MRI Applications to Bioengineering

BENG/ECE 499 – Spring 2010

Lecture location: West Building 1001
Lecture Hours: Mondays and Wednesdays, 5:55 pm – 7:10 pm
Credit Hours: 3
Instructor: Vasiliki N. Ikonomidou
E-mail: vikonomi@gmu.edu (preferred)
Office: Engineering, 3909
Office Hours: Mondays/Fridays 2-3 pm; other hours by appointment (e-mail me!)

I will try to respond to e-mails within two business days of receiving them. Due to University regulations, you need to use your GMU e-mail account in all correspondence related to the course. Please put BENG/ECE 499 in the subject line!

Announcements and additional course materials will be posted on Blackboard. It is the student’s responsibility to regularly check it.

Grading policies

(a) Homework – 25%

Homework constitutes a major component of the course. It should demonstrate an understanding of the background, and a clear and critical presentation of the procedure followed and the results obtained. “Critical” means questioning what was done and why such results were obtained.

Assignments should be typed and delivered in hard copy. They will require use of MATLAB, so please make sure you have access to it in the ECE labs.

In order to maximize your grade, state all assumptions made in approaching a problem. Define all variables; this is especially true in your code. Any computer code should have comments to help make it readable; variables should have meaningful names. Computer code should be working; there won’t be partial credit for non-working code. Overall, all solutions should have enough comments to make the thinking process clear. Take care to use proper grammar and syntax.

Homework due at the beginning of the class the week after the experiment was completed; there will be a 10% penalty for every day delay after that, starting with the beginning of the lecture. In case of a documented medical emergency that doesn’t allow you to submit the
report on time, please notify the instructor. Also, if you are unable to submit an assignment due to observance of a religious holiday, please notify the instructor in advance.

(b) **Midterm exam – 25%**

The midterm exam will be paper and pencil, open notes/book.

(c) **Final exam – 25%**

The final exam will be pen and pencil, open notes/book. The final exam will not be cumulative, but only on material covered after the midterm.

Both the midterm and the final exam will be held during the regular lecture time. In the event that the University dismisses classes on a day that an exam is scheduled, the exam will take place in the next scheduled class time.

(d) **Presentations – 25%**

Students should prepare, in groups of 2 or 3, a presentation on an MRI-related topic of their choice. Topics should be chosen by the midterm, and approved by the instructor. Presentations should be 10 minutes long, using PowerPoint or other presentation software, with a 5-minute question session to follow, and will take place in the last session of the class.

Any request for re-grading should be submitted in writing within a week from the day the homework or test was returned. Any such request invalidates the current grade; the whole assignment or test will be subject to re-grading. The final (letter) grade of the course will be based on relative performance.

**Academic Integrity**

All George Mason University students have agreed to abide by the letter and the spirit of the Honor Code. You can find a copy of the Honor Code at academicintegrity.gmu.edu. All violations of the Honor Code will be reported to the Honor Committee for review.

If for an assignment you use material from other sources, like books, articles or the web, such sources must be cited appropriately. All assignments and exams must contain a signed honor pledge: “On my honor, I have not given nor received any help on this assignment/exam”, otherwise they will not be graded.

**Disability statement**

If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; http://www.gmu.edu/student/drc/) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.
Academic courtesy

You can help make this a better experience by:

• Arriving in time for the class
• Silencing your cell phone and not using any electronic devices other than your laptop (but, no web surfing!). No electronic devices are allowed in class during exams.
• Not eating or drinking in class
• Not preparing to leave until the instructor indicates that the lecture is over

Detailed Course Information

This course aims at providing the student with an introduction to medical imaging and magnetic resonance imaging. It will cover basic MRI physics, and basic problems in medical image processing. At the end of the course, the student will be expected to be able to:

• Understand the basics of tomography
• Describe what happens during an MRI experiment
• Understand the sources of MRI contrast, and calculate/predict the contrast of the final image
• Recognize common artifacts in MR images, and suggest solutions for them
• Understand the main problems in medical image processing
• Devise and evaluate the appropriateness of an MRI experiment

The course is focused on medical neuroimaging; it is expected that the student will gain some familiarity with basic brain structures and orientation in the brain.

Recommended textbooks:


C.T.W. Moonen, P. A. Bandettini (Editors) Functional MRI, Springer-Verlag, 2000

Calendar (tentative – ALL dates and assignments are subject to change)

Unit 1: Basic MRI Physics
Jan 20 Nuclear Magnetic Resonance – The Bloch Equations
Jan 25 Image formation 1: Computerized Tomography & Backprojection Reconstruction
Jan 27 Image formation 2: Gradients / Projection / k-space / 2D Fourier
Feb 1 Image formation 3: continued and 3D imaging
Feb 3 Image formation 3 Excitation / Flip Angle / Selective Excitation
Feb 8 Image formation 4: What is an image? Resolution, SNR, contrast
Feb 10 MRI equipment and safety

Unit 2: Basic Contrast in MRI
Feb 15 The echo concept – Spin echo & T2 measurement
Feb 17 T1 weighted spin echo, T2 weighted fast spin echo. “Center of k-space”
Feb 22  Gradient echo; T2* weighting. EPI
Feb 24  Inversion recovery – T1 measurement/FLAIR
Mar  1  Contrast agents & Review

Mar  3  Midterm
Mar  8  Spring break
Mar 10  Spring break

Unit 3: Medical Image Processing
Mar 15  Image reconstruction (filtering / zero padding / SNR / resolution)
Mar 17  MPRAGE and the volumetric imaging problem
Mar 22  Image segmentation
Mar 24  Image registration
Mar 29  EPI revisited: common image artefacts

Unit 4: Non-conventional MRI
Mar 31  Magnetization Transfer – introduction to quantitative MRI
Apr  5  Diffusion Imaging
Apr  7  MR Angiography
Apr 12  Functional Imaging: Perfusion Imaging
Apr 14  Functional Imaging: BOLD
Apr 19  More on fMRI

Unit 5: Advanced Topics
Apr 21  Parallel Imaging
Apr 26  Introduction to PET – data fusion
Apr 28  Review
May  1  Presentations

May 10  Final Exam