Skew Angle Detection and Correction using Radon Transform

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Abstract: In this paper, skew estimation and correction method for document image has been presented. Image of text document can be acquired via camera or other type of machines which cause sometime a skew angle (alignment) on its horizontal direction. To find skew angle of document image, the Radon transform method is used here. The skew angle used in database within the range of ±90° w.r.t x-axis.

Kew words: Skew estimation, Radon transform, Skew correction

1. INTRODUCTION
This paper analyzes a novel method for detecting the skew angle based on the Radon transform, which is briefly discussed. The methods presented here are appropriate for small angle rotations, in the interval degrees [-90,+90]. Larger imperfections should be treated through other means. A skew detection algorithm analyzes the digital image of a document and determines the angle of rotation with respect to x-axis.

A simple solution for skew detection was to determine the location of at least two corners of the original document and compute the skew angle from the point. However, this can be error-prone because of non-linear distortions that occur when document were not on flat surface during capturing. Also, the entire scan surface may be obscured by the input document or the input may itself have been produced from a skewed original. In either case, deriving the skew angle from the corners or edges of the page is problematic.

Here a skew detection algorithm derives the skew angle for a document image is presented. Techniques described uses Radon transform. The general characteristics of this technique are discussed and examples of how they are applied to skew detection are presented.

In the following sections, related work is expressed in section 2. Section 3 describes the proposed approach and the results are presented in section 4. Finally, section 5 contains the conclusions.

2. RELATED WORK
To deskew the document, numbers of techniques were used. For accurate detection of skew angle many techniques are available like Radon transform method, wavelet and Radon transform method[5], Vertical projection method[11], Projective transform method[6], Hough transform method[8] and centre of gravity method[4]. As Radon transform method gives high accuracy with less processing time, it is selected for accurate detection of skew angle.

3. PROPOSED METHOD
Skew angle Detection and correction using Radon Transform
Radon transform is a mapping of Cartesian coordinates to a distance and angle (s,θ) coordinates. The radon function computes projections of an image matrix along specified directions. A projection of a two-dimensional function f(m,n) is a set of line integrals. The radon function computes the line integrals from multiple sources along parallel paths, or beams, in a certain direction. The beams are spaced one pixel unit apart. To represent an image, the radon function takes multiple, parallel-beam projections of the image from different angles by rotating the source around the center of the image[1].

Figure 3.1: Schematic illustration of Radon transform[14]
Fig. 3.1 shows the 1D projection \( g(s, \theta) \) of the 2D function \( f(m,n) \). Where the X-ray beams are passing through the object \( f(m,n) \). When the beam pass through the object, then number of photons are absorb by the object and that number is projected in the polar Cartesian system \( (s, \theta) \) at angle \( \theta \) to the horizontal axis \( m \) as shown in above figure.

Definition of Radon transform is as below.

\[
g(s, \theta) = \int_{-\infty}^{\infty} f(m, n) \delta(m \cos \theta + n \sin \theta - s) \, dm \, dn \tag{3.1}
\]

Where, \(-\infty < s < \infty\) and \(0 \leq \theta < \pi\)

\[
g(s, \theta) = \int_{0}^{\theta} f(s \cos \theta - u \sin \theta, s \sin \theta + u \cos \theta) \, du \tag{3.2}
\]

Here, \( s = \) perpendicular distance between two parallel beams
\( \theta = \) angle between horizontal axis \( m \) and \( s \)
\( u = \) vector in direction of X-rays
\( f(m,n) = \) 2D object in Cartesian coordinate system \( (m,n) \)
\( g(s, \theta) = \) Radon transform of \( f(m,n) \) in polar coordinate system \( (s, \theta) \)

This equation is also known as Radon transform. And the projected data from Radon transform is often called a sinogram.

**Algorithm for Skew Detection**

The document images were used for an implementation, having different skew angles ranging from 0 to 90 degree w.r.t x-axis. the algorithm used for skew angle detection is as follows.

**Step 1:** Binarize the input image and apply morphological filling operation.

**Step 2:** Detection of edges using canny edge detector.

Edge detection is the process of finding meaningful transitions in an image. Typically at the border between different objects sharp changes in the brightness occur[13].

**Step 3:** Apply Radon transform on the output obtain from pervious step

**Step 4:** Search for maximum value in Radon transform co-efficients.

**Step 5:** Find value of theta for maximum intensity calculated in step 4.

**Step 6:** The detected skew angle was found using Eq. 3.5.

\[
\theta = \begin{cases} \text{theta, } \theta \leq 90^\circ \\ \theta - 180^\circ, \text{ Otherwise} \end{cases} \tag{3.3}
\]

**Step 7:** Rotate original image with skew angle.

**4. RESULTS AND DISCUSSION**

Skew Angle Detection and Correction:

![Figure 4.1: Image with skew angle](image)

1. Binarize the input image (Fig. 4.1) and apply morphological filling operation. Morphological filling operation using was used for document region detection operation.
Morphological filling:
\[ X_k = (X_{k-1} \oplus B) \cap A^c, \quad k = 1, 2, 3, \ldots \]
After applying this to above image (Fig. 4.1), we got the resultant image as shown in Fig. 4.2

2. For detection of skew angle, first the boundary pixels of an object were detected using an edge detection operation.
The result of applying canny edge detector is shown in Fig.4.3

3. Apply Radon transform on the output of previous step using Eq. 3.2.
4. The skew angle corresponding to maximum radon co-efficient was found for the given image as \( \theta = 13^\circ \).
5. Calculate the skew angle using Eq. 3.3.
6. Correct the object using skew angle detected in previous step. The resultant image is shown in Fig. 4.4
In Fig. 4.5, input image is black and white rectangle image. Which have left side skew angle of 5º. So the algorithm for skew detection and correction is applied on input image so output i.e deskewed image will be as shown in Fig. 4.5.

In Fig. 4.6, input image is black and white rectangle image. Which have left side skew angle of 61º. So the algorithm for skew detection and correction is applied on input image so output i.e deskewed image will be as shown in Fig. 4.6.

We have seen simulation results for rectangle images. Now we are having different shape. In Fig. 4.7, input image is black and white oval image. Which have left side skew angle of 30º. So the algorithm for skew detection and correction is applied on input image so output i.e deskewed image will be as shown in Fig. 4.7.
In Fig. 4.8, input image is black and white rectangle image. Which have right side skew angle of -25º. So the algorithm for skew detection and correction is applied on input image so output i.e deskewed image will be as shown in Fig. 4.8.

We have seen simulation results for rectangle images. Now we are having different shape. In Fig. 4.9, input image is black and white oval image. Which have right side skew angle of -30º. So the algorithm for skew detection and correction is applied on input image so output i.e deskewed image will be as shown in Fig. 4.9.

5. CONCLUSION
For improving OCR accuracy, the skew detection and skew correction was applied. Here Radon transform method is used to detect the skew angle because it has less processing time and also it gives accurate result.

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