Visualization Design Methods

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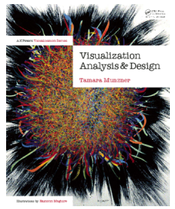
http://www.cs.ubc.ca/~tmm/talks.html#ucsd17 @tamaramunzner

Visualization (vis) defined & motivated

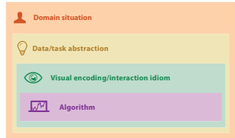
Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

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.
Munzner. AK Peters Visualization Series, CRC Press, 2014.



A Nested Model

for Visualization Design and Validation

http://www.cs.ubc.ca/labs/imager/tr/2009/NestedModel

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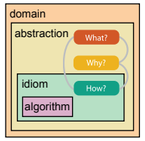
A Nested Model for Visualization Design and Validation.
Munzner. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 09), 15(6):921-928, 2009.

Analysis framework: Four levels, three questions

- *domain* situation
  - who are the target users?
- *abstraction*
  - translate from specifics of domain to vocabulary of vis
  - **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

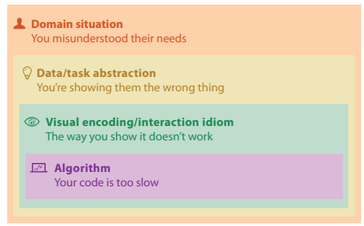
[A Nested Model of Visualization Design and Validation. *Munzner. IEEE TVCG 15(6):921-928, 2009 (Proc. InfoVis 2009).*]



[A Multi-Level Typology of Abstract Visualization Tasks *Brehmer and Munzner. IEEE TVCG 19(12):2376-2385, 2013 (Proc. InfoVis 2013).*]

Why is validation difficult?

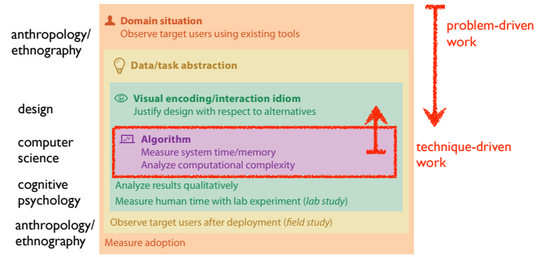
- different ways to get it wrong at each level



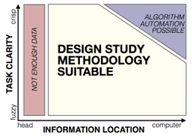
[A Nested Model of Visualization Design and Validation. Munzner. IEEE TVCG 15(6):921-928, 2009 (Proc. InfoVis 2009).]

Validation solution: use methods from appropriate fields at each level

- avoid mismatches!



[A Nested Model of Visualization Design and Validation. Munzner. IEEE TVCG 15(6):921-928, 2009 (Proc. InfoVis 2009).]



Michael Sedlmair

Miriah Meyer

Design Study Methodology

Reflections from the Trenches and from the Stacks

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

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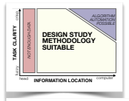
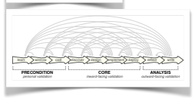
Design Study Methodology: Reflections from the Trenches and from the Stacks.
Sedlmair, Meyer, Munzner. IEEE Trans. Visualization and Computer Graphics 18(12): 2431-2440, 2012 (Proc. InfoVis 2012).

Methodology for problem-driven work

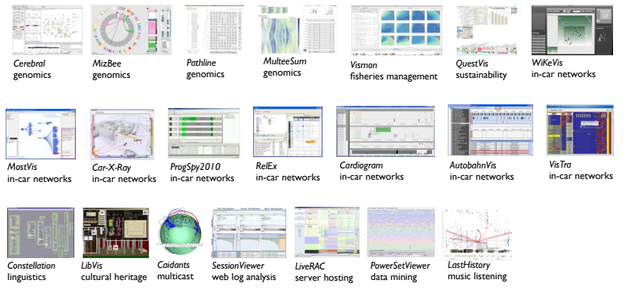
- definitions
- 9-stage framework
- 32 pitfalls & how to avoid them
- comparison to related methodologies



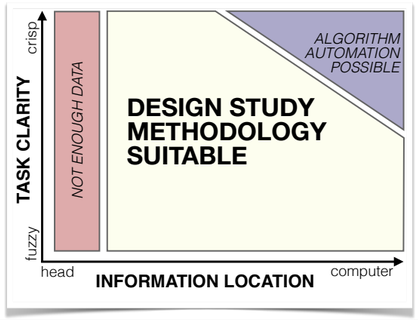


PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
PF-5	insufficient time available from potential collaborators	winnow
PF-6	no need for visualization: problem can be automated	winnow
PF-7	researcher expertise does not match domain problem	winnow
PF-8	no need for research: engineering vs. research project	winnow
PF-9	no need for change: existing tools are good enough	winnow

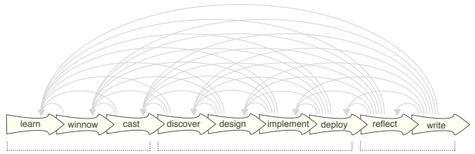
Lessons learned from the trenches: 21 between us



Design study methodology: definitions

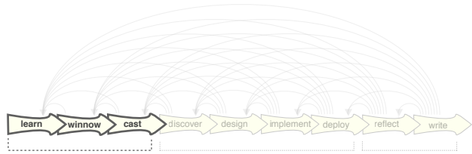


9 stage framework



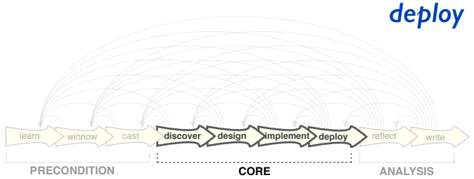
9-stage framework

learn
winnow
cast



9-stage framework

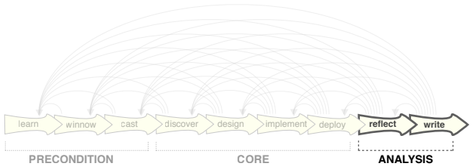
discover
design
implement
deploy



9-stage framework

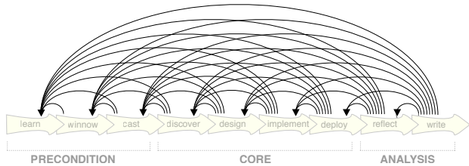
reflect
write

- guidelines: confirm, refine, reject, propose



9-stage framework

iterative



Design study methodology: 32 pitfalls

- and how to avoid them

PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
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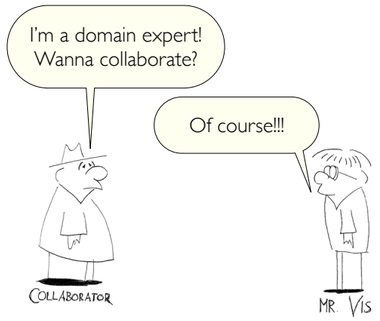

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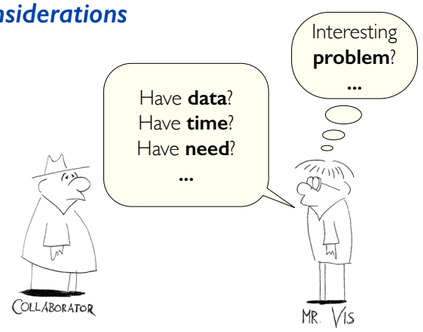
considerations



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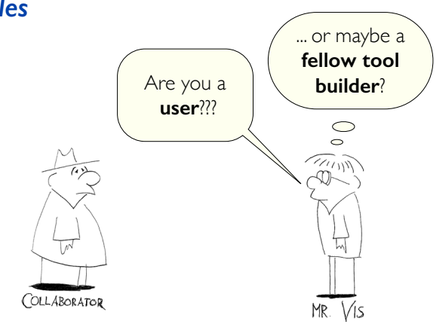
roles



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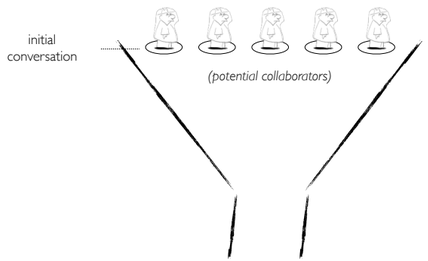
Collaborator winnowing



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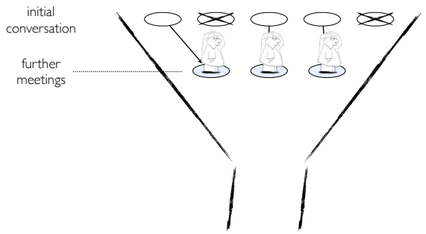
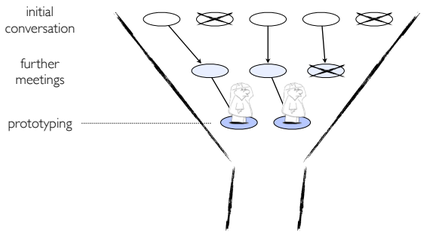
Collaborator winnowing



22

Collaborator winnowing



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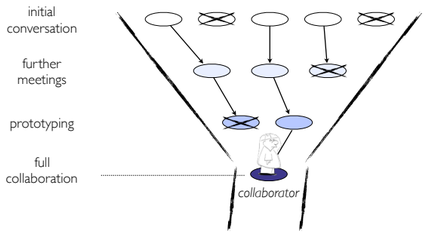
Collaborator winnowing



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Collaborator winnowing

Talk with many, stay with few!

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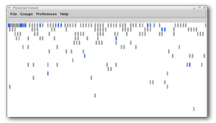
EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers



WikeVis
0.5 years / 2 researchers

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EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers

WikeVis
0.5 years / 2 researchers

- **Fellow tool builders**
- **Data promised**

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Design study methodology: 32 pitfalls

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

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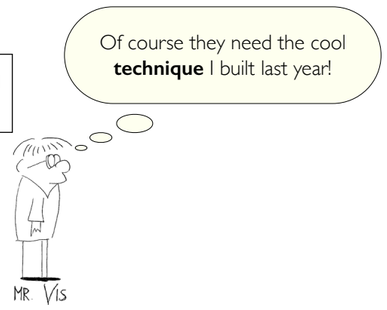
PITFALL

PREMATURE DESIGN COMMITMENT



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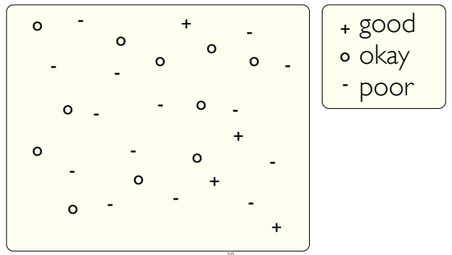
METAPHOR

Design Space



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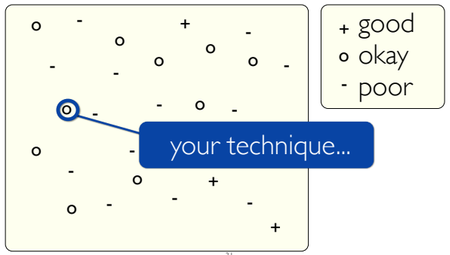
METAPHOR

Design Space



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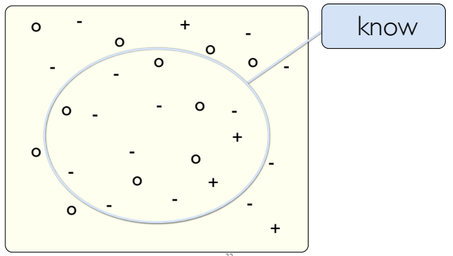
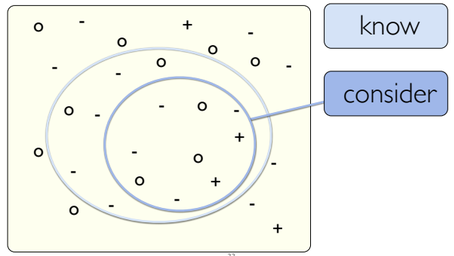
METAPHOR

Design Space



32

METAPHOR
Design Space



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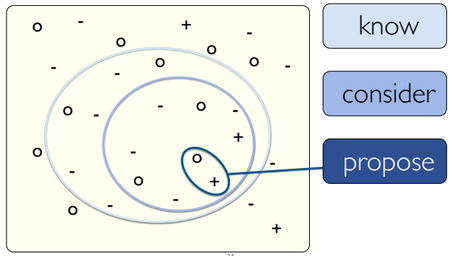
METAPHOR
Design Space



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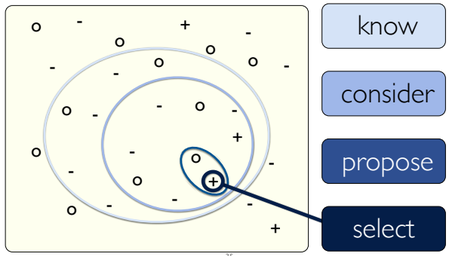
METAPHOR
Design Space



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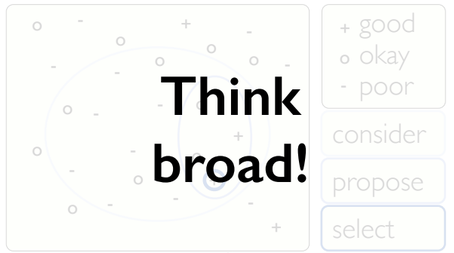
METAPHOR
Design Space



Design study methodology: 32 pitfalls

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

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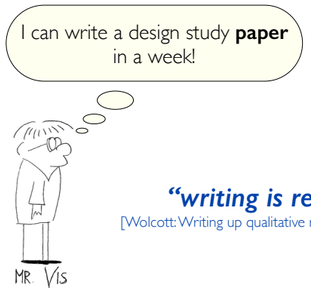
PITFALL
PREMATURE PUBLISHING



"writing is research"
[Wolcott: Writing up qualitative research, 2009]

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METAPHOR
Horse Race vs. Music Debut

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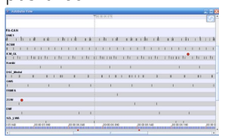
EXAMPLE FROM THE TRENCHES
Don't step on your own toes!

First design round published



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

Subsequent work not stand-alone paper

AutobahnVis 2.0
[Sedlmair et al., Information Visualization 10(3), 2011]

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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

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Angles of attack: My own work

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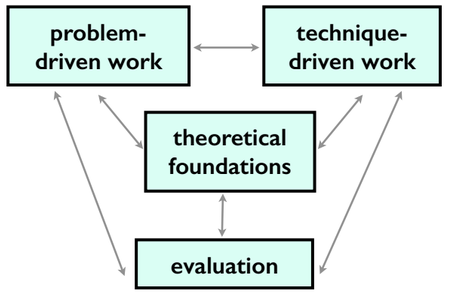
Angles of attack



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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

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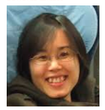
Problem-driven: Tech industry

T P F E

Heidi Lam



Diane Tang (Google)

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

Peter McLachlan

Stephen North (AT&T Research)

LiveRAC: systems time-series logs
https://youtu.be/ld0c3H0VSkw

methods reflection: staged model of access to target users

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Problem-driven: Energy, sustainability

T P F E

Matt Brehmer

Kevin Tate (Pulse/EnerNOC)

Energy Manager

redesign success: industrial swdev resources committed

Maryam Booshehrian

Torsten Moeller (SFU)

Vismon
https://youtu.be/h0kHoS4VYmk

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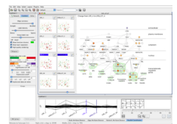
Problem-driven: Genomics

T P F E

Aaron Barsky

Jenn Gardy (UBC Micro)

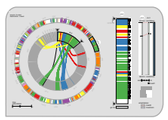
Robert Kincaid (Agilent)



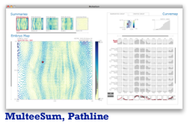
Cerebral
https://youtu.be/76HhG1FQngI

Miriah Meyer

Hanspeter Pfister (Harvard)



MizBee
https://youtu.be/86p7brwuz2g



MulteeSum, Pathline

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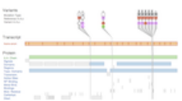
Problem-driven: Genomics, journalism

T P F E

Joel Ferstay

Cydney Nielsen (BC Cancer)



Variant View
https://youtu.be/AHDnv_qMXxQ

Jonathan Stray (Assoc Press)

Overview
https://vimeo.com/71483614

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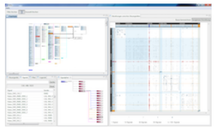
Problem-driven: Autos, e-commerce

T P F E

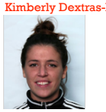


Michael Sedlmair

ReIEx (BMW)
https://youtu.be/89IsQXc6Ao4

current work:
Mobify clickstream collaboration

Kimberly Dextras-Romagnino



Overview

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

Matthew Brehmer @mattbrehmer

Stephen Ingram @FroweFace

Jonathan Stray @jonathanstray

Tamara Munzner @tamaramunzner

Overview: The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists.
Brehmer, Ingram, Stray, and, Munzner. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2014), 20(12):2271-2280, 2014.

From design

Case Study	#1
Document Collection	4,500 pages from FOIA
Question	*What did security contractors do during Iraq war?*

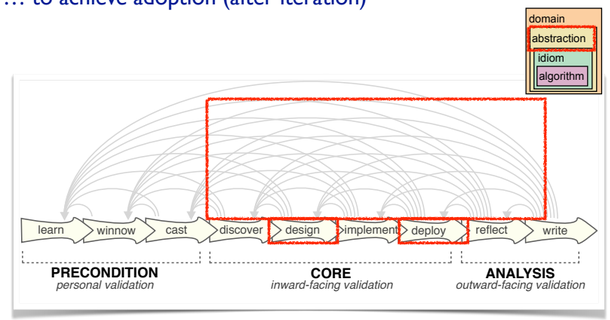
From design, to deploy, …

Case Study	#1	#2	#3	#4	#5	#6
Document Collection	4,500 pages from FOIA	5,996 emails from FOIA	8,680 pages from FOIA	1,278 survey comments	4,653 emails from FOIA	1,680 bills
Question	*What did security contractors do during Iraq war?*	*Were municipal police funds mismanaged?*	*Were Paul Ryan's campaign statements hypocritical?*	*What is the gun ownership debate about?*	*Was gov't response to emergency incident effective?*	*Did gov't fail to pass bills addressing police misconduct?*

… to redesign, to reflect on task abstractions…

Case Study	#1	#2	#3	#4	#5	#6
Document Collection	4,500 pages from FOIA	5,996 emails from FOIA	8,680 pages from FOIA	1,278 survey comments	4,653 emails from FOIA	1,680 bills
Question	*What did security contractors do during Iraq war?*	*Were municipal police funds mismanaged?*	*Were Paul Ryan's campaign statements hypocritical?*	*What is the gun ownership debate about?*	*Was gov't response to emergency incident effective?*	*Did gov't fail to pass bills addressing police misconduct?*
		find the needle in the haystack				prove haystack contains no needles!

… to achieve adoption (after iteration)



Technique-driven work

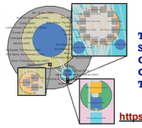
- scalable algorithms & systems
  - typical evaluation: computational benchmarks
- new layout & interaction idioms
  - typical evaluation: usage scenarios
  - typical evaluation/characterization: controlled experiments on human subjects

Technique-driven: Graph drawing

T P F E

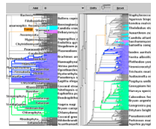
Daniel Archambault

David Auber (Bordeaux)



TopoLayout
SPF
Grouse
GrouseFlocks
TugGraph

https://youtu.be/AWXAe8zvkt8



TreeJuxtaposer
https://youtu.be/GdaPj8a9QEo

Benjamin Renoust

Guy Melançon (Bordeaux)

Detangler
https://youtu.be/QOtnHSsUV6k

Evaluation experiments: Graph drawing

T P F E

Dmitry Nekrasovski

Adam Bodnar

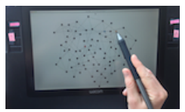
Joanna McGrenere

Stretch and squish navigation

outcome: increasingly disenchanted with "focus+context" idioms

Jessica Dawson

Joanna McGrenere



Search set model of path tracing

1 qualitative study: coding observational video

2 create & implement behavioral model

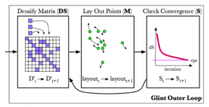
3 multiple regression to untangle factor relationships

Technique-driven: Dimensionality reduction

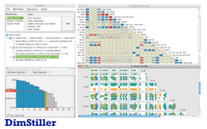
T P F E

Stephen Ingram

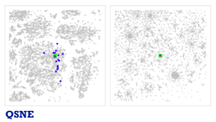
Glimmer



Glint



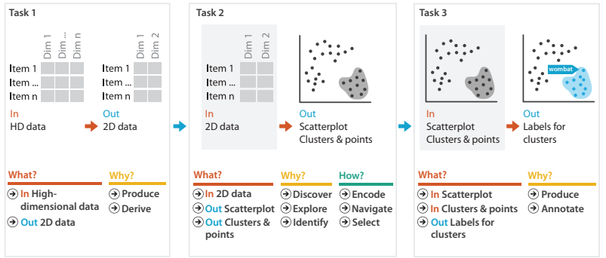
DimStiller



QSNE

Dimensionality reduction for documents

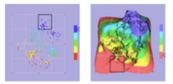
- derive low-dimensional target space from high-dimensional measured space



Evaluation experiments: Dimensionality reduction

T P F E

Melanie Tory



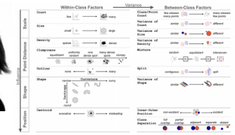
Points vs landscapes for dimensionally reduced data

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

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

Michael Sedlmair

Melanie Tory

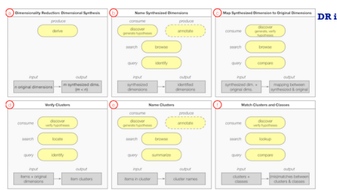


Guidance on DR & scatterplot choices

Taxonomy of cluster separation factors

Evaluation in the field: Dimensionality reduction

T P F E



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

T P F E

TimeLineCurator
https://vimeo.com/123246662

Matt Brehmer

Johanna Fulda **(Sud. Zeitung)**

Timelines Revisited
timelinesrevisited.github.io/

Matt Brehmer

Bongshin Lee **(Microsoft)**

Benjamin Bach **(Microsoft)**

Nathalie Henry-Riche **(Microsoft)**

TimeLineCurator

Interactive Authoring of Visual Timelines from Unstructured Text

http://about.timelinecurator.org

http://timelinecurator.org

Johanna Fulda @jofu_

Matthew Brehmer @mattbrehmer

Tamara Munzner @tamaramunzner

TimeLineCurator: Interactive Authoring of Visual Timelines from Unstructured Text.
Fulda, Brehmer, Munzner. IEEE Trans. Visualization and Computer Graphics (Proc IEEE VAST 2015) 22(1):300-309, 2015.

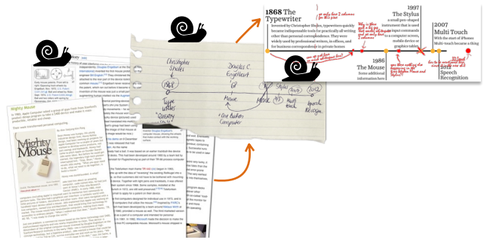
TimeLineCurator

visual & browser-based

https://vimeo.com/jofu/tlc

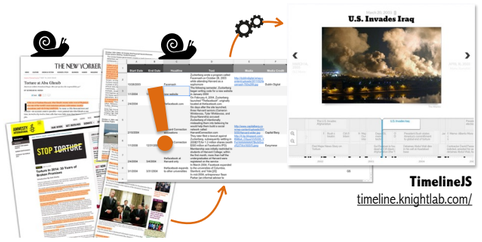
Manual creation process

Browse → Extract → Format → Show → Update



Structured creation process

Browse → Extract → Format → Show → Update



TimelineJS
timeline.knightlab.com/

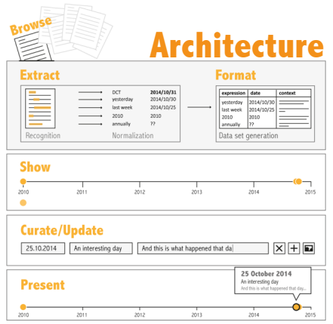
Timeline authoring model

- time required for each task

	Browse	Extract	Format	Show	Update
Manual Drawing	slow	slow		slow	slow
Structured Creation	slow	slow	slow	automated	fast
TimeLine Curator	fast	automated	automated	fast	fast

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

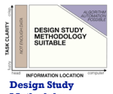
TimeLineCurator: Speculative Browsing

https://vimeo.com/jofu/tlc

Theoretical foundations

T F P E

Nested Model



Design Study Methodology

Michael Sedlmair

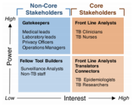
Miriah Meyer

Papers Process & Pitfalls

Abstract Tasks

Matt Brehmer

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



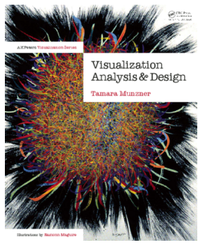
Regulatory & Organizational Constraints

Anamaria Crisan

More information

@tamaramunzner

- theoretical foundations: book (+ free tutorial/course lecture slides)
  http://www.cs.ubc.ca/~tmm/vadbook
  - 20% promo code for book+ebook combo: HVN17
  - http://www.crcpress.com/product/isbn/9781466508910
- 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



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Munzner. A K Peters Visualization Series, CRC Press, Visualization Series, 2014.