Reconstruction of Neuronal pathways by Diffusion-Weighted MRI

Fibre tracking is a method for the reconstruction of neuronal pathways using measurements of the anisotropic diffusion of water molecules in the fibrous structure of white matter. Such information is made available by a recent advances in magnetic resonance imaging (MRI). Fiber tracking promises a high impact in fundamental neuroscience and its clinical applications.

Global Reconstruction of Neuronal Pathways

Fiber tracking approaches can be divided into two groups: local and global methods. Local methods construct fibers independently path-by-path, the fibers do not influence each other. The reconstruction of long neuronal pathways is performed in small successive steps, either deterministic or probabilistic by following the local, voxelwise defined distribution of fiber directions. A major problem of such methods is difficult to resolve regions of crossing fibers by a chain of local decisions. Another problem is that a minor imperfection in the rule of performing local steps can accumulate and significantly affect the final result.

Download the Algorithm .

Transcallosal fibers color-coded by their saggital position in corpus callosum.

To overcome this problems, we have pioneered a novel, global approach to fiber tracking, in which the number and shape of fibers found in the whole brain are adjusted to the best agreement with measured diffusion-weighted signal (HARDI), taking into account the preliminary knowledge about their geometry. This approach, inspired by the path integral formulation of a free energy in statistical physics, results in a high quality fiber reconstruction within clinically acceptable time frame. The method has been quantitatively validated in a phantom, winning the 1st place at the Fiber Cup, a competition between 10 tracking algorithms, in September 2009. Our global tracking algorithm, together with other quantitative tools, are implemented in our free DTI and Fibertools Software .

Our Method [7] won the FiberCup 2009 (DMFC in conjuction with MICCAI'09)

Scores and summary
, presentation of
the winners
and summarizing
paper

The winning tracking result on the physical phantom [6].

An anterior crossing region is nicely resolved by our approach

PhD projects of: Dr. Björn W. Kreher (former group member)

MDT/SDT Method [1]

Detection and resolving of neuronal fiber crossings by using a more complex model than the diffusion tensor resolving more fiber directions and take into account partial volume effects.

Combining Probability Maps [2]

Mapping the probability of connectivity is a powerful tool to determine the fiber structure of white matter in the brain. These probability maps are related to the degree of connectivity of the seed area. Nevertheless, in many applications it is necessary to isolate a fiber bundle connecting two areas. Multiplying two probability maps with different seed areas, results a new map. However, this maps show not exactly the connectivity between the two ROIs, but also fibers starting from these ROIs and join proceeding to another brain region (false-positive). In this paper we introduce a method, suppressing these false-positive detected areas.

Contact Person

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- Dr. Marco Reisert

Publications

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[3] B.W. Kreher, I. Mader, V.G. Kiselev: Gibbs Tracking: A Novel Approach for the Reconstruction of Neuronal Pathways. Magnetic Resonance in Medicine 60(4), 953-963, 2008

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