Course Syllabus

OPTI 556B Computational Photography (3 credits)

Instructor Information

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Course Description

This examines the fundamental physical and mathematical basis of emerging camera systems. Computational photography uses digital processing to form multidimensional images from diverse measurements. This course begins with a review of forward models for focal and interferometric measurements of random optical fields. The course then considers models for discrete sampling of focal images and calibration of intrinsic and extrinsic camera parameters. Resolution and display of sampled images is also discussed. The course then considers design of multiaperture and dynamic sampling systems for light field imaging. Neural camera control, image estimation and compression strategies are described for diverse sampling systems.

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 how to represent optical signals in photographic systems and how to use algorithms in python, OpenCV and Pytorch to transform and analyze such signals. The course introduces neural image processing methods and teaches students to use such methods to create space-time, spatio-spectral, multidimensional and multiscale photographic representations.

Expected Learning Outcomes

1) Design and model camera systems and build algorithms for image data fusion from camera arrays.
2) Use optical coherence theory to model focal measurements in cameras, including defocus and tomographic imaging
3) Build discrete sampling and image estimation models for camera systems
4) Calibrate the structure and performance of cameras
5) Design array camera systems and how to estimate scenes from array camera data
6) Control focus, exposure and frame rate in camera systems.

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	Coherence functions and diffraction
2	Measuring coherence functions
3	Focal imaging
4	Defocus and resolution limits
5	Imaging with partially coherent illumination
6	Discrete models for camera systems
7	Interpolation, display and neural estimators
8	Image data compression
19	Camera performance and calibration
10	Multiframe image fusion
11	Feature specific measurement and forward model evaluation
12	Spectral imaging

13	Focus and 3D imaging
14	Video
15	Array camera design and neural radiance fields

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