Medical Imaging

BMSC-GA.4426 ECE6813 BE6203

3 credits, Fall Semester 2019

Dates, times and Faculty are indicative and will be confirmed at a later date.

Course description:

This course introduces the physics, instrumentation, and signal processing methods used in X-ray (projection radiography), X-ray computed tomography, ultrasound imaging, nuclear medicine (SPECT/PET), and magnetic resonance imaging. The course builds on fundamental signal processing, basic electricity and magnetism, and multivariate calculus.

Course Webpage: http://eeweb.poly.edu/~yao/EL6813

Goals and Objectives:

- Familiarity with the basic biomedical imaging modalities and their history
- Working knowledge of the basic physics, engineering and instrumentation principles of each modality
- Understanding of the typical applications for each modality
- Understanding of each modality strength and weaknesses
- Current research directions for each modality

Prerequisites:

Undergraduate level courses in multivariable calculus (MA-UY 2112 & MA-UY 2122 or MA-UY 2114), physics (PH-UY 2033), probability (MA-UY 3012), signals and systems (ECE-UY 3054). Students who do not have prior courses in signals and systems must take ECE-GY 6113 / BE-GY 6403 - Digital Signal Processing I as a prerequisite or must obtain instructor's approval; ECE-GY 6123 - Image and Video Processing is also recommended but not required.

Course Director EL6813/BE6203:

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Course Director GA4426:

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Instructors:

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Teaching Assistant:

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Format:

The course is organized as 12 150-minute lectures, two exams, and 1 lecture session used for a tour of medical imaging facilities. Students will be evaluated based upon course participation, homework and programming assignments, a midterm exam, a final exam.

Homework policy:

Homework will be assigned weekly and collected a week later. Homework solution will be provided the following week. Select homework problem will be graded and count towards the final grade. Exams will be primarily based on homework problems. There will also be several MATLAB assignments, and these will be collected and counted towards the final grade.

Grading policy:

Exam 1: 40%, Exam 2: 40%, Homework Assignments: 10%, Programming Assignments: 10%.

Lectures:

For lectures 1-6 and both exams: Friday, 9:50 am-12:20 pm, Rogers Hall, Rm 605, Brooklyn Campus (NYU Tandon)

For lectures 7-12: Friday, 9:50 am – 12:20 pm, Center for Biomedical Imaging, 3rd floor large conference room, 660 1st Avenue, New York, NY 10016.

Textbooks:

J. L. Prince and J. M. Links, Medical imaging: signals and systems, 2/E, Prentice Hall, 2015. ISBN-10: 0132145189.

Outline:

Lecture #1 Introduction (September 6, 2019)

- Introduction to the course
- Overview of medical imaging modalities (history and basic principles)
- Review of signals and system basic concepts
- Image quality metrics

Lecture #2 Physics of radiography (September 13, 2019) (to be rescheduled)

- Ionizing radiation
- Electromagnetic radiation
- Compton scattering

Lecture #3 Projection radiography (September 20, 2019)

- X-ray tubes
- Film/screen detectors
- conventional x-ray imaging equation

Lecture #4 X-Ray computed tomography (CT) part 1 (September 27, 2019)

- Instrumentation
- Image formation
- Radon transform

Lecture #5 X-Ray computed tomography (CT) part 2 (October 4, 2019)

- Back projection
- Filtered back projection
- Image quality

Lecture #6 Nuclear Medicine (October 11, 2019)

- The physics of nuclear medicine
- Positron Emission Tomography (PET)

MIDTERM EXAM (October 18, 2019)

Lecture #7 Clinical aspects of PET (October 25, 2019)

- Tracer Development and Validation
- Drug Pharmacokinetics & Pharmacodynamics
- Preclinical & Translational Research
- Clinical Applications

Lecture #8 Physics of Ultrasound (November 1, 2018)

- Acoustic waves: properties of media
- Wave propagation: speed, reflection, attenuation
- Axial vs Lateral resolution
- Doppler effect

Lecture #9 Ultrasound Imaging (November 8, 2019, CBI 3rd floor small conference room)

- Ultrasound imaging principles
- Beam pattern formation and focusing
    - Instrumentation (transducers, system components)

Lecture #10 Physics of Magnetic Resonance Imaging (November 15, 2019, CBI 3rd floor small conference room)

- Magnetization
- Precession and Larmor frequency
- RF excitation
- Relaxation

Lecture #11 Magnetic Resonance Imaging (November 22, 2019, CBI 3rd floor small conference room)

- Instrumentation
- Data acquisition
- Image reconstruction

Lecture #12 Advanced Magnetic Resonance Imaging (December 6, 2019)

- Image quality
- Diffusion MRI
- Functional MRI

Tour of the NYU Center for Biomedical Imaging (December 13, 2019)

- Tour of the RF Lab and explanation of RF coils components
- Tour of the MRI facilities (including a 7T whole body scanner)
- Practical session at the MRI console

FINAL EXAM (December 20, 2019)