CogSci 260: Introduction to Diffusion Tensor Imaging
Winter 2016

Week 1:

Jan 05 Lecture 1: Introduction

a. Class objectives
b. Required knowledge
c. Course outline
d. Lab lectures
e. Grading

Jan 07 Lecture 2: Basic mathematics

a. Vectors
b. Matrices
c. Complex numbers

Week 2:

Jan 12 Lecture 3: Diffusion

a. Biological systems
b. Probability theory
c. Microscopic theory: random walk
d. Macroscopic theory: diffusion equation

Jan 14 Lecture 4: MRI: Basic physical principles

a. Spin and bulk magnetization
b. Excitation
c. Isochromats
d. The NMR signal
e. Relaxation
f. Spin echo

Week 3:

Jan 19 Lecture 5: MRI: Image formation

a. The spin echo
b. Magnetic field gradients
c. Spatial modulation of phases
d. The gradient echo
e. The NMR signal
f. The NMR image

Jan 21 Lecture 6: MRI: Relaxation contrast, fast imaging, artifacts

a. Review of spatial location
b. Creating relaxation contrast
c. Snapshot imaging (EPI, spiral)
d. Image artifacts

Week 4:

Jan 26 Lecture 7: MRI sensitivity to diffusion

a. Gradient and phase I: stationary spins
b. Gradient and phase II: flowing spins
c. Gradient and phase III: diffusing spins

Jan 28 Lecture 8: Analyzing the diffusion weighted signal

a. Review of diffusion signal
b. Estimating the diffusion tensor
c. Calculating diffusion parameters

Week 5:

Feb 02 Lecture 9: Basic DTI acquisition

a. NMR diffusion sensitivity reviewed
b. Integration with MRI
c. Basic DTI acquisition
d. EPI artifact correction
e. Sampling schemes
f. Visualization
g. The shape of diffusion

Feb 04 Lecture 10: Lab 1: Basic DTI processing

a. Introduction to the AFNI platform
    i. Computing DTI parameters
    ii. Visualize DTI data and parameters
b. Introduction to the QUEST platform
    i. Computing DTI parameters
    ii. Visualize DTI data and parameters

Week 6:

Feb 09 Lecture 11: DTI artifacts and corrections

a. Static field inhomogeneities
    i. Susceptibility artifacts
    ii. TOPUP
b. Eddy currents
    i. Eddy current generation and effects
    ii. Dual Spin Echo
    iii. EDDY
c. Motion artifacts
    i. Generation
    ii. Navigation

Feb 11 Lecture 12: Tractography I: Standard methods

a. Streamlines
b. Tensorlines

c. Probabilistic methods
d. Visualization

Week 7:

Feb 16 Lecture 13: Spatial Normalization and Group Comparisons
a. The spatial normalization problem
b. Non-linear registration

Feb 18 Lecture 14: Lab 2: QUEST spatial normalization

Week 8:

Feb 23 Lecture 15: Advanced methods I: Inhomogeneous tissues
a. Failure of standard DTI
b. DWI-ESP
i. Probability theory
ii. ESP
iii. Transition probability

Feb 25 Lecture 16: Advanced methods II: Inhomogeneous tissues
a. Failure of standard DTI tractography
b. GO-ESP
i. Probability theory
ii. Macroscopic prediction
iii. Hamiltonian formalism
iv. Geometrical optics

Week 9:

Mar 01 Lecture 17: Lab 3: Fiber tract mapping with QUEST

Mar 03 Lecture 18: Lab 4: CFMRI DTI demo

Week 10:

Mar 08 Lecture 19: Pre-processing of CFMRI data
a. Review of theory
b. Hands on analysis

Mar 10 Lecture 20: Post-processing of CFMRI data
a. Review of theory
b. Hands on analysis