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Haykel Snoussi[1], Emmanuel Caruyer[1,2], Olivier Commowick[1], Elise Bannier[1,3], Anne Kerbrat[3], Christian Barillot[1,2]

[1] VisAGeS Reseach Unit, Inria Rennes - Bretagne Atlantique, France
[2] CNRS, IRISA UMR 6074, Rennes, France
[3] Centre Hospitalier Universitaire de Rennes, Neurinfo platform, France

1 Introduction

Diffusion MRI (dMRI) is a modality that describes the geometry of neural architecture. Diffusion images suffer from various artifacts originating from subject and physiological motion, eddy currents and B0-field inhomogeneity. These can severely affect image quality particularly in the spine region. However, strategies exist to correct these distortions, including co-registration, point spread function, phase field map and reversed gradient polarity method (RGPM). In this work, we focus on the comparative evaluation of correction methods using RGPM which provides best results [1]. More precisely, we compared Voss [1, 2] plus two other recent methods: Topup (FSL) [3] and HySCO (ACID/SPM) [4].

2 Subjects and Methods

Data acquisition: 116 dMRI datasets were acquired on 61 multiple sclerosis subjects and 9 healthy volunteers (between 1 and 3 yearly visits/subject) from Rennes and Montpellier hospitals (3T Siemens Verio and Skyra, respectively) using the following parameters: sagittal orientation, TR/TE=3600/90ms, 2x2x2mm^3 resolution, 6 b=0 and 30 non-collinear DWI (900 s.mm^{-2}) plus one b=0 image with reverse phase-encoding direction. After a conservative quality control (see below), we kept 69 acquisitions.

Quality control: In order not to bias the distortion correction comparison, we eliminated images with too many artifacts not related to B0-field inhomogeneity (motion, ghosting) and acquisitions for which rigid registration between anatomical and diffusion failed.

Comparing distortion correction methods: The whole spinal cord was segmented using the Spinal Cord Toolbox [5] on a T2-weighted scan to obtain a binary mask which is registered to the first b=0 volume. Cross-correlation was computed (Fig. 1) between each corrected dMRI and the rigidly registered T2 image (Fig. 2), only within the spinal cord region.
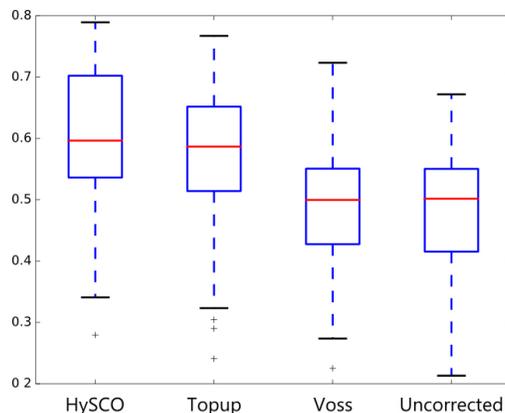

Fig. 1. Cross-correlation between T2 and corrected b=0 diffusion images

3 Results

ANOVA was performed on the cross-correlation scores, and confirmed that there is a significant improvement using correction distortion ($F=19.8$, $p=1.2710^{-11}$). Further, a Tukeys test showed that both HySCO and Topup perform better than Voss and uncorrected ($p<210^{-4}$). However there is no significant difference between Voss and no correction. This last result is in contradiction with [1] which included 3 datasets, while we report results on 69 acquisitions.

Another finding (data not reported) is that changing the order in which RGPM images are given as input (first F>H then H>F, or reverse) yields different results, albeit no significant difference was noted.
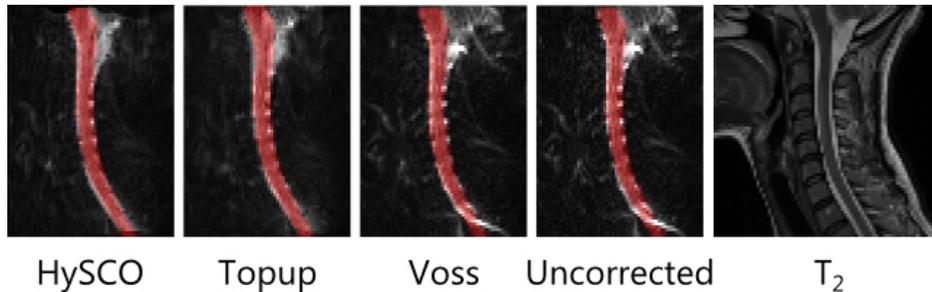
Fig. 2. Example of a corrected b=0 volume; the mask of the spine computed using T2 and registered to the diffusion image is overlaid

4 Discussion and Conclusion

This comparative study conducted on 69 images confirms that performing a distortion correction step gives better alignment with anatomical image which is important for the accuracy of the subsequent analysis; out of the 3 methods tested, HySCO and Topup provide best results.

Acknowledgments

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