BIM 242: Introduction to Biomedical Imaging

Instructors

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To schedule an appointment to meet an instructor, please email the instructor directly.

Course Description

Course Goals: To introduce the basic physical principles, instrumentation methods, and imaging algorithms of major biomedical imaging modalities, including x-ray, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and optical imaging. Preclinical and clinical aspects are included where possible to provide students with a better understanding of the applications of biomedical imaging.

Course Time: Monday and Wednesday, 8:00-9:50 AM

Prerequisites: Graduate standing or consent of Instructor of Record. Background in engineering with basic knowledge of signals and systems, e.g., Fourier transform and convolution.

Grading

Letter grade: Based on:

Home Work	=	40%
Pop Quizzes	=	20%
Final Exam	=	40%
		100%

Pop quizzes will be administered during randomly chosen lectures. The final exam will be take-home.

Late submission: A homework assignment turned in late will receive a 10% penalty if received prior to 5:00 pm of the following day and a 5% penalty for every additional day. No work will be accepted after one week.

Required Text

Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone,
"The Essential Physics of Medical Imaging, Third Edition",
http://www.amazon.com/Essential-Physics-Medical-Imaging-Edition/dp/0781780578

Reference Texts: Simon R. Cherry, James A. Sorenson, Michael E. Phelps,
"Physics in Nuclear Medicine, Fourth Edition,"
http://www.amazon.com/Physics-Nuclear-Medicine-Expert-Consult/dp/1416051988

Lihong Wang,
"Biomedical Optics: Principles and Imaging,"
http://www.amazon.com/Biomedical-Optics-Principles-Lihong-Wang/dp/0471743046

Specific Class Objectives

Topics	Learning Objectives	Lectures	Learning Materials
Signals, system and image quality	• Understand and illustrate the concepts of Fourier transform, inverse transform, and convolution • Understand the Shannon sampling theorem • Understand how signal contrast, spatial resolution, image noise are measured • Understand the concepts of point spread function and modulation transfer function	1	Bushberg book (Chps 4, Appendix G)
Interaction of radiation with matter	• Understand the concepts of particle interactions • Understand X-ray and gamma-ray interactions • Understand attenuation of photons • Understand beta particles • Discuss radiation safety	1	Bushberg book (Chps 3)
X-ray production and projection imaging	• Understand the concepts of x-ray production and the construction of x-ray tube components and peripherals • Show how x-ray generators control x-ray beam energy and intensity • Illustrate concepts of x-ray tube output as a function of kV, waveform, mA, time, and focal spot • Discuss x-ray spectrum concepts related to kVp, HVL, filtration, and radiation dose to the patient • Radiography and fluoroscopy	1	Bushberg book (Chps 6-9)
Radiation Dose in X-ray Imaging	• Dose concepts: absorbed dose, equivalent dose, effective dose • Dose in radiography • Dose in fluoroscopy • Dose in mammography • Dose in computed tomography	1	Bushberg book (Chps 11)
X-ray Computed Tomography (CT)	• The CT generations • Detectors and CT acquisition • Reconstruction • Spatial and contrast resolution • CT dosimetry • Display and formatting • Artifacts • Applications	2	Bushberg book (Chps 10)
Ultrasound	• Review of basic physics of ultrasound (US) • Understand basic US characteristics • Describe US interactions, production, beam properties • Illustrate image acquisition methods and details • Discuss US equipment and special techniques • Show Doppler methods and velocity easurements • Demonstrate ways that artifacts occur • Overview ultrasound intensity issues and bioeffects	2	Bushberg book (Chps 14)

Nuclear Magnetic Resonance	• Understand magnetic fields and magnetization • Describe characteristics of tissue magnetization • Demonstrate stimulation, excitation, emission, and signal capture of proton magnetization	1	Bushberg book (Chps 12)
Magnetic Resonance Imaging	• Describe how MR signals are localized • Understand factors about image acquisition time and image quality • Illustrate image artifacts and causes • Discuss MR safety concerns and directives	2	Bushberg book (Chps 13)
Optical Imaging	• Understand the concepts of interaction of light with tissue, including absorption, refractive index, scattering, anisotropy, reduced scattering • Understand the objectives of designing optical systems, including performance, configuration and productivity considerations • Demonstrate applications of optical imaging	2	Wang book Lecture slides
Nuclear Medicine	• Define functional imaging • Understand radiotracers • Illustrate the requirements for radionuclide imaging • Understand the concept of half-life • Understand how detectors detects gamma rays	1	Bushberg book (Chps 15-18)
Positron Emission Tomography (PET)	• Understand the concepts of positron emission and annihilation • Understand how coincidences are detected • Understand different PET radiotracers • Understand how PET camera works • Illustrate the use of PET for therapy response assessment • Understand the corrections needed for quantitative PET imaging, including attenuation correction, scatter correction, randoms correction, dead-time correction, and normalization • Understand the basic concepts of tomographic image reconstruction	2	Bushberg book (Chps 19) Lecture Slides
Hybrid PET/CT and PET/MR Imaging	• Illustrate the need for hybrid imaging • Understand the design of PET/CT • Understand the design of PET/MR • Understand the challenge of attenuation correction	1	Cherry paper on multimodality imaging
Parametric Imaging	• Illustrate dynamic imaging in CT, MR and PET • Understand the basic conept of tracer kinetic modeling • Understand how parametric imaging is created • Understand the advantages of parametric imaging • Demonstrate applications of parametric imaging	1	Cherry Book (chapter 21) Lecture Slides
Tour of Center for Molecular and Genomic Imaging (CMGI)	• Introduce various imaging modalities at CMGI • Understand the differences between different imaging modalities	1	NA