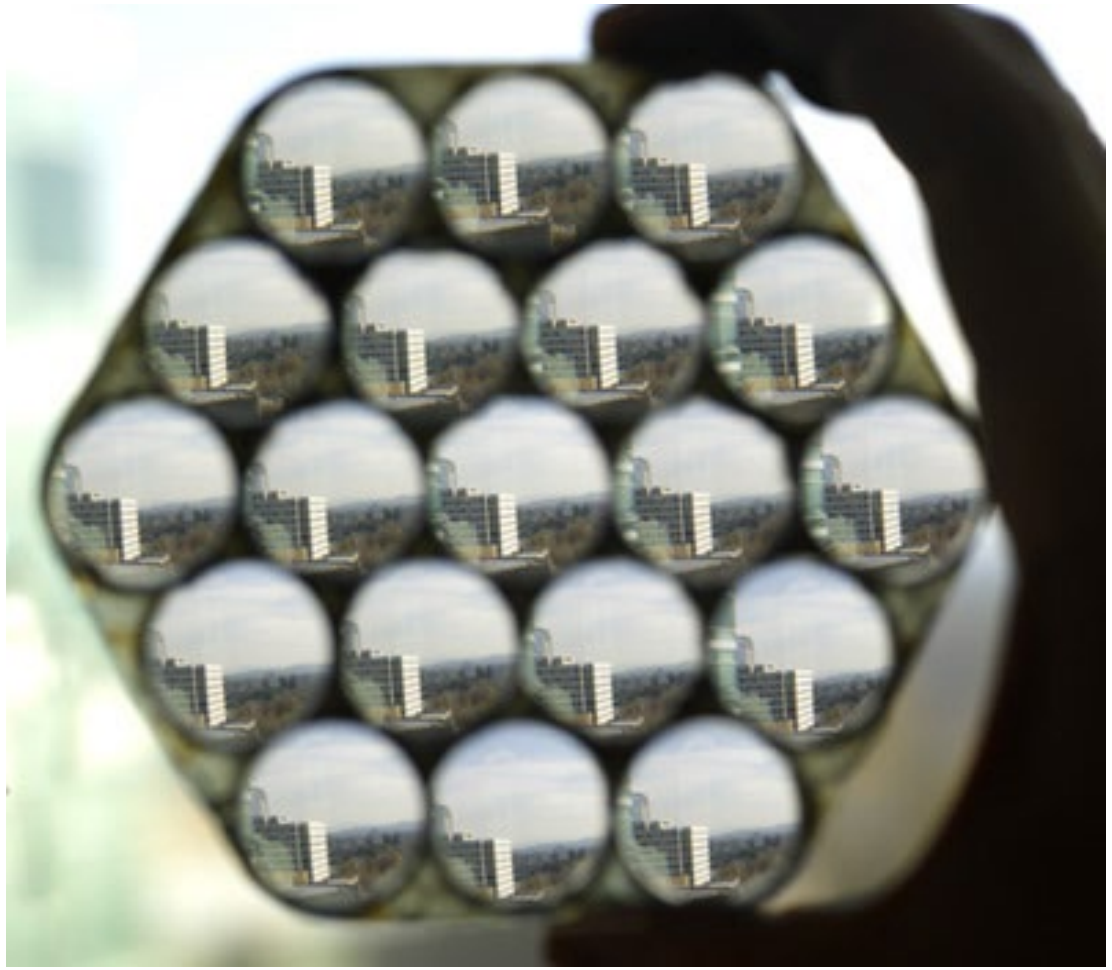
Wrap-up and discussion



15-463, 15-663, 15-862
Computational Photography
Fall 2022, Lecture 20

http://graphics.cs.cmu.edu/courses/15-463

Class evaluation*s* – please take them!

- CMU's Faculty Course Evaluations (FCE): https://cmu.smartevals.com/
- TA evaluation: https://www.ugrad.cs.cmu.edu/ta/F22/feedback/
- 15-463/663/862 end-of-semester survey: https://docs.google.com/forms/d/e/1FAIpQLSeCq-TuFORk8HDbZSQRGnxccP2zqfwNpGz1nLePUdQUz8At8w/viewform
- Please take all three of them, super helpful for developing future offerings of the class.
- Thanks in advance!

Course overview

1. Photographic optics and pipeline. ← Lectures 2 – 4.
2. Exposure, HDR, and noise. ← Lectures 5 – 7.
3. Color and image editing. ← Lectures 8 – 10.
4. Focus and coded photography. ← Lectures 11 – 13.
5. Radiometry and photometric stereo. ← Lectures 14 – 15.
6. Geometry and stereo. ← Lectures 16 – 18.
7. Computational light transport. ← Lectures 19 – 21.

Photographic optics and pipeline

- pinhole and lens cameras
- lenses and other optical elements
- paraxial optics
- aperture
- image processing pipeline

Exposure, HDR, and noise

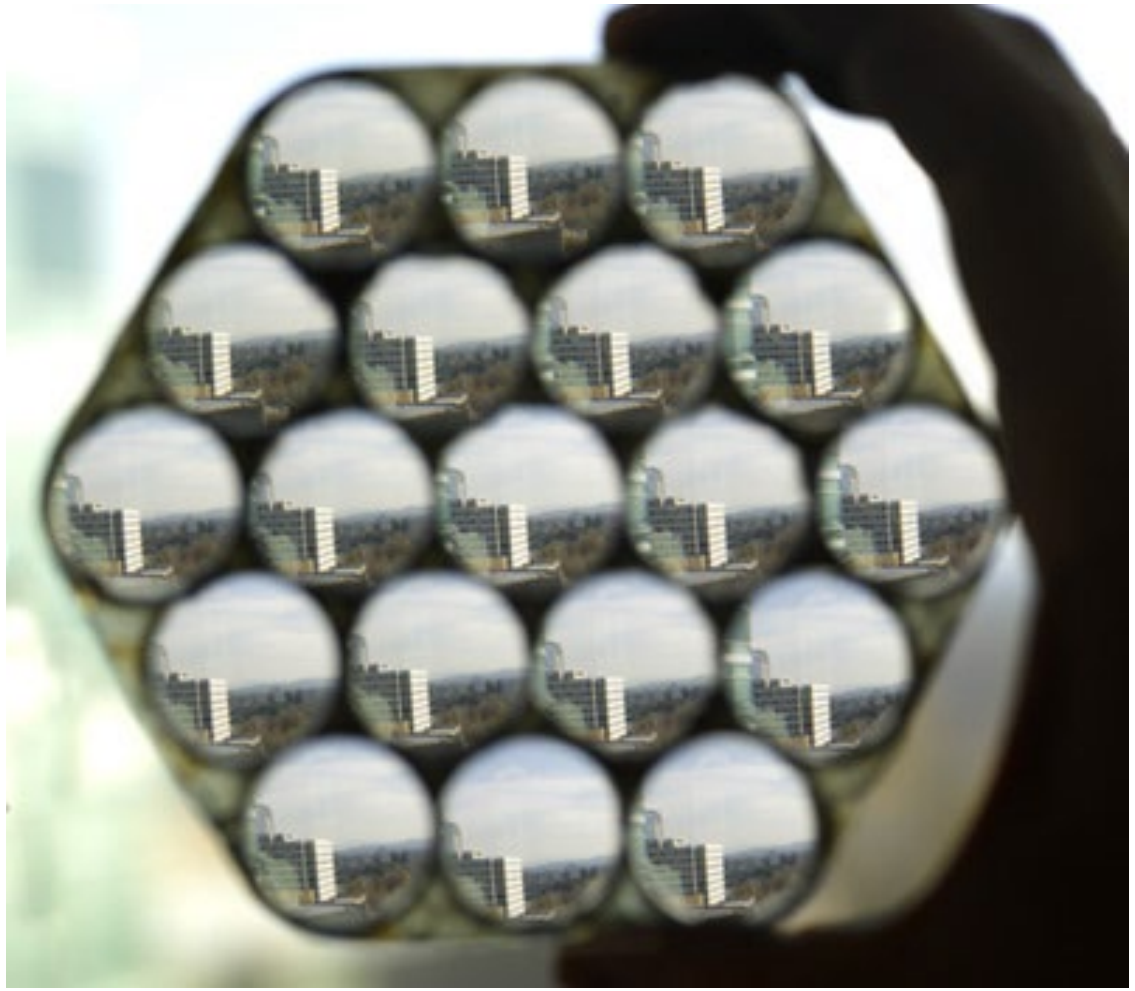
- exposure control
- high-dynamic-range imaging
- radiometric calibration
- noise modeling
- noise calibration

Color and image editing

- tonemapping
- color processing
- color calibration
- edge-aware and bilateral filtering
- gradient-domain processing
- Poisson integration

Focus and coded photography

- focal stacks
- depth from (de)focus and confocal stereo
- lightfields and lightfield processing
- plenoptic camera
- deconvolution and motion deblurring
- coded aperture
- coded exposure

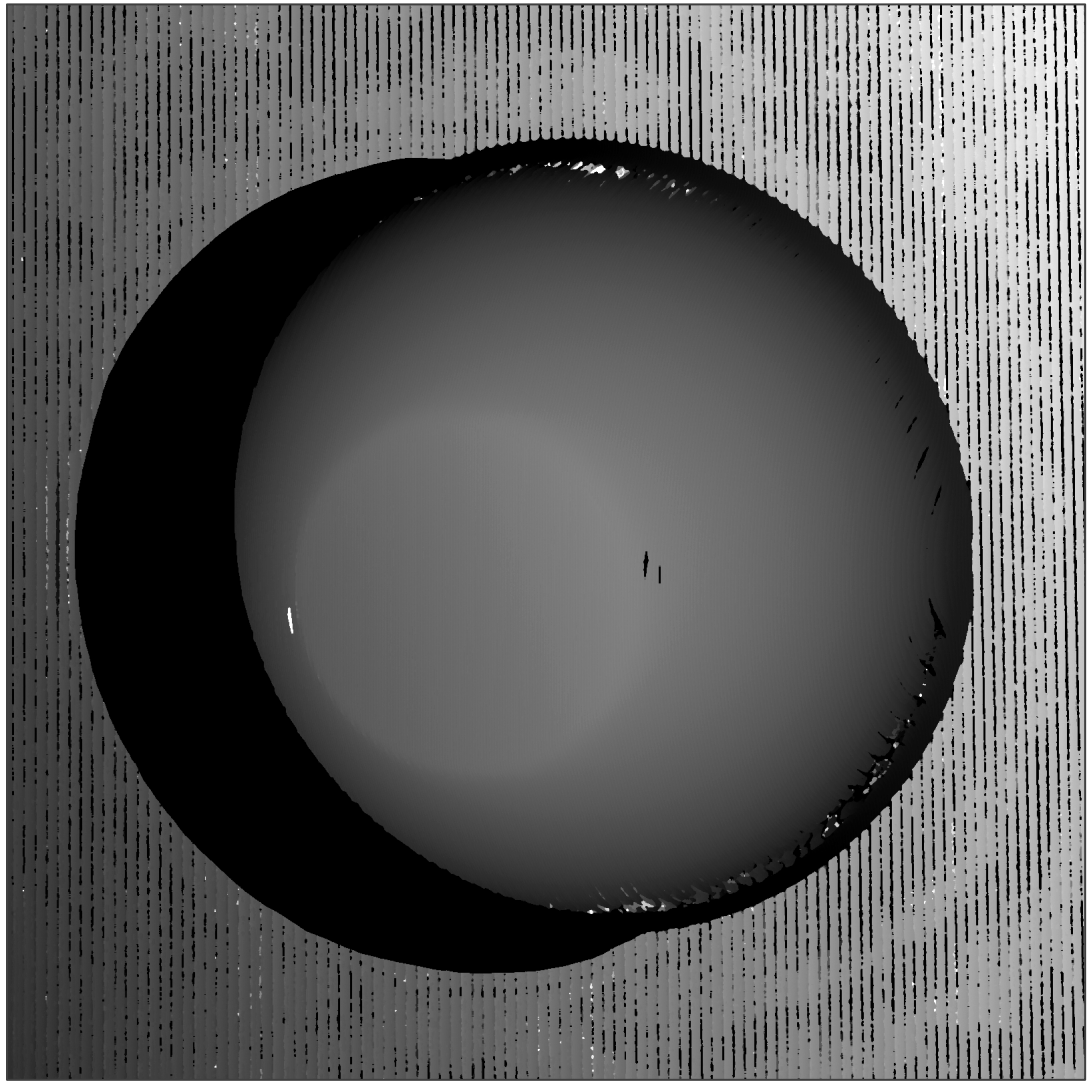


Radiometry and photometric stereo

- radiometry
- reflectance equation
- BRDF models
- illumination models
- calibrated photometric stereo
- uncalibrated photometric stereo

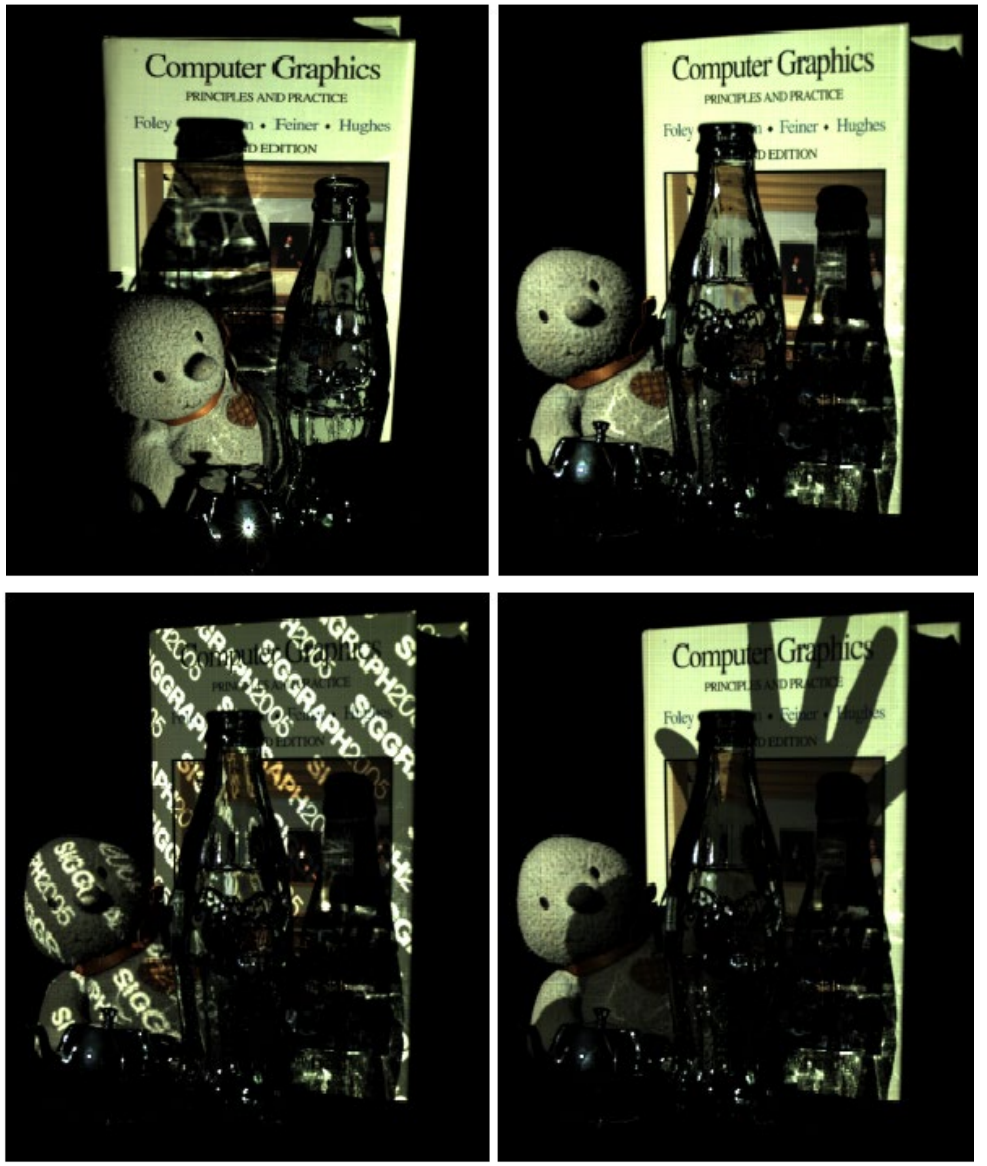
Geometry and stereo

- geometric camera models
- geometric camera calibration
- triangulation
- epipolar geometry
- stereo and disparity
- depth from lightfields
- structured light scanning



Computational light transport

- time-of-flight imaging
- direct and global illumination
- light transport matrices
- dual photography
- optical computing
- probing and epipolar imaging



Things you should know how to do

1. Build simple pinhole cameras, use DSLR cameras and modern lenses.
2. Write your own LDR and HDR image processing pipelines.
3. Calibrate the radiometric, color, noise, and geometric properties of a camera.
4. Fuse images and perform flash/no-flash photography.
5. Use bilateral and gradient-domain filtering for image editing tasks.
6. Capture and refocus your own lightfields and focal stacks.
7. Build three different types of depth and shape sensing systems: depth-from-defocus, photometric stereo, structured light.

Do you plan on taking any other vision/graphics courses?

If you are an undergraduate, check out the **graphics concentration**.

Background courses (ideally you should take both):
- 15-462/662 computer graphics.
- 16-385/16-720 computer vision.

More advanced courses directly relevant for computational photography and imaging:
- **15-468 physics-based rendering – modeling, simulating, and inverting light transport. ← Spring 2023, offered by Yannis**
- 15-458 discrete differential geometry – background for 3D geometry processing and geometric optics.
- 16-822 geometry-based methods in vision – all about epipolar geometry.
- 16-726 learning-based image synthesis – learning-based variants of computational photography algorithms.
- 16-722 sensing and sensors – background on vision and other sensors and noise modeling.
- 16-866 sensor systems – similar to above, background on vision and other sensors and noise modeling.
- 33-353 intermediate optics – wave optics, hands-on experience with optical components.
- 18-416 nano-bio-photonics – modern photonics systems and applications to biology.

More general vision (left) and graphics (right):
- 16-824 visual learning and recognition
- 10-703 deep reinforcement learning
- 16-831 statistical techniques in robotics
- 16-833 robot localization and mapping
- 16-881 deep reinforcement learning for robotics

- 15-365 experimental animation
- 15-464 technical animation
- 15-465 animation art and technology
- 15-466 computer game programming
- 15-469 algorithmic textiles design

Interested in doing research in computational imaging or rendering? Talk to me!

Many, many possible projects, including:

- Projects on rendering and inverse rendering.
- Projects on theory of light transport.
- Projects on coherent imaging and optical coherence tomography.
- Projects on material inference (reflectance, scattering, refractive fields, particle sizing).
- Projects on tissue imaging.
- Projects on non-line-of-sight imaging.
- Projects on combining physics (rendering) and deep learning.
- Projects on data-driven optimization of imaging systems.
- Projects derived from your final project for a paper publication.

Many 15-463/663/862 alumni have worked on various research projects in my group.

Ideal background:

- Knowledge of (at least one of) graphics, vision, physics, numerical computing.
- If you've taken 15-463, you have the background.

Aswin Sankaranarayanan
Faculty
saswin@andrew.cmu.edu

Ioannis Gkioulekas
Faculty
igkioule@andrew.cmu.edu

John Galeotti
Faculty
jgaleott@andrew.cmu.edu

Matthew O'Toole
Faculty
mpotoole@cmu.edu

Srinivasa Narasimhan
Faculty
srinivas@andrew.cmu.edu

Adithya Pediredla
PostDoc
apedired@andrew.cmu.edu

Joe Bartels
PostDoc
josephba@andrew.cmu.edu

Mark Sheinin
PostDoc
marksheinin@gmail.com

Vijay Rengarajan
PostDoc
vangarai@andrew.cmu.edu

Alankar Kotwal
PhD Student
alloo@cmu.edu

Arjun Teh
PhD Student
ateh@andrew.cmu.edu

Bakari Hassan
PhD Student
bhassan@andrew.cmu.edu

Byeongjoo Ahn
PhD Student
bahn@andrew.cmu.edu

Chao Liu
PhD Student
chao.liu@cs.cmu.edu

Chengqian (Bruce) Che
PhD Student
cche@andrew.cmu.edu

Dinesh Reddy
PhD Student

Michael De Zeeuw
PhD Student
mdezeeuw2@andrew.cmu.edu

Minh Vo
PhD Student

Rick Chang
PhD Student
rickchang@cmu.edu

Shumian Xin
PhD Student
sxin@andrew.cmu.edu

Tiancheng Zhi
PhD Student
tzhi@cs.cmu.edu

Vishwanath Saragadam
PhD Student
vsaragad@andrew.cmu.edu

Wei-Yu Chen
PhD Student
weiyuc@andrew.cmu.edu

Yi Hua
PhD Student
yhua1@andrew.cmu.edu

Anqi Yang
MS Student
anqiy1@andrew.cmu.edu

Bhargav Ghanekar
MS Student
bghaneka@andrew.cmu.edu

Roshan Sharma
MS Student
roshansh@andrew.cmu.edu

Jiatian (Caroline) Sun
Undergraduate Student
jiatians@andrew.cmu.edu

Alumni

Convolutional Approximations to the General Non-Line-of-Sight Imaging Operator

Byeongjoo Ahn, Akshat Dave, Ashok Veeraraghavan, Ioannis Gkioulekas, and Aswin C. Sankaranarayanan. *ICCV 2019.*

A Differential Theory of Radiative Transfer

Cheng Zhang, Lifan Wu, Changxi Zheng, Ioannis Gkioulekas, Ravi Ramamoorthi, and Shuang Zhao. *ACM SIGGRAPH Asia 2019.*

Ellipsoidal Path Connections for Time-gated Rendering

Adithya Pediredla, Ashok Veeraraghavan, and Ioannis Gkioulekas. *ACM SIGGRAPH 2019.*

Wave-based Non-Line-of-Sight Imaging using Fast f-k Migration

David B. Lindell, Gordon Wetzstein, Matthew O'Toole. *ACM SIGGRAPH 2019.*

A Monte Carlo Framework for Rendering Speckle Statistics in Scattering Media

Chen Bar, Marina Alterman, Ioannis Gkioulekas, Anat Levin. *ACM SIGGRAPH 2019.*

A Theory of Fermat Paths for Non-Line-of-Sight Shape Reconstruction

Shumian Xin, Sotiris Nousias, Kiriakos N. Kutulakos, Aswin C. Sankaranarayanan, Srinivasa G. Narasimhan, and Ioannis Gkioulekas. *CVPR 2019.*

Multispectral Imaging for Fine-Grained Recognition of Powders on Complex Backgrounds

Tiancheng Zhi, Bernardo R. Pires, Martial Hebert, Srinivasa G. Narasimhan. *CVPR 2019.*

Beyond Volumetric Albedo—A Surface Optimization Framework for Non-Line-of-Sight Imaging

Chia-Yin Tsai, Aswin C. Sankaranarayanan, Ioannis Gkioulekas. *CVPR 2019.*

Non-Line-of-Sight Imaging with Partial Occluders and Surface Normals

Felix Heide, Matthew O'Toole, Kai Zang, David B. Lindell, Steven Diamond, Gordon Wetzstein. *ACM Trans. on Graphics 2019.*

Towards Multifocal Displays with Dense Focal Stacks

Rick Chang, Vijaya Kumar, Aswin C. Sankaranarayanan. *ACM SIGGRAPH Asia 2018.*

http://imaging.cs.cmu.edu/

This class is still evolving, your feedback is invaluable.

- CMU's Faculty Course Evaluations (FCE): https://cmu.smartevals.com/
- TA evaluation: https://www.ugrad.cs.cmu.edu/ta/F22/feedback/
- 15-463/663/862 end-of-semester survey: https://docs.google.com/forms/d/e/1FAIpQLSeCq-TuFORk8HDbZSQRGnxccP2zqfwNpGz1nLePUdQUz8At8w/viewform
- Please take all three of them, super helpful for developing future offerings of the class.
- Thanks in advance!