OPTI 638: Advanced Medical Imaging

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Catalog Description:

This course will describe the physical principles behind the medical cross-sectional imaging modalities of magnetic resonance imaging, computed tomography, ultrasound, positron emission tomography and single photon emission computed tomography. Prerequisites: OPTI 512R, OPTI 604 or equivalent.

Textbooks:


Recommended

- Kak and Slaney. Principles of Computerized Tomographic Imaging.
- Barrett and Swindell. Radiological Imaging.

Grading Policy:
The course grade will be based on three equally weighted components: homework assignments, a midterm exam, and a final paper or project.

Outline

I. Overview

- Linear systems.
- Fourier transforms in rectangular and polar coordinates.
- Concepts in imaging - spatial resolution, signal-to-noise ration (SNR), contrast.

II. Computed Tomography

- Forward and inverse radon transform in 2 and 3 dimensions.
- X-ray CT data acquisition.
- PET and SPECT data acquisition.
- Parallel-beam, fan-beam, and cone-beam geometries.
- Image reconstruction algorithms.
- Direct methods
- Iterative methods.
• Resolution and SNR.
• Artifacts.
• Clinical applications.

III. Magnetic Resonance Imaging

• Physics of nuclear magnetic resonance.
• Bloch equations.
• Relaxation.
• Chemical shift.
• Imaging - gradient fields.
• Imaging sequences.
• Spin-echo.
• Inversion recovery.
• Stimulated echo.
• Gradient echo sequences.
• Echo-planar and segmented data acquisition methods.
• 2D and 3D methods.
• MRI instrumentation - magnets, gradient coils, RF coils.
• MR angiography.
• NMR spectroscopy - localization and chemical shift imaging.
• Resolution and SNR.
• Artifacts.
• Clinical applications.

IV. Ultrasound

• Physics of sound wave propagation.
• Absorption, attenuation, and scattering.
• Ultrasound transducers.
• Pulsed A-mode and B-mode.
• Phased arrays.
• Doppler techniques.
• Instrumentation.
• Resolution and SNR.
• Artifacts.
• Clinical applications.