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Application of Radon Transform for Scaling and Rotation estimation of a digital image

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Abstract—In the field of digital image processing, it is often very necessary to determine the amount of scaling and rotation between two images of the same object or thing. Such situations may be registration of images in remote sensing, medical field, quality control and so many. The paper describes the use of Radon transform for extracting rotation and scaling of such images. The method utilizes the active contour and level set method for feature extraction task as a first part and then radon transform determines the scaling and rotation of the image. The results are discussed with first reference and second sensed image of the same object. The results are most accurate as long as the features in both the images are extracted properly.

***Keywords-** Feature extraction, Radon transform, region filing, rotation, scaling.*

I. INTRODUCTION

The field of digital image processing is very diverse and finds many applications in remote sensing, medical diagnostics and so many. The field has evolved in various sub-areas, such as image de-noising, image compression, image registration, image segmentation [1][2][3], video processing etc. This paper emphasizes most critical process which may be required in above sub-fields. In most of the image processing tasks where it is required to compare two images of the same object for drawing conclusions, it is necessary to determine amount of scaling and rotation between two images of the same object or thing. In this paper, I have used Radon transform [7] for extracting rotation and scaling of such images. Radon transform has special projection properties which are very much helpful in determining the scaling and rotation of an image. [7][8]. First of all, two images of one object, one as a reference image and other as a sensed image, are considered. Then same kinds of three identical features in both the images are identified and segmented using active contour method with level set. [4][5][6]. These extracted features work as control points for the further processing. The triangles are formed by connecting those control points for both the images. Then radon transform is applied on both the triangles separately between 1-360 degrees and it returns maximum value of the pixel intensity matrix formed by radon transform. The ratio of both of these maximum values gives the amount of scaling between both the images. However, the rotation is determined by applying radon transform on two lines formed by joining same kinds of two identical control points in both the images. The difference of the respective angles of both the images where radon transform gives maximum intensity is the rotation between both the images.

II. DISCUSSION ON IMPLEMENTATION

The different steps involved in achieving the final result of this proposed method are summarized in the flow chart of Fig.1 below. As shown in the flowchart, three objects are chosen from the first reference image and three identical objects are also selected from the second sensed image of the same scene. These features are close boundary regions and hence they are extracted one by one for reference image using active contour and level set method of segmentation.[4][5]. It basically works on formulation of local energies and sharply detects the close boundary. [6].

Then after, the centroids of these three regions are determined and they are represented by their single point counterparts. They are considered as control points for further processing. Likewise, three control points from the second sensed image are obtained. Then after, a triangle is formed by connecting three control points in the first image. Using region filing technique, the centroid of this triangle is obtained and it is made the centre of the image by shifting the image. Radon transform is applied on this triangle and it returns the radon matrix R. Similarly, matrix R1 is obtained for the second sensed image. Then the ration of maximum value of R and R1 gives the scaling.

To obtain the rotation, a line is formed in reference image by connecting any two control points and similar kind of line is formed in sensed image by connecting the identical two control points. Then the distance between the triangle centroid and the origin of the image is found and reference image is translated by that much amount so that both the image centre and triangle centre coincides with each other.

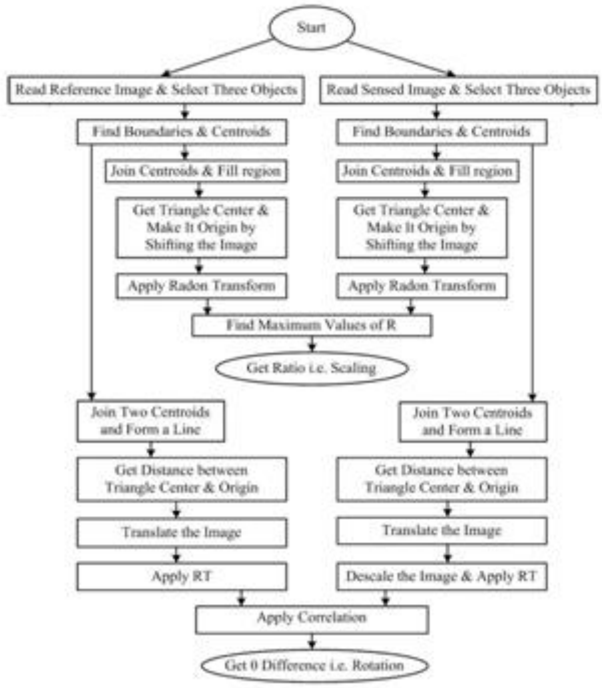


Figure 1 **flowchart for the proposed method.**

This is repeated for the sensed image also and then sensed image is de-scaled by the earlier determined scaling factor. At the end, Radon transform is applied on both the images, which returns the value of angle theta where matrix R gives maximum value. And the difference between these theta values gives the amount of rotation between both these images of the same scene. So cross correlation of both the radon output matrices is taken, which gives maximum value at an angle which is the rotation between both the images.

III. RESULTS OF THE METHOD WITH MATLAB

Here two images of the same building, one as first reference and the other as second sensed image are shown in the Fig.2 below. Here the second sensed image is taken by magnifying the camera and rotating the image in anticlockwise direction. Fig.2 also shows three identical close boundary regions in terms of windows in both images, which will be used as control points in further processing. They are highlighted with pink rectangles.

(a) (b)

Figure 2 **(a) first and (b) second image of same object with identical features.**

The result of active contour and level set method for obtaining control points is shown in Fig.3 below. Here all the three control points in both the image are shown with red circles.

(a) (b)

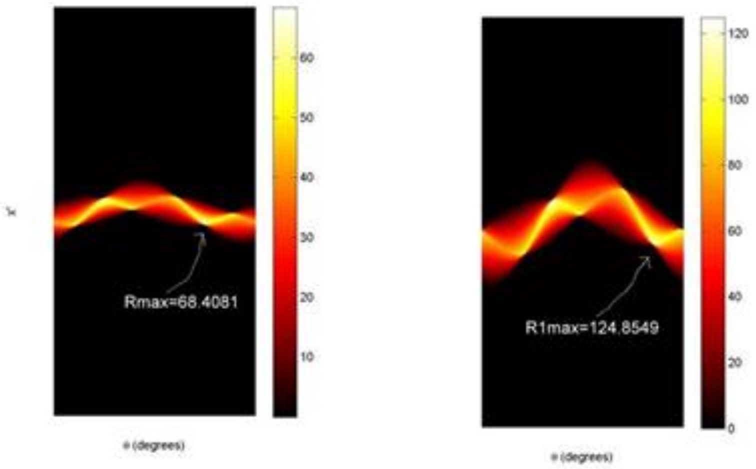
Figure 3 **Control points obtained in (a) first (b) second image.**

The triangle formation and making their centre as the image centre after region feeling is shown in the Fig.4 below. Radon transform is applied on these triangles.

(a) (b)

Figure 4 **(a) first and (b) second image, centered at triangle centre.**

The application of radon transform gives matrix R. Fig.5 below shows the maximum values returned by radon transform graphically. The maximum value is signified with highest intensity of color in the radon output.



(a) (b)

Figure 5 **Radon output for (a) Fig.4 (a) and (b) Fig.4 (b).**

Thus the ratio R1max / Rmax gives us the scaling: 1.8251.

The rotation is determined by forming the lines by joining two control points in both the images and these lines are processed with radon transform. The Fig.6 below shows the lines formed in both the images after centering the image at triangle centre.

(a) (b)

Figure 6 **Lines formed in (a) first and (b) second image with both the images centered at triangle centre.**

The radon transform is applied on these lines and the result of the cross correlation of two radon matrices is shown in the Fig-7 below.

Figure 7 **Cross correlation between two radon outputs obtained from two lines formed in first and second image respectively.**

Here, the difference between the angles gives the value of theta where the cross correlation matrix gives maximum value. Hence it is called rotation. So the second image is rotated 37 degrees in anticlockwise, since the rotation is positive.

IV. CONCLUSION

This method can determine any degree of rotation and satisfactory amount of scaling between two images of the same object. But for that purpose, the features selected in both the images must be such that they must be extracted properly. In other words, the accuracy of segmentation can greatly influence the result of this method.

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