

Diffusion Tensor Tractography

The objective is to understand brain connectivity and integrity through quantitative analysis of DT-MRI images (Diffusion Tensor – Magnetic Resonance Imaging).

MRI is an imaging technique used in medicine to produce high quality images of the internal physical and chemical characteristics of a specific object under examination. The mobility of water to diffuse across fiber tract boundaries is restricted, causing water to diffuse anisotropically, i.e. there is more diffusion in directions parallel to fiber tracts than in perpendicular directions. Diffusion-Weighted Imaging (DWI) allows one to measure the amount of water diffusion at different positions in the biological tissue. However diffusion can no longer be characterized by a single scalar for an anisotropic environment. The diffusion coefficient, as obtained by DWI, can be generalized to the diffusion tensor D which allows one to describe the molecular mobility along any direction. In general, the symmetric second-rank tensor D can be calculated for each voxel of the 3D stack.

Eigen vectors of the diffusion tensor represent the principal directions of diffusion ellipsoid while eigenvalues represents the squares of the semi-axes lengths. These allow the size, shape and orientation of the diffusion ellipsoid to be calculated. The direction of the fibers is collinear with the direction of the eigen-vector associated with the largest eigen diffusivity.

The existing algorithms can be categorized on the basis of what is measured and where it is being measured. The easiest to measure and the most common quantitative parameters are scalar diffusion parameters, such as fractional anisotropy or tensor eigenvalues. In the literature, to date, three major approaches have been pursued to define the location where quantitative parameters are measured: Region of interest (ROI)-based methods, Voxel-based methods, and Tract-oriented methods. ROI-based methods are by far the most popular in clinical studies. Parameters, such as fractional anisotropy (FA), are measured in manually or semi-automatically defined regions of interest and averaged over groups of healthy and diseased populations. In voxel-based quantitative analysis, the data sets are registered into a common coordinate system and then averaged and compared voxel-by-voxel. An alternative approach is to compute the parameters of interest along fiber trajectories.

As the manual ROI selection is the primary source of problems in the ROI based methods, to circumvent this manual selection, a new map (called Stable Fiber Mass (SFM) map) is prepared which defines the boundaries of the white matter structures in an automated manner based on the segmentation of the Principal Eigen Vector Field (PEVF) of the entire dataset. This presentation describes in detail the SFMP map, its advantages and its limitations.