Available online at www.sciencedirect.com

ScienceDirect

Biomedical Journal

journal homepage: www.elsevier.com/locate/bj

Original Article

Multiresolution image registration for multimodal brain images and fusion for better neurosurgical planning

Siddeshappa Nandish [a,*], *Gopalakrishna Prabhu* [b], *Kadavigere V. Rajagopal* [c]

[a] *School of Information Sciences, Manipal University, Manipal, India*
[b] *Department of Biomedical Engineering, Manipal Institute of Technology, Manipal, India*
[c] *Department of Radiodiagnosis, Kasturba Medical College, Manipal, India*

ARTICLE INFO

Article history:
Received 22 March 2017
Accepted 14 September 2017
Available online xxx

Keywords:
Rigid
Deformable
Multiresolution

ABSTRACT

Background: Imaging modalities in medicine gives complementary information. Inadequacy in clinical information made single imaging modality insufficient. There is a need for computer-based system that permits rapid acquisition of digital medical images and performs multi-modality registration, segmentation and three-dimensional planning of minimally invasive neurosurgical procedures. In this regard proposed article presents multimodal brain image registration and fusion for better neurosurgical planning.

Methods: In proposed work brain data is acquired from Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) modalities. CT and MRI images are pre-processed and given for image registration. BSpline deformable registration and multiresolution image registration is performed on the CT and MRI sequence. CT is fixed image and MRI is moving image for registration. Later end result is fusion of CT and registered MRI sequences.

Results: BSpline deformable registration is performed on the slices gave promising results but on the sequences noise have been introduced in the resultant image because of multimodal and multiresolution input images. Then multiresolution registration technique is performed on the CT and MRI sequence of the brain which gave promising results.

Conclusion: The end resultant fused images are validated by the radiologists and mutual information measure is used to validate registration results. It is found that CT and MRI sequence with more number of slices gave promising results. Few cases with deformation during misregistrations recorded with low mutual information of about 0.3 and which is not acceptable and few recorded with 0.6 and above mutual information during registration gives promising results.

* *Corresponding author.*
E-mail address: nandish.s@manipal.edu (S. Nandish).
Peer review under responsibility of Chang Gung University.
https://doi.org/10.1016/j.bj.2017.09.002

At a glance commentary

Scientific background on the subject

Biomedical Images deals with different modalities involving different physics. Each modalities gives different information, which is complementary to each. In the proposed research, CT and MRI of the brain is acquired of the same patient and try to fuse both CT and MRI sequences. CT images provides better characterization of bone structure and MRI gives promising characterization of soft tissue.

What this study adds to the field

Proposed study involves image registration before fusion of CT and MRI data. Where image registration process bring both the data into same geometrical space. Fusion of both provides combined complementary information of CT and MRI respectively. Resultant fused sequence and volume rendering of the fused sequence helps in pre neurosurgical planning. Localization of the space occupying lesion and point to incision on the skull can be identified before surgery.

Background

The clinical diagnosis and treatment of patients suffering from brain abnormalities usually require exhaustive exploration of biomedical images. However, images of a single modality do not provide a set of information. The inadequacy of clinical information makes a biomedical image of single modality insufficient for use in clinical interpretation and diagnosis of disease. In general, information acquired from images resulting from different modalities is complementary in nature. Fusion of multimodal images can be achieved after registration of two images. Registration process takes care of two images getting into on single alignment considering any one of the image as a reference. Considering the medical images, geometric deformation referred to the soft tissues behaviour during the interventional procedure or due to the over a period of time changes takes place in the tissue. Image registration has become more important in recent days. Image registration enables to integrate different images into one representation such that the complementary information can be accessed more easily and accurately. Multimodal images of the same person or of different persons generally differ by local geometric differences, and to map such images into one coordinate system, non-rigid or elastic transformations are required. Fused image data can improve medical diagnosis, surgery planning and simulation as well as intraoperative navigation.

Materials and methods

In proposed methodology as shown in Fig. 1, multimodal medical images, such as Computed Tomography (CT) and

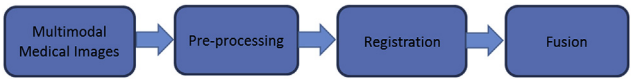

Fig. 1 Proposed methodology.

Magnetic Resonance Imaging (MRI) are used. CT and MRI data of the brain are taken under the guidance and approval of Institutional Ethical Committee (IEC) Kasturba Hospital, Manipal. Eight CT and MRI data sets (each set belongs to same subject) have been collected and same used in the proposed methodology. Among eight scan sets, one scan set has 206 CT images with voxel size $0.46 \times 0.46 \times 1$ mm and 220 MRI images with voxel size of $1 \times 1 \times 1$ mm. Remaining scans have CT images (34–39 images in each case) and MRI images (23–25 images in each case) varying voxel size between $0.45 \times 0.45 \times 4.95 \sim 0.49 \times 0.49 \times 6.31$ mm, respectively. All the data involved in proposed methodology are used in Analyze format (with the extension.hdr and.img).

CT and MRI data are pre-processed and saved into 8 bit analyze format from 16 bit representation. It is done because most the time open source toolkits like Insight segmentation and registration Toolkit (ITK) version 4.4.2 supports 8-bit data. Initially a single slice is used for deformable registration using different techniques and achieved promising result using BSpline deformable registration method. In proposed article it shows BSpline technique outcome on 3D sequence of CT and MRI data and further how 3D sequence of CT and MRI is used with multi resolution registration with rigid registration framework.

Image registration

Image registration is the process of determining the spatial transform that maps points from one image to homologous points on an object in the second image. The components of the registration framework and their interconnections are shown in Fig. 2. For n fusion of two dataset, image registration is the first step to be executed. Registration process makes sure that both the images to be fused are in same geometry.

Basic components of registration framework consists of two input images, metric, optimizer, transform and interpolator as shown in Fig. 2. Basic registration process has two input images. One image is considered as fixed image and other as moving image. Fixed image is the target image where moving image will get the geometry of fixed image. Always registration is treated as optimization problem while aligning

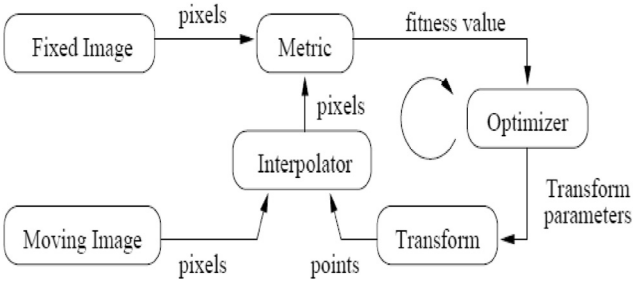

Fig. 2 The basic components of the registration framework. Courtesy: ITK User Guide.

Please cite this article in press as: Nandish S, et al., Multiresolution image registration for multimodal brain images and fusion for better neurosurgical planning, Biomedical Journal (2017), https://doi.org/10.1016/j.bj.2017.09.002