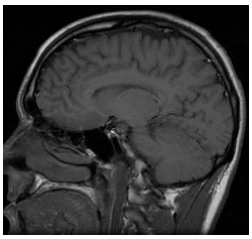
MEDP 7111 Fall 2016



Advanced Medical Imaging Physics

Instructor: Joyoni Dey, PhD
459A Nicholson Hall; 225-578-4289; deyj@lsu.edu

Description: This course covers mathematical topics in imaging, including the theory of image formation, sampling and Fourier analysis; algorithms for image reconstruction; digital image processing, restoration and analysis; image registration (fusion); other topics as possible.

Textbook: (*optional – see list below*) Handouts and material will be provided. No single book covers all the material to be covered.

Class times: **11:30 AM – 12:50 PM on Monday/Wednesday, Room TBD**

Office hours: **Mon, 1:30PM – 2:30pm; NH 459A;** Other times as needed

Policies:

- Attendance at all lectures is required.
- Homework assignments must be individually prepared by each student, and are *due at the beginning of class on due-date*. Requests for late submission must be made *prior* to the due date of an assignment.
- Redistributing, sharing or posting (physically or electronically) is prohibited for any course-related content, including electronic recording of lectures or materials.

Grades: Grades comprise a mid-term exam (20%), a cumulative final exam (40%), and homework assignments (40%). Assignment of final letter grades will be based on grades of Homework, Mid-Semester Exam, and Final Exam, with an anticipated distribution of 90-92.5 = A-, 92.5-97.5 = A, and 97.5-100 = A+; 80-82.5 = B-, 82.5-87.5 = B, and 87.5-90 = B+; 70-72.5 = C-, 72.5-77.5 = C, and 77.5-80 = C+; 60-62.5 = D-, 62.5-67.5 = D, and 67.5-70 = D+; <60%=F.

Homework: Homework assignments will include math and programming exercises. All homework must be submitted on paper, including sample outputs and code snippets as appropriate (code by itself is insufficient). Students can use a programming language with which they are comfortable.

Lecture	Topic	Class Dates (approx.)
1-3	The Fourier Transform; The Delta Function; Discrete and Fast Fourier Transform	8/22, 8/24 8/29
4	Concepts for digital imaging Image format standardization	9/5
5-6	DICOM and PACs in medical imaging	9/7, 9/12
7-9	Linear Systems Theory	9/14, 9/19, 9/21
10-11	Digital Imaging: Sampling and Aliasing	9/26, 9/28
12-17	Image Processing, Restoration; Image Classification and Analysis; Image Registration (fusion)	10/3-10/19
	Midterm Exam	**10/24**

Schedule:

18-20	Image Reconstruction Radon Transform, Central Slice Theorem, and Inverse Radon Transform	10/26, 10/31, 11/2
21-23	Filtered Backprojection, and variants	11/7, 11/9, 11/14
24-26	Iterative and Statistical Reconstruction	11/16, 11/21, 11/28
27-28	Performance assessment of images and systems (ROC analysis)	11/30, 11/30
	Final Exam, tentatively 3:00PM – 5:00PM	**~12/5 (TBA)**
Handouts provide primary material for most lectures; textbook is supplementary		

Topical outline:

1. Introduction: overview of course and schedule;
2. The Fourier Transform: review of Fourier principles; discrete Fourier transform; Fast Fourier Transform; the Delta function
3. Theory of Image Formation: linear systems and shift invariance; point-, line- and edge-spread functions; OTF and MTF; DQE; noise power spectrum; deterministic vs. stochastic models;
4. Digital vs. Analog: consequences of digitization of analog data; sampling theorem; Nyquist rate, bandwidth and aliasing
5. Image Enhancement: point operations; histogram manipulation; spatial filtering; morphological filtering; interpolation
6. Filtering and Restoration: de-blurring; inverse and Weiner filtering;
7. Image Analysis: feature extraction; edge detection; shape and texture analysis; implications for computer-aided diagnosis
8. Image Reconstruction: the Radon transform; the inverse Radon transform; filtered back-projection, iterative reconstruction techniques
9. Performance Assessment: ROC analysis; practical experimental methods for imaging system analysis
10. Fundamentals of PACS; image compression, storage, and retrieval; DICOM; consequences of lossy compression techniques; multimodality imaging and image registration techniques
11. Optional topics: mathematical basis of MR imaging; mathematical basis of ultrasound imaging; dynamic PET and SPECT

Supplemental books (a few of many):

Jain, A. **Fundamentals of Digital Image Processing**. Prentice Hall: Englewood Cliffs, 1989; ISBN 0-13-336165-9

Oppenheim, A. V., Schafer R. W. and Buck, J. R. **Discrete Time Signal Processing**, Prentice Hall, 2nd Edition 1999, Prentice Hall

Oppenheim, A. V. and Schafer R. W., **Digital Signal Processing**, Prentice Hall, 1975

Papoulis, A**. Probability, Random Variables and Stochastic Processes,** Ed. 3, 1991

Dudgeon, D. E and Mersereau, R. M., **Multidimensional Digital Signal Processing**, Prentice Hall Signal Processing Series, 1984, ISBN 0-13-604959-1

Duda, R.O., Hart, P. E and Stork, D.G, **Pattern Classification,** Ed. 2, **John Wiley & Sons, inc,** 2001

Kimmel, R., **Numerical Geometry of Image, Theory Algorithms and Applications,** Springer, 2004, ISBN 978-0-387-21637-9

Epstein, C. **Introduction to the mathematics of medical imaging, 2nd ed**. SIAM, 2008; ISBN 978-0-89871-642-9

Deans, S. **The Radon Transform and Some of Its Applications**. Krieger Publishing Co.: Malabar, FL, 1993; ISBN 0-89464-718-0

Prince, J and Links, J. **Medical Imaging Signals and Systems**. Prentice Hall, 2005; ISBN 978-0130653536

Barrett, H and Myers, K. **Foundations of Image Science**. Wiley-Interscience: Hoboken, NJ, 2004; ISBN 0-471-15300-1

Gonzalez, R and Woods, R. **Digital Image Processing, 2nd ed**. Prentice Hall: Upper Saddle River, NJ, 2002; ISBN 0-201-18075-8

Press, Teukolsky, Vetterling, and Flannery. **Numerical Recipes in C: The Art of Scientific Computing, 2nd ed**. Cambridge University Press: Cambridge, 1992; ISBN 0-521-43108-5

Barrett, H and Swindell, W. **Radiological Imaging: The Theory of Image Formation, Detection, and Processing**. Academic Press: San Diego, 1981; ISBN 0-12-079603-1

Dhawan, A. **Medical Image Analysis**. IEEE Press / Wiley-Interscience: Hoboken, 2003; ISBN 0-471-45131-2