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Document Image Skew Detection and Correction based on 3 Quadrants Gradient Detection Scheme

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***Abstract*:** *In this paper, a new approach to assess the skew angle for scanned/printed documents and historical document images has been proposed. This is substantial for an automatic document processing system (as text and image segmentation) to avert errors in auxiliary stages. The proposed tactic is based on the statistical analysis of the slope of the connected lines in the document. The proposed technique detects skew and corrects it by initial letter (X1, Y1+200) from left margin of the resized (800X800) image and (X1+200, Y1) from top, (X1, Y1+200) from bottom margin. Final letter (X2, Y2-200) and (X2-200, Y2) were chosen from right and bottom margins of the same image. The skew angle estimation is done for standard skewed dataset and effective correction of the same is performed with minimum errors.*

***Index Terms*:** *Printed text, Multiple Skew, Skew Detection and Correction.*

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I. Introduction

E-documents usage is a more extensive perception with the express advancement of technology and the solidification of environmental consciousness. With the following advantages, E-documents are of small footprint, easy saving, easy modification, and easy transmission. Due to this, scanning process of converting an available hard copy into soft copy is of great importance [1–4]. Due to technical and human error factors during scanning process, the documents may be skew. Skew document images cause inconvenience to subsequent image processing, and may even lead to wrong results, so skew detection and correction are important steps in image preprocessing. Skew detection methods are more popular, now a day. Some of them are projection profile (PP), Hough transform (HT), and nearest neighbor (NN) methods. Besides, some other methods based on the textual characteristics of document have also been proposed [5–7]. As far as we know, processing speed is important when high volumes of scanned documents have to be processed using optical character recognition, especially in some systems with high real-time requirements. So, in addition to the accuracy of angle detection, the speed of angle detection also needs to be concerned. However, some methods require extensive computation, such as Hough transform-based methods. Some methods such as PP-based methods can only deal with small skew angles because they have high computational cost of exhaustive search. And some other methods sacrifice the accuracy in order to increase the calculation speed, such as the axes-parallel bounding box method in [8].

II. State of the Art

Numerous methods have been proposed for skew angle detection of document images. Leading approaches for skew detection include: Hough Transform, Projection Profile, Nearest Neighbor and Principal component Analysis etc.

The proposed approaches are based on Hough transform [6][7][8], an approach [11] uses block-based Hough transform to detect lines and merging methods to correct false alarms achieves 93% detection even though not flexible to follow variation of skew angle of the same text line. Projection profiles [9][10][12] it is one of the common approach to estimate skew. The process of converting binary image (2 dimensional matrix) into one-dimensional array (Projection Profile) is called projection. Each line in the document is represented by horizontal projection profile, whereas each line in projection profile has a value that represents number of black pixels in the corresponding row of the image. For the documents with skewed angle zero, valleys are observed in the horizontal projection profile that corresponds to the space between the lines. Heights of the text lines in document are represented by the height of maximum peak in the profile.

Projection profile methods provide honest results but high computation cost and low efficiency in case of iterative process are the major limitations of the above methods. Furthermore, image with charts or graphs along with data reduces the precision of detecting the angle and also very sensitive to noise interference. Projection profile methods are approximating the skew angle in range from 10° to 15°.

Nearest Neighbor (NN) [13] method, the system finds connection between the adjacent components in the document discovers the histogram of the direction vectors for all nearest neighbors and then calculates the first nearest neighbor of each component. The histogram stores the centroid angles of nearest neighbor components. The main peak in the histogram represents skew angle of the document.

Fairly, nearest neighbor methods can be used to detect and correct skew angles of the document which contains diverse types of font size and scripts. This method is not proposed for the corrupted and historical documents.

From the literature survey we noticed that, most of the existing approaches are designed to estimate skew in printed documents and cannot be suggested for Historical Handwritten documents with noise interference. Figure 1 shows sample Handwritten Historical documents containing multiple skew. To the best of our knowledge there is no work found in the literature which can estimate skew of a Historical Kannada document containing multiple skews and correcting it. Hence in this work we have proposed new algorithm for skew detection and correction of historical handwritten document analysis and recognition.

III. Methodology

Proposed algorithm comprises of two stages: Skew detection and correction.

Step1: Input n X n RGB image is subjected to gray level conversion

$$Lightness = \left(\frac{\max(R,G,B)+\min(R,G,B)}{2}\right) \quad (1)$$

$$Averaging = \left(\frac{R+G+B}{3}\right) \quad (2)$$

$$Luminosity = (0.21\,R\ +\ 0.72\,G\ +\ 0.07\,B) \quad (3)$$

Step2: The gray converted image in the above three formats is compared with each other based on property in terms of size from which minimum likelihood is selected. It is then resized to a factor of 800 X 800 in order to perform segmentation with less overlaps.

Step 3: The resized image is subjected for skew detection by finding coordinates of the initial letter (x_1,y_1+150) of the line chosen to the final one (x_2,y_2-150), horizontally.

Step 4: Resultant image is then subjected for skew detection by finding coordinates of the initial letter (x_1+150,y_1) of the line chosen to the final one (x_2-150,y_2), vertically.

Step 5: After finding the coordinates, the orientation (slope) can be calculated by using the equation of the straight i.e.,

$$(y2 - y1) = m * (x2 - x1) \quad (4)$$

The skew angle obtained by equation (1) will be in radians and it should be converted to degrees in order to rotate the input script to the desired angle.

$$Skew\ (radians) = \tan^{-1}\frac{y2-y1}{x2-x1} \quad (5)$$

$$Skew\ (degrees) = \frac{Skew\ (radians\ )*180}{\pi} \quad (6)$$

Step 6: To the required angle the script is rotated in order to correct the skew.

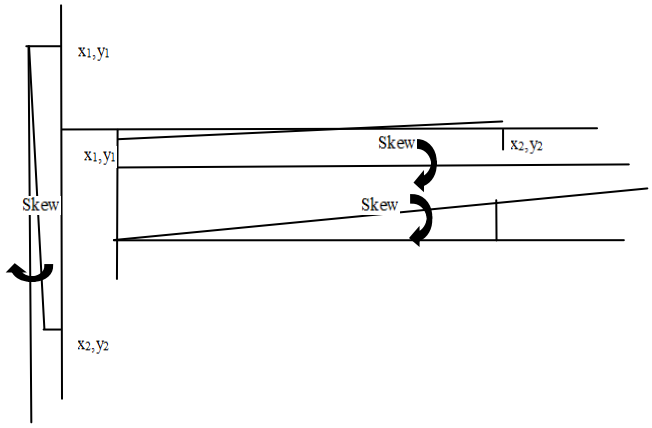

Fig.1 Skew detection in document image

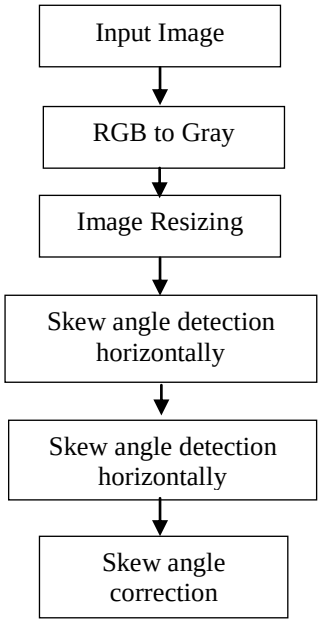

Fig.2 Flow diagram of proposed scheme

PERFORMANCE ANALYSIS

Matlab2016a is used for the exploration of the proposed system with Intel i5 processor. The skew detection analysis is made on the basis of Arithmetic Mean, Variance and Standard Deviation. Five standard images are considered from ICDAR, 13 Chinese data base.

A)Arithmetic Mean Skew:

$$Mean\ Skew\ (X') = \frac{\sum_{i=1}^{n} X_i}{N} \quad (4)$$

Where,

X' - Mean Skew of all the documents,

N - Number of documents

B)Variance:

$$Variance\ (V) = \frac{\sum D^2}{N} \quad (5)$$

Where,

D - Deviation of an item relative to mean

N - The number of observations

C)Standard Deviation:

$$Standard\ Deviation\ (\sigma) = \sqrt{\frac{\sum D^2}{N}} \quad (6)$$

Where,

D - Deviation of an item relative to mean

N - The number of observations

TABLE I Skew angles detected and corrected in degrees for printed document images

Image	Actual Skew (Degrees)[9]	Skew calculated	Deviation to Actual Skew	Deviation to Mean (D)	Square of Mean (D^2)
IMG(002)	-1.8000	-1.90	0.1	0.21	0.0441
IMG(003)	-1.8700	-2.00	0.13	0.18	0.034
IMG(008)	-6.9000	-6.4	0.5	0.19	0.0361
IMG(005)	-7.1100	-7.6	0.49	0.18	0.0324
IMG(006)	-7.6300	-7.75	0.12	0.19	0.0361
Average Skew			0.31		
Variance					0.03465
Standard Deviation					0.19

TABLE II Statistical analysis of Skew detected angle for historical documents

Image	Skew calculated (Degrees) by proposed algorithm	Deviation to Mean (D)	Square of Deviation
Nemichandra	-2.5	0.4562	0.2081
Chavundravya	1.4639	0.5799	0.3362
Kanakadasa	-1.78	0.2638	0.0695
Ratnakaravarni	2.4752	0.4314	0.1861
Mean Skew	2.0438		
Variance			0.1999
Standard Deviation			0.4471

a)Chavundravya b)Nemichandra

c)Kanakadasa d)Ratnakaravarni

Fig.7 Skewed images from Historical database

IV. CONCLUSION

This paper reveals a new method for assessment of slant/skew in printed/scanned document images. Proposed algorithm detects and corrects skew with precision less than a degree with great accuracy. It is found that the proposed algorithm gives more efficiency compared to the existing ones. The skew angle is measured by leaving 150 pixels form three sides of an image reduces the chance of considering any noise contents as context in the image. From this more accuracy is achieved for a set of standard test images as well as data set of Devanagari script. The proposed algorithm detects and corrects positive and negative skews in both clockwise and anticlockwise directions.

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