DTI Fiber Tracking: The Importance of Adjusting DTI Gradient Tables for Motion Correction.
CATNAP – A Tool to Simplify and Accelerate DTI Analysis.

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Word Count: 480 (500 Limit)

Introduction

Diffusion Tensor Imaging (DTI) continues to gain prominence as a research tool and is increasingly part of clinical imaging protocols. However, processing DTI data is not straightforward and combining DTI and anatomical datasets for analysis can be cumbersome and time consuming. If DTI is to become accepted as a clinical research tool, three issues must be addressed:

1) Coregistration of DTI and anatomical data requires familiarity with and correct selection of parameters for 3rd party image registration software.
2) Establishing the correct gradient table for DTI analysis is not simple, and typically requires specific knowledge of the scanner software.
3) Computing the diffusion tensor correctly for multiple DTI datasets is computationally intensive and requires dedicated resources.

To address these challenges, we present a graphical user interface resource with full command line/batch processing capability to meet these challenges for the clinical research community (**Figure 1**). **CATNAP** (**C**oregistration, **A**djustment and **T**ensor-solving, a **N**icely **A**utomated **P**rogram) is an end-to-end data processing pipeline for Philips PAR/REC DTI and anatomical MRI data. Data from other manufacturers' scanners are supported as long as the diffusion weighting (DW) tables are specified relative to the slice orientation.

Methods

CATNAP performs volume-wise coregistration using RADAR (1), a method based on FSL FLIRT (2), to correct for subject motion to a target volume or atlas of the user's choice. Custom Matlab (Mathworks Inc, Natick, MA) software interprets Philips DW tables into voxel space based on imaging and hardware parameters. Diffusion tensor calculations may be performed with either a custom implementation of log-linear minimum mean squared error method or using either of the AFNI tensor estimation methods (linear or non-linear) (3). Data are block processed to accommodate memory restrictions.

Voxel-wise intra- and inter-session reproducibility was evaluated on two sessions of 15 repeated DTI scans of a 24 y/o healthy volunteer (4). Fiber tracking was performed in DTIStudio (5) with and without correcting the DW gradient tables for motion for intra- and inter-session data analyses.

Results and Discussion

When DTI data is processed (with gradient tables with and without adjustments for motion correction), the effects of are small (<0.1%) for scalar contrasts (FA, ADC). However the effects on the orientation of the principle eigenvector are larger, especially when inter-session motion was ignored (**Figure 2**). The consequences of ignoring intra-session motion correction were apparent in the fiber tracking of a clinical subject (~2.5º head rotation during DTI scan) (**Figure 3**). Inter-session effects on fiber tracking were more pronounced (**Figure 4**).

Given the simplicity of implementing motion correction of DW tables and the possibility for significant errors if ignored, the authors strongly recommend systematic use of proper DW table correction for all DTI studies. CATNAP integrates coregistration, gradient table parsing, and tensor estimation into a graphical, user-friendly package. CATNAP is documented and freely available as open source software (http://iacl.ece.jhu.edu/~bennett/catnap/catnap.html, supporting: Solaris, Linux, Windows/Cygwin).

References
(1)Landman BA,et al. (2006) ISMRM.#2987 (2)Jenkinson M, et al. (2002) Neuroimage 17(2):825.
(3)Cox R, et al. (2006) ISMRM. #349. (4) Farrell JA, et al. (2006) ISMRM#1075. (5) Jiang H, et al. (2006) Comput Methods Programs Biomed 81(2):106.

Figure 1

Figure 2

Figure 3

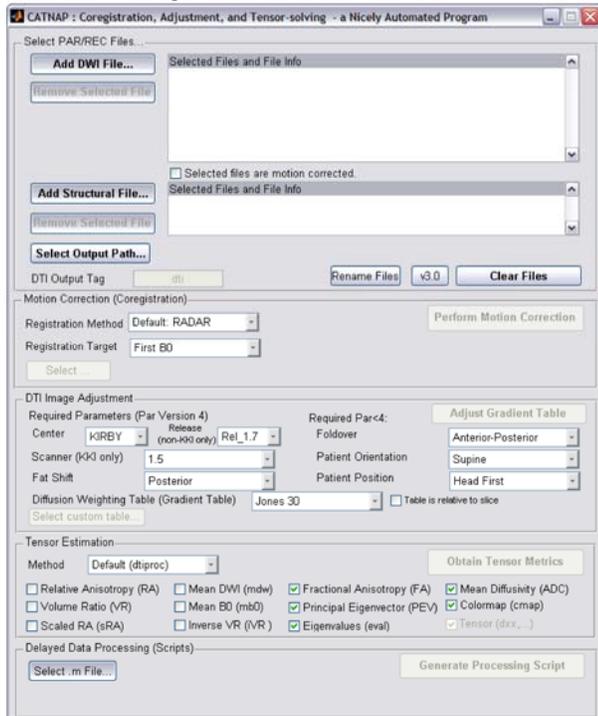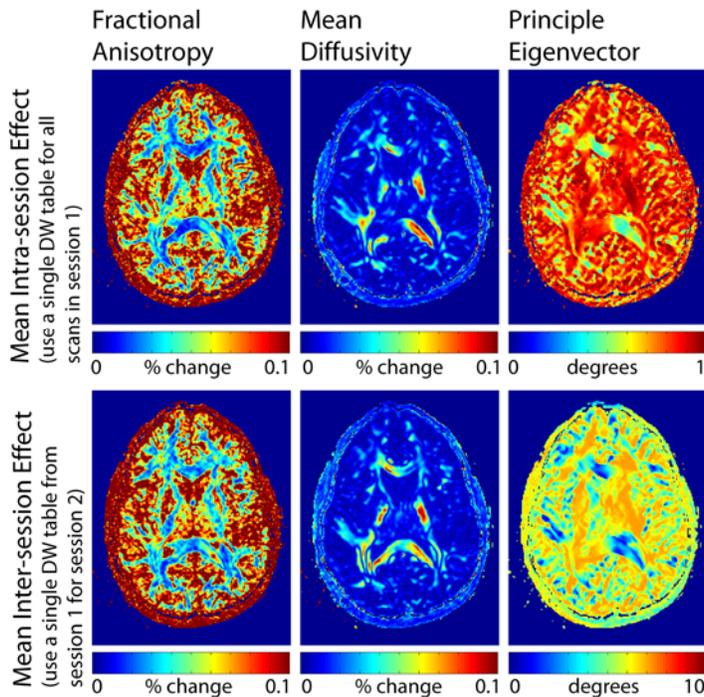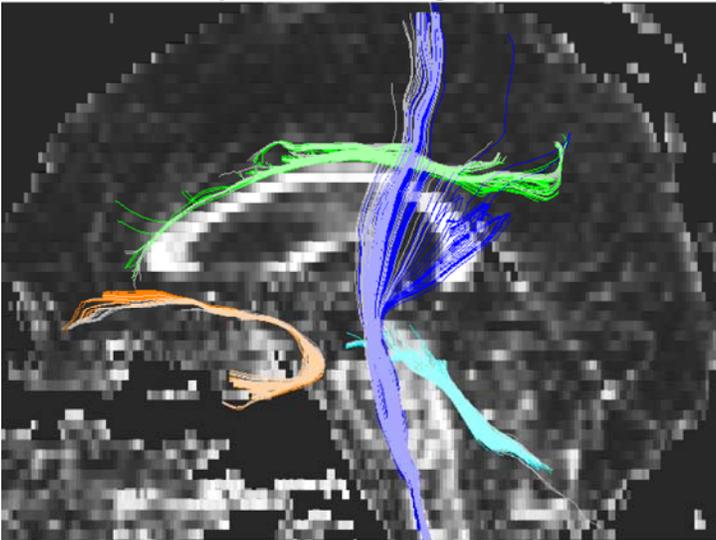## Failure to Correct DW Tables for Intra-Session Motion Correction Corrupts Fiber Tracking

**Legend**

Cortiospinal Tract (CST): **Blue,**   Superior Cerebellar Peduncle (SCP): Cyan
Uncinate Fasiculus (UF): **Gold**   Cingulum (C): **Green**

Fiber tracking in one DTI dataset using DW tables with (dark color) and without (light color) adjustments for motion correction. Changes in tract course are apparent. Fiber counts varied by up to 48 %. Identical ROIs were used for both fiber tracking results.

Figure 4

Failure to Correct DW Tables for Inter-Session Motion Correction Corrupts Fiber Tracking
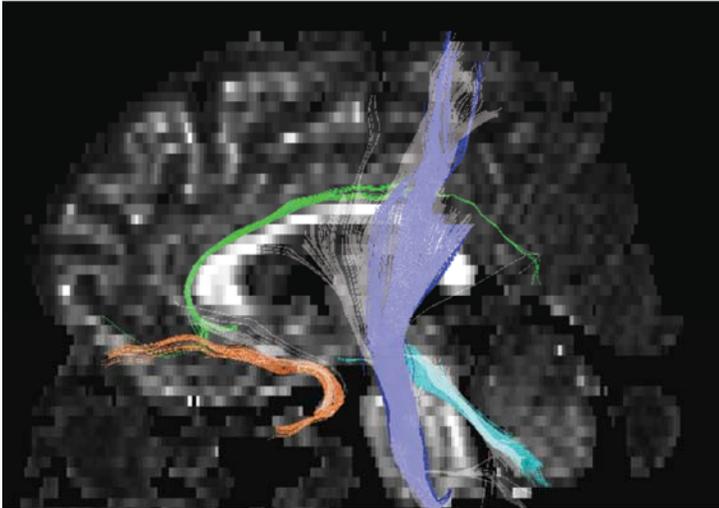
Fiber tracking in one DTI dataset using DW tables with (dark color) and without (light color) adjustments for motion correction across scan sessions.

Fiber tracking results are dramatically altered when motion correction is ignored. The C was not identified; substantially fewer fibers were identified in the UF and SCP; and notably changes in CST and SCP course were observed. Identical ROIs were used for both fiber tracking results.