BMSC-GA 4426 Medical Imaging Systems
3 credits, also offered as EL6813/BE6203 at the Polytechnic School of Engineering of NYU
Fall Semester 2015, Monday 10:30 AM-1:00 PM

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

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

Instructors:
Prof. Yao Wang (Polytechnic Institute of NYU)
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Prof. Riccardo Lattanzi (NYU School of Medicine)
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Prof. Yu-Shin Ding (NYU School of Medicine)
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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 assignments, a midterm exam, and a final exam.

Homework policy:
Homework will be assigned weekly and due the following week. Late submissions are not accepted. Exams will be primarily based on homework problems. Same assignments may include MATLAB or C programming of image reconstruction algorithms.
Grading policy:
Exam 1: 40%, Exam 2: 40%, Homework Assignments: 20% (programming 10%, others 10%)

Facilities:
Matlab will be provided to students under the available NYU institutional license. Lectures will be taught at the NYU Center for Biomedical Imaging (CBI) and at the Polytechnic School of Engineering of NYU (Poly) campus in Brooklyn.

Textbooks:

Outline:
Lecture #1 Introduction (Yao Wang, Poly, 9/14/2015)
• Introduction to the course
• Overview of various medical imaging modalities (Chap 1)
• Review of signals and system (Chap 2)
• Image quality metrics (Chap 3)
Lecture #2 Physics of radiography (Yao Wang, Poly, 9/21/2015)
• Ionizing radiation
• Physics of radiography (Chap 4)
Lecture #3 Projection radiography (Yao Wang, Poly, 9/28/2015)
• Projection radiography - conventional x-ray imaging (Chap 5)
Lecture #4 X-Ray computed tomography (CT) part 1 (Yao Wang, Poly, 10/5/2015)
• Instrumentation
• Image formation
• Radon transform
Lecture #5 X-Ray computed tomography (CT) part 2 (Yao Wang, Poly, 10/13/2015, TUESDAY)
• Back projection
• Filtered back projection
• Image quality
Lecture #6 Nuclear Medicine Imaging (Yao Wang, Poly, 10/19/2015)
• The physics of nuclear medicine (Chap 7)
• SPECT and PET (Chap 9)

MIDTERM EXAM (10/26/2015, Poly)
Lecture #7 Positron Emission Tomography (Yu-Shin Ding, CBI, 11/2/2015)
- Clinical aspects of PET

Lecture #8 Physics of Ultrasound (Daniel Turnbull, CBI, 11/9/2015)
- Physics of Ultrasound (Chap 10)
- Acoustic waves
- Wave propagation
- Beam pattern formation and focusing

Lecture #9 Ultrasound Imaging (Daniel Turnbull, CBI, 11/16/2015)
- Ultrasound Imaging (Chap 11)
- Instrumentation (transducers, probes, etc.)
- Pulse-echo equation
- Ultrasound imaging principles

Lecture #10 Physics of Magnetic Resonance Imaging (Riccardo Lattanzi, CBI, 11/23/2015)
- Physics of MRI (Chap 12)
- Precession and Larmor frequency
- RF excitation
- Relaxation

Lecture #11 Magnetic Resonance Imaging (Riccardo Lattanzi, CBI, 11/30/2015)
- Instrumentation
- Data acquisition
- Image reconstruction

Lecture #12 Advanced Magnetic Resonance Imaging (Riccardo Lattanzi, CBI, 12/7/2015)
- Image quality
- Diffusion MRI
- Functional MRI

Tour of the NYU Center for Biomedical Imaging (Riccardo Lattanzi, CBI, 12/14/2015)
- 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 (12/21/2015, Poly, 10:00 AM – 12:50 PM)