Shape and Connectivity Analysis of the Brain in a Continuous Framework

Analysis of surfaces plays an important role in brain MRI processing. Surfaces representing boundaries of functionally and structurally distinct regions, such as the cortex and subcortical structures, can be locally analyzed and compared in lieu of full volumetric analysis. Succinct and easily visualized, such a representation offers tremendous power for morphometric analysis. However, the non-Euclidean nature of surface geometry significantly complicates this approach compared to volume-based methods.

On the other hand, Diffusion MR imaging allows us to model structural connections in the brain via tractography. Once the geometry of the fiber tracts is known, it can be used to model the relative interconnectedness between brain regions directly. However, the challenge here lies in the fact that both tractography results and cortical parcellations are highly variable. This fact, coupled with the all-or-nothing nature of discrete connectivity, often leads to decreased robustness of the network measures typically used for connectivity analysis.

This talk will be divided into two parts. In the first half, Dr. Gutman will describe some methods for cortical and subcortical shape registration and description. The focus will be on spherical parameterization and non-linear mapping of shapes. Further, he will describe a recently developed Riemannian framework based on a distance on spherical metric tensor fields. Some uses of the framework will be presented.

The second half of the talk will be devoted to the idea of continuous connectivity analysis. Traditional analysis of structural brain connectivity relies on established anatomical parcellations. An alternative approach is to treat the brain connectome as a continuous kernel. This paradigm lends itself naturally to many standard techniques from structural MR, such as registration and segmentation. Dr. Gutman will show some work on registering cortical surfaces based on their continuous connectedness and anatomy simultaneously. Further, he will show how connectivity registration leads to more reliable graph-theoretic measures, whose continuous analogues can be computed directly on the kernel.

Dr. Boris Gutman received his BS in Applied Mathematics in 2006 and PhD in Biomedical Engineering in 2013, both from UCLA. His graduate work focused on analysis of brain MRI, using tools from Differential Geometry to analyze brain anatomy. Following his graduation, Dr. Gutman joined the newly formed Institute for Neuroimaging and Informatics under adviser Paul M. Thompson. His current research interests include biomedical shape analysis for the study of disease in the brain, as well as novel analysis of brain structural connectivity and multi-modality fusion.

Monday, January 26, 2015
1:30 – 2:30pm
Herklotz Seminar, ZNI Room 112