NPRE 435: Radiological Imaging

Course Syllabus

Credit: 3 undergraduate hours or 3 graduate hours.

Meeting Schedule/Contact Hours: Three 50-minute lectures (3.0 contact hours) per week.

Introduction

This course provides an in-depth coverage of modern radiological imaging techniques and their applications in diagnostic and therapeutic radiology. The course content is divided into three major sections. We will start with a brief introduction to the basic physical and mathematical principles, including commonly used radioactive sources, the interaction of ionizing radiation with matter, and basic image formation techniques. These will be followed by a series of advanced topics, including modern imaging sensors, the evolution and current trend of "traditional" radiological imaging techniques, such as position-emission tomography (PET), single-photon emission computed tomography (SPECT), and X-ray computed tomography (CT) and their applications in diagnostic and therapeutic radiology. Finally, we will discuss several emerging radiological imaging modalities, such as X-ray fluorescence and X-ray luminescence CT, X-ray phase-contrast imaging, and their applications. The lecture discussions will be complemented by two lab sessions on X-ray and gamma-ray imaging experiments with cutting-edge imaging hardware.

Topical Outline

Topics	Contact Hours
Introduction to Radiological Imaging	2
Chapter 1: Radiation Sources and Interactions of Ionizing Radiation	
1.1 Commonly used radiation sources for imaging and therapeutics	1
1.2 Radionuclide and radiopharmaceutical production	1
1.2 Interactions of ionizing radiation with matter	1
Chapter 2: Mathematical Preliminaries	
2.1 Linear system theory	2
2.2 Analytical image reconstruction methods	2
2.3 Iterative image reconstruction methods	2
2.4 Image quality assessment	1
Chapter 3: Modern Imaging Sensors	
3.1 Scintillation imaging sensors	3
3.2 Modern semiconductor imaging sensors	3
3.3 Other imaging sensor technology	2
Lab tour: TBD	1
Chapter 4: X-ray Radiography and Computed Tomography	
4.1 X-ray radiography and X-ray CT: image formation	3
4.2 Modern X-ray imaging instrumentations	1

Lab Session 1: Advanced X-ray sensors and X-ray image formation	2
Chapter 5: Emission Tomography	
5.1 Tracer principle and commonly used radionuclides	1
5.2 Single photon emission computed tomography (SPECT)	2
5.3 Positron emission tomography (PET)	2
5.4 Recent advances and future directions of emission tomography	2
Lab Session 2: Advanced emission tomography lab	3
Chapter 6: Emerging Radiological Imaging Techniques	
6.1 Energy-resolved photon-counting X-ray CT	1
6.2 X-ray-fluorescence and X-ray luminescence CT	1
6.3 X-ray phase-contrast imaging.	1
	Total: 43

Textbooks

Required textbook:

[1] Medical Imaging Signals and Systems, J. Prince and J. M. Links, Second Edition, Pearson Prentice Hall, 2013.

Recommended reading:

[1] Foundations of Imaging Sciences, H Barrett, John Wiley & Sons, 2006.

[2] Foundations of Medical Imaging, Z. H. Cho, John Wiley & Sons, 1993.

[3] Radiation Detection and Measurements, Third Edition, G. F. Knoll, John Wiley & Sons, 1999.

[4] Elements of Modern X-ray Physics, Second Edition, J Als-Nielsen, Des McMorrow.

Grading: Homework (40%), Four Quizzes (15% each), Term Projects (15%), Midterm and Final Exams: 30%.