

Mutual Information correction for eddy current-induced Geometric artefacts In Diffusion-Tensor Tractography

¹Kao-Lun Wang, ¹Shiou-Ping Lee, ³You-Jhuan Lee, ²Wen-Yih Isaac Tseng,
¹department of Medical Imaging, Far Eastern Memorial Hospital, ²Center for Optoelectronic Biomedicine
National Taiwan University, and ³Institute of Medical Informatics, Taipei Medical University, Taipei, Taiwan

Correspondence: R90548010@ntu.edu.tw

Abstract

The paper investigated the validity of an image coregistration method, Mutual Information correction(MI) for fiber tractography. We found that mean increase was 18.56(%) in FA and 10.02(°) in first eigen vector variation angle through MI approach for White matter ROIs[1]. In addition, Plotted with the tensor ellipsoid shape, the region of gray matter is more consistent the T2 turbo spin-echo FLAIR image.

Tractography of Cortico-spinal was used to compare with reconstructing pathways of MI correction before and after. Utilization of MI correction of Diffusion-weighted images generate more consistency with CS fiber tracks to lateral aspect of the postcentral and contralateral gyrus. The results reveal that each tract has a unique spatial signature in term of anatomical atlas property[2].

1. Introduction

Geometric distortion of echo-planar images produced by eddy currents induced geometric distortions that vary with the magnitude and direction of the diffusion sensitizing gradients. Such distortions derived from acquiring misalignment that different diffusion gradient strengths and orientation in turn alternate consequence.

While Diffusion-Tensor Imaging has been an important tool to reveal reveal axonal fiber tracts in cerebral white matter noninvasively technique, single-shot diffusion gradient EPI sequence suffered from geometric distortion that will have an influence on white matter Tractography.

This aim of this is works are to utilize the potential advantage of MI coregistration in the raw diffusion-weighted images and to visualize more accurate Cortico-spinal without use of complicate postprocessing in an extra hardware system.

2. Materials and Methods

Healthy volunteer was scanned on a 1.5T MRI system (Sonata, Siemens, Germany). A diffusion EPI sequence was used to acquire transaxial images encompassing the whole brain. Isotropic spatial resolution was obtained by setting FOV = 280 mm x 280 mm, matrix size = 128 x 128 and slice thickness = 2.2 mm. Diffusion-weighted images using the diffusion sensitivity (b-value) = 1000 s/mm² were acquired with

TR/TE = 8900/95 ms. Diffusion DTI encoding schemes were used 13 icosahedrally-oriented steps. To acquire 55 transaxial view slices covering the whole brain image. The scan time for each DTI data set was about 5 minutes.

T2 FLAIR were obtained by using the Turbo-spin-echo image sequence to finish transaxial images to include whole brain with slice thickness of 5 mm. The spatial resolution was higher than Diffusion-weighted images, the image level was more similar to Diffusion-weighted image. and TR/TE = 8500/99 ms.

We used modified SPM-based procedure that was called normalized Mutual Information to coregister DWIs to non-diffusion weighted reference images method[3-5].

Tractography algorithm used tensor deflection by an adaptive step size approach[6], tracking fiber results based on manual selecting of Cortico-spinal local seed points.

3. Results and Discussion

FA map combining first eigen vector map on 32th axial slice are shown in Figure 1. Note that the white arrow appear clarity of the rim along the brain edges in Mutual Information before and after to exhibit the high intensity difference due to image distortion.

Whereas the MI correction before and after shown an increase that was statistically significant in different white matter ROIs. The ROIs measurement(Table 1) confirmed this improvement in white matter location sampled. A mean increase of 18.56(%) in FA and 10.02 (°) in First Eigen vector variation angle was found for MI correction.

T2 FLAIR Turbo spin-echo transaxial brain image distinctly segmented into gray and white matter was shown in Figure 2(Left) comparing with reconstruction of color-coding FA map(Right) after MI correction on 32th transaxial view image.

As shown in Figure 5, the reconstruction of gray matter region FA < 0.15 is more reasonable after MI correction.

Tractography for Cortico-spinal tracks were launched from selected seed points ROIs in pons to visualize bypass to display fault tracks with red arrows in Figure 4. Compared with in Figure 5 such as anatomical atlas performed CS fiber tracts was correlated to the main pathway of fiber bundles[2].



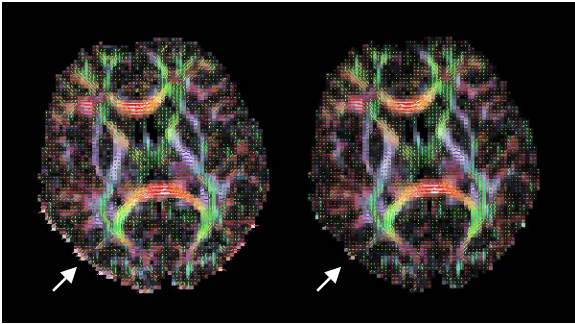


Figure 1. Reconstruction First Eigen vector superimposed FA map with MI before (Left) and after (Right).

Table 1. Illustration of difference in Mean FA and First Eigen vector as measured using MI correction in various ROIs.

White Matter	FA error	First Eigen vector variation
ROI region	(%)	angle (°)
Corpus Callosum	11.68	7.87
Posterior Occipital	18.06	11.25
Internal Capsule	25.94	10.94
Mean	18.56	10.02

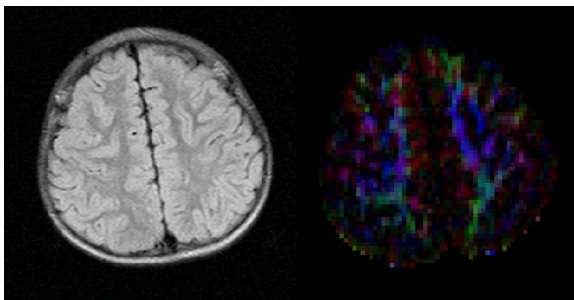


Figure 2. Plot of T2 Turbo spin-echo FLAIR and color-coding FA map on the similar to image level.

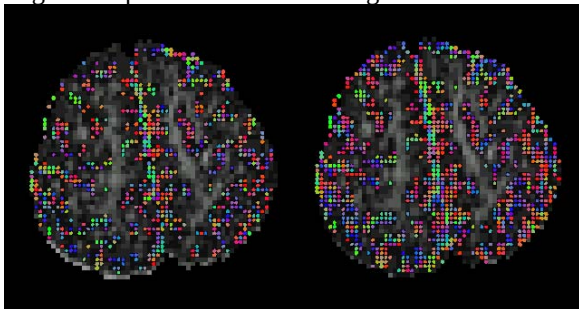


Figure 3. Comparison of Gray matter tensor ellipsoid shape superimposed FA map with MI before(Left) and after(Right).

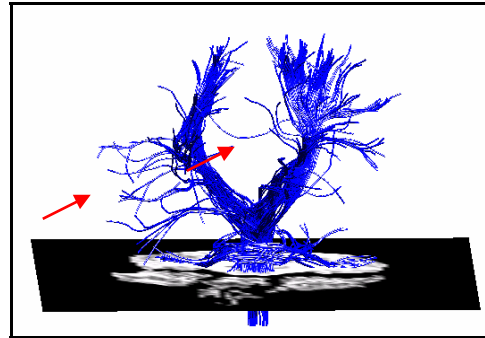


Figure 4. Tractography of Cortico-spinal tracks reconstructed from original Diffusion weighted images.

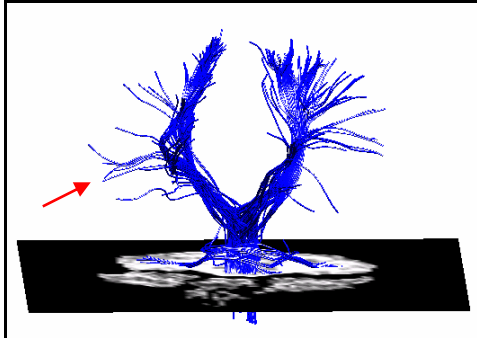


Figure 5. Tractography of Cortico-spinal tracks reconstructed through MI corrected Diffusion-weighted images.

4. Conclusion

Our results indicate that using MI corrected Diffusion-weighted images for White matter Tractography provide alternative calibration approach eddy current induced phase encoding direction geometric distortion.

Despite this method raising postprocessing times, MI coregister reduction extra data acquisition pulse sequences.

5. References

- [1] Yuji Shen, David J. Larkman, Serena Counsell, Ida M. Pu, David Edwards, and Joseph V. Hajnal, "Correction of High-Order Eddy Current Induced Geometric Distortion in Diffusion-Weighted Echo-Planar Images", *MRM*, 2004; 52, p1184-1189.
- [2] Mori S et al, "Diffusion-Tensor MR Imaging and Fiber Tractography: A New Method of Describing Aberrant Fiber Connections in Developmental CNS Anomalies", *RadioGraphics*, 2005; 25, p53-68.
- [3] J.-F. Mangin, C. Poupon, C. Clark, D. Le Bihan, I. Bloch, "Distortion correction and robust tensor estimation for MR diffusion imaging", *Medical Image Analysis*, 2002; 6, p191-198.
- [4] D. Kim, H.-J. Park, W.-J. Moon, E.-C. Chung, I.-Y. Kim, S. Kim, "Comparison of Registration Technologies for the Evaluation of Diffusion Tensor Imaging", *Proc ISMRM*, 2005; 13, p2340.

[5] Mark E. Bastin, "CORRECTION OF EDDY CURRENT-INDUCED ARTEFACTS IN DIFFUSION TENSOR IMAGING USING ITERATIVE CROSS-CORRELATION", MRI, 1999; 17, p1011-1024.

[6] M-C. Chou, M-L. Wu, H-W. Chung, C-Y. Wang, C-Y. Chen, "TENsor Deflection (TEND) Tractography with Sub-pixel Adaptive Step Size", Proc ISMRM, 2005; 13,p1308.

