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## Skew Detection and Correction in the Document Image

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**ABSTRACT:** Document image processing has become a growingly important technology in the field of image processing; it is generally used in historical studies and digital libraries. Document image analysis mainly used for improving the human readability and the OCR quality of the document. When a paper documents are captured using cameras or scanned using scanners for digitizing, it often suffers from some level of skew or gradient. After the skew correction is done successfully then the character segmentation of the word will be more perfect and as a consequence the percentage of the correct word recognition will be higher. This paper compared four existing skew correction techniques, they are Hough Transformation, Cross Correlation, K- Nearest Neighbour and Fast Fourier transformation. It has been observed that the Fast Fourier transform technique correct the skew in the document image and it have produced higher accuracy and less execution time compared with other techniques.

**KEYWORDS:** Skew Detection and Correction, Hough Transformation, Cross Correlation, K- Nearest Neighbour, Fast Fourier transformation.

### I. INTRODUCTION

Traditional libraries and organizations are maintained large amount of hard copy/printed materials, but this system is not efficient because maintenance of textbook system was a challenging task way for keeping the records because it has many drawbacks- time consuming process, low security, low efficiency, inconsistency of data, difficult to compensate in case failures, difficult to achieve operation like editing, searching etc. Hence each and every libraries and offices are slowly getting digitized. Digitalization of documents emerges as a bridge over the gap of past and present technologies. Scanners have an inclination use for the digitalization of documents. The problem of scanning the documents is not always correctly placed on the flat-bed scanner either manually by operators or by the automatic supporting device. User's rotated images are sharp for visualization and introduce extra difficulty in text reading. Sometimes pages are not fed properly into the scanner causing skewness of these bitmapped-image pages.

For machine processing, image skew creates a number of problems in storage to make more sensitive the recognition and transcription of the image by using OCR. The skew makes more difficult to visualize the images and it increases the complexity of any kind of automatic image recognition, degrades the performance of OCR, increases the space needed for image storage, etc. Hence, skew correction is an important part of any document image processing system. Following reasons for skew in the document images are enumerated below.

- Skew in Scanning Process
- Skewed Handwriting
- Skewed Original Document

The remaining portion of this paper is discussed as follows. Section 2 discusses the related works. Section 3 provides the types of document skew. Section 4 gives skew detection techniques. Section 5 represents the output results. Conclusion is given in Section 6.

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## II RELATED WORKS

There are several popular methods for skew estimation and correction. In this section, some of the related works are discussed.

**Kaur, et.al** [4] presented a hybrid approach to determine the processed time and speed taken by skew detection approach, the Fast Fourier transform (FFT) technique was applied as it is the fastest method for determining the angle of skewed documents. Their method included an accurate evaluation of skew, with in-line, and between-line spacing and locates text lines and text blocks.

**Ramandeep Kaur, et.al** [11] analysed two existing algorithms, they are Fast Fourier transform and nearest neighbour, to estimate the text skew angle in a document image. Then the skew image is corrected by a rotation at such an angle which is estimated by the algorithm. The Fast Fourier transform technique is applied as it is fast approach for finding the angle of skewed document. Nearest neighbour method is found on connected components in which the first nearest-neighbours of all connected components are and the histogram of the direction vectors for all nearest-neighbours is acquired.

**Yang Cao, et.al** [12] proposed a novel skew detection method based on straight-line fitting, and also they introduced an Eigen-point concept. After the relations between the neighbouring Eigen-points in every text line within a suitable sub-region were analysed, the Eigen-points most possibly laid on the baselines are selected as samples for the straight-line fitting. The average of these baseline directions is computed, which corresponds to the degree of skew of the whole document image. Then a fast skew correction method based on the scanning line model is also presented.

**Loveleen Kaur, et.al** [13] discussed about the technique used to detect Skew which are introduced during the scanning of the documents and also discussed about the tool which have been used to implement the technique. The algorithm has been implemented on various scripts. The method provides a very efficient way to calculate the Skew. Correction in the skewed scanned document image is very important, because it has a direct effect on the reliability and efficiency of the segmentation and feature extraction stages. The method deals with an accurate measure of skew, within-line, and between-line spacing and locates text lines and text blocks

**Rajib Ghosh et.al** [14], proposed a new method for skew detection and skew correction of online Bengali handwritten word through holistic approach. Their approach is based on centre of gravity of left part and right part of a handwritten word. After finding the centre of gravity, calculates the angle  $\theta$  of the line which connected the two gravity centres in relation to horizontal line. Then Rotates the word clockwise by the angle  $\theta$  if  $\theta < 90^\circ$ , or anti-clockwise by the angle  $(180^\circ - \theta)$  if  $\theta > 90^\circ$ . All the pixel moves to the particular angle to correct the skew.

## III. TYPES OF DOCUMENT SKEW

There are basically three types of skew in the images, they are:

1. Single Skew
2. Multiple Skew
3. Non-uniform text line Skew

**1. Single Skew:** In this single skew, the complete document is skewed to single angle. Most of the document images have this different types of skewness. A lot of work has been done in this field and lot of research continues to be occurring.

**2. Multiple Skew:** In this, scanned document will have several sections; each may be skewed to totally different angles. Detecting such variety of skewness needs lot of efforts. Multiple Skew issues are present, but it has not got a lot of attention from researchers.

**3. Non-uniform text line skew:** Once documents contain many orientations within the single line is named as non-uniform text line skew. In non-uniform text line skew there are many orientations in every line of the document. Each line of a document skewed on multiple angles. Detecting such kind of skewness needs lot of efforts. Multiple Skew problems occur rarely and had not got a lot of attention from researchers.

## IV. SKEW DETECTION TECHNIQUES

Skew detection and correction is a part of the pre-processing stage, which affects the performance of an OCR system significantly, if the image suffers from skew OCR system not recognized text properly. The skew angle of a few

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degrees has a significant effect on these methods and thus it is important to accurately estimate and eliminate the issues of the skew. Numerous techniques have been proposed as alternatives for skew angle detection of document images. Some of the skew detection techniques are Hough Transformation, Cross Correlation, K- Nearest Neighbour and Fast Fourier transformation.

### 3.1 Hough Transformation

Hough transformation is the most popular technique used in detecting the skew angle of a document image. It is a feature based descriptor which is used to identify lines and find any shape position in an skewed image. Hough transform technique is designed to detect the lines using parametric representation. Hough parametric space is described in  $(a, b)$  form in the Cartesian coordinate system. Where,  $a$  and  $b$  are intercepts of a line passing through point  $(x_1, y_1)$ , Hough transform is given below.

$$b = -ax_1 + y_1$$

For example, a grayscale image can be represented by the line running length codes, and the codes within a certain range should be selected as candidate points for Hough transformation. The main idea of the above methods is to reduce the amount of input data, but their computational convolutions are still very high.

### 3.2 Cross Correlation

The cross correlation method is based on the correlation between two vertical lines in the document image. Since the pixels in the two parallel lines are translated due to skew, then a correlation matrix can be produced in given below.

$$R(x_0, S) = \sum_y L_1(x_0, y) L_2(x_0 + d, y + s)$$

Here  $L_1(x, y)$  and  $L_2(x, y)$  denote the two parallel vertical lines respectively,  $d$  is the space between  $L_1$  and  $L_2$ , and  $S$  is the maximum of translation.

### 3.3 K- Nearest Neighbour (K-NN)

This method is being founded on connected components in which the first  $k$ - nearest neighbours of all connected components are and the histogram of the direction vectors for all nearest-neighbours are acquired. This dependency can be very problematic when dealing with complex or degraded data, such as historical documents. Let there be a digitally sampled image  $g(m, n)$ , linear sampling of all variables implies that  $p_k x_m + \tau_h$  in general never coincides with the samples  $y_n$ . This problem can be corrected by using a nearest neighbourhood approximation in the  $y$ -direction. Hence the Radon transform can be approximated by the discrete Radon transform. This term is desired for continuous Radon transform as given below.

$$g(k, h) = \Delta x \sum_{m=0}^{M-1} g(m, n(m; k, h))$$

Where

$$n(m; k, h) = \left\lceil \frac{p_k x_m + \tau_h - y_{min}}{\Delta y} \right\rceil$$

The advantage of the first K-NN method is that it is not limited to any range of skew angles. However, this method requires special attention for dealing with different scripts, broken characters and heavily predicates on the quality of the binarization process output.

### 3.4 Fast Fourier transformation (FFT)

By using Fast Fourier transform, the image is filtered in the Fourier domain to retain predominantly text and edge information. A direction histogram is extracted from the Fourier spectrum of the image. FFT is the faster interpretation of discrete Fourier transform, it obtains the discrete frequency over only one period of continuous frequency domain. When the region of one frequency cycle is examined, it is concluded that there is even symmetry around the centre point, the Nyquist frequency. The phase of maximum frequency is the skew angle. The FFT based skew estimation approach can be applied to both document image and other pictures. When the image was converted from its Spatial Domain  $f(a, b)$  to its frequency domain  $f(p, q)$ , then by using Fast Fourier transform technique it is easy to process the image and its further calculations such as skew angle, speed, time etc. because the frequency at each point of the image can be easily calculated. This technique based upon removal of certain range of frequencies from a processed image.

This technique mainly contains the following steps:

- Computes the Fast Fourier transform of an Image  $f(a, b)$ .

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- Computes a new transform  $f(p,q)$  by setting some values to zeros

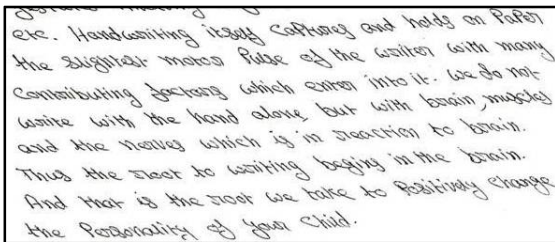
The FFT of 2D image having spatial domain  $f(a,b)$  of size  $M \times N$  is given by following Fourier equation [3].

$$f(p, q) = \frac{1}{MN} \sum_{a=0}^M \sum_{b=0}^N f(a, b) e^{-j2\pi(u \times a/M + vb/N)}$$

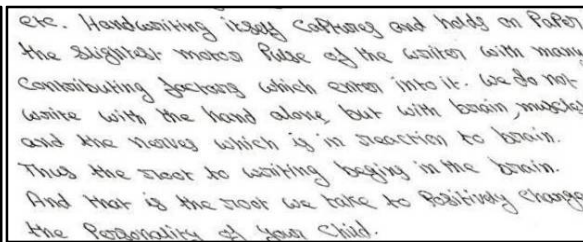
This formula calculates the frequency spectrum of the spatial coordinate function  $f(a,b)$ . The Fourierfunction  $f(p, q)$  may have complex values but for betteraccuracy, only absolute values of the frequency spectrumhave been taken. As the image is rotated, its frequencyspectrum also rotates and shifts the energy of the image to theCentre of the image.

## V. EXPERIMENTAL RESULTS

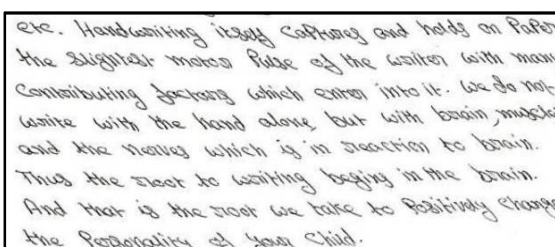
Skewed document imagesare considered as the input for applying theskew correction techniques.This workcompared four skew correction algorithms, they are Hough Transformation, Cross Correlation, K- Nearest Neighbour and Fast Fouriertransformation is to estimate the text skew angle in a document image. This work has calculated accuracy measures using SSIM (Structural Similarity Index for Measuring) and PSNR (Peak Signal Noise Ratio), which is used for measuring the similarity between two images. From the experimental results, the performance of Fast Fourier transform technique give better result than other technique.



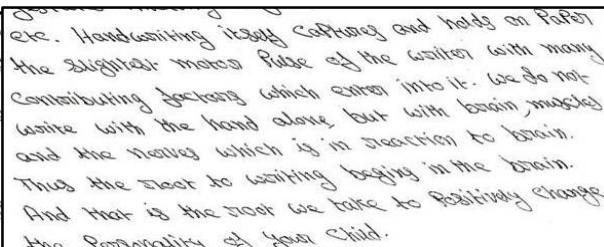
(a) Input image



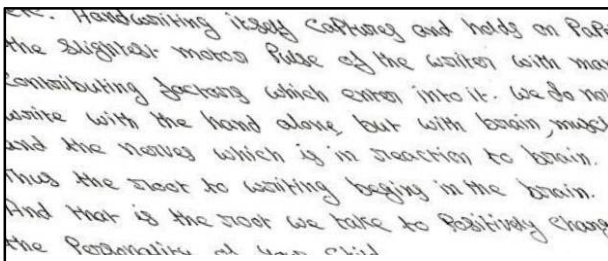
(b) Hough transform



(c) Cross Correlation



(d) K-Nearest Neighbor



(e) Fast fourier transform





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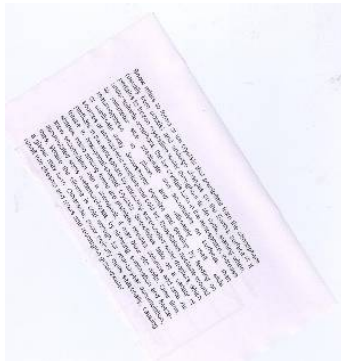
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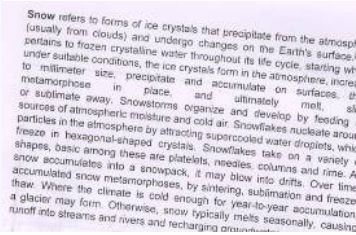
(d) K-Nearest Neighbor



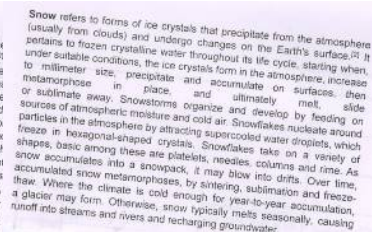
(e) Fast fourier transform



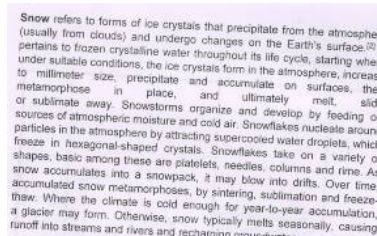
(a) Input image



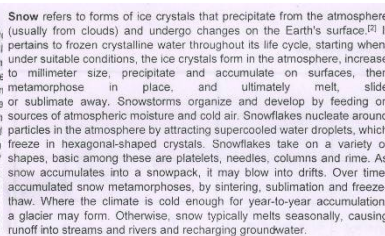
(b) Hough transform



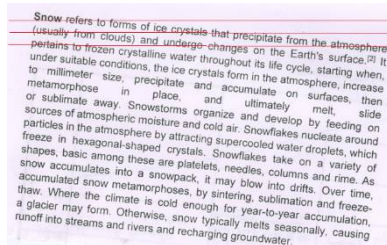
(c) Cross Correlation



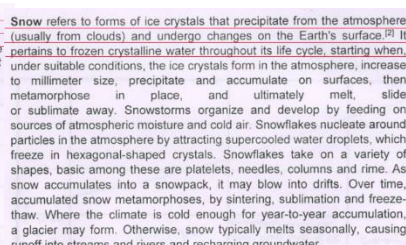
(d) K-Nearest Neighbor



(e) Fast fourier transform



(u) Angle  $75^{\circ} - 345^{\circ}$



(v) Angle  $90^{\circ} - 360^{\circ}$

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Table 1 Performance Measure using SSIM

Input images	SSIM			
	Hough Transform	Cross Correlation	K-Nearest Neighbour	Fast Fourier Transform
Image1	21.6	21.62	19.19	29.69
Image2	29.09	32.22	26.02	34.9
Image3	24.51	27.82	18.38	37.9
Image4	22.31	21.64	20.31	21.13
Image5	18.68	17.83	17.98	24.71
Image6	23.76	24.12	23.62	26.74



Figure 1 Performance Measure using SSIM

Table 2 Performance Measure using PSNR

Input images	PSNR			
	Hough Transform	Cross Correlation	K-Nearest Neighbour	Fast Fourier Transform
Image1	23.14	23.62	21.46	30.05
Image2	31.55	35.23	28.03	36.23
Image3	26.08	29.84	23.25	39.33
Image4	23.25	24.47	22.07	24.89
Image5	20.81	20.63	19.93	26.73
Image6	25.53	31.45	24.12	37.17

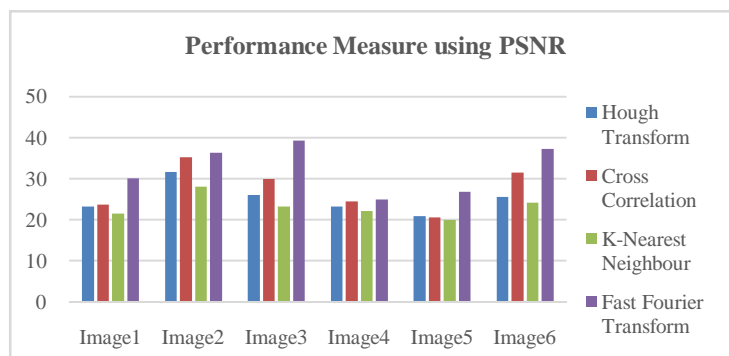


Figure 2 Performance Measure using PSNR



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Table 3 Execution Time in Milli Seconds

Input images	Execution Time (Milli Seconds)			
	Hough Transform	Cross Correlation	K-Nearest Neighbour	Fast Fourier Transform
Image1	1189	2307	417	221
Image2	547	1145	643	419
Image3	265	375	418	255
Image4	167	117	218	113
Image5	215	165	307	163
Image6	3375	1378	2070	1359

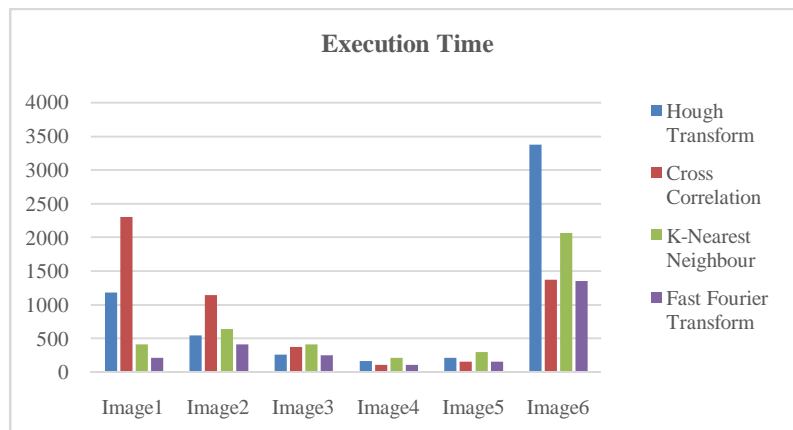


Figure 3 Execution Time for Existing Algorithms

## VI. CONCLUSION

Digitized document is suffers from some level of skew or gradient. After skew correction is done successfully then the character segmentation of the word will be more perfect and as a consequence the percentage of the correct word recognition will be higher. In this paper discussed three types of document skew and also discussed and compared various skew detection and correction techniques. They are Hough Transformation, Cross Correlation, K- Nearest Neighbour Clustering and Fast Fourier transformation. The performance of the skew detection and correction techniques are analysed and compared. It has been observed that the Fast Fourier transform technique correct the skew in the document image and it have produced higher accuracy and less execution time compared with other techniques.

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