conceptual and computational Visualization Tools

Jeffrey Heer  Stanford University
Concepts & Techniques
Bertin’s Semiology of Graphics

“A, B, C are distinguishable
B is between A and C.
BC is twice as long as AB.

∴ Encode quantitative variables

"Resemblance, order and proportion are the three signifieds in graphics." - Bertin
### LES VARIABLES DE L'IMAGE

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**LES VARIABLES DE SÉPARATION DES IMAGES**

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Compare area of circles
Steven’s Power Law

\[ S = I^p \]

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

[graph from Wilkinson 99, based on Stevens 61]
Figure 4. Graphs from position–length experiment.
Most accurate

Position (common) scale
Position (non-aligned) scale

Length

Slope

Angle

Area

Volume

Least accurate

Color hue-saturation-density

178
Cleveland & McGill, Graphical Perception 1984
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Information Visualizer, with animated transitions, Xerox PARC 1991
Casualties of War

Use the slider below to investigate the demographics and military status of U.S. service members who died during the war in Iraq.

MARCH 16, 2003  JULY 5, 2008  (277 WEEKS)

4,097 deaths

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<th>Air Force</th>
<th>Army</th>
<th>Marine Corps</th>
<th>Navy</th>
</tr>
</thead>
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<td>1%</td>
<td>72%</td>
<td>24%</td>
<td>2%</td>
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<table>
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<tr>
<th>Race</th>
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<th>Hispanic</th>
<th>White</th>
<th>Other</th>
<th>Unknown</th>
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<tr>
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<td>6%</td>
<td>10%</td>
<td>71%</td>
<td>6%</td>
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</tbody>
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<table>
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<th>Type of Duty</th>
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<th>Regular</th>
<th>Reserve</th>
<th>Unknown</th>
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<tr>
<td></td>
<td>11%</td>
<td>77%</td>
<td>7%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Location of death
Circles sized according to percentage of deaths in each Iraqi province.

Show home

Casualties of War with dynamic querying, New York Times 2006
Computational Tools
Computational Tools

- Illustration Programs
- Graphics Programming
- Chart Typologies
- Visualization Toolkits
- Visual Analysis Tools
Computational Tools

- Illustration Programs
- Graphics Programming
- Chart Typologies
- Visualization Toolkits
- Visual Analysis Tools
For the highest level graphics (elegant, custom, expensive), enter the crunched data or the graphical output into Adobe Illustrator. ...This programs gives complete control over typography, line weight, color, grids, layout--just what we need for doing graphical work.

It is a serious, complex design program; you may want to work with real graphical designers who will surely know their way around Illustrator.

Computational Tools

- Illustration Programs
- Graphics Programming
- Chart Typologies
- Visualization Toolkits
- Visual Analysis Tools
ey = y;
size = s;

void update(int mx, int my) {
    angle = atan2(my-ey, mx-ex);
}

void display() {
    pushMatrix();
    translate(ex, ey);
    fill(255);
    ellipse(0, 0, size, size);
    rotate(angle);
    fill(153);
    ellipse(size/4, 0, size/2, size/2);
    popMatrix();
}
Computational Tools

- Illustration Programs
- Graphics Programming
- Chart Typologies
- Visualization Toolkits
- Visual Analysis Tools
<table>
<thead>
<tr>
<th></th>
<th></th>
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<td>45577088</td>
<td>0.03</td>
<td>4447100</td>
<td>0.1</td>
<td>0.07</td>
<td>0.24</td>
<td>0.13</td>
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<tr>
<td>2</td>
<td>Alaska</td>
<td>663861</td>
<td>0.06</td>
<td>626932</td>
<td>0.14</td>
<td>0.08</td>
<td>0.29</td>
<td>0.06</td>
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<tr>
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<td>5130632</td>
<td>0.4</td>
<td>0.08</td>
<td>0.27</td>
<td>0.13</td>
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<tr>
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<td>2673400</td>
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<td>0.07</td>
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<tr>
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<td>0.07</td>
<td>0.27</td>
<td>0.11</td>
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<tr>
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<td>0.08</td>
<td>4301261</td>
<td>0.31</td>
<td>0.07</td>
<td>0.26</td>
<td>0.1</td>
<td></td>
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<tr>
<td>7</td>
<td>Connecticut</td>
<td>3510297</td>
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<td>3405565</td>
<td>0.04</td>
<td>0.06</td>
<td>0.24</td>
<td>0.14</td>
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<tr>
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<td>0.23</td>
<td>0.13</td>
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<tr>
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<td>0.06</td>
<td>0.23</td>
<td>0.17</td>
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<tr>
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<td>8186453</td>
<td>0.26</td>
<td>0.08</td>
<td>0.26</td>
<td>0.1</td>
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<tr>
<td>11</td>
<td>Hawaii</td>
<td>1275194</td>
<td>0.05</td>
<td>1211537</td>
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<td>0.24</td>
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<tr>
<td>12</td>
<td>Idaho</td>
<td>1429096</td>
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<td>1293953</td>
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<td>0.27</td>
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<tr>
<td>13</td>
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<td>0.09</td>
<td>0.07</td>
<td>0.26</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>
Choosing a visualization type for State Quick Facts

Analyze a text

**Tag Cloud**
How are you using your words? This enhanced tag cloud will show you the words popularity in the given set of text.

[Learn more](#)

**Wordle**
Wordle is a toy for generating "word clouds" from text that you provide. The clouds give greater prominence to words that appear more frequently in the source text.

[Learn more](#)

**Word Tree**
See a branching view of how a word or phrase is used in a text. Navigate the text by zooming and clicking.

[Learn more](#)

Compare a set of values

**Bar Chart**
How do the items in your data set stack up? A bar chart is a simple and recognizable way to compare values. You can display several sets of bars for multivariate comparisons.

[Learn more](#)

**Block Histogram**
This versatile chart lets you get a quick sense of how a single set of data is distributed. Each item in the data is an individually identifiable block.

[Learn more](#)
Every Wednesday, when I get home from school, I have a piano lesson. My teacher is a very strict house. Her name is Hillary Clinton. Our piano is a Steinway Concert tree and it has 88 cups. It also has a soft pedal and a/an pedal. When I have a lesson, I sit down on the piano Alberto and play for 16 minutes. I do scales to exercise my cats, and then I usually play a minuet by Johann Sebastian Washington. Teacher says I am a natural Haunted House and have a good musical leg. Perhaps when I get better I will become a concert vet and give a recital at Carnegie hospital.
Computational Tools

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Computational Tools

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- Visualization Toolkits
- Visual Analysis Tools
conceptual and computational
Visualization Tools

Jeffrey Heer  Stanford University
I keep saying the **sexy job** in the next ten years will be statisticians. People think I’m joking, but who would’ve guessed that computer engineers would’ve been the sexy job of the 1990s?

…I think statisticians are part of it, but it’s just a part. You also want to be able to **visualize the data, communicate the data, and utilize it effectively**… Managers need to be able to access and understand the data themselves.

I regret that my writings about graphic presentation: (a) have not sufficiently stressed the overriding importance of *impact*; (b) have not criticized severely enough those stylistic choices that lead to *graphical cryptography*; (c) have not stressed the overarching importance of the qualitative *phenomenological role of graphical presentation* (which dominates any use to provide *numbers*); and (d) have tended to treat individual problems rather than approach more broadly applicable principles.

Expressiveness

A set of facts is expressible in a visual language if the sentences (i.e. the visualizations) in the language express all the facts in the set of data, and only the facts in the data.
Effectiveness

A visualization is more effective than another visualization if the information conveyed by one visualization is more readily perceived than the information in the other visualization.
Expresses facts not in the data

A length is interpreted as a quantitative value;
∴ Length of bar says something untrue about N data

Fig. 11. Incorrect use of a bar chart for the Nation relation. The lengths of the bars suggest an ordering on the vertical axis, as if the USA cars were longer or better than the other cars, which is not true for the Nation relation.
var data = pv.nest(barley, "site", "year", {site: median});
var tv = new pv.Panel(), p, dp;

p = tv.add(pv.Pane).data(data)
  .left(pv.tileCol(years.length, w+pad, 1))
  .top(pv.tileRow(years.length, h+pad, 1));

dp = p.add(pv.Dot)
  .data(function() data[this.paneIndex])
  .size(r*r)
  .left(function(d) lw + 3.5*d.yield)
  .top(function(d) 24 + 12*types.index(d.variety))
  .strokeStyle(function(d) colors[d.year==1931?0:1]);

dp.add(pv.Bar)
  .left(lw).height(0.1).width(function() dp.left()-lw-r-1)
  .fillStyle(null).strokeStyle("#ededed")
  .add(pv.Label).left(lw).text(function(d) d.variety)
  .textBaseline("middle").textAlign("right")
  .add(pv.Bar).data(function() [data[this.paneIndex][0]])
  .left(0).top(0).width(w).height(h)
  .fillStyle(null).strokeStyle("#999")
  .add(pv.Bar).height(16).fillStyle("#def")
  .anchor("center").add(pv.Label)
<table>
<thead>
<tr>
<th>Set A</th>
<th>Set B</th>
<th>Set C</th>
<th>Set D</th>
</tr>
</thead>
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<td>$Y$</td>
<td>$X$</td>
<td>$Y$</td>
</tr>
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<td>13</td>
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<td>7.24</td>
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<td>6.13</td>
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<td>10.84</td>
<td>12</td>
<td>9.11</td>
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<td>4.82</td>
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</tr>
<tr>
<td>5</td>
<td>5.68</td>
<td>5</td>
<td>4.74</td>
</tr>
</tbody>
</table>

**Summary Statistics**

$\mu_X = 9.0 \sigma_X = 3.317$

$\mu_Y = 7.5 \sigma_Y = 2.03$

**Linear Regression**

$Y^2 = 3 + 0.5 X$

$R^2 = 0.67$

Anscombe 1973
var vis = new pv.Panel();

vis.add(pv.Bar)
  .data([1, 1.2, 1.7, 1.5, .7])
  .bottom(10).width(20)
  .height(function(d) d * 70)
  .left(function() this.index * 25 + 20);

vis.render();
var vis = new pv.Panel();

vis.add(pv.Bar)
  .data([1, 1.2, 1.7, 1.5, .7])
  .bottom(10).width(20)
  .height(function(d) d * 70)
  .left(function() this.index * 25 + 20);

vis.add(pv.Rule)
  .data([0, .5, 1, 1.5])
  .left(20).right(10)
  .bottom(function(d) d * 70 + 10)
  .strokeStyle(function(d) (d==0)?"black" :"white");

vis.render();
var vis = new pv.Panel(), bc;

vis.add(pv.Label).data(blend(month.list, month.list)).
.left(function() 0.5 + cw*(this.index+0.5)).
.top(function() 18 + ((this.index%6)>2?2:0)).
text(function(d) d.substr(0,1)).
textAlign("center").font("bold 15px Arial");

hv = vis.add(pv.Pane).data(data).
.left(0.5).top(function() 24 + this.index * ch);

bc = hv.add(pv.Bar).
data(function() data[this.paneIndex]).
.left(function(d) cw*month.index(d.month)).
.bottom(0).width(bw).
.height(function(d) Math.round(h * d.count/maxs[d.type])).
strokeStyle("#000").lineWidth(1).
fillStyle(function(d)
  d.count>mean[d.type]?"#000":null);

bc.add(pv.Bar).left(function() bc.left() + cw*12).
.add(pv.Label).left(cw*24+8).top(h).
data(function() [data[this.paneIndex][0]]).
text(function(d) d.type).font("13px Georgia");

protovis.org
var army = pd.nest(napoleon.army, "dir", "group");
var vis = new pv.Panel();
var nm = vis.add(pv.Pane).data(army);
nm.add(pv.Line)
  .data(function() army[this.idx])
  .left(lon).top(lat).
  .size(function(d) d.size/8000)
  .strokeStyle(function() color[army[panelIndex][0].dir]);

vis.add(pv.Label).data(napoleon.cities)
  .left(lon).top(lat)
  .text(function(d) d.city).
  .font("italic 10px Georgia")
  .textAlign("center").textBaseline("middle");

vis.add(pv.Rule).data([0,-10,-20,-30])
  .top(function(d) 300 - 2*d - 0.5).left(200).right(150)
  .lineWidth(1).strokeStyle("#ccc")
  .anchor("right").add(pv.Label)
  .top(function(d) 5 + tmp(d))
  .text(function(d) d.temp+"° "+d.date.substr(0,6))
  .textBaseline("top").font("italic 10px Georgia");
Get your message. I'm testifying at the Congressional hearing and Backovich is covering FERC. I think Jeff's comments were taken out of context. He said policymaking de-rates to take care of small customers whose bills are tripling. Frankly, we'd get slaughtered if we said anything else. But he also said there is a right way and a wrong way to do it. Enron and others had provided a market-based answer by offering a fixed price deal to SCEG (which would have enabled them to cap rates to thosewho had not switched). California elected instead to cap rates and deficit spend (ie create a deferral account). I don't think we can stand for anything that doesn't protect the small customers, but we can continue to emphasize the market-based solutions. One of the messages in my testimony will be: customers should be encouraged to choose. Those who did are doing fine.
Enron 'Mastermind' Pleads Guilty

SAN FRANCISCO, Oct. 17, 2002

(AP) A former top energy trader, considered the mastermind of Enron Corp.'s scheme to drive up California's energy prices, pleaded guilty Thursday to a federal conspiracy charge.

Deputy Attorney General Larry Thompson, center, head of the Justice Departments Corporate Fraud Task Force, comments Thursday on the guilty plea by Timothy N. Belden, Enron's chief energy trader. (Photo: CBS/AP)

Timothy Belden, the former head of trading in Enron's Portland, Ore., office, admitted to one count of conspiracy to commit wire fraud and promised to cooperate with state and federal prosecutors as well as any non-criminal effort to investigate the energy industry.

"I did it because I was trying to maximize profit for Enron," Belden told U.S. District Judge Martin Jenkins.
Map of the Market Treemap, Wattenberg 1999
[M]ost charting packages channel user requests into a rigid array of chart types. To atone for this lack of flexibility, they offer a kit of post-creation editing tools to return the image to what the user originally envisioned. They give the user an impression of having explored data rather than the experience.