ROTATION INVARIANT IMAGE REGISTRATION WITH RADON TRANSFORM

Shehan Fernando[1], Thilan Cooray[2]

[1] Faculty of Engineering, University of Moratuwa, Sri Lanka, Email: shehan117@gmail.com
[2] Department of Mechatronics, Faculty of Engineering, South Asian Institute of Technology and Medicine (SAITM), Sri Lanka. Email: thilan.cooray@gmail.com

ABSTRACT

This paper presents a methodology for rotation invariant image registration technique using Radon transform. Image based operations such as desktop scanning is performed in a domain which is vulnerable mainly to geometric attacks such as rotation. For this task we have employed radon transformation to correct any image rotation which can be either clockwise or counter clockwise in image scanning. Moreover, this method utilizes image processing techniques such Canny edge detection and morphological operations on binary images, such as thickening. The experimental results prove the effectiveness of the algorithm for correcting the amount of rotation.

***Key words*:** Edge detection, Radon transform, Morphological Operations

1. INTRODUCTION

Feature extraction is a crucial step in invariant pattern recognition criteria. Good features or prominent features must satisfy the following requirements [1]: First the intraclass variance must be small and interclass separation should be large. Features should be independent of various parameters such as size, orientation, and location of the pattern, which means the features, should be scale, rotation, and translation invariant. The translation invariance can be achieved by moving the centroid of the data pattern to the center of the pattern image. Also, the scale invariance can be done by scaling the pattern to a predefined image size. To achieve a rotation-invariant descriptor Tsai et al. [2] has proposed a wavelet decomposition approach for rotation-invariant template matching. In this method, an image will be decomposed into different multi-resolution levels in the wavelet-transformed domain [3], and used only the pixels with high wavelet coefficients in the decomposed detail image at a lower resolution level to compute the normalized correlation between two corresponding patterns [4].

Lahajnar et al. [5] first obtained energy-normalized features using Gabor and Gaussian filters, and then the rotation invariance is achieved by the Fourier expansion of these features with respect to orientation. Arivazhagan et al. [6] presented a new approach for rotation invariant texture classification using Gabor wavelets.

Those methods are quite effective in extracting rotation-invariant features, however, most of them have the shortcoming in the way the number of features is limited, which will decrease the correction accuracy. The Radon transform (RT) is an alternative representation that allows one to derive more number of features from an image.

In this paper, we employ the approach of Radon transform and it's property of rotational invariance in order to correct small rotational errors caused during image scanning.

The paper is organized as follows. Section 2 briefly explains the methodology. Section 3 deals with the experimental results obtained, Section 4 presents the conclusion.

2. METHODOLOGY

A. Overview

The Fig. 1 shows the basic functions used in the system. The color to gray image transformation, edge detection with Canny method, edge linking through morphological operations and Radon transformation.

B. Radon Transform

Radon transform forming a very important mathematical tool and is based upon works of Johann Radon. His doctoral thesis has been defended in Vienna in 1910 and his most appreciated works were devoted to integral geometry. The Radon transform belonging to this category introduced in 1917 is defined as a collection of 1D projections around an object at angle intervals θ. The Radon transform of a two-dimensional (2-D) function or image function $f(x, y)$ is denoted by $R(\theta, r)$, which is defined as follows;

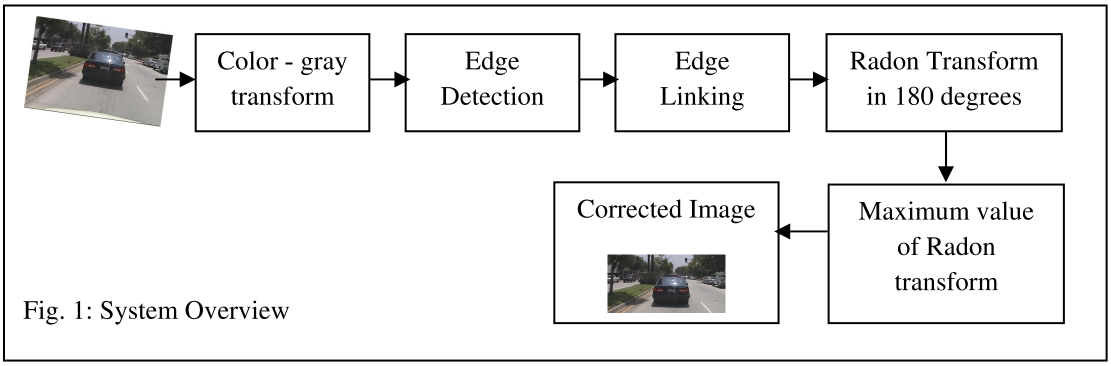

Fig. 1: System Overview

$$R(\theta, r) = \Re\{f(x, y)\} = \iint f(x, y)\delta(r - x\cos\theta - y\sin\theta)dxdy \quad (1)$$

Where $\delta(.)$ is the Dirac function. We can image RT as the line integrals from multiple sources along parallel paths called beams as shown in Fig 2, where $\theta \in [0, \pi)$ denoting the angle between the beam and x-axis. $r \in (-\infty, \infty)$ is the perpendicular distance from the beam crossing the origin.

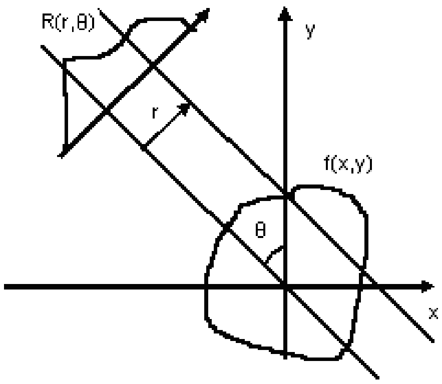

Fig.2: Geometric illustration of RT

C. Some properties of RT

The first advantage of RT is its robustness to zero mean white noise. Suppose an image is represented by,

$$g(x, y) = f(x, y) + \sigma \times \varepsilon(x, y) \quad (2)$$

Where $\varepsilon(x, y)$ is the white noise with zero mean and unit variance of noise. Then it's RT is,

$$\Re\{g(x, y)\} = \Re\{f(x, y)\} + \sigma \times \Re\{\varepsilon(x, y)\} \quad (3)$$

For the continuous case, the line integral of the RT of white noise is constant for all of the points

and all the directions, and the result is equal to its mean value which is assumed to zero. Therefore,

$$\Re\{g(x, y)\} = \Re\{f(x, y)\} \quad (4)$$

The second advantage is that it is rotation invariant. RT of the rotation of $f(x, y)$ by angle φ leads to a circular shift of the RT of original $f(x, y)$, in the variable θ,

$$\Re\{f(x, y)\} = R(\theta, r) \Rightarrow \Re\{f_\varphi(x, y)\} = R(\theta + \varphi, r) \quad (5)$$

Here, $f_\varphi(x, y)$ denotes the rotation of $f(x, y)$ by angle φ, and $R(\theta + \varphi, r)$ denotes the circularly shift by angle φ along the θ dimension.

D. Edge Detection

Edges characterize boundaries and are therefore a problem of fundamental importance in digital image processing. Edges in images are areas with strong intensity contrasts, a change in intensity from one pixel to the next. Edge detecting of an image significantly reduces the amount of data to be processed and filters out useless information, while preserving the important structural properties in an image. Several algorithms exists, and in this project we are only focusing on a particular one developed by John F. Canny (JFC) in 1986. Even though it is quite old, it has become one of the standard edge detection methods and it is still used in research.

E. Morphological Operations

Thickening is a morphological operation that is used to grow selected regions of foreground pixels in binary images. It has several applications, including determining the approximate convex hull of a shape, and determining the skeleton by zone of influence. Thickening is normally only applied to binary images, and it produces another binary image as output. A thickening operation is related to hit-and-miss transform. If I be an image and J is the

(a) Clockwise Rotated Image

(b) Corrected Image

(c) Anti-clockwise Rotated Image

(d) Corrected Image

structuring element, then the thickening operation can be written as,

$$thicken(I, J) = I \cup hit\_and\_miss(I, J) \qquad (6)$$

Thus the thickened image consists of the original image plus any additional foreground pixels switched on by the hit-and-miss transform. This operation was used as a edge linking method after detection of edges.

3. EXPERIMENTAL RESULTS

A. Setup

The system was developed using a low cost video capturing device, where matlab image processing toolbox was used to develop the software system.

B. Results

Fig. 3 shows the results for obtaining corrected images of rotated images.

4. CLUSION and DISCUSSION

In this paper an image rotation correction method was presented where the image can be rotated either clockwise or anti-clockwise. This method was implemented as a method to correct any rotations resulting from desktop scanners.

5. REFERENCES

[1]Du-Ming Tsai, Cheng-Huei Chiang, "Rotation-invariant pattern matching using wavelet decomposition," Pattern Recognition Letters, Vol. 23, No. 1-3, pp. 191-201, 2002.

[2]Du-Ming Tsai, Cheng-Huei Chiang, "Rotation-invariant pattern matching using wavelet decomposition," Pattern Recognition Letters, Vol. 23, No. 1-3, pp. 191-201, 2002.

[3] LOWE, D. G. 1999. Object recognition from local scale-invariant features. In International Conference on Computer Vision

[4]Matlab Image Processing Toolbox

[5]Franci Lahajnar, Stanislav Kovacic, "Rotation-invariant texture classification," Pattern Recognition Letters, Vol. 24, No. 9-10, pp. 1151-1161, 2003.

[6] S. Arivazhagan, L. Ganesan, S. Padam Priyal, "Texture classification using Gabor wavelets based rotation invariant features," Pattern Recognition Letters, Vol. 27, No. 16, pp. 1976-1982, 2006.