ISSN 2278-5612

A comparative approach to image registration methods

Gurpreet Rathore[1], Vijay Dhir[2]
[1]Lecturer CSE, SBBSPGC Jalandhar
rathore3002@gmail.com
[2]HOD CSE, SBBSIET Jalandhar
vijaykdhir@yahoo.com

ABSTRACT

Image processing methods are possibly able to visualize objects inside the human body. Efficient image processing methods are useful in medical diagnosis, treatment planning and medical research. Medical images are used for medical diagnosis. These images should be geometrically aligned for better observation. Registration is necessary technique to integrate data taken from different measurements. Image Registration is a process of overlaying two or more images that can taken at different times, using different devices, different viewpoints and from different angles in order to have 2D or 3D perspectives. The purpose of this paper is to present comparative approach to various image registration methods. This will be a useful document for researchers to implement alternative image registration methods for specific purpose.

Keywords

Image registration, Transformation.

Academic Discipline

Computer Science & Engineering.

Council for Innovative Research

Peer Review Research Publishing System

Journal: International Journal of Management & Information Technology

Vol. 6, No. 2
editor@cirworld.com
www.cirworld.com, member.cirworld.com

ISSN 2278-5612

1. INTRODUCTION

Image registration is establishment of correspondence between images of the same scene. Various image processing applications like remote sensing for change detection, estimation of wind speed and direction for weather forecasting, fusion of medical images like PET-MRI, CT-PET etc need image registration [1]. Image registration is a process of aligning two images acquired by same/different sensors, at different times or from different viewpoint. Initially geometric transformation is deployed that aligns images with respect to the reference image. Distortions causes misregistration that can be removed by determining transformation class that optimally aligns the two images [2]. A number of methods have been proposed to automate the process of image registration. These methods differ in their specific approach to the automatic image-registration problems, the majority of these methods can be broken down into the following steps [3].

- Feature Detection: Distinctive objects i.e. closed-boundary regions, edges, contours, line intersections, corners etc in both reference and sensed images are detected.
- Feature Matching: Similarity analysis is performed on the features in the reference and sensed image.
- Transform Model estimation: The type and parameters of the so-called similarity analysis i.e. aligning the sensed image with the reference image, is estimated.
- Transformation and Resampling: The sensed image is transformed by means of similarity analysis functions.

The figure 1 shows basic image registration steps that are adopted by most of the methods to register an image.

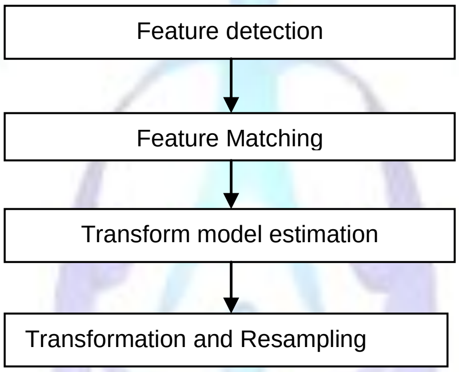

Figure 1: Image registration steps

The image registration methods involving medical images are based on nine criteria's [4]. These methods can be applied according to following criteria's:

a) Dimension of data: 2D/2D, 2D/3D, 3D/3D image registration are possible. There may be situations where time can be fourth dimension.

b) Nature of registration: This is based on Extrinsic and Intrinsic methods. Extrinsic methods are based on foreign objects introduced in imaged space whereas Intrinsic are based on image information. In case of non-image based, imaging co-ordinates of two devices are matched.

c) Transformation nature: The most common transformations are rigid, affine, projective, curved, non-rigid, prospective and global [5].

d) Transformation domain: It could be global or local depending on whether the whole image or its parts is to be registered.

e) Interaction: It could be interactive, automatic and semiautomatic depending upon role of user.

f) Parameter optimization procedure: This procedure could be of two types, one in which parameters computed directly and another in which parameters are searched for.

g) Modalities involved: It could be monomodal, multimodal based on which image registration method is applied.

h) Subject: It could be intrasubject and intersubject. If the two images contain the same subject it is intrasubject registration. If the subject in two images differs it is intersubject registration.

i) Object: It can be type of data. It can be raw data; features extracted from data or introduced markers in data.

Registration methods have been validated using simulated data, phantoms but no accepted method for judging the accuracy of an individual registration has been described [6].

2. METHODS OF REGISTRATION

There are various methods available for registering images. These methods can be applied according to specific requirements in terms of achieving accuracy of image registration.

2.1 Pixel based methods

This is the basic approach of registration. In pixel based methods similarity measure of images is calculated in terms of Cross-correlation. It is used for pattern/template matching or pattern recognition. Presentation and location of pattern can be found in a given image. For template $T$and image$I$, where T is small as compared to I, the two dimensional normalized cross-correlation function measures the match metric for each translation.

$$C(u,v) = \frac{\sum x \sum y T(x,y) I(x-u, y-v)}{\sqrt{\sum x \sum y I2(x-u, y-v)}}$$

If template matches the image, then cross correlation will have its peak at $C(u,v)$. Cross correlation must be normalized so that it can consider intensity as well as color spacing too. Main drawback of the correlation-like methods is high complexity in computation.

2.2 Feature based method or Point mapping method

Feature based matching techniques consider objects such as closed-boundary regions, marks, edges, contours, line intersections, corners etc. Feature extraction algorithm is used to collect substantial information for matching entities so no need to consider grey values. Distinct features are selected from both images and they are quite resistant to distortions. The sufficient number of detected features results into computation of proper transformation. This is primary approach to register two images whose type of misalignment is unknown. In this we can use landmarks and match them using general transformation. This method consists of three stages:

- Selecting features in the image.
- Match control points in reference image with feature points in data image.
- Spatial Mapping of image.

Feature based registration methods overcomes the limitation of correlation method. Due to easy hardware implementation and less complexity in computation they are more often used for real-time applications. Disadvantage of these methods is remarkableness of the window content. A window containing a smooth area without any salient feature will be matched incorrectly with other smooth areas in the reference image due to its non-saliency.

2.3 Contour based registration method or Registration based on high level features

This method makes use of high level features for matching image feature points. Color image segmentation is used for extracting regions of interest from the image. Given a set of colors of interest, obtain mean of color 'm'. Classify each RGB pixel in image as having a color in the specified range for segmentation. Euclidean distance is used to measure similarity. 'z' is an arbitrary point in RGB space and T is threshold. Euclidean distance between 'z' and 'm' is given by:

$$D(z,m) = |z-m| = \sqrt{(z-m)^T(z-m)}$$
$$D(z,m) = \sqrt{(z_R - m_R)^2 + (z_G - m_R)^2 + (z_B - m_B)^2}$$

Here RGB denotes RGB components. Feature based methods do not use the gray values for matching and hence overcomes the limitations of spatial methods. Feature based method filter out the redundant information. Accuracy of this method is more but the limitation is, it is manual and slow.

2.4 Multimodal image registration using mutual information

Multispectral image registration is also called as multimodal analysis. Mutual information is a relation between neighboring image elements but is independent of intensity value of neighboring image elements. Mutual information based methods are group of area based methods [8].These methods emphasis on feature matching step instead of feature detection. Matching is done without detecting salient objects. A predefined size window or entire images are used for estimation of correspondence between images. Registration of multispectral/ multisensor images is a challenging area because such images have different gray level characteristics and simple techniques such as those based on area correlation cannot be applied directly. Applications of these methods are, in remote sensing fusion of information from sensors with different characteristics like better spatial resolution, color/multispectral images with better spectral resolution. Medical imaging applications are, combination of sensors recording the anatomical body structure like MRI, ultrasound or CT with sensors monitoring functional and metabolic body activities like PET, SPECT. But this method has its own limitations. Mutual information results in misregistration due to low resolution images or when complex geometric transformations are present then simple shape windows is violated. It has one more limitation of speed.

2.5 Image registration in frequency domain

Registration in frequency domain works for simple parameters such as translation, rotation and scaling. Phase Correlation method of frequency domain accepts two images and produces a third image which contains a single peak. The location of this peak is relative translation between images. This method uses Fourier transform to compute cross-correlation between images. The Fourier transform of an image $F(x,y)$ is a complex function; each function value has real part $R(\omega_x, \omega_y)$and an imaginary part $I(\omega_x, \omega_y)$at each frequency (ω_x, ω_y) of frequency spectrum.

$$F(\omega_x \omega_y) = |F(\omega_x \omega_y)| e^{\omega - \varphi(\omega_x \omega_y)}$$

Where $\left|F\left(\omega_x \omega_y\right)\right|$ is magnitude and $\varphi(\omega_x \omega_y)$ is phase angle.

$$|F(\omega_x \omega_y)|^2 = R^2(\omega_x \omega_y) + I^2(\omega_x \omega_y)$$

$$\omega\varphi\left(\omega_x \omega_y\right) = tan^{-1}[I\left(\omega_x \omega_y\right)/R\left(\omega_x \omega_y\right)]$$

Cross power spectrum of two images is defined as:

$$F(\varphi_x \varphi_y) = \frac{F1(\varphi_X \varphi_Y)F2 * (\varphi_x \varphi_y)}{\left|F1(\varphi_X \varphi_Y)F2 * (\varphi_x \varphi_{y)}\right|}$$

The Fourier transform computes translation difference between images. However this method can be used to determine rotation and scaling differences between images by converting images to polar coordinates.

2.6 Wavelet Transform Based Image Registration

Registration of image using wavelets is being discussed in this section. In this method wavelet decomposition is performed on images. The wavelet-based image registration can be performed in two ways:

1) Selecting wavelet coefficients by selection rules such as the maximum absolute wavelet coefficient in the multi-spectral image and the high-resolution image for each band.
2) Replacing partial wavelet coefficients of the high-resolution image with these of the multi-spectral low-resolution image.

Feature that are extracted using wavelet decomposition or other transforms are used as input and correspondence between these features will be recognized. Cross correlation, Mutual Information, scale invariant feature transform could be used as a measure of similarity. Wavelet transform decomposes an image into various sub images based on local frequency content. Using discrete wavelet transform (DWT), a function $F(t)$ can be represented by

$$F(t) = \sum a_{j,k} \varphi_{j,k}(t)$$

Here $a_{j,k}$is wavelet coefficient and $\varphi_{j,k}(t)$ is basis function. j is scale and k is translation of $\omega\varphi(t)$.

The DWT coefficients are computed by using a series of low pass filter h[k], high pass filters g[k] and down samplers across both rows and columns. The results are the wavelet coefficient. After finishing all steps, inverse discrete wavelet transform (IDWT) was applied in order to obtain the registered image [9].

2.7 Atlas method

If one image is acquired from a single patient, and the other image is taken from an image information database, we call it atlas registration. In the literature, registration of a patient image to an image of a normal subject is termed atlas registration. Rigid body registration is a fundamental task in medical image processing that serves to align two or more 3-D scans that were taken at different times [10]. The standardized brain coordinate system has been used in automatically segmenting individual cerebral structures in brain image volumes and stereotactic neurosurgical planning. These techniques have been proved to be useful in medical diagnosis that simultaneously registers all images to a common reference space. Gradient projection method has been applied to maximize the similarity between the images. Whether a single atlas is appropriate for a given sample or whether there is an image based evidence from which we can infer multiple atlases, each constructed from a subset of the data, referring this process as atlas stratification.

2.8 *Artificial Neural Networks*

An artificial neural network is often called a neural network. It is a computational model based on biological neural networks. It is defined by following three parameters:

1) Interconnection pattern between different neurons.
2) Learning process of updating interconnections weights.
3) Activation function that converts neuron input to output.

It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. A set of input neurons may be activated by pixels of image. These activations are then transformed by some functions. Practically neural networks are non-linear statistical data modeling tools. They can be used to model complex relationships between inputs and outputs or to find patterns in data. An artificial neural network is a computational structure that is composed of a number of single processors connected through a set of links, which have some weight associated with them. There are two types of network architectures:

1) Feed-forward networks in which the links have no loops.
2) Radial basis function neural networks (RBF) recurrent networks in which loops occur within links.

Current neural networks do not require previous knowledge about the expected output. The training process in an artificial neural network involves modification of the network architecture and the connection weights to learn complex non-linear input-output relationships.

2.9 Fuzzy sets

Fuzzy sets are sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition - an element either belongs or does not belong to the set. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set; this is described with the aid of a membership function valued in the real unit interval [0, 1]. Fuzzy sets generalize classical sets, since the indicator functions of classical sets are special cases of the membership functions of fuzzy sets, if the latter only take values 0 or 1. The fuzzy set theory can be used in a wide range of domains in which information is incomplete. Fuzzy Sets are able to express the notion of partial membership (expressed by a real number in the unit interval [0, 1] of an element to a particular information granule). This property allows Fuzzy sets to handle uncertainty and imprecision. A method using Fuzzy sets to solve 3D registration Problem by dividing the image registration process in two phases. Phase 1 is used to obtain an accurate estimate of the rotations and a rough estimate of the translations. Phase 2 is used to achieve precision in the translation estimates. In each phase, a fuzzy logic controller is used to adjust the registration parameters to obtain accurate transformation estimates.

3 CONCLUSION

Various methods are reported in literature to register images. In pixel based method cross correlation is used as similarity measure. It is observed that in natural images like buildings or scenery, correlation method shows match at multiple points. The feature based method makes use of features like point of intersection, edges, corners, centers of contours etc. for matching sample template with reference image. But this method is manual and hence time consuming. The method combining image features with correlation method have many advantageous properties of both feature-based and intensity based. It overcomes the limitation of intensity based method. Contour based methods do not use the gray values for matching and hence overcomes the limitations of spatial methods. Feature based method filter out the redundant information. Accuracy of this method is more but the limitation is, it is manual and slow. In frequency based method accuracy is more than correlation method but less as compared to other methods. Mutual Information, Fuzzy logic are some of the approaches that can be used for multimodal image registration. Combinational approach of wavelet and mutual information gives better results as compared to wavelet - correlation combination. Even wavelet mutual information combination can be used in case of multimodal image registration. If we involve mutual information as similarity criteria, speed decreases and hence we can’t use this combination in applications where speed is required. Combination of Neural networks and fuzzy logic techniques can be better approach for image registration.

4 FUTURE SCOPE

A major challenge in the current literature is to perform registration on large collections of data sets. Currently available tools pre selects comparatively small collections of data sets and registers in a pair wise fashion. The computational complexity and accuracy of these approaches can be eliminated by performing a simultaneous registration on the whole collection of data sets. The methods, we have explored in this paper have appropriate computational speed for achieving desired registration. An immediate next step would be to develop a new method using neural networks and fuzzy logic techniques that may lead to a significant contribution towards registering image having rotation, translation and scaling parameters along with enhanced accuracy.

REFERENCES

[1] Manjusha Deshmukh, Udhav Bhosle "A survey of image registration", "International Journal of Image Processing (IJIP), Volume (5): Issue (3), 2011".

[2] Lisa Gottesfeld Brown "A survey of image registration techniques", "ACM computer surveys, 24, 4, 1992, 325-376".

[3] Alexander Wong, David A. Clausi "ARRSI: Automatic Registration of Remote-Sensing Images", " IEEE Transactions on Geoscience and Remote Sensing, volume(45), No. 5, May 2007".

[4] J. B. Antoine Maintz and Max A. Viergever "An overview of medical image registration methods", "August 1998 UU-CS-1998-22 ISSN: 0924-3275".

[5] J. Michael Fitzpatrick, Derek L. G. Hill and Calvin R. Maurer "Image Registration", "Volume (4) 2007".

[6] N. M. Alpert, D. Berdichevsky, Z. Levin, E. D. Morris and A.J. Fischman “Improved methods for image registration” "Neuroimage 3, 10-18(1996)”.

[7] Dejan Tomazevic, Bostjan Likar and Franjo Pernus "Multi Feature Mutual Information Image registration", "Image Anal Stereol 2012; 31:43-53".

[8] Barbara Zitova, Jan Flusser "A survey on image registration methods", "Image and vision computing 21(2003) 977-1000".

ISSN 2278-5612

[9] Nagham E. Mekky, F.E-Z Abou-chadi, S.Kishk "Wavelet based image registration techniques: A study of performance", "International journal of computer science and network security, Volume (11) No. 2, February 2011".

[10] A. Collignon, F.Maes, D. Delaere, P. Suetens and G. Marchal "Automated multi-modality image registration based on information theory", "Medical imaging research".