CS160: User Interface Design

Visual Information Design  3/21/2012

UI of the Day: PenLight

http://www.youtube.com/watch?v=8VHwZHIYtVU
Due Today: Turn in now.

Peer Review Form

Feedback will determine whether you score higher or lower than your group average.

There will be a 2nd round of feedback later.

Due Today: Mid-Semester Feedback

Google form online

Help us improve the course. Tell us what is good and not so good about the course.
## Assignment: Interactive Prototype

**Interactive Prototype (due Apr 9)**
- Redesign interface based on low-fidelity feedback
- Create first working implementation on device
- Can include Wizard of Oz parts *where justified*
- Can include pre-built functionality but *only if heavily justified*

**In class Presentations (Apr 9 & 11)**
- 5 min presentation (short! be careful about timing)
- Focus on two items:
  - tell the high-level story
  - show the prototype (live may not be best idea)
- Feedback from class
  (you will provide feedback on each presentation)

## Topics

**Visualization**
- Why do we create visualizations?
- Data and image
- Estimating magnitude
- Deconstructions
Why Do We Create Visualizations?

What is Visualization?

**Definition [www.oed.com]**

1. The action or fact of visualizing; the power or process of forming a mental picture or vision of something not actually present to the sight; a picture thus formed.

2. The action or process of rendering visible.
Examples

Why Do We Create Visualizations?
Three Primary Functions

**Record information**
- Photographs, blueprints, …

**Support reasoning about information (analyze)**
- Process and calculate
- Reason about data
- Feedback and interaction

**Convey information to others (present)**
- Share and persuade
- Collaborate and revise
- Emphasize important aspects of data

Record Information
Drawing: Phases of the Moon

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

Answer Question

Gallop, Bay Horse “Daisy” [Muybridge 1884-86]
Other Recording Instruments

Marey’s sphygmograph [from Braun 83]

Support Reasoning
Data in Context: Cholera Outbreak

In 1864 John Snow plotted the position of each cholera case on a map. [from Tufte 83]

Data in Context: Cholera Outbreak

Used map to hypothesize that pump on Broad St. was the cause. [from Tufte 83]
Make a Decision: Challenger

2 of 13 pages of material faxed to NASA by Morton Thiokol [from Tufte 1997]
Visualizations by booster rocket manufacturer of damage to O-rings [Tufte 97]

Visualizations drawn by Tufte show how low temperatures damage O-rings [Tufte 97]
Convey Information to Others

Present Argument: Exports & Imports

[Playfair 1786]
Tell Story: Most Powerful Brain?

The Dragons of Eden [Carl Sagan]
Tell Story: Most Powerful Brain?

![Graph showing brain weight vs. body weight for different species.]

The Elements of Grapine Data [Cleveland]

Attention

“What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.”

~Herb Simon
as quoted by Hal Varian
Scientific American
September 1995

[slide from PARC UIR group]
Data Types

**Physical type (model)**
- Characterized by storage format
- Characterized by machine operations

Example:
- bool, short, int32, float, double, string, …

**Abstract type**
- Provide (conceptual) descriptions of the data
- May be characterized by methods/attributes
- May be organized into a hierarchy

Example:
- nominal, ordinal, quantitative, …,
- plants, animals, metazoans, …
Nominal, Ordinal & Quantitative

N - Nominal (labels)
Fruits: Apples, oranges, …

O - Ordered
Quality of meat: Grade A, AA, AAA

Q - Quantitative
Real numbers
Ordered, with measurable distances, or amounts
Dates: Jan, 19, 2006; Location: (LAT 33.98, LONG -118.45)
Physical measurement: Length, Mass, Temp, …

S. S. Stevens, On the theory of scales of measurements, 1946

From Data Model to Data Type

Data model
32.5, 54.0, -17.3, …
floats

Conceptual model
Temperature

Data type
Burned vs. Not burned (N)
Hot, warm, cold (O)
Continuous range of values (Q)

[based on slide from Munzner]
Visual Variables

- Position
- Size
- Value
- Texture
- Color
- Orientation
- Shape

Note: Bertin does not consider 3D or time
Note: Card and Mackinlay extend the number of vars.
Information in Position

1. A, B, C are distinguishable
2. B is between A and C.
3. BC is twice as long as AB.
4. \[ \therefore \] Encode quantitative variables (Q)

Information in Color and Value

Value is perceived as ordered
\[ \therefore \] Encode ordinal variables (O)

\[ \therefore \] Encode continuous variables (Q) [not as well]

Hue is normally perceived as unordered
\[ \therefore \] Encode nominal variables (N) using color
### Bertins’ “Levels of Organization”

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Nominal (N)</th>
<th>Ordinal (O)</th>
<th>Quantitative (Q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>N</td>
<td>O</td>
<td>Q</td>
</tr>
<tr>
<td>Size</td>
<td>N</td>
<td>O</td>
<td>Q</td>
</tr>
<tr>
<td>Value</td>
<td>N</td>
<td>O</td>
<td>Q</td>
</tr>
<tr>
<td>Texture</td>
<td>N</td>
<td>O</td>
<td>Q</td>
</tr>
<tr>
<td>Color</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Estimating Magnitude**
Detecting Brightness

Which is brighter?

[Gray squares with RGB values (128, 128, 128) and (144, 144, 144)]
Just Noticeable Differences

**JND (Weber's Law)**

\[ \Delta S = k \frac{\Delta I}{I} \]

Ratios more important than magnitude

Most continuous variations perceived in discrete steps

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**Steven's Power law**

\[ S = I^p \]

- \( p < 1 \): underestimate
- \( p > 1 \): overestimate

[graph from Wilkinson 99, based on Stevens 61]
### Exponents of Power Law

<table>
<thead>
<tr>
<th>Sensation</th>
<th>Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loudness</td>
<td>0.6</td>
</tr>
<tr>
<td>Brightness</td>
<td>0.33</td>
</tr>
<tr>
<td>Smell</td>
<td>0.55 (Coffee) - 0.6 (Heptane)</td>
</tr>
<tr>
<td>Taste</td>
<td>0.6 (Saccharine) - 1.3 (Salt)</td>
</tr>
<tr>
<td>Temperature</td>
<td>1.0 (Cold) – 1.6 (Warm)</td>
</tr>
<tr>
<td>Vibration</td>
<td>0.6 (250 Hz) – 0.95 (60 Hz)</td>
</tr>
<tr>
<td>Duration</td>
<td>1.1</td>
</tr>
<tr>
<td>Pressure</td>
<td>1.1</td>
</tr>
<tr>
<td>Heaviness</td>
<td>1.45</td>
</tr>
<tr>
<td>Electric Shock</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*Psychophysics of Sensory Function, Stevens 61*

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**Compare area of circles**
Proportional Symbol Map

Newspaper Circulation

[Cartography: Thematic Map Design, Figure 8.8, p. 172, Dent, 96]

Apparent Magnitude Scaling

Circles drawn by absolute scaling

Circles drawn by apparent scaling (Flannery)

[S = 0.98A^{0.87} [from Flannery 71]]
Figure 3. Graphs from position–angle experiment.

[Cleveland and McGill 84]

Figure 4. Graphs from position–length experiment.

[Cleveland and McGill 84]
Relative Magnitude Estimation

Most accurate
- Position (common) scale
- Position (non-aligned) scale
- Length
- Slope
- Angle
- Area
- Volume

Least accurate
- Color hue-saturation-density
Deconstructions

Stock Chart

March 1986: Bert Ellis founded DL. It is backed initially with money from Kelsen & Co., a New York investment firm, and Ellis.

Jan 21, 2001: DL hiring a new CEO.


Dec 15, 1990: DL hires a new CEO, where Ellis predicts the stock will top $100 in 2000. Stock watchdog rating.

Jan. 11, 2001: DL tops 10-fold return; 3,000 shares. CEO: 'The run to $5 billion a month.'

Tuesday: DL announces it will merge with Great Western Corp., based in New York. Ellis becomes new chairman of board.

Feb 18, 2001: DL hits 30-day high.
Stock Chart

x-axis: time (Q)
y-axis: price (Q)

Exports and Imports [Playfair 1786]
Exports and Imports [Playfair 1786]

x-axis: year (Q)
y-axis: currency (Q)
color: imports/exports (N)
color: positive/negative (O)

Map of the Market [Wattenberg 1998]

http://www.smartmoney.com/marketmap/
Map of the Market [Wattenberg 1998]

rectangle size: market cap (Q)
rectangle position: market sector (N), market cap (Q)
color hue: loss vs. gain (N, O)
color value: magnitude of loss or gain (Q)

Summary

We create visualizations to
Record information
Support reasoning about the information
Convey information to others

Choose the right mark for your data
Position good for N, O, Q, but Hue best only for N

With careful design it is possible to display many dimensions at once