Comp/Phys/APSc 715

Evaluation of Visualization
Vector Visualization Redesign

Example Videos

- Vis 2008, Wang: vis-1013_final_video.mp4
  - Focus + context display in 3D
- Vis 2008, Wangchao: idtvdv.avi
  - Importance-driven rendering
- Vis 2008, Zhou: 2008 Vis. Visibility Based Mesh Analysis.submission.mov
  - Importance-driven rendering from CAD model

Administrative

- There will be more data and more questions for all of the projects than was in the HW.
  - To determine, meet with scientist
- Let me know your project preferences
  - Total of 100 points to allocate to all 4
  - More points means more preference
  - Trade-offs to being both client and on team…
  - Email me by tomorrow (Friday)

Evaluation

- "…we often design and evaluate methods by presenting results informally to potential users." [Kosara et al 2003]
  - We will be doing this in this course
  - We'll also add a more formal task but only for a single person doing one task: see instructions
  - Note that even this will be a nontrivial effort – start planning for it now

Potential Types of Evaluation

- Re-use existing designs (art, cartography)
- Hire an expert visual designer to leapfrog into known "best-practice" space
- Videotaping one or more users working with the system
- User Studies: evaluating performance

Why Conduct User Studies?

Why Conduct User Studies?

- Offer scientifically sound method to measure a visualization's performance
  - Accuracy and speed
- Provide insight into why a technique is effective
  - By varying conditions and parameters to see effect
- Determine if theoretical principles derived from psychophysics apply to visualization design
  - Taking the study up one level of complexity

Types of Studies

- Perceptual studies
  - Very simple tasks and stimuli
    - "Which types of texture enhance surface perception, and which camouflage it?"
    - "What is the best color map to display ratio scalar fields with high spatial frequency data?"
- Usability studies
  - User performs a (perhaps complex) task

What to collect?

- Careful statistical data about performance
  - time and error measures
- Close observation of user behavior
  - when did they get frustrated?
  - when did they make errors?
- Free-form comments from the users

Doing Experiments on People is Serious Business

- Requires serious commitment of time and effort
  - Planning the experiment (seek help from psych!)
  - Evaluating the results (seek help from stat during plan!)
  - Iterating 2-3 times (uncompelling results)
- Requires approval of Institutional Review Board on campus
  - Seeks to preserve respect for and rights of subjects
  - Seeks to prevent new occurrences of egregious past acts of misconduct
- Kosara, et al, report that it is usually worth the effort

Laidlaw Vector Field Study

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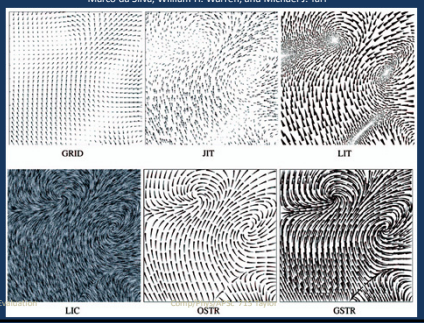
David H. Laidlaw, Robert M. Kirby, Cullen D. Jackson, J. Scott Davidson, Timothy S. Miller, Marco da Silva, William H. Warren, and Michael J. Tarr



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- Question 1: Where are the critical points?

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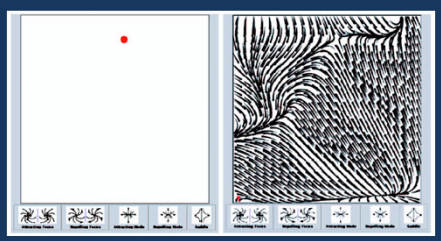
- Question 2: What type of critical point?



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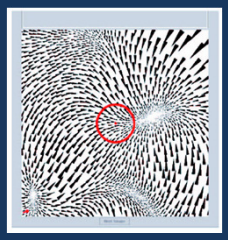
- Question 3: Where would the point go?



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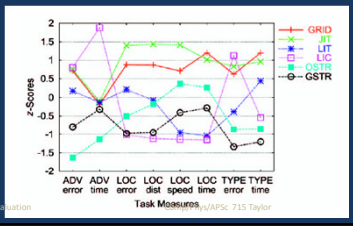
- Results: Which was the best?
  - It depends on the task
  - GSTR better than average on all metrics



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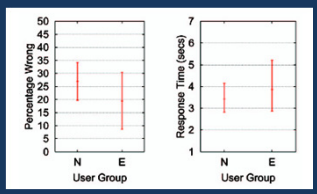
- Of note: Experts and non-experts similar!
  → Brief training sufficient



N= non-
E= expert

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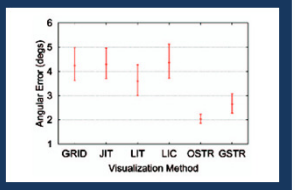
- Of note: Advection was always pretty good!
  - < ~5 degrees of error



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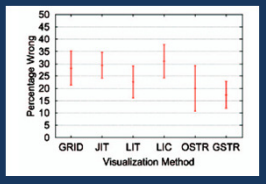
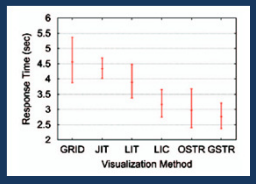
- Of note: Not significantly better, but faster
  - – for critical point type





Compared to Class Guesses…

Par	*Li*	*Gl1*	*2*	*3*	*4*	*5*	*Tex*	*Sfc*	*Clr*	
L	L+	Ok/4	5	3	2	1	Ok/6	X	X	Sources and sinks (Identify critical points)
L	L+	Ok/4	5	3	2	1	Ok/1	X	X	Sources and sinks (Locate critical points)
Ok	Tr	Ok/4	5	1	3	2	Ok/6	X	Ok	Fast/slow/still (Find zero-flow locations)
Ok	L	Ok					Ok	X	X	Center of rotation
Ok	+	Ok					Ok	X	X	Shape of flow
Ok	++	?					Ok	X	X	Where is flow laminar vs. turbulent?
++	T	L/4	4	3	1	2	Dye/4	L	X	Where would a pushed object end up?
T	T	L					T	L	X	Where does a concentration come from?
Ok	Ok	Ok					?	+	X	Where does stress cause strain?
T	T	Ok					T	T	++	Positive vs. negative field (scalar)?

Evaluation in this class

- Formal
  - Asks primary goal of the scientist
  - On a data set truth is known for (often synthetic)
  - Non-team-member who has not seen the data
- Informal client feedback
  - What new things did the client learn?
  - How is it better/worse than existing tools?
  - How do they like it?

3D DDS User Study

- How well does 3DS work?
  - At what?
  - Compared to what?
- More specific
  - At identifying relationships and extracting values.
  - Compared to other glyph-based technique.

Feng D., Lee, Y., Kwock L., and Taylor, R., "Evaluation of Glyph-based Scalar Multivariate Volume Visualization Techniques," in *Proceedings of the 6th Symposium on Applied Perception in Graphics and Visualization 2009*. ACM Press, New York, NY, pp. 61-68.

Relationships

- What kinds of relationships?
  - **Linear**
  - Overlap/Intersection
  - Multivariate
  - Etc.
- Data
  - Real? No. goal is to discover relationship
  - Fake? What kind?

Data

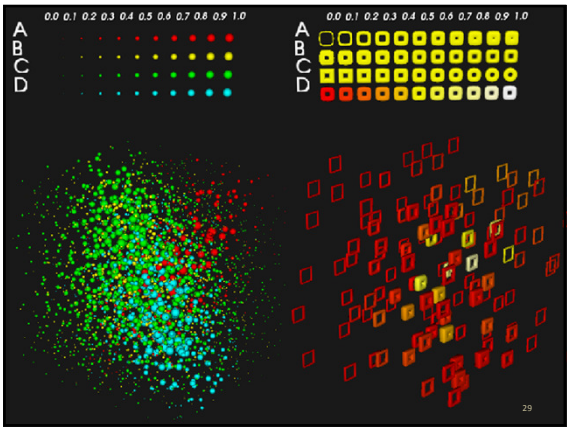
- Application driven
  - Controlled, but resembles original data
  - 3D randomly oriented Gaussian splats
- What resolution?
  - Again, application driven
  - 15x15x15

Compare to SQ Glyphs

- Superquadric glyphs
- Recently published for use in multivariate 3D scalar vis.
- 4 parameters
  - 2 roundnesses
  - thickness
  - color

Legend?

- 2D Legend?
- 3DS
  - It's a 3D glyph, pointless for size-varying
- SQ
  - 4D parameter space.
  - Can't show it all
  - Four examples: full range in 1 var, middle in others.

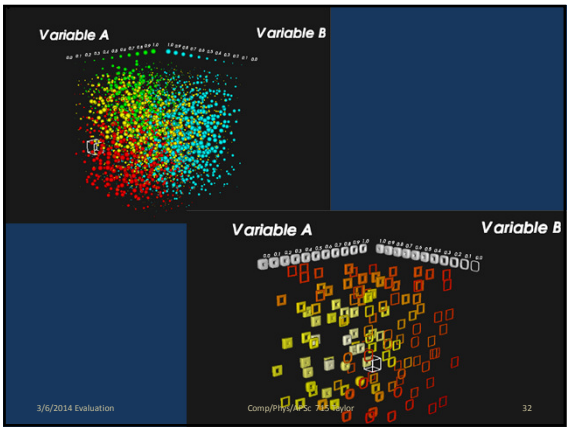


Other Controls

- Control skill level
  - No mouse, keyboard
  - Spacebar for camera rotate, keypad for value selection
- Control environment
  - Dark room
  - 3D stereo glasses, Eye-separation corrected

Value Extraction

- Easy in 2D, how to label a spot in 3D?
  - Dot, sphere, cube…
- Wireframe cube
  - What color?
  - White probably a bad choice in-band for color). Oops.
- Average value? Interpolated value?
  - Confused users…



Between Sub vs. In Sub

- Between subject
  - Compare absolute performance of different participants between conditions
  - Compare Sphere avg to SQ average
- In subject
  - Compare relative performance of different participants between conditions.
  - Average improvement

How to pick?

- Variability between subjects
  - First-person-shooter-playing students might be better?
  - Experts vs. non-experts
- Fewer controls → Variability → More subjects
  - Oh boy…
- Lead David to pick In-Subjects design

What to capture?

- Ideally: everything
  - System Interaction
    - Mouse events, keyboard events, etc
  - **Interviews**
  - **Timing**
  - **Performance**

Details details…

- How many subjects do we need?
  - Run a pilot, ask stats person
- How many trials should each participant do?
  - Run a pilot, ask stats person
- How much training to I need to do?
  - Run a pilot
- What age range to we sample?
- Do you offer compensation? How much?
- How much help to give?
- What do you do with outliers?
- How do I know this applies to my real data?
  - Uh…
- Help, I don't know statistics!
  - Me neither…

Vector Visualization Redesign

- Keller & Keller
- How does wind velocity correlate with temperature?
  - Magnitude
  - Direction
  - Critical Points