Content Creation: Design Principles

CS 347 - Spr 2022
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Announcements

We are grading Project Brainstorm — will return in the next day

Coming up: Project Abstract due this Friday 9am
Subway Map
Subway Map

Users' task: Understand how to get from point A to point B

Important information: Sequence of stops/interchanges along each line
Design Principles

Users' task:
Understand how to get from point A to point B

Important information:
Sequence of stops/interchanges along each line

Design principles:
Straighten lines & evenly space stops to emphasize sequence
De-emphasize geographic shape of subway lines

Techniques used to emphasize/de-emphasize information
Phases of the Moon

Galileo’s drawings from 1616
http://galileo.rice.edu/sci/observations/moon.html
Phases of the Moon

Users’ task:
Understand shape of moon’s surface

Galileo’s drawings from 1616
http://galileo.rice.edu/sci/observations/moon.html
Design Principles

Users’ task:
Understand shape of moon’s surface

Important information:
Variation in illumination, especially along terminator

Design principles:
Detail light/dark variation at terminator
Reduce detail elsewhere

Galileo’s drawings from 1616
http://galileo.rice.edu/sci/observations/moon.html
Procedure

Step 1: Identify design principles
- Analyze most effective visualizations within domain (consider user’s task)
- Connect with prior work in human perception and cognition to determine important information
- Analyze techniques used to emphasize/de-emphasize information

Step 2: Instantiate design principles
- Encode design principles into algorithms and interfaces
- Constrained optimization, controls that match user’s mental models

Step 3: Evaluate/validate design principles
- Measure improvements in task performance, quality of results, etc.
Visualizing Routes
A Better Visualization
Cognition of Route Maps

**Essential information**
- Turning points
- Route topology

**Secondary context information**
- Local landmarks, cross streets, etc.
- Overview area landmarks, global shape

**Exact geometry less important**
- Not apprehended accurately
- Not drawn accurately

[Tversky 81] [Tufte 90] [Tversky 92]
[MacEachren 95] [Denis 97] [Tversky 99]
Design Principles

- Exaggerate road length
- Regularize turning angles
- Simplify road shape
LineDrive

Hand-drawn route map

LineDrive route map
Map Design via Optimization

Set of graphic elements
Roads, labels, cross-streets, …

Choose visual attributes
Position, orientation, size, …
Distortions increase flexibility

Develop constraints based on design principles

Simulated annealing
Perturb: Form a layout
Score: Evaluate quality
Minimize score
Road Layout

Choose road lengths and orientations
Label Layout
Find overlap-free position for each label
Context Layout
Place cross-streets and exit signs if possible
Bellevue to Seattle
Cross-Country Route
# System Performance

7727 routes  
(sampled over 1 day at MapBlast!)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median distance</td>
<td>52.5 miles</td>
</tr>
<tr>
<td>Median number turning points</td>
<td>13</td>
</tr>
<tr>
<td>Median computation time</td>
<td>0.7 sec</td>
</tr>
<tr>
<td>Short roads</td>
<td>5.4 %</td>
</tr>
<tr>
<td>False intersections</td>
<td>0.3 %</td>
</tr>
<tr>
<td>Missing intersections</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Label-label overlap</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Label-road overlap</td>
<td>11.7 %</td>
</tr>
</tbody>
</table>
Results

**Beta version**
- 6 months
- 150,000 maps served

**2242 responses**
- Replace standard: 55.6%
- Use with standard: 43.5%
- Prefer standard: 0.9%

**Status**
- Was deployed at: mappoint.com
- At peak: 750,000 maps/day
- Went offline in 2011
Original Design

Layout
- Map and text close together
- Overview and destination maps for more content
Assembly Instructions


Geometric Analysis

[Romney 95]

Input Parts

Blocking Graph

B blocked by A  B → A
both parts free to move
A blocked by B  A → B
Geometric Assembly Planning

Valid

Valid

Invalid
Many Geometrically Valid Sequences

How do we choose the best sequence?
Identifying Design Principles

Stage 1: Production
Stage 2: Preference
Stage 3: Comprehension
Spatial Ability Tests

Mental Rotation [Vandenburg 78]

Navigation [Money 78]

Separate high and low spatial ability
Stage 1: Production

43 Participants
Assemble TV Stand without instructions
Write instructions for novice assembler
Stage 1: Mean completion time

Time to assemble (min)

- Low spatial: 12.76 minutes
- High spatial: 7.29 minutes
Stage 1: Instructions produced

Almost all contained diagrams  98%
Text redundant with diagrams    62%
Stage 1: Classes of Diagrams

- Structural diagrams depict completed step
- Action diagrams show assembly action/operation

Parts menu to differentiate parts
Stage 1: Action diagrams

- High spatial
  - More action diagrams
  - More 3D diagrams
  - Less text

- Low spatial

<table>
<thead>
<tr>
<th>Spatial Level</th>
<th>Mean Number Per Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low spatial</td>
<td>0.64</td>
</tr>
<tr>
<td>High spatial</td>
<td>2.67</td>
</tr>
</tbody>
</table>
Stage 2: Preference

21 Participants
Assemble TV Stand without instructions
Rated 39 sets of redrawn instructions
Stage 2: Step-by-step Highest Rated

Ratings similar across all participants
Spatial ability does not affect preference
Stage 3: Comprehension

44 Participants
Given 1 of 4 instruction sets from Stage 2
Assemble TV stand using instructions
Stage 3: Results

No difference in assembly time by condition

Instruction consultations:  Low 8.9  High 7.1
Box picture consultations: Low 9.1  High 3.4

Comments
Should show relevant parts and attachments
Structural diagrams and exploded view hard to use
Text not very useful
Design Principles

Step-by-Step
Action diagrams
Good visibility

TV stand instructions generated by our system
Lego Car

Input model
9 Parts

Design: 48s
25 Parts

Design: 53s
Evaluation

30 Participants
Given 1 of 3 instruction sets: factory, hand-drawn, computer
Assemble TV stand using instructions
Factory
1) Stand the finished board up as shown in the picture. (You should have two of these boards, but we only use one for now.)

2) Place the widest and longest board on a flat surface such that the unfinished surface faces up, and the two sides can rest on the sides facing up with the bottom sides of the first board as shown in the picture. **(Note that the finished edges of both boards face the same direction.)**

3) Place a white plastic rod in each of the holes of each side of the dimpled board.

4) Place this board as shown in the picture. Again, make sure the finished surface side faces the same direction as the finished edges of the other boards.

5) Take the remaining long board and screw it in as shown. Make sure unfinished surfaces face up, and the edges face same direction as the other boards.

6) Place the remaining board and line it up such that all of its holes line up. See picture.

7) Place the wheels into the holes as indicated in the picture and then flip the cart over.
1. Assemble the side panel and the horizontal support.
2. Attach the side panel to the horizontal support.
3. Place the top panel on the support structure.
4. Install the bottom shelf.
5. Attach the legs to the bottom shelf.
6. The assembled table is now complete.
Results

Mean time to assemble (min)

<table>
<thead>
<tr>
<th></th>
<th>Factory</th>
<th>Hand-drawn</th>
<th>Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>18.9</td>
<td>16.0</td>
<td>10.2</td>
</tr>
<tr>
<td>Errors</td>
<td>1.6</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Errors: Factory 1.6  Hand-drawn 0.6  Computer 0.5

Task rated easiest in computer condition
Summary

Identification of design principles by experiment
  Production
  Preference
  Comprehension

Instantiation of design principles

Validation of design principles
Image-Based Exploded Views

Design Principles

Clarify spatial relationships
  Direct manipulation [Shneiderman 83]
  Animated transitions [Woods 84] [Robertson 91] [Grossman 01]

Reduce visual clutter
  Interactive filtering [Shneiderman 96] [MacEachren 97]
  Highlight most important information [Tufte 83] [MacEachren 97]
Authoring Pipeline

Input  Segment  Stack  Fragment  Assign ordering  Annotate
Interactive Viewing
Remember the Steps

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