BIM 286: Nuclear Imaging in Medicine and Biology

Instructor: Prof. Simon Cherry

Description:

Radionuclides are widely used in imaging applications in medicine and biology, ranging from simply exposing radiolabeled tissue sections to photographic film to sophisticated tomographic imaging techniques such as positron emission tomography (PET). Students will be introduced to nuclear imaging technologies by considering specific patient case studies that lead to a discussion of the principles governing these technologies, detector and system design and engineering, image reconstruction techniques and the corrections and analysis that need to be applied to obtain clinically relevant information from nuclear medicine images. Classes will be a mix of didactic lectures and student group presentations in a highly interactive style, culminating in group presentations that cover how nuclear imaging technologies have been brought to bear on a particular clinical problem.

Units: 4

Lecture and student presentations, based on interactive format, driven by case examples.

Class meets twice per week, for two hours each time
Offered alternate years only – in Winter or Spring

Grading

Letter grade based on:

- Mid-Term
- Final
- Project/Presentation

Syllabus:

Introduction

- what is nuclear imaging, examples of the use of nuclear imaging in medicine and biology, historical perspective on use of radiation in biology and medicine, role of engineering in nuclear imaging

Brief Review

- basic atomic and nuclear physics
- modes of radioactive decay
- interaction of radiation with matter

Radionuclide Production

- Nuclear reactors (neutron bombardment and fission products), cyclotrons radionuclide generators
- cross-sections for radionuclide production

Gamma Camera Fundamentals
- Position sensitive NaI(Tl) detectors
- Anger logic
- Intrinsic spatial resolution

Collimators
- General concepts
- Parallel-hole
- Pinhole
- Diverging, converging and cone-beam

Gamma Camera Performance Characteristics
- Intrinsic spatial resolution
- Detection efficiency
- Energy resolution
- Count-rate performance
- Non-uniformity correction
- Non-linearity correction
- Performance

Emission computed tomography
- Inverse problem
- Backprojection
- Filtered backprojection
- Sampling
- Iterative reconstruction

Single Photon Emission Computed Tomography (SPECT)
- SPECT system design
- Practical implementation of SPECT
- Performance characteristics of SPECT systems
- Clinical applications of SPECT

Positron Emission Tomography (PET)
- Annihilation coincidence detection
- PET detector and scanner designs
- PET data acquisition
- Data corrections and quantitative aspects of PET
- Clinical and Research applications of PET

Image Quality
- Methods for characterizing image quality
- Spatial resolution
- Contrast

Noise
Observer performance studies

Tracer Kinetic Modeling
Basic concepts
Tracers and compartments
Tracer delivery and transport
Formulation of a compartmental model
Examples of tracer kinetic models

Internal Radiation Dosimetry
Radiation dose: quantities and units
Calculation of radiation dose

Textbook:

Physics of Nuclear Medicine
Authors: Simon Cherry, James Sorenson, Michael Phelps
Edition: 3rd
Publisher: Elsevier