Brainnetome dMRI Toolkit: An Integrated Software Package for Analyzing Brain Diffusion MRI Data

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Introduction:

Diffusion MRI is a non-invasive imaging technique that, to date, is unique in that it can be utilized to reveal the white matter fibers of the in-vivo human brain (Assaf, et al., 2013). There are various software packages written in different programming languages that can process diffusion tensor imaging (DTI) data, high angular resolution diffusion imaging (HARDI) data as well as perform fibertracking, network analysis and visualization. However, most of the existed software packages only include some of these functionalities. Here we developed an integrated software package called Brainnetome dMRI Toolkit that can be used to perform reconstruction, tractography, structure connectivity based network analysis and 3D visualization. It can not only process DTI data but also work on single or multiple-shell HARDI data.

Methods:

Brainnetome dMRI Toolkit is written in C++ and Graphical User Interface (GUI) is implemented with Fast Light Toolkit (http://www.fltk.org). Visualization Toolkit (http://www.vtk.org) is used for the visualization part to display MRI images, tensors, orientation distribution function (ODF) glyphs, fibers and brain networks. The software is compiled on various operation systems to make it stand-alone, cross-platform (including Windows XP/7 and Linux) and fast. In the HARDI component of the software, spherical polar Fourier imaging method (Cheng, et al., 2010) and constrained spherical deconvolution method (Tournier, et al., 2007) are implemented to handle single sphere or multiple spheres HARDI data. In the fibertracking component, we provide a deterministic streamline method modified from the fiber assignment by continuous tracking (Mori, et al., 1999) to deal with multiple principal directions in the ODF.

Results:

Brainnetome dMRI Toolkit, an integrated software package that can handle diffusion MRI data is developed. Figures 1 and 2 show the reconstruction interface and fibertracking interface of Brainnetome dMRI Toolkit. The software package consists of four major components: reconstruction, fibertracking, network analysis and visualization. The major features are: 1) Integration of multiple process and analysis methods in diffusion MRI. All the operations can be achieved in the interface of the software by clicking mouse. Every component is assigned according to the usual analysis procedure of diffusion MRI data. 2) Support various types of diffusion MRI data, including DTI data, single shell and multiple-shell HARDI data. The software provides the reconstruction of diffusion tensor, diffusion ODF and fiber ODF. 3) The computation part provides two operation modes: GUI-based mode for ease of use and command-line based mode for efficient batch processing. The user-friendly interface helps users to get start with the software quickly and easily. The command-line mode allows researchers to write specific scripts to process big data automatically. 4) Whole brain and region of interest based (inclusion, intersection, union and exclusion) fibertracking both are available. It offers the function that exports tract density imaging (Calamante, et al., 2010) and a statistics (number of fibers, mean fiber length, mean FA and so on) on the tractography after tractography is generated. 5) It provides the function of network analysis. Some topological properties, such as degree, path length and efficiency, can be computed to measure the architecture of the brain networks (Jiang, 2013).

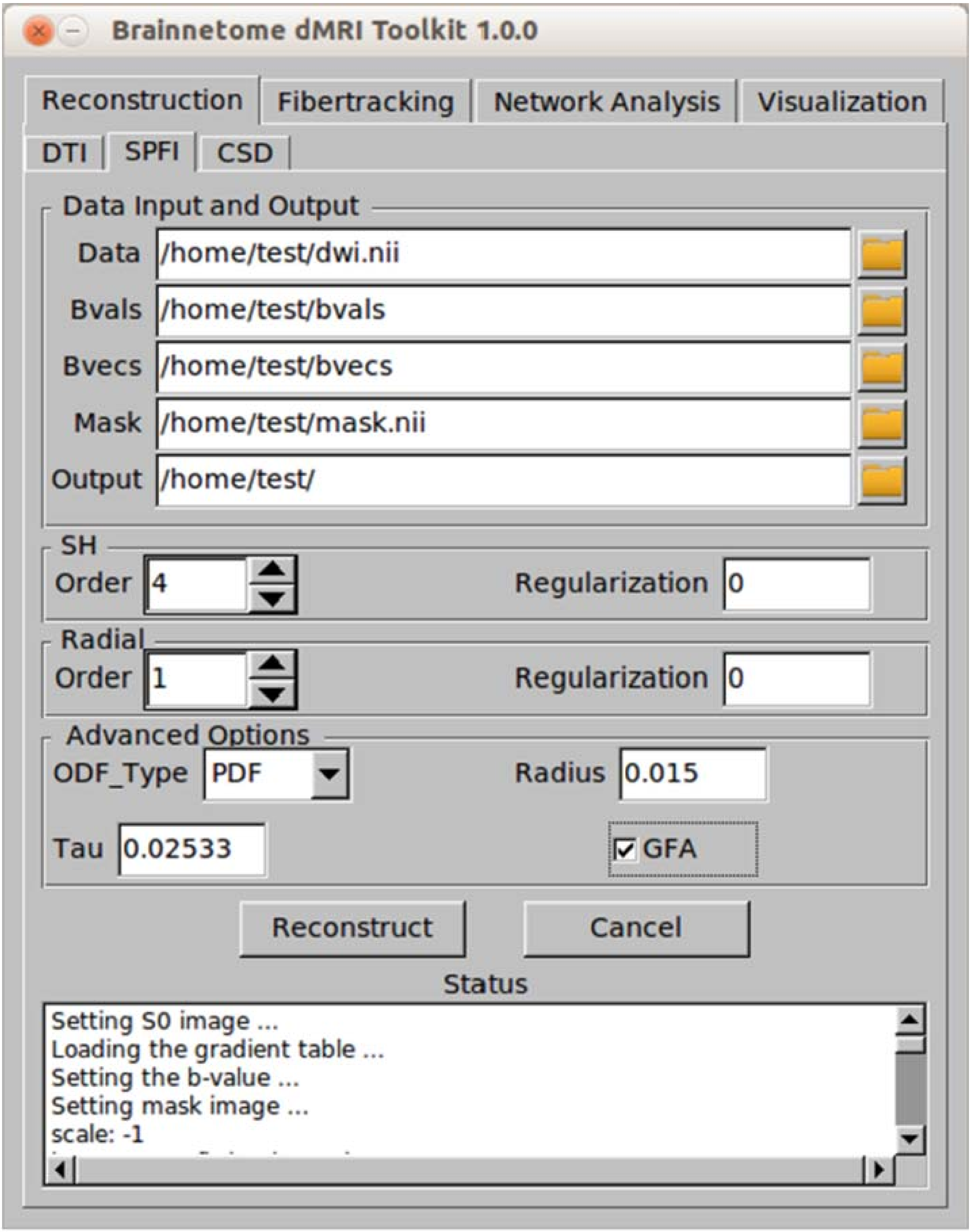

Figure. 1 The reconstruction interface of Brainnetome dMRI Toolkit.

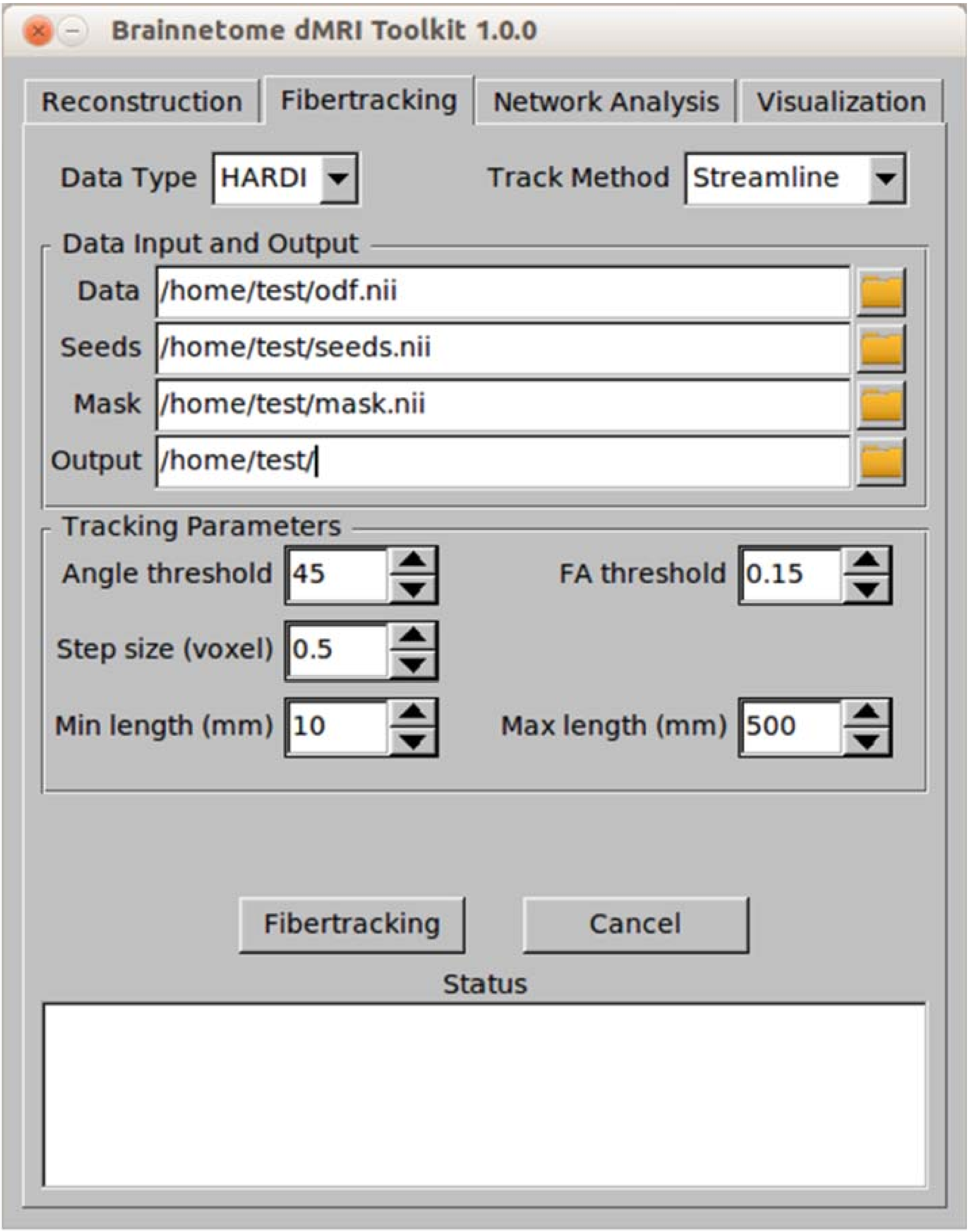

Figure. 2 The fibertracking interface of Brainnetome dMRI Toolkit.

Conclusions:

Brainnetome dMRI Toolkit is a versatile software package that can process, analyze and visualize different types of diffusion MRI data. Both researchers and clinicians can use this software package to reconstruct tensor and ODF quickly, obtain white matter tracts efficiently, construct structure network with the tractography and perform network analysis. They can view and handle the images, tensors, ODF glyphs and fibers in the visualization part interactively. The software package has been adapted to various diffusion MRI datasets successfully.

Modeling and Analysis Methods:

Diffusion MRI Modeling and Analysis

Reference

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