BIOE 483 Biomedical Computed Imaging Systems

3/4 credit hours, **Fall 2026**

Course Website: https://canvas.illinois.edu/courses/71525
Classes: Tuesday/Thursday, 9:30 - 10:50 AM, 2101 Everitt Laboratory
Instructor: Prof. Fan Lam, fanlam1@illinois.edu; 2246 Everitt Lab/4061 Beckman Institute
Office hours: Friday, 3 - 4 PM, 4061 Beckman Institute (no office hour on 9/11, 10/16)

Computed imaging is a modern process governing how (bio)medical images are acquired, optimized, analyzed and visualized. This course describes the physics of radiographic, magnetic resonance, and nuclear imaging modalities with a focus on computational modeling (of the physics), image formation and performance analysis. Imaging system modeling and signal processing principles that are common to different modalities are covered in the context of specific biomedical imaging applications. Integration of physics-based modeling, computation, and iterative reconstruction techniques are covered in depth.

Student Learning Objectives: Upon completion of this course, students will be able to

- Understand the canonical imaging physics that underlies X-ray radiography and CT, nuclear imaging, and MRI modalities
- Identify the physical factors that limit diagnostic performance of each technique
- Understand mathematical and numerical models of data acquisition and image formation
- Articulate the principles of image reconstruction from encoded measurements (e.g., projections)
- Understand and apply iterative image reconstruction methods
- Understand image quality metrics as a motivation for technology development
- Apply the computational skills needed to form and evaluate medical images

Prerequisites:
Proficiency in foundational math including linear algebra, calculus and probability
Reasonable familiarity with scientific computer programming (Matlab and/or Python)
Preferred: BIOE210, 205 or equivalent, ECE/BIOE 380 or equivalent

A note on AI tools and why we still work things out by (our) hands. In this course we will go over many foundational concepts such as Fourier transform, linear shift-invariance, and implement reconstruction algorithms, not because doing these quickly is valuable (AI tools now do them faster and more accurately than most, if not all, of us), but because the goal was never speed or the derivation itself. The goal is understanding, and from understanding, intuition and judgement, the kind that lets you look at an image and know whether/what artifacts are present and if they make sense. That intuition cannot be handed to you or prompted from a tool. It is abstracted from the mechanical work. You may eventually throw the derivation or the detailed implementation away; the understanding is what stays. In an age where a flawless-looking answer is no longer evidence that anyone understood it, that retained understanding is the one part of your expertise that is genuinely yours, and the only reliable basis for judging whether the tools can be trusted, and *hopefully* make sure you are not replaced by an AI (you will definitely be replaced otherwise). With these said, you can use LLM or AI tools to help you understand the materials as well as the homework, but you *should not* offload your work entirely to AI.

Required Textbooks (See instructor on required book purchase)

- Course notes distributed on Canvas.
- Jerry L. Prince, Jonathan Links, *Medical Imaging Signals and Systems*, 2nd Edition, Pearson, 2015
- Jerrold T. Bushberg, John M. Boone, J. Anthony Seibert, Edwin M. Leidholdt, *The Essential Physics of Medical Imaging*, Lippincott Williams & Wilkins, 2002

Recommended Textbooks

- Paul Suetens, *Fundamentals of Medical Imaging*, Cambridge University Press, 3rd Edition, 2017

You can use either Matlab or Python to complete the assignments. We encourage the use of Python for students in the MS-BIC program. **Computing results, descriptions and analysis** are to be included in the homework submission. DO NOT include codes unless asked.

Grading

Homework Assignments	25%
In-Class Quizzes	15%
Exam (midterm, "open" book)	20% (one book and your notes allowed; others not)
Participation (lectures and labs)	10%
Final Project	30% (20% presentation and 10% final report)

>90% = A >87% = A- >84% B+ >80% = B >77% = B- >74% = C+ >70% = C >65% = C-

Preliminary Schedule

Date	Class Meeting	Lecture Topics	Notes
08/25	**1**	Course Introduction and Computational Imaging	
08/27	**2**	Mathematical Preliminaries for Imaging (Review)	
09/01	**3**	Mathematical Modeling of Images (e.g., basis exp)	
09/03	**4**	Mathematical Modeling of Image Acquisition	
09/08	**5**	Fourier Analysis and its Connection to LSI Systems	
09/10	**6**	Introduction to Radiographic Imaging, X-Ray (Online)	HW1 Due
09/15	**7**	Modeling Radiographic Imaging Systems	
09/17	**8**	Image Quality Metrics for Linear Imaging Systems (Guest)	
09/22	**9**	Vector Space Treatment and Inverse Problem in Imaging	
09/24	**10**	Introduction to X-Ray CT, Instrumentation and Acquisition	HW2 Due
09/29	**11**	Classic CT Reconstruction (FBP, Fan/Cone Beams, etc)	
10/01	**12**	Iterative and Model-Based Reconstruction	
10/06	**13**	Sampling Consideration (e.g., sparse sampling) or Guest lec	*TBD*
10/08	**14**	MRI Imaging Physics I	HW3 Due
10/13	**15**	MRI Imaging Physics II	
10/15	**16**	Mid-term exam	**Travel*
10/20	**17**	Fast sequences and MRI Reconstruction	
10/22	**18**	"Classic" MRI Reconstruction Methods	
10/27	**19**	Iterative MRI Reconstruction (Optimization)	**Travel*
10/29	**20**	*Experiments at the MRI Lab (Beckman)*	HW4 Due
11/03	**21**	Learning-based Reconstruction	
11/05	**22**	Nuclear Imaging, Isotope Decay Modes and Statistics	
11/10	**23**	Instrumentation for Planar Scintigraphy	
11/12	**24**	Image Equation for Gamma Camera Acq.	
11/17	**25**	SPECT Acquisition and Reconstruction	HW5 Due
11/19	**26**	PET Acquisition and Reconstruction, Image Quality	
11/24	**27**	*No class (Fall break)*	
11/26	**28**	*No class (Fall break)*	
12/01	**29**	*Experiments at the Molecular Imaging Lab (Beckman)*	
12/03	**30**	Objective/quantitative image quality assessment	
12/08	**31**	Final presentation session	

Homework Assignments

- Homework is to be submitted in a pdf format. Please scan your homework in the right page order, convert them into a single PDF.
- You are encouraged to work together on assignments. However, everyone must submit an individual report with clear figures. All plots and images must be clear labeled.