The Johns Hopkins University

Whiting School of Engineering

Department of Electrical and Computer Engineering

Human Brain White Matter Analysis Using Tractography-An Atlas-Based Approach

Dissertation Defense by

Kegang Hua

Graduate Research Assistant

Electrical and Computer Engineering

Abstract

The human brain is connected via a vastly complex network of white matter fiber pathways. However, this structural connectivity information cannot be obtained from conventional MRI, in which much of white matter appears homogeneous. Diffusion tensor imaging can estimate fiber orientation by measuring the anisotropy of water diffusion. Using tractography, the brain connectivity can be studied non-invasively.

Past tractography studies have shown that the cores of prominent white matter tracts can be faithfully reconstructed. Superimposing the tract coordinates on various MR images, MR metrics can be quantified in a tract-specific manner. However, tractography results are often contaminated by partial volume effect and imaging noise. Particularly, tractography often fails under white matter pathological conditions, which render tract-specific analysis impractical.

In order to address these issues, we introduced an atlas-based approach. Four novel atlas-based approaches were included in this data analysis framework. First, statistical templates of major white matter tracts were created using a DTI database of normal subjects. The statistical white matter tract templates can serve two purposes. First, the statistical template can be used as a reference to detect abnormal white matter anatomy in neurodegenerative diseases. Second, the statistical template can be applied to individual patient data for automated white matter parcellation and tract-specific quantification.

In the second approach, the trajectory of white matter fiber bundles was used to estimate the cortical regions associated with specific tracts of interest. Using this approach, cortical regions were reproducibly identified on the population-averaged cortical maps of brain connectivity.

Third, we improved the accuracy of the population-based tract analysis by incorporating a highly elastic image transformation technique, called Large Deformation Diffeomorphic Metric Mapping (LDDMM). As a testament to the power of this algorithm, we successfully applied tract-specific analysis on Alzheimer's patients.

The last approach was to analyze the brain cortical connection networks using automatic fiber tracking. A tracking pipeline was built by combining White Matter Parcellation Map (WMPM), brute-force tractography and topology-preserving image transformation LDDMM. This novel tracking pipeline was applied on patient group with Alzheimer's disease. The connectivity networks of Alzheimer's patients were compared with age-matched controls using multivariate pattern classification.

Wednesday, September 10, 2014

10 a.m.

Maryland 104

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