EE591: Magnetic Resonance Imaging and Reconstruction
Fall 2013

Instructor: Prof. Justin P. Haldar

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Objectives: Magnetic Resonance Imaging (MRI) technology has developed into a powerful tool for investigating the anatomy, physiology, and metabolism of living subjects. MRI techniques have revolutionized various biomedical research fields and modern medical practice.
This course is intended to teach students the fundamental principles of MRI from an engineering perspective, with a particular emphasis on signal processing aspects. Course topics will include: basic physical principles (MRI hardware, magnetized spin systems, signal generation and detection; signal characteristics); imaging principles (selective excitation, spatial encoding techniques); image reconstruction principles and techniques (concepts of ill-posedness and point spread function, Fourier transform, Radon transform, and algebraic reconstruction methods); image contrast, resolution, signal-to-noise, and artifacts; fast-scan techniques; applications; advanced topics.

Schedule:

Lectures:	2:00pm-3:20pm Tue,Thu VHE 206
Office Hours:	3:30pm-5:00pm Tue 2:00pm-3:30pm Wed
First Class:	Tue, August 27th
Midterm:	Tue, October 8 2:00pm-3:20pm (in class)
Last Class:	Thu, December 5th
Final Exam:	Thu, December 12 2:00pm-4:00pm

Website: USC Blackboard

Credit: 3.0 Units

Required Text: Z.-P. Liang and P. C. Lauterbur, *Principles of Magnetic Resonance Imaging: A Signal Processing Perspective*, Wiley-IEEE Press, 2000.

Additional References:

M. A. Bernstein, K. F. King, X. J. Zhou, *Handbook of MRI Pulse Sequences*, Elsevier Academic Press, 2004.

E. M. Haacke, R. W. Brown, M. R. Thompson, R. Venkatesan, *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, Wiley-Liss, 1999.

Grading:

30% Homework Assignments
30% Midterm Exam
40% Final Exam/Project (To Be Determined)

All exams are cumulative and closed book – please mark the scheduled exam times on your calendars, and inform me as soon as possible if you have any conflicts.

Written homework assignments must all be turned in by the beginning of class on the due date. Electronic homework assignments must be submitted to the course Blackboard page by 2:00pm on the due date. Late homeworks will not be graded. The final homework grade will be based on your average score after discarding the lowest.

Several of the homeworks will require MATLAB programming. It is your responsibility to make sure that you know how to access the software and read/write/debug MATLAB code.

Prerequisites:

EE 483 (Introduction to Digital Signal Processing)
Familiarity with MATLAB

Recommended Preparation:

EE 441 (Applied Linear Algebra for Engineering)
EE 503 (Probability for Electrical and Computer Engineers)
BME 525 (Advanced Biomedical Imaging)

Course Timeline (subject to change):

Week 1 (8/27, 8/29)	Introduction, History, Context
(Book: Ch. 1 and 3.1)	Magnetized Nuclear Spin Systems
Week 2 (9/3, 9/5)	RF Excitation
(Book: Ch. 3.2-3.3)	Free Precession and Relaxation
Week 3 (9/10, 9/12)	Signal Detection
(Book: Ch. 3.4 and 4)	Spin Echoes and Gradient Echoes

Week 4 (9/17, 9/19) (Book: Ch. 5.1-5.2.1)	Slice Selection Frequency Encoding
Week 5 (9/24, 9/26) (Book: Ch. 5.2-5.4)	Phase Encoding, Pulse Sequences, k-Space
Week 6 (10/1, 10/3) (Book: Ch. 6)	Basic Image Reconstruction
Week 7 (10/8, 10/10) (Book: Ch. 8.1-8.2)	Midterm Image Resolution and Noise
Week 8 (10/15, 10/17) (Book: Ch. 7)	Image Contrast
Week 9 (10/22, 10/24) (Book: Ch. 9)	Fast-Scan Imaging
Week 10 (10/29, 10/31) (Book: Ch. 8.3)	MR Difference Equations Image Artifacts
Week 11 (11/5, 11/7) (Book: Ch. 10.1-10.2)	Half-Fourier Reconstruction Bandlimited Extrapolation Parallel Imaging
Week 12 (11/12, 11/14)	Algebraic Image Reconstruction Non-Cartesian/Non-Fourier Reconstruction
Week 13 (11/19, 11/21)	Constrained Reconstruction Dynamic MRI
Week 14 (11/26)	NMR Spectroscopy and MR Spectroscopic Imaging
Week 15 (12/3, 12/5)	Functional MRI and Diffusion MRI
Final Exam (12/12)	

Suggestions:

My goal is to teach you and your fellow students as much as possible about MRI, while simultaneously inspiring your interest, excitement, and curiosity about the material. This will be easier if you:

- Come to class on time and pay attention.
- Do all of the assignments.
- Ask questions and participate in classroom discussion.
- Make use of office hours.
- If you're struggling with the material, don't wait until the last minute to talk to me about it.

Statement for 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.

Statement on 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 (http://scampus.usc.edu/university-student-conduct-code/). A list of academic violations and recommended sanctions can be found here:

http://www.usc.edu/student-affairs/SJACS/forms/sjacs_appa.pdf.

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/studentaffairs/SJACS/

I have reported students to SJACS before in a previous course, and do not want to have to do it again. Cheating on exams or plagiarism on any assignment is unacceptable, and will result in a failing grade in the course. You are free to discuss assignments with your friends and classmates, but your solutions should be your own work. I reserve the right to submit any and all assignments to plagiarism detection software. If you have any doubts on plagiarism or other aspects of academic integrity, I encourage you to take the academic integrity tutorial at :
http://www.usc.edu/libraries/about/reference/tutorials/academic_integrity/index.php.