A Novel Approach to Area Based Image Registration in Medical Imaging

Nishant Nath, Anisha Das

Abstract— Image registration is the process of overlaying two or more images of the same scene taken at different times, by different sensors and/or from different viewpoints and geometrically aligning them. Image Registration finds extensive use in medical imaging where information from multiple types of scans is registered to obtain more complete information. In this paper we propose a novel approach to Area Based Medical Image Registration. We also present a brief review of recent as well as classical area based image registration methods. The main contributions, advantages, and drawbacks of the methods are reviewed. Issues and outlook for the future research are discussed too.

Index Terms— Image, Registration, Region, Template, Window, Confidence, Correlation,

1 INTRODUCTION

Image registration establishes correspondence between two or more images of same scene taken from different viewpoint or different sensors or at different times. It has got a wide applications like in medical diagnosis, weather forecasting, image mosaicing, environment monitoring, creating super-resolution images, in cartography (map updating) , in computer vision (target localization, automatic quality control), etc.

Typically, it is required in medical diagnosis in order to obtain more complete information about the patient, combining computer tomography (CT) and NMR data to obtain more complete information about the patient, monitoring tumor growth, treatment verification, and comparison of the patient's data with anatomical atlases.

In image registration, images (Reference image and sensed image) are geometrically aligned for better comparison. Basically it tries to find corresponding points between two images and spatially align them to minimize the error", i.e. a consistent distance measure between two images.

Reference image is the original image and sensed image is the one on which the four steps of image registration are being performed. These steps include – feature detection, feature matching, mapping function design, and image transformation and resampling.

Image registration basically follows two approaches – a feature based approach (Eg: SURF/SIFT based) and Area based approach (Eg: NCC based)

- *Nishant Nath is currently pursuing Bachelor of Technology degree program in Electronics and Communication Engineering in ITER, S'O'A University, India. E-mail: nishant.nath91@gmail.com*
- *Anisha Das is currently pursuing Bachelor of Technology degree program in Electronics and Communication Engineering in ITER, S'O'A University, India. E-mail: anisha.das2007 @gmail.com*

2 METHODOLOGIES

Image Registration Methodologies can be classified on the basis of acquisition of the frames (Reference and Sensed)

2.1 Multiview Analysis

Image Registration Techniques applied on images of the same scene, acquired from different viewpoints to gain a larger 2D view or a 3D representation of the scanned scene are referred as Multiview Image Registration.

Common Areas of Applications: Shape Recovery from Stereo-systems in Computer Vision, Image Mosaicing of Surveyed Areas in GIS/Remote sensing.

2.2 Multitemporal Analysis

Multitemporal Image registration involves images of the same scene acquired at different times under different conditions, often on regular basis. The aim is to find and evaluate changes in the scene which appeared between the consecutive image acquisitions.

Common Areas of Applications: Automatic security monitoring through change detection, motion tracking. Global land usage via Remote sensing. Monitoring of the tumor evolution in Medical imaging.

2.3 Multimodal Analysis

Different sensors are used for acquiring images of the same scene. Integration of the information obtained from different source streams to gain more complex and detailed scene representation is the aim of this method of Image Registration.

Common Areas of Applications: Image fusion of MRI/PET/CT in Medical imaging.

Medical Imaging mostly involves multitemporal and multimodal image registration.

3 Literature Survey

Since advent of the idea of Image Registration, correlation has been the prime area of focus. Ghaffary and Sawchuk in [1] were in all probability the first to review image registration. L. G. Brown in [2] provides a comprehensive review of image registration techniques prevalent in pre-1990 era. Post 1990, medical imaging garnered pace with Elsen et al [5] and Maintz et al [4] providing comprehensive review in the field of medical image registration. Post 2000, Hill et all [3] provided a review on the emerging approaches to medical image registration. Audette et al [6] gives a new look into surface based image registration while Ding et al [7] gives a new look into volumetric image registration.

4 Area Based Image Registration

Area-based methods, often called correlation-like methods or template matching. These methods deal with the images without attempting to detect salient objects. Windows of predefined size or even entire images are used for the estimation of image correspondence.

The limitations of the area-based methods originate in their basic idea. Registration of images mostly differ locally by a translation hence the rectangular window best suits the purpose. For images are deformed by more complex transformations, this type of the window is not able to cover the same parts of the scene. For mutually rotated images, a circular window has been proposed. For more complicated geometric deformations (similarity, perspective transforms, etc.) comparability of such simple-shaped windows is violated too.

Consequently, area based methods are sensitive to the intensity changes, introduced for instance by noise, varying illumination, and/or by using different sensor types

Feature correspondence or Feature Matching refers to the establishment of a relation of similarity or equality by means of a close-neighborhood intensity matching and/or spatial descriptors.

Area-based or Correlation-like feature matching makes use of predefined windows which in cases can be the entire image itself for matching of reference and sensed images without focusing on salient feature being evaluated.

$$NCC(i,j) = \frac{\sum_W (W-\bar{W})(I-\bar{I})}{\sqrt{\sum_W (W-\bar{W})^2}\sqrt{\sum_{I(i,j)} (I-\bar{I})^2}}$$

Sarvaiya et al [8] provides a skeleton for the NCC evaluation.

5 Proposed Algorithm

This algorithm employs a multi-stage NCC about the center of the image. We assume the prime features can be found in the square encompassing 1/3 of the diagonal distance between center of image and corner of the image. The selected window for NCC is assumed to have an edge of 0.05% of the total pixels of the image. For larger images a 0.01% window can also be considered for better results. So rounding all values to highest integral value less than equal to the non-integral value (say) for an image of dimension 100x100, the diagonal is 70 pixels whose 1/3 is 23 pixels. From Pythagorean geometry our points of 1/3 square are (34 34), (66 34), (66 66), (34 66). A 0.05% of the image implies 5 pixels

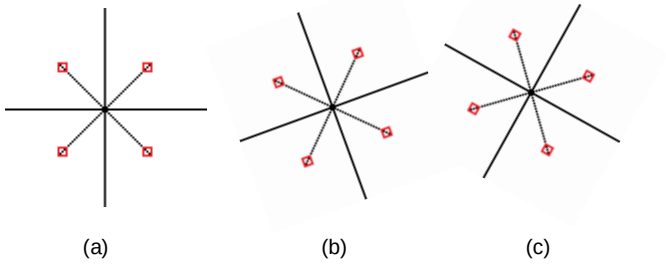


Fig. 1. (a) Reference Image with 4 windows. (b) and (c) are rotated representations of the image

NCC is employed at all four windows and a correspondence between reference and sample image is found. The window being a small element, rotated images can also be matched with a pre-defined confidence level. A 95% and above match confidence is considered ideal for large images while 98% is considered ideal for smaller images. Once the coordinates for NCC matched position are found, calculation of rotation angle is based on simple geometry. Say $(x_1\ y_1)$ and $(x_2\ y_2)$ are two such coordinates, the angle implied can be found as:

$$\boldsymbol{\varphi_i} = \tan^{-1}[(y_2-y_1)/(x_2-x_1)] \quad (1)$$

4 distinct angles can be calculated using the 4 locations of NCC match. Translating these to same horizontal measure and averaging those leads to the most approximate value of rotation of the image.

$$\varphi_1 \ | \ \varphi_2=(180-\varphi_2') \ | \ \varphi_3 \ | \ \varphi_4 \quad (2)$$

$$\boldsymbol{\varphi} = (\varphi_1+\varphi_2+\varphi_3+\varphi_4)/4 \quad (3)$$

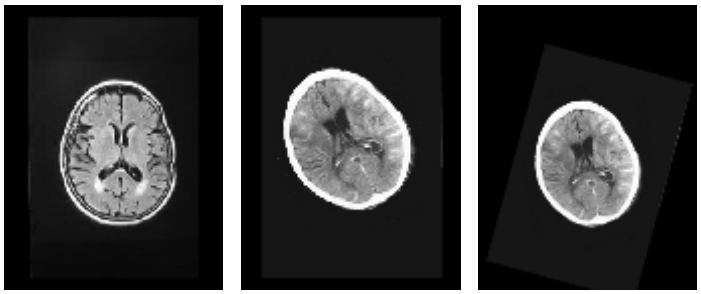
Finding the ratio between any two locations of reference and sample image gives us the scaling factor.

$$Scaling\ Factor = \frac{\text{Euclidean Dist}\,[(y2\ y1),(x2\ x1)]_{\text{Ref Image}}}{\text{Euclidean Dist}\,[(y2\ y1),(x2\ x1)]_{\text{Sample Image}}}$$

Once scaling factor is found the registered image can be descaled to bring to original scale and the rotation can be done using an iterative rotate and match approach.

6 Results

The algorithm was tested for 24-bit RGB images of dimensions 283 x 369 – one a CT Scan and other an MRI Scan. The confidence limit for window was taken to be 0.01% and match confidence of 95%. The MRI Scan was taken as reference image and slightly rotated and up-scaled CT Scan as sample image.



(a) (b) (c)

Fig. 2. (a) MRI Scan (b) CT Scan (c) Registered image with rotation and scaling corrected.

4 Conclusion

The algorithm was tested with *Matlab R2012b* installed on a system with *Intel i3 2.2 GHz Processor, 4GB RAM and 1GB Graphics Driver*. The algorithm was applied to various images and returned positive results to a great degree of accuracy. The novel algorithm proposed by us performs better on images whose prime features are centered at the center of the image. A misaligned image results in poorer results nevertheless positive. We suggest a pre-processing step for aligning the prime feature to the center of image for better results. A comparison between the proposed algorithm and standard SURF based feature-based image registration showed that while the proposed algorithm is slower yet is more consistent than the latter.

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Parameter	SURF	Proposed Algorithm
Scaling Ratio Found	1.1603	1.1600
Rotation Angle Found	15.1946	15.2000
Time Taken for Computation	2.246414	3.124461
Consistency in Results (above)	42/50	50/50

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