OPTI 536, Introduction to Image Science
Course description, Spring 2023

Please visit the course website (https://wp.optics.arizona.edu/opti536/) for updates and more information.

The course covers the basics of image science. This includes the theoretical and mathematical foundations of image science, as well as their application to the analysis of modern (computational) imaging systems. Concrete examples from medical imaging, industrial inspection, remote sensing, virtual reality, or microscopy will be introduced and discussed.

Course Goals: By taking the course, students are expected to gather a broad "toolbox" of basic optical, mathematical, and computational principles used in imaging science. The goal is that students can apply these tools to concrete future tasks they might face in industry or their future research.
Students will be able to identify the measured object properties and how the respective imaging system collects and processes the captured data to extract the desired information. Moreover, students will learn about the analysis of imaging systems and the concept of task-based assessment of image quality.

Prerequisites: This course is intended for graduate students in optical sciences or engineering with an appropriate mathematical background at the level of advanced calculus.

Program: The four key parts of the course include (tentative outline):

Part I: Mathematical formalism of image science
- Image formation
- Objects as vectors in a vector space, image formation as a continuous to continuous or continuous to discrete mapping from an object vector space to an image vector space
- Eigenfunctions, linear systems, Fourier transforms

Part II: The role of optics and computation in modern imaging science
- Indirect imaging, inverse problems, iterative algorithms
- Radiometry
- Geometrical optics description of imaging
- Coherent and incoherent imaging, diffraction
- Physical optics description and fundamental limits
- Digital imaging, sampling, image detectors, displays
- Image processing

Part III: Modern (computational) imaging systems
- X-ray imaging, computed tomography
- Microscopy
- Radar, Lidar, Time-of-Flight cameras, Non-Line-of-Sight imaging
- (Multi-wavelength) Interferometry, optical coherence tomography
- Sonar, ultrasound imaging
- Remote sensing
- Shadow casting, coded apertures
- Triangulation (structured light)
- Deflectometry and Photometric Stereo
- Neuromorphic Imaging / Event Cameras

Part IV: Observers and task-based image quality assessment
- Noise in imaging systems
- Classification and estimation tasks, ideal observer
- Image quality, task-performance evaluation