Information Visualization and Visual Analytics (M1522.000500)

How to Design and Validate VIS?

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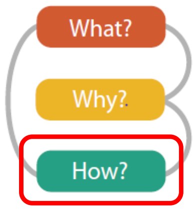
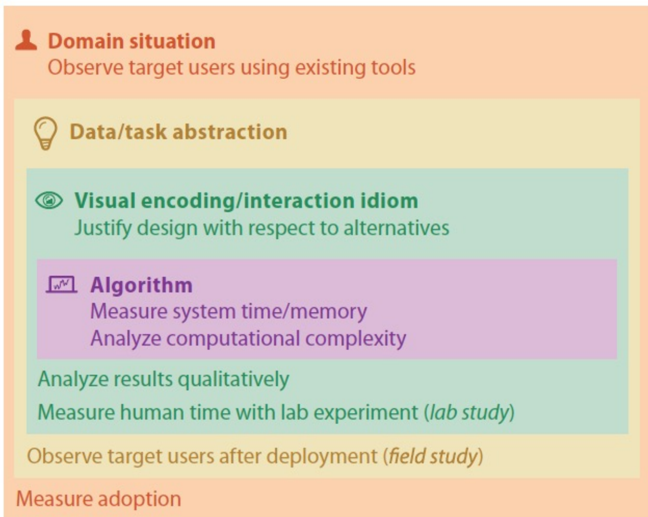


Model for Design and Validation of Vis Systems

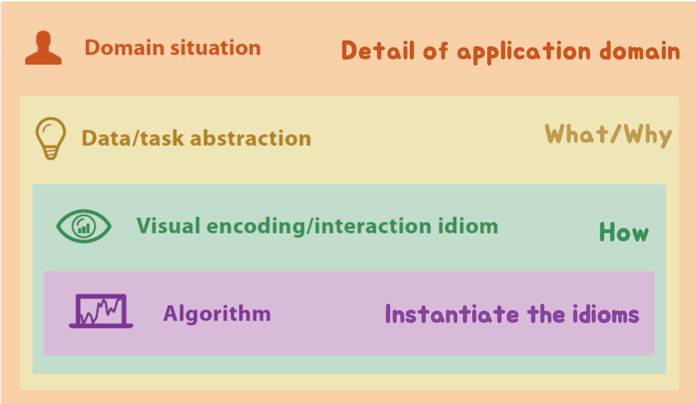
- Four nested levels of vis design

- Why validate?
  - *VIS Design space is huge, and most designs are ineffective*
  - *valuable to think about how you might validate your choices from the very beginning of the design process*



Nested Model unifying Design and Validation

- guidance on when to use what validation method
- different threats to validity at each level of model



Who is in detail of application domain

Four kinds of threats to validity

- What could fail you in your VIS design?

Four kinds of **threats** to validity

- wrong **problem**
  - they don't do that

domain problem characterization

Four kinds of **threats** to validity

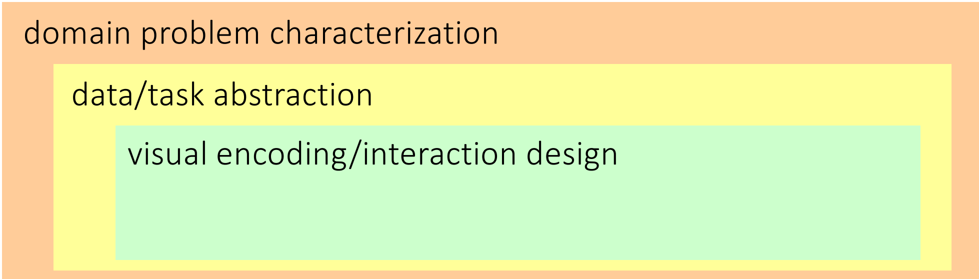
- wrong problem
  - they don't do that
- wrong abstraction
  - you're showing them the wrong thing

domain problem characterization

data/task abstraction

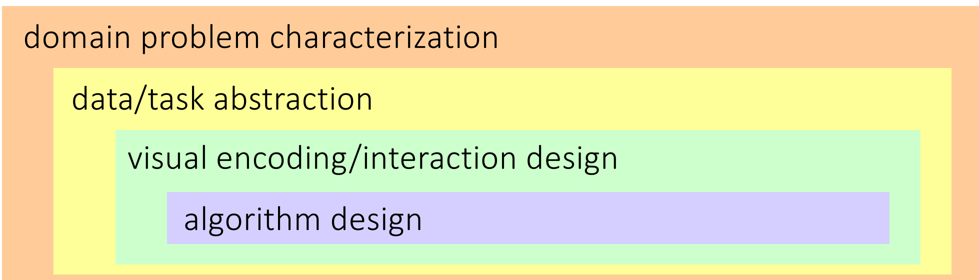
Four kinds of **threats** to validity

- wrong problem
  - they don't do that
- wrong abstraction
  - you're showing them the wrong thing
- wrong **encoding/interaction technique**
  - the way you show it doesn't work



Four kinds of **threats** to validity

- wrong problem
  - they don't do that
- wrong abstraction
  - you're showing them the wrong thing
- wrong encoding/interaction technique
  - the way you show it doesn't work
- wrong **algorithm**
  - your code is too slow



Match validation method to contributions

- each validation works for only one kind of threat to validity

threat: wrong problem

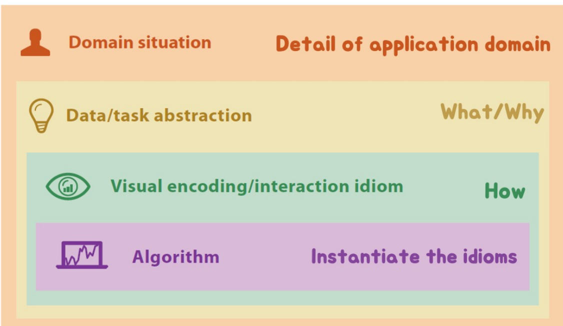
threat: bad data/operation abstraction

threat: ineffective encoding/interaction technique

threat: slow algorithm

이런 허들을 넘어서 비쥬얼라이제이션을 체크함

The Four Levels



- Value of separating these concerns into four levels
  - you can separately analyze the question of whether each level has been addressed correctly,
  - independently of whatever order design decisions were made in the process of building the vis tool.
  - in practice you wouldn't finalize design decisions at one level before moving on to the next -> iterative design
- Nested levels
  - Output of **upstream** level → Input to the **downstream** level
  - **challenge**: upstream errors inevitably cascade down
    - if poor abstraction choice made, even perfect technique and algorithm design will not solve intended problem

Domain Situation

- Situation about particular field of interest of the target users
  - Group of target users / Domain of interest / Question / Data Collections
  - User-centered design

- Identify situation blocks
  - Users typically cannot directly (verbally) articulate their needs clearly
  - Reach the needs of target users
    via *interviews*, *observation*, *research about target users*
  - Result : Detailed set of questions or actions by target users

Task and Data Abstraction

- Abstraction of specific domain questions and data
  - Domain specific → Domain independent representation
  - Browsing, comparing, summarizing, …

- Design abstract data blocks (data transformation/**derivation**)
  - In which form the data should be used?
  - Vis idioms are specific to the data type!
    - determine which data type would support a visual encoding that solves the user’s problem

Task and Data Abstraction

- Explicitly consider the **decisions made in abstracting** from domain-specific to **generic**
- Justify your decision by comparing it to alternatives

- Assumptions for many early web vis papers : solving the "**lost in hyperspace**" problem should be done by showing the searcher a **visual representation of the topological structure of the web's hyperlink connectivity graph**.
- People do not need an internal mental representation of this extremely complex structure to find a page of interest

Visual Encoding and Interaction Idiom

- Decide on the specific way of **creating** and **manipulating** the visual representation of the abstract data block
  - Each distinct possible approach => Idiom
  - **Visual encoding idioms** for controlling *what* users see
  - **Interaction idioms** for controlling *how* users change what they see

- **Design** idiom blocks
  - Should match task/data abstractions (the data type)
  - Consider human abilities: **visual perception** and **memory**
  - Vis may contain one or more visual idioms that can be chosen

Four Levels of Design

Algorithm

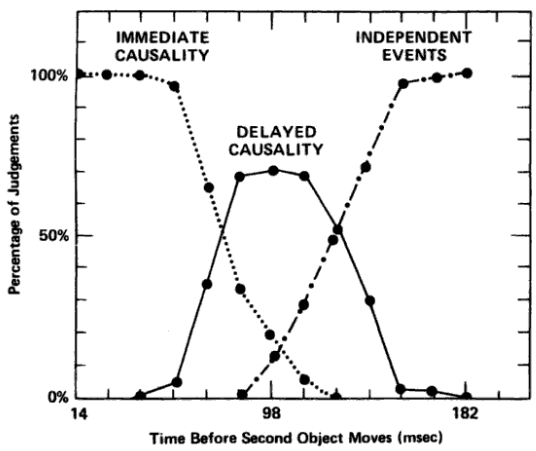
- Detailed procedure of computer to carry out desired goal
  - Efficiently handle visual encoding and interaction idioms

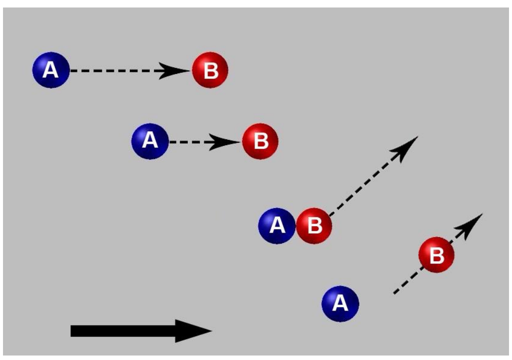
- **Design** algorithm blocks
  - Computation speed / memory / level of approximation
  - Computational issues
  - perceptual issues to consider
    - feedback within 100ms for immediate response

Perceptual Causality

Perceptual Fusion

- Perceptual Fusion: Two stimuli within a perceptual processor cycle appear *fused*
  → the first event appears to *cause* the other





Angles of Attack for Designing Vis

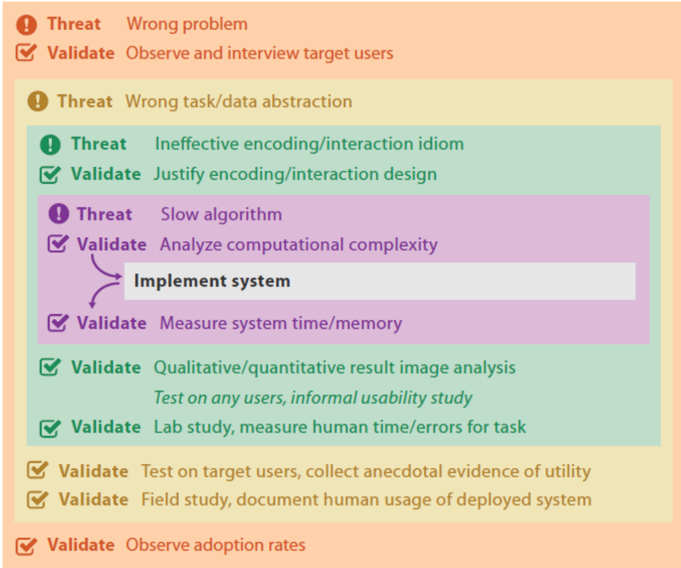
- Top down
  - **Problem driven**: search for existing idioms to solve real world user's problem → Design study
- Bottom up
  - **Technique driven**: new encoding, new interaction
    - articulate your assumptions at a level above
- Levels of design help both approaches to designing vis
  - Top down: What idiom to choose/make?
  - Bottom up: your idiom's relationship between existing idioms?

Threats to Validity

- Validating (Evaluating) the effectiveness of a vis design
  - Is hard
  - You may have made the wrong decision

Validation Approaches

- **Immediate**
- **Downstream**
  - Require result from downstream level
- (rapid) Prototyping
  - Downstream validation occur earlier
  - Wizard of OZ



Domain Validation

- **Problem** being mischaracterized
- Interview and observe target audience
  - Not just relying on assumptions or conjectures
  - **Field study** to observe target users in real-world setting
  - **Contextual inquiry** (observation in real context with questions for clarifications during the inquiry)
- Report adoption rate
  - Not the whole story

Data/Task Abstraction Validation

- Task and data abstractions do not solve the *specific topic of the target audience*
  - Must be tested after implementation
- So **no immediate** validation approach

- Let target users try the tool → anecdotal evidence
- Field study
  - Different from field study of domain validation
    - Observe how users use your design
    - Observe **change** of behavior

Visual Encoding Idiom Validation

- Is the idiom effective?
- Justify the design of idiom
  - According to perceptual and cognitive **theories** and **principles**

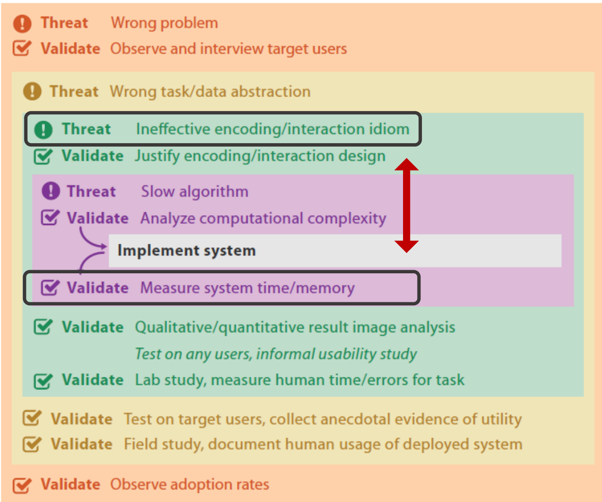
- Lab study
  - Controlled experiment with quantitative/qualitative measure
- Presentation and qualitative discussion of result (image analysis)
  → Usage scenario
- Quality Metric: Measure quality of result (e.g., # of edge crossings)

Algorithm Validation

- Time/memory performance
- Calculate computational complexity
- Measure wall-clock time / memory performance of the implemented
  - **Scalability**, Benchmarks
  - Implementation not same as expected speed

Avoid mismatches

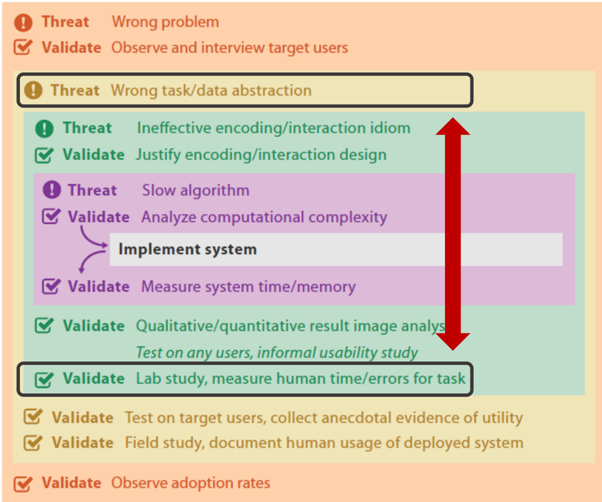
- can't validate encoding with wall clock timings



Match Validation Approach

Avoid mismatches

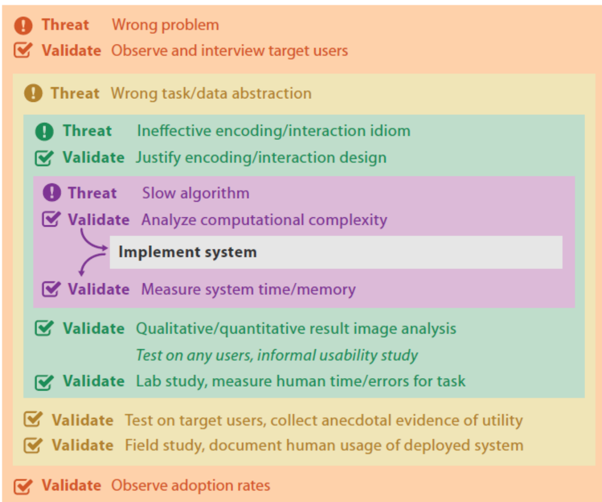
- can’t validate abstraction with lab study



Research Perspective

Single paper would include only subset

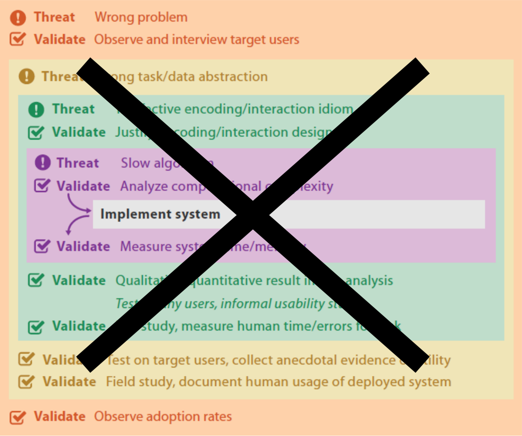
- can’t do all for same project → not enough space in paper or time to do work



Research Perspective

Single paper would include only a subset

- Pick validation method according to contribution claims
- level at which the benefit is claimed : validation method



Real Design Process

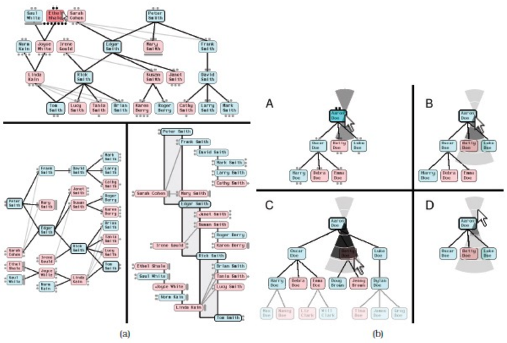
Iterative Design Process

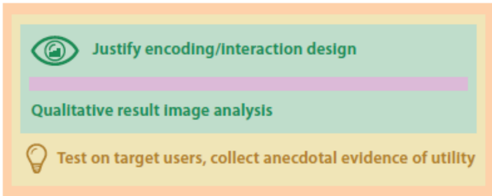
- Vis design is usually a highly ***iterative refinement*** process
  - the act of design is inherently about revisiting and reinterpreting existing designs: design as redesign
  - a better understanding of the blocks at one level will **feed back and forward** into refining the blocks at the other levels
  - levels don't need to be done in strict order
  - intellectual value of level separation
    - framework for exposition and analysis

- shortcut across inner levels + implementation
  - rapid prototyping, etc.
    - low-fidelity stand-ins so downstream validation can happen sooner

Examples (1)

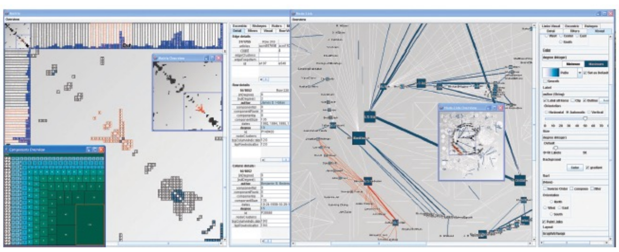
- Genealogical Graphs
  - New tree-based visual idioms

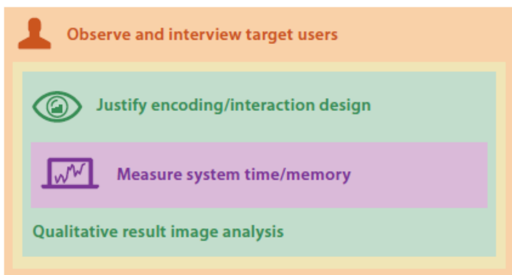




Examples (2)

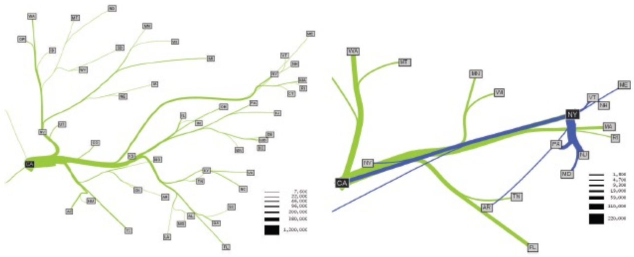
- Matrix Explorer
  - Tool for social science researchers used at social network analysis



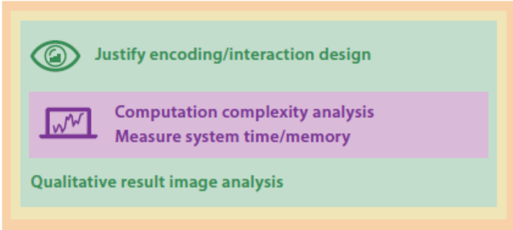


Examples (3)

- Flow Maps
  - Map of movement – reduced clutter by merging edges

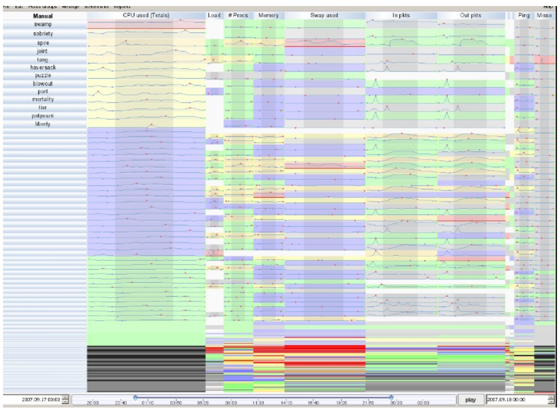


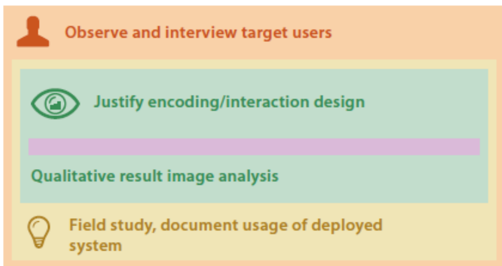
(a) (b)



Examples (4)

- LiveRAC
  - Time series data observation for system management





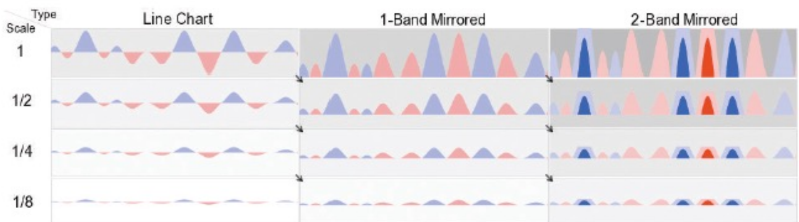
Examples (5)

- LinLog
  - Energe model for graph designed to reveal clusters

Qualitative/quantitative result image analysis

Examples (6)

- Horizon Graphs
  - Is Horizon graphs effective when chart height is reduced?



Lab study, measure human time/errors for task

Note

- Questions?