Syllabus – Fall 2024

BME I5000: Biomedical Imaging
Prerequisites: complex variables, linear algebra, some programming, probabilities.
Instructor: Lucas C. Parra, parra@ccny.cuny.edu
Office Hours: on zoom, book a time on my calendar.
TA office hours: Thursday 12:15PM, ST 40xS
Recitation:

Summary: This course introduces basic medical imaging methods such as computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET). Students will gain understanding in the basic physics of image acquisition and the algorithms required for image generation. Basic image enhancement, and image analysis will be presented in the context of X-ray imaging and microscopy. The course will include linear systems, random variables, and estimation theory. Students will gain hands-on experience in image processing through MATLAB or Python programming in class and in assignments.

Online classes: When we move to zoom for whatever reason, classes will be here: https://us06web.zoom.us/j/9460803414 . Video is required, and in particular in order to participate in the midterm and final exams, including appropriate bandwidth to support video. Lectures will be recorded and links provided after class. They will be available for a few weeks only. If you want to preserve them for longer, you must download. You may not post video lectures online. If you do not feel well, please stay home and let me know that you want to attend remotely. However, this course is not easy. To complete it successfully my advice it to be in class in-person every time, and ask many questions.

Prerequisites: Calculus, complex variables, coding.

Schedule (rough order, topics covered based on student interest)
1. Introduction, Spatial Resolution, Intensity Resolution, Noise
2. X-Ray Imaging, Mammography, Angiography, Fluoroscopy
3. Intensity manipulations: Windowing, Histogram Equalization
4. Computed Tomography
5. Image Reconstruction, Radon Transform, Filtered Back Projection
6. Positron Emission Tomography
7. Maximum Likelihood Reconstruction
8. Magnetic Resonance Imaging
9. Fourier reconstruction, k-space, frequency and phase encoding
10. Optical imaging, Fluorescence, Microscopy, Confocal Imaging
11. Enhancement: Point Spread function, Filtering, Un-sharp Masking, Wiener filter
12. Segmentation: Thresholding, Matched filtering, Morphological operations
13. Segmentation: Deep learning.
14. Pattern Recognition: Feature extraction, PCA, Wavelets
15. Pattern Recognition: Bayesian Inference, Linear classification

Learning Outcomes:
- Practical programming skill in image reconstruction, filtering and segmentation
- Matlab or Python programming skills.
- Understanding who medical imaging systems work.

Literature: (all optional, for self study)
Prince &Links, Medical Imaging, Signals and Systems, Pearson Prentice Hall, 2006
Gonzalez & Woods, Digital Image Processing, Prentice Hall, 2003
Francois Chollet, Deep Learning with Pythong, 2nd Edition, Manning, 2021 (don't buy Amazon)