EE 591: Magnetic Resonance Imaging and Reconstruction
Spring 2015 Syllabus

Instructor: Prof. Krishna Nayak
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OH: TBD

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Grader: TBD

Lectures: Fridays 1:00 - 3:50pm
Location TBD

Website: http://ee-classes.usc.edu/ee591/
Handouts and Homework will be posted here
https://piazza.com/usc/spring2015/ee591/home
Discussion and Q/A will happen here

Prerequisites: Required: EE 483 (digital signal processing)
Required: Familiarity with MATLAB

Magnetic resonance imaging (MRI) is an incredibly powerful and widely used technique for imaging structure, function, and other properties of soft tissues within the human body. Roughly 80 million clinical MRI scans are performed each year. MRI is also used extensively in biomedical and neuroscience research. The acquisition and reconstruction of images is rooted in Fourier transforms and linear systems. The first half of the course will cover the physics of MRI, selective excitation, image acquisition, linear image reconstruction, image contrast, volumetric imaging, and various system imperfections. The second half will cover advanced topics such as ultra-fast imaging, contrast manipulation, RF pulse design, application of compressed sensing, image artifact correction, the patent landscape, and unique features of the MRI industry. At the end of the course, you will know precisely how 95% of all MRI's are obtained, and will be able to follow the latest trends in the field. Coursework will be motivated by current clinical and research applications that include brain, spine, musculoskeletal, and cardiac imaging. Class will meet once per week for three hours, there will be weekly homework, two exams, and a final project.

Required Text:
- DG Nishimura, *Principles of Magnetic Resonance Imaging*
  http://tinyurl.com/usc-ee591-text
- ZP Liang and PC Lauterbur, *Principles of Magnetic Resonance Imaging: a Signal Processing Perspective*, Wiley-IEEE

Additional References:
- MA Bernstein et al., *Handbook of MRI Pulse Sequences*, Academic Press
- EM Haacke et al., *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, Wiley
- RN Bracewell, *The Fourier Transform and it's Applications*, McGraw Hill

Software:

- MATLAB™ Mathworks, Inc., South Natick, MA
- SpinBench™ http://www.spinbench.com/ (Mac OSX only)

Grading:

- Homework 40%
- Project 20%
- Exams 40%

TOPICS:

PHYSICS, ACQUISITION, RECONSTRUCTION

Classical description of NMR "spins"
Polarization, precession, relaxation and the Bloch Equation
Magnetic fields used in MRI
k-space
Selective Excitation (small-tip approximation)
Pulse sequence design, resolution and field of view
Bloch Simulation in MATLAB and SpinBench
Basic Image Reconstruction in MATLAB
Image Contrast based on tissue relaxation properties
Imaging Considerations: Flow and Motion; System Imperfections
Noise in MRI
3D Imaging

ADVANCED TOPICS

Innovation and Entrepreneurship in MRI
Parallel Imaging Reconstruction
Non-Cartesian **k**-space reconstruction
Constrained and Model-based Reconstruction
Partial **k**-space
Fat-Water separation
Spoiled Gradient Echo Imaging
Steady-State Free Precession Imaging
Excitation **k**-space, 2D pulses, spectral-spatial pulses
Shinnar-LeRoux RF pulse design
Adiabatic RF pulses

SUGGESTIONS

My primary interest is that you learn as much as possible, that you find the material interesting, and that you finish the course wanting to know more about this subject. There are a few important things you can do: (i) ask questions, (ii) actively respond to questions posed in class, (iii) make use of office hours, (iv) read about applications of the course material, (v) learn to use MATLAB and SpinBench, (vi) remember that exams, grades, and degrees are a means to an end and not an end in itself.

STUDENTS WITH DISABILITIES:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is

located in STU 301 and is open 8:30 a.m. – 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

ACADEMIC INTEGRITY:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.