Project Discussion

M229 Advanced Topics in MRI

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Homework Sets

- Homework 1 solutions
- Homework 2 solutions

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

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

Final Project

- ~5 weeks; start thinking now!
  - Discuss with Holden
- Can be your own research
  - Incorporate course topics
- Can be from list of ideas
  - Can combine several ideas
- Components
  - Proposal (1 page), due 5/9 Fri by 5 pm
  - Abstract (1 page), due 6/6 Fri by 5 pm
  - Presentation + Q&A, 6/10 and 6/12

Project Ideas

- Pulse sequences
  - bSSFP catalyzation
  - bSSFP banding artifact reduction
  - Design of variable flip-angle TSE
  - Simulation of diffusion-weighted SSFP
  - RF + seq simulator (Bloch, EPG)
  - MR fingerprinting
  - Motion and flow encoding
  - Gradient waveform optimization

Project Ideas

- RF pulse design
  - Low SAR / wide bandwidth adiabatic pulse
  - Velocity selective RF pulse
  - 2D excitation RF pulse
  - Spectral-2D spatial pulse design (e.g., fat suppression + 2D excitation)
  - Low SAR multi-band RF pulse (e.g., for simultaneous multi-slice imaging)

Project Ideas

- Fast imaging
  - Trajectory design (EPI, spiral, etc.)
  - Gradient waveform optimization
  - Fast 3D re/gridding (or nuFFT) recon
  - Gradient measurement / calibration
  - Off-resonance correction

- Motion compensation
  - Self navigation
  - Model-based reconstruction

Project Ideas

- Image reconstruction
  - Coil combination (preserve phase, etc.)
  - Parallel imaging (e.g., GRAPPA vs. SENSE)
  - Sparsity and low-rank constraints
  - k-t methods

- Image analysis
  - Measure/reduce geometric distortion in DWI
  - B_1+ mapping with improved spatial interpolation
  - Denoising
  - Multi-component tissue signal modeling

Project Ideas

- Deep learning / machine learning
  - Image enhancement / reconstruction
  - Super-resolution MRI
  - Motion compensation
  - Quantitative parameter fitting
  - Texture analysis for multi-parametric MRI
  - Prediction models for disease diagnosis
  - Image segmentation
  - Image registration
  - Contrast synthesis

Project Ideas

- Quantitative imaging
  - Relaxometry (T_1, T_2, T_2* mapping)
  - Diffusion
  - Perfusion
  - Fat/water
  - Temperature
  - Tissue stiffness
  - Acquisition and signal modeling/fitting

Final Project

- Proposal due 5/9 Fri by email
  - Template on course webpage
  - Scope should be feasible in 4-5 weeks
- Titles of past projects listed in Lecture 1
- Ask about public datasets
- Come to office hours!
  - Email to make an appointment

Thanks!

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