

ExploreDTI: a graphical toolbox for processing, analyzing, and visualizing diffusion MR data

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Introduction

Diffusion tensor imaging (DTI) is becoming a standard addition to routine MR imaging for investigating microstructural tissue properties (e.g., see [1] for a recent review). With this research field rapidly evolving, the need for efficient and user-friendly diffusion MR processing/analysis software packages is also increasing. Here, a new MR diffusion toolbox – dubbed *ExploreDTI* – is officially presented for the first time. *ExploreDTI* is a non-commercial package that combines many of the key MR diffusion processing tools that have appeared in the recent literature, but which have not necessarily been widely available. The package will be made freely available to academic institutions following the ISMRM meeting in Hawaii. The main features of *ExploreDTI* are summarized in the following sections.

Platform

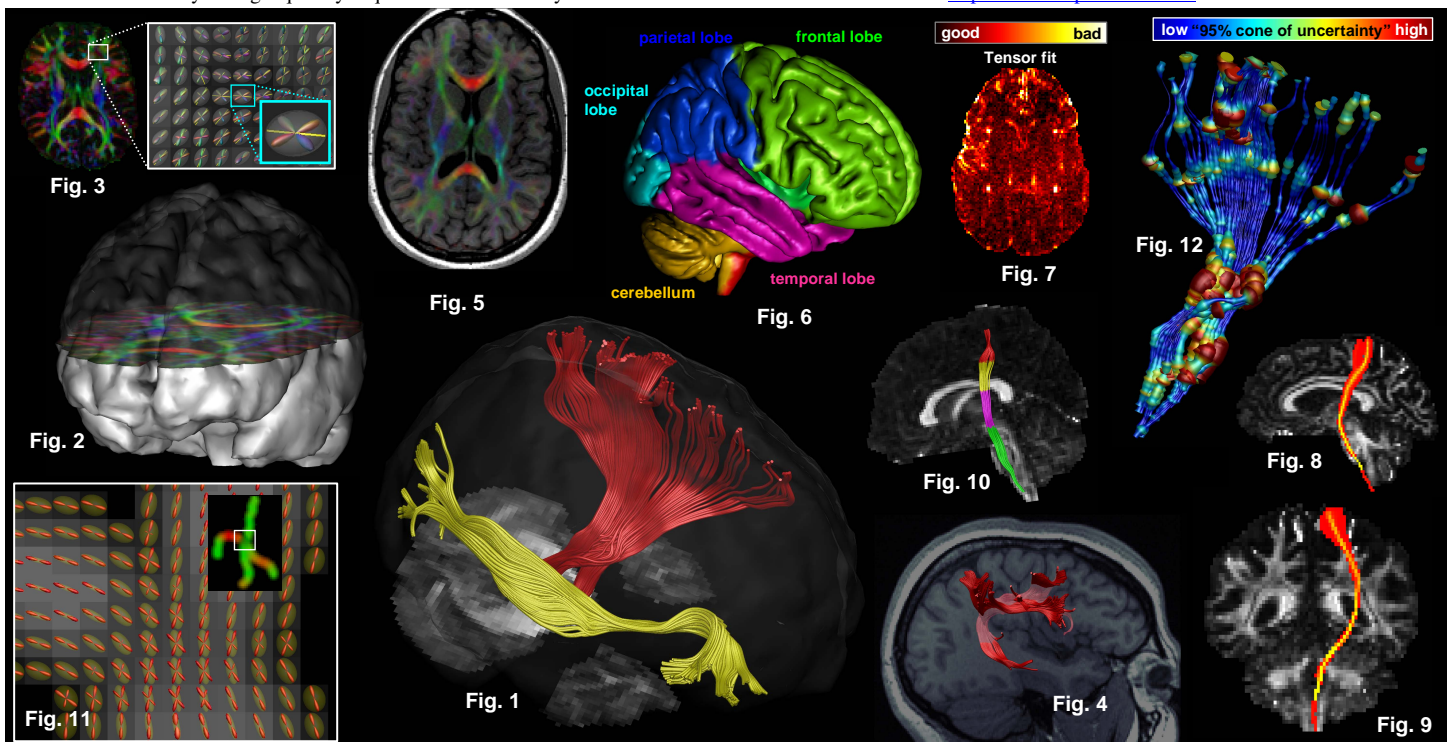
ExploreDTI is written in Matlab (The Mathworks Inc., Natick, Massachusetts, USA) and, as such, works across multiple platforms (Windows PC, Unix, Mac). The focus of *ExploreDTI* is on interactive display and manipulation of data, such as WM fiber tracts (Fig. 1), brain surface renderings (Fig. 2), and diffusion glyphs (principal diffusion directions (PDD), cuboids, ellipsoids, and fiber orientation distribution (FOD) objects – Fig. 3). While many aspects of the processing have been vectorized, optimal results will be obtained with a high-performance graphics card.

Key features

- **Data Reconstruction:** *ExploreDTI* can take, as input, raw diffusion-weighted (DW) data in multiple formats including Dicom, Analyze, NIFTI, and Matlab formats – and is easily adapted to handle others. The diffusion tensor can be estimated by linear, weighted linear, and non-linear least squares methods with (or without) the RESTORE method [2]. Q-ball Imaging (QBI) [3] and Constrained Spherical Deconvolution (CSD) [4] reconstructions are integrated as are overlays of other modalities, such as T1 structural data (Figs. 4, 5) or atlas labels (Fig. 6).
- **Motion / Eddy Current Correction:** This pre-processing step corrects the DW images for subject motion and Eddy-current-induced distortions, incorporating the *B*-matrix rotation to preserve the orientational information correctly [5].
- **Quality Assessment Tools:** *ExploreDTI* contains quality assessment tools to investigate artefacts (due to motion, distortions, signal dropouts, etc.) based on analyses of residuals and outliers of the diffusion tensor fit [6] (Fig. 7).
- **Fiber tractography:** Both deterministic [7] (Figs. 1, 4) and wild bootstrap (Figs. 8, 9) [8] streamline tracking algorithms are supported for DTI, QBI, and CSD [2, 3]. Atlas labels and ROIs ('AND', 'OR/SEED', 'NOT') can be defined to select fiber tracts of interest (or segments thereof – Fig. 10), such as described, for instance, in [9]. *ExploreDTI* also incorporates the PASTA tools [10] so that quantitative measures along the tracts, such as fractional and relative anisotropy, the 'Westin'-measures [11], mean/longitudinal/transverse diffusivity, or other modality information can be calculated.
- **Synthetic fiber phantoms:** *ExploreDTI* allows for the generation of synthetic MR diffusion fiber phantoms with a wide range of architectural complexity given a set of predefined parameters, such as the b-value, voxel size, number of gradient directions, mean diffusivity, width of the fiber bundle(s) etc. [12, 13] (Fig. 11).
- **Visualizations:** In addition to brain surface renderings, diffusion glyphs for DTI/CSD/QBI, and image maps (FA, mean diffusivity, etc.), hyper-streamtubes (streamtubes with variable width – Fig. 12) are integrated to visualize specific local fiber tract properties, such as the 95% "cone of uncertainty" [10]. Snapshot and Movie tools are included for rapid and easy export of key results into presentations.

Summary

Although developed in Matlab, *ExploreDTI* can be compiled as a standalone application, obviating the need for a Matlab licence. *ExploreDTI* can take output from other tracking packages – and provide a way of navigating through them in an efficient manner. *ExploreDTI* incorporates a detailed manual, with worked examples and screenshots to enable you to get quickly acquainted with its many features. More information can be found on <http://www.ExploreDTI.com>.



References [1] Nucifora P *et al*, *Radiology* 245(2):367-84, 2007; [2] Chang LC *et al*, *Magn Reson Med* 53(5):1088-95, 2005; [3] Tuch DS, *Magn Reson Med* 52(6):1358-72, 2004; [4] Tournier JD *et al*, *NeuroImage* 35(4):1459-72, 2007; [5] Leemans A and Jones DK, *Magn Reson Med*, in press; [6] Leemans A *et al*, *ISMRM*, p. 3300, Toronto, Canada, 2008; [7] Bassar PJ *et al*, *Magn Reson Med* 44, 625-32, 2000; [8] Jones DK, *IEEE Trans Med Imaging* 27(9):1268-74, 2008; [9] Wakana S *et al*, *Radiology* 230(1):77-87, 2004; [10] Jones DK, *Magn Reson Med* 53(6):1462-7, 2005; [11] Westin CF *et al*, *Med Image Anal* 6(2):93-108, 2002; [12] Leemans A *et al*, *Magn Reson Med* 53(4):944-53, 2005; [13] Close TG *et al*, *ISMRM*, p. 431, Toronto, Canada, 2008