Principles of Image Science, OPTI 637, Spring 2022

Course contents: Mathematical description of imaging systems and noise. Introduction to inverse problems. Introduction to statistical decision theory. Image reconstruction and the radon transform. Image quality.

Pre-requisites: OPTI 508, 512 or 604, or good understanding of Fourier analysis and linear systems from other sources; elementary understanding of matrix algebra. This course is a companion to OPTI 636, "Noise in Imaging Systems," but neither is a prerequisite to the other.

Learning Outcomes:
- Design numerical experiments to simulate *measurements* from discrete and continuous linear systems with an understanding of relevant free parameters and affects on results.
- Use linear systems theory to compute system performance metrics.
- Design numerical experiments to *reconstruct* data from discrete and continuous linear systems with an understanding of relevant free parameters and affects on results.
- Use linear systems theory to compute reconstruction metrics.

Instructor: Meredith Kupinski, Research Professor
Wyant College of Optical Sciences, The University of Arizona
1630 East University Boulevard, Meinel Building Room 645 Tucson, AZ 85721
Phone: 520-626-3985 meredith@optics.arizona.edu

Class Hours: Monday & Wednesday & Friday 1:00 - 1:50 pm in Meinel 432

Office Hour: Tuesday 1:30 pm https://arizona.zoom.us/my/meredithkupinski

D2L Web Site: is set up for posting problem sets and solutions, and submitting homework. Homework is submitted through D2L. The late policy is as follows:
- Within 24 hours of due date: -10%
- Within 1 week of due date: - 20%
- More than 1 week late: -50%

i.e. the *maximum* score attainable for submissions more than one week late is 50%. All students will receive a one-time late submission grace period of one week without any grade reduction. On time homework will be graded and returned within a week of submission, late assignments will be graded within 2 weeks of submission.

Please put the problem number and your name on every page to facilitate grading. Only D2L homework submissions will be accepted.

Course Syllabus

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Required Textbook: Barrett, H.H. and Myers, K.J. (2004), Foundations of Image Science.

Available at the UA bookstore ISBN 9781498700566

UA library (electronic version)

https://ebookcentral.proquest.com/lib/uaz/detail.action?docID=708238

Grading:

Due on 11:59 PM-MST of dates listed below

- 4 Homework Assignments   40%   Mondays:
  Feb 7, Feb 28, Mar 21, April 4

- Project Report   30%

  1. Blind peer submission   Monday April 11
  2. Peer feedback   Monday April 18
  3. Final submission   Monday April 25

- Project presentations in class   30%   May 2, 4
- (15 min each student)

Course Outline:

Unit 1
- **The Imaging Chain**. Classifications of imaging system. Image formation, continuous and discrete models. Image reconstruction and processing. Image quality (brief here, more emphasis in OPTI 636).

Unit 2
- **Mathematical Background**. Basic concepts from linear algebra. Imaging systems as operators in Hilbert space. Singular-value decomposition. Systems of linear equations, pseudoinverses. Wavelets and related topics.

Unit 3
- **Image Formation**. Mathematical properties of imaging systems. Radiometry and radiative transport. Coherent and incoherent imaging. Geometric image formation.

Unit 4
- **Inverse Problems and Image Reconstruction.** Inverse problems. How to enforce agreement with the data. Why not to enforce agreement with the data. Positivity and other constraints. Radon transform and tomography. Continuous formulation. Discrete formulation. Reconstruction from Fourier data. Systems that sample Fourier space (interferometry, MRI, polarimetry). Reconstruction from sparse samples.

Course Syllabus

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Absence and Class Participation Policy

The UA's policys concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: https://deanofstudents.arizona.edu/absences

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. *To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu.* If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.
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Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog: http://deanofstudents.arizona.edu/codeofacademicintegrity http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity. The UA Libraries have some excellent tips for avoiding plagiarism, available at: http://new.library.arizona.edu/research/citing/plagiarism. Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Students with a Learning Disability

Accessibility and Accommodations: At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu) to establish reasonable accommodations.

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (http://drc.arizona.edu/instructor/syllabus-statement.shtml).

Nondiscrimination and Anti-harassment Policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others. The UA is committed to creating and maintaining an environment free of discrimination; see http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.