CS63500
Capturing, Modeling, and Rendering 3D Structures

Daniel G. Aliaga
Department of Computer Science

http://www.cs.purdue.edu/cgvlab

Purdue University
• Topic:
  – Covers fundamental problems and challenges encountered when capturing, modeling, and rendering 3D structures and objects.
  – Covers material in computer graphics, computer vision, and visualization

• Goal:
  – To bring students up to speed in latest methods (research)
  – To enable students to develop new and improved approaches
Syllabus

• Toolbox
  – Images, optimization/minimization, stochastic, HC, DL
• Camera Calibration
• Geometry and Image-based Acquisition
• Deep Learning Based Reconstruction
• Light-Transport based Methods
• Computational Images and Displays
• Inverse Optics
• 3D Printing
Workload

- 3 “short warm-up” assignments
- In-class presentations (lit. review, mid-project)
- Final project (demo/presentation)
  - Suitable for conference or journal submission...
Camera Calibration
Active/Passive Reconstruction

Illuminated (ON)  Non-illuminated (OFF)
Photogeometric Acquisition

To provide an easy-to-use and high-resolution acquisition platform for deployment.
Deep Learning and 3D Reconstruction

• RayNet: volumetric 3D reconstruction
Deep Learning and 3D Reconstruction

- OccNet: occupancy-based reconstruction
Deep Learning and 3D Reconstruction

- Semantic Segmentation
Light Transport Based Methods

- Can encode light (or projector) to camera “transport” in a large matrix $T$

$$\begin{align*}
\text{Camera } c &= \begin{bmatrix} T \end{bmatrix} \begin{bmatrix} p \end{bmatrix} \\
\text{Projector } p &= \begin{bmatrix} T^t \end{bmatrix} \begin{bmatrix} c \end{bmatrix}
\end{align*}$$

As seen from camera...

As seen from projector!!!
Light Transport Based Methods

• Can encode light (or projector) to camera “transport” in a large matrix $T$

$$
c = Tp
$$

As seen from camera...

$$
p = T^tc
$$

As seen from projector!!!
Light in Slow Motion

• https://www.youtube.com/watch?v=Y_9vd4HWlVA
Build your own coded aperture
Build your own coded aperture
Voila!
Coded Aperture Deblurring
Single input image:

Output #1: Depth map
Single input image:

Output #1: Depth map

Output #2: All-focused image
Rectified Crop

Deblurred Result
Computational Displays

- [http://gl.ict.usc.edu/Research/3DDisplay/](http://gl.ict.usc.edu/Research/3DDisplay/)
Inverse/Computational Optics

• Some deblurring approaches:
  – Inverse Filter
  – Wiener Filter
  – Lucy Richardson
  – And more!
Inverse/Computational Optics

- Family of methods that “prevent” blurring...
3D Printing: Self Standing
3D Printing: Self Standing

- Automatic balancing
  - Stability & shape preservation
  - Inner carving & shape deformation
Questions?