Course Syllabus

OPTI 556A Computational Imaging (3 credits)

Instructor Information

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Course Description

Computational imaging consists of joint design of measurement strategy and estimation algorithms. Tomography, consisting of estimation of multidimensional objects from lower dimensional measurements, is the core challenge. This course reviews principles of forward model and inversion algorithms for computational imaging and analyzes imaging systems for geometric and coherent wave field models. Forward models, consisting of discrete representations of continuous image and measurement spaces, are fundamental to computational imaging. The course reviews how to form and evaluate such models. Image estimation combines linear regression and artificial neural networks. Convolutional networks, neural representations and transformer networks are reviewed. Coded aperture and structured illumination systems are considered for x-ray imaging, phase retrieval, holography and wave front sensing are considered for wave imaging.

Course Prerequisites or Co-requisites

Graduate standing in optical sciences.

Course Format and Teaching Methods

In person for main campus students and fully online for students enrolled in Arizona Online programs. Course lectures will be broadcast online and recorded to support remote learning. Evaluation will rely on homework and course projects. Both homework and projects will consist of python programming exercises.

Course Objectives

This course teaches

1. How to build a discrete mathematical forward model for continuous imaging systems
2. How to estimate images from measurements
3. How to code for ray model computational imaging
4. How to code for coherent wave model computational imaging

Expected Learning Outcomes

Students completing this course will be able to model imaging systems using radiation fields, to compare and optimize measurement strategies and to design imaging systems for x-ray, lidar and coherent microscopy.

Required Texts and Materials

The course will be taught from notes posted on D2L.

Schedule of Topics and Activities

The course will consist of two 75 minute lecture/discussion periods each week. Homework exercises, consisting of python programming assignments will be completed weekly. Students will submit a final project, consisting of a larger scale forward/inverse model and analysis of a full imaging system as a term project. The schedule of topics is as follows:

Week	Topic
1	Discrete representation of continuous functions
2	Forward models
3	Linear Regression, point estimation and Regularization
4	Artificial Neural Networks
5	Convolutional Neural Networks
6	Neural representations and generative networks
7	Geometric Fields and Coded Aperture Imaging
8	Radon Transformations and Coding Strategies
19	Snapshot Compressive Imaging
10	Wave Fields and Numerical Modeling of Diffraction
11	Holography and Phase Retrieval
12	Diffraction Tomography and Compressive Holography

13	Optical Elements and the Coherent Transfer Function
14	Ptychography
15	Design of Coherent Imaging Systems

Assessments

Assessment Categories	Percentage of final grade
Weekly homework assignments	75%
Term Project	25%
Total	100%

Final Examination or Project

Students will propose a detailed analysis of a specific imaging system at week 10. They must present a preliminary analysis of the system, including resolution, field of view, information capacity and information rate, in week 12 and detailed forward and inverse model simulations at the conclusion of the term in the form of annotated Jupyter notebooks. The project proposal will correspond to 10% of the project grade, the preliminary analysis 25% and the final report 65%.

Grading Scale and Policies

Letter grades will be assigned with cumulative scores about 90% corresponding to A, 80% corresponding to B, 70% corresponding to C, 60% corresponding to D and <60% corresponding to E.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

University Policies

All university policies related to a syllabus are available at: https://academicaffairs.arizona.edu/syllabus-policies.

Subject to Change Notice

Information contained in the course syllabus, other than the grade and absence policies, may be subjectto change with reasonable advance notice, as deemed appropriate by the instructor of this course.

Graduate Student Resources

http://basicneeds.arizona.edu/index.html