Fall 2016 Fundamentals of Optical Imaging [ECE 6126]
Co listed with Optics for BMEs [BME 6126]
Fridays 1:25-4:25pm Location: ITEB 125

INSTRUCTOR: Prof. B. JAVIDI, ECE Dept., U-4157
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Text Book: Introduction to Fourier Optics by J. W. Goodman, Roberts Publishers

Recommended to students interested in Imaging Systems, Biomedical Imaging, Optics, Photonics, 3D Imaging

Prerequisite: Undergraduate Electrical Engineering or Physics Degree or Equivalent or Consent of the Instructor

Course description: Learning optical imaging fundamentals. Topics include: review of some fundamentals, including linear systems, Fourier transform, impulse response, transfer function, etc. Two-dimensional linear system theory; scalar diffraction theory, wave optics, Fresnel and Fraunhofer diffraction; imaging properties of lenses; image formation; optical resolution in imaging, frequency analysis of optical imaging systems; imaging with coherent and incoherent sources, coherent transfer function; optical transfer function, point spread function, fundamentals of microscopy, two-dimensional spatial filtering; coherent optical information processing; frequency-domain spatial filter synthesis; holography; 3D imaging.

This course is aimed at students interested to learn fundamentals of optics and optical systems and their applications to imaging systems. This course will review fundamentals of optics, geometrical optics, wave optics, polarization, diffraction, interference, lenses, optical imaging, resolution, fundamentals of microscopy, fundamental limitations to resolution in optical imaging, super resolution, optical image processing, holography, 3D imaging using holography, and optical spatial filtering. The course will describe examples of these techniques for real-time applications. Laboratory demonstration of optical systems for imaging and image processing will be presented [NO laboratory assignments].

Course Outline:
0. Review of some fundamentals
1. Optical Waveforms, Wave Equation
2. Review of two-dimensional systems theory, linear systems, Fourier transform analysis, sampling theory, correlation, and convolution.
3. Wave optics, Optical Diffraction theory, Fraunhoffer diffraction, and Fresnel diffraction, linear system representation of diffraction.
4. Lenses, Fourier transforming and imaging properties of lenses; image formation, frequency analysis of optical imaging systems, modulation transfer function, imaging quality analysis, image resolution, limits to optical resolution, super resolution, image contrast, point spread function, numerical aperture.
5. Two-dimensional spatial filtering, coherent optical information processing, and Frequency domain spatial filter synthesis

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6. Interferometry, interference, Holography, Fourier holograms, computer generated holograms, volume holograms, 3-D imaging, and nonlinear holograms.
8. Laboratory demonstration of real-time optical imaging systems, optical image processing, and optical spatial filtering. No laboratory assignments. Laboratory Periods are for demonstration only and are held once or twice in the semester during the regular lecture periods.

Note: The course includes regular lectures. There is only one written exam, and the course focuses primarily on projects, computer assignments, and presentations by students for hands on experience. The student will focus on one project for the entire semester and will present a proposal, 2 written mid-term reports with oral presentations, and a comprehensive written final report and oral presentation at the end of the semester. For team projects, the contribution of each team member should be clarified in each report. The projects are chosen primarily based on the areas of interest of the students.

It is expected that the students/teams demonstrate independence in analysis, design, troubleshooting, and problem solving as applied to their projects.

Evaluation:
First Midterm Project presentation: 15%, Second Midterm Project presentation: 20%, Final Project Presentation: 40%. Mid-Term project reports and Final project report require oral PPT presentation and written report. Short presentations will be held during the semester to report on student's progress on their project.
Written Exam (at the end of the semester): 25%

Suggested Books and Sources for the Project:
Text Book by J W Goodman; Papers/Handouts/WEB sites presented by the Instructor.

Accessible from http://www.opticsinfobase.org/
- Optics Express, Biomedical Optics Express
- Optics Letters
- Applied Optics
- Journal of Optical Society of America A
- IEEE/OSA Journal of Display Technology

Accessible from http://www.spie.org/
- SPIE Journal of Biomedical Optics (www.spie.org)

Accessible from http://ieeexplore.ieee.org/
- IEEE Medical Image Processing
- IEEE Transactions on Image Processing
- Proceedings of the IEEE Journal

B. Javidi, "Optical Imaging Sensors and Systems for Homeland Security Applications," Springer-Verlag, New York, 2005
B. Javidi and F. Okano eds, "*Three Dimensional Television, Video, and Display*

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Technologies," Springer Verlag Berlin, 2002.
B. Javidi and Th. Fournel, "Information Optics and Photonics," Springer 2009.

Please go to the following WEB site to read policies about **Policy Against Discrimination, Harassment and Related Interpersonal Violence, Sexual Assault Reporting Policy, and Statement on Absences from Class:**

http://provost.uconn.edu/syllabi-references/