
Introduction

M229 Advanced Topics in MRI

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UCLA

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Introduction

- Your instructors
 - Holden and Kyung
- Your TAs
 - TBD
- Guest lecturers
 - Drs. Fatemeh Zabihollahy, Kai Zhao
 - Drs. William Hsu, Ida Sonni
- You

MRI Research

Technical Developments

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



Clinical Applications

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

- RF Pulse Design
- Pulse Sequences
- Fast Imaging Trajectories
- Motion in MRI
- Parallel Imaging
- k-t Reconstruction
- Compressed Sensing
- Artificial Intelligence
- Invited Speakers
- Imaging Informatics
- PET/MRI

Course Logistics

- Textbook: Handbook of MRI Sequences

- Course website:

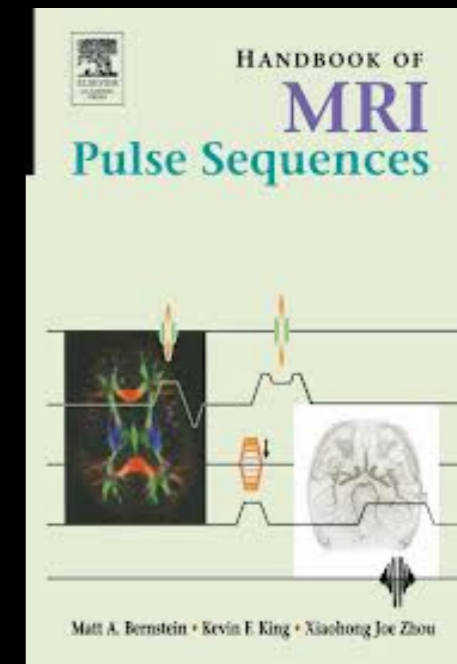
<https://mrrl.ucla.edu/pages/m229>

- with materials and links
- sample code and data

- Web resources

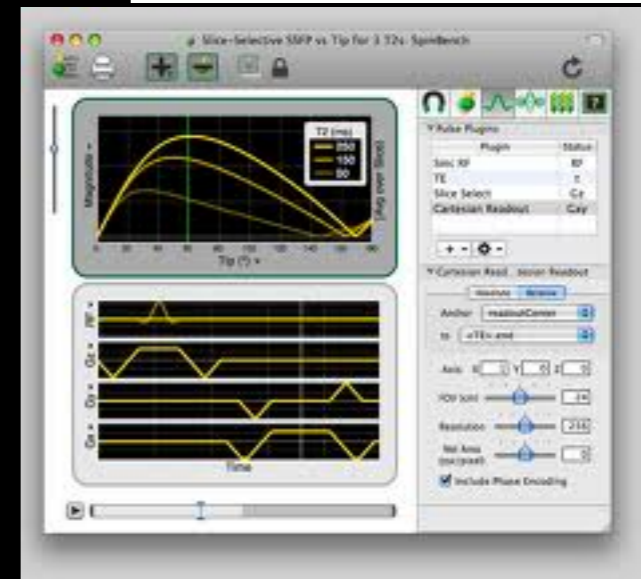
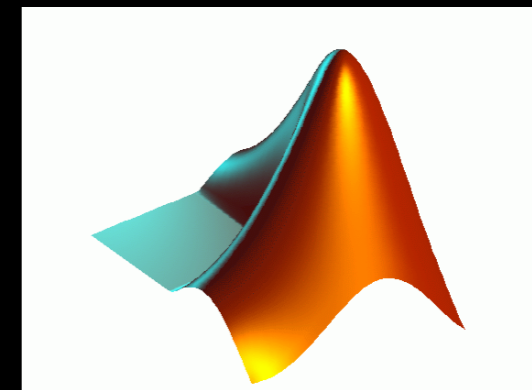
- past ISMRM education talks

- Mailing list: pbm229@lists.ucla.edu



Course Logistics

- Office hours
 - instructors: Fri 10 am - 11 am; appointment
 - TAs: TBD
 - send email
- MATLAB
 - available through UCLA
- SpinBench
 - available for free (Mac only)



Course Logistics

- Grading
 - Participation (10%)
 - Homework (30%)
 - Final Project (60%)
- 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 early May
 - Abstract (1 page), due in early June
 - Presentation, in mid June

2014 Projects

- Evaluation of Temporal Blurring Effect in Dynamic MRI using Golden Angle Radial Acquisition and K-Space Weighted Image Contrast (KWIC)
- Phase Contrast MRI with Flow Compensation View Sharing (FCVS)
- Motion Sensitivity of Diffusion Encoding Gradient Schemes in Cardiac Diffusion MRI
- Comparison of TSE and SSFP for Myocardium T2 Mapping
- Diffusion of Contrast Agent in Dynamic Contrast Enhanced (DCE)-MRI

2014 Projects

- Effects of T1/T2 and B1 on bSSFP Catalyzation
- Real Time MR Imaging Using Dynamic Golden Angle Radial Acquisition with SPIRiT Reconstruction
- Comparing Fat-Water Separation for Radial and Cartesian Acquired Data
- Partially-Dephased SSFP: with Applications in fMRI
- Accelerated left ventricular twist measurement using CAIPIRINHA
- Effects of Under-sampling Pattern on GRAPPA, SPIRiT and ESPIRiT

2015 Projects

- Design and Validation of a Minimum Time VERSE Pulse for 4D Flow MRI
- Polymer Drug Delivery Release Study: Modeling In Vivo Drug Release Using Contrast Agent
- T2-Prepared Gradient Echo for Simultaneous T2-Thermometry Imaging
- 2D Multi-Slice Background Suppression for Brain Arterial Spin Labeling Perfusion Imaging
- Motion Compensation with Localized Translations for High Respiratory Gating Efficiency
- Toward Improved Respiratory Self-Gating: From SI Projection Acquisition to Motion Extraction

2016 Projects

- Evaluation of Polynomial Surface Fitting for In Vivo Eddy Current Correction of PC-MRI Data Sets
- Prospective Motion Tracking by Using Multiple Temporal Resolution Imaging Navigators
- Automated Tissue Segmentation Using MRI Fingerprinting
- Evaluation of Rapid Cardiac Imaging Using a bSSFP Pulse Sequence at 0.345 T
- Evaluation of Sparsifying Transforms for Low-Rank Tensor Imaging
- NUFFT-Based CLEAR Algorithm for Non-Cartesian MRI

2016 Projects

- Comparison of Various Sampling Trajectories for Accelerated Cardiac DTI Reconstruction Using Joint Low-Rank Model Sparsity Constraint
- Parameters Analysis and Image Quality Assessment in k-t SLR Method
- Validation of Using 3D Stack-of-Stars with Dixon Fat-Only Signal for Respiratory Motion Detection in DCE-MRI

2017 Projects

- Magnetization Preparation: Enhancing T1 Contrast in Infarcted Myocardium
- Compressed-Sensing Phase-Contrast MRI with Hybrid One and Two-Sided Flow-Encoding and Velocity Spectrum Separation
- Optimization of Magnetic Resonance Fingerprinting Acquisition Scheme
- Estimating Diffusion Time for CODE Optimized Monopolar Diffusion Weighted MRI EPI Sequence
- Estimation of Non-Excitable Area Around Ferromagnetic Objects in MRI

2017 Projects

- Efficient Super-Resolution in Magnetic Resonance Imaging Based on Deep Neural Networks
- High Resolution Distortion Reduced Diffusion Prostate MRI with Minimal Echo Time using ENCODE (Eddy Current Nulled Convex Optimized Diffusion Encoding)

2018 Projects

- Dynamic Magnetization Evolution Visualizer
- CEST Fingerprinting Using Low-Rank Constraint
- Prostate Cancer Lesion Prediction using Multi-Parametric MRI via Deep Convolutional Neural Network
- Contrast Optimization of T1-Weighted Inversion Recovery in Cardiac MRI for Chronic Myocardial Infarction Detection without Contrast Agent
- Undersampled MR Image Reconstruction Using Convolutional Neural Network
- Glioma Segmentation in Multimodal MRI Scans using 3D Convolutional Neural networks

2018 Projects

- Dynamic Myocardial Hyper-Intensity in FLASH Cardiac Cine Imaging: Is it an Artifact?
- Optimizing Parameters to Enhance T2 Mapping Accuracy and Efficiency with Fast Spin Echo
- Plug and Play ADMM with Deep CNN Prior for MRI Reconstruction from Under-Sampled Data
- Using Prospectively Trained Artificial Neural Networks to Improve Cardiac Diffusion Tensor Reconstruction
- Implementation of Magnetic Resonance Image Example-Based Contrast Synthesis Method
- Prospective Single Self-Gating for Bulk Motion Correction

2019 Projects

- Semi-Quantitative Low-Field DCE Perfusion Analysis: A Proof of Concept
- Brain Connectivity Study of Bipolar Disorder Based on fMRI
- Improved Correlation of Prostate Multi-Parametric MRI with Histologic Findings using Deep Learning
- Investigation of Robustness of Two Myocardium Segmentation Models to Training Datasize and Shifts on Training Masks
- Anisotropic Super-Resolution in Prostate MRI using Deep Learning

2019 Projects

- Assessment of Time Optimal Simultaneous Multi-Slice Excitation Pulses with Low Peak RF Power
- Myocardial Blood Volume Measurement using MOLLI Sequence and Water Exchange Model
- Accelerated Volumetric Free-Breathing Liver Fat Quantification using Low-N-Rank Tensor Reconstruction
- A SPIRiT-Like Deep Learning Network with Better Robustness for Diverse Sampling Trajectories
- T1 Mapping with Flow Effect

2020 Projects

- Ferumoxytol Relaxometry at 0.35 T to Investigate Optimized T1-weighted Imaging
- Evaluation of Spiral-Cartesian Sampling for 4D Real-time MR Multi-contrast Imaging Using Digital Motion Phantom
- A Deep Learning Method for Undersampled MRI Reconstruction
- Hyperpolarized ^{13}C MRI Cellular Metabolism and Transport Modeling with Parameters Estimation
- Probabilistic Tractography
- Evaluation of T2-weighted MRI Pulse Sequence for Visualization and Sparing of Urethra with MR-guided Radiation Therapy (MRgRT) on-board MRI

2020 Projects

- Image Synthesis in Multi-contrast MRI with Deep Neural Network
- An Investigation on the Flip Angle Dependence of Diffusion-Weighted Steady-State Free Precession using Monte-Carlo Simulations
- Deep Learning based Cardiac MRI Cine Super Resolution
- Automatic Segmentation of Myocardium in First-pass Cardiac MRI Datasets Using a Patch-Based Convolutional Neural Network Approach

2021 Projects

- Using Feed-Forward Neural Network to Generate Amide Proton Transfer Maps from Field Corrected Undersampled Z-Spectrum in the Brain at 3T
- Technique Development for Motion-Resolved Quantitative Imaging and Quantitative Susceptibility Mapping for Heart Chamber Oxygenation
- Coronary MR Image Reconstruction Using Convolutional Neural Networks
- Dynamic MR Reconstruction from Undersampled Data: A Comparison between KWIC and GRASP Reconstruction
- Effect of Attention Mechanisms on Prostate Segmentation in MRI

Questions?

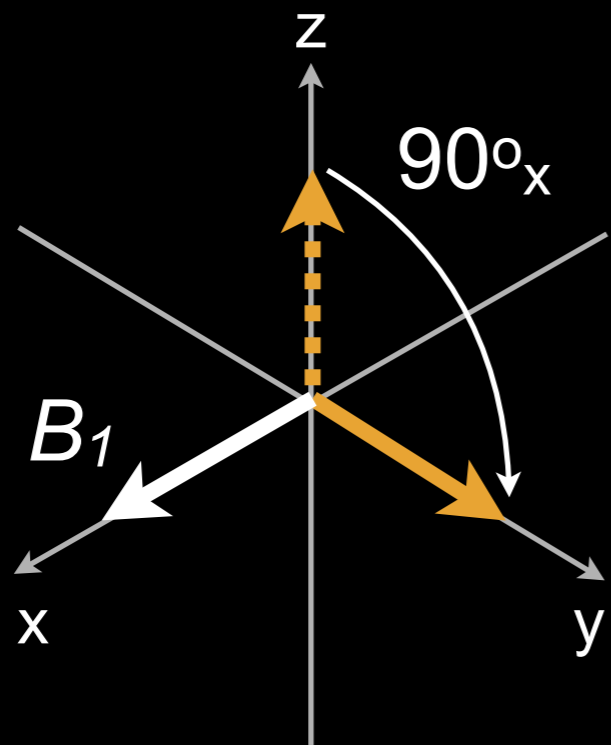
Notation and Conventions

- $\omega = \gamma B$
 - $|B| = B_0 + G_x x + G_y y + G_z z + B_1 + \Delta B$
 - $\omega_0 = \gamma B_0$
- RF pulse
 - flip angle θ
 - phase ϕ (=0 along x)

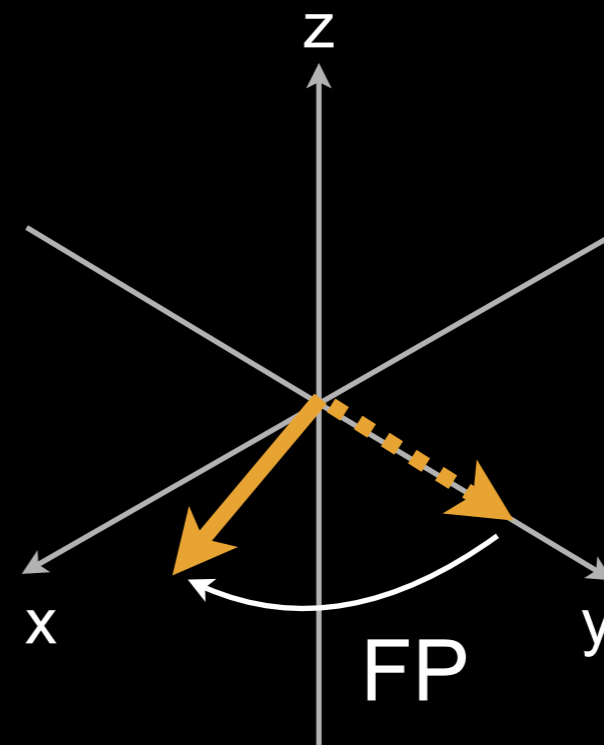
$$\vec{B} = B_0 \hat{k} + B_1(t) [\cos \omega t \hat{i} - \sin \omega t \hat{j}]$$

Notation and Conventions

- Left-handed rotation and precession



rotating frame at ω_0



rotating frame at ω_0

Preview

- Closer look at course schedule
 - https://mrrl.ucla.edu/pages/m229_2022

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 225 MR Contrast Mechanisms

Thanks!

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