Comparison of diffusion weighted image distortion correction

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Introduction:

Diffusion weighted imaging (DWI), is noninvasive imaging technique that reveals important properties of brain tissues in diseases like MS[1,2]. However, diffusion images usually have geometric distortion due to B_0 in homogeneity, gradient eddy currents, radiofrequency pulse frequency offset, and chemical shift effect and so on. Different methods for distortion correction have been used, such as modifying the acquisition procedures[3] , or by using deformation maps of phantoms[4]. Linear and nonlinear image registration have been used to retrospectively correct the diffusion distortion and obtained the good results[1,5]. In this paper, we compared 2 of the more popular methods, AIR 5.0[6] and Insight Toolkit[ITK][7], for their ability to correct geometric distortion.

Methods: After IRB approval, 20 subjects had dual fast spine echo images of whole brain acquired on 1.5T GE scanner (TE1/TE2/TR =/15/90/3566 ms), 240mm x 240mm FOV, 3 mm thickness and 256 x256 matrix. Diffusion weighted images were acquired using EPI (b=1000 s mm^{-2} and TE/TR = 91/9999 ms), 400mm x 400mm FOV, 256 x 256 matrix, 5.6 mm thickness. The T2 FSE image in each subject was used as reference image and the b0 DWI was warped onto it. The T2 was re-sampled to be 0.938mm isotropic voxels with cubic B-spline interpolation. Then b0 image was linearly registered to T2 with ITK mutual information registration. Non-brain tissues were removed with BET[8] with some manual editing to remove leftover non-brain tissues. The B0 image was warped to the T2 image using 1).AIR5.0 using first order linear 12 parameter model to fifth nonlinear 168 parameter model; and 2) ITK B-Spline deformable registration with mutual information as cost function. The warped images were mean-normalized to T2 image. The RMS error between the original unwarped as well as the 2 warped images versus the T2 image (all slices) was computed for each subject. The ratio of the AIR to ITK RMS error was also computed. Finally, 3 experts blinded to the warping method rated the quality of alignment.

Results and discussion:

Fig.1 shows that ratio of RMS error between ITK and AIR was consistently less than 1 among all 20 cases, indicating ITK performance was superior to AIR. Fig. 2 shows the average RMS between un-warped, warped image and T2 among all 20 subjects and also indicates ITK was superior. Visual evaluation shows strong preference for ITK warping over AIR with p-value of 0.002618.

Our results indicated that both ITK and AIR can effectively correct the most diffusion distortions. We also found that ITK appears to be mathematically and visually superior to AIR for our situation.

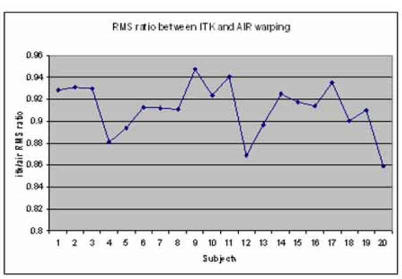

Fig.1 the Comparison of RMS ratio between ITK and AIR warping

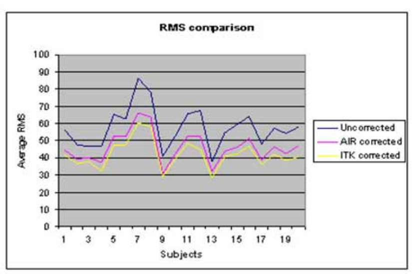

Fig.2 Comparison of RMS among un-warped, ITK and AIR warping images

References:

1. Mogatadakala K.V et al, "Identification of abnormal White Matter in Multiple Sclerosis". Proc. Intl. Soc. Mag. Reson. Med, vol.14, 2006
2. Rovaris M et al, "Diffusion MRI I multiple sclerosis". Neurology vol. 65 pp.1526-1532, 2005
3. Chang H. and Fitzpatrick J. M., "A technique for accurate magnetic resonance imaging in the presence of field inhomogeneities," *IEEE Transactions on Medical Imaging*, vol. 11, pp. 319–329, 1992.
4. Jezzard P. and Balaban R. S., "Correction for geometric distortion in echo planar images from *B*0 field variations," *Magnetic Resonance in Medicine*, vol.34, pp.65– 73, 1995.
5. Tianming L, et al. "76-space Analysis of Grey Matter diffusivity: method and applications",Neuroimage,vol.31(1), pp.51-65 , 2006
6. Woods R.P et al. "Automated Image Registration: II. Intersubject validation of linear and non-linear models",J Comp Assist Tomogr, vol. 22, pp. 153-165, 1998
7. http://www.itk.org
8. http://www.fmrib.ox.ac.uk/fsl/bet/