Fiber Tractography Using Slice Accelerated High-Angular-Resolution Diffusion Imaging

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Target Audience: Researchers who are interested in fast and high diffusion resolution imaging and fiber tracking.

Introduction: Slice accelerated (multiband) DTI shows great potential[1, 2] for accelerating lengthy acquisitions. Multiband imaging can provide significant time savings in lengthy scans, such as high angular diffusion resolution imaging (HARDI)[3]. Typical HARDI data are acquired with >50 diffusion directions, and if this is to be combined with high spatial resolutions the scan times may become excessively long. **This study shows that slice accelerations of 2-3 can be used to reliably reduce the otherwise long scan time of HARDI to clinically feasible times, without losing image quality.**

Methods: Acquisitions: Standard and multiband DTI scans were acquired on a GE 3T scanner (MR750, GE Healthcare, Waukesha, WI, USA) using a 32-channel head coil (Nova Medical, Wilmington, MA, USA). Two subjects were scanned with similar protocols. The consistent scanning parameters across all scans were: 75 diffusion directions, matrix size: 128x128, a FOV/z-FOV= 24/16 cm. The varied scanning parameters are summarized in Table 1. Because of the limited scan time of 7 min allowed for our clinical setting, the un-accelerated acquisition allowed for Subject B had only 32 slices, and thus a slice thickness of 5mm to cover the full z-FOV. Matching EPI calibration scans which took less than a minute without simultaneously acquired slices were used for ghost correction and GRAPPA calibration. Reconstruction: SENSE-GRAPPA[4] implemented in MATLAB (Mathworks, Natick, MA, USA) was used to reconstruct the final diffusion weighted images.

	Subject A			*Subject B*		
Bands	1	2	3	1	2	3
TE (s)	5.1	3.2	2.2	5.1	5.1	3.5
Scan (min)	6.8	4.3	2.9	6.8	6.8	4.6
Thick (mm)	4	4	4	5	2.5	2.5
Slices	40	40	40	32	64	64

Table 1: Scanning Parameters for the subjects.

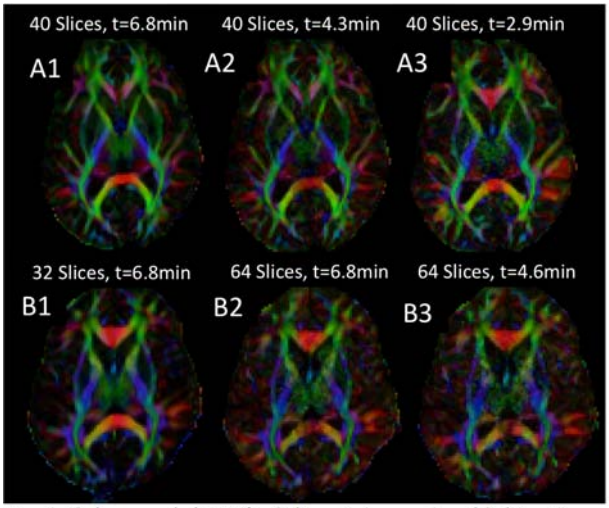

Fig. 1: Color-encoded DTI for Subject A (top row) and Subject B (bottom row) with slice accelerations of 1, 2 and 3(from left to right).

Results and Discussion: Data were corrected for motion and eddy current induced distortions in ExploreDTI[5] prior to tensor estimation[6]. Fig.1 shows the comparisons of color-encoded DTI for the same slice with slice accelerations of 1-3 (l-r) for both subjects, with scan time noted. As with parallel imaging, the SNR decreases as the parallel imaging factor increases. Since the 64-slice scan has close to isotropic voxels, we performed DTI-based fiber Tractography[4]. Fig. 2 shows fiber tracking results from a seeded ROI in the corpus callosum on the mid-sagittal slice for volunteer B. The tracking results look comparable, while the scan time for 2 bands and 3 bands dropped by 50% and 65% respectively. The effect of increasing the slice acceleration factor produces a slight decrease in the SNR, especially in the center of the brain. This can be mitigated to some extent with the use of blipped-CAIPIRINHA[1], however this work shows that even with a straightforward approach to slice separation, scan times of <5 minutes can be achieved which allow for DTI-based fiber tracking.

Conclusion: Using slice-acceleration allows the reduction of scan time in HARDI by at least two- or three-fold. This reduction allows a significant reduction in scan time, making HARDI-type acquisitions possible in clinically acceptable scan times on the order of 5 mins. This acceleration puts high spatial resolution and high angular resolution scans in the realm of possibility in clinical protocols.

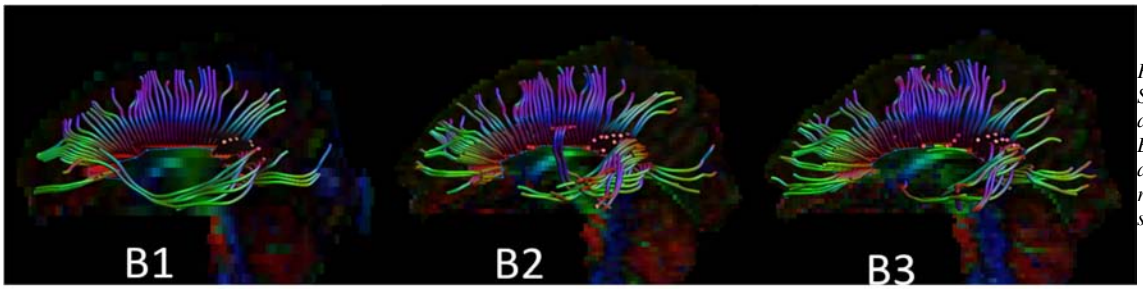

Fig. 2: Fiber tracking for Subject B for 1 band, 2 bands and 3 bands (left to right). Data B2 and B3 were acquired in about 50% and 64% less time respectively than a fully sampled dataset (13.6 minutes).

References: [1] Setsompop K. et. al., MRM. 2012. 67(5): 1210-24. [2] Setsompop K. et. al., NeuroImage. 2012. 63(1): 569-80. [3] David. S.T. et. al., MRM. 2004. [4] Moeller. et. al., MRM. 2010. 65:1144-56. [5] Leemans et al. ISMRM 2009 p3536. [6] Veraart et al., NeuroImage 2013 in press.
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