JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

520.432/520.632 MEDICAL IMAGING SYSTEMS
Syllabus
FALL 2018

Description

An introduction to the physics, instrumentation, and signal processing methods used in general radiography, X-ray computed tomography, ultrasound imaging, magnetic resonance imaging, and nuclear medicine. The primary focus is on the methods required to reconstruct images within each modality, with emphasis on the resolution, contrast, and signal-to-noise ratio of the resulting images. Students will additionally engage in hands-on activities to reconstruct medical images from raw data.

Prerequisites

EN.580.222 or EN.520.214 Signals and Systems

Instructor

Muyinatu Bell <mledijubell@jhu.edu>
Assistant Professor
Office: Barton 208
Office Hours: Tuesdays 12 noon-1pm

Teaching Assistants

Derek Allman <dallman1@jhu.edu>
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Office Hours:
Mondays & Wednesdays 12 noon-2pm
Barton 223C

Lecture Times

TTh 10:30-11:45am, Hackerman 320

Textbook

Medical Imaging Signals and Systems (2nd Edition) by Prince and Links, 2015.
Errata for textbook (as of December 12, 2016): https://pulselab.jhu.edu/wp-content/uploads/2017/08/MISS_TextbookErrata_122116.pdf

Online Resources

Please log in to Blackboard for all materials related to this course.

Course Objectives

(1) Students will learn the physics of image formation in medical imaging
(2) Students will learn the main instrumentation used in medical imaging
(3) Students will learn the mathematics of image reconstruction
(4) Students will learn how to assess image quality in medical imaging
(5) Students will learn how to model and analyze medical imaging systems using signals and systems concepts and mathematics
(6) Students will learn how to manipulate real medical imaging data

Course Topics

- Signal and image processing concepts
- Image quality
- Physics of radiography
- Projection radiography
- Computed tomography
- Physics of nuclear medicine
- Nuclear medicine
- Ultrasound imaging
- Ultrasound physics
- Nuclear magnetic resonance
- Magnetic resonance imaging

Course Expectations & Grading

Homework

Homework problems will be assigned with each new topic, and they are due at the beginning of class on each indicated due date (see the course schedule for homework due dates).

Examinations

There will be three in-class examinations (see the course schedule for their dates). These in-class exams address the most recent material; thus, they are not cumulative. The final exam will take place in the registrar-scheduled 3-hour exam period during exam week.

Presentations

All students taking the graduate version of this course are required to give a presentation to the entire class that delves deeper into one of the topics discussed in class. This topic must be related to medical imaging, and proposals for the selected topic must be approved by Professor Bell (see course schedule for proposal due dates). There will be a question and answer period after each presentation and student performance during both the presentation and the question and answer period will be evaluated. Undergraduate student participation is particularly encouraged during the question period and this participation will count toward your final grade.

Grading

The final numerical score for the course will be based on the following breakdown:
Homework 30%
Exams 40%
Presentations* 10%
Final 20%

*Includes overall presentation, class participation, questions asked, and grad student responses to questions

Key Dates

Date	Subject	Reading Assignment	HW # & Due Date
9/4	Introduction to Medical Imaging, Review of Signals & Systems Review of Fourier Transforms	Chapters 1,2	
9/6	Review of Fourier Transforms (cont.) *Lecturer: Derek Allman*	Chapter 2	#1 – 9/11
9/11	Image Quality: Contrast, Resolution	Chapter 3	
9/13	Image Quality: Noise, SNR, Accuracy	Chapter 3	#2 – 9/18
9/18	Physics of Radiography	Chapter 4	
9/20	Projection Radiography	Chapter 5	#3 – 9/25
9/25	Projection Radiography: Image Formation	Chapter 5	
9/27	**Exam 1**		
10/2	Computed Tomography (CT): Equipment, Image Formation	Chapter 6	
10/4	CT: Image Formation (cont.), Image Quality	Chapter 6	#4 – 10/9
10/9	Physics of Nuclear Medicine (NM)	Chapter 7	
10/11	NM Planar Scintigraphy	Chapter 8	#5 – 10/16
10/16	NM Planar Scintigraphy: Image Formation, Image Quality	Chapter 8	
10/18	SPECT & PET: Image Formation *Lecturer: Alycen Wiacek*	Chapter 9	
10/23	**Exam 2**		
10/25	Ultrasound (US) Imaging Systems *Lecturer: Michelle Graham*	Chapter 11a	
10/30	US Physics	Chapter 10	
11/1	US Steering, Focusing, Beamforming, Image Quality	Chapter 11b	#6 – 11/6
11/6	Magnetic Resonance Imaging (MRI): Instrumentation, Data Acquisition, Physics	Chapters 13a, 12a	
11/8	MRI Contrast, Frequency Encoding, Phase Encoding	Chapter 12b, 13a	#7 -11/13
11/13	MRI Pulse Sequences, Image Reconstruction, Image Quality	Chapter 13b	
11/15	**Exam 3, Grad Student Proposals Due**		
11/20	Thanksgiving Break		
11/22	Thanksgiving Break		
11/27	Hands-on Image Formation (Part 1)		
11/29	Hands-on Image Formation (Part 2)		#8 – 12/4
12/4	Grad Student Presentations		
12/6	Grad Student Presentations		
12/12-21	Final Exam Period		

Assignments & Readings

Expected reading assignments are indicated in the syllabus (see above) and associated homework problems will be assigned on Blackboard as we progress through the material.

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are as follows:

Homework: You are free to work together to solve the assigned homework problems, however, the work appearing on your submitted homework assignment must be your own.

Examinations: Your examination solutions must be your own. The examinations are closed book and closed notes. However, for the 1st in-class exam, you may bring one 8-1/2" by 11" sheet of paper with any equations or notes *handwritten* on both sides. For the 2nd in-class exam, you may bring two such equation/note sheets. For the 3rd exam and final exam, you may bring three such equation/note sheets. PDA's, computers, tablets, cell phones, pagers, and other electronic aids or storage devices (except for standard calculators) are not allowed to be used during exams. Equation sheets that are used for Exams 1–3 and the final exam must be handwritten–no photocopied and/or miniaturized text will be permitted.

More information: After your formal educational studies, you will be expected to continue to maintain integrity in all that you do in graduate school or in your profession. Many societies and professional organizations have their own ethical codes. One worth reading is the IEEE Code of ethics: http://www.ieee.org/about/corporate/governance/p7-8.html. More information about JHU misconduct policies is available on the university's website:

- For undergraduates: http://e-catalog.jhu.edu/undergrad-students/student-life-policies/
- For graduate students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/

Students with Disabilities

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516-4720, studentdisabilityservices@jhu.edu . Please make Professor Bell aware of your circumstance as soon as possible.

ABET Outcomes

- Ability to apply mathematics, science and engineering principles (a)
- Ability to design a system, component, or process to meet desired needs (c)
- Recognition of the need for and an ability to engage in life-long learning (i)
- Knowledge of contemporary issues (j)
- Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (k)