CS 160: User Interface Design

Visual Information Design

3/30/2011
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.
UI of the Day: PenLight

http://www.youtube.com/watch?v=8VHwZHIYtVU
Due Next Week

**Interactive Prototype (due Apr 4)**
- 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 4 & 6)**
- 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)
Presentation Schedule: 4/4

1. Group R - Rarer error
2. Group P - What 9000?!
3. Group T - Under the Underdogs
4. Group C - Charmander
5. Group L - Lambda
6. Group S - Scrumptious
7. Group E - Droid Rage
8. Group I - OneHundredAndSixty
9. Group A - Awsomeness
10. Group D - Innovationers
Android Devices

One device per group.

We have a mix of Archos 5, Archos 70.

Check out device at end of class

Write a collateral check over $200 to UC Regents.
Topics

Midterm Review

Visualization

Why do we create visualizations?
Data and image
Estimating magnitude
Deconstructions
Midterm

**Mean**: 82.0 / 110

**Median**: 85.5

**Std. Dev.**: 14.3
Midterm: Review of hard questions

You pick the questions …
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

<table>
<thead>
<tr>
<th>Location</th>
<th>AVG/Total</th>
<th>MAX/(AUTO+THEFT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stadiums</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belltown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Lake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seattle Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leschi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capitol Hill</td>
<td></td>
<td></td>
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<tr>
<td>West Lake</td>
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<td>Rainier Valley</td>
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</tr>
<tr>
<td>Eastlake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harbor Island</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Lake</td>
<td></td>
<td></td>
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<tr>
<td>Ravenna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pioneer Square</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beacon Hill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mount Baker</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observation: A large number of auto thefts occur in the University district, even though the area ranks relatively low in total crime.
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
Galileo’s drawings of the phases of the moon from 1616
http://galileo.rice.edu/sci/observations/moon.html
Gallop, Bay Horse “Daisy” [Muybridge 1884-86]
Other Recording Instruments

Marey’s sphygmograph [from Braun 83]
Support Reasoning
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]
Make a Decision: Challenger

Visualizations by booster rocket manufacturer of damage to O-rings [Tufte 97]
Make a Decision: Challenger

Visualizations drawn by Tufte show how low temperatures damage O-rings [Tufte 97]
Convey Information to Others
Present Argument: Exports & Imports

Exports and Imports to and from Denmark & Norway from 1700 to 1780.

[Playfair 1786]
Tell Story: Most Powerful Brain?

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Body Weight</th>
<th>Brain Weight</th>
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<tbody>
<tr>
<td>1</td>
<td>Lesser Short-tailed Shrew</td>
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<td>0.14</td>
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<tr>
<td>2</td>
<td>Little Brown Bat</td>
<td>10</td>
<td>0.25</td>
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<tr>
<td>3</td>
<td>Mouse</td>
<td>23</td>
<td>0.3</td>
</tr>
<tr>
<td>4</td>
<td>Big Brown Bat</td>
<td>23</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>Musk Shrew</td>
<td>48</td>
<td>0.33</td>
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<tr>
<td>6</td>
<td>Star Nosed Mole</td>
<td>60</td>
<td>1</td>
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<tr>
<td>7</td>
<td>Eastern American Mole</td>
<td>75</td>
<td>1.2</td>
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<td>8</td>
<td>Ground Squirrel</td>
<td>101</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Tree Shrew</td>
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<td>2.5</td>
</tr>
<tr>
<td>10</td>
<td>Golden Hamster</td>
<td>120</td>
<td>1</td>
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<tr>
<td>11</td>
<td>Mole Rate</td>
<td>122</td>
<td>3</td>
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<td>12</td>
<td>Galago</td>
<td>200</td>
<td>5</td>
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<td>13</td>
<td>Rat</td>
<td>280</td>
<td>1.9</td>
</tr>
<tr>
<td>14</td>
<td>Chinchilla</td>
<td>425</td>
<td>6.4</td>
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<tr>
<td>15</td>
<td>Desert Hedgehog</td>
<td>550</td>
<td>2.4</td>
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<tr>
<td>16</td>
<td>Rock Hyrax (a)</td>
<td>750</td>
<td>12.3</td>
</tr>
<tr>
<td>17</td>
<td>European Hedgehog</td>
<td>785</td>
<td>3.5</td>
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<tr>
<td>18</td>
<td>Tenrec</td>
<td>900</td>
<td>2.6</td>
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<tr>
<td>19</td>
<td>Arctic Ground Squirrel</td>
<td>920</td>
<td>5.7</td>
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<tr>
<td>20</td>
<td>African Giant Pouched Rat</td>
<td>1000</td>
<td>6.6</td>
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<td>21</td>
<td>Guinea Pig</td>
<td>1040</td>
<td>5.5</td>
</tr>
<tr>
<td>22</td>
<td>Mountain Beaver</td>
<td>1350</td>
<td>8.1</td>
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<tr>
<td>23</td>
<td>Slow Loris</td>
<td>1400</td>
<td>12.5</td>
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<tr>
<td>24</td>
<td>Genet</td>
<td>1410</td>
<td>17.5</td>
</tr>
<tr>
<td>25</td>
<td>Phalanger</td>
<td>1620</td>
<td>11.4</td>
</tr>
</tbody>
</table>
Tell Story: Most Powerful Brain?

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

The Elements of Graping 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
Data
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.
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
∴ Encode ordinal variables (O)

∴ Encode continuous variables (Q) [not as well]

Hue is normally perceived as unordered
∴ Encode nominal variables (N) using color
Bertins’ “Levels of Organization”

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>O</th>
<th>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></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>

N Nominal  
O Ordinal  
Q Quantitative
Estimating Magnitude
Detecting Brightness

Which is brighter?
Detecting Brightness

Which is brighter?

(128, 128, 128)  

(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
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]
Compare area of circles
Proportional Symbol Map
Newspaper Circulation

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

\[ S = 0.98A^{0.87} \] [from Flannery 71]

[Cartography: Thematic Map Design, Figure 8.6, p. 170, Dent, 96]
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 1996: Bert Ellis founds iXL. It is backed initially with money from Kelso & Co., a New York investment firm, and Ellis.

Dec. 18, 1999: iXL throws a big Christmas party, where Ellis predicts the stock will top $100 in 2000. Stock was trading at under $50 a share.


Jan. 11, 2001: iXL taps PricewaterhouseCoopers Chris Formant, 49, as CEO. He vows to turn iXL around.

Tuesday: iXL announces it will merge with rival Scient Corp., based in New York. Ellis becomes vice chairman of Scient.
Stock Chart

x-axis: time (Q)

y-axis: price (Q)
Exports and Imports from Denmark and Norway, 1700 to 1780

BALANCE in FAVOUR of ENGLAND.

BALANCE AGAINST
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