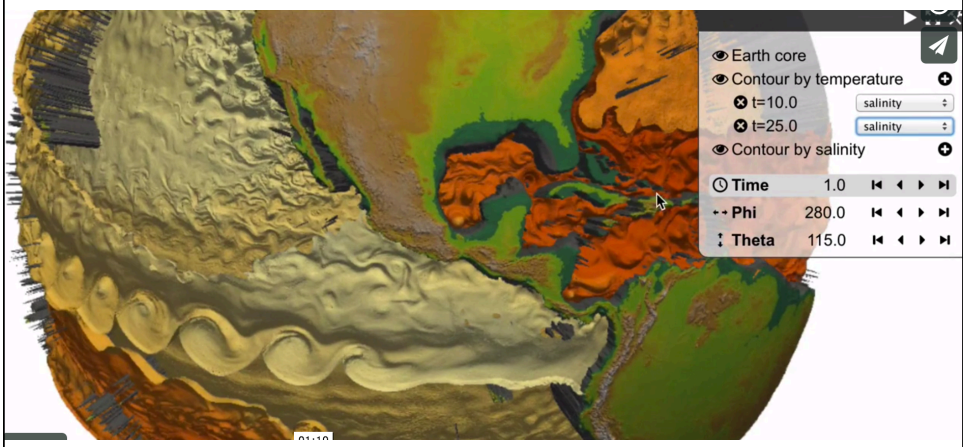
Large Scale Visualization



An Image-based Approach to Extreme Scale In Situ Visualization and Analysis

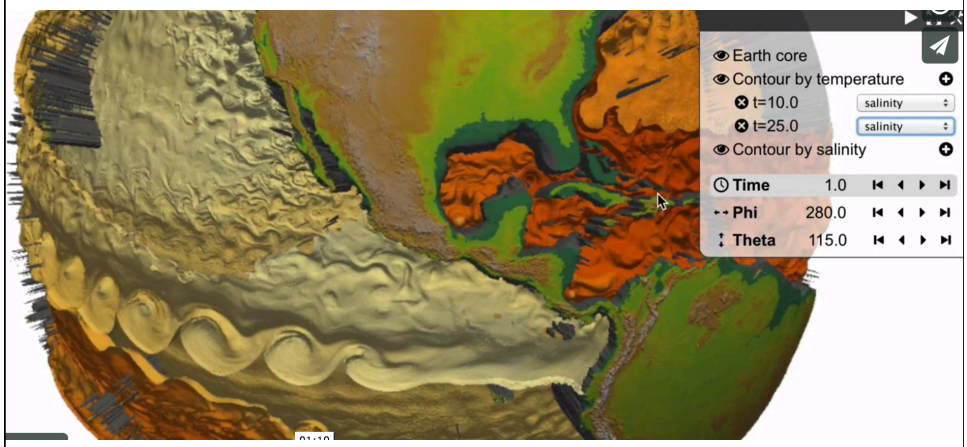
Today's Class

- Mini-presentations
  - Mark, Jazmine, Ian
- Reading for Today
  - "An Image-based Approach to Extreme Scale In Situ Visualization and Analysis"
- Crayon Exercise on User Feedback

Today's Class

- Mini-presentations
  - Mark, Jazmine, Ian
- Reading for Today
  - "An Image-based Approach to Extreme Scale In Situ Visualization and Analysis"
- Crayon Exercise on User Feedback

"An Image-based Approach to Extreme Scale
In Situ Visualization and Analysis",
Ahrens, Patchett, Jourdain, Rogers, O'Leary, & Petersen,
Supercomputing 2014



- "in situ" definition: "in its original place", "on site", "in position", "locally", "in place"
- In computer science:
  - An in situ operation is one that occurs without interrupting the normal state of a system
  - Without taking the system down, while still running, without rebooting
  - In place algorithm (no extra memory)
  - UI: without going to another window
  - For Big Data: Doing computation where the data is located

[From http://en.wikipedia.org/wiki/In_situ]

- Motivation: power & I/O constraints
- Without in situ: write huge files to disk (size: ?), then later input those files for interactive exploratory visualization & analysis
  - However, storage bandwidth is significantly falling behind processing power & data generation
- Instead: compute & save many images to disk (size: 1 image 10^6, set of images 24 TB=10^{13}), then later explore & analyze by viewing those images interactively
  - Preserve important elements from simulations
  - Significantly reduce data needed
  - Be flexible for post-processing interactive exploration
  - Perform predefined (by expert scientist) set of analyses & predefined data bounds of interest
  - (Rarely) make automated decisions about what visualization & analyses to perform

Requirements/Features

- Animation & Selection of objects
- Control over Camera & Time
  - Temporal exploration encouraged
- Responsive, Interactive System (constant time retrieval & assembly/compositing of images)
  - Computationally intensive analyses (precomputed) encouraged
- Enables Metadata Searching
  - Image-based visual queries
  - prioritize exploration of matching results
- Provides interface for scientists to make decisions for the production of this in situ visualization

---

- When designing in situ visualization (preprocess) use Paraview
  - provides cost estimate (# of images, total size of image dataset, time to produce)
- No penalty/disincentive/bias against exploring "expensive" visualizations, because they have already been computed and saved as images
- Query image database for all images that match XXX, then sort by YYY
  - Where is the largest visible mass of low salinity in the northern hemisphere?
  - What is the "best view"?

- Compositing allows user to reason about simulation results from visualization space, not just image space rendering & sampling
- Interactive tool for displaying & compositing items from the image database with interface very similar to Paraview – simulates experience of exploring simulation data
  - Interactive, at least 12 fps (surprisingly slow? What's the bottleneck? Could some quality be sacrificed for speed?)
- Data saved per image for compositing (2X normal image)
  - color (rgb) + depth (z-buffer)
  - sprite layers
  - For opaque layers: save simulation data (geometry?) which allows recoloring/relighting
  - Image provenance (how image was created, parameters, etc.)
  - Images can be compressed into video format

- Well-written, good illustrations
- Good motivation & good explanation of features… but lacked detail on how things worked
- Impressive use of real-world datasets
- Niche but critical audience for this tool
- How powerful are their camera settings? Can you rotate about an arbitrary point or limited to the initially chosen rotation center?
- What hardware is needed to run the simulation? *A supercomputer.*
- What hardware is needed to analyze/visualize the resulting data? *A fancy desktop or a supercomputer*
- What hardware is needed to display/composite the pre-generated visualization images? *A fancy desktop*
- Image based (feature based) search of simulation results is inspiring for my final project
- MPAS: Model for Predication Across Scales
- 24 TB, 2^{15} is "reasonable". Impressive. Ridiculous.
- Each image 1 MB. Will increasing the image size help scientists better explore the data? Or is this the limit of the simulation resolution?

"Semotus Visum: A Flexible Remote Visualization Framework", Luke & Hansen, IEEE Visualization 2002

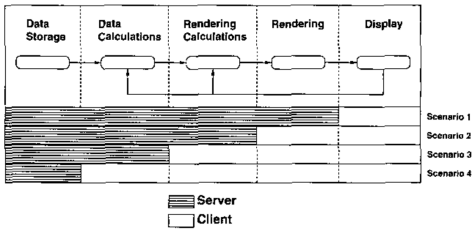


Figure 1: Dataflow in scientific visualization applications. In scenario 1, images are streamed from server to client. In scenario 2, part of the rendering calculations are done on the server. Scenario 3 allows the client to do all rendering calculations. Scenario 4 uses the server for data storage only; all calculations are done on the client.

"A Review of Image-based Rendering Techniques" Shum & Kang, Visual Communication & Image Processing

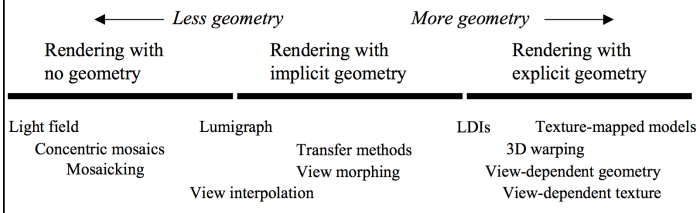
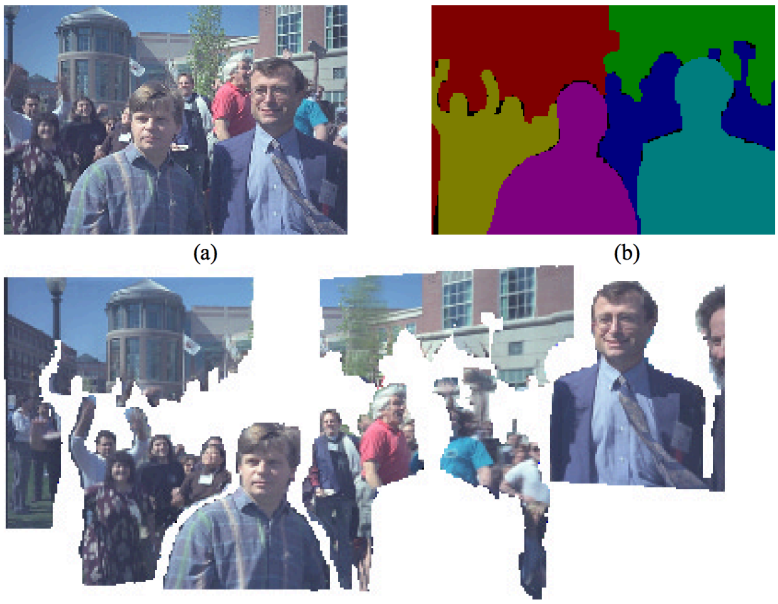
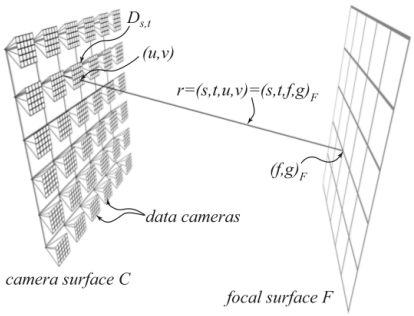


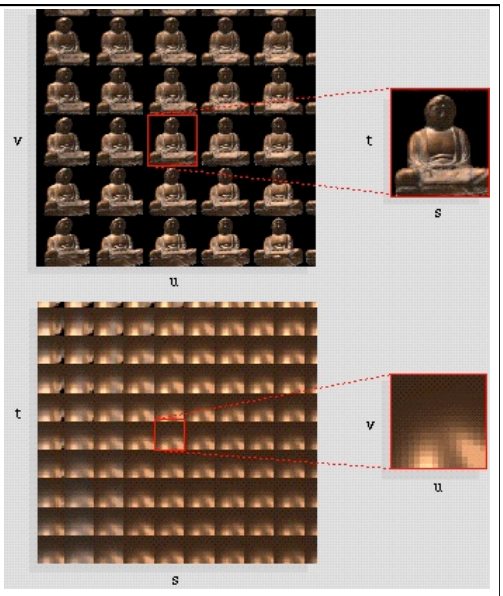
Figure 1: Categories used in this paper, with representative members.

"Layered Depth Images", Shade, Gortler, Hey, & Szeliski, SIGGRAPH 1998



Light Fields





Plenoptic Modeling: An Image-Based Rendering System, McMillan & Bishop, SIGGRAPH 1995

Dynamically reparameterized light fields, Isaksen, McMillan, & Gortler, SIGGRAPH 2000

Light Field Rendering, Levoy & Hanrahan, SIGGRAPH 1996

Unstructured Lumigraph Rendering" Buehler et al. SIGGRAPH 2001

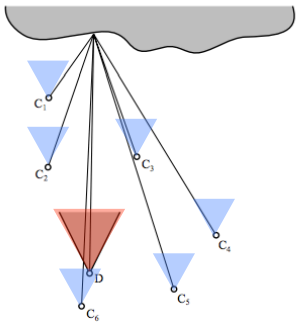


Figure 1: When available, approximate geometric information should be used to determine which source rays correspond well to a desired ray.

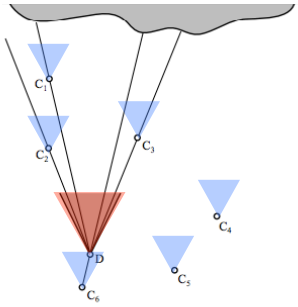


Figure 2: When a desired ray passes through a source camera center, that source camera should be emphasized most in the reconstruction.

"Unstructured Lumigraph Rendering"
Buehler et al. SIGGRAPH 2001

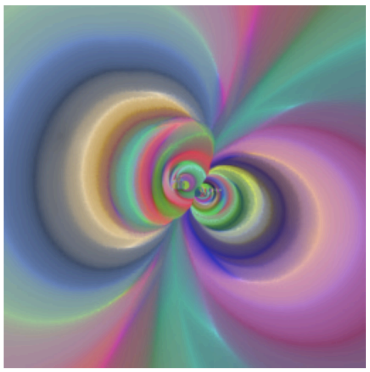
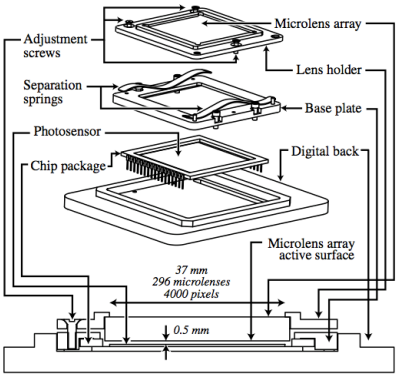


Figure 7: A visualized color blending field. Camera weights are computed at each pixel. This example is from the "hallway" dataset

Video at: http://gvi.seas.harvard.edu/paper/unstructured-lumigraph-rendering

Light Field Camera

- *After* taking the photograph, we can:
  - Adjust focus
  - Change viewpoint
  - Change illumination
  - & more?



Light Field Photography with a Hand-Held Plenoptic Camera,
Ng, Levoy, Bredif, Duval, Horowitz, & Hanrahan,
Stanford Tech Report, 2005

Today's Class

- Mini-presentations
  - Mark, Jazmine, Ian
- Reading for Today
  - "An Image-based Approach to Extreme Scale In Situ Visualization and Analysis"
- Crayon Exercise on User Feedback

Today's Crayon Exercise & Assignment # 12: User Feedback

- Show your final project visualization, in its current form, to:
  - at least 5 people in this class, and
  - at least 5 people outside of this class
- Get feedback on all aspects of the design
  - visualization style, color, layout, interaction, presentation, etc.
  - Is your intended message conveyed? Does the user draw a correct and logical analysis or interpretation from the data?
- Ask for suggestions for improvement for:
  - short term: can be implemented before the deadline
  - longer term: if you continued working on this visualization, what big visualization implementation challenges or other related datasets could you tackle?
- Engage in the discussion & take detailed notes of feedback
  - Teams are encouraged to split up to gather feedback
- When giving feedback to your classmates, you are encouraged to sketch your suggestions for design revision
- Focus: Visualization Revision & Presentation

How to Solicit Useful Feedback

- Welcome criticism
  - Avoid becoming defensive
  - Remember you're looking for feedback, not just approval
- Listen carefully & Listen actively
  - Seek to understand accurately
  - Ask for clarification
- Don't decide [accept/dismiss] the feedback right away
  - Write it all down, and sort through it after you take a break
- Have a hypothesis
  - Be prepared for feedback
- Consider having a focus for feedback
  - Direct the conversation

Some material from: http://oregonstate.edu/instruct/comm440-540/criticism.htm

How to give Constructive Feedback

- Understand why and on what you are giving feedback
- Be direct & sincere
- Emphasize observation, rather than evaluation
  - Describe what you see, use "I" statements
- Invite collaborative discussion rather than just giving advice
  - Present criticism that allows the other party to make decisions
- Avoid overload the person, don't give more feedback/ criticism than he/she can handle at this time
- Include positive feedback and areas for improvement

Some material from: http://oregonstate.edu/instruct/comm440-540/criticism.htm