Statistical Methods for Neuroimaging Data Analysis

Syllabus for Bios 772, Spring 2015

Instructor: Dr. Hongtu Zhu.

Class Time: 12:30pm-1:45pm: MW.

Class Location: MGH 1304.

Office: McG-G 3105C.

Office number: 919-966-7272.

Office Hours: Appointment.
Please not visit my office without appointment, because I am very busy with multiple duties. Sorry for inconvenience.
If you have any small issues, such as typos in the note and homework assignment, please send me/TA an email.

e-mail: hzhu@bios.unc.edu or htzhu@email.unc.edu

References:

Chen, T. F. and Shen, J. (2005). *Image processing and analysis: variational, PDE, wavelet, and stochastic methods.* Siam.

Grenander, U. and Miller, M. (2007). *Pattern Theory: From Representation to Inference.* Oxford University Press.

Huettel, S. A., Song, A. W., and McCarthy, G. (2009). *Functional Magnetic Resonance Imaging,* Second Edition. Sinauer Associates.

Lazar, N. A. (2008). *The Statistical Analysis of Functional MRI Data* Springer, New York.

Modersitzki, J. (2004). *Numerical Methods for Image Registration.* Oxford University Press, New York.

Packages: The following image packages may be used throughout the course.

FSL, SPM, Fair, Slicer and Connectome Workbench

Data sets:

Please download the testing datasets from http://fsl.fmrib.ox.ac.uk/fslcourse/.

I will release parts of PNC, HCP, and ADNI datasets for your projects.

Prerequisites: Some advanced knowledge of statistical inference and linear models with lots of enthusiasm. More specifically, this course will use extensively some advanced knowledge including **linear models**, **advanced calculus including Taylor expansion and multivariate differentiation**, **Bayesian methods**, and **time series**.

Graders: Chao Huang (Email: huangchao.seu@hotmail.com)

Grading System: Final grade is based on the performance of five projects. The grades reported will be transformed into HPF scale (H: 90-100; P: 70-90; LP: 60-69; F: 0-59).

No middle term and final exams.

Students are required to present a journal paper to demonstrate their understanding of the subject.

Course Description and Goals: With modern imaging techniques, massive imaging data can be observed over both time and space. Such imaging techniques include functional magnetic resonance imaging (fMRI), electroencephalography (EEG), diffusion tensor imaging (DTI), positron emission tomography (PET), and single photon emission-computed tomography (SPECT) among many other imaging techniques. The subject of medical imaging analysis has exploded from simple algebraic operations on imaging data to advanced statistical and mathematical methods on imaging data. This course on statistical methods for MIA is designed to provide students the detailed mathematical and statistical techniques underlying imaging techniques (e.g., imaging cluster) used in the field of medical image analysis, with an emphasis on computer implementation.

This course is designed for researchers and students who wish to analyze and model medical image data quantitatively. The course material is applicable to a wide variety of medical and biological imaging problems. The topics cover basic statistical principle, functional magnetic resonance imaging, diffusion tensor imaging, functional connectivity, image feature, image segmentation, image registration, shape representation, population statistics, and data mining. This course will cover the mathematical and statistical fundamentals and implementation of these methods. For instance, participants will learn basics that will help them to understand the methods and tools built into packages like SPM, FSL, Slicers, and others in order to optimally use them.

Homework: Six homework assignments.

If you have any question regarding homework problems, please directly send an email to TA.

Tips for Success:

(i) Read lecture slices and assigned reading materials carefully before and after class.

(ii) It is critical to solve all homework problems independently.

(iii) Ask TA and instructor directly for helps when you feel uncomfortable with some course materials.

Final: Details to be announced.

Course Schedule:

Topic 1: Introduction

Topic 2: Basic Image Processing Methods

Topic 3: MRI and Functional MRI

Topic 4: PET and MEG/EEG

Topic 5: Diffusion Weighted Imaging

Topic 6: Image Segmentation and Registration

Topic 7: Image Smoothing and MARM.

Topic 8: Functional Data Analysis.

Topic 9: Low-rank Representation.

Topic 10: Manifold Data Analysis.

Topic 11: Prediction Models.

Topic 12: Imaging Genetics.

Topic 13: Big Data Integration.

Typos in lecture notes

Due to time limit, the instructor cannot eliminate all typos in the lecture slides, although he has done his best. The instructor will acknowledge your helps for any typos that you could find.