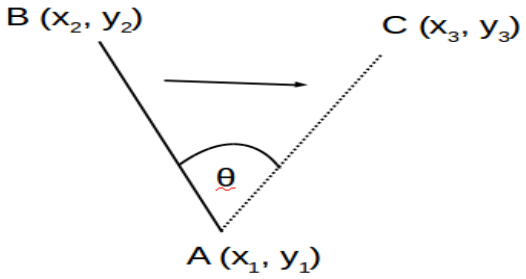

Figure 4. Genarate new co-ordinates (x3,y3) during rotation by slant angle θ.

V. RESULTS 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 3,500 Bengali handwritten words are collected as samples for the experiment. Out of them 2655 words are slanted words which have been tested (e.g., Figure 5) in our system and around 96% accuracy is obtained (e.g., Table 1). The slant correction accuracy obtained from the classifier is shown in Table:

Figure 5. Before Slant Correction and after Snalt Correction

Table 1: Result of Slant Estimation and Correction Algorithm

Total Words	*Slanted Word*	*Corrected*	*Incorrected*	*Skew Correction Accuracy In %*
3500	2655	2549	106	96%

VI. CONCLUSIONANDFUTURE SCOPE

This paper tends to uphold a new technique of slant estimation and correction of online handwritten word based on detecting the angle of almost vertical straight lines inside the busy zone. By this algorithm any online handwritten word can be made slant less even if there are many prolonged parts in a word as we consider only busy zone. We tested the proposed system on 3500 data out of them 2655 are words with slant 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

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] Fitrianingsih, Sarifuddin Madenda, Suryarini Widodo, Rodiah, "*Slant Correction and Detection for Offline Cursive Handwriting using 2D Affine Transform*", International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 08, August-2016.

[3] A. Papandreou, B. Gatos, "*Slant estimation and core-region detection for handwritten Latin words*", Pattern Recognition Letters, Vol. 35 (2014) , pp- 16–22.

[4] Ch. N. Manisha, Y.K. Sundara Krishna, E. Sreenivasa Reddy, "*Slant Correction for Offline Handwritten Telugu Isolated Characters and Cursive Words*", International Journal of Applied Engineering Research, Volume 11, Number 4 (2016) pp 2755-2760.

[5] Alceu de S. Britto Jr, Robert Sabourin, Edouard Lethelier, Flávio Bortolozzi and Ching Y. Suen. (1999). "*Slant normalization of handwritten numeral strings*". [Online] Available: www.etsmtl.ca/ETS/media/ImagesETS/Labo/LIVIA/Publications/1999/BrittoISKDM.pdf.

[6] Ali, M. A., and Jumari, K. B., "*Base-Area Detection and Slant Correction Techniques Applied for Arabic Handwritten Characters Recognition Systems*", Int. Conf. on Artificial Intelligence and Pattern Recognition, Orlando, USA. 2009. pp. 133-138.

Authors Profile

Mr. Gouranga Mandal pursed Bachelor of Technology in Information Technology from West Bengal university of Technology, Kolkata in 2009 and Master of Technologyin Computer Science & Engineering from West Bengal university of Technology, Kolkata in year 2012. He is currently working as Assistant Professor in Computer Science & Engineering Department, Faculty of Science & Technology, The ICFAI University Tripura since 2017. He has published many research papers in reputed international journals. His main research work focuses on Online Document Image Processing, Pattern Recognition, Optical Character Recognition, Natural Language Processing and analysis in Bengali and other Indian Script and Online Handwritten DocumentRecognition. He has 6 years of teaching experience.

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