

SDSU Foundations of Neuroimaging 569/769

Professor:

Marty Sereno -- email: msereno@sdsu.edu
time (2022): MWF 9:00-9:50 AM (grad/advanced: F 8:00-8:50)
location: [SSW 2667](#) (occasional Zoom question-sessions TBA)
take hand-written notes for better memory consolidation!
take-home exams, final/paper based on lecture content

Readings:

Huettel, S., A.W. Song, and G. McCarthy (2014) *Functional Magnetic Resonance Imaging*, 3rd ed. (2nd ed. OK, too)
Sereno Lecture Notes PDF (single-page links on homepage)
<http://www.cogsci.ucsd.edu/~sereno/569/notes.pdf>
Additional background readings, references:
<http://www.cogsci.ucsd.edu/~sereno/569/readings.html>

Exams:

[Homework #1](#) (due Oct 11, 2022, code/graphs PDF or printout)
[Homework #2](#) (due Nov 22, 2022, PDF/printout (img [here](#)))
Final Paper: 5(ugrad)/10(grad)-page literature review on narrow methodological topic (~1 paper) (start search in *Magnetic Resonance in Medicine*, *Neuroimage*, *Human Brain Mapping*)

Learning Objectives:

Students will be able to do the following:

- (1) explain precession/excitation/recording/contrast of magnetic resonance signals and echoes using the Bloch equation
 - (2) compute Fourier transform, use it to explain how RF simulation, gradients, and RF coil signals generate k-space data and how brain images are reconstructed from that data
 - (3) diagram main classes anatomical/functional pulse sequences
 - (4) describe diffusion, perfusion, and spectroscopic imaging
 - (5) describe origin/localization of EEG/MEG signals, cortical surface-based methods, and how to combine them w/fMRI
- N.B.: consult with me if a disability hinders your performance so we can use University resources to maximize learning

Lecture Topics: (Fall 2022)

Week of Aug 22 (MWF) -- Introduction

Introduction to Neuroimaging -- MRI, fMRI, EEG, MEG
MRI hardware
Spin and Precession

Week of Aug 29 (MWF) -- Bloch Equation

Bloch Equation
Dot/Cross/Complex Products
Precession solution
Initial-Value Solutions to Differential Equation
T1, T2 solutions
Bloch Equation/Solution -- matrix version

Week of Sep 05 (WF) -- Signal Equation

[no class: Mon, Sep 05]
RF Excitation
Signal Equation
Phase-Sensitive Detection

Week of Sep 12 (MWF) -- Echoes

Free Induction Decay
Spin Echo
Spin Echo Equations
Stimulated Echo, Spin Echo Trains
Gradient Echo, Gradient Echo Trains

Week of Sep 19 (MWF) -- Using the Bloch Equation

Saturation-Recovery Signal
Inversion-Recovery Signal
Spin Echo Signal
Gradient Echo Signal
Gray-White Contrast
Signal-to-Noise

Week of Sep 26 (MWF) -- Fourier Transform

Complex Algebra
Fourier Transform

Negative Exponents, Orthogonality
Spatial Frequency Space (k-Space)
One k-Space Point -- 3 representations

Week of Oct 03 (MWF) -- Gradients, Slice Selection

Gradient Fields
Gradient Combination
Slice Selection
RF Pulse Details

Week of Oct 10 (MWF) -- MRI Image Formation

1st Take-Home Exam Due
Frequency-Encoding -- A Misnomer
Frequency-Encoding -- Incorrect and Correct Intuition
Imaging Equation (ID)
Phase Encoding
3D Imaging
Spin Phase in Image Space
Gradients Move Signal in k-Space

Week of Oct 17 (MWF) -- Image Reconstruction

Image Reconstruction
Aliasing and FOV
Under/Over Sample
Replicas, FTs
General Linear Inverse for MRI Reconstruction

Week of Oct 24 (MWF) -- Practical Pulse Sequences

Fast Spin Echo
Fast Gradient Echo
Quantitative T1/PD/T2* Methods
Gradient Echo EPI, Spin Echo EPI, Single-Shot Spiral
SENSE, GRAPPA, Simultaneous Multi-Slice, 3D EVI

Week of Oct 31 (MWF) -- Image Artifacts

Fourier Shift Artifacts
EPI vs. Spiral Artifacts
Image-Space View Localized B0 Defect
Effect Local B0 Defect on Reconstruction
Shimming, B0-Mapping, Navigators
Gradient Non-linearities
RF Field Inhomogeneities

Week of Nov 07 (MW) -- Diffusion and Perfusion Imaging

Diffusion-Weighted Imaging and Tract Tracing
Perfusion Imaging (Arterial Spin Labeling)
[no class: Fri, Nov 11]

Week of Nov 14 (MWF) -- Phase-Encoded, Block Design

Phase-Encoded Stimulus for Mapping
Convolution
General Linear Model and Solution, Geometric Picture
Cluster Correction -- 3D and Surface-Based
Normalize, Strip Skull, Non-Isotropic Filtering
Region-Growing, Tessellation: 3D -> 2D
Cortical Unfolding and Flattening
Sulcus-Based Alignment

Week of Nov 21 (Mon-only) -- Cortical Surface Methods

2nd Take-Home Exam Due
Cortical Thickness Measurement
Mapping Cortical Visual Areas
[no class Wed/Fri, Nov 23/25]

Week of Nov 28 (MWF)-- Source of EEG/MEG

Intracortical Source of EEG/MEG
Grad, Div, Curl
1D/2D/3D Current Source Density
Why We Can Ignore Magnetic Induction

Week of Dec 05 (MWF) -- Neuroimaging EEG/MEG

Forward Solution
Minimum Norm Linear Inverse
Noise-Sensitivity Normalization

Week of Dec 12 (M)

Spatiotemporal Covariance Filters
Final Paper/Exam: Due Dec 16