EE 591: MAGNETIC RESONANCE IMAGING AND RECONSTRUCTION
FALL 2007 SYLLABUS

Instructor:	Prof. Krishna Nayak EEB 406, (213) 740-3494, knayak@usc.edu OH: MW 1:00 – 3:00 PM
Teaching Assistant:	Zungho Zun RTH 317, (213) 821-4110, zun@usc.edu OH: Th 3:00 – 6:00 PM (or by appointment)
Lectures:	Mon & Wed 10:00 – 11:30 AM KAP 167
Website:	**http://mrel.usc.edu/class**
Required Prerequisites:	EE 483 (digital signal processing) Familiarity with MATLAB
Useful Preparation:	EE 441 (applied linear algebra for engineers) EE 464 (probability theory for engineers)

Magnetic resonance imaging (MRI) is a powerful, flexible, and relatively new modality for imaging structures within the body. The acquisition and reconstruction of MRI data is uniquely rooted in Fourier analysis, sampling, and linear systems. The course will first cover the physics of MR, selective excitation, image acquisition, image contrast, volumetric imaging, and various system imperfections; and will then cover image reconstruction from non-uniform frequency domain data, reconstruction from incomplete data, de-blurring techniques, and the correction of various image artifacts. Coursework will be motivated by clinical and research applications such as cardiac imaging, flow measurement, and functional MRI.

This course will address the following general concepts and questions:

- Understanding of how magnetic resonance imaging systems work. What are the basic physics involved? Multidimensional signals and systems concepts. In-depth understanding of Fourier transforms.
- How do you form an image and how can you manipulate its content? How do you selectively excite a small region? How do you resolve signal from different spatial positions? What are the main sources of image contrast?
- How are MR images reconstructed? What are the main sources of noise, distortions, and artifact? What types of artifact can be corrected? Automatic correction techniques. Measurement-based correction techniques.

This course will feature a tour and demo at the 3T MRI facility at University Hospital.

Required:

- DG Nishimura, *Principles of Magnetic Resonance Imaging*
- Handouts and Articles.

Recommended:

- MA Bernstein et al., *Handbook of MRI Pulse Sequences*, Academic Press

Additional References:

- ZP Liang and PC Lauterbur, *Principles of Magnetic Resonance Imaging: a Signal Processing Perspective*, Wiley-IEEE
- 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/

Grading (tentative):

• Homework	20%	Due Fridays at noon
• Project	20%	
• Midterm	30%	Wed, Oct 17th, in class (tentative)
• Final Exam	30%	Mon, Dec 17th, 8:00 – 10:00 AM

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.

TENTATIVE OUTLINE:

IMAGING PHYSICS AND ACQUISITION (WEEKS 1-8)

Classical description of NMR "spins"
Polarization, precession, relaxation and the Bloch Equation
Magnetic fields used in MRI (static field, linear gradients, RF field)
k-space
Selective Excitation (small-tip)
Pulse sequence design, resolution and field of view
Bloch Simulation in MATLAB and SpinBench
Image Reconstruction in MATLAB (including normalized coordinates)
Generating Image Contrast
Imaging Considerations
Flow and Motion
System Imperfections
Noise in MRI

MIDTERM

ADVANCED TOPICS (WEEKS 9-15) SOME, NOT ALL OF THE FOLLOWING:

Matrix Treatment of MRI
Parallel Imaging (SENSE and GRAPPA)
Steady-State Free Precession (SSFP) Imaging
Spin De-phasing and Phase Graphs
Contrast Agents
Fast Imaging Sequences
Reconstruction of non-Cartesian data (gridding)
Reconstruction of sparse data
Partial **k**-space reconstruction
Fat-Water separation
Off-resonance measurement and correction
Simulation of Flow and Off-Resonance in MATLAB
Cardiac Imaging (will not be tested on this material)
Current Research Topics (will not be tested on this material)

PROJECT PRESENTATIONS

FINAL EXAM