Multimodal Medical Image Fusion for Computer Aided Diagnosis

H.N. Yadav
V.B.S Purvanchal University, Jaunpur

Abstract

Medical image fusion has revolutionized medical analysis by improving the precision and performance of computer assisted diagnosis. In this research, a fusion algorithm is proposed to combine pairs of multi spectral magnetic resonance imaging such as T1, T2 and Proton Density brain images. The proposed algorithm utilizes different features of Redundant Discrete Wavelet Transform, mutual information based non-linear registration and entropy information to improve performance. Experiments on the Brain Web database show that the proposed fusion algorithm preserves both edge and component information, and provides improved performance compared to existing Discrete Wavelet Transform based fusion algorithms.

Introduction

Medical imaging has encountered extensive development owing to the capability to attain data pertaining to human body for purpose of diagnoses. Medical imaging technique aid to create visual representation of internal structure of human body which can be deployed for many clinical applications. The development of multiple image sensor modalities such as x-ray, Magnetic image resonance (MRI), Computed tomography (CT),

Computer assisted diagnoses and therapy strongly depend on image processing methods and are of increasing importance in modern medicine and health care. Over the past decade, research in processing and analysis of medical data has begun to flourish. Sophisticated imaging techniques such as MRI and CT scanning provide abundant information that are useful for diagnosis. These advancements have driven the need for algorithm development which in turn has provided a major impetus for new algorithms in signal and image processing. Typically, the field of medical image analysis is divided into six categories:

Post-acquisition

Preprocessing techniques such as de-noising and restoration are used to restore the images so that they can be used for diagnosis.

Segmentation

Images such as brain MRI or abdomen CT scan contain multiple features (organs). Delineating features of interest is important for analysis and accurate diagnosis.

Registration

In computer assisted surgery, it is required to register or align the captured image with a model or a previously captured image.

Computation

Physical quantity derivation and other computation such as fusion and compression are also required in several computer assisted therapy.

Visualization

It is important to display medical images on screen so that a medical professional a diagnose diseases.

Security

Personal medical health-care information is very sensitive and it is very important to secure it using techniques such as water marking so that only legitimate user can access it and also accurately associate with the medical record with the correct patient.

An important research issue in medical image processing, specifically in information computation, is fusion of multi modal information [5, 7, 8, 9, 10, 11]. Medical images from different modalities often provide complementary information. Several diagnostic cases require integration of complementary information for better analysis. Fusion of multi modal medical images can provide a single composite image that is dependable for improved analysis and diagnosis. Existing algorithms generally use Discrete Wavelet

Transform (DWT) [3] for multi modal medical image fusion[5, 7, 8, 11] because DWT preserves different frequency information in stable form and allows good localization both in time and partial frequency domain. However, one of the major drawbacks of DWT is that the transformation does not provide shift invariance. This causes a major change in the wavelet coefficients of the image even for minor shifts in the input image. In medical imaging, it is important to know and preserve the exact location of these information; but shift variance may lead to inaccuracies. For example, in medical image fusion we need to preserve edge information, but DWT based fusion may produce secularities along the edges. Redundant discrete wavelet transform (RDWT) [3, 4],another variant of wavelet transform, is used to overcome the shift variance problem of DWT. It has been applied indifferent signal processing applications but it is not well researched in the field of medical image fusion. RDW Tcan be considered as an approximation to DWT that removes the down-sampling operation from traditional critically sampled DWT, produces an over-complete representation, and provides noise per-subband relationship [4]. Thes hift variant characteristic of DWT arises from the use of down-sampling whereas RDWT is shift invariant because the spatial sampling rate is fixed across scale. Similar toDWT, RDWT and Inverse RDWT (IRDWT) of a two dimensional image or three dimensional volume data is obtained by computing each dimension separately where detailed and approximation bands are of the same size as thein put image/data 1.The main objective of this research is to investigate the utility of RDWT in medical image fusion. Specifically, we introduce RDWT based image fusion algorithm to fuse properties of medical images of different modalities such as brain proton density (PD) and T1 brain images. The proposed algorithms utilize properties of RDWT such as shift invariance and noise per-subband relationship along with other techniques such as mutual information based nonlinear registration and entropy features for improved performance.Experimental results on the Brain Web data bases how the usefulness of this member of the wavelet family and clearly indicate its potential in medical image fusion.

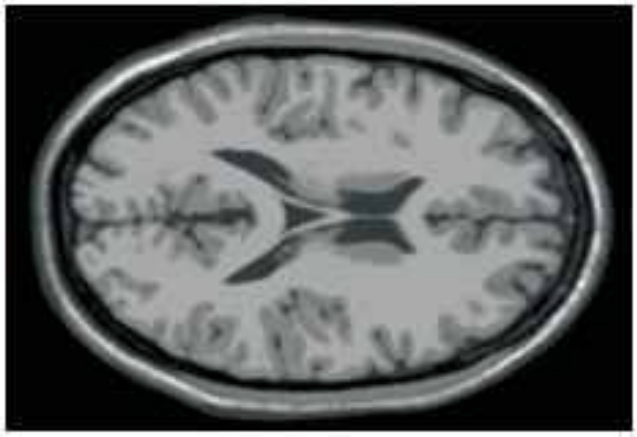
2 Fusion of Multi Modal Brain Images using RDWT

Medical images captured at different time instances canhave variations due to geometric deformations. To optimally fuse two 2D/3D medical images (e.g. T1 and T2 brain images), we first need to minimize linear and non-linear differences between them using registration technique. Medical image registration is about determining geometrical transformation that aligns points in one medical data set with corresponding points in another data set [6]. We first propose mutual information based non-linear registration algorithm for registering multimodal medical images. Mutual information is a concept from information theory in which statistical dependence is measured between two random variables.

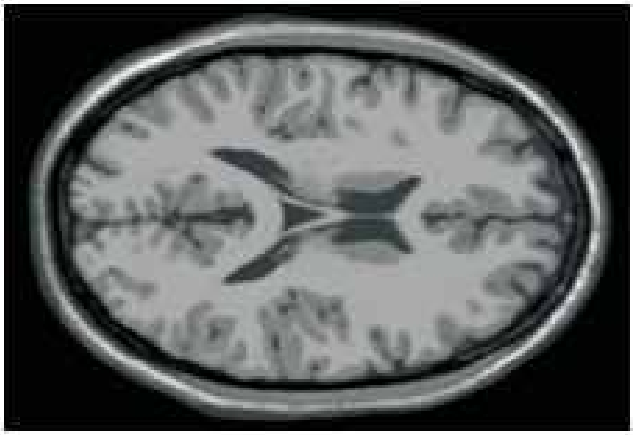
Let $I1$ and $I2$ be the input multi modal brain images for registration. Mutual information between the two image scan be represented as,

$$M(I1, I2) = H(I1) + H(I2) - H(I1, I2)$$

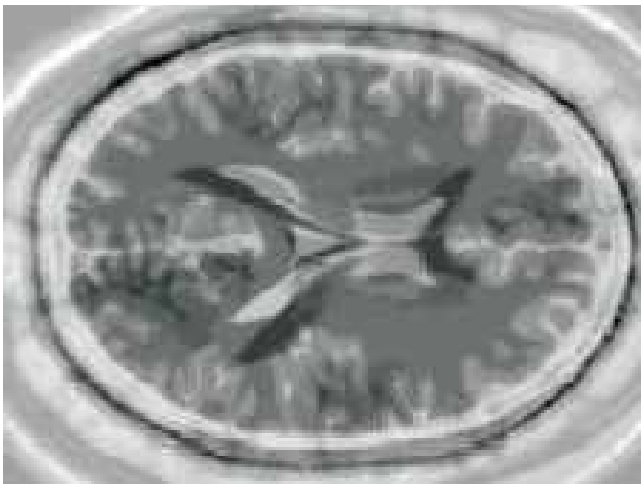
Experimental Result



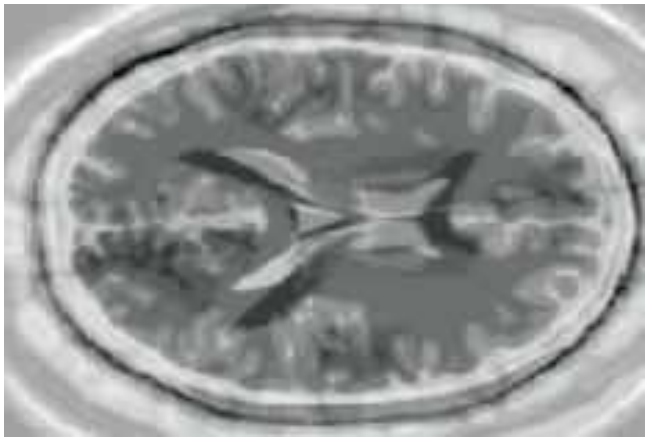
Source image 1



Source image 2

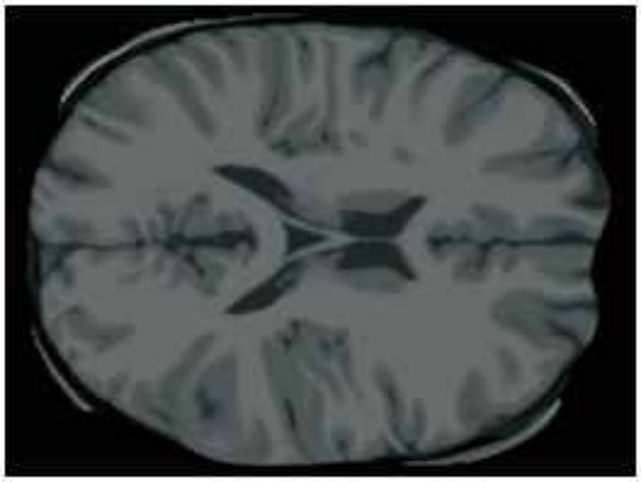


Difference of source and target image

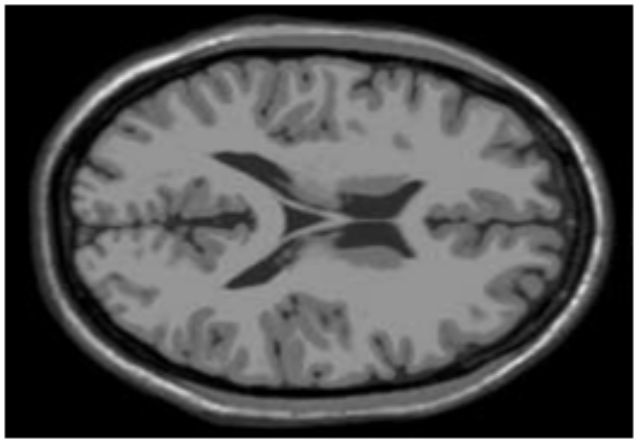


Difference of registered target image

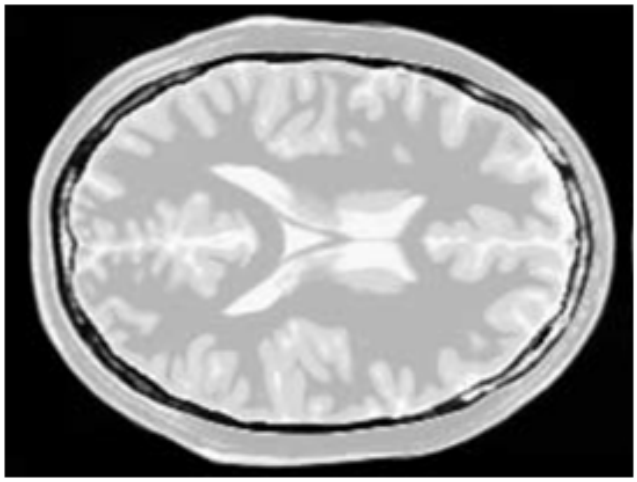
Target image



Registered image
Figure 1. Example of multimodal brain image registration.



T1 Image



PD image

DWT Fused Image

RDWT Fused Image

REFERENCES

[1] http://www.bic.mni.mcgill.ca/brainweb/.
[2] D. Hill and C. Studholme and D. Hawkes. Voxel similaritymeasures for automated image registration. In *Proceedingsof the Third SPIE Conference on Visualization in Biomedical Computing*, pages 205–216, 1994.

[3] I. Daubechies. *Ten lectures on wavelets*. Society for Industrialand Applied Mathematics, 992.

[4] J. Fowler. The redundant discrete wavelet transform and additivenoise. *IEEE Signal Processing Letters*, 12(9):629–632, 2005.

[5] Q. Guihong, Z. Dali, and Y. Pingfan. Medical image fusionby wavelet transform modulus maxima. *Optics Express*,9(4):184–190, 2001.

[6] J. Hajnal, D. G. Hill, and D. Hawkes. *Medical Image Registration*.CRC Press, 2001.

[7] Y. Kirankumar and S. Devi. Transform-based medical imagefusion. *International Journal of Biomedical Engineeringand Technology*, 1(1):101–110, 2007.

[8] Y. Licai, L. Xin, and Y. Yucui. Medical image fusion basedon wavelet packet transform and self-adaptive operator. In*Proceedings of International*

Conference on Bioinformaticsand Biomedical Engineering, pages 2647–2650, 2008.

[9] D. Townsend and T. Beyer. A combined PET/CT scanner:the path to true image fusion. *The British Journal of Radiology*,75:S24S30, 2002.

[10] Z. Wang and Y. Ma. Medical image fusion using m-PCN.*Information Fusion*, 9(2):176–185, 2008.

[11] H. Zhang, L. Liu, and N. Lin. A novel wavelet medicalimage fusion method. In *roceedings of International Conferenceon Multimedia and Ubiquitous Engineering*, pages
548–553, 2007.

[12] Richa Singh, Mayank Vatsa,Multimodal Medical Image Fusion using Redundant Wavelet Transform, prceedings Afzel Noore 2010.

[13] vikram Bhatia, suresh Chandra satapathy Multimodal Medical Image Fusion using Cpmputer aided diagnosis, csi communication , vol 39, issue 6, pp24-26, September 2015

{14]Kanisetty Venkata SwathiModified Approach of Multimodal Medical ImageFusion Using Daubechies Wavelet Transform, International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 11, November 2013