BRAINLAB

iPlan® FiberTracking

Clinical White Paper

OVERVIEW

With iPlan FiberTracking, anatomical images are enhanced with information about neural structures. These fiber bundles can be tracked by using so-called Regions of Interest (ROI) for easy local detection of selected bundles or whole neural connection networks. iPlan FiberTracking can be easily combined with BOLD MRI Mapping to provide a powerful and comprehensive functional package with information about significant white matter structures, eloquent functional areas and different perfusion maps. This combination offers detailed information about the topographic relation of functional brain areas that are near a lesion and the connecting fibers originating from these regions.

INTRODUCTION

Diffusion imaging is based on the measurement of diffusion anisotropy in the brain using diffusion weighted images that were scanned in several directions. Such scans can be used to get information about the local diffusion of water molecules. As water diffusion would be isotropic in uniform tissue, anisotropic regions in white matter reflect areas of different density. Water molecules moving along neural pathways can thus be tracked by following the major diffusion direction as long as the FA value, an anisotropic coefficient, is over a certain threshold.
DTI represents diffusion information that can be applied to identify major white matter tracts such as the pyramidal tract or the visual pathways. Displacement or interruption of white matter tracts caused by a tumor or edema can be easily detected with this technique. For technical details see papers [1-4].

TECHNICAL BACKGROUND

PREPOCESSING

Diffusion weighted images with at least six diffusion directions and the corresponding B0 are needed for the calculation of volumetric diffusion information. The result is a volume containing tensor values (DTI: diffusion tensor imaging) that describes the information about the local diffusion in each voxel of the original data. Eddy current correction can be applied as preprocessing step to improve registration of the DTI volumes. This is useful as DTI images are susceptible to distortions caused by eddy currents induced by the different gradients. This causes potential shift, scale and shear artifacts in the phase encode direction.
The import of DICOM diffusion data includes the conversion of the data and the calculation of additional maps containing the apparent diffusion coefficient (ADC) and the fractional anisotropy (FA). Noise artifacts outside of the brain are deleted based on a mask obtained from the B0 images. All generated image sets are automatically co-registered to each other and can be fused to the anatomical images (i.e., MPRAGE data) by an automatic rigid registration.

TRACKING ALGORITHM

BrainLAB implemented a tracking algorithm based on a local diffusion approach. Starting at any point in the volume, a fiber is constructed step by step by following the Principal Diffusion Direction (PDD), provided the local diffusion is higher than a threshold that is used as stop criterion. In a second step, we start again at the same point and repeat the procedure along the inverse PDD to get the second half of the fiber. By using several seed points located in one or more ROIs, the connecting fiber bundles can be tracked. This approach is called FACT (fiber

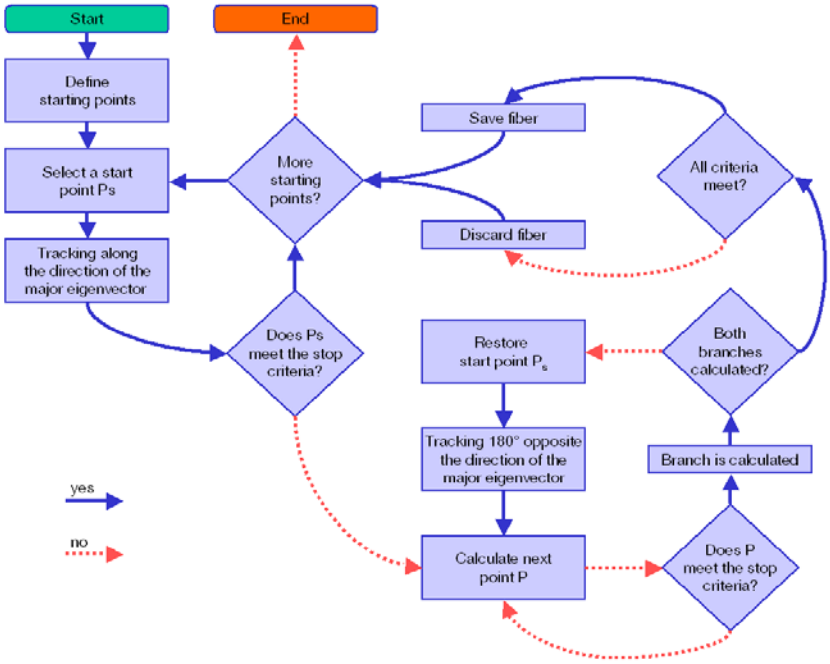

Figure 1: Schematic overview of the tracking algorithm

assignment by continuous tracking) and was first published by Mori et al (see [1]). To get smooth results despite of the low resolution of normal DTI scans, the tensors are interpolated from the surrounding voxels.
This attempt to pass such areas was first described by Weinstein et al [2]. and is called Tensor Deflection (TEND).
The result of the tracking is a parametric display of fibers, which is represented as streamlines, using the standard direction color encoding. Fibers oriented from left to right are displayed in red, anterior to posterior in green, and cranial to caudal in blue. Simple Boxes, hand drawn areas, and existing objects can be used as ROI. Additionally, existing objects can be enlarged to cover white matter structures near functional areas. Depending on the size of the ROI, seed points are set more or less densely to assure a minimum number of seeds. Thereby, small ROIs lead to very dense fiber bundles whereas large ROIs give a good overview about global white matter structures.

REFERENCES

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