Abstract: In this paper, a new approach to assess the skew angle for scanned/printed documents and historical document images has been proposed.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 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.

I. INTRODUCTION

Deskewing is a procedure to align the image properly, before further processing the data in the image. There are many existing approaches for deskewing the image such as mathematical morphology, principal of connected components, projection profile technique, Fourier transform, Hough transform, Radon transform and KL Transform. These methods for deskewing have their own constraints with respect to font style, font size and are not rotation invariant [1-4].

A number of skew estimation and deskewing techniques of document images is proposed in the literature. It has been bracketed into two types, they are, spatial and frequency domain approaches. The following are the frequency domain procedures for skew estimation and correction.

Bo Yuan proposed an approach to deskewing based on Hough Transform. Skew estimation method was based on the presence of noises like the straight lines; edges exist in the images and not textual content present in that image. This model works if the input image has well-defined edges from the black bars around the pages, the graphical inserts, and the separators of tables, columns or paragraph [2]. Jonathan Fabrizio presented an algorithm for skew estimation for binary images in the frequency domain. In this methodology first preprocessing of the image using KNN clustering method is to be done and then Fourier transform should be applied to the image to the outlines of the convex hulls of the clustered regions. But preprocessing an image using KNN clustering requires parameter (K) number of nearest neighbours and also computation cost is very high [3]. Nandini N et al proposed a model algorithm based on connected component analysis and Hough transform. There are two approaches namely word centroid approach and dilate & thin approach. In this approach, an only printed document containing text are taken into consideration. But the method restricts for images containing pictures [5].

M. Sarfraz et al proposed an algorithm for deskewing of the image by using Haar wavelet transform and principal component Analysis. Initially, the image was decomposed into detailed sub images into various levels with the help of Haar wavelet transform. PCA was used to estimate the orientation of the principal axis in horizontal, vertical direction in each level. Output was accurate for the input image of Arabic font which is connected and English Font which is isolated in nature [6]. Mandip Kaur et al proposed an algorithm based on Fast Fourier Transform and Discrete Cosine Transform. The main purpose of using FFT is to find the skew angle. Initially, the DCT compression technique was applied on the image to reduce timing computation. Fourier spectrum is obtained for the compressed image. The obtained spectrum is divided into four quadrants and the skew angle of each quadrant is obtained. At last input image is rotated using the bilinear interpolation method. Here skew angle of 45 degree to -45 degree was taken into consideration [7]. Sargur N. Srihari et al used the Hough transform method for deskewing of the image. Here various problem faced in the Hough transform like Aliasing and Quantization Problem were discussed as well as the solution to those problems was mentioned. The output image in some case was found to be upside-down or right side-up [8]. Xiaoyan Zhu presented an approach where the image with textual and non-textual content is taken into consideration. Initially, document image was divided into blocks of equal size using Fourier Transform and Support Vector Machines were applied to determine whether each block is textual or non-textual. They determined the skew for only textual blocks by taking standard deviation of the projection profile of various angles [9]. The following are the spatial domain approaches for skew estimation and correction. Nguyen D.T et al came up with a mathematical morphology operation which can be used for deskewing of the image.
Filter noise, accents and large connected components are included initially for preprocessing procedure. Next to estimate a range of skew angle a coarse estimation algorithm is used. Here skew angle of every text line was considered to determine the skew angle of the entire document. The output was tested for 1080 images, out of which 900 document images were from Latin, and 180 of other languages. These documents resolutions vary from 150 to 300 dpi and skew angle vary from -90° to 90° [10]. M. Sarfraz et al proposed technique based on Histogram statics and connected component analysis. Here four different methods for deskewing of the image are compared. The four methods are Projection Profile Technique, Principal Component Analysis, Peaks and Valleys Analysis, Connected Component Analysis. An Input image of skew angle of 1 degree to 25 degree was taken into consideration, accuracy and time taken were noted for all. Connected Component Analysis was found to be more accurate when compared to other methods [11]. Zhiyong Ju et al came up a skew detection algorithm based on a low pixel set of characters. In this algorithm initially, bottom pixels of some characters present in text line was detected because the number of ascenders is much larger than that of the descender in English text. The Skew angle of text is estimated based on moment calculation. Here document image with the large skew angle as well as document image with few characters is taken into consideration. The input image with inverted text and flipped image are not taken into consideration [12]. K.R. Arvind et al used correction algorithm based on Horizontal Projection Profiles of a block image and their entropy was considered for deskewing of the image. The output was tested for 100 document images which had text related to English Kannada and Chinese scanned at 200 dpi. These documents contain signatures, logos and text paragraphs. The skew angle ranging from +10° to -10° was taken into consideration and precision of 0.1° was achieved [13]. Robert S. Caprari proposed an algorithm for up/down orientation determination. The text is divided into three parts, based on the percentage of the text present in that part the orientation of the text was decided. Horizontal and vertical line profile was plotted to check whether the text is horizontal or vertical. Output was tested for 39 pages of 12 point and 10-point roman text, both clean and degraded by 10% impulse noise. Input image with the text of smaller font sizes and sanserif fonts was found not effective [14].

II. METHODOLOGY

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

Step 1: Input n X n RGB image is subjected to gray level conversion

\[
\text{Lightness} = \left( \frac{\max(R,G,B) + \min(R,G,B)}{2} \right)
\]  \hspace{1cm} (1)

\[
\text{Averaging} = \left( \frac{R+G+B}{3} \right)
\]  \hspace{1cm} (2)

\[
\text{Luminosity} = (0.21 R + 0.72 G + 0.07 B)
\]  \hspace{1cm} (3)

Step 2: 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.,

\[
(y_2 - y_1) = m \times (x_2 - x_1)
\]  \hspace{1cm} (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.

\[
\text{Skew (radians)} = \tan^{-1} \frac{y_2 - y_1}{x_2 - x_1}
\]  \hspace{1cm} (5)

\[
\text{Skew (degrees)} = \frac{\text{Skew (radians)} \times 180}{\pi}
\]  \hspace{1cm} (6)

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

![Fig.1: Skew detection in document image](image1)

![Fig.2: Flow diagram of proposed scheme](image2)
III. 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:

\[
\text{Mean Skew } (X') = \frac{\sum_{i=1}^{N} X_i}{N} \quad (4)
\]

Where,
- \( X' \) - Mean Skew of all the documents,
- \( N \) - Number of documents

B) Variance:

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

Where,
- \( D \) - Deviation of an item relative to mean
- \( N \) - The number of observations

C) Standard Deviation:

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

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)[16] | Skew calculated | Deviation to Actual Skew | Deviation to Mean (D) | Square of Mean (D²) |
|----------|---------------------------|-----------------|--------------------------|-----------------------|---------------------|
| IMG(002) | -1.8000                   | -1.9327         | 0.1327                   | -0.1691               | 0.0286              |
| IMG(003) | -1.8700                   | -2.0738         | 0.2038                   | -0.0980               | 0.0096              |
| IMG(008) | -6.9000                   | -6.4894         | 0.4106                   | 0.1088                | 0.0118              |
| IMG(005) | -7.1100                   | -7.6099         | 0.4999                   | 0.1981                | 0.0392              |
| IMG(006) | -7.6300                   | -7.8921         | 0.2621                   | -0.0397               | 0.0016              |

Average Skew

| Variance | 0.0182 |
|----------|--------|

Standard Deviation

| 0.1340 |

Fig.3 Skew angles detected and corrected in degrees for printed document images
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Fig. 4 Skewed images from standard test database
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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    | -2.4563                                       | -0.4125               | 0.17                |
| Chavundravya   | 1.4639                                        | 0.5799                | 0.34                |
| Kanakadasa     | -1.78                                         | 0.2638                | 0.07                |
| Ratnakaravarni | 2.4752                                        | -0.4314               | 0.19                |
| Mean Skew      | 2.0438                                        |                       |                     |

Variance 0.19
Standard Deviation 0.4358

Fig. 6 Statistical Analysis of Skew detected Historical Images

Fig. 7 Skewed images from Historical database

a) Chavundravya  
b) Nemichandra  
c) Kanakadasa  
d) Ratnakaravarni
IV. CONCLUSION

This paper reveals a new method for assessment of slant/skew in printed/scanned document images. The algorithm based on the variations in pixel intensities of the script in the image. An instant based method evaluates its angular alignment, which signifies the overall skew in the image. This oriented morphology method shows restitutions over the existing approaches. Since the actual skew is compared with the existing one, the method shows clear advantage under noise. The estimation points can be further increased under skew, to get an average value among those with high provisional detection and correction in future.

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Fig. 8 Skew Corrected Images from Historical Database
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