UNIVERSITY OF CENTRAL FLORIDA

CREOL
The College of Optics and Photonics

OSE4830 - Imaging and Display

Course Syllabus

Instructor: Bahaa Saleh
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Office: CREOL Rm A331
Office Hours: T, R 3:00-5:00 PM (zoom)

Term: Fall 2021
Class Meeting Days: Tuesday, Thursday
Class Meeting Time: 12:00 – 1:15 PM
Class Location CREOL Rm 102
Website:

Course Catalog Description:
Mathematical and physical models of two- and three-dimensional imaging systems including gazing, scanning, interferometric, tomographic, and hyperspectral systems. Applications to remote sensing, biology, and medicine.

Prerequisites: EEL 3123C, OSE 3052

Credit Hours: 3

Detailed Description
This course introduces the basic principles of two- and three-dimensional imaging systems. It begins with the mathematical description of image formation as a linear system and draws on the student's knowledge of signals and systems to introduce the concepts of point spread function, transfer function, resolution, and restoration. Actual physical imaging systems (such as microscopes, telescopes, and copiers) operating in the gazing and scanning configurations are subsequently modeled and their resolution assessed. Interferometric imaging systems and their applications in metrology are described. Techniques for depth profiling are then introduced including point-by-point scanning (as in laser scanning fluorescence microscopy), echo ranging (as in sonar and radar imaging), and interferometry (as in optical coherence tomography). This is followed by an introduction to computational imaging, including the techniques of computed tomography (CT), range tomography, and magnetic resonance imaging (MRI). Hyperspectral imaging systems and their various configurations are then described including applications in detection (of tumors, for example) and classification (of different targets). Performance measures such as sensitivity and specificity are introduced. Applications for remote sensing, nondestructive testing, and biology and medicine are highlighted.

Textbook: Course notes

Recommended Reference: Introduction to Subsurface Imaging, B. Saleh, Cambridge University Press, 2011

Other Reference Books: Flat Panel displays, ST Wu

Dates:

First Day of Class	August 23, 2021
Last Day to Drop Classes:	August 27, 2021
Last Day to Add Classes:	August 27, 2021
Withdrawal Deadline	October 29, 2015
Final Exam:	December 9, 10:00 AM-12:50 PM

Course Grading and Requirements for Success:

Quizzes and homework	20%
Midterm Exam	30%
Term Paper	10%
Final Exam	40%
Total	100%

Make up Exam Policy: If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student **must** give notification to the instructor **no less than 24 hours before** the scheduled date and **no more than 48 hours after the** scheduled

Financial Aid and Attendance: As of Fall 2018, all faculty members are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete the following academic activity by the end of the first week of classes, or as soon as possible after adding the course, but no later than August 27. Failure to do so will result in a delay in the disbursement of your financial aid.

Grade	Rubric Description
100 ≥ A > 85	Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course.
85 ≥ B > 75	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
75 ≥ C > 65	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
65 ≥ D > 60	Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situtations.
60 ≥ F ≥ 0	Demonstrates no understanding of the course content.

Grade Objections:
All objections to grades should be made **in writing within one week** of the work in question.
Objections made after this period has elapsed will **not** be considered – NO EXCEPTIONS.

Class Website:
Materials used for classes will be available on UCF Webcourses for download before each class.

Professionalism and Ethics:
Per university policy and plain classroom etiquette, mobile phones, etc. must be silenced during all classroom lectures, unless you are specifically asked to make use of such devices for certain activities. Academic dishonesty in any form will not be tolerated! If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule in the UCF Student Handbook (www.goldenrule.sdes.ucf.edu) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and the student receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

Students with Special Testing/Learning Needs:
Students with special needs and require special accommodations must be registered with UCF Student Disability Services prior to receiving those accommodations. Students must have documented disabilities requiring the special accommodations and must meet with the instructor to discuss the special needs as early as possible in the first week of classes. UCF Student Disability Services can be contacted at www.sds.sdes.ucf.edu or at (407) 823-2371.

Course Topics:

Introduction and overview

Part A. Image Representation & Processing

1. An image as: a distribution of a physical quantity, a mathematical function, an array, a matrix
2. Introduction to MatLab Image Processing Toolbox
3. Image processing operations: geometric transformations, contrast manipulation
4. Linear blur. Point spread function. Resolution criteria. MatLab implementation
5. Image processing in Adobe Photoshop
6. Concept of spatial frequency. 1D and 2D Fourier transform. MatLab implementation
7. Transfer function, MTF, and spatial bandwidth

Part B. Image Acquisition

1. Physical models of optical imaging systems. PSF, OTF, MTF, resolution
2. Imaging instruments: microscope, camera, and telescope
3. Image scanners, copiers, laser scanning fluorescence microscopy
4. Axial imaging. Echo-based ranging (radar, sonar, and laser metrology)
5. Interferometric axial imaging. Optical metrology. Optical coherence tomography (OCT)
6. Computational imaging: X-ray computed tomography (CT)

Part C. Color Imaging

1. Basic theory of color. The color cube
2. MatLab manipulation of color images
3. Multispectral imaging

Part D. Display

1. Printing, lithography and display. Contrast and resolution.
2. LCD and LED flat panel display. System characteristics and specifications
3. Color LCD and LED displays. Color rendition

Learning Outcomes:

Upon completing this course, the students will be able to

- recognize the various configurations of imaging instruments, including gazing, scanning, interferometric, and tomographic systems.
- select appropriate imaging modalities for various imaging applications.
- model and simulate imaging system using linear systems principles.
- write simple codes for tomographic and computational imaging
- distinguish between structural and functional imaging.
- recognize the fundamental analogies between electrical and optical systems (by virtue of the analogy between one-dimensional and two-dimensional concepts).
- solve an unmixing problem and estimate concentrations or two materials using data produced by a spectrophotometer

Relationship of Course to ABET Criteria

ABET Criteria	Level of Emphasis
(a) An ability to apply knowledge of mathematics, science, and engineering.	High
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.	Low
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Medium
(d) An ability to function on multidisciplinary teams.	Low
(e) An ability to identify, formulate, and solve engineering problems.	High
(f) An understanding of professional and ethical responsibility.	Low
(g) An ability to communicate effectively.	Low
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	Medium
(i) A recognition of the need for, and an ability to engage in life-long learning.	Medium
(j) A knowledge of contemporary issues.	Medium
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	High

Detailed Schedule

Week	Date	Topics
1	T 8 /24	Introduction and overview
	R 8//26	A1 Image representation
2	T 8/31	A2 Image transformations
	R 9/2	A3 Linear blur – Impulse response function
3	T 9/7 --	A4 Linear systems – PSF
	R 9/9	A5 Image blur and resolution
4	T 9/14	A5 Linear systems –Frequency analysis and Fourier transform
	R 9/16	A7 Spatial frequency analysis and Fourier transform
5	T 9/21	A8 Transfer function and MTF
	R 9/23	B1 Image acquisition: optical instruments.
6	T 9/28	B2 Single-lens cameras
	R 9/30	Midterm Exam
7	T 10/05	B3 Resolution of single-lens cameras Selection of term paper topics
	R 10/07	B2 Scanning systems
8	T 10/12	B3 Axial imaging
	R 10/14	B4 Interferometric imaging
9	T 10/19	B5 Optical metrology
	R 10/21	B6 Computational imaging
10	T 10/26	B7 Tomography
	R 10/28	C1 Color
11	T 11/02	Veterans Day
	R 11/04	C2 Color imaging
12	T 11/09	C3 Color image processing
	R 11/11	C4 Spectral imaging
13	T 11/16	D1 Display, printing, and lithography
	R 11/18	D2 LCD and LED flat panel displays
14	T 11/23	D3 Color display
	R 11/25	Thanksgiving
15	T 11/30	Presentation of term papers
	R 12/02	Presentation of term papers
	R 12/9	FINAL EXAM