Large Scale and In Situ Visualization

Today's Class

- Definition of In Situ (for Computer Science)
- SpatioTemporal Definition & Examples
- Random Graphics Topic: Light Field Rendering
- Readings for Today
  - "An Image-based Approach to Extreme Scale In Situ Visualization and Analysis"
  - "Globe Browsing: Contextualized Spatio-Temporal Planetary Surface Visualization"
- Readings for Tuesday
- Leftover from last time...

- “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]

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

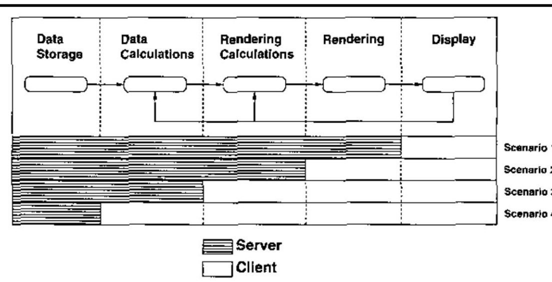

Figure 1: Dataflow in scientific visualization applications. In scenario 1, images are streamed from server to client. In scenario 2, part of the rendering calculations are done on the server. Scenario 3 allows the client to do all rendering calculations. Scenario 4 uses the server for data storage only;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

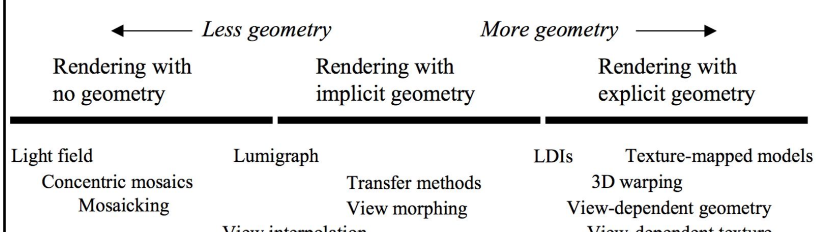

Figure 1: Categories used in this paper, with representative members.

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

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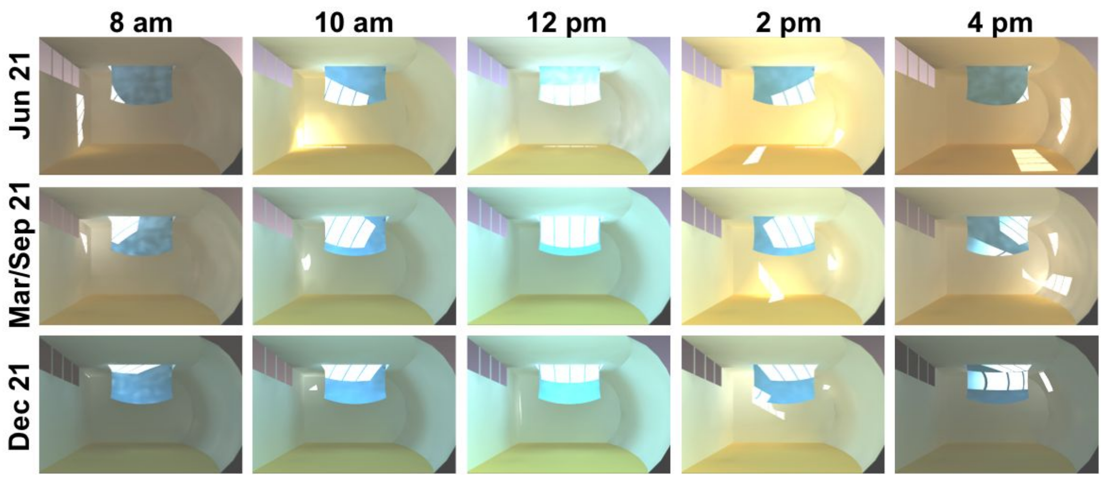
Spatiotemporal (Databases)

- both space and time information. Examples:
  - Tracking of moving objects, which typically can occupy only a single position at a given time
  - A database of wireless communication networks, which may exist only for a short timespan within a geographic region
  - An index of species in a given geographic region, where over time additional species may be introduced or existing species migrate or die out
  - Historical tracking of plate tectonic activity
- Not just an extension of spatial data. Specifically includes
  - geometry changing over time and/or
  - location of objects moving over invariant geometry (known variously as moving objects databases or real-time locating systems)

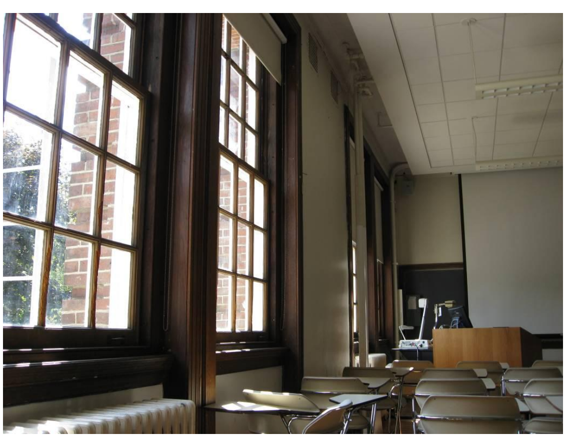
From: http://en.wikipedia.org/wiki/Spatiotemporal_database

Architectural Daylighting Design: The use of windows and reflective surfaces to allow natural light from the sun and sky to provide effective and interesting internal illumination.

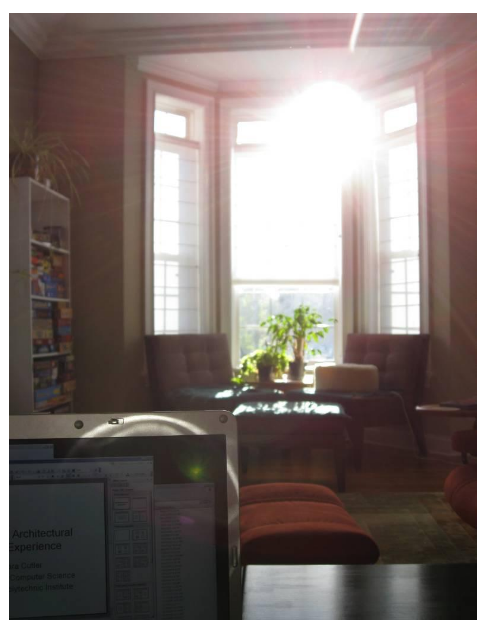


Residential design proposal by Mark Cabrinha

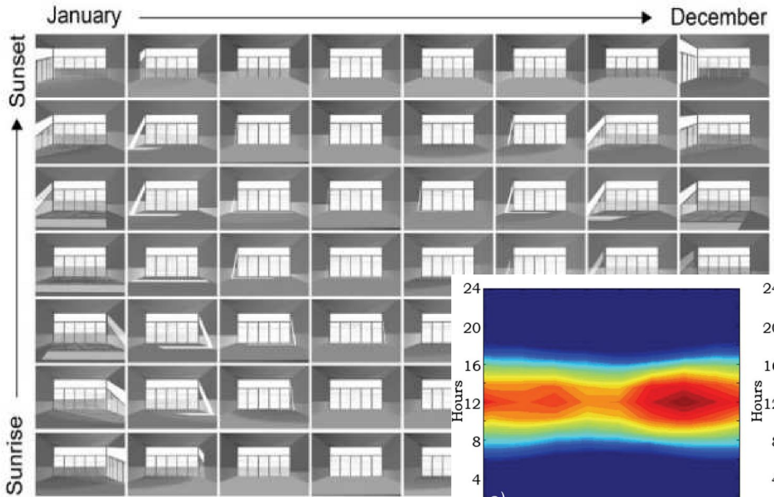
Daylighting Challenges



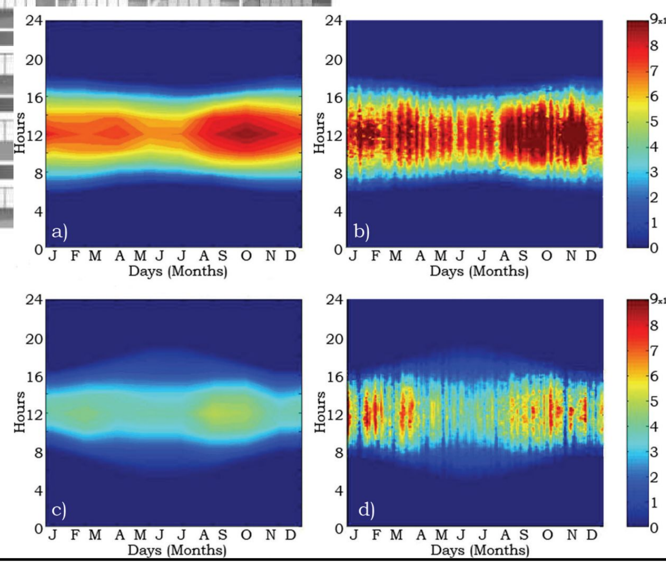
Daily & Seasonal variations



Discomfort/Disability Glare: too much contrast reduces visibility



“Measuring the Dynamics of Contrast & Daylight Variability in Architecture: A Proof of Concept Methodology”
Rockcastle & Andersen



“Graphical Representation of Climate-Based Daylight Performance to Support Architectural Design”
Kleindienst, Bodart, & Andersen

- Motivation
  - Detect direct illumination on sensitive objects (artwork, chalkboard, tv, etc.)
  - Detect under-illumination (artificial light needed)
- What is correct sampling frequency?
  - 56 “moments”
    - 8 days of the year
    - 7 times of the day
- Visualization
  - Requirements: Show min & max & average lighting in each day/timespan (~45 days & ~ 2 hours)
  - How?
    - Animation: full year, or range of hours for usage, multiple windows for day, animation of a day, play it on a loop, bin into common ‘image features’, sliders for 3 axes (day/time/weather)

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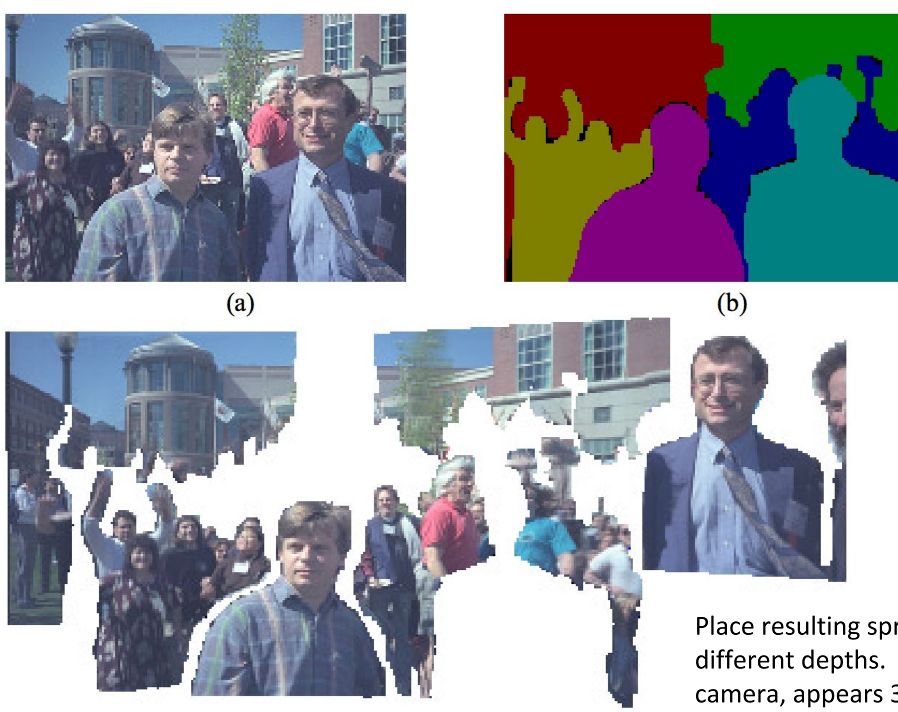
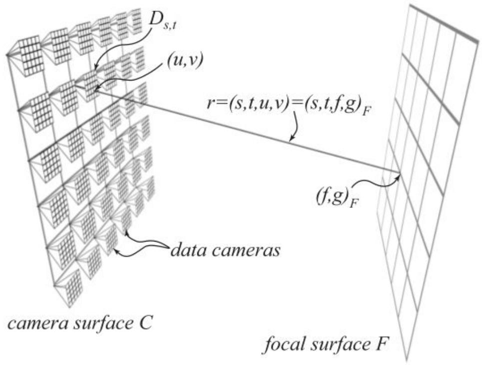
"Layered Depth Images", Shade, Gortler, Hey, & Szeliski, SIGGRAPH 1998



(a) (b)

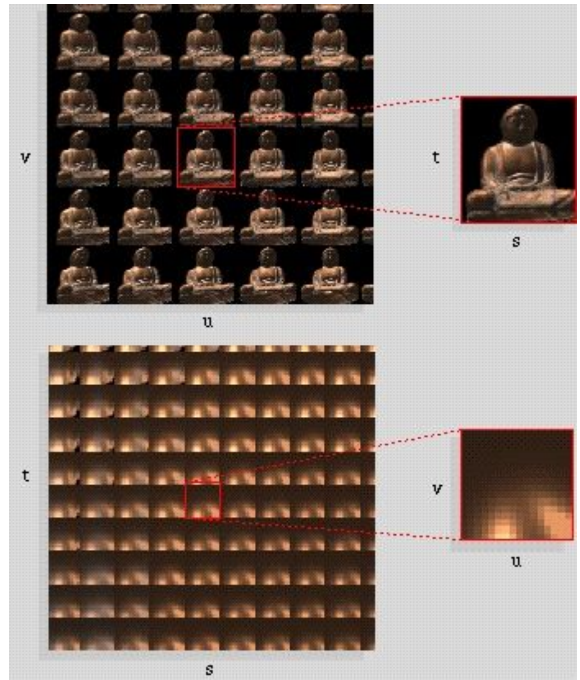
Place resulting sprites at different depths. Move the camera, appears 3D!

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

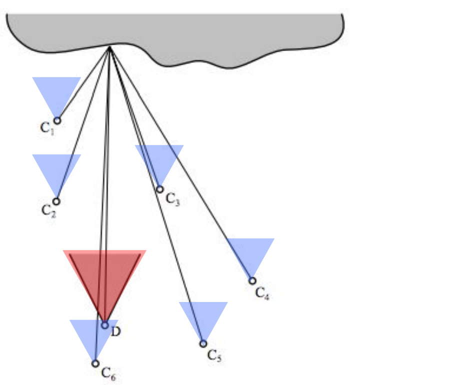


Figure 1: When available, approximate geometric information should be used to determine which source rays correspond well to a desired ray.

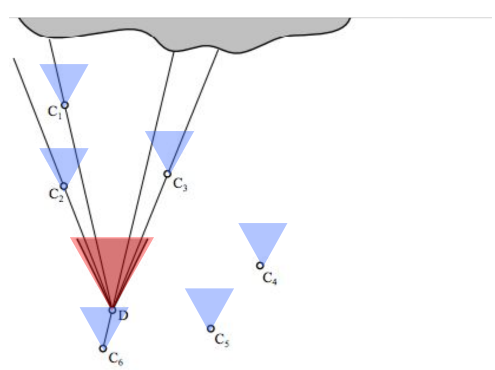


Figure 2: When a desired ray passes through a source camera center, that source camera should be emphasized most in the reconstruction.

“Unstructured Lumigraph Rendering”
Buehler et al. SIGGRAPH 2001

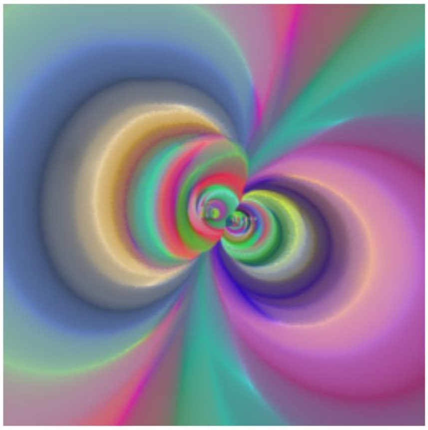
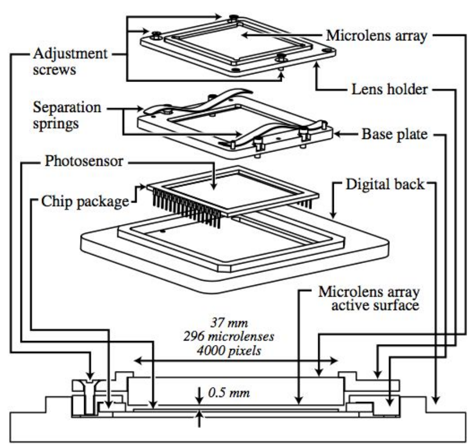


Figure 7: A visualized color blending field. Camera weights are computed at each pixel. This example is from the “hallway” dataset

Video at: http://gvi.seas.harvard.edu/paper/unstructured-lumigraph-rendering
https://www.youtube.com/watch?v=za4HIll9N7c

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

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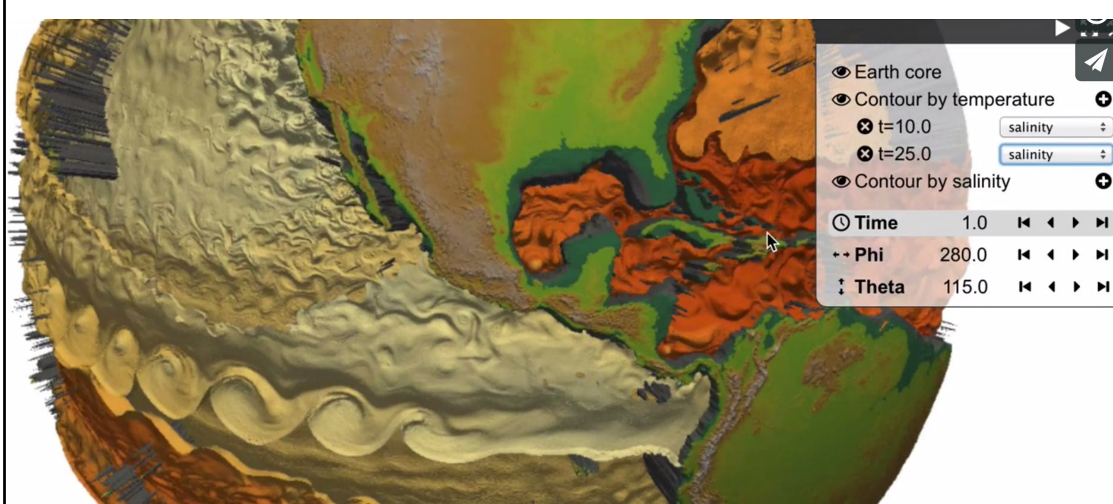
Readings for Today

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



- 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?

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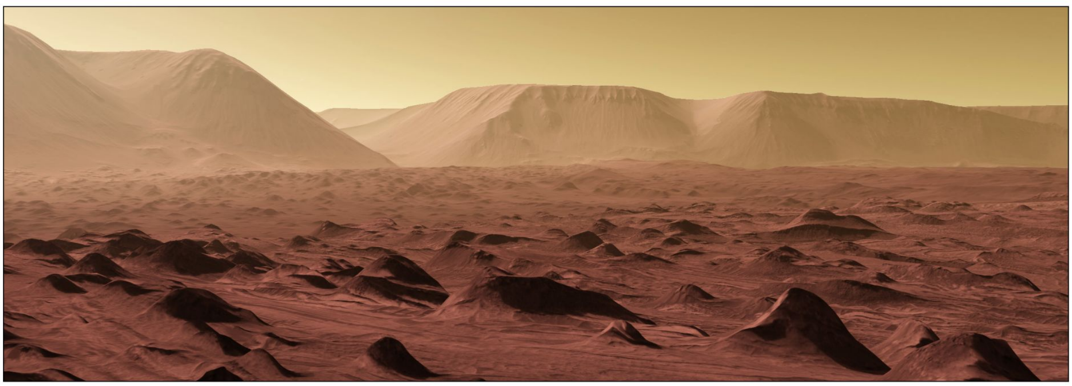
Reading for Friday *(pick one)*

"Globe Browsing: Contextualized Spatio-Temporal Planetary Surface Visualization", Bladin, Axelsson, Broberg, Emmart, Ljung, Bock, & Ynnerman, IEEE SciVis 2017



- Challenges in astrovisualization: extreme distances
- Sensing/Imaging from orbiting or non-orbiting spacecraft
- Planetary atmosphere
- Resolution: Earth&Mars: 240 m/pixel,
  Pluto 161km/pixel->1km/pixel->50m/pixel
- all data must be images,
  convert meters into degrees
- LOD: Level of detail

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Reading for Tuesday *(pick one)*

"DimpVis: Exploring Time-varying Information Visualizations by Direct Manipulation",
Kondo and Collins, IEEE Visualization 2014

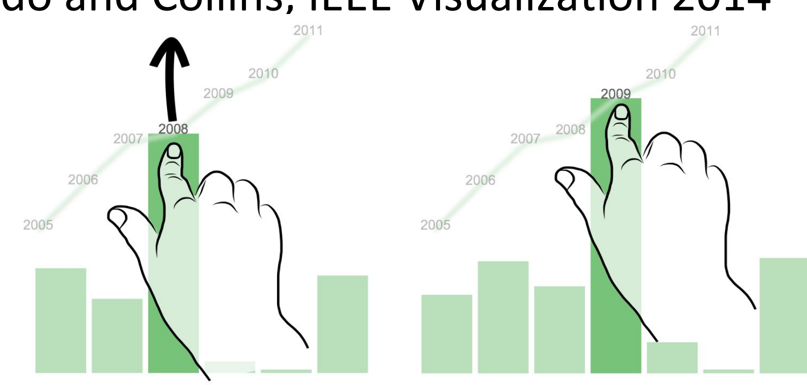
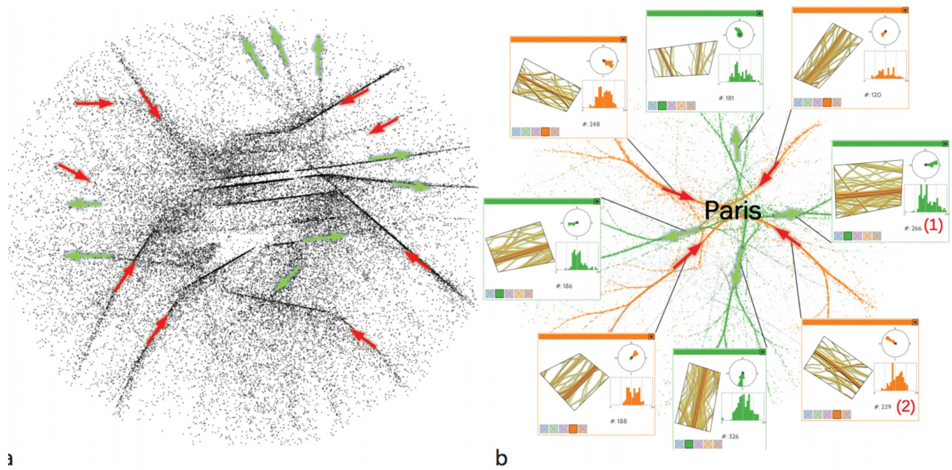


Fig. 4. Navigation in time for bar charts is achieved by dragging a selected bar vertically along its hint path. The hint path slides horizontally to stay connected with the bar and finger.

Reading for Tuesday *(pick one)*

"Visualization, Selection, and Analysis of Traffic Flows",
Scheepens, Hurter, van de Wetering, van Wijk, IEEE InfoVis 2015



ı. 10. (a) An overview of traffic flows over the Paris area. Outgoing traffic flows have been marked with the green arrows, while incoming traffic ws have been marked with a red arrow. (b) The traffic flows have been bundled, selected, and the dynamics of these traffic flows are displayed ng the movable windows.

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Jones, B., Sodhi, R., Murdock, M., Mehra, R., Benko, H., Wilson, A. D., Ofek, E., MacIntyre, B., Shapira, L. RoomAlive: Magical Experiences Enabled by Scalable, Adaptive Projector-Camera Units. ACM UIST, 2014.

http://projection-mapping.org/roomalive-uist/

Interaction Technology Applications? Implementation Challenges?

- Well controlled environment? Non white colored walls/furniture/clothes? Works best in big empty white walled rooms.
- Disorienting? Danger of looking into projector?
- Less nauseating than VR (for people who can't handle VR)?
- VR -> AR -> "spatially-augmented reality" (SAR)
- Low maintenance cave
- What is the perspective view? For just one person, or ok for many people?
- Low resolution? Hot & noisy projectors
-

Interaction Technology Applications? Implementation Challenges?

- Color compensation? Non white surfaces?
- Can’t move furniture after calibration
- Windows & different lighting?
- How accurate is the touch?
- How adaptable to odd shaped rooms, partial rooms?
- Audio – is surround sound necessary, will it add something, make more immersive, what if target audience member is moving, multiple people
- Seems expensive, power, not home use, but permanent installation charge admission
- Interactive puzzle experience, group, solve riddles (escape the room), adding augmented reality would be interesting
- How does perspective work for multiple viewers for synthetic 3d objects?

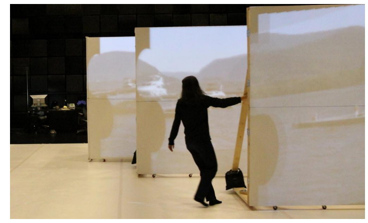
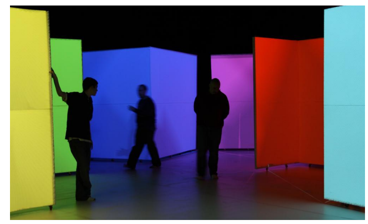
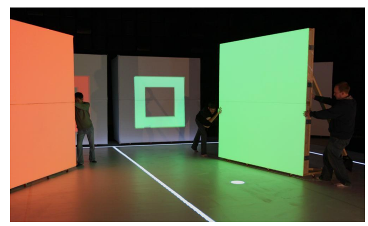
Dynamic Projection Surfaces for Immersive Visualization

Theodore C. Yapo, Yu Sheng, Joshua Nasman,
Andrew Dolce, Eric Li, and Barbara Cutler

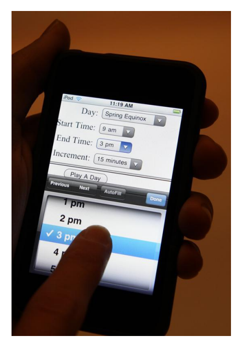
PROCAMS 2010 IEEE International Workshop on Projector-Camera Systems, June 2010

Our System Goals/Requirements

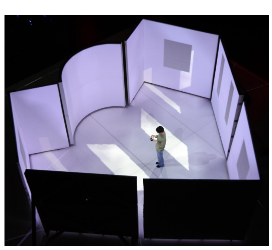
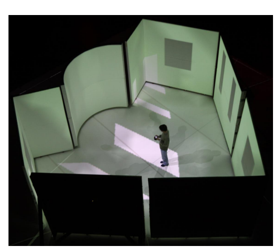
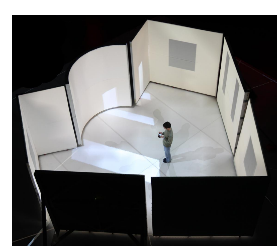
- Large, human-scale projection environment
- People move freely within the space
- Projection surfaces can be moved interactively
- Varying illumination conditions
- Robust & real-time tracking and display

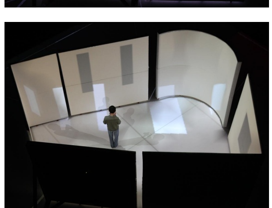
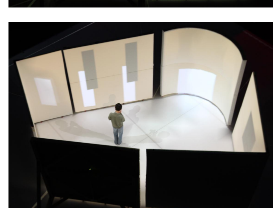
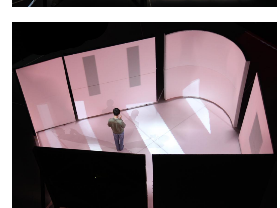




Architectural Daylighting Design



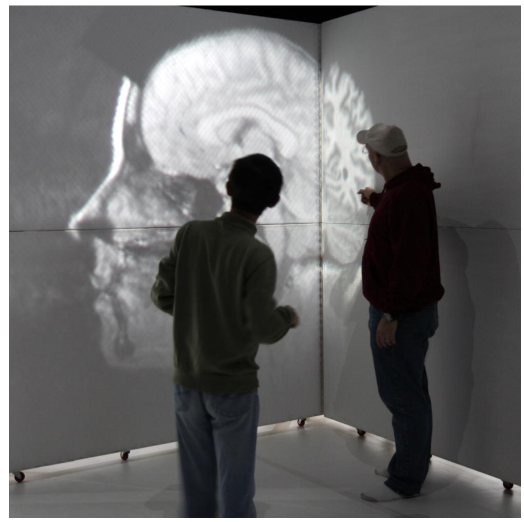
- Windows, wall colors, & time of day controlled through iTouch interface

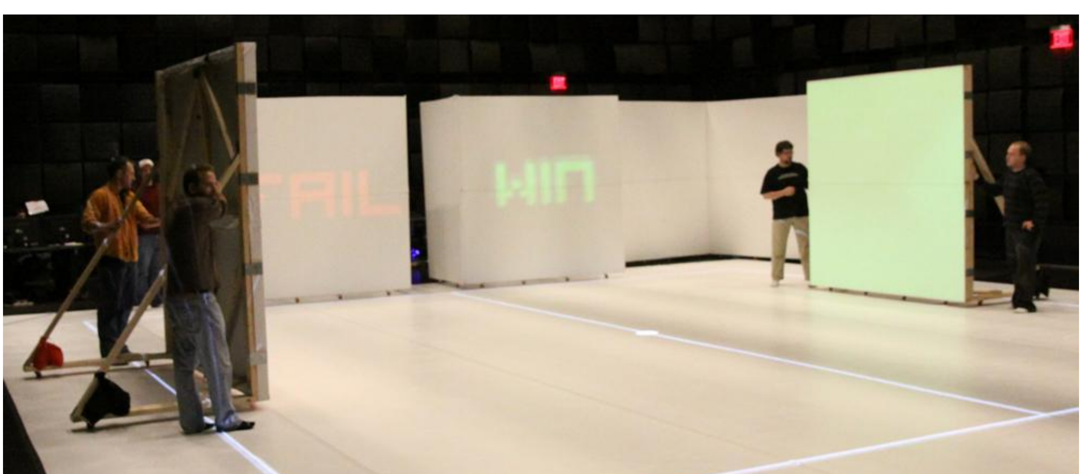
Volumetric Visualization

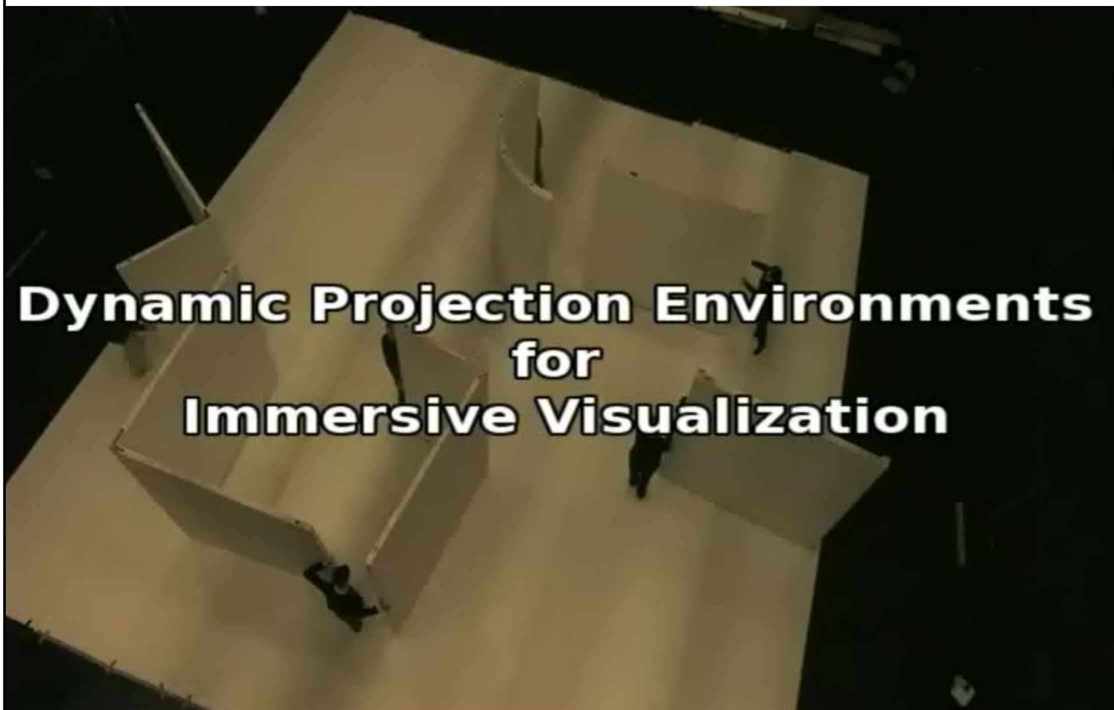
- Cross sections of a 3D medical dataset virtually placed within the projection volume



General User Interface Elements

- Projection surfaces as input devices
- No instruction necessary to play the game!





Panorama from Gehua Yang, DualAlign