CSE 412 - Data Visualization

Interaction

Jane Hoffswell  University of Washington
[There is an] apparent challenge that computational artifacts pose to the longstanding distinction between the physical and the social, in the special sense of those things that one designs, builds, and uses, on the one hand, and those things with which one communicates, on the other.

“Interaction”- in a sense previously reserved for describing a uniquely interpersonal activity - seems appropriately to characterize what goes on between people and certain machines as well.

Lucy Suchman, *Plans and Situated Actions*
Interaction between people and machines requires mutual intelligibility or shared understanding.
Gulfs of Execution & Evaluation

[Norman 1986]
Gulf of Execution

The difference between the user’s intentions and the allowable actions.

[Norman 1986]
Gulf of Execution
The difference between the user’s intentions and the allowable actions.

Gulf of Evaluation
The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

[Norman 1986]
Gulf of Evaluation

Conceptual model: x, y related?

Evaluation

Real world:

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.67</td>
<td>0.79</td>
</tr>
<tr>
<td>0.32</td>
<td>0.63</td>
</tr>
<tr>
<td>0.39</td>
<td>0.72</td>
</tr>
<tr>
<td>0.27</td>
<td>0.85</td>
</tr>
<tr>
<td>0.71</td>
<td>0.43</td>
</tr>
<tr>
<td>0.63</td>
<td>0.09</td>
</tr>
<tr>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>0.20</td>
<td>0.54</td>
</tr>
<tr>
<td>0.51</td>
<td>0.38</td>
</tr>
<tr>
<td>0.11</td>
<td>0.33</td>
</tr>
<tr>
<td>0.46</td>
<td>0.46</td>
</tr>
</tbody>
</table>
Gulf of Evaluation

Conceptual model: x, y related?
Gulf of Execution

Conceptual model:
Draw a scatterplot

Execution

Move 90 30
Rotate 35
Pen down
...

Real world
Gulf of Execution

Conceptual model: Draw a scatterplot

Real world
Gulf of Execution
The difference between the user’s intentions and the allowable actions.

Gulf of Evaluation
The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

[Norman 1986]
Interactive Visualization
Interaction Techniques

Are there “essential” interactive operations for exploratory data visualization?
Taxonomy of Interactions
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive

View Manipulation
Select, Navigate, Coordinate, Organize
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive

View Manipulation
Select, Navigate, Coordinate, Organize
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive

View Manipulation
Select, Navigate, Coordinate, Organize

Process and Provenance
Record, Annotate, Share, Guide
Hours of footage lost each month due to dropped frames

- Framedrop problem discovered
- Issue announced publicly
- Upgrade causes glitch
Taxonomy of Interactions

Data and View Specification
Visualize, Filter, Sort, Derive

View Manipulation
Select, Navigate, Coordinate, Organize

Process and Provenance
Record, Annotate, Share, Guide
EXAMPLE:
Bertin’s Hotel Data
<table>
<thead>
<tr>
<th></th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>21</td>
<td>26</td>
<td>28</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>15</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>70</td>
<td>71</td>
<td>37</td>
<td>36</td>
<td>39</td>
<td>39</td>
<td>55</td>
<td>60</td>
<td>68</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>23</td>
<td>14</td>
<td>19</td>
<td>14</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>15</td>
<td>14</td>
<td>15</td>
<td>23</td>
<td>27</td>
<td>22</td>
<td>30</td>
<td>19</td>
<td>19</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>80</td>
<td>85</td>
<td>86</td>
<td>87</td>
<td>70</td>
<td>76</td>
<td>87</td>
<td>85</td>
<td>87</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>20</td>
<td>15</td>
<td>14</td>
<td>15</td>
<td>13</td>
<td>30</td>
<td>24</td>
<td>13</td>
<td>15</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>70</td>
<td>75</td>
<td>74</td>
<td>69</td>
<td>68</td>
<td>74</td>
<td>75</td>
<td>68</td>
<td>68</td>
<td>64</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>18</td>
<td>19</td>
<td>17</td>
<td>27</td>
<td>27</td>
<td>19</td>
<td>19</td>
<td>26</td>
<td>27</td>
<td>21</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>27</td>
<td>37</td>
<td>35</td>
<td>25</td>
<td>25</td>
<td>27</td>
<td>28</td>
<td>24</td>
<td>30</td>
<td>24</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>49</td>
<td>42</td>
<td>48</td>
<td>54</td>
<td>55</td>
<td>53</td>
<td>57</td>
<td>55</td>
<td>46</td>
<td>55</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>22</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>20</td>
<td>19</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>163</td>
<td>167</td>
<td>166</td>
<td>174</td>
<td>152</td>
<td>155</td>
<td>145</td>
<td>170</td>
<td>157</td>
<td>174</td>
<td>165</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td>1.65</td>
<td>1.71</td>
<td>1.65</td>
<td>1.91</td>
<td>1.90</td>
<td>2.</td>
<td>1.54</td>
<td>1.60</td>
<td>1.73</td>
<td>1.82</td>
<td>1.66</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>82</td>
<td>70</td>
<td>83</td>
<td>74</td>
<td>77</td>
<td>56</td>
<td>62</td>
<td>90</td>
<td>92</td>
<td>78</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1% CLIENTELE FEMALE
2% ——“” LOCAL
3% ——“” U.S.A.
4% ——“” SOUTH AMERICA
5% ——“” EUROPE
6% ——“” M.EAST, AFRICA
7% ——“” ASIA
8% BUSINESSMEN
9% TOURISTS
10% DIRECT RESERVATIONS
11% AGENCY ——“”
12% AIR CREWS
13% CLIENTS UNDER 20 YEARS
14% ——“” 20-35 ——“”
15% ——“” 35-55 ——“”
16% ——“” MORE THAN 55—“”
17% PRICE OF ROOMS
18% LENGTH OF STAY
19% OCCUPANCY
20% CONVENTIONS
[Graphics and Graphic Information Processing, Bertin 81]
### Active and Slow Periods

<table>
<thead>
<tr>
<th>% Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Stay</td>
</tr>
<tr>
<td>Conventions</td>
</tr>
<tr>
<td>Businessmen</td>
</tr>
<tr>
<td>Agency Reservations</td>
</tr>
<tr>
<td>South America</td>
</tr>
</tbody>
</table>

### Discovery Factors

| Air Crews |
| Clients Under 20 Years |
| Clients More Than 55 Years |
| Clients From 20-35 Years |
| Female Clientele |
| Local Clientele |

### Recovery Factors

| Asia |
| Tourists |
| Direct Reservation |
| Price of Rooms |
| Middle East, Africa |
| U.S.A. |
| Europe |
| Clients From 35-55 Years |

#### Winter

| Winter-Summer |
| Summer |

[Graphics and Graphic Information Processing, Bertin 81]
[Graphics and Graphic Information Processing, Bertin 81]
[Graphics and Graphic Information Processing, Bertin 81]
EXAMPLE:
Tukey et al.’s PRIM-9
PRIM-9, Tukey, Fisherkeller, Friedman 1972
Administrivia
A2: Exploratory Data Analysis

Use visualization software to form & answer questions

First steps:
Step 1: Pick domain & data
Step 2: Pose questions
Step 3: Profile the data
Iterate as needed

Create visualizations
Interact with data
Refine your questions

Author a report
Screenshots of most insightful views (8+)
Include titles and captions for each view

Due by 11:59pm Monday, Jan 25
Course Participation & Policies

Week 3 Participation - 11:59pm Mon Jan 25th
Quiz (link to Ed Sway) and Discussion Post (link to Ed)
Discussion post should be one subset

Late Policy: We will automatically deduct 10% for each day an assignment is late. Please contact the instructors well in advance to request an extension if needed.

Plagiarism Policy: Assignments should consist primarily of original work. Building off of others' work—including 3rd party libraries, public source code examples, and design ideas—is acceptable and in most cases encouraged. However, failure to cite such sources will result in score deductions proportional to the severity of the oversight.
A3: Ethical & Deceptive Visualization

Use visualizations to communicate and influence insights
Design both an ethical and deceptive visualization

**Ethical Visualization:** honestly and transparently communicate the data with an effective and expressive visualization design that is easy to interpret for viewers

**Deceptive Visualization:** intentionally influence viewer's perception to mislead their insights, without revealing its role as the deceptive design

Due by **11:59 pm PST, Monday February 8**
A3: Ethical & Deceptive Visualization

Use visualizations to communicate and influence insights.
Design both an ethical and deceptive visualization.

**Step 1: Pick a dataset**
Consider using the same data for your final project.

**Step 2: Pose question(s) and identify insights**
Use exploratory data analysis to get familiar with the data.
Document your questions in your assignment write-up.

**Step 3: Design visualizations**
Create your ethical and deceptive visualization designs.
Consider how visual and narrative elements can be incorporated.
A3: Ethical & Deceptive Visualization

**Deliverables** (upload via Canvas; see A3 page)
Image of your visualization (PNG or JPG format)
Image file names **should not give away which design is which**
Write-up including a short description + design rationale

Due by **11:59 pm PST, Monday February 8th**

**Assignment A3b: Peer Evaluation** (see course website)
Provide constructive feedback on **four peer designs**
Guess which visualization designs are deceptive and ethical
Due by 11:59pm PST, Monday February 15th
Selection
Basic Selection Methods

Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)
Basic Selection Methods

Point Selection
Mouse Hover / Click
Touch / Tap
Select Nearby Element (e.g., Bubble Cursor)

Region Selection
Rubber-band (rectangular) or Lasso (freehand)
Area cursors (“brushes”)

Brushing & Linking
Brushing

Direct attention to a subset of data [Wills 95]
Brushing & Linking

Select ("**brush**") a subset of data
See selected data in other views

The components must be **linked**
by *tuple* (matching data points), or
by *query* (matching range or values)
Brushing Scatterplots
Cross-Filtering

Histograms showing:
- Arrival Delay (min)
- Local Departure Time (hour)
- Travel Distance (miles)
Baseball Statistics [Wills 95]
Baseball Statistics [Wills 95]

select high salaries
Baseball Statistics [Wills 95]

1. Select high salaries.
2. Average career HRs vs average career hits (batting ability).
Baseball Statistics [Wills 95]

- How long in majors
- Select high salaries
- Avg career HRs vs avg career hits (batting ability)
Baseball Statistics [Wills 95]

- **Years**
  - How long in majors

- **Log(1+Salary)**
  - Select high salaries

- **Assists – PutO**
  - Avg assists vs avg putouts (fielding ability)

- **CHits/Years – C**
  - Avg career HRs vs avg career hits (batting ability)
Baseball Statistics [Wills 95]

- How long in majors
- Select high salaries
- Avg assists vs avg putouts (fielding ability)
- Avg career HRs vs avg career hits (batting ability)
- Distribution of positions played
Linking Assists to Positions
Dynamic Queries
SELECT house FROM seattle_homes
WHERE price < 1,000,000 AND bedrooms > 2
ORDER BY price
Issues with Textual Queries

1. For programmers
2. Rigid syntax
3. Only shows exact matches
4. Too few or too many hits
5. No hint on how to reformulate the query
6. Slow question-answer loop
7. Results returned as table
HomeFinder

The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it. You may drag the ‘A’ and ‘B’ distance markers to your office or any other location you want to live near.

Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right. Select specific home types and services by pressing the labeled buttons on the right.

[Williamson and Shneiderman 92]
Direct Manipulation

1. Visual representation of objects and actions
2. Rapid, incremental and reversible actions
3. Selection by pointing (not typing)
4. Immediate and continuous display of results
[Ahlberg and Shneiderman 94]
Alphaslider (?)

Title: Moonstruck

[Text box showing possible characters: A B C D F G H L M N P R S T W Z]

[Ahlberg and Shneiderman 94]
Details-on-Demand

Witches of Eastwick, The
Director: Miller, George  Year: 1987
Country: USA  Language: English
Actors: Nicholson, Jack  Jenkins, Richard  Joakum, Keith  Struycker, Carel
Actresses: Cher  Sarandon, Susan  Pfeiffer, Michelle  Cartwright, Veronica

Year of Production

Title: ALL
Actor: ALL
Actress: Pfeiffer, Michelle
Director: Miller, George
Ratings: G  PG  PG-13  R
Films Shown: 210

Copyright (C) 1993 HCIL

[Ahlberg and Shneiderman 94]
• The Attribute Explorer
Zipdecode [Fry 04]

Hit the letter z, or click the word zoom to enable or disable zooming.

Hold down shift while typing a number to replace the previous number (U.S. keyboards only).

http://benfry.com/zipdecode/
Parallel Coordinates [Inselberg]
Builds on Wattenberg’s [2001] idea for sketch-based queries of time-series data.
Query by Slope!
3D Dynamic Queries [Akers 04]
3D Dynamic Queries [Akers 04]
Pros & Cons

Pros
Controls useful for both novices and experts
Quick way to explore data
Pros & Cons

Pros
Controls useful for both novices and experts
Quick way to explore data

Cons
Simple queries
Lots of controls
Amount of data shown limited by screen space

Who would use these kinds of tools?
Summary

Most visualizations are interactive
Even passive media elicit interactions

Good visualizations are task dependent
Pick the right interaction technique
Consider the semantics of the data domain

Fundamental interaction techniques
Selection / Annotation, Sorting, Navigation,
Brushing & Linking, Dynamic Queries