CS63500
Capturing, Modeling, and Rendering 3D Structures

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Who?

- Daniel G. Aliaga
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  Associate Professor of CS doing Graphics
  Doctorate in Graphics
  Master’s in Graphics
  Bachelors in Graphics
  High School Degree doing graphics/robots/science
  1980 [TRS80 Model I](http://www.youtube.com/watch?v=3yuqdC8ld48)
  Then: [http://www.youtube.com/watch?v=3yuqdC8ld48](http://www.youtube.com/watch?v=3yuqdC8ld48)
  [http://thinkingscifi.files.wordpress.com/2012/12/starwars-graphics.png](http://thinkingscifi.files.wordpress.com/2012/12/starwars-graphics.png)
  Now: [http://www.youtube.com/watch?v=QAEkuVgt6Aw](http://www.youtube.com/watch?v=QAEkuVgt6Aw)

- CGVLAB

- You?
http://www.cs.purdue.edu/homes/aliaga

• **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 Visual Computing
- Light-Transport based Methods and NeRFs
- 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 Graphics

• Fundamentals of these and use in graphics/vision
  – CNN
  – GAN
  – RNN
  – GNN
  – Diffusion Models
Deep Learning and Graphics

- 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 $T$

$$c = T p$$

As seen from camera...

$$p = T^t c$$

As seen from projector!!!
Light Transport Based Methods

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

\[
\begin{bmatrix}
  c \\
  p
\end{bmatrix} = \begin{bmatrix} T \end{bmatrix} \begin{bmatrix}
  p
\end{bmatrix}
\]

As seen from camera...

\[
\begin{bmatrix}
  p
\end{bmatrix} = \begin{bmatrix} T^t \end{bmatrix} \begin{bmatrix}
  c
\end{bmatrix}
\]

As seen from projector!!!
Light in Slow Motion

- https://www.youtube.com/watch?v=Y_9vd4HWlVA
NERF

• Neural Radiance Field
  – Deep learning version of lightfields
Build your own coded aperture
Build your own coded aperture
Voila!
Coded Aperture Deblurring

(a) Captured Image 1  (b) Captured Image 2  (c) All-focused Image  (d) Estimated Depth Map

(e) Close-Ups  
Captured  Recovered  Captured  Recovered  Captured  Recovered
Single input image:

Output #1: Depth map
Single input image:

Output #1: Depth map

Output #2: All-focused image
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...
Inverse/Computational Optics

• Family of methods that “prevent” blurring...
  – Defocus blur
  – Motion blur
  – Projector blur

– Question:
  • Are two superimposed blurry images better than one blurry?
3D Printing: Self Standing
3D Printing: Self Standing

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

• I will be at a conference 😊

• Wednesday: Toolbox

• Friday: 1\textsuperscript{st} assignment out
  – Trivial compile something simple, change, and run

• Move class to LWSN 3151A (Conference Room in Graphics Lab)