Tufte’s Design Principles

Information Visualization
April 28, 2008
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Housekeeping

- HISPOS registration from: 
  28.04.2008 - 16.05.2008

- Assignment 2 due on Wednesday
Semester Project

- Group size: 3-4 people
- Grading:
  - Initial project description submitted on time (5%)
  - Poster (15%)
  - Project presentation (15%)
  - Project report write-up (15%)
  - Overall project: quality of work, creativity, effort, thoroughness, etc. (50%).

A good project ...

- consist of visualization designs and a software artifact
- interaction is key! (-> running system is important)
- user testing and evaluation NOT expected
Data Sets

• Contests from InfoVis & Visual Analytics
• Many eyes
• Census webpage

Agenda

• Discuss the design principles that Edward Tufte advocates in his books
Graphical Excellence

- Principles
  - Graphical excellence is the well-designed presentation of interesting data---a matter of *substance*, of *statistics*, and of *design*.
  - Graphical excellence consists of complex ideas communicated with clarity, precision and efficiency.

Graphical Excellence

- Principles
  - Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
  - Graphical excellence is nearly always multivariate.
  - And graphical excellence requires telling the truth about the data.
Leveraging Human Capabilities

• Data graphics should complement what humans do well

“We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, list, abstract, scan, look over, sort, integrate, blend, inspect, filter, lump, skip, smooth, chunk, average, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flop through, browse, glance into, leaf through, skim, refine, enumerate, glean, synopsize, winnow the wheat from the chaff, and separate the sheep from the goats.”  Vol.2, page 50

Summary

• 1. Tell the truth
  – Graphical integrity
• 2. Do it effectively with clarity, precision...
  – Design aesthetics

Let’s look at each of these
1. Graphical Integrity

- Your graphic should tell the truth about your data

Example

Stock market crash?

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Chart Integrity

- Where’s baseline?
- What’s scale?
- What’s context?

Vol 1, p. 54 (1)

Where’s 0?
Note middle ‘70
Vol 1, p 54 (2)

What's being compared?

Vol 1, 57

Scale?
Vol 1, p. 61

Scale?

Vol 1, p. 74

Great work!
Watch Size Coding

- Height/width vs. area vs. volume
Vol 1, p. 69

**The Shrinking Family Doctor in California**

Percentage of doctors devoted solely to family practice:
- 1964: 27.0%
- 1975: 16.6%
- 1990: 12.6%

*Los Angeles Times, August 5, 1979, p. 3.*

area = value?

Vol 1, p. 62

**In the Barrel**

Price per 200,000 bbls of light crude, imported from Saudi Arabia:
- 1976: $14.55
- 1977: $14.55
- 1978: $14.55
- 1979: $14.55

*Time, April 9, 1979, p. 57.*

volume = value?
Measuring Misrepresentation

- Visual attribute value should be directly proportional to data attribute value

\[
\text{Lie factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}
\]

p.62 9.4 = \frac{4280}{454}

2. Design Aesthetics

- Set of principles to help guide designers
Design Principles

• Maximize data-ink ratio

Data ink ratio = \frac{\text{Data ink}}{\text{Total ink used in graphic}}

= proportion of graphic’s ink devoted to the non-redundant display of data-information

Vol 1, p. 94
More...

• Above all else, show the data
• Maximize the data-ink ratio
• Erase non-data-ink
• Erase redundant data-ink
• Revise and edit
More...

• Maximize data density

\[
\text{data density of graphic} = \frac{\text{number of entries in data matrix}}{\text{area of data graphic}}
\]

Quote from bottom of page 168, Vol. 1

Design Principles

• Avoid chartjunk
  – Extraneous visual elements that detract from message
  – Great narrative: Vol.2, bottom page 33-34
Vol 1, p 108

A classic

Vol 2, p.34

A classic
**Design Principles**

- Utilize multifunctioning graphical elements (macro/micro readings)
  - Graphical elements that convey data information and a design function

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**Vol 1, p. 141**

US Army Divisions going to France in WW I

Leonard P. Ayres
*The War with Germany*
1919
Vol 2, p. 36

Michel E. Turgot
Louis Bretz

Plan de Paris
1739

Vol 2, p. 37

Manhattan 1989
Manhattan Map Company
Viet Nam Memorial in Washington D.C.
Maya Ying Lin
58,000+ dead soldiers
Names listed chronologically by death

Design Principles

- Use small multiples
  - Repeat visually similar graphical elements nearby rather than spreading far apart
Vol 1, p. 170

23 hours of LA air pollution

Vol 1, p. 173

Chromosomes of man, chimpanzee, gorilla & orangutan
Vol 2, p. 68

How to draw letters

Vol 2, p. 69

Calligraphy
Design Principles

- Show mechanism, process, dynamics, and causality
  - Cause and effect are key
  - Make graphic exhibit causality

Vol 3, p. 144

Washington Post
Design Principles

• Escape flatland
  – Data is multivariate
  – Doesn’t necessarily mean 3D projection
Design Principles

• Utilize layering and separation
  – 1+1 = 3 or more
  – Good or bad
Here I have 2 equal strips of cardboard (3" x 6")

Here is one (vertical), have another (also vertical). Lining one strip plus one strip, we count 8 stripes:

$1 + 1 = 2$

We recognize the equals width of the strips.

Now, 1 width $\times$ 1 width (strips touching) equals 2 widths: $1 + 1 = 2$.

But now, separating them (both remain vertical) by 1 width — we count 3 widths (one of them negative): $1 + 1 = 3$.

Of the 2 vertical strips, one crosses the other horizontally in their centers.

Results: 2 lines form a crossing thus producing 4 arms, an 8 extensions, to be read inward as well as outward.

We also see 4 rectangles, and with some imagination, 4 triangles, 4 squares.

By shuffling colors and angles, arms and the in-between figures become unequal.

All together: one line plus one line results in many meanings — Quod erat demonstrandum.
**Design Principles**

- Utilize narratives of space and time
  - Tell a story of position and chronology through visual elements

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**Vol 1, p.43 & Vol 2, p 110**

Life of a beetle

L. Hugh Newman

Summer term 2008
Vol 2, p. 102

Czech air schedule

Vol 2, p. 103

China railway timetable
Design Principles

- **Content is king**
  - Quality, relevance and integrity of the content is fundamental
  - What’s the analysis task? Make the visual design reflect that
  - Integrate text, chart, graphic, map into a coherent narrative

Graph and Chart Tips

- Avoid separate legends and keys -- Just have that information in the graphic
- Make grids, labeling, etc., very faint so that they recede into background
Vol 2, p. 54

New Jersey Transit

### Table

<table>
<thead>
<tr>
<th>Train No.</th>
<th>From</th>
<th>To</th>
<th>Station</th>
<th>Departure</th>
<th>Arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td>X001</td>
<td>New York</td>
<td>NJ Transit</td>
<td>05:00</td>
<td>05:10</td>
<td></td>
</tr>
<tr>
<td>X002</td>
<td>New York</td>
<td>NJ Transit</td>
<td>05:15</td>
<td>05:25</td>
<td></td>
</tr>
<tr>
<td>X003</td>
<td>New York</td>
<td>NJ Transit</td>
<td>05:30</td>
<td>05:40</td>
<td></td>
</tr>
</tbody>
</table>

### Diagram

#### Before

Before

#### After

After

Summer term 2008

Vol 2, p. 63

Before

After

Summer term 2008
Using Color Effectively

• “The often scant benefits derived from coloring data indicate that even putting a good color in a good place is a complex matter. Indeed, so difficult and subtle that avoiding catastrophe becomes the first principle in bringing color to information: *Above all, do no harm.*”
Proper Color Use

- To label
- To measure
- To represent or imitate reality
- To enliven or decorate

Examples

- The bad...
"..despite its clever and multifunctioning data measure, formed by crossing two four-colored grids, this is a puzzle graphic. Deployed here, in a feat of technological virtuosity, are 16 shades of color spread on 3,056 counties, a monument to a sophisticated computer graphics system. But it is surely a graphic experienced verbally not visually. Over and over, the viewers must run little phrases through their minds, trying to maintain the right pattern of words to make sense of the visual montage: “Now let’s see, purple represents counties where there are both high levels of male cardiovascular disease mortality and 11.6 to 56.0 percent of the households have more than 1.01 persons per room..."
“Color’s multidimensionality can also enliven and inform what users must face at computer terminals, although some color applied to display screens has made what should be a straight-forward tool into something that looks like a grim parody of a video game.”

Summer term 2008

Vol 2, p. 88
Examples

- The good...
Vol 2, p. 91 & Vol 3, p. 76

Swiss Mountain Map

Vol 2, p. 80

Swiss Mountain Map
Guides for Enhancing Visual Quality

- Attractive displays of statistical info
  - have a properly chosen format and design
  - use words, numbers and drawing together
  - reflect a balance, a proportion, a sense of relevant scale
  - display an accessible complexity of detail
  - often have a narrative quality, a story to tell about the data
  - are drawn in a professional manner, with the technical details of production done with care
  - avoid content-free decoration, including chartjunk

Information Overload

What about confusing clutter? Information overload? Doesn’t data have to “boiled down” and “simplified”? These common questions miss the point, for the quantity of detail is an issue completely separate from the difficulty of reading. Clutter and confusion are failures of design, not attributes of information. Often the less complex and less subtle the line, the more ambiguous and less interesting is the reading. Stripping the detail out of data is a style based on personal preference and fashion, considerations utterly indifferent to substantive content. Vol. 2, p. 51
Minard graphic

Graphical Displays Should

- Show the data
- Induce the viewer to think about substance rather than about methodology, graphic design the technology of graphic production, or something else
- Avoid distorting what the data have to say
- Present many numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- Be closely integrated with statistical and verbal descriptions of a data set
Sources Used

E. Tufte, *The Visual Display of Quantitative Information*
E. Tufte, *Envisioning Information*
E. Tufte, *Visual Explanations*