Visualization Design Methods

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http://www.cs.ubc.ca/~tmm/talks.html#ucsd17  @tamaramunzner
Visualization (vis) defined & motivated

Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

• human in the loop needs the details
  – doesn't know exactly what questions to ask in advance
  – longterm exploratory analysis
  – presentation of known results
  – stepping stone towards automation: refining, trustbuilding

• external representation: perception vs cognition

• intended task, measurable definitions of effectiveness

more at:
Visualization Analysis and Design, Chapter 1.
A Nested Model for Visualization Design and Validation

Tamara Munzner
@tamaramunzner


A Nested Model for Visualization Design and Validation.
Analysis framework: Four levels, three questions

• **domain situation**
  – who are the target users?
• **abstraction**
  – translate from specifics of domain to vocabulary of visualization
  – *what* is shown? **data abstraction**
    • often don’t just draw what you’re given: transform to new form
  – *why* is the user looking at it? **task abstraction**
• **idiom**
  – *how* is it shown?
    • visual encoding idiom: how to draw
    • interaction idiom: how to manipulate
• **algorithm**
  – efficient computation


Why is validation difficult?

• different ways to get it wrong at each level

Validation solution: use methods from appropriate fields at each level

• avoid mismatches!

Anthropology/ethnography

- Domain situation
  Observe target users using existing tools

Design

- Data/task abstraction
  - Visual encoding/interaction idiom
    Justify design with respect to alternatives
  - Algorithm
    - Measure system time/memory
    - Analyze computational complexity

Computer science

- Analyze results qualitatively
- Measure human time with lab experiment (lab study)

Cognitive psychology

- Observe target users after deployment (field study)

Anthropology/ethnography

- Measure adoption

Design Study Methodology

Reflections from the Trenches and from the Stacks

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

Design Study Methodology: Reflections from the Trenches and from the Stacks.
Methodology for problem-driven work

• definitions

• 9-stage framework

• 32 pitfalls & how to avoid them

• comparison to related methodologies
Lessons learned from the trenches: 21 between us

Cerebral genomics
MizBee genomics
Pathline genomics
MulteeSum genomics
Vismon fisheries management
QuestVis sustainability
WiKeVis in-car networks

MostVis in-car networks
Car-X-Ray in-car networks
ProgSpy2010 in-car networks
RelEx in-car networks
Cardiogram in-car networks
AutobahnVis in-car networks
VisTra in-car networks

Constellation linguistics
LibVis cultural heritage
Caidants multicast
SessionViewer web log analysis
LiveRAC server hosting
PowerSetViewer data mining
LastHistory music listening
Design study methodology: definitions
9 stage framework

PRECONDITION

CORE

ANALYSIS

learn
winnow
cast
discover
design
implement
deploy
reflect
write
9-stage framework

**PRECONDITION**
- learn
- winnow
- cast

**CORE**
- discover
- design
- implement
- deploy
- reflect
- write

**ANALYSIS**
- learn
- winnow
- cast
9-stage framework

discover
design
implement
deploy
9-stage framework

- guidelines: confirm, refine, reject, propose
9-stage framework
Design study methodology: 32 pitfalls

• and how to avoid them

<table>
<thead>
<tr>
<th>PF-1</th>
<th>premature advance: jumping forward over stages</th>
<th>general</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-2</td>
<td>premature start: insufficient knowledge of vis literature</td>
<td>learn</td>
</tr>
<tr>
<td>PF-3</td>
<td>premature commitment: collaboration with wrong people</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-4</td>
<td>no real data available (yet)</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-5</td>
<td>insufficient time available from potential collaborators</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-6</td>
<td>no need for visualization: problem can be automated</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-7</td>
<td>researcher expertise does not match domain problem</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-8</td>
<td>no need for research: engineering vs. research project</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-9</td>
<td>no need for change: existing tools are good enough</td>
<td>winnow</td>
</tr>
</tbody>
</table>
I’m a domain expert! Wanna collaborate?

Of course!!!
roles

Are you a user???

... or maybe a fellow tool builder?
Metaphor

Winnowing
Collaborator winnowing

initial conversation

(potential collaborators)
Collaborator winnowing

initial conversation

further meetings
Collaborator winnowing

- Initial conversation
- Further meetings
- Prototyping
Collaborator winnowing

- Initial conversation
- Further meetings
- Prototyping
- Full collaboration
Collaborator winnowing

Talk with many, stay with few!
EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers

WikeVis
0.5 years / 2 researchers
EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers

WikeVis
0.5 years / 2 researchers

- Fellow tool builders
- Data promised
# Design study methodology: 32 pitfalls

<table>
<thead>
<tr>
<th>PF-10</th>
<th>no real/important/recurring task</th>
<th>winnow</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-11</td>
<td>no rapport with collaborators</td>
<td>winnow</td>
</tr>
<tr>
<td>PF-12</td>
<td>not identifying front line analyst and gatekeeper before start</td>
<td>cast</td>
</tr>
<tr>
<td>PF-13</td>
<td>assuming every project will have the same role distribution</td>
<td>cast</td>
</tr>
<tr>
<td>PF-14</td>
<td>mistaking fellow tool builders for real end users</td>
<td>cast</td>
</tr>
<tr>
<td>PF-15</td>
<td>ignoring practices that currently work well</td>
<td>discover</td>
</tr>
<tr>
<td>PF-16</td>
<td>expecting <em>just talking</em> or <em>fly on wall</em> to work</td>
<td>discover</td>
</tr>
<tr>
<td>PF-17</td>
<td>experts focusing on visualization design vs. domain problem</td>
<td>discover</td>
</tr>
<tr>
<td>PF-18</td>
<td>learning their problems/language: too little / too much</td>
<td>discover</td>
</tr>
<tr>
<td>PF-19</td>
<td>abstraction: too little</td>
<td>design</td>
</tr>
<tr>
<td>PF-20</td>
<td>premature design commitment: consideration space too small</td>
<td>design</td>
</tr>
</tbody>
</table>
Of course they need the cool **technique** I built last year!
METAPHOR

Design Space
METAPHOR

Design Space

your technique...

+ good
○ okay
- poor
Metaphor
Design Space
METAPHOR

Design Space

know

consider
**METAPHOR**

**Design Space**

- know
- consider
- propose
Metaphor

Design Space

know
consider
propose
select
Think broad!
## Design study methodology: 32 pitfalls

<table>
<thead>
<tr>
<th>PF-21</th>
<th>mistaking technique-driven for problem-driven work</th>
<th>design</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-22</td>
<td>nonrapid prototyping</td>
<td>implement</td>
</tr>
<tr>
<td>PF-23</td>
<td>usability: too little / too much</td>
<td>implement</td>
</tr>
<tr>
<td>PF-24</td>
<td>premature end: insufficient deploy time built into schedule</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-25</td>
<td>usage study not case study: non-real task/data/user</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-26</td>
<td><em>liking</em> necessary but not sufficient for validation</td>
<td>deploy</td>
</tr>
<tr>
<td>PF-27</td>
<td>failing to improve guidelines: confirm, refine, reject, propose</td>
<td>reflect</td>
</tr>
<tr>
<td>PF-28</td>
<td>insufficient writing time built into schedule</td>
<td>write</td>
</tr>
<tr>
<td>PF-29</td>
<td>no technique contribution ≠ good design study</td>
<td>write</td>
</tr>
<tr>
<td>PF-30</td>
<td>too much domain background in paper</td>
<td>write</td>
</tr>
<tr>
<td>PF-31</td>
<td>story told chronologically vs. focus on final results</td>
<td>write</td>
</tr>
<tr>
<td>PF-32</td>
<td>premature end: win race vs. practice music for debut</td>
<td>write</td>
</tr>
</tbody>
</table>
I can write a design study paper in a week!

“writing is research”

[Wolcott: Writing up qualitative research, 2009]
METAPHOR

Horse Race vs. Music Debut

Must be first!

Am I ready?

technique-driven

problem-driven


http://www.alaineknipes.com/interests/violin_concert.jpg
EXAMPLE FROM THE TRENCHES
Don’t step on your own toes!

First design round published

Subsequent work not stand-alone paper

**AutobahnVis 1.0**
[Sedlmair et al., Smart Graphics, 2009]

**AutobahnVis 2.0**
[Sedlmair et al., Information Visualization 10(3), 2011]
Reflections from the stacks: Wholesale adoption inappropriate

- **ethnography**
  - rapid, goal-directed fieldwork
- **grounded theory**
  - not empty slate: vis background is key
- **action research**
  - aligned
    - intervention as goal
    - transferability not reproducibility
    - personal involvement is key
  - opposition
    - translation of participant concepts into visualization language
    - researcher lead not facilitate design
    - orthogonal to vis concerns: participants as writers, adversarial to status quo, postmodernity
Angles of attack: My own work
Angles of attack
Problem-driven work

• design studies
  – in collaboration with target users
    • real data, real tasks
    • intensive requirements analysis
  – iterative refinement
    • deploy tools/systems
  – typical evaluation: case studies, field studies

• my strategy: opportunistic collaboration
  – many domains
  – both industrial and academic partners
Problem-driven: Tech industry

SessionViewer: web log analysis
https://youtu.be/T4MaTZd56G4

Peter McLachlan
(AT&T Research)

Stephen North
( AT&T Research )

Heidi Lam
(Google)

Diane Tang
(Google)

methods reflection: staged model of access to target users

LiveRAC: systems time-series logs
https://youtu.be/lD0c3H0VSkw
Problem-driven: Energy, sustainability

Matt Brehmer
(Pulse/EnerNOC)

Kevin Tate

redesign success: industrial swdev resources committed

Maryam Booshehrian
Torsten Moeller (SFU)

Vismon

https://youtu.be/h0kHoS4VYmk
Problem-driven: Genomics

Aaron Barsky (UBC Micro)  
Jenn Gardy (Agilent)  
Robert Kincaid (Agilent)

MizBee  
MulteeSum, Pathline

Cerebral  
https://youtu.be/76HhG1FQngI  
https://youtu.be/86p7brwuz2g
Problem-driven: Genomics, journalism

Joel Ferstay (BC Cancer)

Cydney Nielsen (BC Cancer)

Variant View
https://youtu.be/AHDnv_qMXxQ

Jonathan Stray (Assoc Press)

Overview
https://vimeo.com/71483614
Problem-driven: Autos, e-commerce

RelEx (BMW)
https://youtu.be/89lsQXc6Ao4

current work:
Mobify clickstream collaboration

Michael Sedlmair

Kimberly Dextras-Romagnino
The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists

http://www.cs.ubc.ca/labs/imager/tr/2014/Overview/

https://www.overviewdocs.com
From design

Case Study #1

Document Collection 4,500 pages from FOIA

Question

What did security contractors do during Iraq war?
<table>
<thead>
<tr>
<th>Case Study</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document Collection</td>
<td>4,500 pages from FOIA</td>
<td>5,996 emails from FOIA</td>
<td>8,680 pages from FOIA</td>
<td>1,278 survey comments</td>
<td>4,653 emails from FOIA</td>
<td>1,680 bills</td>
</tr>
<tr>
<td>Question</td>
<td>What did security contractors do during Iraq war?</td>
<td>Were municipal police funds mismanaged?</td>
<td>Were Paul Ryan’s campaign statements hypocritical?</td>
<td>What is the gun ownership debate about?</td>
<td>Was gov’t response to emergency incident effective?</td>
<td>Did gov’t fail to pass bills addressing police misconduct?</td>
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</table>
… to redesign, to reflect on task abstractions…

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<th>Question</th>
<th>Document Collection</th>
<th>Case Study</th>
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<td>#1</td>
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<tr>
<td>Were municipal police funds mismanaged?</td>
<td>5,996 emails from FOIA</td>
<td>#2</td>
</tr>
<tr>
<td>Were Paul Ryan’s campaign statements hypocritical?</td>
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<td>1,680 bills</td>
<td>#6</td>
</tr>
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prove haystack contains no needles!
... to achieve adoption (after iteration)

PRECONDITION
personal validation

CORE
inward-facing validation

ANALYSIS
outward-facing validation
Technique-driven work

• scalable algorithms & systems
  – typical evaluation: computational benchmarks

• new layout & interaction idioms
  – typical evaluation: usage scenarios
  – typical evaluation/characterization: controlled experiments on human subjects
Technique-driven: Graph drawing

Daniel Archambault (Bordeaux)

David Auber (Bordeaux)

TopoLayout
SPF
Grouse
GrouseFlocks
TugGraph

https://youtu.be/AWX Ae8zvkt8

TreeJuxtaposer

https://youtu.be/GdaPj8a9QEO

Benjamin Renoust

Detangler

https://youtu.be/QOtnHSsUV6k

Guy Melançon (Bordeaux)
Evaluation experiments: Graph drawing

Outcome: increasingly disenchanted with “focus+context” idioms

1 qualitative study: coding observational video
2 create & implement behavioral model
3 multiple regression to untangle factor relationships
Technique-driven: Dimensionality reduction

Stephen Ingram

Glimmer

Glint

DimStiller

QSNE
Dimensionality reduction for documents

• derive low-dimensional target space from high-dimensional measured space
Evaluation experiments: Dimensionality reduction

Points vs landscapes for dimensionally reduced data

traditional user study: many people for short time, few datasets

data studies: many datasets, few people for long time (experts qual+quant coding)

Guidance on DR & scatterplot choices

Taxonomy of cluster separation factors
Evaluation in the field: Dimensionality reduction

DR in the Wild

Interview study & qualitative coding led to task abstractions: specific to data type, agnostic to domain

Matt Brehmer  Michael Sedlmair  Melanie Tory  Stephen Ingram
Curation & Presentation: Timelines

TimeLineCurator
https://vimeo.com/123246662

Timelines Revisited
timelinesrevisited.github.io/

Matt Brehmer

Johanna Fulda
(Sud. Zeitung)

Matt Brehmer

Bongshin Lee
(Microsoft)

Benjamin Bach
(Microsoft)

Nathalie Henry-Riche
(Microsoft)
TimeLineCurator: Interactive Authoring of Visual Timelines from Unstructured Text.
Manual creation process
Structured creation process

TimelineJS
timeline.knightlab.com/
## Timeline authoring model

- time required for each task

<table>
<thead>
<tr>
<th></th>
<th>Browse</th>
<th>Extract</th>
<th>Format</th>
<th>Show</th>
<th>Update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Drawing</td>
<td>slow</td>
<td>slow</td>
<td></td>
<td>slow</td>
<td>slow</td>
</tr>
<tr>
<td>Structured Creation</td>
<td>slow</td>
<td>slow</td>
<td>slow</td>
<td>automated</td>
<td>fast</td>
</tr>
<tr>
<td>TimeLine Curator</td>
<td>fast</td>
<td>automated</td>
<td>automated</td>
<td>fast</td>
<td>fast</td>
</tr>
</tbody>
</table>
The general case for curation

• build for human in the loop as continuing need
  – automatic processing to accelerate not replace
  – assume computational results good but not perfect
    • for the indefinite future!
  – visual feedback to accelerate
The importance of being brisk

• sexy use case: eureka moment
  – success: enable what was impossible before
  – vis tools for new insights & discoveries

• workhorse use case: workflow speedup
  – success: vis tools accelerate your prior workflow
    • sometimes enables the previously infeasible

• TLC use cases
  – started with speedup use case, for presentation
    • make this doc into a timeline now!
  – two other use cases nudge towards exploration
    • comparison between multiple timelines
    • speculative browsing
TimeLineCurator: Speculative Browsing

https://vimeo.com/jofu/tlc
Theoretical foundations

Nested Model

Design Study Methodology

Papers Process & Pitfalls

Abstract Tasks

Michael Sedlmair  Miriah Meyer

handling contexts where common methods considered harmful: hypothesis generation, agile development

Anamaria Crisan

Regulatory & Organizational Constraints
More information

• theoretical foundations: book
  (+ free tutorial/course lecture slides)
  http://www.cs.ubc.ca/~tmm/vadbook
  – 20% promo code for book+ebook combo:
    HVN17

• this talk
  http://www.cs.ubc.ca/~tmm/talks.html#ucsd17

• papers, videos, software, talks, courses
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm