

**ECE 538/BENG 538 Topics in Bioengineering: Medical Imaging  
Fall 2010**

**Credits 3**

Mondays, 7:20 pm – 10:00 pm, Room: Robinson, A245

**Instructor:**

Siddhartha Sikdar, PhD

Assistant Professor

Department of Electrical and Computer Engineering

Office: Engineering, Room 3908

Email: [ssikdar@gmu.edu](mailto:ssikdar@gmu.edu)

Phone: 703-993-1539

Office hours: Mondays and Tuesdays 2:00-3:00 pm and by appointment

**Course description:**

This course will provide an introduction to the physical, mathematical and engineering foundations of modern medical imaging instruments and image processing methods that enable us to “see” inside the human body to diagnose disease, monitor treatment and perform minimally-invasive interventions. The emphasis will be on diagnostic ultrasound and MRI imaging methods, although several other modalities will also be discussed. The course will also provide an overview of recent developments in the field of medical imaging and discuss some of the challenges and controversies. The students will get hands on experience in applying the methods learnt in class to real-world problems and imaging data. There will be broad scope to individually and collaboratively explore current problems in medical imaging. Students will be expected to do a course project demonstrating in-depth understanding and critical assessment of methods from recent research literature and would be required to submit a written project report formatted as an IEEE conference paper.

**Learning objectives:**

At the end of the course the student should be able to:

1. Demonstrate a strong grasp of the basic physical principles underlying several medical imaging modalities.
2. Demonstrate a solid understanding of the concepts of medical image acquisition, image formation, image quality and display methods.
3. Apply the concepts learnt in class to solve real-world problems in medical image reconstruction, image processing and analysis.
4. Demonstrate an appreciation for the strengths and weaknesses of various imaging modalities and what kind of anatomical and physiological information can be obtained from them.

**Prerequisites:**

1. University physics (PHYS 262 or equivalent).
2. Familiarity with a programming language (C/C++ or MATLAB)
3. Discrete time signal processing (ECE 410 or equivalent) or permission of instructor.

### **Resources:**

#### **Course home page:**

The course material distribution, assignments grading, announcements and discussion boards will be managed using BlackBoard CE6. To access the course home page, log in using your email ID and password on <http://courses.gmu.edu>. If you have difficulties using this system, please speak with the instructor and appropriate accommodations will be considered.

#### **Required readings:**

**Textbook:** Medical Imaging Physics–William R. Hendee, E. Russel Ritenour. Wiley-Liss Inc; 4<sup>th</sup> Edition, 2002. Available at Fenwick:

<http://magik.gmu.edu/cgi-bin/Pwebrecon.cgi?BBID=1559655>

The lecture slides will be available through the course website. Additional reading and reference material wherever appropriate will be distributed to students periodically. Students are expected to read the assigned material prior to class.

#### **Recommended references:**

1. Medical Image Analysis–Atam Dhawan. Wiley-IEEE Press; 2003.  
Available at Fenwick:  
<http://magik.gmu.edu/cgi-bin/Pwebrecon.cgi?BBID=1559656>
2. Diagnostic Ultrasound Imaging: Inside Out–Thomas Szabo. Elsevier Academic Press; 2004. Electronic resource available through GMU Libraries:  
<http://magik.gmu.edu/cgi-bin/Pwebrecon.cgi?BBID=1312573>
3. Handbook of Medical Imaging: Processing and Analysis–Isaac N. Bankman. Academic Press; 2000. Available at Fenwick:  
<http://magik.gmu.edu/cgi-bin/Pwebrecon.cgi?BBID=882057>

### **Course structure:**

The course will consist of weekly lectures, homework assignments, two exams and a course project (details below).

#### **Grade:**

Midterm exam	25%
Final exam	25%
Homework	25%
Course project	25%

#### **Course Project:**

The course will involve a research project. At the end of the semester, all students will be expected to make a 15-min presentation (with slides) on a particular topic in medical imaging. Students should select a topic, discuss with the instructor, and get approval within the first five weeks of class. Students with similar interests can choose to work together and present a joint in-depth project (the contribution of each student should be clearly noted). A list of literature sources should be submitted to the instructor for approval by the ninth week of class. Students are expected to submit a written report on their project topic in addition to the presentation. Your classmates will grade the final presentation. The report should follow the guidelines for an IEEE conference paper, with sections for Introduction, Materials and Methods, Results, Discussion and Conclusion. Grades will be based on: knowledge of the subject and quality of background research, depth of critical analysis, clarity of explanation, and presentation style. For the project, students can select one of the following approaches:

- 1) Review a specific algorithm or technology for medical image formation, processing or analysis, demonstrate its uses, compare against alternative approaches, discuss the strengths and weaknesses, and suggest avenues for improvement.
- 2) Explore medical imaging applications for a specific organ or disease by identifying the clinical need, comparing the applicability of various imaging methods, and critically reviewing the latest research directions.
- 3) Review an emerging medical imaging modality, discuss the physics, instrumentation and image processing involved, describe potential applications, and discuss the strengths and weaknesses compared to existing imaging modalities.

### **Homework:**

There will be assigned homework throughout the semester and will involve processing and analysis of real medical image data, and will involve some programming in C/C++ or MATLAB (depending on the student's preference). Homework submitted late will be penalized. No homework will be accepted after two weeks. 5 points of the homework grade is reserved for class participation. One student will be assigned each week on a rotating basis to take the lead on compiling a summary of the discussions in class and post it on the class home page. These summaries should be used as a supplement to the lecture slides in preparing for examinations and will be graded as class participation. Students are expected to read the assigned material prior to class.

### **Exams:**

The mid term exam will be a take home exam. The mid term will test the students' ability to analyze and interpret real imaging data, and perform relevant calculations. The final exam will be closed book and notes. It will consist of essay-type and multiple-choice questions and numerical problems. Absence from the final exam must be notified ahead of time and alternative arrangements made with the instructor.

## Syllabus

Wk	Date	Topics	Readings and other Comments
1	8/30/10	Introduction: what is medical imaging? Different imaging modalities. Radiology workflow, image informatics.	Chapter 1 Assigned papers
2	9/6/10	Labor day; No class.	
3	9/13/10	Review of relevant digital signal and image processing concepts: filtering, interpolation, Fourier transforms, point spread functions, probability.	Chapter 11 Handouts
4	9/20/10	Medical imaging systems: Image acquisition, reconstruction, resampling, manipulation, visualization; Patient safety considerations.	Handouts
5	9/27/10	Evaluation of image quality: signal to noise, contrast, spatial and temporal resolution. Anatomical and functional imaging modalities. Contrast agents.	Chapters 16, 17, 18
6	10/04/10	Structure of matter Principles of magnetic resonance imaging: spin physics	Chapter 19 Project approval due
7	10/12/10 Columbus day; class meets on Tuesday	MRI signal, data acquisition, image contrast. Image formation and k-space. Guest Lecture.	Chapters 20 and 21
8	10/18/10	Principles of ultrasound imaging: acoustic waves, transmission, reflection, attenuation, image formation.	Chapter 22
9	10/25/10	Ultrasound transducers and instrumentation: steering, focusing. Ultrasound signal and image processing. 2D, 3D and 4D imaging.	Chapter 2, 23 List of literature sources due
10	11/01/10	Principles of Doppler ultrasound. Live demonstration.	Chapters 24 and 25 Take home mid term exam assigned
11	11/08/10	Principles of X-ray and nuclear imaging: radiation, attenuation, scattering, detection	Chapters 4, 7, 13. Take home mid term exam due
12	11/15/10	Computed Tomography image reconstruction. Fourier slice theorem, filtered backprojection. 2D, 3D and 4D imaging. Online lecture.	Chapter 15
13	11/22/10	Introduction to image analysis: enhancement, manual	

		and automated image analysis	Handouts
14	11/29/10	Medical Image segmentation.	Handouts
15	12/06/10	Multimodality imaging, image registration, computer-aided detection. Course wrap up.	Handouts
16	12/13/10	Final presentations.	Project report due.
17	12/20/10	Final exam.	

### **Academic Honesty and Collaboration:**

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product. Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers; however, it is not appropriate to give your work to someone else to review. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be properly cited. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see the instructor.

### **Relevant Campus and Academic Resources**

#### **Disability Services**

Any student with documented learning disabilities or other conditions that may affect academic performance should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; [www.gmu.edu/student/drc](http://www.gmu.edu/student/drc)) to determine the accommodations you might need; and 2) talk with the instructor to discuss reasonable accommodations.

#### **Office of Diversity Programs and Services**

SUB 1, Rm. 345; 993-2700; [www.gmu.edu/student/msaf/index.html](http://www.gmu.edu/student/msaf/index.html)

#### **Writing Center**

Robinson A116; 993-1200; [writingcenter.gmu.edu](http://writingcenter.gmu.edu).