Washington University in St. Louis

SCHOOL OF ENGINEERING & APPLIED SCIENCE

Preston M. Green Department of Electrical & Systems Engineering

Seminar Announcement

Anastasia Yendiki

Assistant Professor of Radiology, Harvard Medical School

Assistant Physicist, Massachusetts General Hospital

Wednesday, February 7, 2018

Green Hall, Room 0120

3:00 P.M.

Title: Inference on Brain Circuitry from Diffusion-Weighted MRI

Abstract: Several aspects of the structure and function of the human brain are still poorly understood. One such aspect is the wiring of the brain, i.e., the white-matter axon bundles that are responsible for transporting signals between brain regions. Currently the only non-invasive modality for imaging this wiring is diffusion-weighted magnetic resonance imaging (dMRI). A dMRI scan consists of a set of images that are weighted by the displacements of water molecules in a set of different directions. These images are used to infer the preferential direction of diffusion at each brain location. Following these diffusion vectors around the brain allows us to reconstruct the shape of white-matter axon bundles.

Parsing dMRI scans manually to identify different brain pathways is time consuming and requires extensive neuroanatomical expertise. In this talk, I will discuss our work on algorithms for performing this task automatically, in a manner that is robust to the effects of disease, as well as the normal changes that occur in the brain across the human lifespan. One part of this work addresses the problem of reconstructing a set of pre-defined white-matter pathways based on manually labeled training data. For this purpose, we have developed a Bayesian framework for estimating the posterior probability distribution of a pathway given an individual's dMRI data, using prior information on the pathway's anatomical neighborhood from the training data. Another line of work addresses the problem of generating paths from all possible brain locations and grouping the hundreds of thousands of resulting paths into clusters, in the absence of any training data. For this purpose, we have proposed a novel anatomical similarity metric and incorporated it into a hierarchical clustering algorithm.

Finally, I will discuss some of the open challenges in this area. Despite the advances of recent years in dMRI acquisition and analysis methods, the resolution of in vivo dMRI scans is still not sufficient for reconstructing the full complexity of the wiring of the human brain, leaving room for errors and ambiguities. While image segmentation problems are being revolutionized by deep learning algorithms, these techniques cannot be applied readily to our problem, due to the lack of high-quality ground truth data on human connectional anatomy that could be used to train such an algorithm. A current direction of our work is to develop accurate models of human white-matter anatomy from post mortem imaging data acquired with MRI and with polarization-sensitive optical coherence tomography, which allows direct visualization of axonal orientations at microscopic resolutions. Our goal is to use these post mortem data not only to validate in vivo reconstructions of connectional anatomy and microstructure, but also to generate prior information on these features that can be used to improve their reconstruction from lower-resolution, in vivo dMRI scans.

Host: R. Martin Arthur