The Johns Hopkins University

Whiting School of Engineering

Department of Electrical and Computer Engineering

Fiber Tracking and Fiber Tract Segmentation Using Diffusion Tensor Imaging

Dissertation Defense by

Chuyang Ye

Graduate Research Assistant

Electrical and Computer Engineering

Abstract

Diffusion tensor imaging (DTI) has become a popular tool for noninvasively investigating fiber tract structures. Fiber tracking and tract segmentation are two major tasks in DTI studies. However, fiber crossing is a well-known issue in DTI because DTI cannot model crossing fiber orientations (FOs). Therefore, fiber tracking and tract segmentation methods that are able to address crossing fibers are needed. In this thesis, three contributions are made to the development of such fiber tracking and tract segmentation algorithms.

First, a fiber tracking method guided by volumetric tract segmentation is presented. Tract segmentation contains anatomical information which can reduce the errors caused by crossing fibers and noise. The FO estimation problem is formulated in a Bayesian framework and the resulting objective function is solved with calculus of variations. The proposed method is able to reduce false positive fibers and generate fibers that correspond to known anatomy. It is also applied to a brain connectome study to show its potential scientific application. Second, we present an algorithm for resolving crossing fibers in situations where limited diffusion gradient directions are achievable. In particular, the algorithm is focused on interdigitated tongue muscles. It incorporates prior knowledge on likely FOs to account for the insufficient information due to limited diffusion gradient directions. Using *max a posteriori* estimation, FOs can be estimated by solving a weighted ℓ_{1}-norm regularized least squares minimization. The method is shown to reduce the effect of noise and resolve crossing fibers with limited DTI. The distributions of the computed FOs in both the controls and the patients were also compared, suggesting a potential clinical use for this methodology. Third, a white matter tract segmentation method is proposed. The method focuses on the cerebellar peduncles, which are major white matter tracts in the cerebellum. The method uses volumetric segmentation concepts based on extracted DTI features.

The crossing and noncrossing portions of the peduncles are modeled as separate objects. They are initially classified using a random forest classifier together with the DTI features, and then refined by a multi-object geometric deformable model. The method is shown to achieve better segmentation results than two atlas-based methods. In the study on spinocerebellar ataxia type 6 (SCA6), the proposed method is shown to reveal anatomical changes in the patients, which demonstrates the benefit of the method for scientific purposes.

Monday, December 8, 2014

1p.m.

Barton 117

FOR DISABILITY INFORMATION CONTACT: Janel Johnson (410) 516-7031 janel.johnson@jhu.edu