Information Visualization and Visual Analytics (M1522.000500)

How to Design and Validate VIS?

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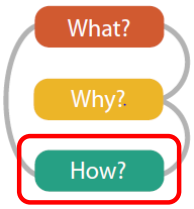
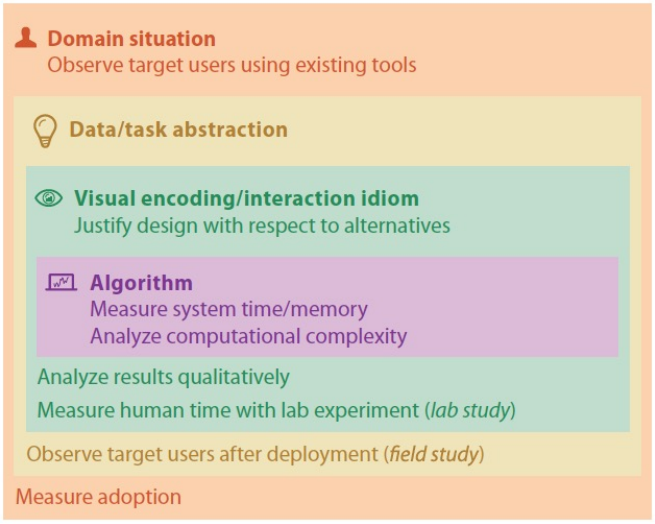


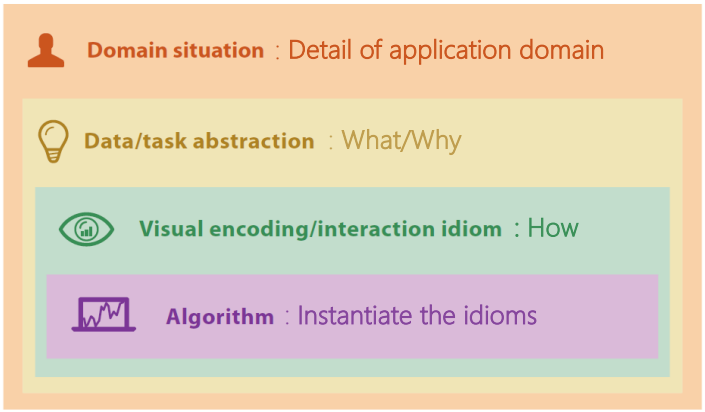
Model for Design and Validation of Vis Systems

- Four nested levels of vis design
- Threats to validating each level
  - Why validate?
  - *Design space is large, and most designs are ineffective*

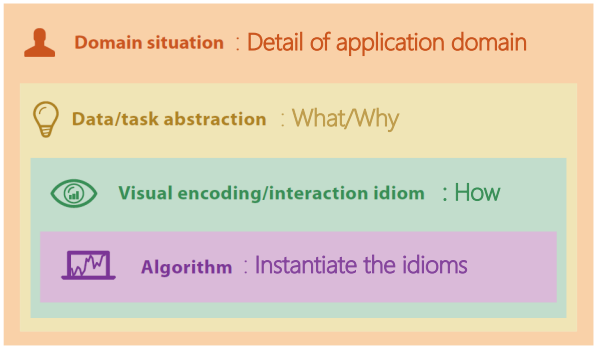


Nested Model unifying Design and Validation

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



The Four Levels



- Value of Separation into four levels
  - can analyze (or validate) whether each level has been addressed correctly, independently of the order of design decisions were made

- 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

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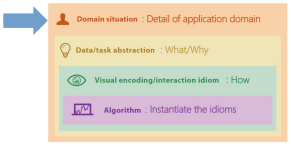
Domain Situation



- 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

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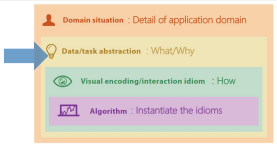
Task and Data Abstraction



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

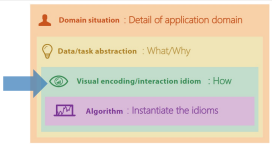
- **Design** abstract data blocks (data transformation/**derivation**)
  - In which form the data should be used?
  - Vis idioms are specific to the data type!
    - determine which data type would support a visual encoding that solves the user's problem

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

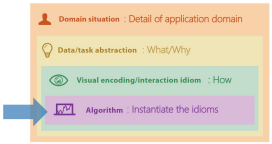
Visual Encoding and Interaction Idiom



- 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

Algorithm

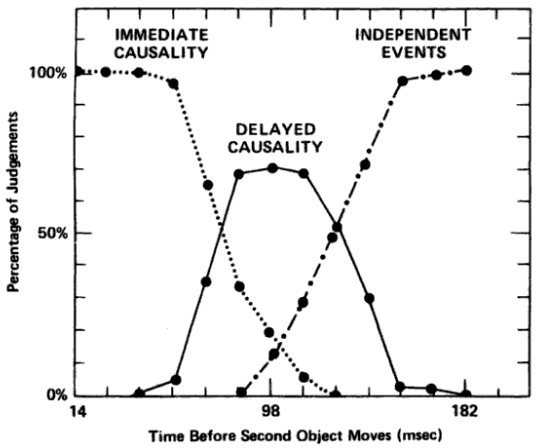


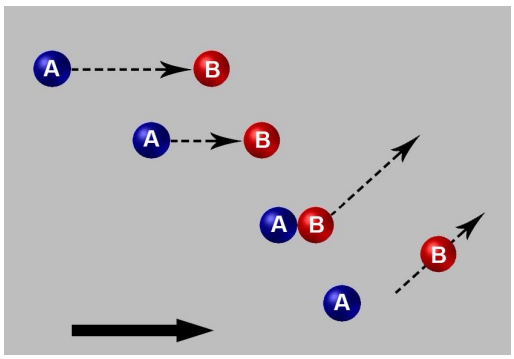
- Detailed procedure of computer to carry out desired goal
  - Efficiently handle visual encoding and interaction idioms

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

Perceptual Fusion

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



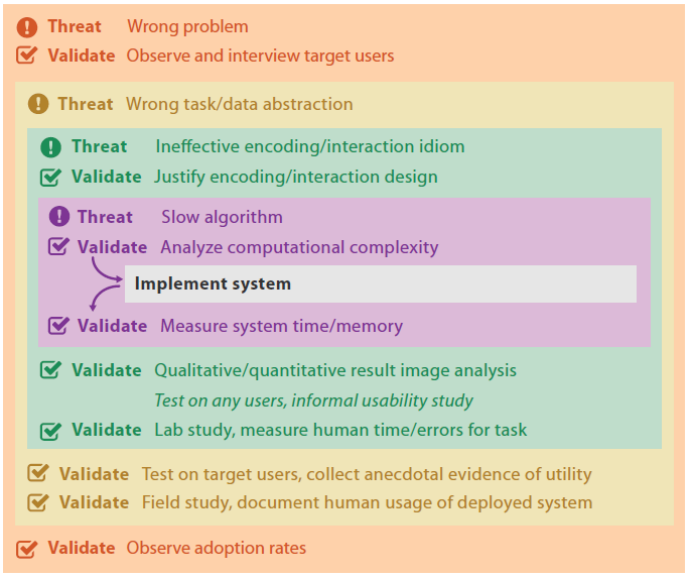


Angles of Attack for Designing Vis

- 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?

Validation Approaches

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



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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

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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

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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
  - → Usage scenario
- Quality Metric: Measure quality of result (e.g., # of edge crossings)

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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

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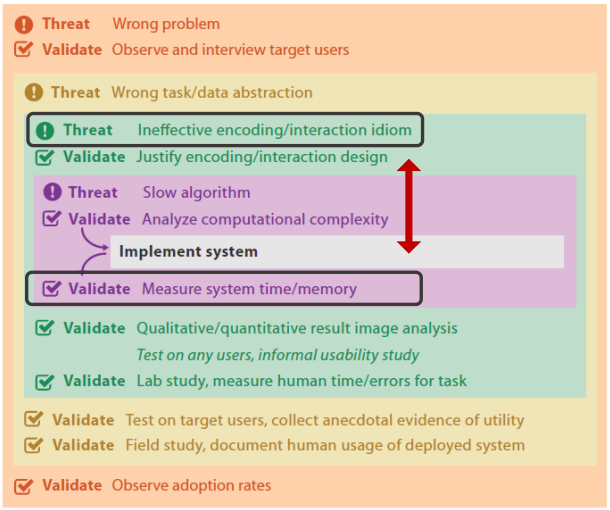
Avoid mismatches

- can't validate encoding with wallclock timings



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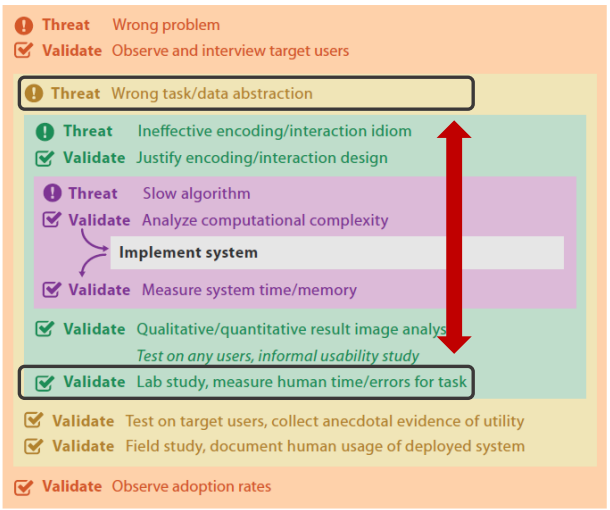
Avoid mismatches

- can't validate abstraction with lab study

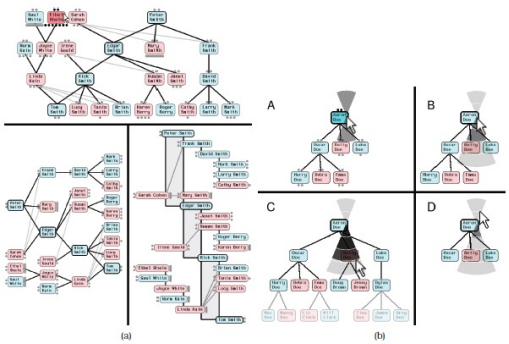


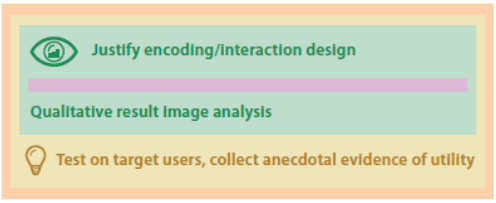
Iterative Design Process

- iterative refinement
  - levels don't need to be done in strict order
  - intellectual value of level separation
    - exposition, analysis
- shortcut across inner levels + implementation
  - rapid prototyping, etc.
    - low-fidelity stand-ins so downstream validation can happen sooner

Examples

- Genealogical Graphs
  - New tree-based visual idioms





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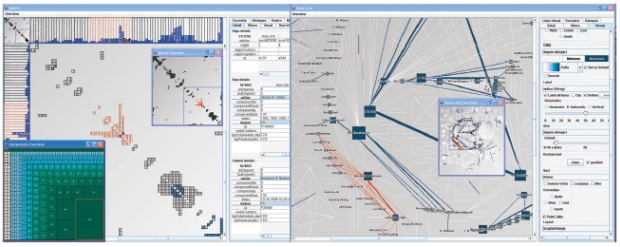
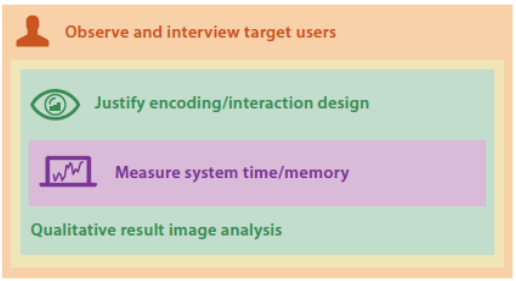
Examples

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





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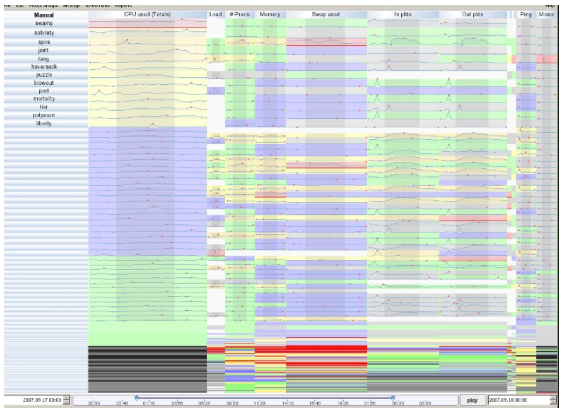
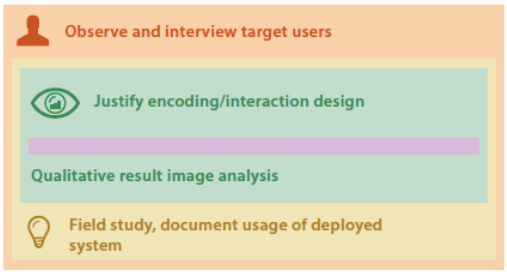
Examples

- LiveRAC
  - Time series data observation for system management





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Note

- Questions?