

A frame-work for DTI Quantitation, Visualization & Analysis

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Introduction: DTI^{1,2,3,4} is an important tool to study brain white matter anatomy/abnormalities. Unlike conventional MRI, DTI requires pre and post processing to produce results. The data processing and analysis in DTI is quite elaborate and so far no commercial and easily extendable/modifiable tool for the same is available. As the importance of DTI technology in clinical practice is growing, the need of a frame-work that researchers and clinicians can use to rapidly process, visualize and analyze DTI data with user friendly interfaces becomes paramount. In view of the same, we present a tool frame-work focusing on DTI technology combining all of the above needs. It is developed using JAVA and C++. It has 4 mutually independent modules namely DTI Processing Module, DTI Visualization Module, ROI Analysis Module and Tracking and Fiber data Visualization Module. The Tool can read various data formats from different scanners including the raw binary format. An automatic de-scalping procedure (limited to axial slices) is also implemented.

Methods: A. DTI Processing Module (Fig. 1): In general, the DTI data analysis involves three major steps: pre-processing, processing, and post-processing. The module performs extraction of tensors and calculation of standard anisotropy indices e.g. FA, RA, ADC, CL, CP, CS, lattice index. It returns the calculated DTI indices along with the tracked fiber bundles in a structured file. The module has: **1. Input-Output module:** with (I) Support for DICOM, ANALYZE, Raw Data in binary format. (II) Support for about 30 standard diffusion encoding schemes including icosahedra⁴, dodecahedra⁴ and standard 6 dir. It also accepts directions by manual feeding. **2. AIR Registration⁵ & Distortion Correction module** corrects the DTI data for shear, scale, rotation, and translation distortions using an automated image registration (AIR⁵) package. The process is necessary because image corruption often occurs due to motion-related phase errors. **3. Cropping module** allows the manual and automatic Cropping of DTI data which decreases the processing time. **4. De-scalping⁶ module** performs brain segmentation on b₀ images (limited to axial slices) which facilitates registration of DWI to b₀-images. **5. Data scaling module** performs the rescaling of DTI data using Linear/Cubic convolution/Cubic B-Spline/Cubic O-MOMS/Quintic B-Spline. **6. Data smoothing module** has Box, Mean, Median, Anisotropic Diffusion Filtering and Gaussian smoothing as options. The smoothing can be performed pre or post tensor calculation from the DTI-data. **7. Fiber tracking^{2,7} module** supports three different tractography methods (Euler, Modified Euler, 4th order Runge-Kutta) with a choice of regularization parameters. The fiber density index can also be calculated.

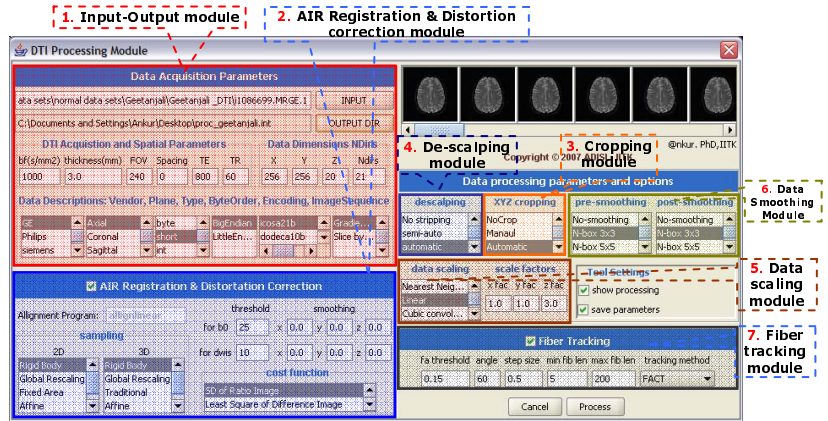


Figure 1: A screen shot of *DTI Processing Module* demonstrating all the sub modules.

B. DTI Visualization Module (Fig. 2) takes the structured file generated from the DTI Processing module as an input. The module has: (I) 2-D Visualization of Axial, Sagittal and Coronal Planes of DTI indices and overlay maps. Views can be connected, flipped, zoomed. (II) Supports general purpose digital image processing routines e.g. smoothing, histogram facilitating visualization. (III) ROI Analysis can also be performed on any of the planes (Statistics being displayed simultaneously in a table, which can be imported to MS-EXCEL). ROI's can be connected and zoomed.

C. ROI Analysis Module (Fig. 3) (I) Allows zooming and selecting ROI's (on Axial, Coronal, Sagittal) of type rectangle, oval, polygon and freehand. (II) Selected ROI's can be listed, rotated, renamed, saved, and reloaded. (III) Computes statistics of derived DTI indices in ROI's and shows them in a table. (IV) To facilitate the ROI placement for quantitative analysis, the DTI-derived maps can be displayed and overlaid on images with different contrasts.

D. Tracking and Fiber data Visualization (Fig 4): (I) Fiber tracking can be done within an ROI for a specified FA threshold. (II) Fibers can be overlaid (as streamlines or streamtubes), using lengths (in number of voxels) as threshold, with three standard orthogonal slices as reference planes. In addition, individual fibers can be displayed with color-coded fractional anisotropy.

Results & Discussion: The introduced frame-work has a nice user friendly interface and memory efficient data structure to make it more robust. It is also free from any dependencies of other libraries. The platform independency and rich features of the tool ensures to fulfill the needs of multiple user bases. Since most common MR file standards are supported, the frame-work is easy to adapt to most of the MR facilities. Furthermore the results (processed, maps, ROI analysis) of the frame-work can either be imported into the most common statistical programs (e.g. EXCEL, ImageJ) or can be saved as images. The Perfusion Imaging (DCE-MRI) data quantification techniques are also being included in the present frame-work. This extension will allow the fusion studies of DTI and Perfusion. The tool has been validated at SGPGIMS, Lucknow, India and AIIMS, Delhi, India and tested on datasets for different scanners and patient/normal studies.

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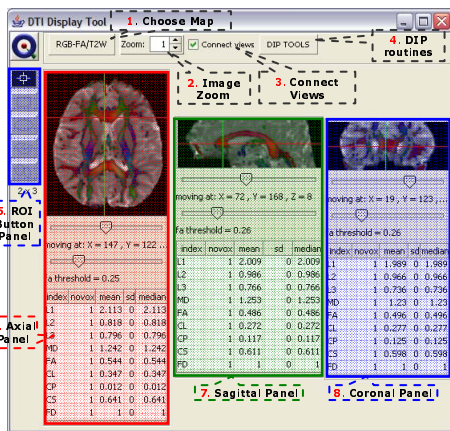


Figure 2: A screen shot of *DTI Display Module* demonstrating all the sub modules

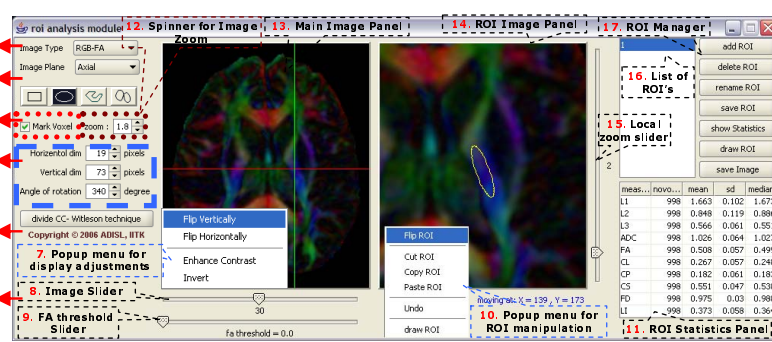


Figure 3: A screen shot of *ROI Analysis Module* demonstrating the sub modules

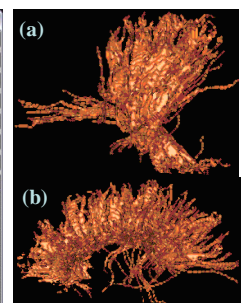


Figure 4: (a) CST tracked from a region around the middle axial slice (b) CC tracked from a region on the middle sagittal slice