Why interaction?

- Perceive the outside world through interactions
- Epistemic actions
  - Moving an object to evaluate its shape
  - Moving away from a painting to see the big picture
  - Moving closer to observe the detail of a photograph
- Discussion with the medium
  - Product design, and architecture
- Indispensable for computer-based visualization
  - Modify the point of view
    - Panning, zooming, 3D interactions
  - Modify the underlying data
Gulfs of Execution & Evaluation

Gulfs

Evaluation

Conceptual model (Goals)

Real world (Interactions)

Execution

Gulf of Evaluation

Conceptual model: x,y correlated?

Real world:

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.81</td>
<td>0.79</td>
</tr>
<tr>
<td>0.82</td>
<td>0.86</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>0.48</td>
<td>0.48</td>
</tr>
</tbody>
</table>
Gulf of Evaluation

Conceptual model: $x, y$ correlated?

Real world:

$\rho = -0.29$

Gulf of Evaluation

Conceptual model: $x, y$ correlated?

Real world:

$\rho = -0.29$
Gulf of Execution

Conceptual model: Draw a rectangle

Real world
Move 90 30
Rotate 35
Pen down...

Execution

Gulf of Execution

Conceptual model: Draw a rectangle

Real world

Execution
Visualization: A Double Gulf?

Visualization user  Visualization designer

Conceptual model  Visualization

Evaluation  Representation  Data

Execution  Manipulation

Bad visualization?

Visualization user  Visualization designer

Evaluation  Representation

x, y correlated?

\begin{tabular}{|c|c|}
\hline
X & Y \\
\hline
0.87 & 0.79 \\
0.32 & 0.63 \\
0.39 & 0.72 \\
0.27 & 0.85 \\
0.71 & 0.43 \\
0.63 & 0.09 \\
0.03 & 0.03 \\
0.20 & 0.04 \\
0.51 & 0.38 \\
0.11 & 0.33 \\
0.46 & 0.46 \\
\hline
\end{tabular}

\begin{tabular}{|c|c|}
\hline
X & Y \\
\hline
0.07 & 0.79 \\
0.32 & 0.63 \\
0.39 & 0.72 \\
0.27 & 0.85 \\
0.71 & 0.43 \\
0.63 & 0.09 \\
0.03 & 0.03 \\
0.20 & 0.04 \\
0.51 & 0.38 \\
0.11 & 0.33 \\
0.46 & 0.46 \\
\hline
\end{tabular}
Good Visualization?

Visualization user  Visualization designer

Evaluation  Representation

$x, y$ correlated?

\[
\rho = -0.29
\]

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.07</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>0.48</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Topics

Rotation and Rocking
Brushing and linking
Dynamic queries
Attribute explorer
Rearrangements
Rotation and Rocking

Brushing and Linking
Query Languages

SELECT house
FROM peninsula
WHERE price < 1,000,000 AND bedrooms > 3
ORDER BY price

GROUP BY and AGGREGATE

Comments

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
Direct Manipulation

1. Visual representation of the world of action, including both the objects and the actions
2. Rapid, incremental and reversible actions
3. Selection by pointing (not typing)
4. Immediate and continuous display of results

Dynamic Queries, Ahlberg and Schneiderman
Title: Moonstruck

Attribute Explorer
Time Searcher

Table Lens
Conclusion

Most visualizations are interactive
  - Even passive media elicit interactions

Visualizations are task dependent
  - Reduce the gulf of evaluation
    - Being in the right space...
  - Reduce the gulf of execution
    - Picking the right interaction technique...

Human factors are important
  - Leverage human strength
  - Assist human limitation