Large-Scale Neural Connectivity Analysis using Graph Theory

Devdutta Warhadpande – Masters Student
Computational Biology & Bioinformatics

Friday, January 11, 2008*
2:00 pm – 3:00 pm
COOK 3118 A&B

ABSTRACT:
Functional Magnetic Resonance Imaging (fMRI) is a technique that is used to detect regional changes in blood flow to different parts of the brain. Traditional analysis methods utilize general linear model (GLM) and other statistical methods to figure out the regions of high activation. They do not shed any light on the interactions between the brain-regions. To date there have been no studies on large-scale brain connectivity analysis. In their 2005 paper, Eguiluz et al. tested and validated the method of using pair-wise correlations to generate a functional network. Their analysis revealed that the networks show scale-free properties. We tested this technique on fMRI data from a study at the Speech Research Lab at Northwestern University. We used a data driven approach to analyze the data. Pair-wise correlations between the gray matter voxel (basic unit of an MRI image) intensities of the entire brain were calculated for each condition for all the subjects, where the correlation coefficients represented the probabilities of a connection between the corresponding voxels. Assuming a threshold value, the voxels with coefficients above the threshold were assumed to be connected and those values were converted to 1. All other values were converted to zero. The resulting binary connection matrix was used to calculate the degree (the number of connections) of each voxel as well as the frequency of each degree. A higher degree translated to more connections for the corresponding voxel. Degree distribution plots for the subjects showed power law relationships – a characteristic of scale-free networks in graph theory. We also projected the degrees back to the brain and those results confirmed previous results by Marguilis et al. giving converging evidence for the effectiveness of this method. The graph generated from this data was an undirected, unweighted graph. We are now evaluating the same methods on an undirected, weighted graph. The correlation coefficients are used as weights for each connection and the graph is viewed as completely connected. The weighted degree for each voxel is simply the sum of the weights of all the connections to the corresponding voxel. The advantage of this type of a graph is that an assumption regarding the threshold is not required. Thus, the information given by this graph is more comprehensive. The clustering coefficients for each voxel in both the unweighted and the weighted graphs were also calculated and the analysis is ongoing. (Work supported by NIH)

Research Advisors:
Patrick Wong, Department of Communication Sciences & Disorders
JiPing Wang, Department of Statistics
David Chopp, Department of Engineering Science & Applied Mathematics

* Please note that this presentation has been re-scheduled from an earlier date