Information Representation

The Value of Data Visualization

Spot the 7s…
http://vimeo.com/29684853
**Beyond Simple Screen Design**
What are the characteristics of good representations?
What are the characteristics of good information visualization?
What role do metaphors play?
How can the use of direct manipulation help us?

**Good information visualization**
...supports making discoveries.
...supports making decisions.
...supports discovering patterns.
...supports finding relevant information.
...capture essential elements of events.
...deliberately leaves out (or at least mutes) irrelevant data.
...is appropriate to the person viewing the data.
...is appropriate to the task being performed.

With good visualizations people can see trends, clusters, gaps, and outliers.

Use of colors, sizes, shapes, and locations all help with this.
How to represent quantity?

Representations

Solving a problem simply means representing it so as to make the solution transparent … (Simon, 1981)

Good representations

• allow people to find relevant information
  – information may be present but hard to find

• allow people to compute desired conclusions
  – computations may be difficult or “for free” depending on representations
**Which is the best flight?**

length, stop-overs, switches...

<table>
<thead>
<tr>
<th>Flight</th>
<th>Depart</th>
<th>Arrive</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 117</td>
<td>Vancouver - Calgary</td>
<td>7:00 9:00</td>
</tr>
<tr>
<td>Cdn 32</td>
<td>Vancouver - Calgary</td>
<td>9:00 12:00</td>
</tr>
<tr>
<td>Cdn 35</td>
<td>Calgary - Montreal</td>
<td>13:30 19:30</td>
</tr>
<tr>
<td>AC 123</td>
<td>Calgary - Toronto</td>
<td>12:30 16:30</td>
</tr>
<tr>
<td>AC 123</td>
<td>Toronto - Montreal</td>
<td>16:45 17:30</td>
</tr>
</tbody>
</table>

*time zone: +1 van-cal, +2 cal-tor, mtl

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**When do I take my drugs?**

<table>
<thead>
<tr>
<th>Medication</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inderal</td>
<td>1 tablet 3 times a day</td>
</tr>
<tr>
<td>Lanoxin</td>
<td>1 tablet every A.M.</td>
</tr>
<tr>
<td>Carafate</td>
<td>1 tablet before meals and at bedtime</td>
</tr>
<tr>
<td>Zantac</td>
<td>1 tablet every 12 hours (twice a day)</td>
</tr>
<tr>
<td>Quinag</td>
<td>1 tablet 4 times a day</td>
</tr>
<tr>
<td>Couma</td>
<td>1 tablet a day</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Bedtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00</td>
<td>Loxin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00</td>
<td>Inderal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00</td>
<td>Quinag</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:00</td>
<td>Carafate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:00</td>
<td>Zantac</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:00</td>
<td>Couma</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: There are high error rates in taking pills, even with pillbox organizers, for a number of reasons.

Note: A better solution might feel like a technology-enhanced pill bottle system, but there are a variety of human-centric factors in that ideas as well as technology failure issues...
Which representation is best? Depends on task…

Do you want to know the precise value is now?

Do you want to know how the performance is now compared to its peak?

Do you want to know how performance changed over time?

Where am I? (Geographic Navigation)

Detailed navigation plus precision

General navigation plus orientation

GAME PAUSED
Press F3 to Continue
Where am I? (Revealing Patterns Interactively)

http://acg.media.mit.edu/people/fry/zipdecode/

Where am I? (maps)
Which folder has the most documents or largest size?

Right-click menu + properties

Why can't I sort **folders** by size like I can sort files by size?

Which folder has the most photos?
Which folder has the most bytes of photos?

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Allocated</th>
<th>Files</th>
<th>Folders</th>
<th>% of Parent</th>
<th>Last Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>C: \My Pictures _STD</td>
<td>310.6 GB</td>
<td>310.6 GB</td>
<td>36,795</td>
<td>1</td>
<td>100.0%</td>
<td>4/12</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS</td>
<td>52.0 GB</td>
<td>52.0 GB</td>
<td>1,869</td>
<td>177</td>
<td>10.0%</td>
<td>4/22</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>25.0 GB</td>
<td>25.0 GB</td>
<td>5,931</td>
<td>219</td>
<td>7.4%</td>
<td>8/24</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>12.0 GB</td>
<td>12.0 GB</td>
<td>1,628</td>
<td>17</td>
<td>3.5%</td>
<td>4/27</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>9.1 GB</td>
<td>9.1 GB</td>
<td>2,585</td>
<td>103</td>
<td>2.9%</td>
<td>3/15</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>4.1 GB</td>
<td>4.1 GB</td>
<td>305</td>
<td>6</td>
<td>1.4%</td>
<td>3/16</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>3.5 GB</td>
<td>3.5 GB</td>
<td>635</td>
<td>29</td>
<td>11%</td>
<td>8/24</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>2.3 GB</td>
<td>2.3 GB</td>
<td>1,274</td>
<td>25</td>
<td>0.8%</td>
<td>1/2</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.0 GB</td>
<td>1.0 GB</td>
<td>1,637</td>
<td>94</td>
<td>0.6%</td>
<td>9/23</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.7 GB</td>
<td>1.7 GB</td>
<td>90</td>
<td>10</td>
<td>0.6%</td>
<td>4/24</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.6 GB</td>
<td>1.6 GB</td>
<td>314</td>
<td>89</td>
<td>0.5%</td>
<td>7/25</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>2.1 GB</td>
<td>2.1 GB</td>
<td>397</td>
<td>18</td>
<td>0.4%</td>
<td>8/24</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.3 GB</td>
<td>1.3 GB</td>
<td>36</td>
<td>0.4%</td>
<td>8/24</td>
<td></td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.3 GB</td>
<td>1.3 GB</td>
<td>407</td>
<td>18</td>
<td>0.4%</td>
<td>10/30</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.4 GB</td>
<td>1.4 GB</td>
<td>903</td>
<td>44</td>
<td>0.4%</td>
<td>2/27</td>
</tr>
<tr>
<td>C: \My Pictures _STD Camera PICS _STD Camera Pics</td>
<td>1.1 GB</td>
<td>1.1 GB</td>
<td>192</td>
<td>10</td>
<td>0.4%</td>
<td>8/24</td>
</tr>
</tbody>
</table>

What do I have to do? (Today? This Week? This Month?)
**Treemaps (developed at UMD)**
Divide a rectangle into smaller rectangles and use the sizes, colors, and even color intensity as representations of different data parameters.

Examples of where you can play around with creating your own…

https://developers.google.com/chart/interactive/docs/gallery/treemap

https://infogram.com/examples/charts/treemap-chart

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**What stock is doing best?**

Current site using similar idea:

Which folder is using the most drive space?

Much of Gonzaga's title game team coming back next season (Apr 4, 2017)

Trump faces test mixing Mar-a-Lago with difficult diplomacy

The Latest: Ryan confirms talks underway on health care bill

The Nintendo Switch is apparently working while setting up its dock.
Who won the 2008 Presidential elections, by how much?
Who won the 2008 Presidential elections, by how much?

By state...

Who won the 2008 Presidential elections, by how much?

By county...
Who won the 2008 Presidential elections, by how much?

By percentage...

Where are the most shootings in Baltimore?

https://spotcrime.files.wordpress.com/2009/03/baltimoreshootingsheatmap.jpg
**Information Visualization**

Graphics should reveal the data...

- show the data
- not get in the way of the message
- avoid distortion
- present many numbers in a small space
- make large data sets coherent
- encourage comparison between data
- supply both a broad overview and fine detail
- serve a clear purpose

*Note: many visual examples on the following slides are taken from Tufte’s books such as Visual Display of Quantitative Information*
Telling a story: Napoleon's march to Moscow
by Charles Minard (1885)

Six Variables Shown:

Not Shown but COULD have been: Mood of the troops with shading? Others? How?

Data Density
New York Weather History
• 181 numbers/sq inch
Small Multiples: Showing Time and Change

Data Ink & Chart Junk: A common error

Information display is not just pretty graphics

graphical re-design by amateurs on computers can give us things like “fontitis” and “chart-junk” in visuals

Dear Sir,
There is a really exciting opportunity!
Will you take advantage of it?
Showing the Right Data: Challenger

Interaction

If a picture is worth a thousand words, then an interactive visualization is worth a thousand pictures.....
Metaphors (I)

Pervade excellent interfaces

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Market value</td>
<td>Land</td>
<td>Improvement</td>
</tr>
<tr>
<td>2</td>
<td>1400</td>
<td>88,850</td>
<td>73,120</td>
</tr>
<tr>
<td>3</td>
<td>1470</td>
<td>77,700</td>
<td>72,070</td>
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<tr>
<td>4</td>
<td>1510</td>
<td>74,950</td>
<td>80,740</td>
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<td>5</td>
<td>1520</td>
<td>86,110</td>
<td>89,410</td>
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<tr>
<td>6</td>
<td>1550</td>
<td>79,950</td>
<td>109,130</td>
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<td>7</td>
<td>1700</td>
<td>94,750</td>
<td>90,960</td>
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<td>8</td>
<td>1720</td>
<td>85,520</td>
<td>110,250</td>
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<tr>
<td>9</td>
<td>1780</td>
<td>78,980</td>
<td>122,680</td>
</tr>
<tr>
<td>10</td>
<td>1800</td>
<td>59,340</td>
<td>107,670</td>
</tr>
<tr>
<td>11</td>
<td>1800</td>
<td>60,090</td>
<td>103,130</td>
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<td>12</td>
<td>1820</td>
<td>76,850</td>
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<td>1850</td>
<td>85,600</td>
<td>115,710</td>
</tr>
<tr>
<td>14</td>
<td>1850</td>
<td>86,870</td>
<td>105,330</td>
</tr>
<tr>
<td>15</td>
<td>1850</td>
<td>86,060</td>
<td>113,920</td>
</tr>
<tr>
<td>16</td>
<td>1934</td>
<td>96,140</td>
<td>131,340</td>
</tr>
<tr>
<td>17</td>
<td>1944</td>
<td>73,400</td>
<td>115,210</td>
</tr>
<tr>
<td>18</td>
<td>1970</td>
<td>84,860</td>
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<tr>
<td>19</td>
<td>2030</td>
<td>91,900</td>
<td>119,170</td>
</tr>
<tr>
<td>20</td>
<td>2050</td>
<td>79,460</td>
<td>137,260</td>
</tr>
<tr>
<td>21</td>
<td>2130</td>
<td>97,860</td>
<td>124,360</td>
</tr>
<tr>
<td>22</td>
<td>2140</td>
<td>87,730</td>
<td>167,920</td>
</tr>
<tr>
<td>23</td>
<td>2250</td>
<td>97,500</td>
<td>101,500</td>
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<tr>
<td>24</td>
<td>2460</td>
<td>97,530</td>
<td>144,840</td>
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<tr>
<td>25</td>
<td>2480</td>
<td>88,470</td>
<td>183,900</td>
</tr>
<tr>
<td>26</td>
<td>2760</td>
<td>82,150</td>
<td>169,720</td>
</tr>
<tr>
<td>27</td>
<td>3025</td>
<td>118,300</td>
<td>169,800</td>
</tr>
<tr>
<td>28</td>
<td>3380</td>
<td>63,100</td>
<td>141,780</td>
</tr>
</tbody>
</table>

spreadsheet (actuary sheet)

games (literal world)

Metaphors (II)

Control Panels with familiar controls from non-digital tech.

Hierarchical Folders
Metaphors (III)

Via metaphor, we apply the name of something or a descriptive term to another object to which it is not literally applicable (do you tape things on a DVR?).

The purpose of this is to provide users with natural models and attempt to leverage their knowledge of familiar, concrete objects/experiences to understand abstract computer and task concepts.

A potential problem is that a metaphor may portray an outdated or inaccurate or naive conceptual model of the system or could limit design creativity.

Generating Metaphors

Use metaphors that matches user's conceptual task
- desktop metaphor for office workers
- paintbrush metaphor for artists...

Ensure emotional tone is appropriate to users
file deletion metaphor possible options:
  trashcan
  black hole
  paper shredder
  recycle bin
  furnace

Given a choice, choose the metaphor close to the way the system works…
Evaluating Metaphors

Consider probable consequences
– will metaphor restrict what people could actually do?
  eg: strict file/folder hierarchy vs system allows links between directories
– will metaphor believe that people can do more than what is possible?
  eg: agent-based systems, Eliza...

Consider how metaphors can evolve
is metaphor extensible to new features?
when is the metaphor no longer useful?

Overdoing Metaphors

Caveat
• metaphors can be overdone!

Common pitfalls
• overly literal
  – unnecessary fidelity
  – excessive interactions
• overly cute
  – novelty quickly wears off
• overly restrictive
  – cannot move beyond
• mismatched
  – does not match user’s task and/or thinking
Direct Engagement & Direct Manipulation

Direct Engagement
• the feeling of working directly on the task

Direct Manipulation
• An interface that behaves as though the interaction was with a real-world object rather than with an abstract system

Central ideas
• visibility of the objects of interest
• rapid, reversible, incremental actions
• manipulation by pointing and moving
• immediate and continuous display of results

Almost always based on a metaphor
• mapped onto some facet of the real world task semantics

Direct Engagement
Xerox Star: pioneered in late 70’s and early ’80s
= copied by almost everyone=

simulates desktop with icons
– in and out baskets
– file folders and documents
– calculators
– printers
– blank forms for letters and memos

small number of generic actions applicable system wide
– move, copy, delete, show properties, again, undo, help
  • eg same way to move text, documents, etc
– property sheets
  • pop-up form, alterable by user

what you see is what you get (WYSIWYG)
Xerox Star continued

Star's observations:

• objects understood in terms of their visual characteristics
  – affordances, constraints

• actions understood in terms of their effects on the screen
  – causality

• intuitively reasonable actions can be performed at any time
  – conceptual model

A subtle thing happens when everything is visible:
the display becomes reality

Object-Action

Select object, then do action

interface emphasizes 'nouns' (visible objects) rather than 'verbs' (actions)

Advantages

closer to real world
modeless interaction

actions always within context of object
  – inappropriate ones can be hidden

generic commands
  – the same type of action can be performed on the object
  – eg drag ‘n drop folders, files, paragraphs, text, numbers…
**Action-Object**

Select action, then, pick object

interface emphasizes ‘verbs’ (actions) rather than ‘nouns’ (visible objects)

**Advantages**

- Pick a setting and then you can reuse it easily.
- Often more efficient for user.

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**Touch- and Penabled- Screens and Sensors**

Direct manipulation can be even MORE direct in the age of touch and penabled screens…

What new metaphors are available? How does the line between science and magic blur as we interact with information in some software on these devices?

What things in reality can you stretch with your fingers? What about on your tablet?
Is direct manipulation the way to go?

Some potential disadvantages…
- Ill-suited for abstract operations
  - spell-checker?
- Tedium
  - manually search large database vs doing a basic query
- Task domain may not have adequate physical/visual metaphor
- Metaphor may be overly-restrictive

Solutions? Most systems will combine direct manipulation and abstractions…
for example, a typical word processor application
WYSIWYG document (direct manipulation)
buttons, menus, dialog boxes (abstractions, but direct manipulation “in the small”)

Conventional Applications: A Mix

Direct Engagement & Direct Manipulation
- Direct Engagement
  - the feeling of working directly on the task
- Direct Manipulation
  - An interface that behaves as though the interaction was with a real-world object rather than with an abstract system
- Central Ideas
  - visibility of the objects of interest
  - rapid, reversible, incremental actions
  - manipulation by pointing and moving
  - immediate and continuous display of results
- Almost always based on a metaphor
  - mapped onto some facet of the real world task semantics
Quick Recap (not exhaustive)

Good Representations
• captures essential elements of the event / world
• deliberately leaves out / mutes the irrelevant
• appropriate for the person, their task, and their interpretation

Metaphors
• uses our knowledge of the familiar and concrete to represent abstract concepts
• need not be literal
• has limitations that must be understood

Direct manipulation
• visibility of the objects of interest
• rapid, reversible, incremental actions
• manipulation by pointing and moving
• immediate and continuous display of results
• action-object -versus- object-action

These three components are the foundation of a true Visual Interface

Closing Thoughts...
"If a picture is worth 1000 words, then an interface is worth 1000 pictures."

Keep user tasks and goals in mind.

Encourage exploration but don't overwhelm the users.

Overview, zoom, filter, details on demand.