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International Journal Of Engineering And Computer Science ISSN:2319-7242

Volume 4 Issue 2 February 2015, Page No. 10489-10492

Image Registration Techniques: A Review

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***Abstract*- Image Registration is process of aligning two different images of same scene taken at a different time, from different view point, or may be different capturing device. There are various methods have been proposed for image registration processing in last some years. But they are not commonly used in practice because of several drawbacks. The goal of the paper is to review and understand image registration process and its different methods.**

Key words- Image Registration, SIFT, Feature Detection, Feature Matching.

I. INTRODUCTION

Image Registration is a process of aligning two images of the same scene taken at different times, from different viewpoints, and/or different sensors (references and sense images) into a common coordinate system [1].

The present differences between images are introduced due to different imaging conditions. Image registration is a crucial step in all image analysis tasks in which the final information is gained from the combination of various data sources like in change detection, image fusion, and multichannel image restoration. Registration is required in remote sensing, in medical, in computer vision(target localization, automatic quality control) and in cartography (map updating)[2]. Figure 1 shows one example of the image registration of two different images which are taken at the different viewpoints.

Figure 1: Image Registration[2]

II. PROCESS OF IMAGE REGISTRATION

A general process for image registration is mentioned in this section. The block diagram for of this process is shown in Figure 2. Figure 2 shows the steps for general image registration steps. Those steps are given as follows[1]:

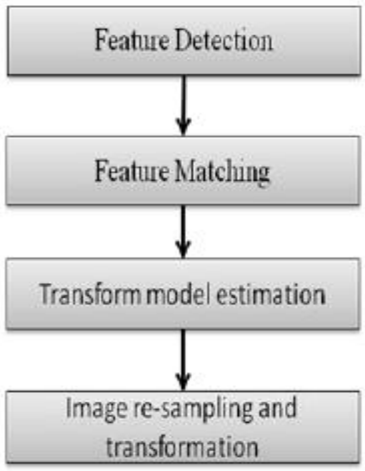

Figure 2: block diagram of image registration process[3]

1) Feature Detection: Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature.
2) Feature matching: In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Various feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose.
3) Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping

functions are computed by means of the established feature correspondence.

4) Image re-sampling and transformation: The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique.

III. METHODS OF IMAGE REGISTRATION[1]

1) Curve methods [2]: Generate sequence of corresponding points to be registered and search for corresponding "open" curves manually, and then registered two-dimensional projection radiographies. Corresponding open curves are matched by searching for the optimal fit of the local curvatures in the two cures.

2) Correlation methods [2]: It is useful for registration of mono modal images. This technique can estimate large translation, scaling, and rotation of images by an extension of phase correlation technique.

3) Steerable Pyramid Transform [5]: It is used for producing multi resolution levels of reference and sensed images.

4) SIFT Algorithm [5, 6]: it is used to extract feature points that can deal with large variation of scale, rotation and illumination between images.

The scale space of an image is defined as a function L (x , y , σ) which is produced from the convolution of a variable-scale Gaussian G(x , y , σ) with an input image I (x , y) :

$$L(x, y, \sigma)*I(x, y)$$

$$G(x, y, \sigma) = \frac{1}{2\Pi\sigma^2} e^{-(x2+y2)/2\sigma 2}$$

For each image sample at this scale L(x, y) the gradient magnitude m(x, y) and orientation θ(x ,y) are precomputed using pixel differences:

m(x, y)=
$$\sqrt{(L(x+1,y)-L(x-1,y))^2+(L(x+1,y)-L(x,y-1))^2}$$

$$(L(x+1,y)-L(x-1,y))$$

$$\theta(x,y) = \tan^{-1}\left(\frac{(L(x,y+1)-L(x,y-1))}{(L(x+1,y)-L(x-1,y))}\right)$$

5) Sobel operator [19]: It ips used for detecting edge from referenced and sensed image as feature points and consist of following 3*3 mask.

-1	-2	-1
0	0	0
1	2	1

gx

-1	0	1
-2	0	2
-1	0	1

gy

The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

The gradient magnitude is given by:

$$|G| = |Gx| + |Gy|$$

6) Canny Edge detector[7]: It is used to detect edge as feature and it consist of following steps:

1) Smoothing image with Gaussian filter;

2) Calculating the gradient magnitude and direction by the finite difference of the first-order partial derivatives:

3) Non-maxima suppression for amplitude of the gradient;

4) Detecting and connecting the edge by double threshold algorithm

7) Harris corner Detector [7,8]: It is used to detect corner from the sensed and reference image as feature point and consist of following steps;
1) For each pixel (x,y) in gray image J, calculate the correlation matrix M.
2) Estimate the comer score of the corresponding pixels.
3) Set the CRF threshold to limit the number of extracted comers.

8) Euclidian Distance [5, 6]: it is used to find feature point pairs (correspondence from feature points of reference image to feature points of sensed image). Euclidian distance between two points P1 and p2 with coordinates (x_1, y_1) and (x_2, y_2) respectively can be given by:

$$ED = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

9) RANSAC Algorithm [5]: it is used to remove false matching pair and consists of following steps.
1) Choose a model.
2) Determine the minimal number of points needed to specify the model.
3) Define a threshold on the inlier count.
4) Fit the model to a randomly selected minimal subset
5) Apply the transformation to the complete set of points and count inliers.

6) If the number of inliers exceeds the threshold, flag the fit as good and stop.

7) Otherwise repeat steps 4 to 6.

There are also other methods available for image registrations like wavelet based methods[9,10], affine transforms[7], soft computing based methods(Artificial neural network, Genetic algorithm, Fuzzy sets)[4].

IV. THE RELEVANCE OF FEATURE BASED IMAGE REGISTRATION

The meaning of feature is point of interest for image processing. Main objective for automatic image registration of satellite images is to obtain accurate set of tie points and then apply the transformation function which is most suitable to the pair of images to be registered[11]. There are many methods that have been used for feature detection for different conditions

In [11] S.Govindarajulu and K.Nihar Kumar Reddy mentioned a robust and efficient method for AIR(Automatic Image Registration) is mentioned which combines image segmentation and SIFT, complemented by an outlier removal stage and PCA(Principle Component Analysis). The performance of this method is evaluated through some measures.

In [12] Hernani Gonçalves, Luis Corte-Real, and Jose A. Gonçalves illustrated a new AIR method based on the combination of image segmentation and SIFT, complemented by a robust procedure of outlier removal. The Landsat and Hyperion images had been used for performance evaluation of the mentioned method. The main benefit of this method is that accurate segmentation of the objects present in the image is not needed. Combination of different techniques in this paper provides a vigorous and precise method for AIR.

In [13] Rachna P. Gajre and Dr. Leena Ragha have compared work done by various authors on image registration of satellite images. From comparison, we can say that these methods including SIFT are time consuming and depend on the size and resolution of the image, which can be overcome further.

In [14] Shiv Bhagwan Ojha and D.V Ravi Kumar illustrated a method for AIR through Histogram based image segmentation. This method is able to estimate the rotation and/or translation between two images. The benefits of this method are: This method is very advantageous to generate accurate rotation and shift of a base image with respect to unregistered image, register base image with unregistered image.

In [15] Mr. D.P.Khunt and Prof. Y.N.Makwana describes one method for image registration using intensity based image registration algorithm and application of image registration. Limitation of this method is that if the difference between two images is very large then it could not be registered properly.

In [16] R.V.Prasad CH and S.Suresh illustrated a way for automatic image registration through histogram-based image segmentation. The mentioned method of image registration in it using enhanced segmentation approach gives accurate results, even in the presence associated with a considerable amount of noise.

In [17] Jianglin Ma, Jonathan Cheung-Wai Chan, and Frank Canters have illustrated a two-step nonrigid automatic registration scheme for multiangle satellite images. They also used techniques like SIFT and NCC for this scheme and this method was tested on the Compact High Resolution Imaging Spectrometer (CHRIS) onboard the Project for On-Board Autonomy (Proba) satellite data.

The mentioned method works well in areas with little difference in topography.

In [18] Bin Fan, Chunlei Huo, Chunhong Pan, and Qingqun Kong mentioned an improved version of the scale-invariant feature transform for optical and SAR(synthetic aperture radar) images. The effectiveness of this method gives with the experiment results in [18]. One disadvantage of this method is that the utilized low distortion constraint restricts its direct use for registering images with large distortion.

V. CONCLUSION

Image registration is a prerequisite step prior to image fusion or image mosaic. It is a fundamental image processing technique and is very useful in integrating information from different sensors, finding changes in images taken at different times, inferring three- dimensional information from stereo images, and recognizing model-based objects. The reference and unregistered images may differ in translation, rotation, and scale and may present distortions. Although many image registration methods have been anticipated in the last few years, but there are several drawbacks which avoid their common use in practice. So a general or new method is required which can overcome those drawbacks.

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