An Approach To Tensor Fields Reorientation Based On Optimized Neighborhood

Dongrong Xu[1] Susumu Mori[2] Dinggang Shen[1] Christos Davatzikos[1]

[1]SBIA, Department of Radiology
University of Pennsylvania
Philadelphia, PA 19104
Email: {xdr|dgshen|Christos}@rad.upenn.edu
[2]F. M. Kirby Research Center for Functional Brain Imaging
Johns Hopkins University
Baltimore, MD 21287
Email: susumu@rad.upenn.edu

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Abstract

Introduction

Diffusion tensor imaging (DTI) is a potentially powerful way to map white matter fibers *in vivo* and study effects of development, aging and diseases on specific white matter tracts of interest. However, the clinical utility of DTI is currently limited. Jointly examining diffusion tensor images from many individuals can statistically characterize the complex white matter architecture and improve the ability to detect abnormalities in brain connectivity. Nevertheless, applying spatial normalization to tensor fields is more complicated than applying it to scalar images [1]. This is because that the tensor must be reoriented on each image voxel, in addition to a voxel displacement that is implied by the spatial normalization transformation. This can be achieved by finding the rotational component of the spatial normalization transformation. Moreover, this rotation depends on the actual orientation of the underlying fiber, which is not known *a priori*.

Method

We solve this problem by adopting a statistically based reorientation strategy in an optimized neighborhood at each voxel. By estimating the probability density function (pdf) of the underlying fiber, based on the tensor measurements, an appropriate rotational component can be estimated. Applying this strategy to both the first and second principal directions (PD), the tensor measurements can be properly reoriented. The optimized neighborhood is essential for the estimation of the underlying fiber orientation and subsequently the reorientation. With T_1-weighted images co-registered with DTIs or derived fractional anisotropy (FA) maps of DTIs, displacement field is generated by using HAMMER[2]. The displacement defines voxel relocation and forms the basis of our reorientation estimation.

We tested our algorithm with both simulated data and real data from normal volunteers. In the simulation experiment, we designed a tensor field with 5 different configurations at different levels of noise. We then applied our algorithm to normalize them and examined the result. We also tested it on a group of 9 normal volunteers. An atlas was generated based on the group of healthy subjects.

Results

All subjects in the 2 experiments are properly normalized to the template space, with tensors appropriately reoriented. In the 9-subject atlas, noise was removed. With the simulation data, examination of the warped results against the ground truth by measuring the PD coincidence show that our algorithm takes advantages over the reorientation strategy without considering the noise issue as done in [1](see Fig. 1).

Discussion

We have developed a statistically based tensor fields normalization method, which can properly reorient the tensors. Our goal is to use this methodology to determine a voxel-wise statistical representation of the diffusion tensor properties in normal populations. This representation can be then used as normative data to identify particular fibers that are affected by disease.

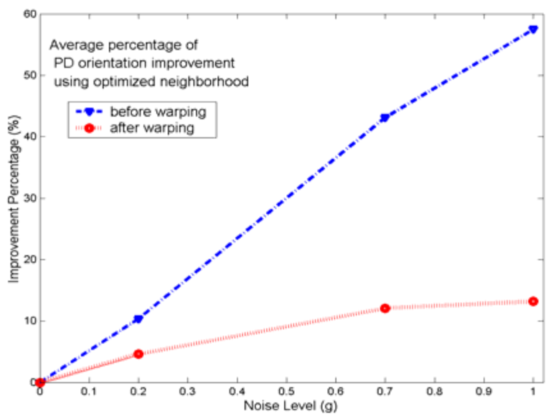

Figure 1

References

[1] D.C. Alexander, et al., IEEE TMI November 2001.

[2] Dinggang Shen, Christos Davatzikos, IEEE TMI, November2002.