DESIGN STUDIES

Miriah Meyer
WHAT IS A DESIGN STUDY?
design study
- a project
- analyze a real-world problem
- design a visualization system
- validate the design
- reflect about lessons learned

design study
- a project
- **analyze** a real-world problem
- design a visualization system
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Design Study Methodology: Reflections for the Trenches and the Stacks.
design study
- a project
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real users and real data are mandatory collaboration is fundamental

Design Study Methodology: Reflections for the Trenches and the Stacks.  
**design study**

- a project
- analyze a real-world problem
- **design** a visualization system
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*explicit consideration of multiple alternatives*
design study
- a project
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**Design Study**

- a project
- analyze a real-world problem
- design a visualization system
- validate the design
- **reflect** about lessons learned

- **DS methodology**: framework for conducting DS
  - acquire knowledge, choose collaborations
  - problem characterization, abstraction, design, implement, deploy
  - analyze, disseminate knowledge

- **DS paper**: paper about a DS
CONTRIBUTIONS
three types of research contributions

- problem characterization / abstraction
  - movement along the axes (see next section)
- visual encoding / design
  - user validated design example
- reflection
  - improve guidelines

not all contributions equally strong in a single design study paper

result is not necessarily a DS paper

- technique paper
- system paper
- algorithm paper
- evaluation paper
- pure problem characterization
- . . .
pitfalls paper
AXES
AXES
AXES

TASK CLARITY

fuzzy  crisp

INFORMATION LOCATION

head  computer
- tasks in vis are usually rather complex
  - not just: buy a train ticket
  - instead: wicked problems

- what is a wicked problem?
-tasks in vis are usually rather complex
  -not just: *buy a train ticket*
  -instead: *wicked problems*

-what is a wicked problem?
wicked problems

- alternative to linear, step-by-step approach to design
  - approach: problem definition | problem solution
  - appealing as a “logical” understanding of design process

- Horst Rittel argued in the 1960s that most problems addressed by designers are “wicked”
  - “class of social system problems which are ill formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing”

- determinacy versus indeterminacy
  - linear model: determinate problems have definite conditions
    - designer should identify conditions and design solution
  - wicked model: indeterminate problems have no definitive conditions or limits
    - designer must discover or invent a particular subject out of the problem

[Wicked Problems in Design Thinking, Buchanan 92]
10 properties of a wicked problem

(1) Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution.
(2) Wicked problems have no stopping rules.
(3) Solutions to wicked problems cannot be true or false, only good or bad.
(4) In solving wicked problems there is no exhaustive list of admissible operations.
(5) For every wicked problem there is always more than one possible explanation, with explanations depending on the Weltanschauung of the designer.
(6) Every wicked problem is a symptom of another, “higher level,” problem.
(7) No formulation and solution of a wicked problem has a definitive test.
(8) Solving a wicked problem is a “one shot” operation, with no room for trial and error.
(9) Every wicked problem is unique.
(10) The wicked problem solver has no right to be wrong—they are fully responsible for their actions.
Richard Buchanan
Wicked Problems in Design Thinking

SUGGESTED READING

This essay is based on a paper presented at “Colloque Recherches sur le Design: Incitations, Implications, Interactions,” the first French university symposium on design research held October 1990 at l’Université de Technologie de Compiègne, Compiègne, France.

Introduction
Despite efforts to discover the foundations of design thinking in the fine arts, the natural sciences, or most recently, the social sciences, design eludes reduction and remains a surprisingly flexible activity. No single definition of design, or branches of professionalized practice such as industrial or graphic design, adequately covers the diversity of ideas and methods gathered together under the label. Indeed, the variety of research reported in conference papers, journal articles, and books suggests that design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as understanding. This follows the trend of design thinking in the twentieth century, for we have seen design grow from a trade activity to a segmented profession to a field for technical research and to what now should be recognized as a
- **SubAxes**
  - task scope
    - broad vs. narrow
    - task decomposition
  - task characterization
    - shared understanding
  - task stability
    - designer influence is disruptive
    - abstraction and tools change user’s needs: **CONTRIBUTION**
  - user’s needs change during project
    - **DANGER**

- Diagram:
  - User certainty
    - **good**
  - Time
  - Good
  - Code monkey
  - Really hard problem (failure)
**Task Clarity**

- **SubAxes**
  - task scope
    - broad vs. narrow
    - task decomposition
  - task characterization
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  - task stability
    - designer influence is disruptive
      - abstraction and tools change user’s needs: **CONTRIBUTION**
    - user’s needs change during project: **DANGER**

**User certainty**
- good vs. time

**Design and Tools**
- code monkey
- really hard problem (failure)
be aware...

-changing user practice

- researcher is actively intervening: change can be good (contribution!), but might be hard to track

-demand characteristics | experimenter bias

- the system your are studying is changing by the fact that you are studying it
  - users change behavior because they know they are being studied
  - unconscious bias by experimenters that effect subjects

- Pitfall: “But they liked it ...”
  - necessary but not sufficient
-how much information is made explicit in digital form vs implicit in user head

- more than just ‘data’
  - metadata
  - surrounding knowledge and context
-how much information is made explicit in digital form vs implicit in user head
  - more than just ‘data’
    - metadata
    - surrounding knowledge and context
You have to be at least this far in order to start designing a visualization solution.

Now it’s so well-defined that we can write an algorithm to solve the problem.
- movement along the axes
  - back and forth along task
  - usually only forward along information

- movement along one axis often causes movement along the other
  - increased task clarity facilitates understanding of derived data needs
  - increased information articulation facilitates understanding of analysis needs

- forward movement along the axes as a problem characterization/abstraction contribution
  - vs. technique driven: you are at a specific point on these axes
-using task axis to compare vis to other areas

- in vis we wanna build tools for ill-defined hard problems (wicked problems), that’s what makes us different form Stats or ML

- we share this with other communities: CSCW, UbiComp

  - but in these areas: no or little data involved
Vis: Relation to other areas/fields

Vis vs.

- HCI: The user task is larger, more complex; more data
- CSCW, Ubicomp: Share the squishy task, but it’s not about data analysis
- Stats/ML: Data Analysis but crisp task

amount of data

task clarity

CSCW/Ubicomp

Generic HCI

Stats/ML

Vis
OTHER RESEARCH TYPES
Process and Pitfalls in Writing Information Visualization Research Papers

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Abstract. The goal of this paper is to help authors recognize and avoid a set of pitfalls that recur in many rejected information visualization papers, using a chronological model of the research process. Selecting a target paper type in the initial stage can avert an inappropriate choice of validation methods. Pitfalls involving the design of a visual encoding may occur during the middle stages of a project. In a later stage when the bulk of the research is finished and the paper writeup begins, the possible pitfalls are strategic choices for the content and structure of the paper as a whole, tactical problems localized to specific sections, and unconvincing ways to present the results. Final-stage pitfalls of writing style can be checked after a full paper draft exists, and the last set of problems pertain to submission.

1 Introduction

Many rejected information visualization research papers have similar flaws. In this paper, I categorize these common pitfalls in the context of stages of the research process. My main goal is to help authors escape these pitfalls, especially the ones that arise early.
THE MIZBEE DESIGN STUDY
MizBee
A Multiscale Synteny Browser

Miriah Meyer¹
Tamara Munzner²
Hanspeter Pfister¹

Harvard University¹
University of British Columbia²
design study

- data from the field of comparative genomics
- series of interviews with two biologists
- validate, analyze, and communicate computational results
contributions

1. characterization of the problem domain
2. taxonomy of the design space
3. MizBee, a multiscale synteny browser
4. validation through two case studies
conserved feature similarity
conserved feature
conserved feature similarity
biology concepts

- compare genomes
biology concepts

• compare genomes

• genomes made of chromosomes
biology concepts

• compare genomes
• genomes made of chromosomes
• stuff on the same chromosome: synteny
biology concepts

• compare **genomes**
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• stuff = **features** (genes)
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biology concepts

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- similar blocks on different chromosomes implies **conservation**
MizBee
characterization
high level biology questions

low level data-centric questions
high level biology questions

evolution:

function:

low level data-centric questions
high level biology questions

evolution: How long ago did two species share a common ancestor?

function: Which segment of the genome is responsible for a specific function in the cell?

low level data-centric questions
high level biology questions

**evolution:** How long ago did two species share a common ancestor?

**function:** Which segment of the genome is responsible for a specific function in the cell?

low level data-centric questions

**algorithm refinement:**
high level biology questions

**evolution:** How long ago did two species share a common ancestor?

**function:** Which segment of the genome is responsible for a specific function in the cell?

low level data-centric questions

**algorithm refinement:** Are the paired features within a block contiguous?

**refinement:** Which chromosomes share conserved blocks?

**refinement:** Are similarity scores alike within a block?
conservation relationships  multiple scales
conservation relationships
multiple scales

proximity
size
orientation
similarity
conservation relationships

proximity
size
orientation
similarity

multiple scales

genome
chromosome
block
feature
difficult to answer multiple questions across a range of scales using computational algorithms alone
difficult to answer **multiple questions** across a range of scales using computational algorithms alone

visually encode conservation relationships at different scales to validate, analyze, and communicate results
abstraction
synteny
synteny on the same ribbon
synteny on the same ribbon

features occur on the same chromosome
synteny on the same ribbon

features occur contiguously on the same chromosome
synteny

for each feature on the source, find the most similar feature on the destination
synteny

filter pairs based on similarity value
group pairs into syntenic **blocks**, taking into account **orientation**, **destination**, and **locality**
synteny

group pairs into syntenic **blocks**, taking into account **orientation**, **destination**, and **locality**
difficult to answer multiple questions across a range of scales using computational algorithms alone
difficult to answer multiple questions across a range of scales using computational algorithms alone

use visual inspection to validate, understand, and communicate data
Which chromosomes share conserved blocks?

For one chromosome, how many other chromosomes does it share blocks with?

What is the density of coverage and where are the gaps on: chromosomes? blocks?

Where are the blocks: on chromosomes? around a specific location on a chromosome?

What are the sizes and locations of other genomic features near a block?

How large are the blocks?

Do neighboring blocks go to the same: chromosomes? relative location on a chromosome?

Are the orientations matched or inverted for: block pairs? feature pairs?

Do the orientations match for pairs of: neighboring blocks? features within a block?

Are similarity scores alike: with respect to neighboring blocks? within a block?

Are the paired features within a block contiguous?

How large is a feature relative to other genes within a block?

What are the sizes, locations, and names of features within a block?

What are the differences between individual nucleotides of feature pairs?
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<th>Question</th>
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<th>chromosome</th>
<th>block</th>
<th>feature</th>
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design space
taxonomy
of the design space
taxonomy of the design space

- represent chromosomes as segments
taxonomy
of the design space

- represent chromosomes as segments
- encode conservation
taxonomy of the design space

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```
src [chromosome representation]
color [representation for different types of data]
dst [representation for different types of data]
```
taxonomy of the design space

- represent chromosomes as segments
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src  dst

color

Cinteny [Sinha07]
• represent chromosomes as segments
• encode conservation

taxonomy of the design space

color

connection
taxonomy of the design space

- represent chromosomes as segments
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Mauve [Darling04]
taxonomy
of the design space

- represent chromosomes as segments
- encode conservation

Circos [Krzywinski]
• represent chromosomes as segments

• encode conservation

\[ \text{src} \quad \text{chrI} \quad \text{chrII} \quad \text{chrIII} \quad \text{chrIV} \quad \text{chrIX} \quad \text{chrV} \quad \text{chrVI} \quad \text{chrVII} \quad \text{chrVIII} \quad \text{chrIX} \quad \text{chrX} \quad \text{chrXI} \quad \text{chrXII} \quad \text{chrXIII} \quad \text{chrXIV} \quad \text{chrXIX} \quad \text{chrXV} \quad \text{chrXVI} \quad \text{chrXVII} \quad \text{chrXVIII} \quad \text{chrXX} \quad \text{chrXXI} \quad \text{chrUn} \quad \text{quatation} \quad \text{line} \quad - \quad + \]

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- encode similarity
taxonomy of the design space

- represent chromosomes as segments
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[Rasko05]
taxonomy
of the design space

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MizBee novelty

- first synteny browser with side-by-side linked views
  - across the range of scales
  - encoding all four relationship types
MizBee novelty

• first synteny browser with side-by-side linked views
  - across the range of scales
  - encoding all four relationship types

• redundantly encodes conservation
  - color and connection
  - edge bundling to enhance trends
MizBee novelty

• first synteny browser with side-by-side linked views
  - across the range of scales
  - encoding all four relationship types

• redundantly encodes conservation
  - color and connection
  - edge bundling to enhance trends

• encode similarity in context of other three relationship types
validation
rhizopus
difficult to simultaneously show the location of interesting features and other conservation relationships in a static image
stickleback and the pufferfish
stickleback and the pufferfish
“The first time I saw my data in [MizBee] I was totally disappointed. The data was very noisy, and there were many small blocks that went to different chromosomes.”
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Genome-wide synteny through highly sensitive sequence alignment: Satsuma, M. Grabherr et al., submitted.
“The first time I saw my data in [MizBee] I was totally disappointed. The data was very noisy, and there were many small blocks that went to different chromosomes.”

“Honestly, I don’t know. I don’t think I would ever have gotten here. The noise was very hard see in the scatter plots while [MizBee] is much more unforgiving.”

*Genome-wide synteny through highly sensitive sequence alignment: Satsuma. M. Grabherr et al., submitted.*
discussion
and
future work
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<td>early in MizBee design</td>
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implemented in Processing
processing.org
implemented in Processing
processing.org

released open source
mizbee.org
implemented in Processing
processing.org

released open source
mizbee.org

encourage broader user base
conclusions

- presented characterization and taxonomy

**MizBee**

- first synteny browser to show side-by-side linked views across multiple scales and conservation relationships

- collaboration with two domain experts
questions?

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inspiration: Vis Group at the Broad
funding: IIC at Harvard

visit: mizbee.org
L3: Design Model

REQUIRED READING
A Visualization Design Framework

Many computer-based visualization techniques and systems have been created in the past thirty years. If you simply look at them one by one as a big collection of different possibilities, it is hard to decide what to do when you are confronted with a visualization problem as a designer. You might be able to check whether a particular idea that you have has been tried before, and if you dig into the literature on empirical evaluation you might even be able to check whether it worked well or poorly for the tasks that it was tested against. However, it is hard to learn from past work without an underlying framework for thinking about your design choices systematically.

This book is built around such a framework, which is summarized in this chapter. The first section discusses the structure of the book itself. The next section presents a four-level model for design and validation, followed by the threats to design validity at each level. The chapter concludes with six case studies of visualization projects that focus on design and validation at different levels; they also serve as a preview of the wide scope of possibilities for interactive visualization systems.
The Four-Level Nested Model Revisited: Blocks and Guidelines

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ABSTRACT

We propose an extension to the four-level nested model for design and validation of visualization systems that defines the term “guidelines” in terms of blocks at each level. Blocks are the outcomes of the design process at a specific level, and guidelines discuss relationships between these blocks. Within-level guidelines provide comparisons for blocks within the same level, while between-level guidelines provide mappings between adjacent levels of design. These guidelines help a designer choose which abstractions, techniques, and algorithms are reasonable to combine when building a visualization system. This definition of guideline allows analysis of how the validation efforts in different kinds of papers typically lead to different kinds of guidelines. Analysis through the lens of blocks and guidelines also led us to identify four major needs: a definition of the meaning of block at the problem level; mid-level task taxonomies to fill in the blocks at the abstraction level; refinement of the model itself at the abstraction level; and a more complete set of guidelines that map up from the algorithm level to the technique level. These gaps in visualization knowledge present rich opportunities for future work.

Categories and Subject Descriptors

H.5.2 Information Interfaces and Presentation: User Interfaces—Visualization

General Terms

Design, Human Factors, Algorithms

Keywords

Visualization, Design, Guidelines, Blocks, Levels,

11, 25, 28, 30, 33], technique-driven work [19], evaluation [1, 32], models [8, 10, 18, 20, 29, 31, 36], and systems [4, 12].

We use the nested model extensively as a way to guide and reflect about our own work, and propose an extension of the model motivated by our desire to clarify the meaning of the term guideline. This term is loosely defined within the visualization literature to describe knowledge that guides how we make design decisions. One of our goals with this work is to clarify the meaning of this term for visualization research in order to assess the impact of both problem- and technique-driven work on guidelines.

The extension proposes blocks as a generic term for the outcomes of the design process at the three lower levels: abstractions, techniques, and algorithms. Concrete examples of blocks at each of these levels are that a network is a data abstraction block, a node-link diagram is a visual encoding block, and a specific force-directed layout approach such as GEM [13] is an algorithm block. We can then define guidelines as statements about the relationships between blocks, such as a node-link diagram is a good visual encoding of small graphs, or a specific force-directed layout algorithm is faster than another. We consider guideline and characterization to be synonyms.

Guidelines may pertain to blocks within a single level, and we call these within-level guidelines. Guidelines may also cross between blocks at adjacent levels, and we call these cross-level guidelines.
TBD