EE 693I – Medical Imaging Systems

Spring 2025

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Course Time/Location: MW 1030-1145 AM

Course Description

- Physics and engineering principles associated with image acquisition and reconstruction for X-ray, computed tomography, nuclear medicine, ultrasound, and magnetic resonance and clinical applications of respective imaging modalities
- Prerequisites: Previous knowledge of linear systems, signals, and systems. Similar to EE 315 or Consent

Textbook

- Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems, 2nd edition, United Kingdom: Pearson, 2015, ISBN: 9780132145183
- Paul Seutens, Fundamentals of Medical Imaging, 2nd Edition, Cambridge University Press, 2009, ISBN:9780521519151

Course Objectives

Through this course, the students will develop a comprehensive understanding of the following aspects relevant to Medical Imaging:

- Develop basic knowledge of common medical imaging modalities, including magnetic resonance imaging, ultrasound, X-ray, computed tomography, and nuclear medicine imaging
- Understand basic physical principles of image formation in different modalities
- Perform basic image reconstruction using computational tools
- Simulating fundamentals of medical imaging signals and systems using MATLAB
- Describe and analyze hardware components of medical imaging systems
- Describe clinical applications of different imaging modalities
- Safety considerations for common clinical imaging modalities

Course Topics

- Image Characteristics and Visual Perception: Concepts of resolution, point-spread function, modulation transfer function, signal-to-noise level, Multi-dimensional Fourier transform, Spatial frequencies, Image filtering in spatial frequency domain, Structure and function of the human visual system.
- X-ray and Computed Tomography: Instrumentation; Electronic structure; Mechanisms of absorption and scattering of X-rays in tissue; Contrast in radiographic images; Computed tomography; Data acquisition; Iterative reconstruction schemes; Clinical applications.

- Nuclear Imaging: Radioactivity and types of radioactive decay; The gamma camera; Tissue attenuation; Choice of radio nuclide; The technetium generator; Biodistribution of radionuclides in the body; Resolution and image processing in nuclear medicine; Positron emission tomography.
- Ultrasound Imaging: Wave propagation; Scattering, absorption, and attenuation of ultrasound; Instrumentation; Resolution in ultrasound imaging; Transducer focusing; Phased and linear arrays; A mode imaging; B-mode imaging; Real-time imaging; Doppler instrumentation; Clinical applications.
- Magnetic Resonance Imaging: Classical description of nuclear magnetic resonance; Quantum mechanical description of NMR; Effect of radio frequency pulses; The free induction decay; Mechanisms and measurement of relaxation processes; Fourier imaging methods; Pulse sequences in MRI; Contrast agents: paramagnetic and ferromagnetic; Construction of magnetic field gradients and rf coils