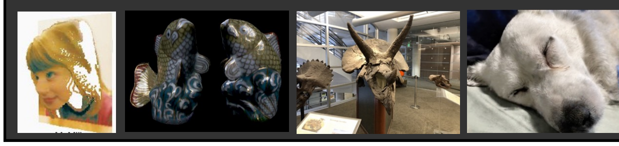
Image-Based Rendering

CSE 274, Lecture 1: Keynote and Logistics

Ravi Ramamoorthi
http://www.cs.ucsd.edu/~ravir



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Instructor

Ravi Ramamoorthi http://www.cs.ucsd.edu/~ravir

- PhD Stanford, 2002 [with Pat Hanrahan, 2020 Turing Award]
  "*Spherical Harmonic Lighting*" widely used in games (e.g. Halo series), movies (e.g. Avatar), etc. (Adobe, …)
- At Columbia 2002-2008, UC Berkeley 2009-2014
- *"Monte Carlo denoising"* inspired raytracing offline, real-time; consults at NVIDIA
- At UCSD since Jul 2014: Director, Center for Visual Computing
- "*NeRF: Neural Radiance Fields for View Synthesis*" widely cited IBR technique

- Awards for research: White House PECASE (2008), SIGGRAPH Significant New Researcher (2007), ACM Fellow (2018), Two Frontiers Science Awards (23,24)
- https://www.youtube.com/watch?v=qpyCXqXGe7I
- Computer Graphics online MOOC (CSE 167x) finalist for two edX Prizes.

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Outline of Lecture

- *Lecture: Image-Based Rendering: From View Synthesis to Neural Radiance Fields and Beyond (originally Eurographics Keynote Apr 24)*
- Logistics of course

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Virtual Experiences of Real-World Scenes

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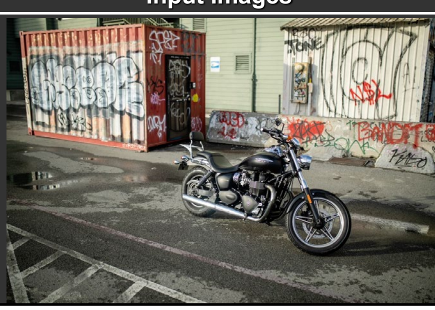
Input Images



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Output Virtual Experience

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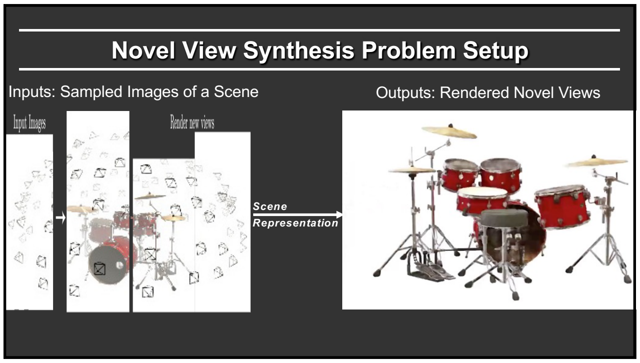
Novel View Synthesis Problem Setup
Inputs: Sampled Images of a Scene
Outputs: Rendered Novel Views
Input Images
Render new views
Scene Representation

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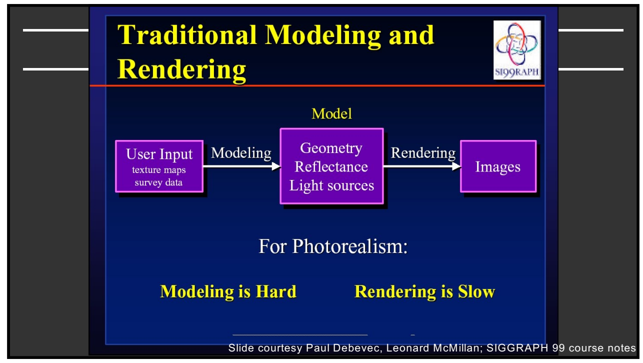
Traditional Modeling and Rendering
SI99RAPH
Model
User Input
texture maps
survey data
Modeling
Geometry
Reflectance
Light sources
Rendering
Images
For Photorealism:
Modeling is Hard
Rendering is Slow
Slide courtesy Paul Debevec, Leonard McMillan; SIGGRAPH 99 course notes

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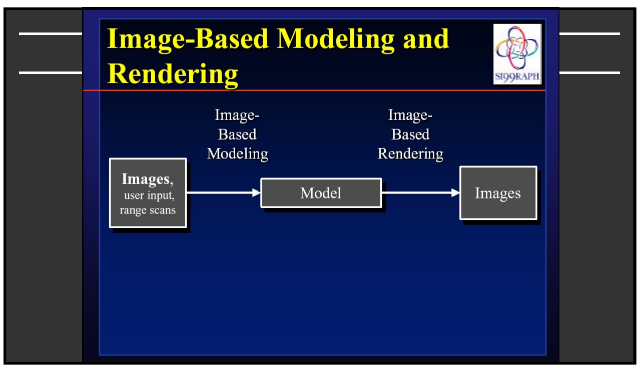
Image-Based Modeling and Rendering
SI99RAPH
Image-Based Modeling
Image-Based Rendering
Images, user input, range scans
Model
Images

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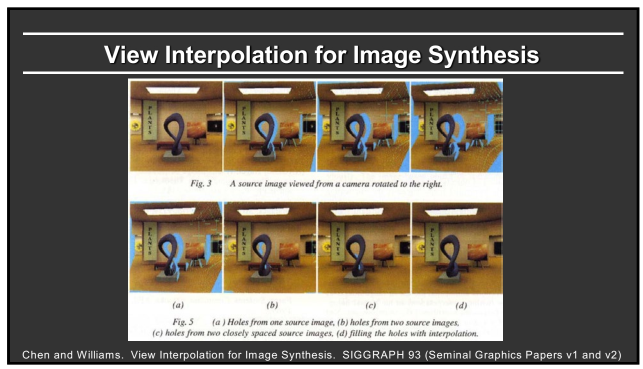
View Interpolation for Image Synthesis
Fig. 3 A source image viewed from a camera rotated to the right.
(a) (b) (c) (d)
Fig. 5 (a) Holes from one source image, (b) holes from two source images, (c) holes from two closely spaced source images, (d) filling the holes with interpolation.
Chen and Williams. View Interpolation for Image Synthesis. SIGGRAPH 93 (Seminal Graphics Papers v1 and v2)

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Warping in Action
SI99RAPH
✔ A 3D Warp
McMillan course notes, SIGGRAPH 99
See also Ezzat and Poggio, EG 96

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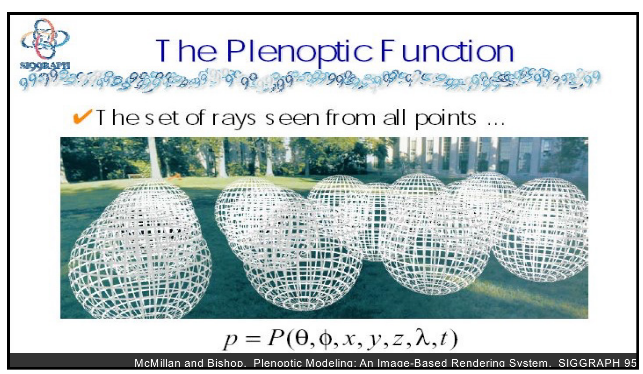
The Plenoptic Function
SI99RAPH
✔ The set of rays seen from all points …
$p = P(\theta, \phi, x, y, z, \lambda, t)$
McMillan and Bishop. Plenoptic Modeling: An Image-Based Rendering System. SIGGRAPH 95

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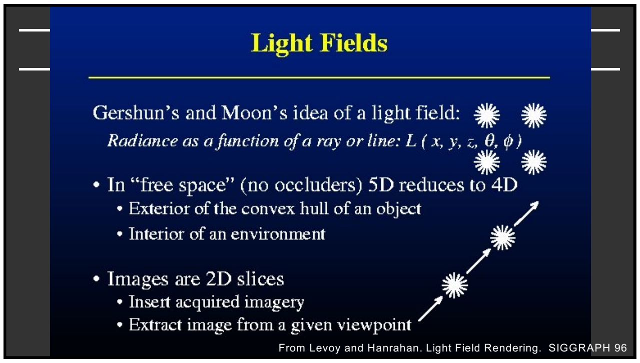

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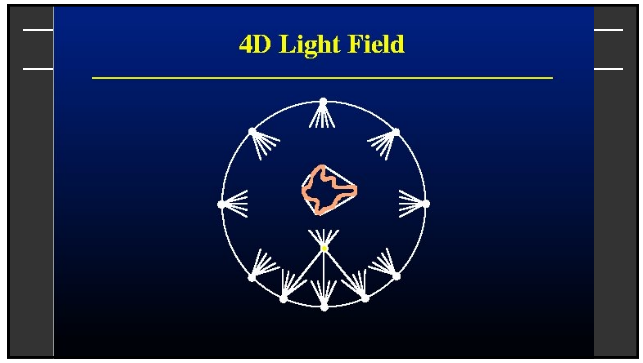

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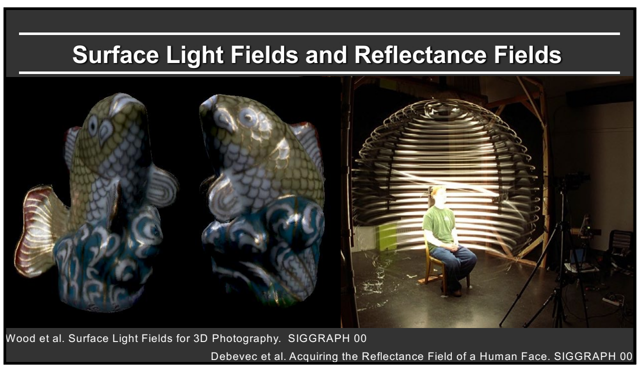

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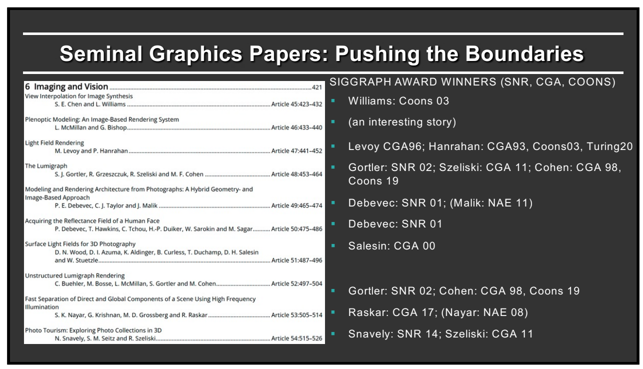

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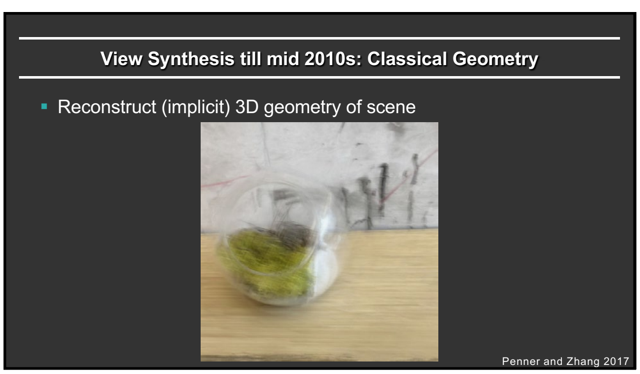

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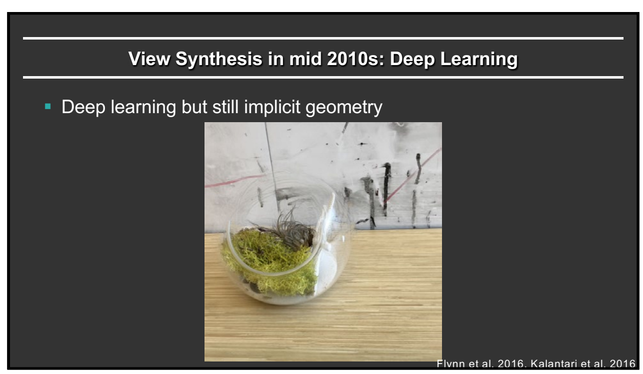

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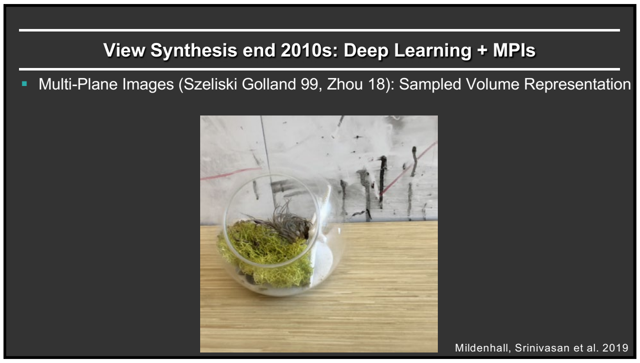

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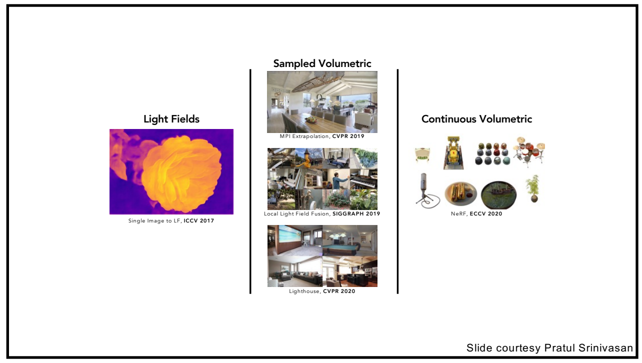

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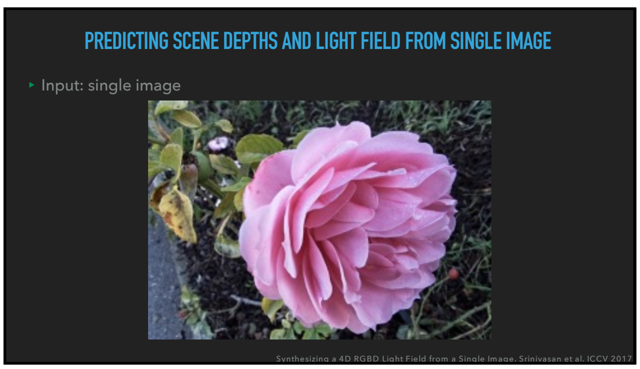

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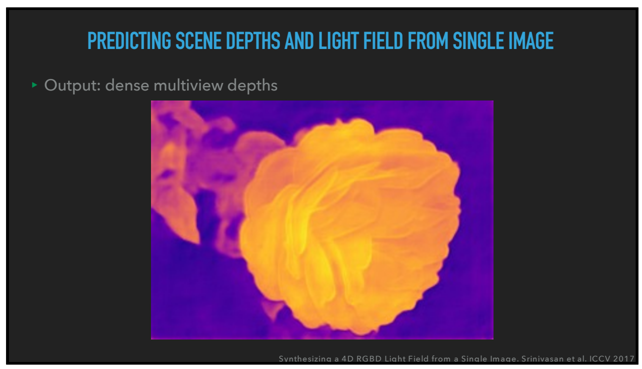

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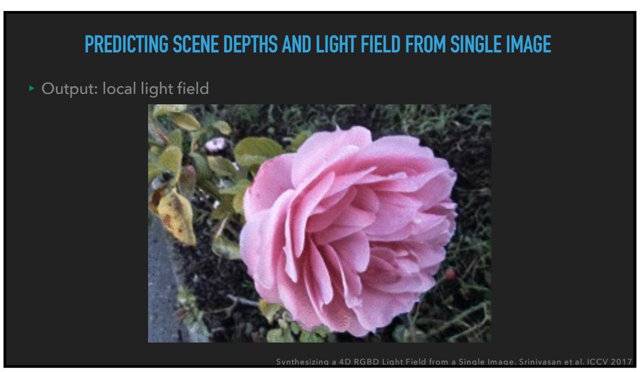

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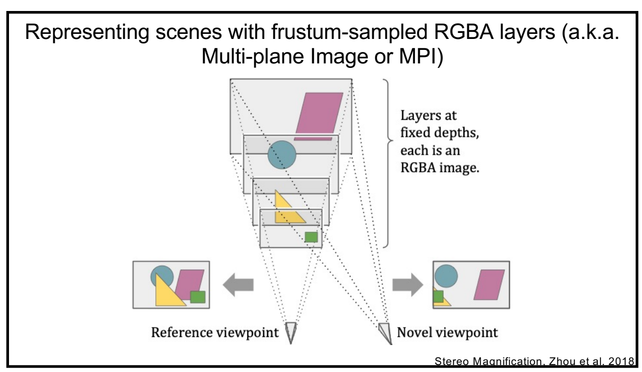

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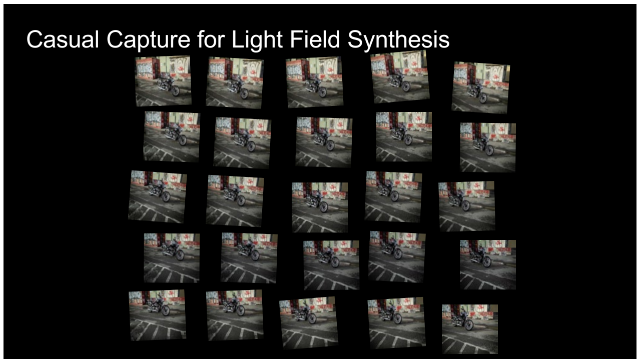

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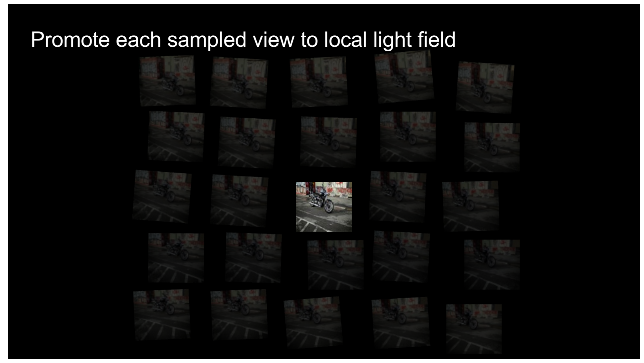

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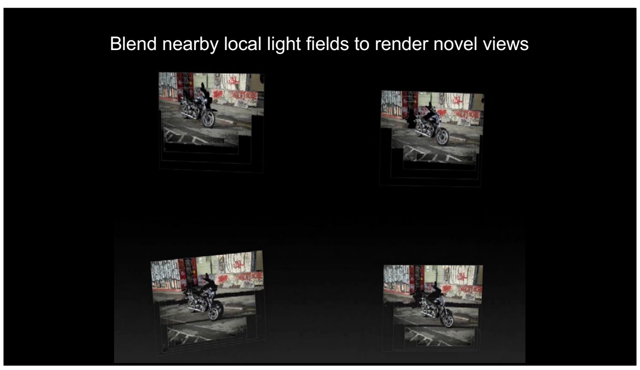

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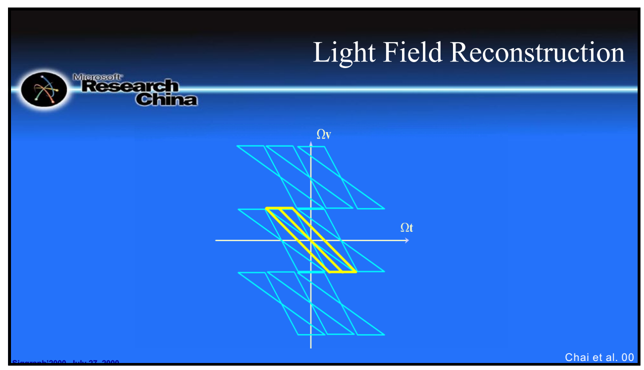

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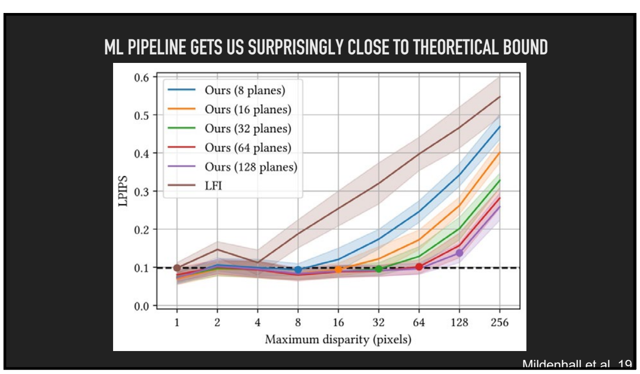

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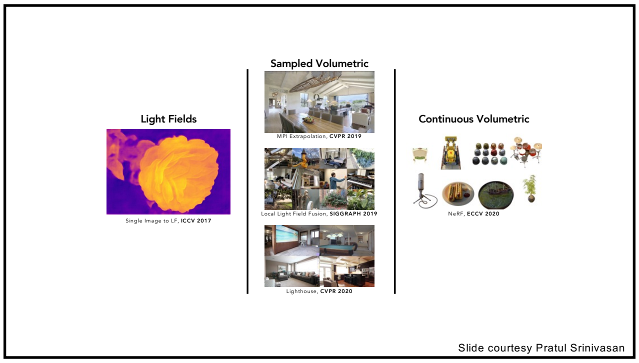

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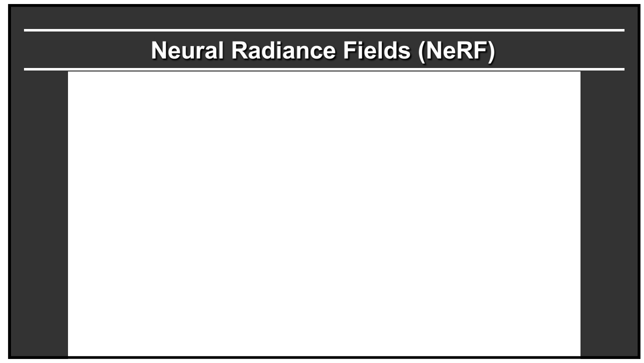

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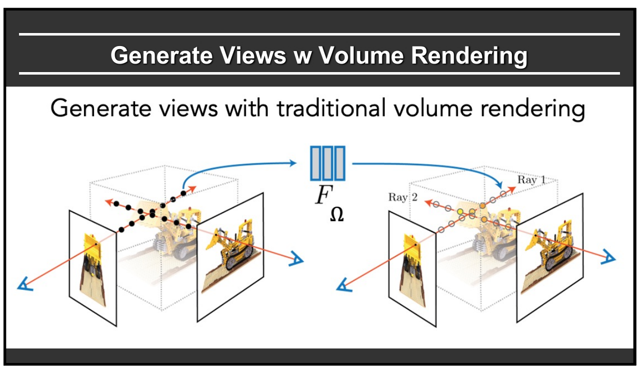

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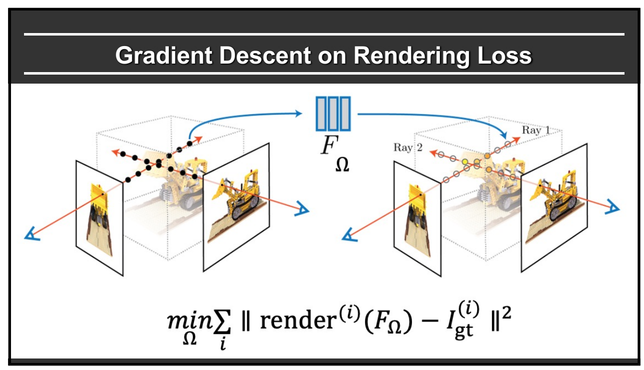

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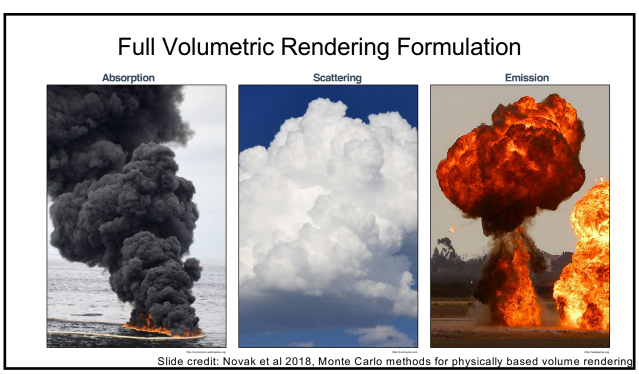

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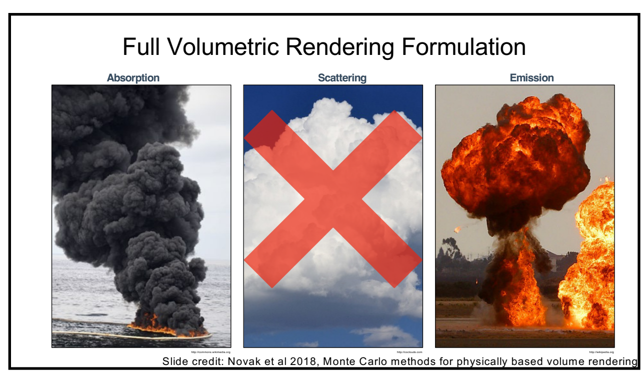

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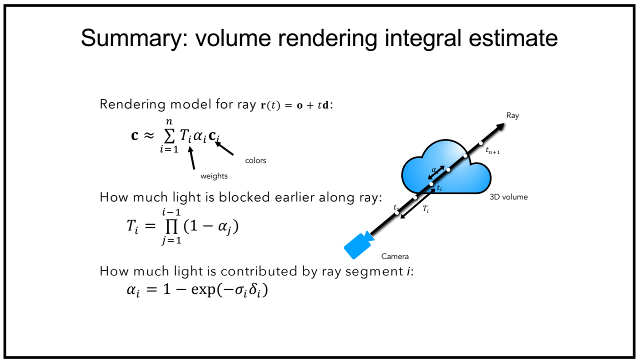

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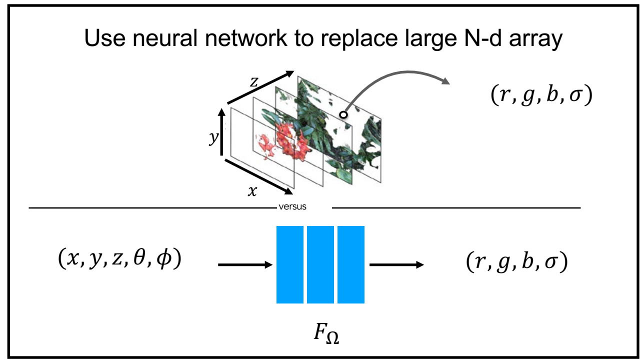

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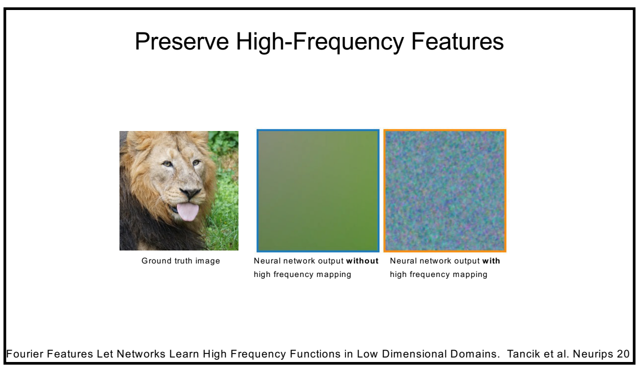

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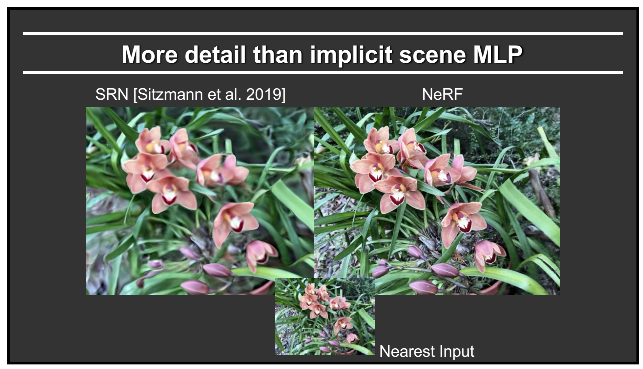

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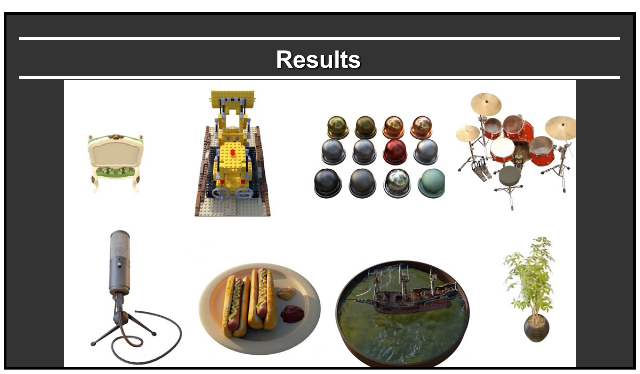

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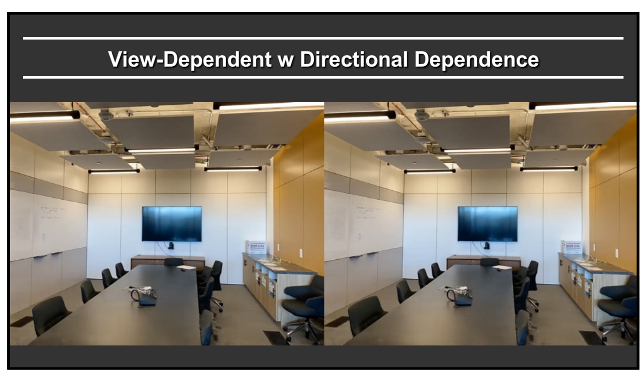

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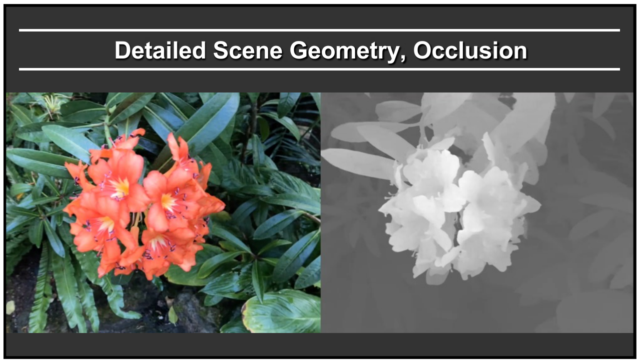

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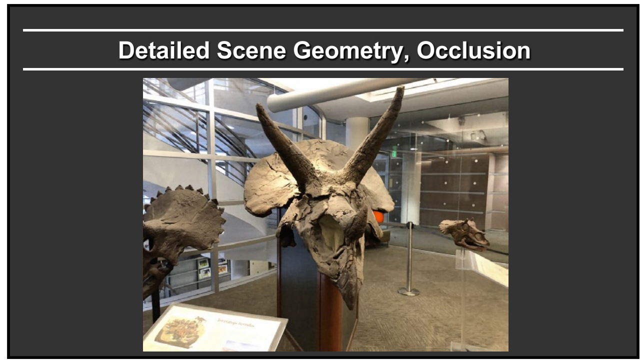

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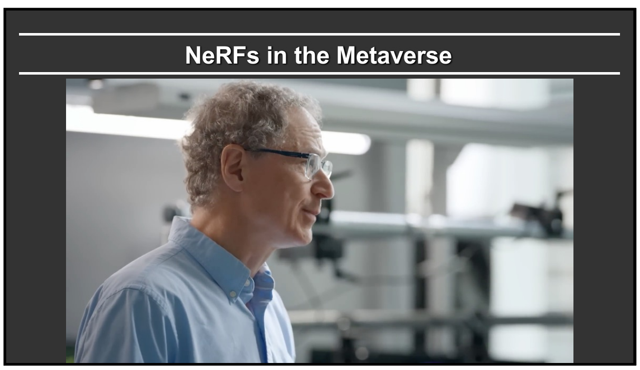

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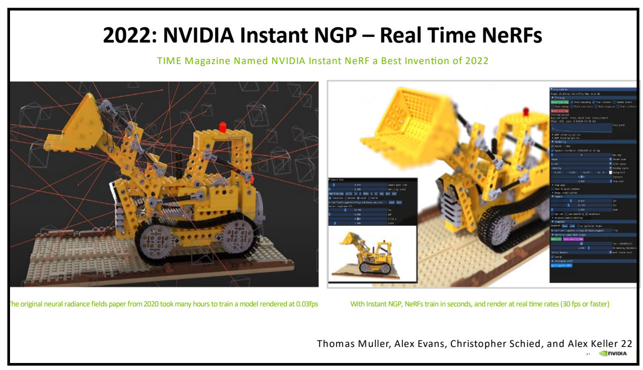

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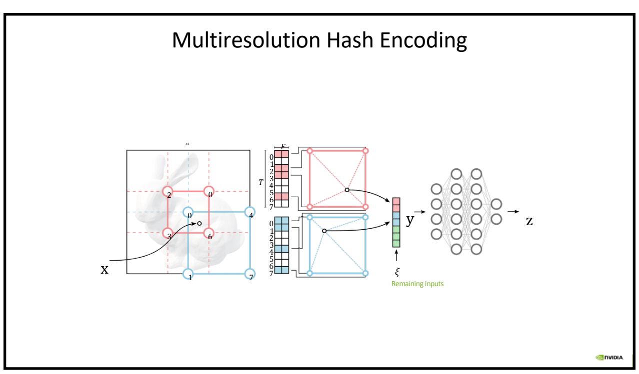

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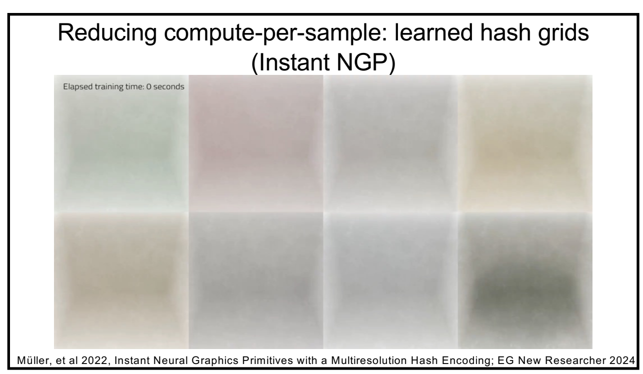

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3D Gaussian Splats for Radiance Fields

Kerbl, Kopanas, Leimkuhler, Drettakis 23; EG Distinguished Career Award 24

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NeRFs for Digital Twins

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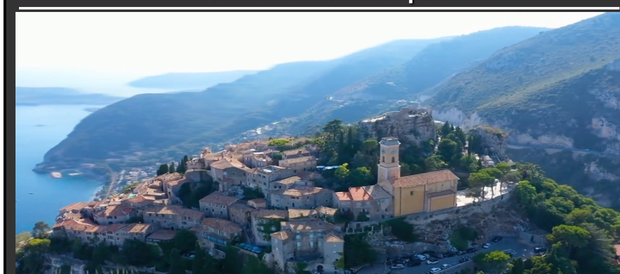
NeRFs for Landscapes



Instant NeRF (@jonstephens85 on Twitter); slide courtesy Thomas Muller

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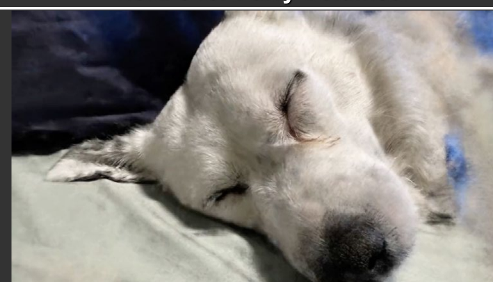
NeRFs for Furry Volumes



Instant NeRF (@vibrantnebula on Twitter); slide courtesy Thomas Muller

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NeRFs + Language Models

- Text-based editing with large language models (Haque et al.)

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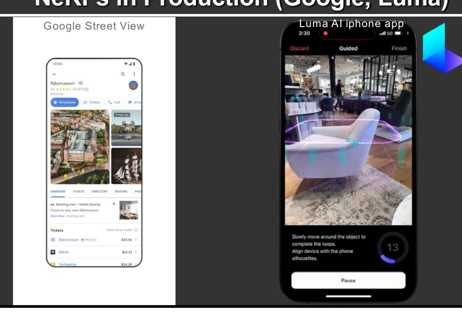
NeRFs in Production (Google, Luma)



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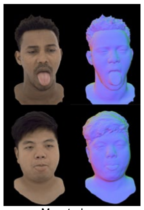
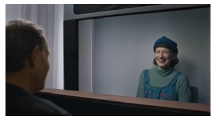
Personalized Avatars

Vision Pro (Apple) | **Codec Avatars (Meta)** | **Project Starline (Google)**

Vision Pro Teaser



Ma et al.



blog.google/technology/research/project-starline

Require multiple cameras, light stage capture, or depth information

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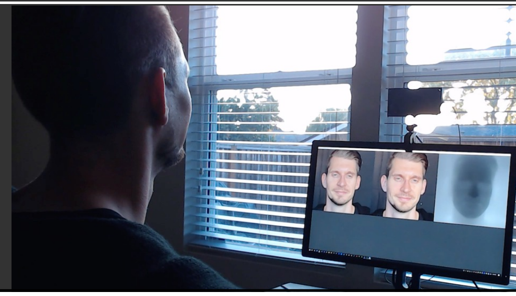
Real-Time Radiance Fields from Single Image



Trevithick et al. 23

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Lifting Text-Based Avatars to 3D

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3D Videoconferencing

SIGGRAPH 23 Emerging Technologies

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Outline of Lecture

- Lecture: Image-Based Rendering: From View Synthesis to Neural Radiance Fields and Beyond (originally Eurographics Keynote Apr 24)
- *Logistics of course*

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Course Goals, Format

- Goal: Background and current graphics research
  - Topic: *Image-Based Rendering*
  - Need to cover a lot of background research papers
  - Then discuss current frontiers in the field
- Also some basics of rendering to cover for CSE 168
- UCSD is the best place for this!!
- Format: Alternate lectures, student presentations of papers
- Website: http://viscomp.ucsd.edu/classes/cse274/wi26/274.html

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Course Logistics

- No textbooks. Required readings are papers online (and some handouts)
  - Handouts at http://viscomp.ucsd.edu/classes/cse274/wi26/readings
- Office hours: after class or email. My contact info is on my webpage: http://www.cs.ucsd.edu/~ravir
- Zoom: https://ucsd.zoom.us/my/ravir11 (if we need to move to remote instruction temporarily or permanently)
- TA: Nithin Raghavan n2raghavan@ucsd.edu Office hours: see website or email for another time.
- Should count for PhD, MS, BS electives in graphics and vision, see me if there is a problem or you need a certification

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Requirements

- Pass-Fail (2 units)
  - Show up to class regularly
  - Present 1 or 2 paper(s) if needed
  - Prefer you do this rather than just sit in
- Grades (4 units)
  - Attend class, participate in discussions
  - Present 1 or 2 papers (please do this well)
  - If class is large, groups of 2 can present 1 paper
  - Project (key part of grade)

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Project

- Wide flexibility if related to course. Can be done groups of 2
  - Default: Implement (part of) one of papers and produce an impressive demo for image-based rendering or view synthesis
  - See/e-mail me re ideas
  - Best projects will go beyond simple implementation (try something new, some extensions)
  - ML support only through basic DSMLP or AWS Educate through UCSD
  - We may have some old GPUs but largely on own (or do non-ML project)
- Alternative (less desirable): Summary of 3+ papers in an area
  - Best projects will explore links/framework not discussed by authors, and suggest future research directions

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Prerequisites

- Strong interest in graphics, vision, want to learn about image-based rendering
- Computer graphics experience (167 or equivalent)
  - Experience with rendering not required; first few weeks will cover basics. But also doesn't hurt, consider UCSD online CSE 168. And computer vision.
- Course will move quickly
  - Covering recent and current active research
  - Some material quite technical
  - Considerable background material is covered
  - Assume some basic knowledge
  - Many topics. Needn't fully follow each one, but doing so is most rewarding.

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Assignment this week

- E-mail me (ravir@cs.ucsd.edu) [only if not done already]
  - Name, e-mail, status (Senior, PhD etc.)
  - Will you be taking course grades or P/F
  - Background in graphics/any special comments
  - *Optional for all: Papers you'd like to present FCFS (only those that say "presented by students")*

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Questions?

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