Introduction

M229 Advanced Topics in MRI

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Introduction

- Your instructor: Holden
- Your TAs: Wenqi, Timo
- Guest lecturers
  - Dr. Kyung Sung, Dr. Shu-Fu Shih, Dr. Xiaodong Zhong, Dr. Jingwen Yao, Dr. Anthony Christodoulou, Dr. Jason Chiang
- You

MRI Research

<u>Technical Developments</u>

Physics
Contrast mechanisms
Mathematical models
Hardware
Data acquisition
Data reconstruction
Data processing
Quantitative analysis
Data integration
Software

<u>Clinical Applications</u>

Anatomical imaging
Functional imaging
Multi-modal imaging
Quantitative imaging

for

Diagnosis / screening
Treatment planning
Procedural guidance
Treatment assessment
Monitoring

MRI Research

- MRI provides powerful information
- MRI is slow …
  - develop new acquisition and reconstruction methods

Goals of M229

- Understand state-of-the-art MR image acquisition and reconstruction
- Understand impact of MR technical developments on clinical applications
- Prepare for research in MRI

Prerequisites

- M219 or equivalent
- Strong interest in MRI research
- Some programming experience

Course Topics

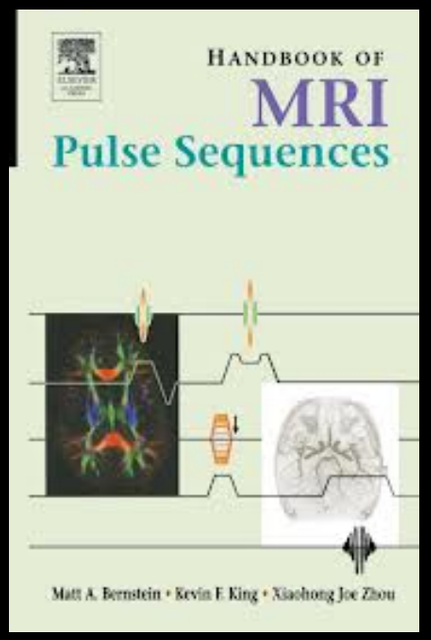
- Pulse Sequences
- RF Pulse Design
- Fast Imaging Trajectories
- Parallel Imaging
- Compressed Sensing
- Deep Learning Recon
- Motion in MRI
- Fat-Water Imaging
- Susceptibility Imaging
- Advanced Applications

Course Logistics

- Textbook: Handbook of MRI Sequences
  - *Digital copy available through UCLA library*
- Course website:

https://mrrl.ucla.edu/pages/m229

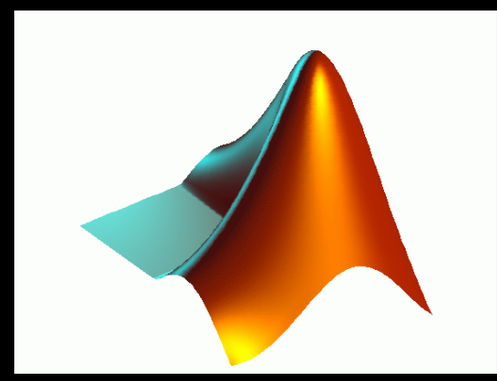
  - Materials and links
  - Sample code and data



- Web resources
  - Past ISMRM education talks
- Mailing list: m229@lists.ucla.edu

Course Logistics

- Office hours
  - Instructor: by appointment
  - TAs: TBD
  - Send email
- MATLAB
  - available through UCLA



Course Logistics

- Grading
  - Participation (10%)
  - Homework (30%)
  - Final Project (60%)
  - Extra Points
- Homework
  - 2 MATLAB programming assignments
  - Turn in electronically (PDF and code)

Final Project

- Have ~6 weeks; start thinking now!
  - Take advantage of office hours
- Can be your own research
- Can be from list of ideas
- Components
  - Proposal (1 page), due in May
  - Abstract (1 page), due in early June
  - Presentation, in mid June

2024 Projects

- Image Synthesis for Multi-Contrast Brain MRI
- Classification of Ischemic Placental Disease Comparing Two Supervised Learning Algorithms
- Weakly Supervised Learning for Multi-parametric Mapping from Conventional Contrast-weighted MRI Images
- Potential of Deep Learning in High SNR Carotid Imaging Informed by Specialty-Coils

2023 Projects

- Random Matrix Theory-Based Image Domain Denoising for Diffusion-Relaxation Correlation Spectrum Imaging
- Comparison of T1-T2 Fitting Strategies Based on Multitasking Framework
- Universal Sequence-Invariant Deep Learning for CMR Multitasking Image Reconstruction
- Fractional Myocardial Blood Volume Estimation using Ferumoxytol-Enhanced Magnetic Resonance Imaging: Early Findings in Human Subjects
- A Novel Local Shim Array for B0 Shimming of the Prostate

2023 Projects

- MRI-based Radiomics Feature Analysis for Clinically Significant Prostate Cancer Diagnosis
- Myocardial Scar Detection in Ferumoxytol-Enhanced Cardiac MRI: A Dictionary Learning Approach Using LGE-Labeled Ferumoxytol-Enhanced MOLLI Images
- Deep-Learning Based Parametric Maps Generation for Undersampled CEST MRI Data
- The Influence of Undersampling Schemes on Compressed Sensing Reconstruction in Brain MRI
- 5D Cardiorespiratory Resolved Imaging with Ferumoxytol for Pediatric Congenital Heart Disease

Questions?

Notation and Conventions

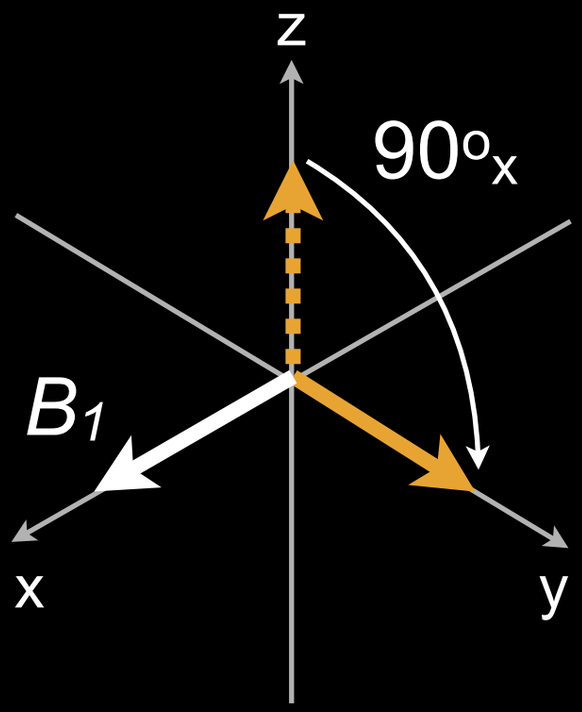
- $\omega = \gamma B$
  - $|B| = B_0 + G_x x + G_y y + G_z z + B_1 + \Delta B$
  - $\omega_0 = \gamma B_0$

- RF pulse
  - flip angle θ
  - phase ϕ (=0 along x)

$$\vec{B} = B_0 \hat{k} + B_1(t)[\cos \omega t \hat{i} - \sin \omega t \hat{j}]$$

Notation and Conventions

- Left-handed rotation and precession



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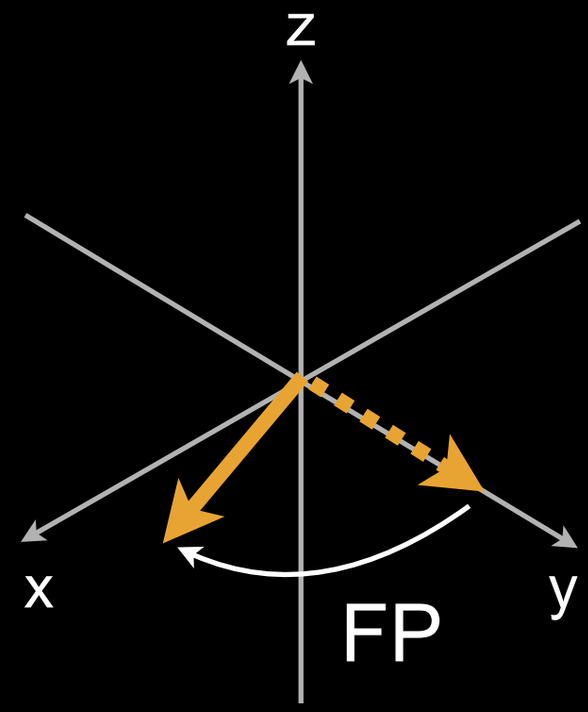

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Preview

- Closer look at course schedule
  - https://mrrl.ucla.edu/pages/m229_2025

Preview: Pulse Sequences

- Rapid Gradient Echo
- Fast (Turbo) Spin Echo
- Bloch Simulation (MATLAB)
- Extended Phase Graphs (MATLAB)

Preview: RF Pulse Design

- Adiabatic Pulses
- Multi-dimensional Excitation
- SLR
- RF Pulse Design Tool (MATLAB)

Questions?

- Related courses of interest
  - PBM 222 MR Spectroscopy
  - PBM/BE M236 MR Contrast Mechanisms

Thanks!

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http://mrrl.ucla.edu/wulab