Introduction

- Your instructors
  - Holden and Kyung

- Your TAs
  - Sevgi Kafali and Jiahao Lin

- Guest lecturers
  - Drs. Le Zhang, Rohan Dharmakumar, Yingli Yang, Fabien Scalzo

- 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

Invited Speakers

- Temperature Mapping
- Cardiac BOLD MRI
- Machine Learning
- TBD
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 student version**
  - available at UCLA bookstore

- **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)
  - Presentation slides
tentatively due on 6/11 (Thu)
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
Questions?
Notation and Conventions

• $\omega = \gamma B$

- $|B| = B_0 + G_{xx}x + G_{yy}y + G_{zz}z + B_1 + \Delta B$

- $\omega_0 = \gamma B_0$

• RF pulse

  - flip angle $\theta$

  - phase $\phi$ (=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

![Diagram showing left-handed rotation and precession](image-url)
• Closer look at course schedule
  - https://mrrl.ucla.edu/pages/m229_2020
Preview: Pulse Sequences

- Rapid Gradient Echo
- Fast (Turbo) Spin Echo
- Bloch Simulation (MATLAB)
- Extended Phase Graphs (MATLAB)
Preview: RF Pulse Design

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

- Read textbook before Thu class
Questions?

• Related courses of interest
  - PBM 222 MR Spectroscopy
  - PBM 225 MR Contrast Mechanisms
Thanks!

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