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Skew correction for mushaf Al-Quran: a review

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ABSTRACT

Skew correction has been studied a lot recently. However, the content of skew correction in these studies is considered less for Arabic scripts compared to other languages. Different scripts of Arabic language are used by people. Mushaf A-Quran is the book of Allah swt and used by many people around the world. Therefore, skew correction of the pages in Mushaf Al-Quran need to be studied carefully. However, during the process of scanning the pages of Mushaf Al-Quran and due to some other factors, skewed images are produced which will affect the holiness of the Mushaf Al-Quran. However, a major difficulty is the process of detecting the skew and correcting it within the page. Therefore, this paper aims to view the most used skew correction techniques for different scripts as cited in the literature. The findings can be used as a basis for researchers who are interested in image processing, image analysis, and computer vision.

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1. INTRODUCTION

Document Image processing is the method that used to apply some operations on an image in order to extract specific information. There are various applications in real life that implement the concept of image processing. A huge amount of information is paper-based; thus, there is a need for better storage that guarantees data are well stored and to convert that information into an electronic format. Mushaf Al-Quran can be in two different form (digital- printed). In addition, the way Mushaf Al-Quran is written is different comparing to the other Arabic/Jawi based image document because it has additional characters called "diacritics". The problems that happen through the process of converting paper-based documents to an electronic document format using OCR systems are some factors that can have negative effects on the printed documents. These factors can be due to the weakness of the computer system, the printing devices and human errors, thus some of the scanned papers are skewed and rotated as shown in Figure 1. Skew detection and correction have been studied recently for different handwritten languages such as Urdu, English, and Tamil. In fact, skew correction for Mushaf Al-Quran must be studied carefully because it is a very case sensitive book as it is the book of Allah swt and written with "diacritics"; therefore, any incorrect step in the processes will have a bad impact on the holiness of the Mushaf Al-Quran.

This paper aims to review a few of the techniques that are proposed by other researchers for the skew detection and correction on the document image.

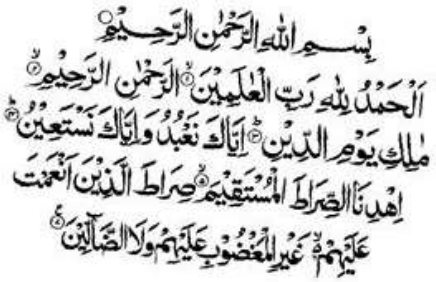

Figure 1. Al-Quran Surah Al-Fatiha image with skewed angle 5

2. BACKGROUND

Mushaf Al-Quran has different printed versions based on the size of the pages, handwriting styles, arts inside each page of Mushaf Al-Quran, page numbers, and lines in each page. Skew detection and correction are important steps in image analysis and OCR. Optical character recognition system consists of two stages; the first is preprocessing which includes noise removal, binarisation, skew detection and correction, page analysis, and segmentation, and the second is recognition which includes feature extraction and classification. Many techniques and algorithms are proposed by researchers for the skew detection of the skewed images. In [1] Skewness in the images can be grouped into three types as shown in Figure 2.

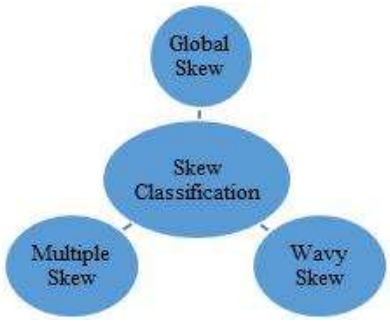

Figure 2. Skew classification [1]

Skew correction process for Mushaf Al-Quran is discussed in order to estimate the skewed text. Normal printed documents with a text has a skew angle of zero. Since document analysis algorithms in some systems such as OCR usually assume zero skewed pages, skew correction are important steps in the preprocessing stage. However, skew correction is performed on the document after scanning the document and before it appears on the computer screen. Arabic/Jawi based skew correction processes have been proposed by [2]. However, the step to detect the skew of pages or lines for the Mushaf Al-Quran cannot be the same as Arabic/Jawi documents. This is because Mushaf Al-Quran contains diacritics (Tashkil) that do not exist in Arabic/Jawi handwritten documents.

3. RELATED WORK

3.1. Binarisation

A number of studies regarding binarisation techniques are reviewed in this paper. Binarisation is required in the first place before detecting the skew it because it is usually performed in the preprocessing stage for converting the gray-scale image into a binary image form which can facilitate other tasks that can be made on an image document such as skew detection and correction. In [3] an improvement of binarization technique for binarizing degraded Jawi ancient document using Wiener filtering for background estimation, image contrast adjustment, and local Otsu thresholding to extract the text from the background and spot noise removal.

According to [4], the binary image is the image which has two values for every pixel; the two colours feasible for the image in a binary format are black and white. The objects in the image could be represented as the foreground colour and the rest of the image could be represented as the background colour.

In [5] Otsu's thresholding algorithm was used to compute threshold from the grayscale image and to finally recognize the Arabic character. In [6] smart binarisation technique of the image was tested on different degradations of document. In [7], the term binarisation can be the first stage in all the systems of the document analysis. Furthermore, once there is a document that is not clear enough, one of the binarisation methods must be applied to get the relevant information. There are some systems such as OCR word spotting and indexation which are used to recognise all characters on the document. Most of the mentioned systems are used to decrease the quantity of the information present in the document and focus more on the information or the data in need. In addition, the performance of the document analysis systems such as OCR depends on the algorithm of the binarisation, which means that the binarisation must be performed as accurately as possible [7]. In addition, the evaluation was tested on twelve binarisation algorithms for different old Arabic scripts. Binarisation for the gray-level documents can be classified into two groups which are global thresholding and local thresholding. For the global thresholding, one thresholding is used in the entire image in order to separate it into two classes which are text and background. On the other hand, for local thresholding, the threshold values are located locally as pixel by pixel or region by region. In [8] evaluation of binarisation techniques is presented. The evaluation was tested on a set of gray-level handwritten and machine printed images. The binarisation techniques were used for the testing as follows: (1) Otsu's method, (2) Bernsen's method, (3) Niblack's method, (4) Sauvola's method, (5) Adaptive Logical method, (6) Adaptive Degraded Document method. [9] Proposed a framework that was used in order to produce better performance of the binarisation techniques combination. The framework separates the input image pixels to three groups namely as foreground pixels, background pixels, uncertain pixels. The separation of the pixels is based on the binary outcomes of the given document binarisation methods. In addition, classifier was applied in order to categorize the uncertain pixels into foreground and background. In [5] Arabic word recognition system is proposed for the off-line text, the proposed system can be used for extracting Arabic character with high level of accuracy by processing the character with binarization and noise removal.

3.2. Skew Correction Techniques for Handwritten Scripts

Many studies regard the techniques that are used by some researchers in the preprocessing stage. Moreover, these techniques are used in order to first detect the skewness that might be in the scanned document due to some other factors, and then make the correction of that skew. Many researches had been published for estimating the skew angle of the documents using some techniques. [12] Grouped the most used techniques for skew detection as Projection Profile Analysis, Hough Transform, and Nearest Neighbour.

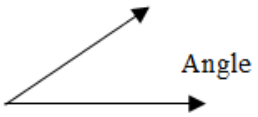

Figure 3. Basic skew angle [10]

Skew angle that is found in between the two lines as in Figure 3. In general, documents in the normal form have the skew angle of zero. However, while scanning the documents and due to some other factors, a skew angle that is greater than zero comes up. Skew detection and correction are required in this case. Moreover, skew detection takes place in the preprocessing step. Several methods or techniques have been used to detect the skew and correct it. In [11] three groups of skew detection namely as project profile, Hough transform, and nearest neighbour clustering. [13] Evaluation for the most used skew detection techniques namely as (1) Projection Profile Analysis Technique (2) Hough Transform Technique (3) Nearest Neighbour Technique.

The evaluation result stated nearest neighbour technique was the fastest technique among them with the respect of speed, but its accuracy estimation evaluation was poor compared to other techniques. Projection profile technique considered as the best angle estimation with the respect of accuracy, but its process time was the longest. In [12] a novel skew detection approach is proposed. The aim of the approach is to enhance quality and accuracies of optical character recognition systems. The proposed approach consists of four stages named as (1) Detect lines in Region of Interest (RoI), (2) Find angles of detected lines, (3) Find the exact skew angle from detected lines, (4) De-skewed image and rotate the image. The proposed skew correction approach focuses on two stages firstly find the angles of the lines in the image with respect to the

x-axis and secondly find the exact skew angle from the angles using the detected lines. These two stages are very important for detecting the skew in the scanned documents as there are many lines which can be detected besides the exact lines in the scanned documents. However, the exact lines detected are the ones responsible for measuring the skew angle, therefore, once exact lines are detected, it is easy to find the skew angle. Therefore, the novelty in this approach comes from the ability to differentiate between the exact lines and the false lines by grouping all detected lines in clusters. Then, the lines that are going parallel are selected in one cluster and finally, the line which has the maximum length is taken for the skew detection measurement.

3.3. Classification of Skew Correction Techniques

Based on literature review, a summary for all the techniques that might be used for skew correction as in Figure 4.

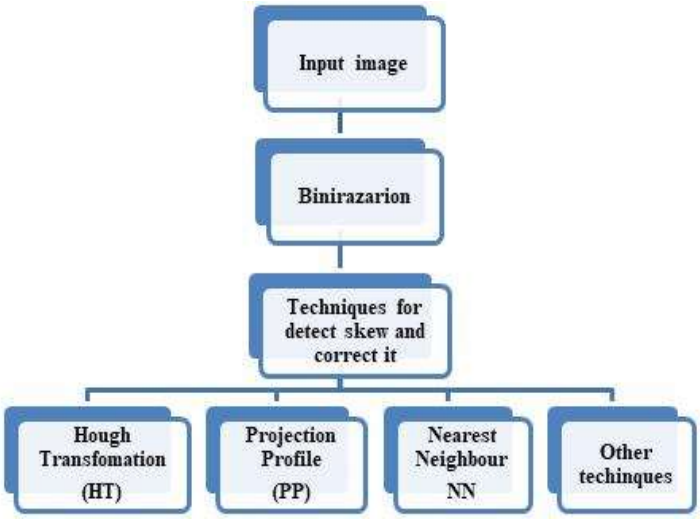

Figure 4. Classification of skew detection and correction techniques

3.3.1 Projection Profile Analysis (PP)

Projection profile techniques was proposed by Postl [13] in 1986. It is considered as one of the most used methods for detecting the skew of the image documents and correct it. The term projection in this method means the way in which the binary image form is converted into a one-dimensional array called projection profile. Moreover, the number of lines located in the document image can be called as the horizontal projection profile, where each line of these lines in the projection profile form consists of values that represent the number of the black pixels for the row line of the document image. In [14] projection profile is one of the most famous methods for skew detection and correction with the use of horizontal projection profile of the skewed document image as most of document images consist of horizontal lines and each of these lines is the sum of pixels as mentioned. In [15] a method was proposed based on projection profile analysis. The proposed method in this paper combined Fast Fourier Transform (FTT) with the projection profiles method in order to eliminate the skew in the document image; projection profile analysis was applied in order to estimate the skew of the fabric image, FTT method was then applied in order to get the power spectrum which helped to extract the peaks of projection profile analysis from the vertical and horizontal directions and finally, the fabric image was reconstructed based on the peaks. In [10] a proposed method for skew correction of Mushaf Al-Quran images was proposed. Moreover, the proposed method implements Hough Transform method for detecting skew lines and correct them. In [16] a new algorithm based on the projection profile for skew estimation was presented. This algorithm worked along with fiducial points by extracting them and decoding the lowest resolution layer of a JBIG compressed image. The presented algorithm works for estimating the skew detection by three functions, namely, fiducial reduction function represented by the letter (F) which is responsible for reducing the desired image source into a set of triples (x; y; w), projection profile function represented by the letter (P), in which this function projects the given fiducial points from the previous function into an accumulator array, and the last function is optimization function which is responsible for calculating the skew angle. In [17] a comparison was made

between horizontal and vertical projection profile analysis for the skew correction, and the comparison included the difference and similarities between the two methods as shown in Table 1.

Table 1. Comparison between Horizontal Projection Profile and Vertical Projection Profile

Comparison	Horizontal projection profile analysis	Vertical projection profile analysis
Similarities	Both approaches are computationally expensive compared to others for skew detection and correction for diffident angle ranges. Both are in the range of between ±10° to 15°. Accuracy for both method is affected by resolution of the projection profile. Disability in controlling noisy documents and broken characters.	
Difference	The document image is scanned in the way of row-wise form. Error is produced because of the noise effect that comes from the multiple peaks. Time complexity for this algorithm is less. The angle obtained by using this algorithm is -6.	The document is scanned in the way of column-wise form. Error is reduced because of the single peak value. Time complexity for this algorithm is high. The angle obtained by using this algorithm is -8.

3.3.2 Hough Transform (HT)

[18] produced this method first, and then in 1952, Paul Hough generalised the idea more in his research titled "Machine Analysis of bubble chamber pictures". After that, many researchers applied this method in their research. In [19] applying HT to detect arbitrary shapes and Illingworth in 1988 used the same method to detect the skew angle of the pages. In HT method each point in the Cartesian space (x, y) is mapped to a sinusoidal curve in ρ- θ Hough space using transform function or the equation:

$$p = xcos\theta + ysin\theta \quad (1)$$

In [20] a Hough transform based skew correction system was presented and the system consists of three phases, namely, preprocessing phase to preprocess the input image and decrease the number of pixels in, processing phase which applies Hough transform in order to detect the skew in the document image, and skew correction phase which is responsible for the skew rotation. In [20], the two issues of using Hough transform method are slow in speed and uses a lot of space for memory. In [21] a fast approach was used to correct the skew angle with the use of Hough transform method. The goal of this approach is to increase the speed of detecting the skew angle as well as the process of correcting it with the use of Hough transform method. In [22], an approach based on Hough transform was used to extract the text lines in handwritten documents using iterative hypothesis-validation strategy.. In [23] Hough transform algorithm was proposed to reduce the data in the image by the computation of the horizontal and the vertical black run-lengths. Then, a gray-scale image was created from the run-lengths form which helped to speed up the computation process of Hough transform. The Hough transform method was applied to either the vertical gray-scale image or the horizontal gray-scale image to detect the skew angle. In [24], the Hough transform method was used for analysis of images of printed pages since it can detect the straight lines in the textual images and based on the given analysis of the textual image, the skew detection and other applications can be done.

3.3.3 Nearest Neighbour (NN)

Nearest Neighbour method is one of the methods used for skew detection and correction of the document image. In [1] NN was considered as a base that was used to find the connected components located in the document image, then, histogram was used to find the direction of vectors of all the nearest neighbours for each component in the document image. The skew angle was also computed using a histogram. [25] first proposed the nearest neighbour method which consists of four parts, namely, (1) create a matrix that includes all the component attributes, (2) create a proximity tree which is used to show the distance between components, (3) produce a direction histogram, and (4) analyse the histogram output of the document image. The proposed method was used to detect the skew of a set of aligned components in the document image. However, the nearest neighbour method was generalised later on in [11] by the use of K value for each connected component. The K value uses the nearest neighbour for the text lines with the use of the histogram. In [26], a method was proposed with the use of the nearest neighbour method for estimating the skew angle of the document image and this method can be used for any feature points to find the page orientation of the document images. Moreover, the proposed method in [J] concentrated the clustering process to a subset of

plausible candidates from all nearest neighbours which can be helpful in estimating the local skew angle in the document image by fitting the least-square line on these plausible neighbours. The skew angle connected to the computed straight line was used to build up a histogram. In [27], there was an improvement made of the nearest neighbour based approach in order to improve the way of estimating the skew angle of the document image. The improvement was done by introducing the size restriction for the detection of the nearest neighbour pairs, followed by selecting the chains with the largest possible number of the nearest neighbour pairs and their slopes were calculated in order to produce the skew angle that was located in the document image. Skew detection and correction techniques summarization as shown in Table 2.

Table 2. Skew Detection and Correction Techniques Summarization

Ref.	Year	Method	Dataset	Findings
[28]	2007	A method presented for skew angle detection based on linear regression analysis and wavelet with skew angle between 0°-180°.	Printed documents.	A fast and robust method was introduced for skew detection for printed documents which dealt with skew angle in the range of 0°-180°; compared to the methods that are based on Hough transform, the time consumed was less and this method was considered as a fast method with an accuracy of 77.33% for estimating the skew angle with an error of ±1°.
[29]	2009	A novel method for skew correction of Arabic documents based on the center of gravity.	Multiple skewed documents.	The proposed method produced 87% of accuracy in detecting the skew and correcting it for different documents with less computing time.
[30]	2002	A method for detecting the skew and slant and correcting it for Jawi images with the use of gradient orientation histogram.	Jawi text images.	A simple and fast method was proposed for the Jawi text images with the use of gradient orientation histogram. The same algorithm can also be used for detecting the slant angle of letters in the text line. It produced 78% accuracy in performance.
[32]	2018	Hough Transform method for skew detection and correction of the documents images that has skew lines.	Quran images pages	It was tested on a set of different printed Mushaf Al-Quran image documents. It works for different version of Mushaf Al- Quran image pages which has skewed text zones. Moreover, it can detect and correct the skew angle in the range between 20 degrees. Experiment conducted on different Mushaf Al-Quran image pages shows the accuracy of the method.
[12]	2016	a novel approach for skew detection and correction in scanned documents, it was based on the heuristic that text lines in a documents are always parallel to each other.	Arabic script documents	Results show that the overall success rate is 98.8%, and the average time taken by our method to de-skew an image is 0.78 second.
[33]	2019	A method is presented for binarization of historical documents using the learning concept.	Handwritten documents dataset HDIBCO2014, DIBCO2012 and DIBCO2016	The experimental results demonstrated that RGB values and grey level values could be used as a descriptor for a particular pixel and the F-measure and NRM values were found to be better when using grey level values compared to RGB.

4. CONCLUSION

In this paper, the most popular methods that are used for estimating the skew angles of document images were presented. Furthermore, the main aim of this paper is to review the most used techniques in image analysis. The presented methods include projection profiles, Hough transform and nearest neighbour methods as well as some other base methods used for detecting the skew angle for different document scripts. Literature included some of binarization techniques as well. However, among the different techniques used to skew detection and correction, nearest neighbour method can be considered as the one of the best among them.

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