Visualization: Why It's Tricky, Where To Start

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http://www.cs.ubc.ca/~tmm/talks.html#bellairs14
Vis Definition: Why It’s Tricky

- vis systems provide visual representations of datasets designed to help people carry out tasks more effectively
- augment human capabilities
  - not replace people with computational decision-making
- design space of possible visualization idioms is huge
  - most possibilities ineffective
  - validating effectiveness of a design is both necessary and difficult
- three very different kinds of resource limitations
  - computers
  - humans
  - displays
Questions Answered Elsewhere (VAD Ch 1)

- why have a human in the decision-making loop?
- why have a computer in the loop?
- why use an external representation?
- why depend on vision?
- why show the data in detail?
- why use interactivity?
- what is the design space of visualization idioms?
- why focus on tasks?
- why are most designs ineffective?
- why care about effectiveness?
- why is validation difficult?
Where To Start: Five Flavors of Paper Types

• Problem-driven work
  – design studies

• Technique-driven work
  – algorithms, idioms

• Systems
  – (as in other fields)

• Evaluation
  – lab/field/data studies

• Theoretical foundations
  – models
Theory/Models

- nested model for vis design and validation
  - revisited: blocks and guidelines

- multi-level typology of abstract visualization tasks

- design study methodology

- papers process and pitfalls
A Nested Model of Visualization Design and Validation


A Nested Model of Visualization Design and Validation.

Nested Levels of Design

• four levels of design problems

- domain situation
- data/task abstraction
- visual encoding / interaction idiom
- algorithm
Nested Levels of Design

• four levels of design problems
  – different threats to validity at each level

  **domain situation:**
  you misunderstood their needs

  **data/task abstraction:**
  you’re showing them the wrong thing

  **visual encoding / interaction idiom:**
  the way you show it doesn’t work

  **algorithm:**
  your code is too slow

• data abstraction: don’t just use what you’re given, derive the right thing!
domain situation:
observe target users using existing tools

data/task abstraction:
encoding/interaction idiom:
justifying design wrt alternatives

algorithm:
measure system time
analyze computational complexity

analyze results qualitatively
measure human time with lab experiment (“user study”)

observe target users post-deployment (“field study”)

measure adoption

- mismatch: cannot show idiom good with system timings
- mismatch: cannot show abstraction good with lab study
A Multi-Level Typology of Abstract Visualization Tasks

joint work with:
Matt Brehmer

http://www.cs.ubc.ca/labs/imager/tr/2013/MultiLevelTaskTypology/

Previous Work

Classifying Tasks, Goals, Intentions, Objectives, Activities, Interactions

low level of abstraction
e.g. “retrieve value”

Heer & Shneiderman (2012)
Mullins & Treu (1993)
Pike, Stasko, et al. (2009)
Springmeyer et al. (1992)
RE Roth (2012)

high level of abstraction
e.g. “integration of insight”

Card, Mackinlay, Shneiderman (1999)
Klein, Moon, & Hoffman (2006)
Liu & Stasko (2010)
Pirolli & Card (2005)
Spence (2007)

A mid-level gap?
Meyer, Sedlmair, & Munzner (BELIV 2012)
Multi-Level Typology of Abstract Visualization Tasks

\{ \textit{why, what, how} \}
Multi-Level Typology of Abstract Visualization Tasks (VAD version)
{ why, what, how }

- **what?**
  - item
  - link
  - attribute (categ./ord./quant.)
    - single
    - many
      - dependency
      - correlation
      - similarity
Multi-Level Typology of Abstract Visualization Tasks *(VAD version)*

{ why, what, how }

- **introduce**
  - import
  - derive
  - annotate
  - record

- **encode**
  - arrange (space)
  - express
  - separate
  - order
  - align
  - use
  - map (colour)
  - size, angle, ...

- **facet**
  - partition
  - superimpose
  - change
  - select
  - coordinate

- **reduce**
  - filter
  - aggregate
  - navigate
  - embed
Design Study Methodology: Reflections from the Trenches and from the Stacks

joint work with: Michael Sedlmair, Miriah Meyer

http://www.cs.ubc.ca/labs/imager/tr/2012/dsm/
Design Studies

• long and winding road with many pitfalls
  – reflections after doing 21 of them
    • many successes, a few failures, many lessons learned
How To Do Design Studies

• definitions
How To Do Design Studies

• definitions

• 9-stage framework
How To Do Design Studies

• definitions

• 9-stage framework

• 32 pitfalls and how to avoid them
Pitfall Example: Premature Publishing

- technique-driven
- problem-driven

Must be first!

Am I ready?


http://www.alainekipes.com/interests/violin_concert.jpg
Where To Start: Many Flavors of Work

- Problem-driven work
  - design studies
- Technique-driven work
  - algorithms, idioms
- Evaluation
  - lab/field/data studies
- Theoretical foundations
  - models
Design Studies: Biology Domain

• Variant View: gene sequence variants

• MulteeSum, Pathline: comparative functional genomics

• MizBee: comparative genomics (synteny)

• Cerebral: gene expression + interaction network
Design Studies: Other Domains

- RelEx: automotive networks
- Vismon: fisheries simulation/mgmt
- LiveRAC: large-scale system monitoring
- SessionViewer: web logs
Techniques/Systems: Dimensionality Reduction

- Glint: costly distance functions

- DimStiller: visual dimensional analysis and reduction toolkit

- Glimmer: GPU accelerated MDS
Techniques: Graphs/Trees

• general multilevel/compound graphs
  – layout
    • TopoLayout
  – interaction
    • Grouse
    • GrouseFlocks
    • TugGraph

• evolutionary tree comparison
  – TreeJuxtaposer
Evaluation: Dimensionality Reduction

• guidance on scatterplot/DR choices

• taxonomy of cluster separation factors

• 2D points vs 3D landscapes
Evaluation: Focus+Context

• overviews: separate vs. integrated views

• navigation: stretch and squish vs. pan/zoom navigation

• impact of distortion on visual search, visual memory
Evaluation, When and How
(excerpt)

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Evaluation: How Much Evaluation Is Enough?
Panel, VIS13
Victories and challenges: I

• evolving sophistication: the user study pendulum swings
• we’ve come a long way!
  - no user studies at all
  - a few dubious ones, lacking rigor
  - some good ones appear
  - rigorous studies are common
• but pushes to change culture often overshoot...
  - some reviewers expect all papers to have user studies
  - some authors do user studies without understanding why or how
Victories and challenges: II

• significance testing with controlled experiments
  
  - we’ve moved beyond “my friends liked it”

- new frontier: multiple regression for comparison
  

- new frontier: thinking beyond time and error
  
  • qualitative vs quantitative
    
    - different axis from lab/field
  
  • BELIV workshops
    
    - 06 AVI, 08 CHI, 10 CHI, 12 VisWeek
Victories and challenges: III

• post-deployment studies with target users
  - we’ve moved beyond “I’m the only one who’s used it”
  - new frontier: post-adoption studies
    • Seven Scenarios: only 5 out of 800!


• what happens after you get that first paper out?...
Of course...

- ...you should evaluate your work
  - use appropriate methods!
- ...you should **not** have a user study in every paper
  - avoid litmus test and cargo cult thinking