Lecture 13: User Studies

Information Visualization
CPSC 533C, Fall 2009

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Readings Covered

Ware, Appendix C: The Perceptual Evaluation of Visualization Techniques and Systems

The Perceptual Scalability of Visualization. Beth Yost and Chris North. Proc. InfoVis 06, published as IEEE TVCG 12(5), Sep 2006, p 837-844.

Effectiveness of Animation in Trend Visualization. George G. Robertson, Roland Fernandez, Danyel Fisher, Bongshin Lee, and John T. Stasko. IEEE TVCG (Proc. InfoVis 2008). 14(6): 1325-1332 (2008)

Sizing the Horizon: The Effects of Chart Size and Layering on the Graphical Perception of Time Series Visualizations. Jeffrey Heer, Nicholas Kong, and Maneesh Agrawala. ACM CHI 2009, pages 1303 - 1312.

Turning Pictures into Numbers: Extracting and Generating Information from Complex Visualizations. J. Gregory Trafton, Susan S. Kirschenbaum, Ted L. Tsui, Robert T. Miyamoto, James A. Ballas, and Paula D. Raymond. Intl Journ. Human Computer Studies 53(5), 827-850.

Further Readings

Task-Centered User Interface Design, Clayton Lewis and John Rieman, Chapters 0-5.

The challenge of information visualization evaluation. Catherine Plaisant. Proc. Advanced Visual Interfaces (AVI) 2004

Snap-Together Visualization: Can Users Construct and Operate Coordinated Views? Chris North, B. Shneiderman. Intl. Journal of Human-Computer Studies, Academic Press, 53(5), pg. 715-739, (November 2000).

Navigating Hierarchically Clustered Networks through Fisheye and Full-Zoom Methods. Doug Schaffer, Zhengping Zuo, Saul Greenberg, Lyn Bartram, John C. Dill, Shelli Dubs, and Mark Roseman. ACM Trans. Computer-Human Interaction (ToCHI), 3(2) p 162-188, 1996.

Ware: Evaluation Appendix

- perceptual evaluation of infovis techniques and systems
  - empirical research methods applied to vis
  - difficult to isolate evaluation to perception
- research method depends on research question and object under study

[Ware, Appendix C: The Perceptual Evaluation of Visualization Techniques and Systems. Information Visualization: Perception for Design.]

Psychophysics

- method of limits
  - find limitations of human perceptions
- error detection methods
  - find threshold of performance degradation
  - staircase procedure to find threshold faster
- method of adjustment
  - find optimal level of stimuli by letting subjects control the level

Cognitive Psychology

- repeating simple, but important tasks, and measure reaction time or error
  - Miller's 7+/- 2 short-term memory experiments
  - Fitts' Law (target selection)
  - Hick's Law (decision making given n choices)
- interference between channels
- multi-modal studies
  - MacLean, "Perceiving Ordinal Data Haptically Under Workload (2005)
  - using haptic feedback for interruption when the participants were visually (and cognitively) busy

Structural Analysis

- requirement analysis, task analysis
- structured interviews
  - can be used almost anywhere, for open-ended questions and answers
- rating/Likert scales
  - commonly used to solicit subjective feedback
  - ex: NASA-TLX (Task Load Index) to assess mental workload
    - "it is frustrating to use the interface"
    - Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

Comparative User Studies

- hypothesis testing
- hypothesis: a precise problem statement
  - ex: Participants will be faster with a coordinated overview+detail display than with an uncoordinated display or a detail-only display with the task requires reading details
  - measurement: faster
  - objects of comparison:
    - coordinated O+D display
    - uncoordinated O display
    - uncoordinated D display
  - condition of comparison: task requires reading details

Comparative User Studies

- study design: factors and levels
- factors
  - independent variables
  - ex: interface, task, participant demographics
- levels
  - number of variables in each factor
  - limited by length of study and number of participants

Comparative User Studies

- study design: within, or between?
- within
  - everybody does all the conditions
  - can lead to ordering effects
  - can account for individual differences and reduce noise
  - thus can be more powerful and require fewer participants
  - combinatorial explosion
    - severe limits on number of conditions
  - possible workaround is multiple sessions
- between
  - divide participants into groups
  - each group does only some conditions

Comparative User Studies

- measurements (dependent variables)
  - performance indicators: task completion time, error rates, mouse movement
  - subjective participant feedback: satisfaction ratings, closed-ended questions, interview
  - observations: behaviors, signs of frustration
- number of participants
  - depends on effect size and study design: power of experiment
- possible confounds?
  - learning effect: did everybody use interfaces in a certain order?
  - if so, are people faster because they are more practiced, or because of true interface effect?

Comparative User Studies

- result analysis
  - should know how to analyze the main results/hypotheses BEFORE study
  - hypothesis testing analysis (using ANOVA or t-tests) tests how likely observed differences between groups are due to chance alone
  - ex: a p-value of 0.05 means there is a 5% probability the difference occurred by chance
    - usually good enough for HCI studies
- pilots!
  - should have good idea of forthcoming results of the study BEFORE running actual study trials

Evaluation Throughout Design Cycle

- user/task centered design cycle
  - initial assessments
  - iterative design process
  - benchmarking
  - deployment
- identify problems, go back to previous step

Task-Centered User Interface Design, Clayton Lewis and John Rieman, Chapters 0-5.

Initial Assessments

- what kind of problems are the system aiming to address?
  - analyze a large and complex dataset
- who are your target users?
  - data analysts
- what are the tasks? what are the goals?
  - find trends and patterns in the data via exploratory analysis
- what are their current practices
  - statistical analysis
- why and how can visualization be useful?
  - visual spotting of trends and patterns
- talk to the users, and observe what they do
- task analysis

Iterative Design Process

- does your design address the users' needs?
- can they use it?
- where are the usability problems?
- evaluate without users
  - cognitive walkthrough
  - action analysis
  - heuristics analysis
- evaluate with users
  - usability evaluations (think-aloud)
  - bottom-line measurements

Benchmarking

- how does your system compare to existing ones?
- empirical, comparative studies
  - ask specific questions
  - compare an aspect of the system with specific tasks
    - Amar/Stasko task taxonomy paper
  - quantitative, but limited
    - The Challenge of Information Visualization Evaluation, Catherine Plaisant, Proc. AVI 2004

Deployment

- how is the system used in the wild?
- how are people using it?
- does the system fit into existing work flow? environment?

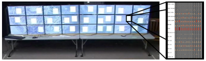
- contextual studies, field studies

Comparing Systems vs. Characterizing Usage

- user/task centered design cycle:
  - initial assessments
  - iterative design process
  - benchmarking: head-to-head comparison
  - deployment
  - (identify problems, go back to previous step)
- understanding/characterizing techniques
  - tease apart factors
  - when and how is technique appropriate
- line is blurry: intent

Perceptual Scalability

- what are perceptual/cognitive limits when screen-space constraints lifted?
  - 2 vs. 32 Mpixel display
  - macro/micro views
- perceptually scalable
  - no increase in task completion times when normalize to amount of data

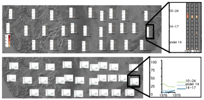


[The Perceptual Scalability of Visualization. Beth Yost and Chris North. IEEE TVCG 12(5) (Proc. InfoVis 06), Sep 2006, p 837-844.]

Perceptual Scalability

- design
  - 2 display sizes, between-subjects
    - (data size also increased proportionally)
  - 3 visualization designs, within
    - small multiples: bars
    - embedded graphs
    - embedded bars
  - 7 tasks, within
  - 42 tasks per participant
    - 3 vis x 7 tasks x 2 trials

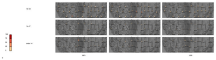
Embedded Visualizations



[The Perceptual Scalability of Visualization. Beth Yost and Chris North. IEEE TVCG 12(5) (Proc. InfoVis 06), Sep 2006, p 837-844.]

Small Multiples Visualizations

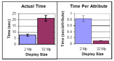
- attribute-centric instead of space-centric



[The Perceptual Scalability of Visualization. Beth Yost and Chris North. IEEE TVCG 12(5) (Proc. InfoVis 06), Sep 2006, p 837-844.]

Results

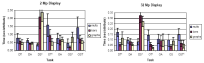
- 20x increase in data, but only 3x increase in absolute task times



[The Perceptual Scalability of Visualization. Beth Yost and Chris North. IEEE TVCG 12(5) (Proc. InfoVis 06), Sep 2006, p 837-844.]

Results

- significant 3-way interaction
  - between display, size, task



[The Perceptual Scalability of Visualization. Beth Yost and Chris North. IEEE TVCG 12(5) (Proc. InfoVis 06), Sep 2006, p 837-844.]

Results

- visual encoding important on small displays
  - DS: mults sig slower than graphs on small
  - DS: mults sig slower than embedded on large
  - OS: bars sig faster than graphs for small
  - OS: no sig difference bars/graphs for large

- spatial grouping important on large displays
  - embedded sig faster+preferred over small mult
  - no bar/graph differences

Critique

Critique

- first study of macro/micro effects
  - breaking new ground

- many possible followups
  - physical navigation vs. virtual navigation
    - The Effects of Peripheral Vision and Physical Navigation in Large Scale Visualization. GI 08
    - Move to Improve: Promoting Physical Navigation to Increase user Performance with Large Displays. CHI 07

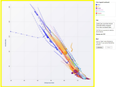
Animation for Trends

- Gapminder: animated bubble charts + human
  - x/y position, size, color, animation
  - is animation effective?
    - presentation vs analysis
    - trend vs transitions

[Effectiveness of Animation in Trend Visualization. Robertson et al. IEEE TVCG (Proc. InfoVis 2008). 14(6): 1325-1332 (2008)]

Trends

- many countertrends lost in clutter



[Effectiveness of Animation in Trend Visualization. Robertson et al. IEEE TVCG (Proc. InfoVis 2008). 14(6): 1325-1332 (2008)]

Small Multiples

- individual plots get small

[Effectiveness of Animation in Trend Visualization. Robertson et al. IEEE TVCG (Proc. InfoVis 2008). 14(6): 1325-1332 (2008)]

Design

- 2 use: presentation vs. analysis (between-subjects)
- 3 vis encodings: animation vs. traces vs. small mults
- 2 dataset size: small vs. large
  - 3 encoding x 2 size: within-subjects
- 24 tasks per participant
  - 4 tasks x 3 encodings x 2 sizes

Results

- small multiples more accurate than animation
- animation faster for presentation, slower for analysis
  - than small multiples and trends
- dataset size matters (unsurprisingly)

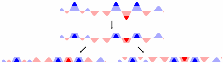
Critique

Critique

- nice idea to investigate the gapminder phenomenon!
- well done study

Sizing the Horizon

- high data density displays
  - horizon charts, offset graphs



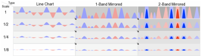
[Sizing the Horizon: The Effects of Chart Size and Layering on the Graphical Perception of Time Series Visualizations. Heer, Kong, and Agrawala. CHI 2009, p 1303-1312.]

Experiment 1

- how many bands? mirrored or offset?
- design: within-subjects
  - 2 chart types: mirrored, offset
  - 3 band counts: 2, 3, 4
  - 16 trials per condition
  - 96 trials per subject
- results
  - surprise: offset no better than mirrored
  - more bands is harder (time, errors)
    - stick with just 2 bands

Experiment 2

- mirror/layer vs line charts? effect of size?
- design: within-subjects
  - 3 charts: line charts, mirror no banding, mirror 2 bands
  - 4 sizes
  - 10 trials per condition
  - 120 trials per subject



[Sizing the Horizon: The Effects of Chart Size and Layering on the Graphical Perception of Time Series Visualizations. Heer, Kong, and Agrawala. CHI 2009, p 1303-1312.]

Results

- found crossover point where 2-band better: 24 pixels
  - virtual resolution: unmirrored unlayered height
  - line: 1x, 1band: 2x, 2band: 4x
- guidelines
  - mirroring is safe
  - layering (position) better than color alone
  - 24 pixels good for line charts, 1band mirrors
  - 12 or 16 pixels good for 2band

Critique

Critique

- very well executed study
  - best paper award
- finding crossover points is very useful

Pictures Into Numbers

- field study
- participants: professional meterologists
  - two people: forecaster, technician
- interfaces: multiple programs used
- protocol
  - talkaloud
  - videotaped sessions with 3 cameras

[Turning Pictures into Numbers: Extracting and Generating Information from Complex Visualizations. Trafton et al. Intl J. Human Computer Studies 53(5), 827-850.]

Cognitive Task Analysis

- initialize understanding of large scale weather
- build qualitative mental model (QMM)
- verify and adjust QMM
- write the brief

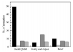
- task breakdown part of paper contribution

Coding Methodology

- interface
  - which interface used
  - whether picture/chart/graph
- usage (every utterance!)
  - goal
  - extract
    - quant/qual
    - goal-oriented/opportunistic
    - integrated/unintegrated
  - brief-writing
    - quant/qual
    - QMM/vis/notes

Results

- sig difference between vis used at CTA stages
  - charts to build QMM
  - images to verify/adjust QMM
  - all kinds during brief-writing
- many others...



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Critique

Critique

- video coding is huge amount of work, but very illuminating
  - untangling complex story of real tool use
- methodology of CTA construction not discussed here
  - often bottomup/topdown mix

Credits

- Heidi Lam guest lecture

http://www.cs.ubc.ca/~tmm/courses/cpsc533c-06-fall/#lect10

Proposals

- due 5pm this Fri (Oct 30) by emailing me a URL
  - Subject: 533 submit proposal
  - format - PDF great, HTML ok, Word acceptable

Presentations

- days/topics now posted
  - seed papers posted for first day
  - rest up soon
- slides required, PPT or PDF
  - if using my laptop: email me URL by 10am
  - if your own laptop, email me URL by 3:00pm
- you need both summary and critique/synthesis
  - important difference from me: audience hasn't read papers!
- grading (probably)
  - summary 50%
  - synthesis/critique 20%
  - style 15%
  - materials %15
- 20 min total: 15-17 present, 3-5 questions
  - must practice to get timing right!