Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 45 (2015) 305 – 311

Procedia Computer Science

International Conference on Advanced Computing Technologies and Applications (ICACTA-2015)

Skew Detection and Correction of Devanagari Script Using Hough Transform

Trupti A. Jundale[a]* Ravindra S. Hegadi[b]

[ab]*Department of Computer Science, Solapur University, Solapur-413255,India*

Abstract

In this paper we have proposed a method for skew detection and correction of handwritten Devanagari script using Hough transform. In this approach we used Hough transform algorithm for skew detection at word level. Skew of the word is the angle of distortion from horizontal line. The image is acquired using scanner or camera and pre-processed for noise removal. After removing noise, each word of document is extracted. Finally Hough transform is applied on each word for skew detection and rotation transformation is used for skew correction. If skew of the word is in positive angle then it is corrected by rotating it in clockwise direction, otherwise it will be rotated in anti-clockwise direction. The proposed system segment words with 97% accuracy and corrects skew with 92.88% accuracy.

Peer-review under responsibility of scientific committee of International Conference on Advanced Computing Technologies and Applications (ICACTA-2015).

*Keywords:*Pre-processing; word extraction; skew detection; skew correction

1. Introduction

Devanagari is one of the most used and adopted writing system in the world. India's national/official language, Hindi uses Devanagari script. Also Marathi (state language of Maharashtra), Nepali (national language of Nepal) uses Devanagari script. Many other languages like Sanskrit, Maithili, Bhojpuri, Konkani, Kashmiri, Bodo, Dogri etc.

* Corresponding author. Tel.: +919021857387
*E-mail address:*trupti_jundale@yahoo.com

Peer-review under responsibility of scientific committee of International Conference on Advanced Computing Technologies and Applications (ICACTA-2015).
doi:10.1016/j.procs.2015.03.147

and other sub-dialects [7] such as Dangi vadvali, Samavedi, Khandeshi, Ahirani, Dangi, Vadvali, and Malwani comes under Devanagari script.

In the rapid digitization of today's world, the area of digitizing the handwritten and printed data is also growing fast. To make data digitized, the Optical Character Recognition (OCR) system is carried out. The skew detection and correction of text is one the necessary step in any character recognition system. The skew detection and correction of Devanagari script is quite difficult as compared to any other script because of writing style. The writing style of every person may vary so there is presence of multiple skew in data. Skew is the angle which deviates from x-axis. The successful skew detection and correction turns next process like analysis of character or OCR to be accurate. There is lot of research available for skew detection of scanned document image but less work is available for skew detection of text/word.

The various methods are used for skew detection and correction which are based on algorithms like, nearest-neighbor clustering, Fourier transform, projection profile, binary moments, cross correlation, principle component analysis and others. A projection profile approach for detecting skew and slant angles of handwritten signature is proposed in [1]. For detection of skew they use horizontal projection profile and correct it by applying rotation transformation. For slant, vertical projection profile is applied and it is corrected by shear transformation. B. V. Dhandra, Ravindra Hegadi and others in [2] proposed a new and efficient method for estimation of skew angle in a binary document image based on image dilation and region labeling technique. In [3] an extension of the moment based method with the introduction of bounding boxes for estimation of the handwritten text skew of English language. An approach towards an orientation and skew detection for texts in scanned documents based on histogram processing is described in [4]. In [5] two algorithms are implemented, one detects skewing of word and another corrects the skewing from handwritten word. Both algorithms use the random transform based projection profile. Algorithm [6] employs only gradient information, in this skew angle and slant of character; both are obtained by searching for a peak in the histogram of the gradient orientation of the input image. Sarfraz, Muhammad, and Zeehasham Rasheed [8], proposes an algorithm for document skew detection based on bounding box technique.

In this paper we propose Hough transform based approach for skew detection. Section 2 describes characteristics of Devanagari script. Proposed methodology is described in section 3. Experimental result and conclusion are described in section 4 and section 5 respectively.

2. Devanagari Script

Devanagari script is a part of Brahmic family and it belongs from Indo-Aryan languages. It is written from left to right. Unlike English language, concept of upper/lower case is absent in Devanagari script. It consists of 33 consonants and 14 vowels. Generally every word written in most of the Devanagari script will have a header line on group of characters, called as 'Shirorekha' and this is considered as one word. Our proposed approach uses this header line for its implementation. Vowels that can be written as separate characters or by using diacritic marks on below, upper, before or after consonants are called modifiers. In Devanagari script, two or three consonants can be written as a single character, which is known as compound character.

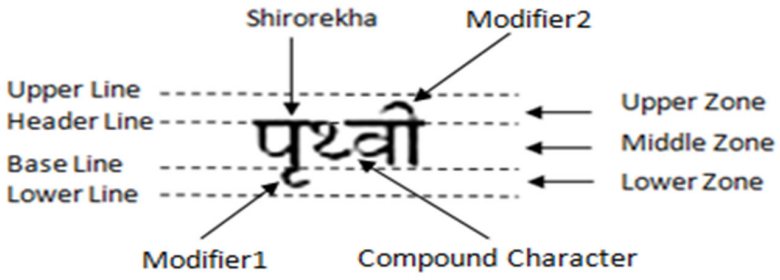

Fig 1. Devanagari script word

Figure 1 shows different features of Devanagari script. The main characters of word are written in middle zone. Upper zone and lower zone are for modifiers and Shirorekha is drawn at header line. In Figure 1 two characters are combined and form a new shape of single character is a compound character.

3. Proposed Methodology

The proposed methodology for skew detection and correction is described here. Section 3.1 describes the pre-processing step. Extraction of words from input image is described in section 3.2. Section 3.3 describes skew detection technique using Hough transform and last section describes skew correction technique. Figure 2 shows the block diagram of our work

.

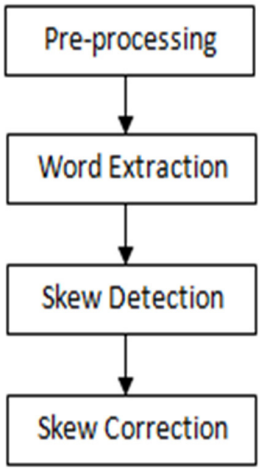

Fig 2. Block diagram of proposed system

3.1. Pre-processing

The document containing skewed Devanagari words which must have a header line is scanned using optical scanner or captured by digital camera to obtain input image. Acquired image is pre-processed for removing noise. Firstly image is converted into gray scale image and then thresholding is applied over for converting given image into binary image containing only black and white pixels. In this binarized image, white pixels represent background and black pixels represent foreground. Structuring element of shape disk is used for applying morphological dilation operation on binary image for further processing.

3.2. Word Extraction

In this stage, each word from the scanned document will get segmented. Bounding box is used for extracting all words from image. If every character of word is not connected to Shirorekha, then bounding box will not emerge correctly. Due to this reason the dilated image is used for finding the required area for word. Dilation expands object by adding pixels around its edges. Because of the dilation foreground pixels are expanded and the characters which are not connected to Shirorekha will get connected. After labeling each connected component of dilated image, area of each word is calculated and using these values, same area is segmented from original image to extract all words for skew detection. Successful segmentation of word gives more accurate result of skew correction. Figure 3 shows detection of all bounding boxes of input image.

Fig 3. Detection of bounding boxes

3.3. Skew Detection

Once all words are detected from original image, each word is processed for skew detection. Hough transform algorithm is used for detecting the skew of each word.

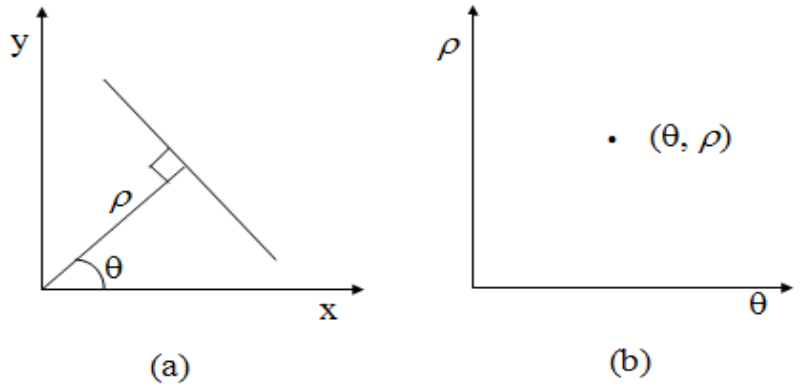

Fig 4. (a) Image space; (b) Parameter space

Hough transform is a feature extraction technique used in computer vision, image analysis and digital image processing [9]. The purpose of technique is to find lines, curves or any other parametric curves. It was introduces in 1962 by Paul Hough. The simplest case of Hough transform is the linear transform for detecting straight lines. The slope-intercept model of straight line is $y = mx + c$ where m is the slope and c is the y intercept. This straight line equation can be written in the form of parameter space is; $\rho = x \cos\theta + y \sin\theta$ where ρ is the distance of line from origin, and θ is the angle of ρ with respect to x axis. The line in the image space is just a point in the parameter space shown in Figure 4. Hough transform uses two dimensional arrays called an accumulator array for detecting the existence of lines in image space where each row and column corresponds to θ and ρ values respectively. Peak is the strong point in the accumulator array which represents straight line in the image space. Once peak points are detected we can find end points of line segments corresponding to peak values.

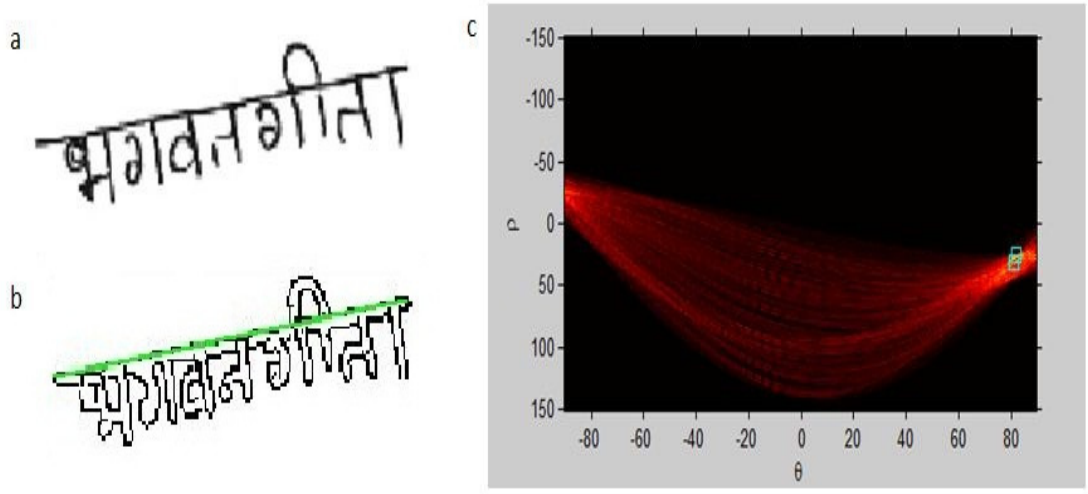

Fig 5. (a) Original word; (b) Line detection; (c) Hough space with peak points

The "Shirorekha" feature of Devanagari script which is longest line of word is used for detecting the line in this approach. For that edge detector is applied on each word for detecting the longest line. Hough transform uses this feature for calculating the angle θ of straight line. We calculate angle of deviation of the line with horizontal axis. It is a logical assumption that parson can write in skew up to $\pm 45°$. But for efficiency we use our algorithm for angle θ which lies within $\pm 60°$. Figure 5 shows Hough space and line detection of word.

3.4. Skew Correction

After the skew angle of the word has been detected, the word must be rotated in order to correct this skew. Various methods are used for skew correction are; direct method, indirect method and others like contour-oriented, projection based etc. The direct method uses rotation transformation in which corresponding pixels in the input image will be transformed to new location by using equation (1)

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos(-\theta) & -\sin(-\theta) \\ \sin(-\theta) & \cos(-\theta) \end{pmatrix} \cdot \begin{pmatrix} x \\ y \end{pmatrix} \tag{1}$$

Where (x, y) are the co-ordinates of skew detected word and (x', y') are the co-ordinates for skew correction of word. The opposite of direct method is the indirect method. For a pixel (x', y') in the output image, the indirect method finds corresponding pixel in the input image and assigns a value of (x', y') to (x, y) using equation (2).

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{pmatrix} \cdot \begin{pmatrix} x \\ y \end{pmatrix} \tag{2}$$

We apply indirect method for skew correction which simply rotate calculated skew angle to horizontal angle. The detected angle by Hough transform is corrected by applying rotation transformation. The word is rotated with θ angle. If angle of word is positive then it is corrected by rotating at negative angle and if angle of word is negative then it is corrected by rotating at positive angle.

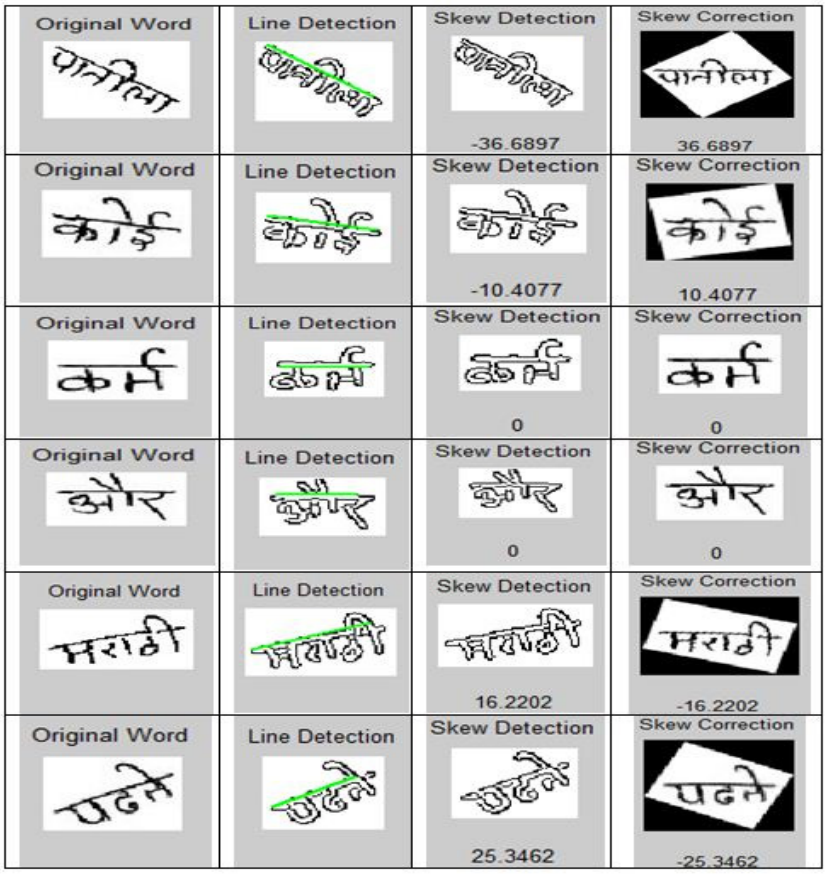

Fig 6. Skew detection and correction of words at different angles

4. Experimental Result

We tested our algorithm for input images of handwritten document for Hindi and Marathi languages. The algorithm is tested on 1050 words of Devanagari script. The accuracy rate for segmenting word is 97% and the accuracy rate for skew correction is 92.88%. Mostly the word with single character or small size length does not give accurate result because of the small size length of the header line. Figure 6 shows words with skew detection at different angles which may be positive skew, zero skew or negative skew and skew correction of all these. The results of word containing break in the header line and word containing characters which are not touching to the header line are shown in Figure 7. Even for such type of words the skew correction yields correct result since the dilation in pre-processing stage leads to joining of Shirorekha among the separated word components.

5. Conclusion

We have proposed a methodology for skew detection and correction of handwritten Devanagari script. Hough transform algorithm is used for skew detection and it is corrected by simply rotating word by calculated angle. This method is tested on handwritten data of Hindi and Marathi language. The word dataset is collected from various writers for testing purpose which contains 1050 words. This approach can be modified for further research to get more accuracy. Also work will be continued in future to calculate the skew angle of non-Shirorekha word means word which do not have a header line.

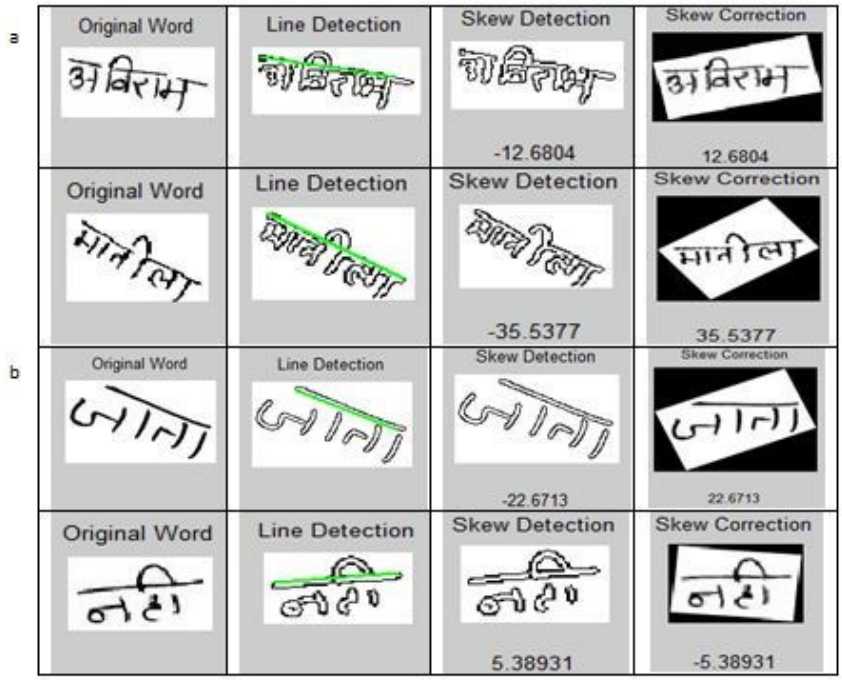

Fig 7. (a) Words with break in header line and (b) Words not connected to header line

References

[1] L. B. Mahanta, Alpana Deka. Skew and Slant Angles of Handwritten Signature. *International Journal of Innovative Research in Computer and Communication Engineering*; 2013. Vol. 1. Issue 9. p. 2030-2034.

[2] B. V. Dhandra, V. S. Malemath, H. Mallikarjun, R. Hegadi. Skew detection in binary image documents based on image dilation and region labeling approach. *Pattern Recognition*; 2006. Vol. 2. p. 954-957. IEEE.

[3] D. Brodic, Z. Milivojevic. Estimation of the Handwritten Text Skew Based on Binary Moments. *Radioengineering*, 21(1); 2012. P. 162-169.

[4] B. Costin-Anton, B. Raducanu, A. C. Spataru. High-precision orientation and skew detection for texts in scanned documents. *Intelligent Computer Communication and Processing*; 2009. p. 145-148. IEEE.

[5] R. Kapoor, D. Bagai, T. S. Kamal. A new algorithm for skew detection and correction. *Pattern Recognition Letters, 25*(11); 2004. p. 1215-1229.

[6] Sun Changming, Si Deyi. Skew and slant correction for document images using gradient direction. *Document Analysis and Recognition*; 1997. Vol. 1. p. 142-146. IEEE.

[7] R. S. Hegadi, P. M. Kamble. Recognition of Marathi Handwritten Numerals Using Multi-Layer Feed-Forward Neural Network. *Computing and Communication Technologies (WCCCT)*; 2014. p. 21-24. IEEE.

[8] M. Sarfraz, Z. Rasheed. Skew estimation and correction of text using bounding box. *Computer Graphics, Imaging and Visualisation*; 2008. p. 259-264. IEEE.

[9] http://en.wikipedia.org/wiki/Hough_transform.