Design Principles

Alark Joshi
Design Excellence

• “Well designed presentations of interesting data are a matter of substance, of statistics, and of design.”
  – Edward Tufte
Tufte’s Principles for Graphical Integrity

1. The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented.

2. Clear, detailed and thorough labeling should be used to defeat graphical distortion and ambiguity.

3. Write out explanations of the data on the graphic itself. Label important events in the data.
Tufte’s Principles for Graphical Integrity

4. In time-series displays of money, deflated and standardized units of monetary measurement are nearly always better than nominal units.

5. Show data variation not design variation

6. The number of information-carrying (variable) dimensions depicted should not exceed the number of dimensions in the data
every time you make a powerpoint

edward tufte kills a kitten
Design Principles

• Use Decomposition

Beer sales
Hierarchical Display
Show Context

100 combat deaths per month

Iraq

M. Ericson, NY Times
Maximize Data-Ink Ratio

- Data-ink = ink used to show data
- Data-ink ratio = data-ink/ total ink used
Maximize Data-Ink Ratio

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Data Density

- Data density = \( \frac{\text{number of entries in data array}}{\text{area of data graphic}} \)
Data Density - Sparklines

• Sparklines are simple, word-sized graphics
• Show trends and allow users to understand the presented data better

Credits: Edward Tufte, Beautiful Evidence
Sparklines – Spreadsheets & Dashboards
Avoid Chartjunk

- Extraneous visual elements that distract from the message
Avoid Chartjunk
Avoid Chartjunk
Bring in the Clowns

World Population in 2008
A better representation

World Population in 2008

- China
- India
- United States
- Indonesia
- Brazil
- Pakistan
- Bangladesh
- Nigeria
- Russia
- Japan
Tufte’s Design Principles

- Above all else show the data
- Maximize data-ink ration
- Eliminate non-data ink
- Eliminate redundant data ink
- Revise and Edit
Subjective Dimensions

• Aesthetics – Attractive things are perceived as more useful than unattractive ones
• Style – Communicates brand, process, who the designer is
• Playfullness – Encourages experimentation and exploration
• Vividness – Can make a visualization more memorable
Design Elements
CRAP
Contrast
Repetition
Alignment
Proximity
Contrast

Before

After

Credits: Presentation Zen, G. Reynolds
Contrast

Mobile phone internet connectivity rate

Japan: 94%
South Korea: 89%
U.S.A.: 34%
France: 13%
U.K.: 13%
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Repetition

Faces of the Dead

Each United States service member who has died in Iraq or Afghanistan and been identified by the Defense Department is represented by a small square to the right. The squares are ordered by date of death, with the most recent deaths appearing in the upper left corner.

Learn about the individuals by clicking on any square to see information about that person. Or search for a person by last name, home state or hometown. Search results are ordered by date of death.

<table>
<thead>
<tr>
<th>Last Name</th>
<th>State</th>
<th>Hometown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter Last Name</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By GABRIEL DANCE, ARON PILHOFER, ANDY LEHREN and JEFF DAMENS

Alignment

Before

After

Credits: Stephen Few
Proximity

Q1 2003 Planned vs. Actual Sales by Region

Credits: Stephen Few
Scalar Data

Alark Joshi
Topology

- If points are arbitrarily distributed and there is no connectivity between them, the data is called scattered.
- Otherwise, data is composed of cells bounded by grid lines.
- **Topology** specifies the connectivity of data.
- Geometry specifies the position of the data.
Topology

- Properties of geometric shapes that remain unchanged even when under distortion

Same geometry (vertex positions), different topology (connectivity)
Topologically equivalent

- Things that can be transformed into each other by stretching and squeezing, without tearing or sticking together bits which were previously separated.
Types of grids

• **Uniform grids** are similar to Cartesian grids
• Consist of equal cells but with different resolution in at least one dimension (dx ≠ dy ≠ dz)
• Typical example is medical imaging data that consists of slices
  – Slice images with square pixels (dx = dy)
  – Larger slice distance (dz > dx = dy)
Types of grids

- **Rectilinear grids**
- Topology is still regular but irregular spacing between grid points
- Topology is still implicit
Types of grids

• **Curvilinear grids**
  – Topology is still regular but irregular spacing between grid points
  – Topology is implicit, but vertex positions are explicitly stored
Scalar Data Visualization
Basic Strategies

• Mapping to geometry
  – Function plots
  – Height fields
  – Isolines and isosurfaces

• Color coding

• Techniques for 3D scalar data
  – Volume visualization
  – Slicing

• Visualization method depends heavily on dimensionality of domain
Function Plots

- Function plot for a 1D scalar field
  \[ \{(s, f(s)) \mid s \in \mathbb{R}\} \]
  - Points
  - 1D manifold: line
  - Errors bars possible
Function Plots

- Gnuplot examples
Function plots for 2D scalar field

- Points
- 2D manifold: surfaces

- Surface representations
  - Wireframe
  - Hidden lines
  - Shaded surface
Function plots for 2D scalar field

- Shaded surface
Isolines

- Visualization of 2D scalar fields
- Given a scalar function $f: \Omega \to R$ and a scalar value $c \in R$
- Isoline consists of points $\{(x, y)|f(x, y) = c\}$
- If $f()$ is differentiable and $\operatorname{grad}(f) \neq 0$ then isolines are curves
- Contour lines

Image credits: http://giscommons.org/?page_id=18
Isolines
Isolines

- Pixel by pixel contouring
- Straightforward approach: scan all pixels for equivalence with isovalue
- Input: $f : (1, \ldots, x_{\text{max}}) \times (1, \ldots, y_{\text{max}}) \to R$
- Isovalues $I_1, \ldots, I_n$ and isocolors $c_1, \ldots, c_n$
- Algorithm:

```plaintext
for all $(x, y) \in (1, \ldots, x_{\text{max}}) \times (1, \ldots, y_{\text{max}})$ do
  for all $k \in \{1, \ldots, n\}$ do
    if $|f(x, y) - I_k| < \varepsilon$ then
      draw $(x, y, c_k)$
```
Color coding

• Easy to apply colors to 1D and 2D scalar fields
  – Map color each pixel on a 1D input signal or 2D image
Color coding

• Example:
  – Separate color table to visualize the brain
  – Separate color table to visualize the tissue
Interpolation

- Linear interpolation
  \[ x = x_1 \times \frac{x-x_0}{x_1-x_0} + x_0 \times \frac{x_1-x}{x_1-x_0} \]

- Bilinear interpolation
  \[ P'(x, y) = P(1,1) \times (1 - d) \times (1 - d') + P(1,2) \times d \times (1 - d') + P(2,1) \times d' \times (1 - d) + P(2,2) \times d \times d' \]
Interpolation

Nearest Neighbor Binary

Trilinear Interpolation Smooth/Weighted