A REVIEW ON MULTIMODALITY IMAGE REGISTRATION USING HYBRID TECHNIQUE

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Abstract: *Image Registration is the process of matching two or more images of the same target at different time, or from different sensors or different perspectives. This paper mainly focuses on Moravec, Harris, SUSAN (Smallest Univalue Segment Assimilating Nucleus) corner detector methods. The non-rigid registration methods like Thin plate and B-spline has also been studied with multimodal images such as CT/MRI/PET. Moreover, a hybrid technique has been discussed which consists of feature detection for detecting feature points and a non-rigid registration method for large image distortion correction.*

Keywords: Image Registration, Corner detection, Non-Rigid registration, Spline method.

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I. INTRODUCTION

Registration is the initial step, before making image fusion. Image registration is the process of matching two or more images of the same target by different time, or from different sensors or different perspectives. Image registration is an essential step in all image analysis tasks in which the final information is gained from the combination of various data sources like in image fusion, change detection, and multichannel image restoration. It has wide range of applications like, clinical diagnosis (cancer detection), radiation therapy, treatment planning, surgical planning and evaluation, fusion of multimodal images etc[1].

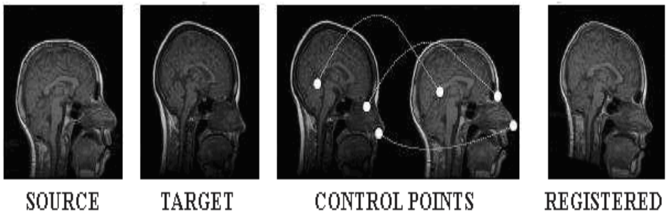

Fig. 1 The Image Registration Process[5]

There are two types of registration methods, rigid and non-rigid registration. To align images from the same subject without any deformations, rigid registration is used where images are considered to be of objects which simply needs to be rotated and translated with respect to another to achieve correspondence. In order to achieve a good match, non-rigid registration is used which is a further extension of rigid registration and it also allows deformations where either through biological differences or image acquisition or both, correspondence between structured in two images cannot be achieved without stretching the images[2].

Wei Yaoguang et.al. proposed a new image registration method which was based on maximum mutual information to find the optimal geometric transformation parameters and the immune optimal algorithm was proposed for it[6]. R.Suganya et.al. proposed an intensity based biomedical image registration by applying maximization of mutual information, to increase accuracy of the registration and reduces the processing time[7].

Due to various type of degradations and diversity of images which needs to be registered, it is impossible to design a universal method applicable to all registration tasks. This is one of the most fundamental issues underlying the design of image analysis. Image registration methodology consists of the following four steps:

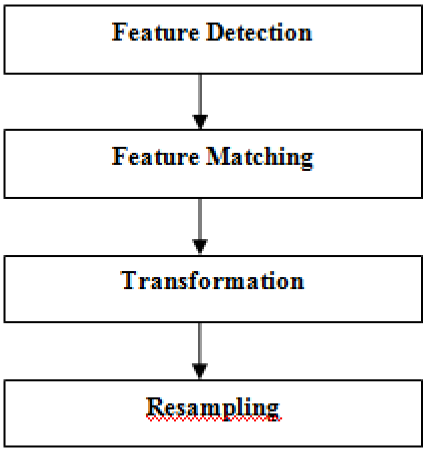

Fig. 2 Block Diagram of Image Registration[1].

- *Feature detection:* In this phase, edges, contours, line intersection, corners etc. are manually or automatically detected.
- *Feature matching:* In the sensed image and the reference image, common features are detected and matched in this phase.
- *Transform model estimation:* The type and parameters of the so-called mapping function should be chosen according to the prior knowledge, aligning the sensed image with the reference image, are estimated. The parameters of mapping functions are computed by feature correspondence.
- *Image re-sampling and transformation:* The registration image needs to be resampled, after determining the transformation parameters.

Image registration can be classified according to the dimensionality, nature of the registration basis, nature of transformation, domain of transformation, interaction, optimization procedure, modalities involved in the registration, subject and object [1].

II. METHODS

A. Corner Detection Methods

Corners is the intersection of two edges, it represents a point, in which the direction of the two edges change. Corner detection has an importance in shape description, image registration, stitching of panoramic photographs, object detection and matching field. There are many corner detectors to find corners like Moravec, Harris, SUSAN etc[3].

Moravec corner detector was developed by Hans P. Moravec in 1977 which defines a corner to be a point where there is a large intensity variation in every direction, but it only considers shifts in discrete 45 degree angles[3].

Harris corner detector was published in 1988 which was improvement upon Moravec corner detector and resolves the problem of Moravec corner detector by using Gaussian window, to reduce noise. It is based on the local auto-correlation function and involves the first derivative of the image. Its principle is to make the image window w moved in any direction, its intensity variation can be defined as[8],

$$\begin{aligned} E_{x,y} &= \sum w_{u,v}[I_{x+u,y+v} - I_{u,v}]^2 \\ &= \sum_{u,v} w_{u,v}[xX + yY + O(x^2, y^2)]^2 \\ &= Ax^2 + 2Cxy + By^2 \\ &= (x, y)M(x, y)^T \end{aligned}$$

where $M = \begin{bmatrix} A & C \\ C & B \end{bmatrix}$, among them $A = X^2 \otimes w$, $B = Y^2 \otimes w$, $C = (XY) \otimes w$, X and Y is the is the first-order gray gradient, they can be obtained by seeking the image convolution, $X = \frac{\partial I}{\partial x} = I \otimes (-1, 0, 1)$ $Y = \frac{\partial I}{\partial y} = I \otimes (-1, 0, 1)$

Gaussian method is used to smooth the image window and to improve noise immunity using following formula:

$$w_{u,v} = \exp[-\frac{1}{2}(u^2 + v^2)/\delta^2]$$ [8]

Yijian Pei, Hao et.al. proposed an improved Harris corner detection method for effective image registration. During corner detection process, this method effectively avoids corner clustering phenomenon. Harris corner detector measures the strength of detected corners and determines which case holds. Corner detection works on the following principle of window function, over an image:

- If the window is placed over a corner of the image, there will be a large change in intensity, when the window moves in any direction.
- If the window is placed over a flat area of the image, then there will be no intensity change, when the window moves.
- If the window is placed over an edge, there will only be an intensity change, when the window moves in one direction[8].

The entire process of Harris corner detector is shown as follows:

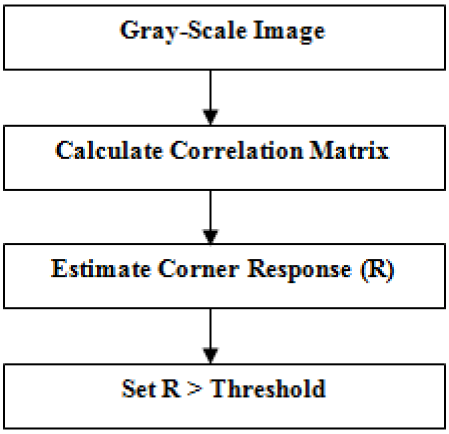

Fig. 3 Block Diagram of Harris Corner Detector[8]

Harris use Gaussian window to reduce noise. It is rotationally and partially invariant to affine intensity change but it is still sensitive to noise, computationally demanding and its localization is good only for L-Junctions.

SUSAN (Smallest Univalue Segment Assimilating Nucleus) assumes that within a relatively small circular region pixels belonging to a given object will have relatively uniform brightness. The algorithm computes the number of pixels with similar brightness to the pixel at the center of the mask (the nucleus of the mask). These pixels are called the USAN (Univalue Segment Assimilating Nucleus) of the mask. Corners are detected by applying the mask to all pixels in the image and then finding the local minima in this new USAN map. SUSAN corner detector is robust to noise (no spatial derivatives are computed), fast to compute, but has an average repeatability rate[3].

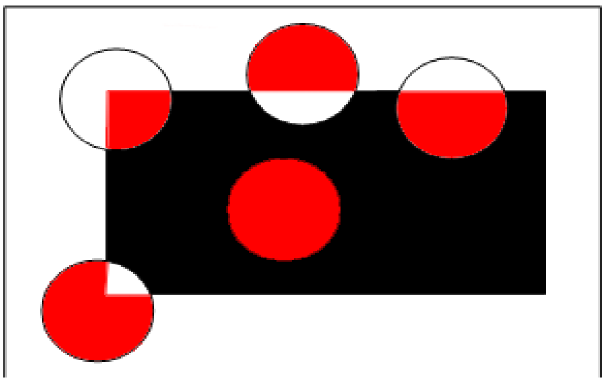

Fig. 4 USAN for different circular masks on a uniform rectangle[3]

B. Non- Rigid Image Registration

A non-rigid registration is the process of transformation of the nonlinear image. Various medical images like X-ray, CT, MRI and US images are used in medical field. CT images can provide good details about bony structure than MR images, but on the other hand, MR provides good details about soft tissues. Compared with the rigid medical image registration, the non-rigid medical image registration has higher accuracy and it is suitable for large deformation of image registration. Thus, generally non-rigid transformations are required[9][10].

The non rigid medical image registration based on thin plate spline was discussed for the images with large distortion and gives better effect for the large image distortion. For the registration of large image distortion of some special places, the non-rigid registration is more accurate and necessary compared with the rigid registration. It is the generalized approach for distortion correction and made a better registration effect for the large image distortion that was experimentally proved[4]. Wenhong Sun et.al. proposed a non-rigid registration method for medical images by applying thin-plate spline (TPS) transform and Coherent Point Drift method so that robust results can achieve[10].

Physical and function based models are the two different categories of non-rigid transformation models. Plate Spline and B-spline are function based models[9]. Thin-plate spline is a landmarking based registration technique with radial basis functions and it was firstly introduced by Harder and Desmarais in 1972. It is used for surface reconstruction and deformable objects. TPS has many advantages like smooth deformation with physical analogy, closed-form solution, few free parameters (no turning is required). Due to excellent interpolation properties, minimization of a blending energy, computational efficiency and ease of implementation, thin-plate spline is used. TPS have been used in the field of computer graphics for surface interpolation, image warping, and remote sensing applications[11]. The main disadvantage of the technique is that each control point in the image has a global effect on the transformation and thus all other points in the image do not get mapped correctly even if one point can be perturbed and the computational cost rises, as the number of control points increases[5][2].

B-spline based non-rigid registration technique is used due to their general applicability, transparency and computational efficiency but special measures are required to prevent folding of the deformation field and these measures become more difficult to enforce at finer resolutions[2].

The whole process of image registration technique can be summarized as follows:

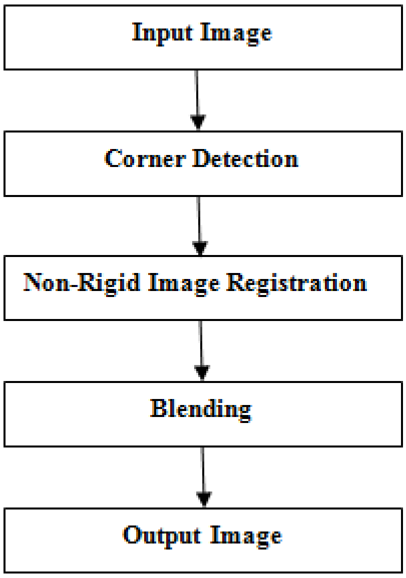

Figure 5: Flowchart of Multimodal Medical Image Registration

III. CONCLUSION

Corner detection has an importance in shape description, object detection and matching field. Moravec corner detector finds corners at large intensity variations but considers shift in discrete 45 degree angle. On the other hand, harris considers all directions and uses a circular Gaussian window, to reduce noise. SUSAN (Smallest Univalue Segment Assimilating Nucleus) corner detector is robust to noise and fast to compute. For large distortion correction of medical images non-rigid registration has been required. A non-rigid registration can be used as landmarks in Thin-plate and B-spline transformation registration which has efficient computational cost. So, a hybrid technique of corner detection and a non rigid transformation can be studied for registration accuracy.

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