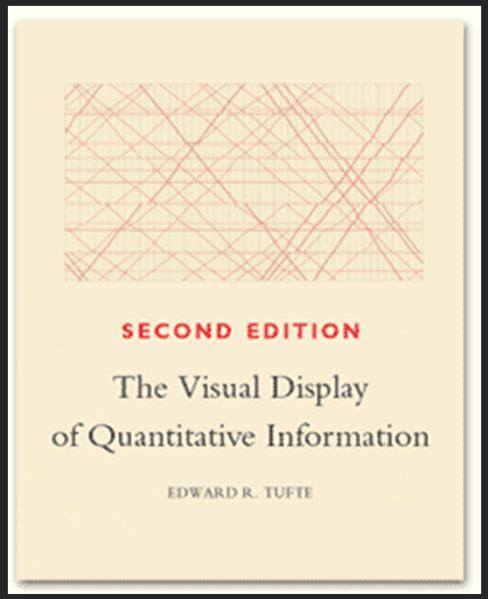
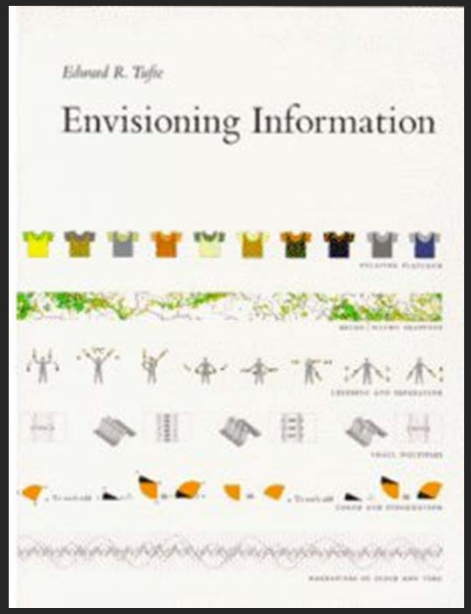
Design Principles

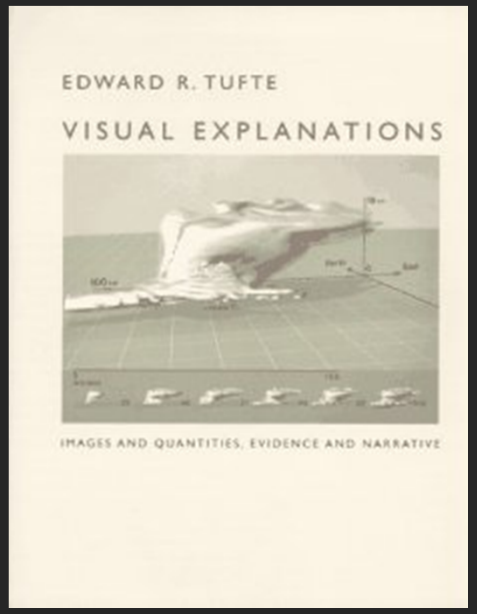
Alark Joshi

Design Excellence

- "Well designed presentations of interesting data are a matter of substance, of statistics, and of design."
  - Edward Tufte





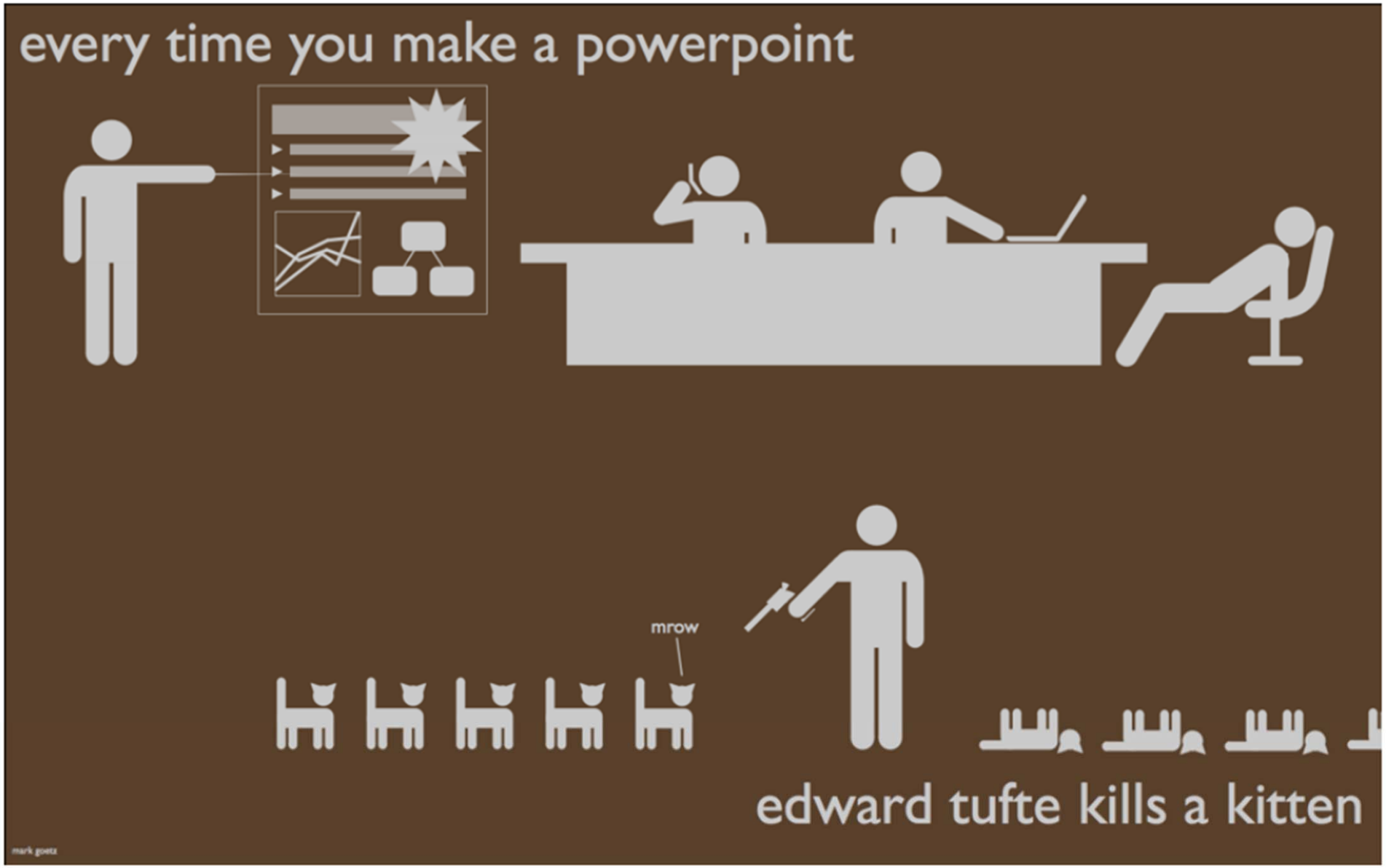


Tufte's Principles for Graphical Integrity

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

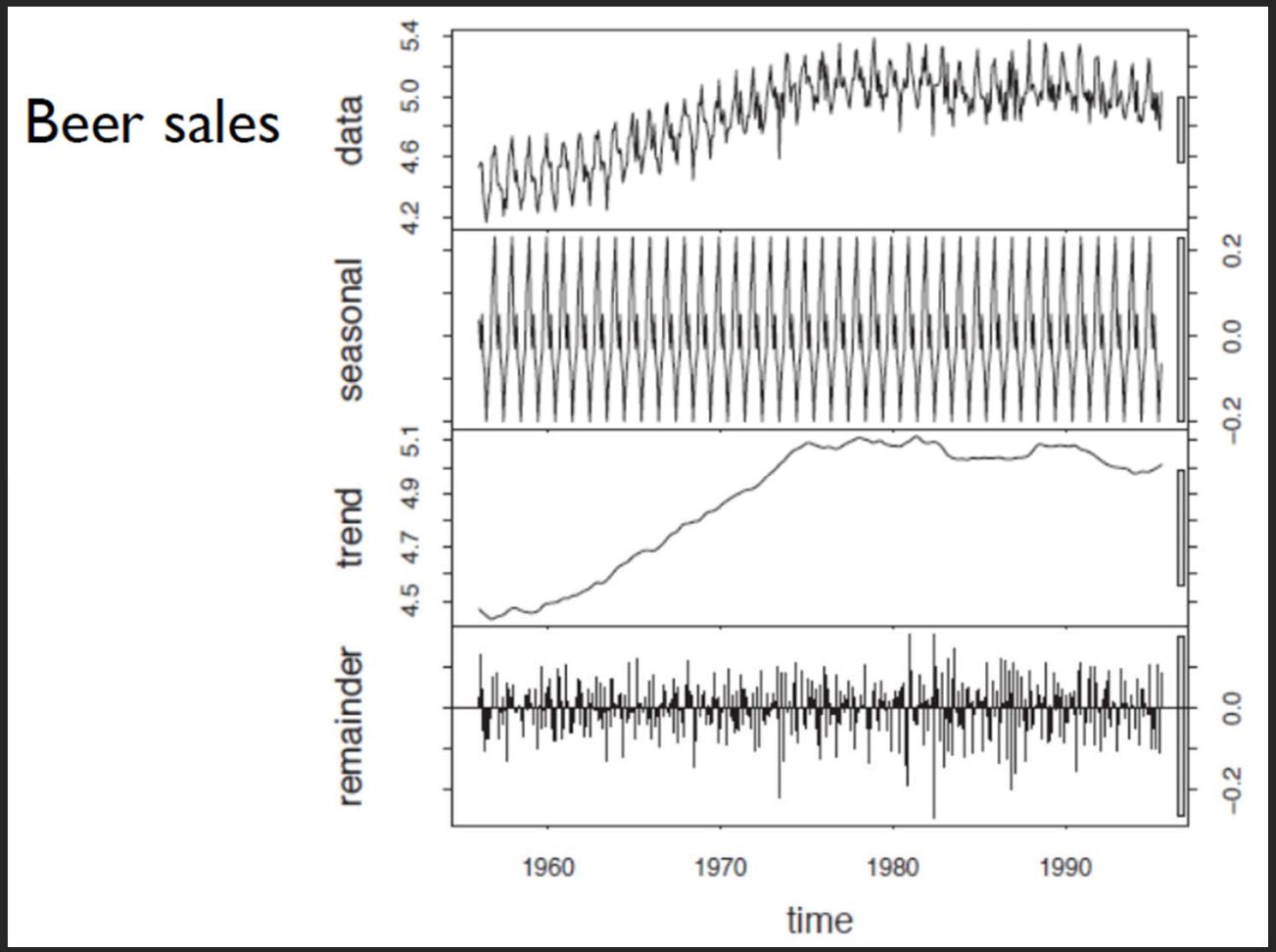
4. In time-series displays of money, deflated and standardized units of monetary measurement are nearly always better than nominal units.
5. Show data variation not design variation
6. The number of information-carrying (variable) dimensions depicted should not exceed the number of dimensions in the data


every time you make a powerpoint
mrow
edward tufte kills a kitten
mark goetz

Mark Goetz

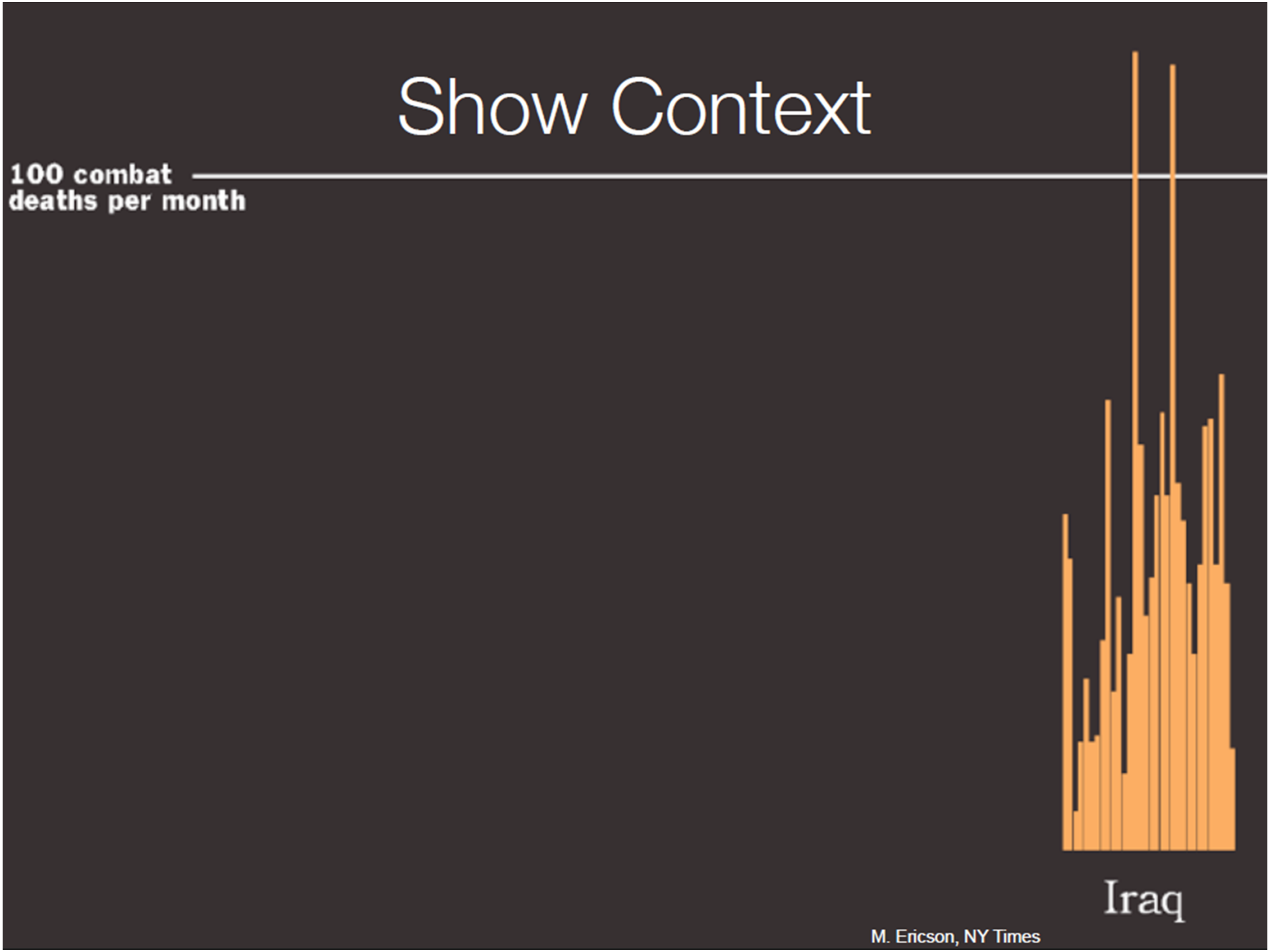
Design Principles

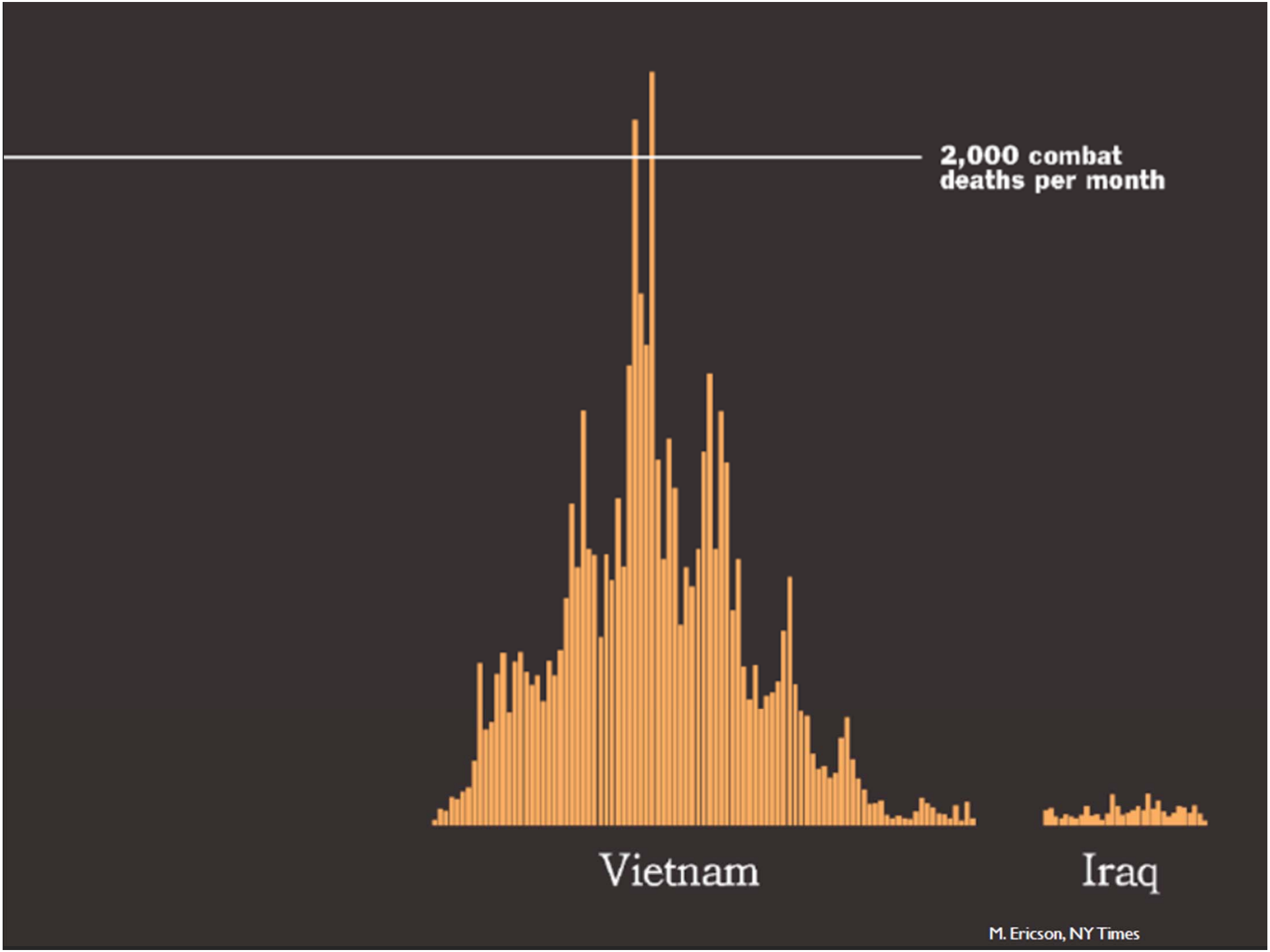
- Use Decomposition

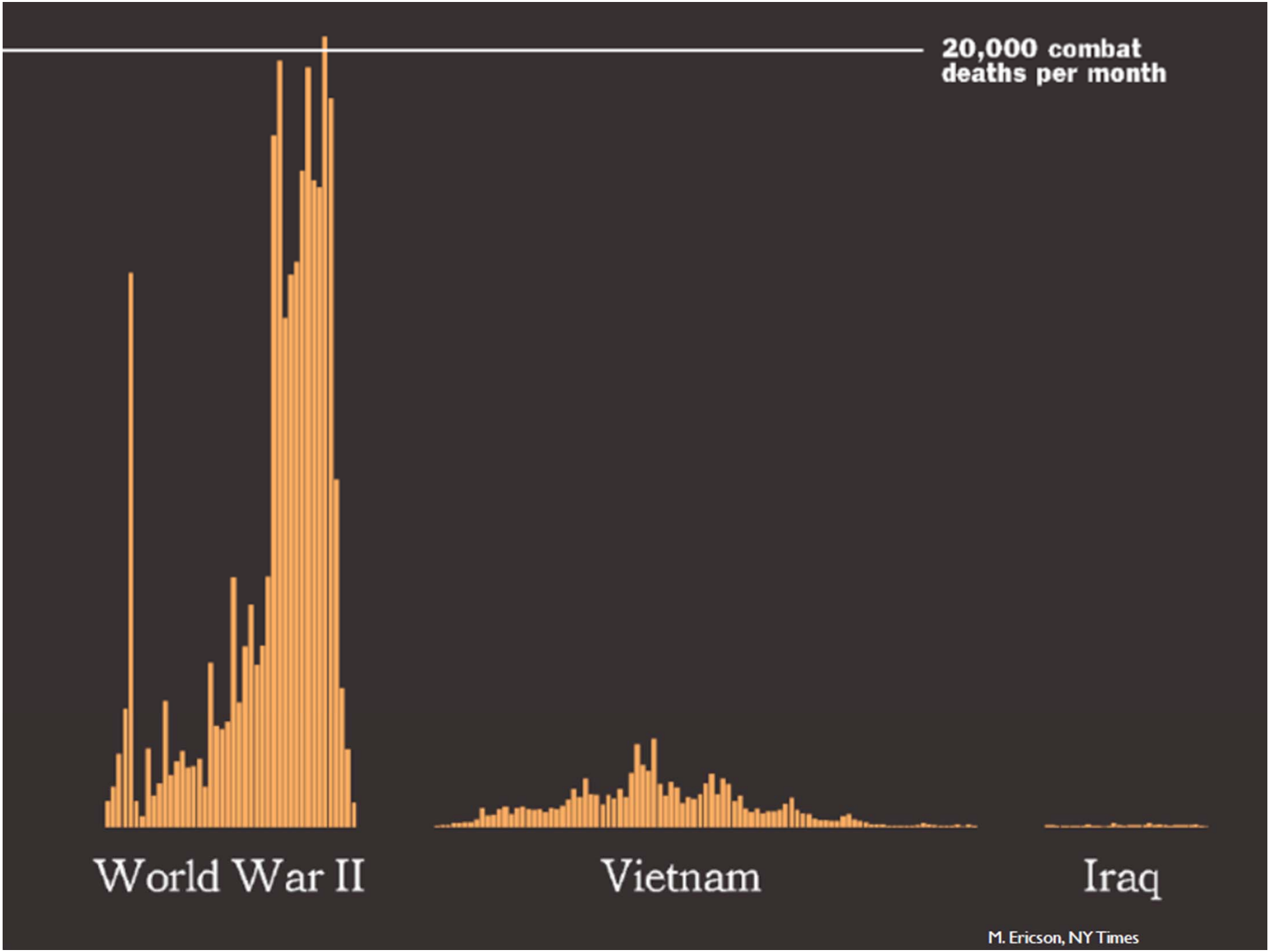


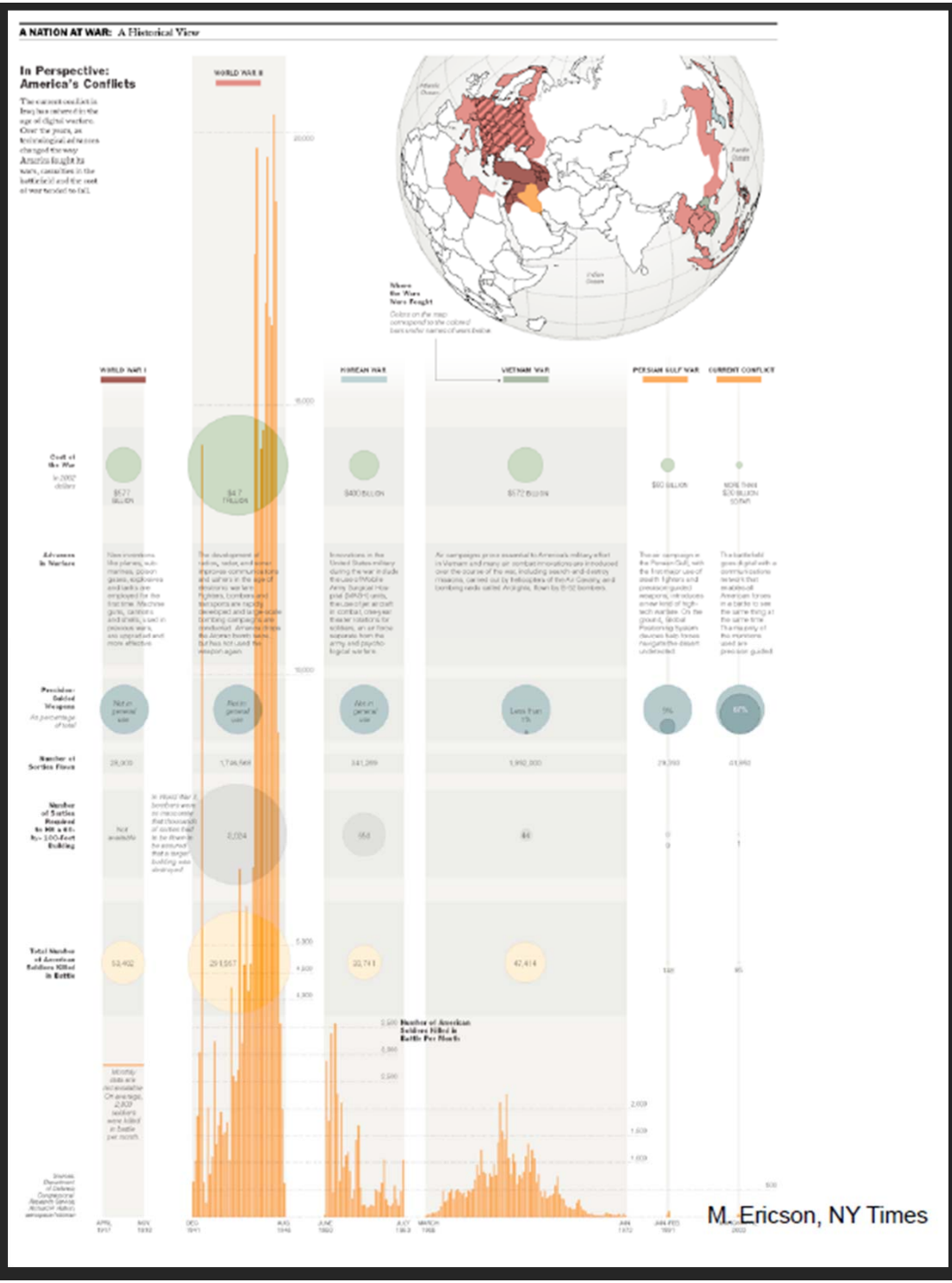
Hierarchical Display

Show Context



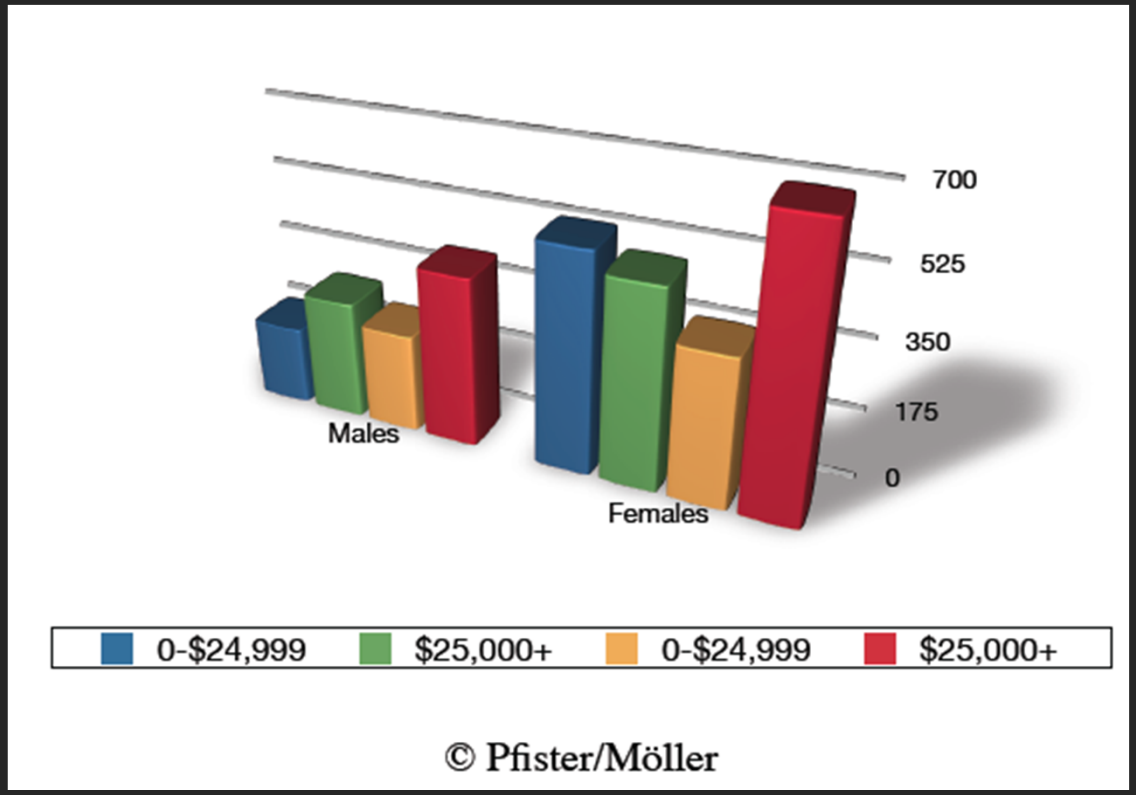

2,000 combat deaths per month
Vietnam
Iraq
M. Ericson, NY Times


20,000 combat deaths per month
World War II
Vietnam
Iraq
M. Ericson, NY Times


A NATION AT WAR: A Historical View
In Perspective: America's Conflicts
WORLD WAR II
WORLD WAR I
KOREAN WAR
VIETNAM WAR
PERSIAN GULF WAR
CURRENT CONFLICT
Where the Wars Were Fought
Cost of the War
Advances in Warfare
Precision-Guided Weapons
Number of Sorties Flown
Number of Battles Required to Hit a 60-by-100-Foot Building
Total Number of American Soldiers Killed in Battle
Number of American Soldiers Killed in Battle Per Month
M. Ericson, NY Times

Maximize Data-Ink Ratio

- Data-ink = ink used to show data
- Data-ink ratio = data-ink/ total ink used



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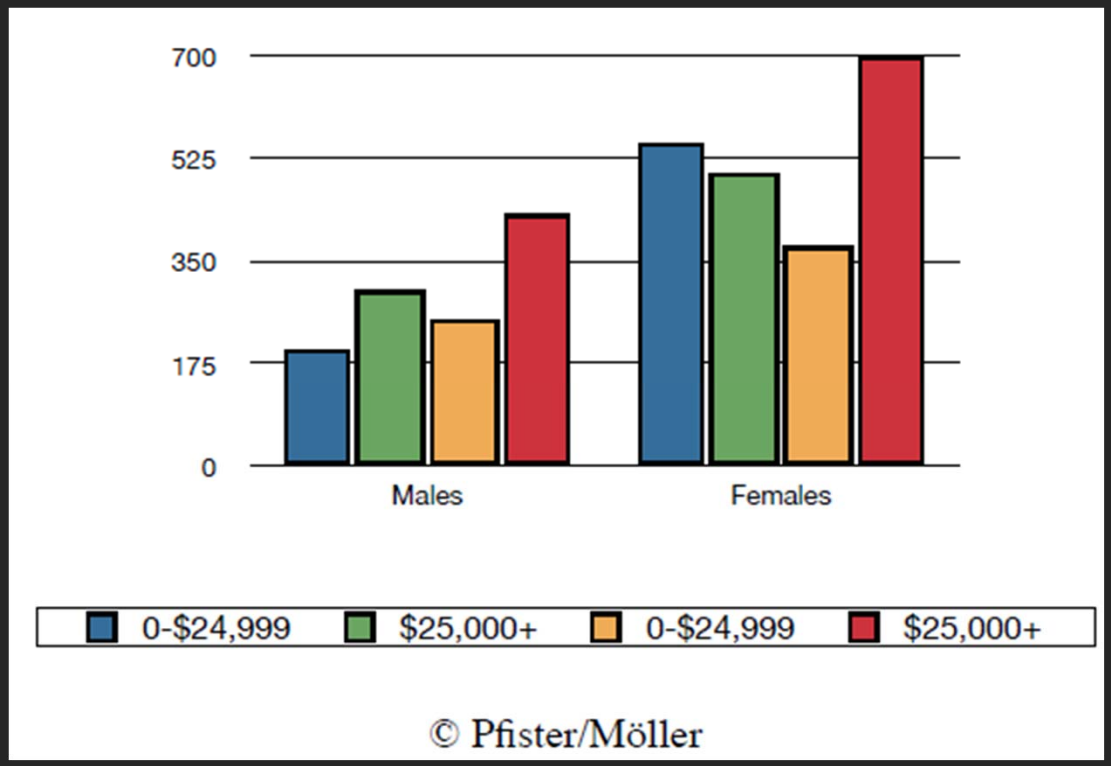
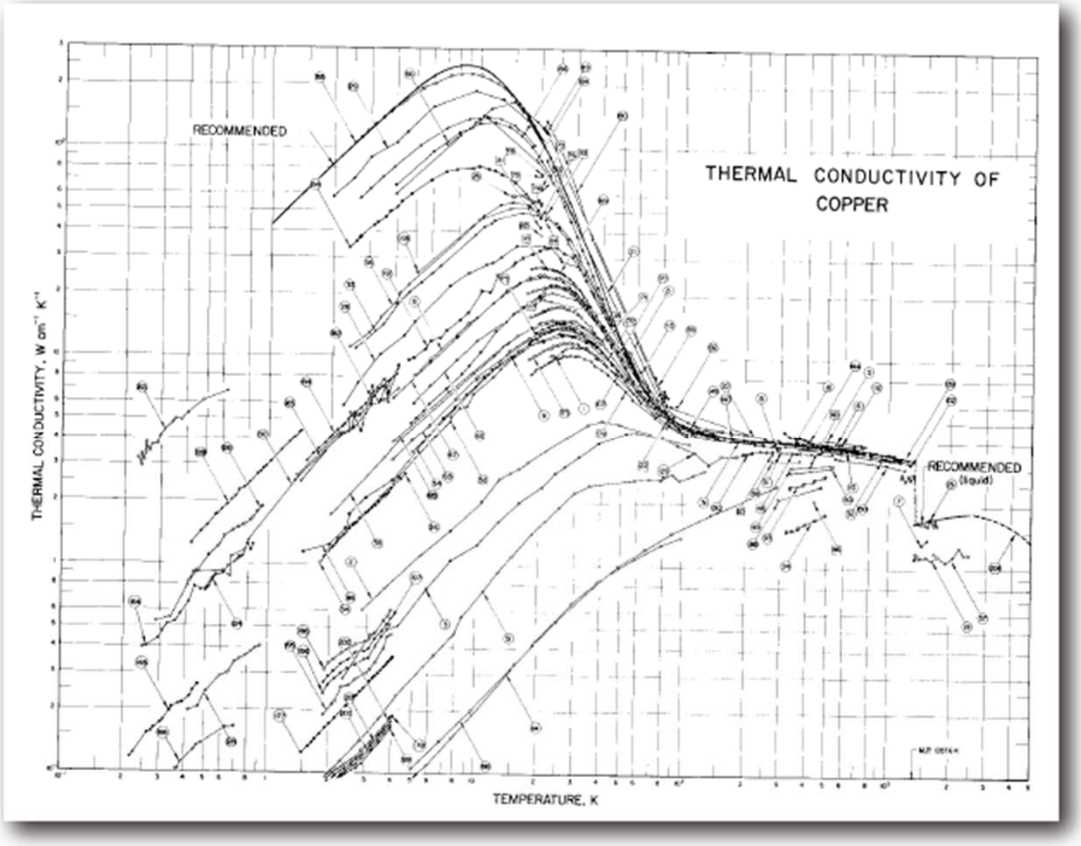


Data Density

- Data density = $\frac{\text{number of entries in data array}}{\text{area of data graphic}}$



Ho et al., "Thermal Conductivity of the Elements: A Comprehensive Review" J. Phys. Chem. 1974

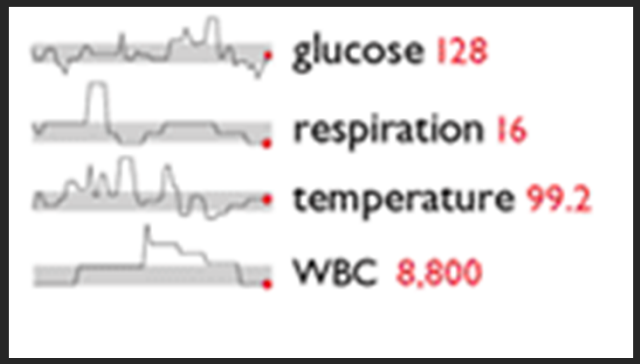
Data Density - Sparklines

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

Shows past 80 readings

Highlights specific data element

Shows normal range of glucose



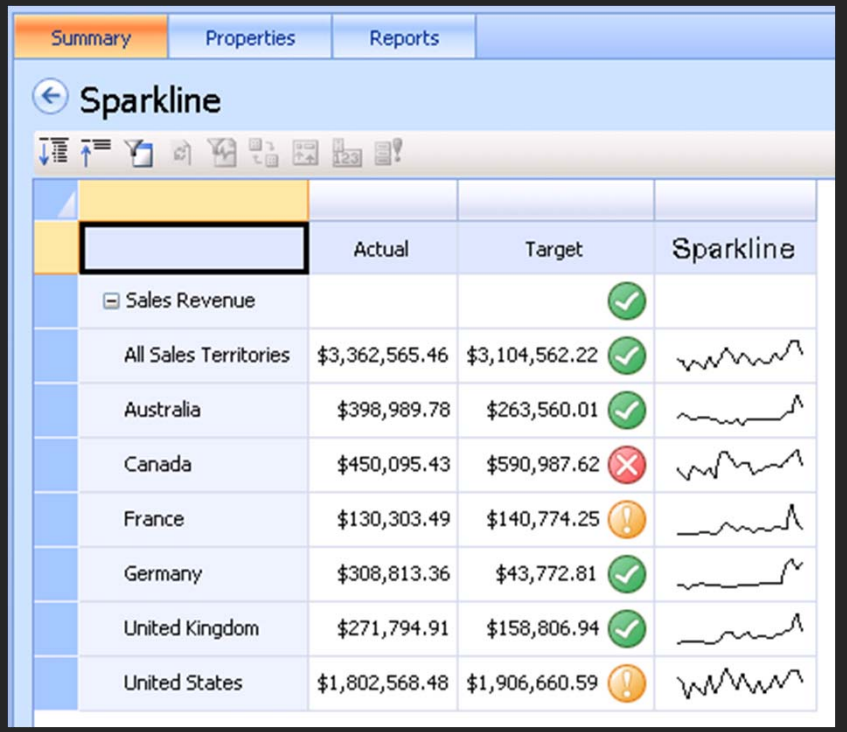
Credits: Edward Tufte, Beautiful Evidence

Sparklines – Spreadsheets & Dashboards

		Close	Max	Min
AT&T		40,28	41,34	33,30
Boeing		98,15	100,59	84,79
Citigroup		53,98	55,20	48,27
Exxon Mobil		85,94	85,94	69,56
General Electric		38,12	38,12	34,09
General Motors		34,66	36,20	28,85
Intel		24,24	24,24	18,76
Microsoft		30,49	31,11	26,63

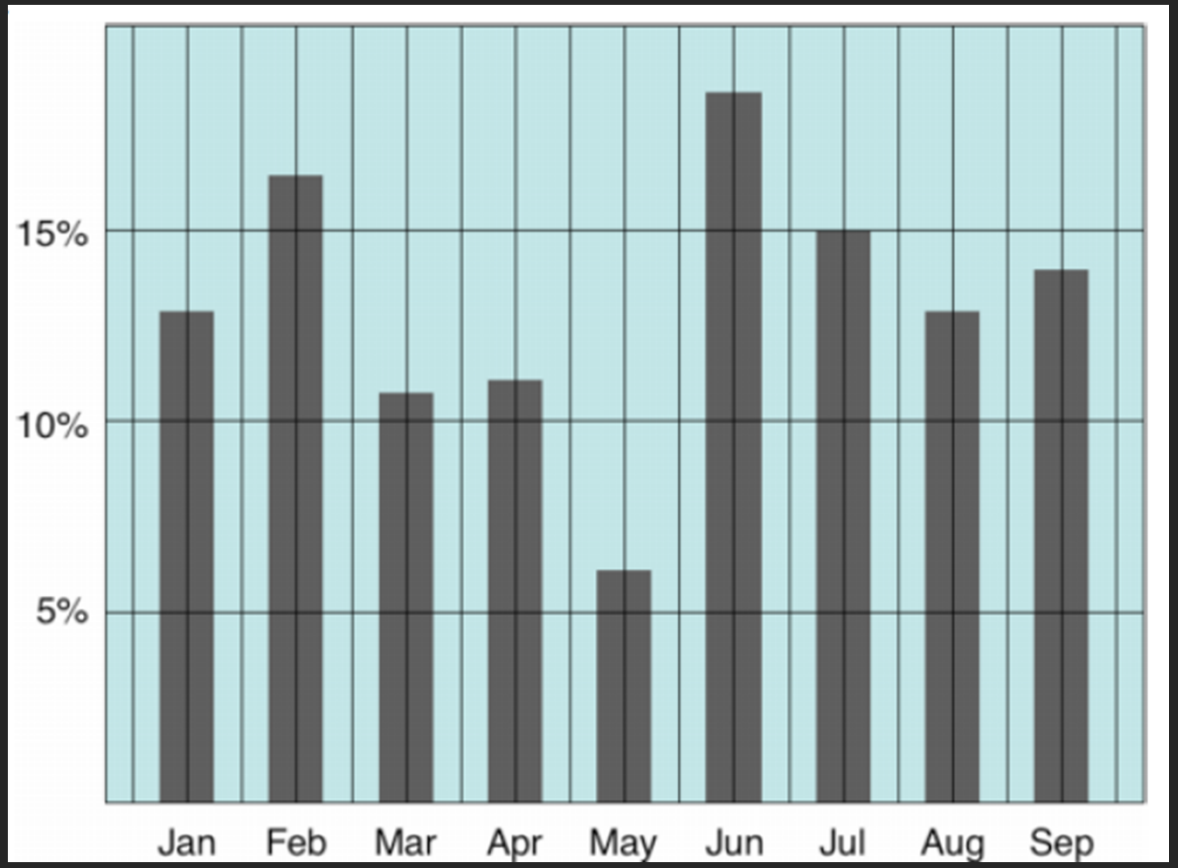
Top 10 Application Software Companies by Market Cap

	1/2/2009 - 12/7/2009	low	high	open	close	Market Cap ($B)
MSFT		15.28	29.98	20.33	29.57	264.5
ORCL		14.47	22.86	18.41	21.91	112.7
SAP		31.81	51.75	36.62	44.47	54
ADBE		16.7	36.51	23.02	36.08	19
CA		15.95	23.71	18.9	21.91	11.7
INTU		22.65	30.39	24.4	29.32	9.5
CRM		26.05	66.13	34.02	64.14	8.2
BMC		25.33	39.13	27.65	38.16	7.1
RHT		13.43	28.63	13.99	27.73	5.3
VRSN		18.05	24.26	20.62	22.11	4.3

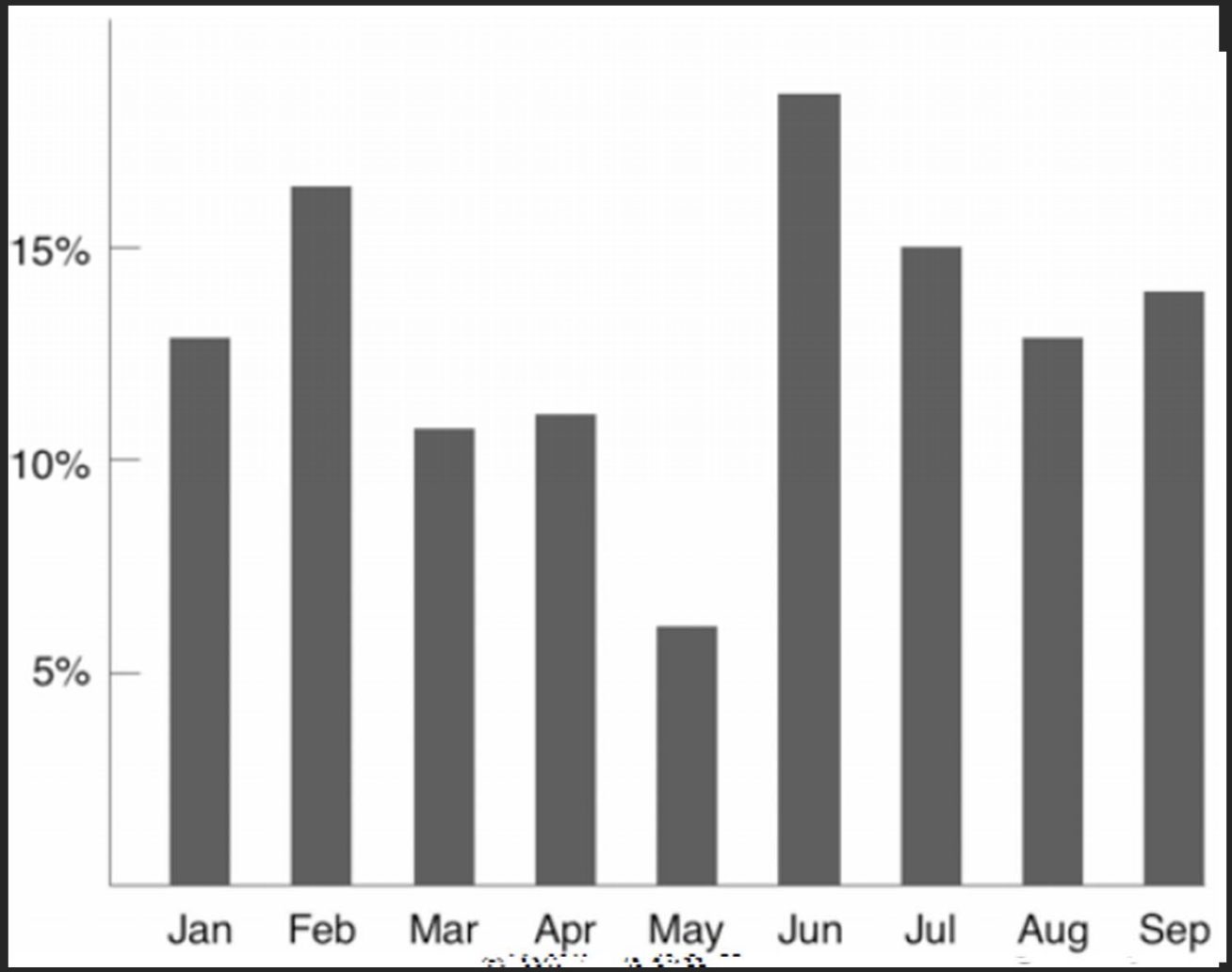


Avoid Chartjunk

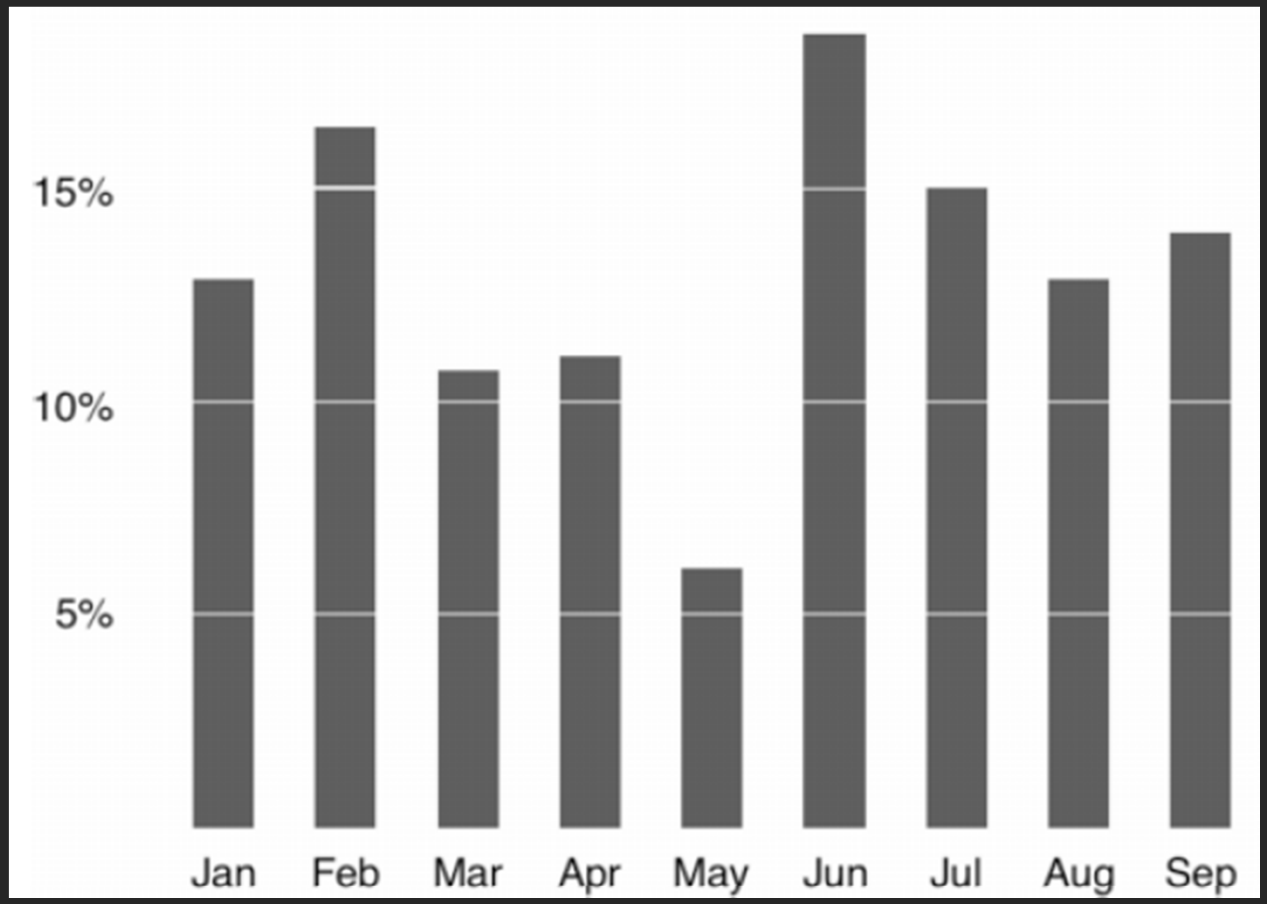
- Extraneous visual elements that distract from the message



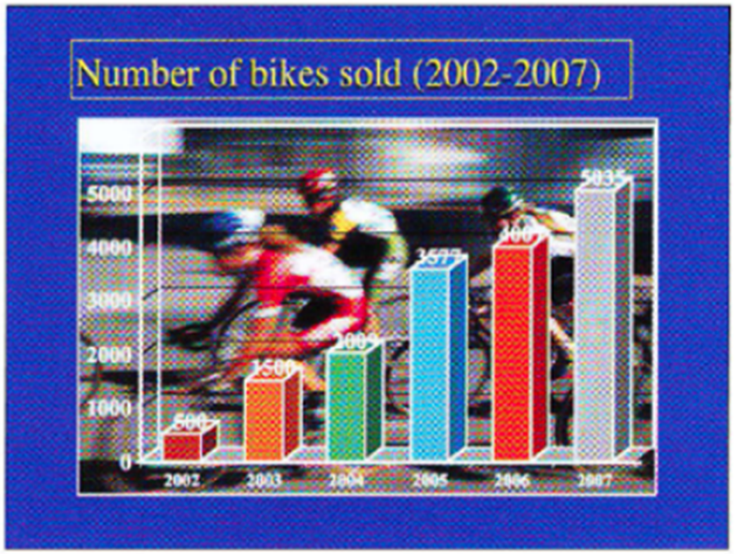
Avoid Chartjunk



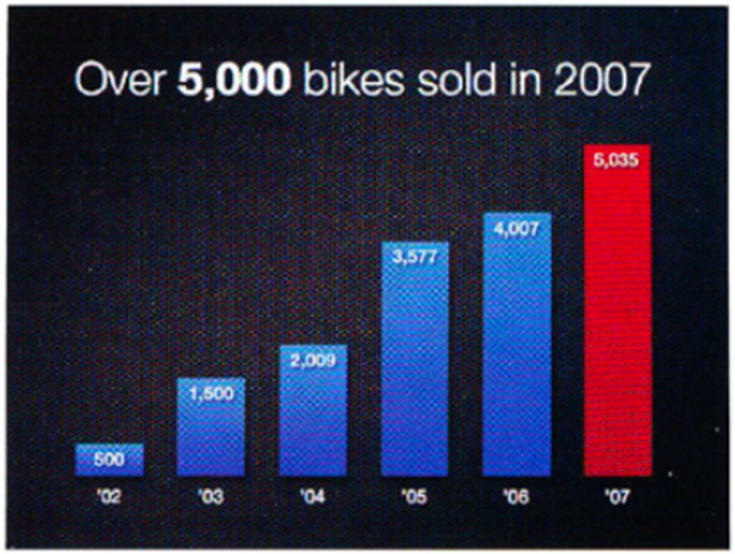
Avoid Chartjunk

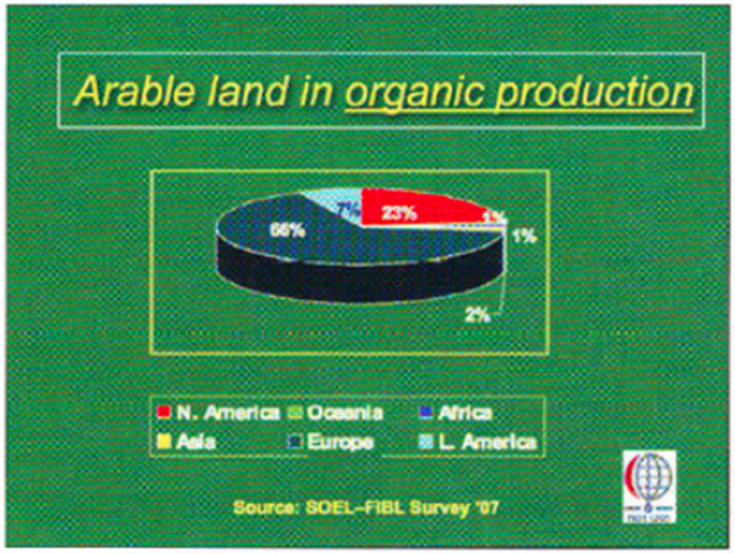


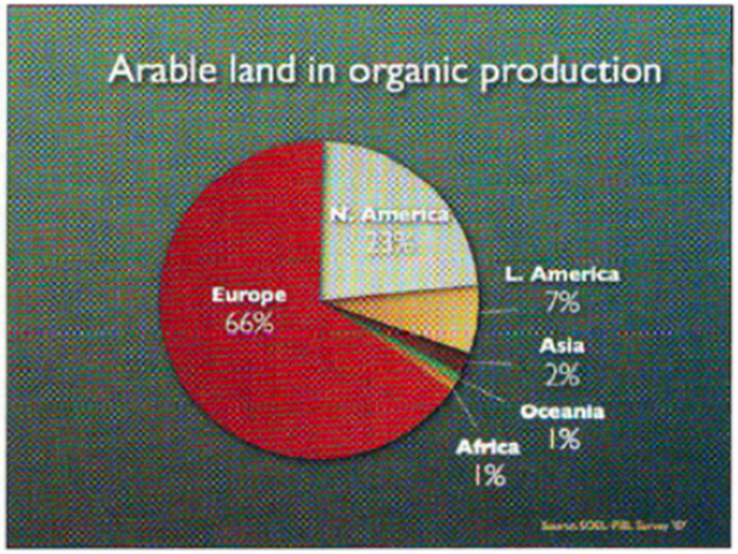
Before



After

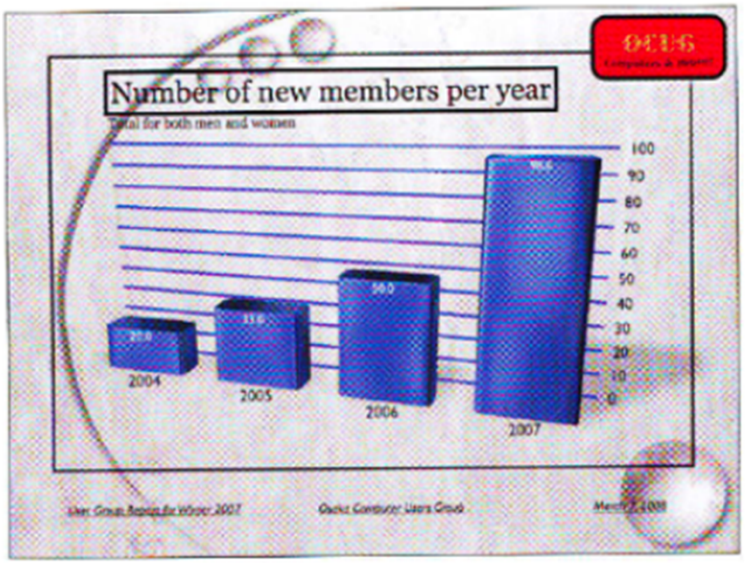




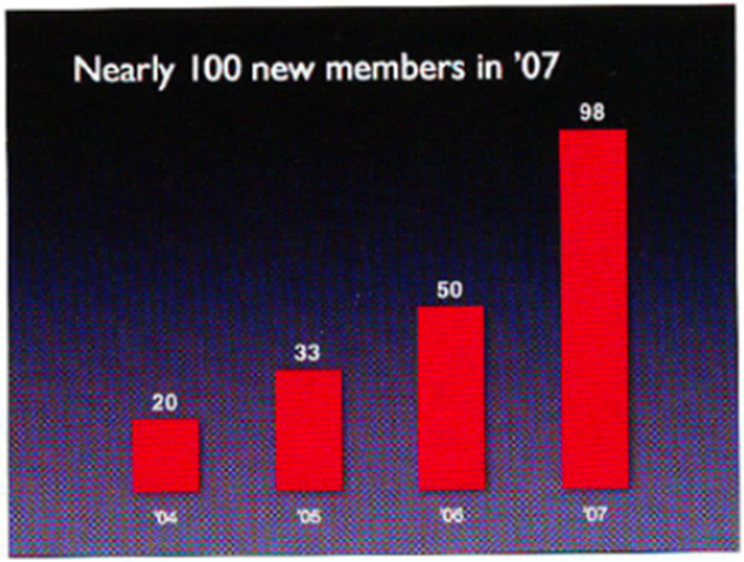


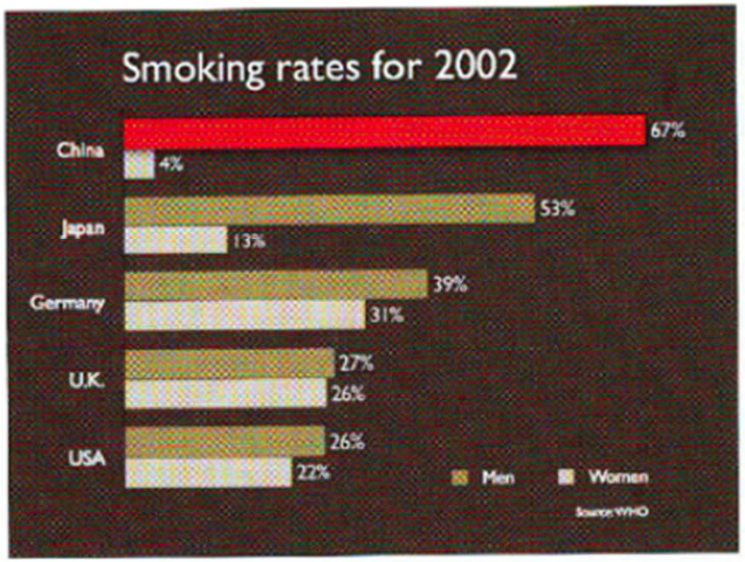
G. Reynolds, Presentation Zen

Before



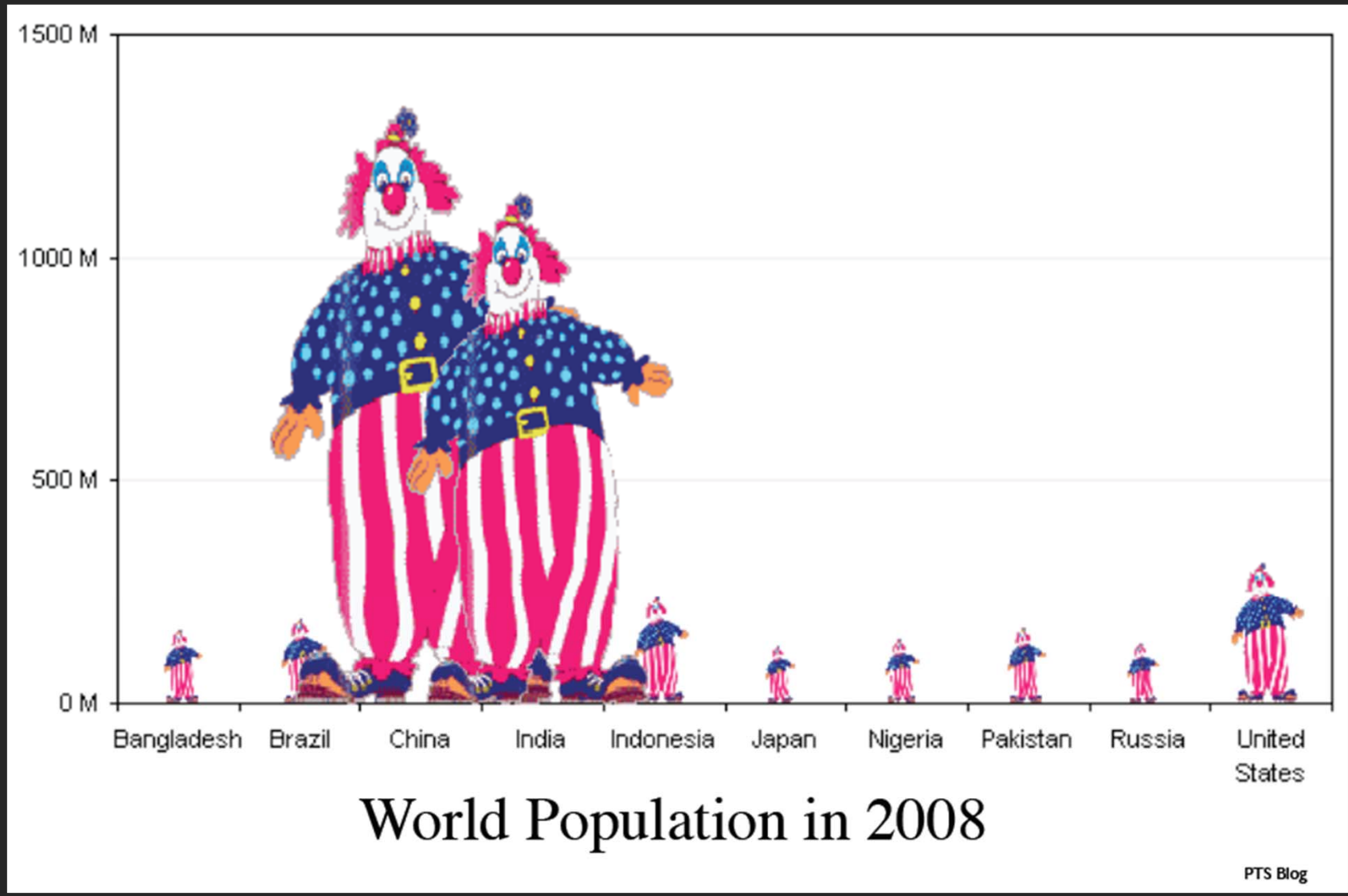
After



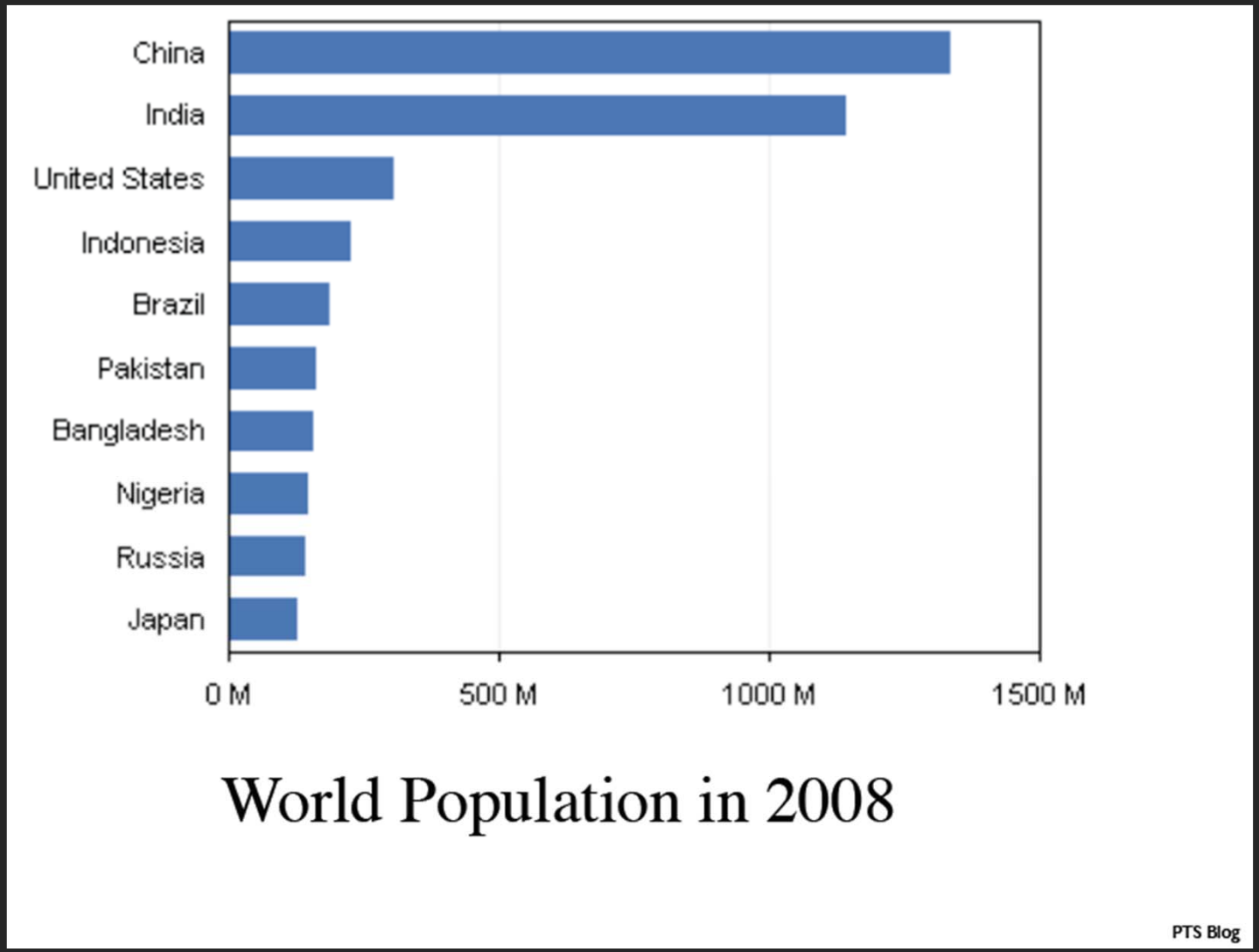


G. Reynolds, Presentation Zen

Bring in the Clowns



A better representation



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

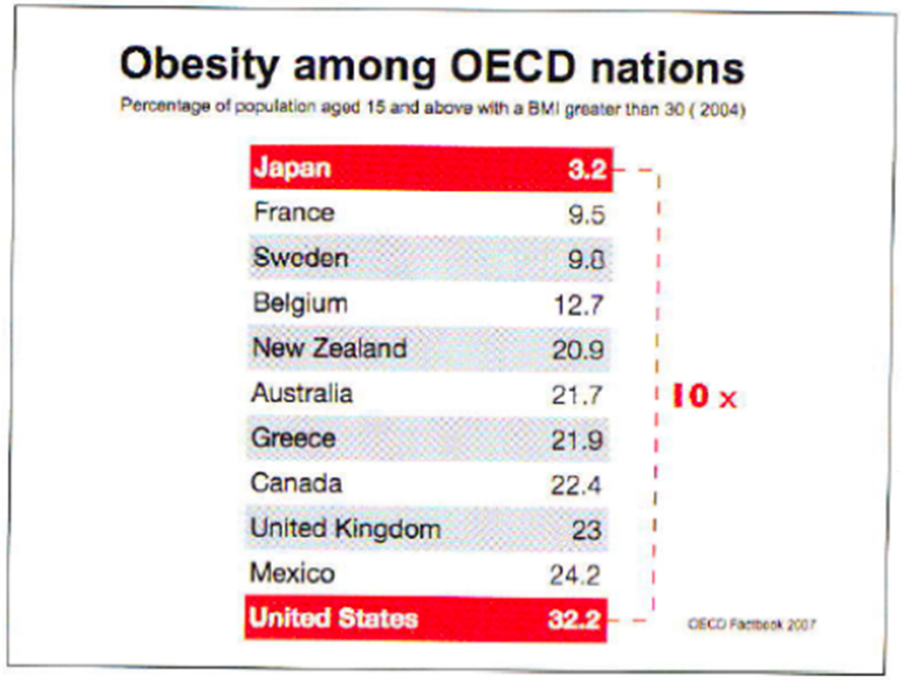
CRAP

Contrast
Repetition
Alignment
Proximity

Contrast

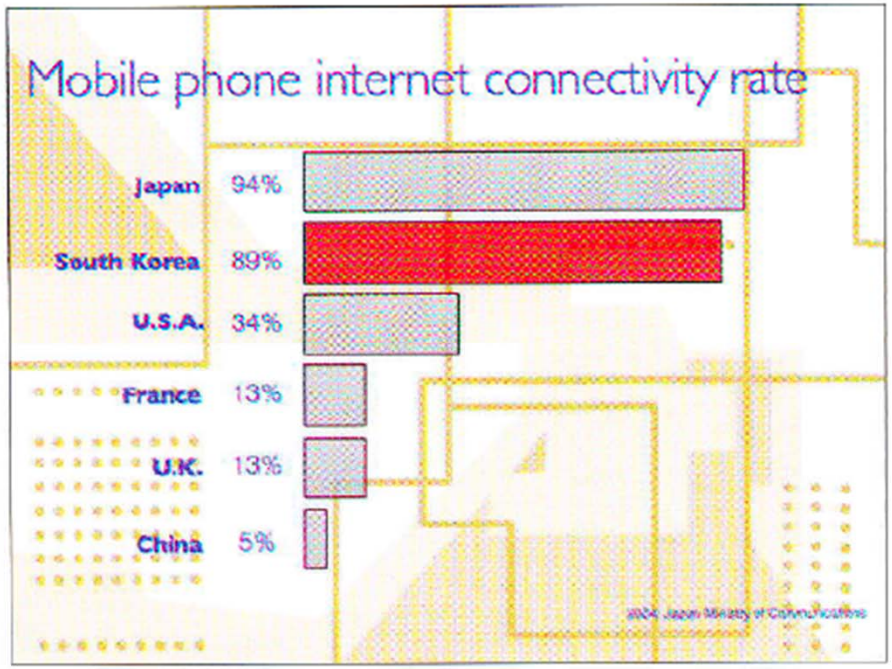
Before

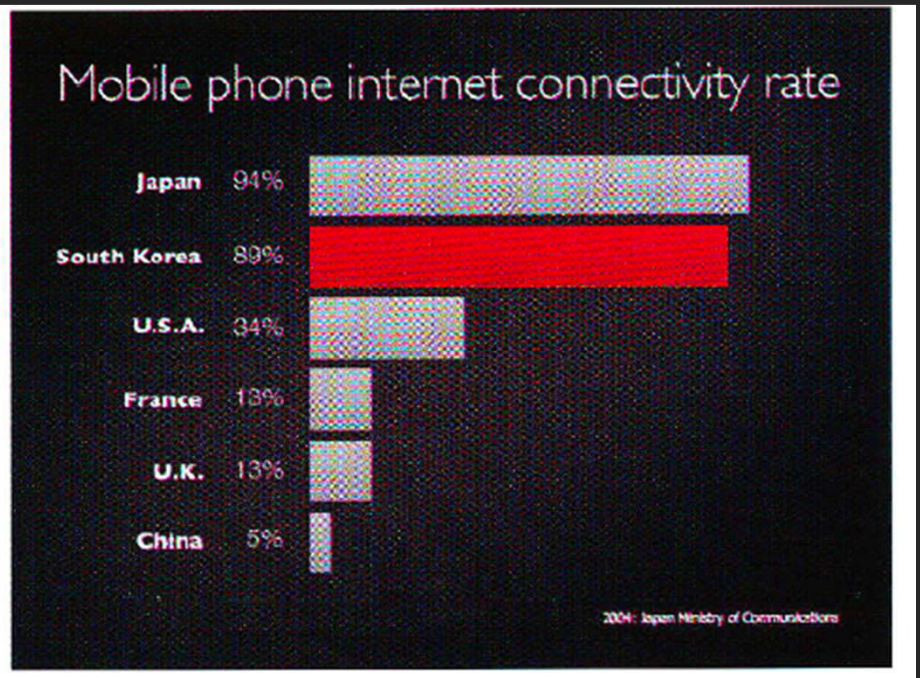
After



Credits: Presentation Zen, G. Reynolds

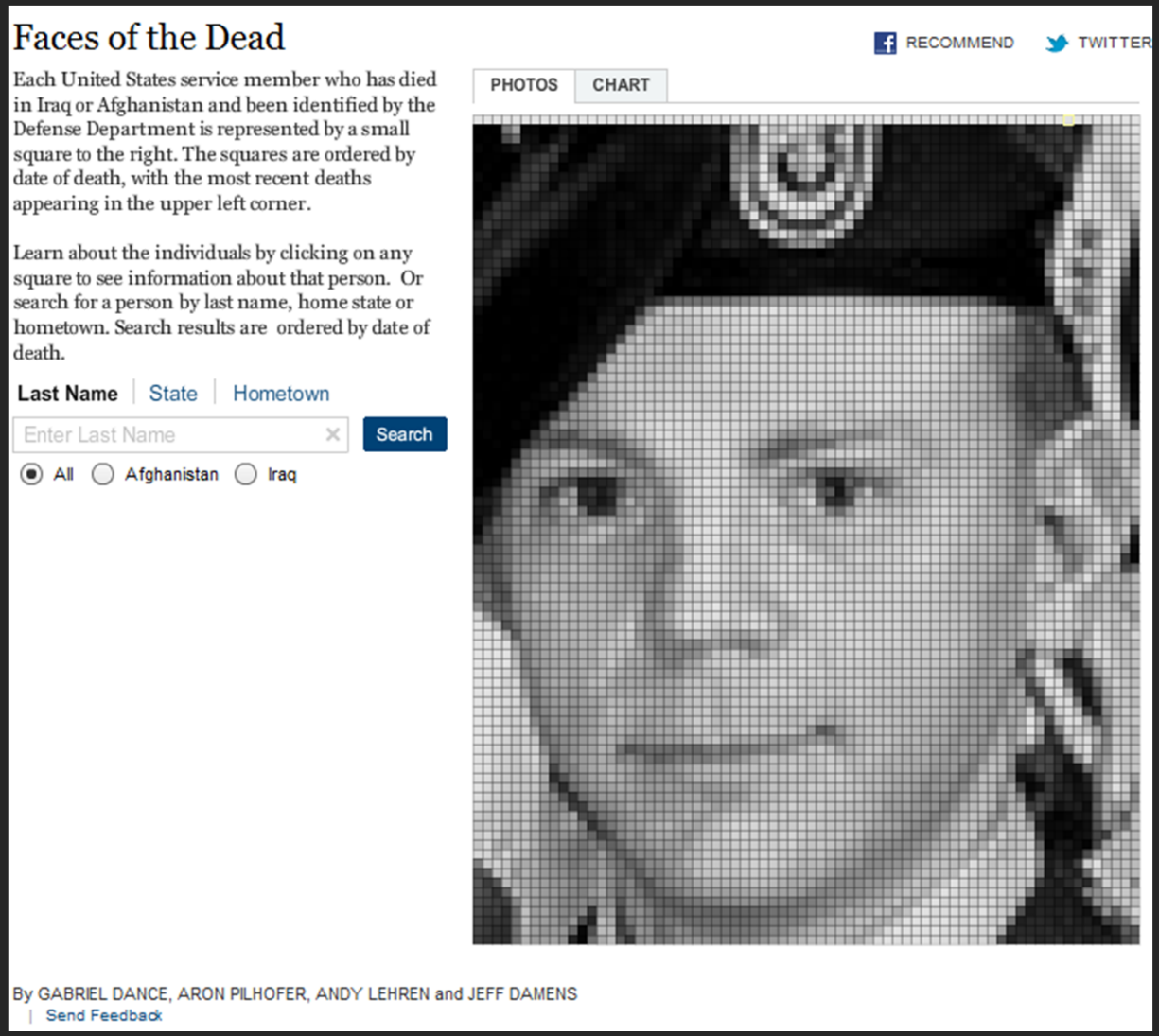
Contrast





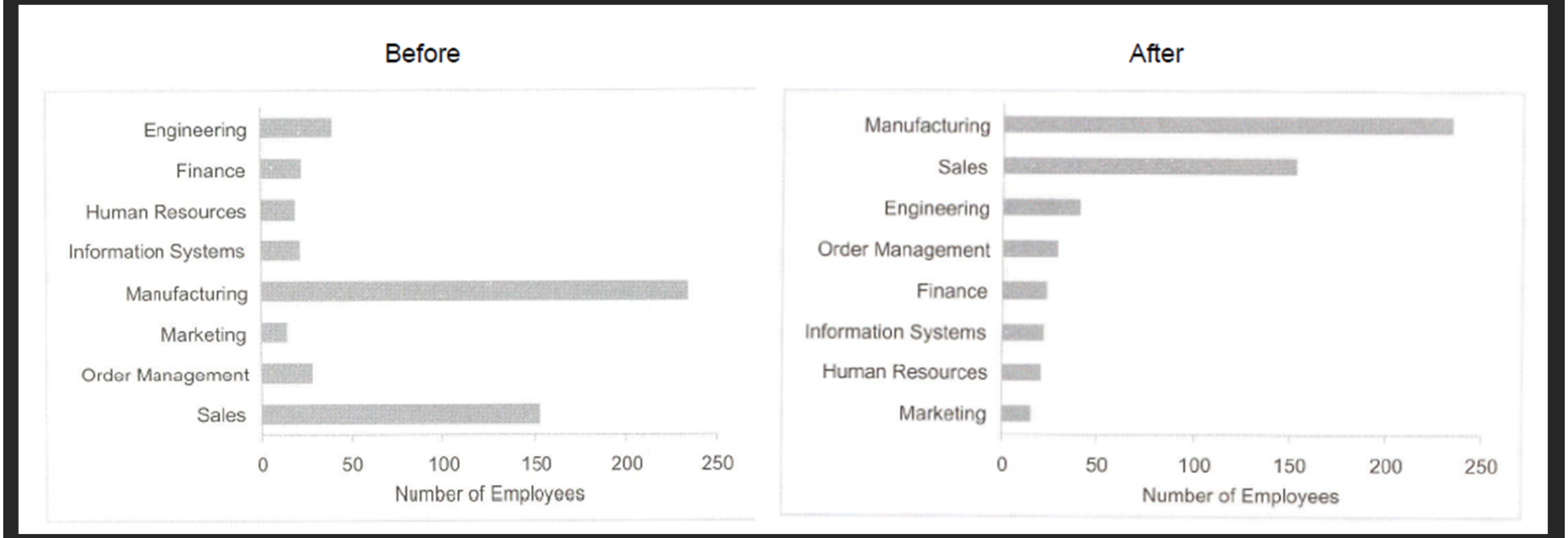
Credits: Presentation Zen, G. Reynolds

Repetition



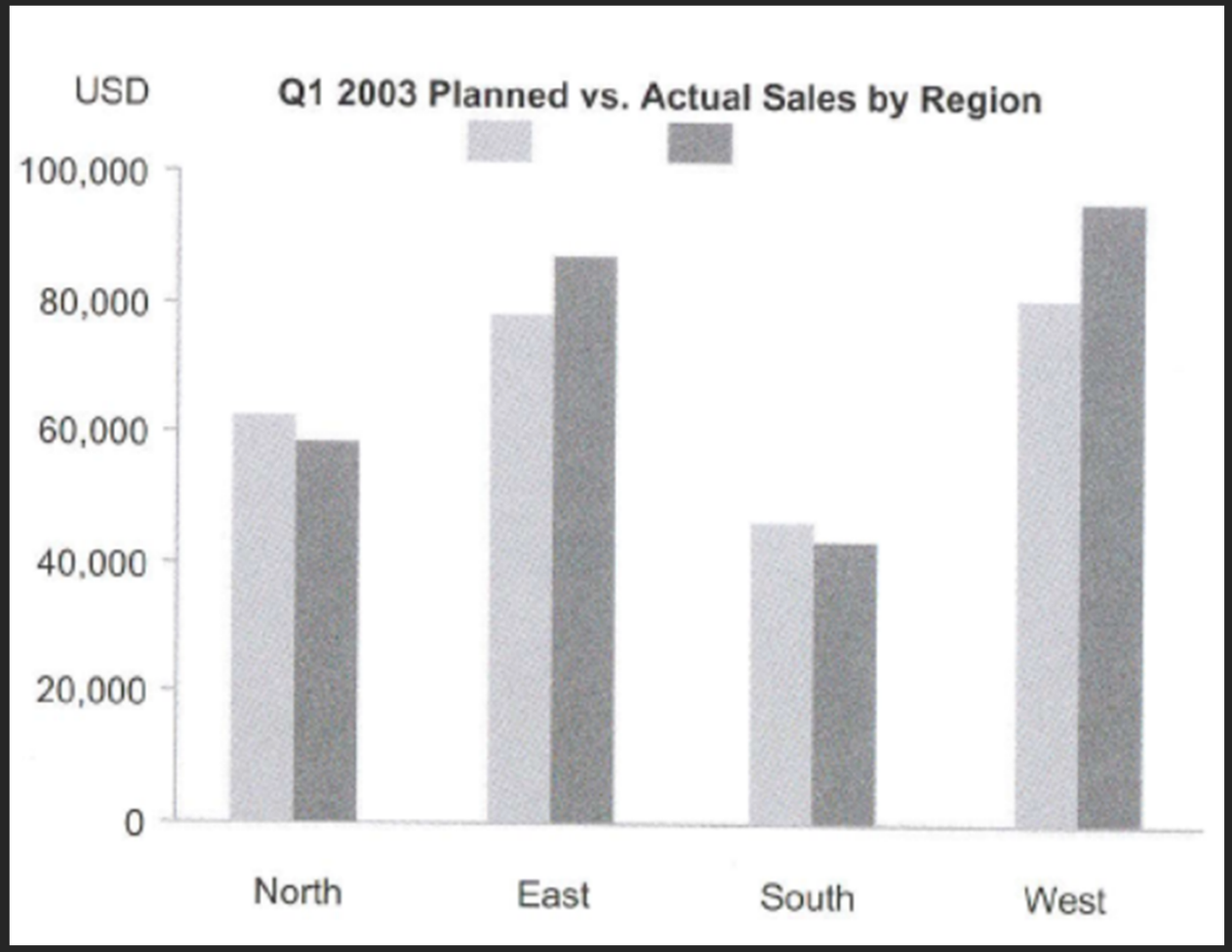
http://www.nytimes.com/interactive/us/faces-of-the-dead.html

Alignment



Credits: Stephen Few

Proximity



Credits: Stephen Few

Scalar Data

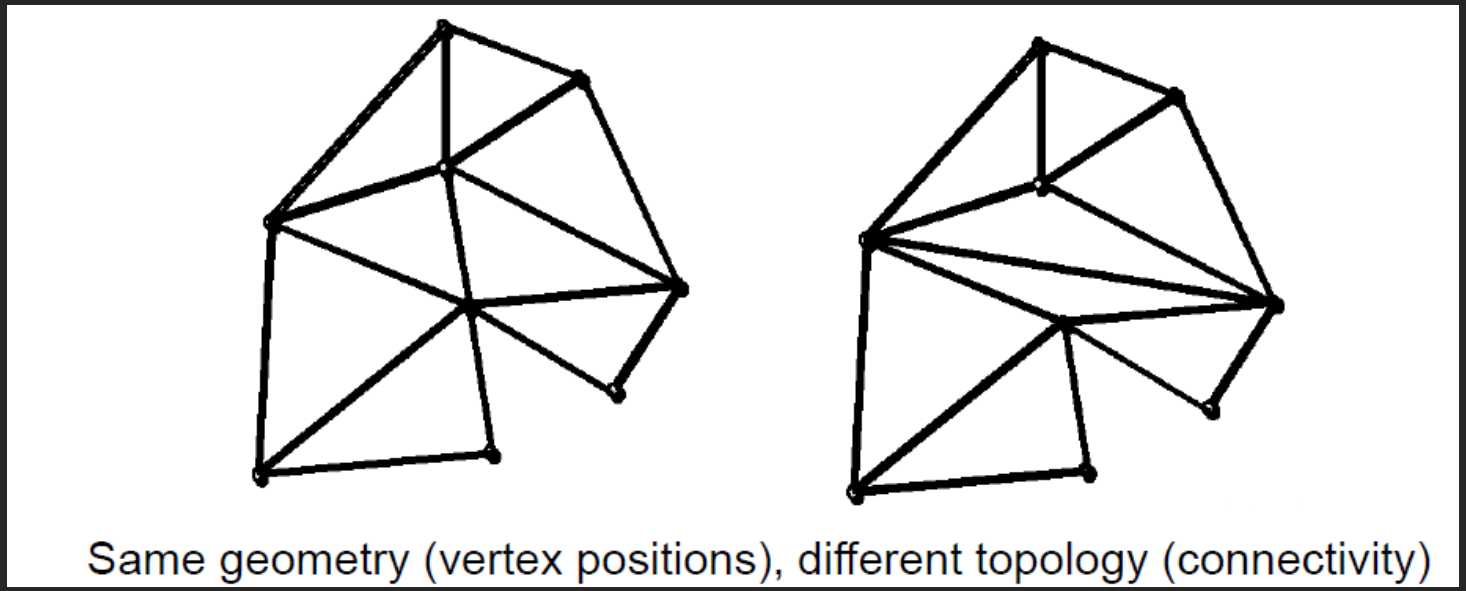
Alark Joshi

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

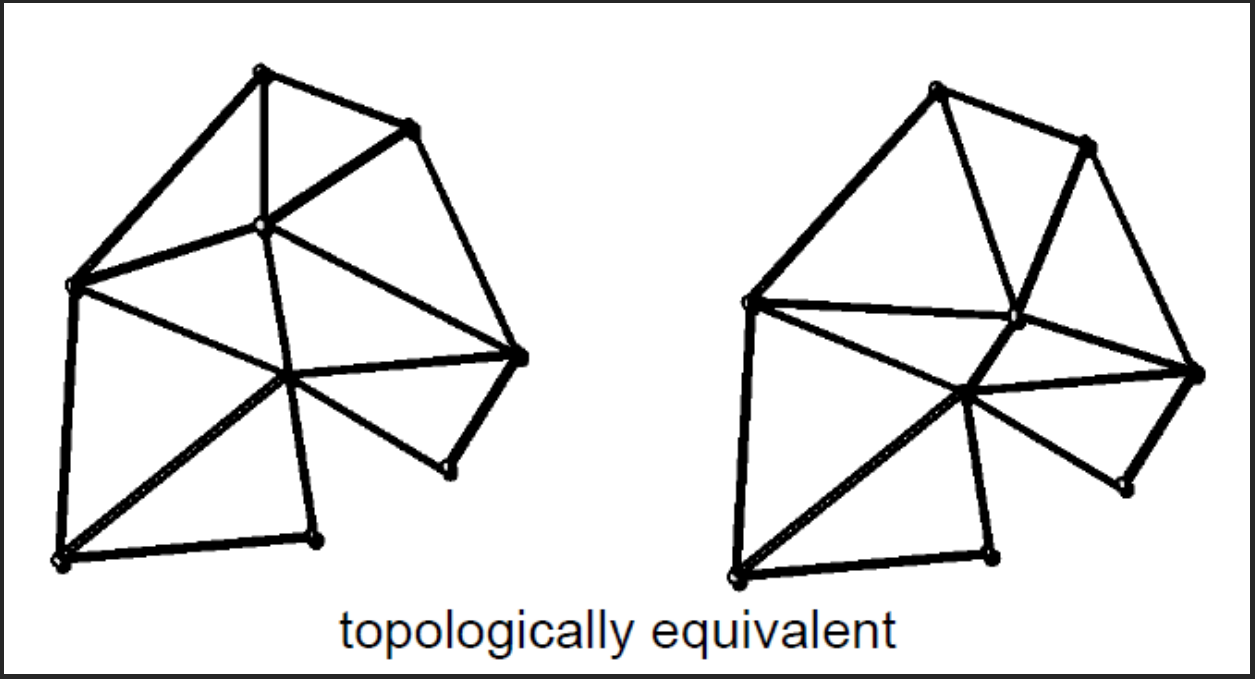
Topology

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



Topologically equivalent

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

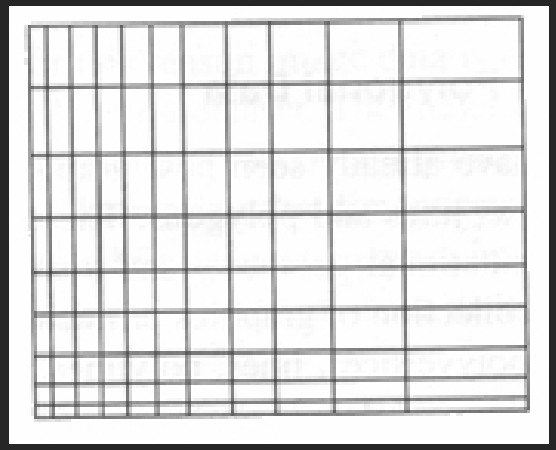


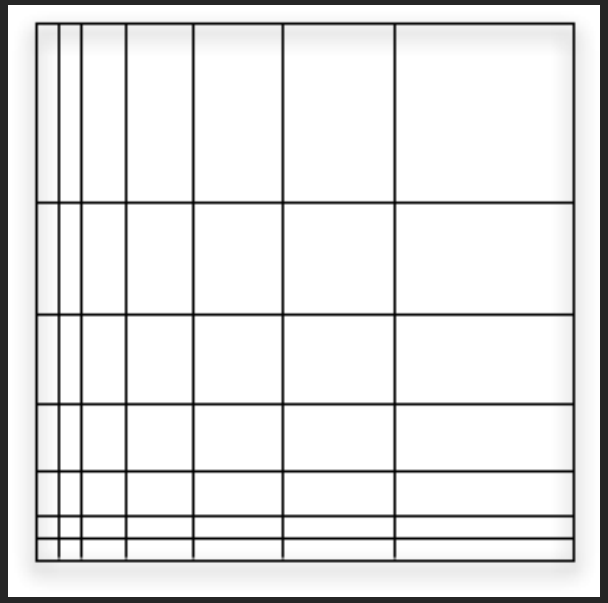
Types of grids

- Uniform grids are similar to Cartesian grids
- Consist of equal cells but with different resolution in at least one dimension ($dx \neq dy \neq dz$)
- 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

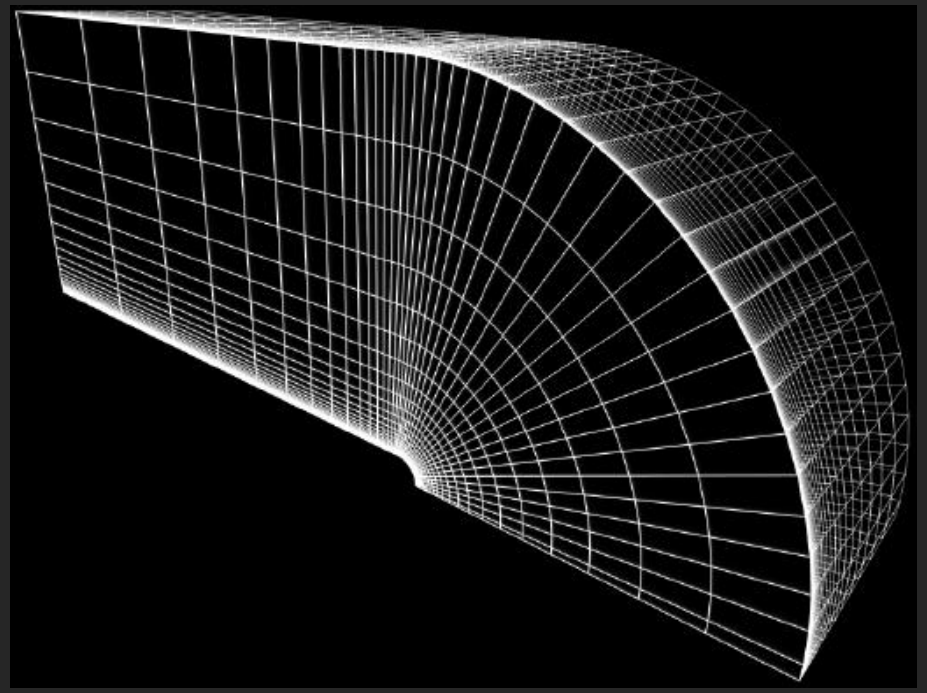
- Rectilinear grids
- Topology is still regular but irregular spacing between grid points
- Topology is still implicit





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

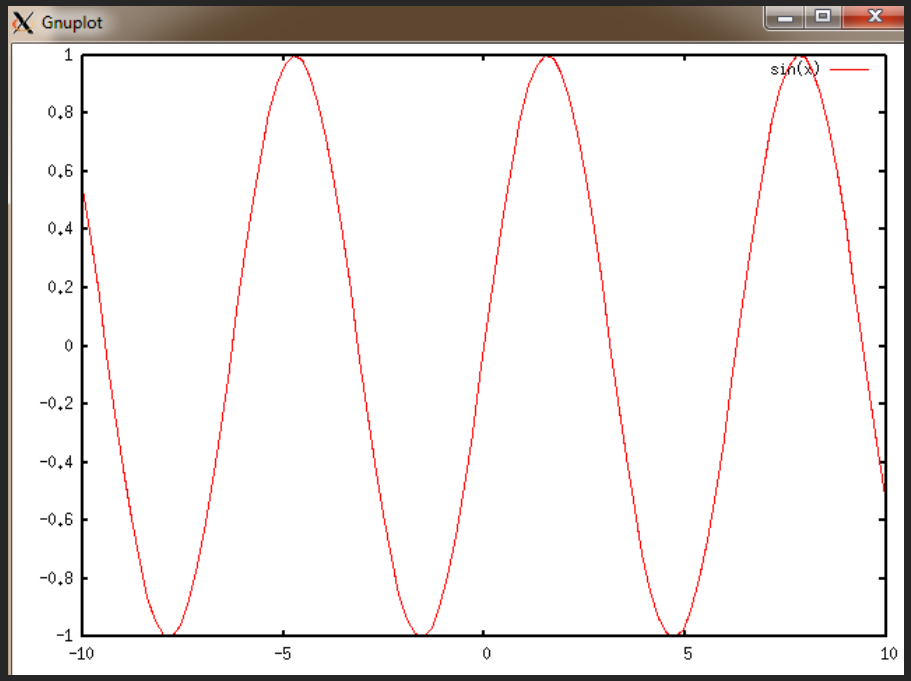
- Function plot for a 1D scalar field

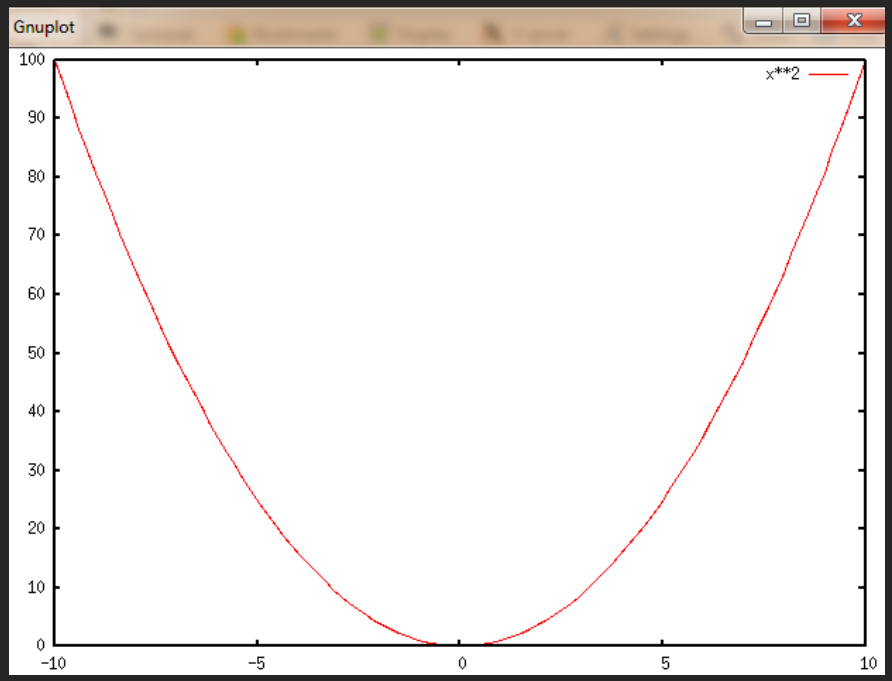
$$\{(s, f(s))|s \in R\}$$

  - Points
  - 1D manifold: line
  - Errors bars possible

Function Plots

- Gnuplot examples

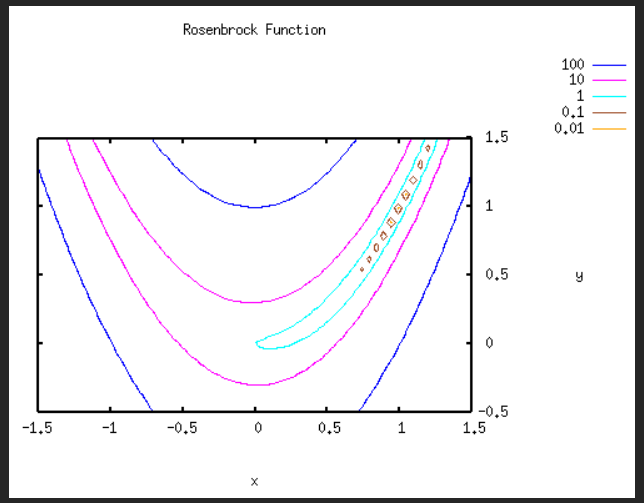


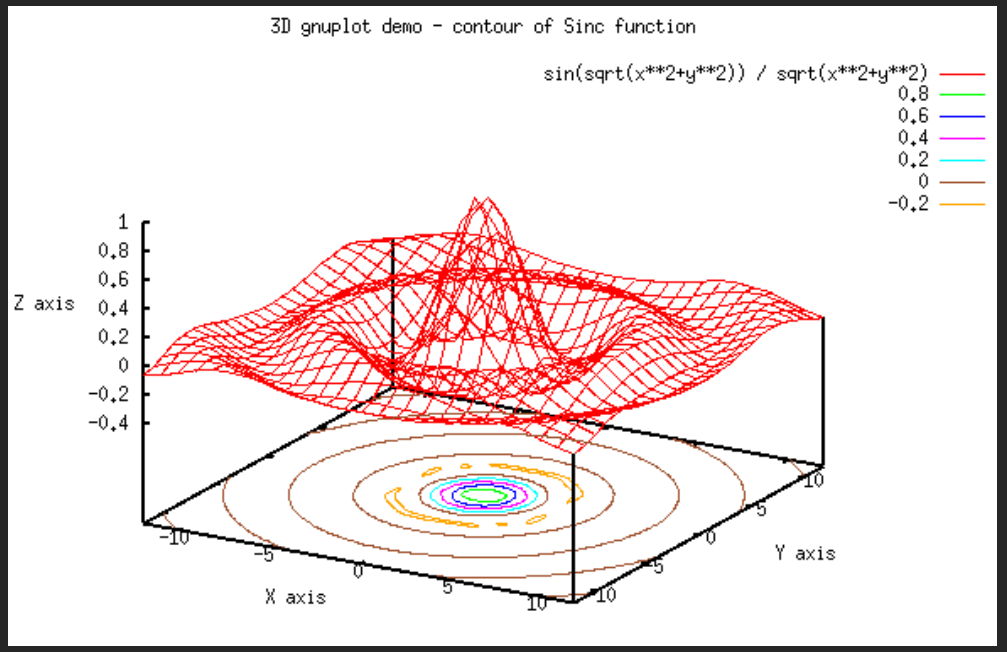


Function plots for 2D scalar field

- Points
- 2D manifold: surfaces

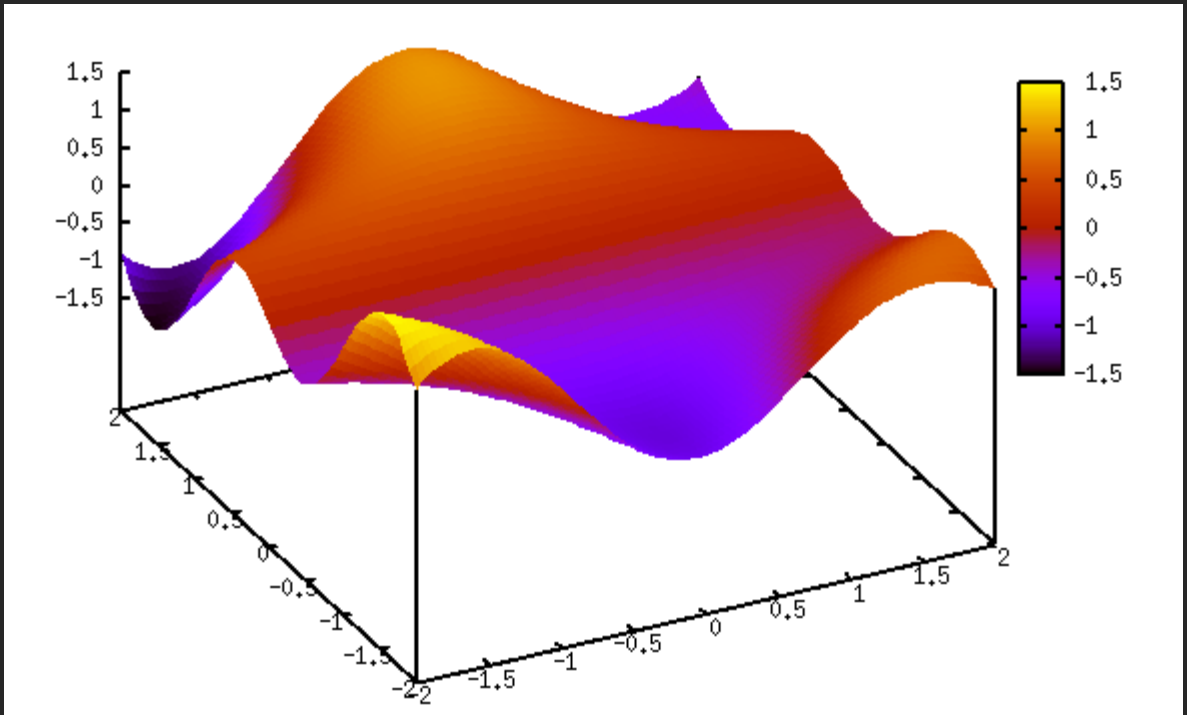
- Surface representations
  - Wireframe
  - Hidden lines
  - Shaded surface





Function plots for 2D scalar field

- Shaded surface



Isolines

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

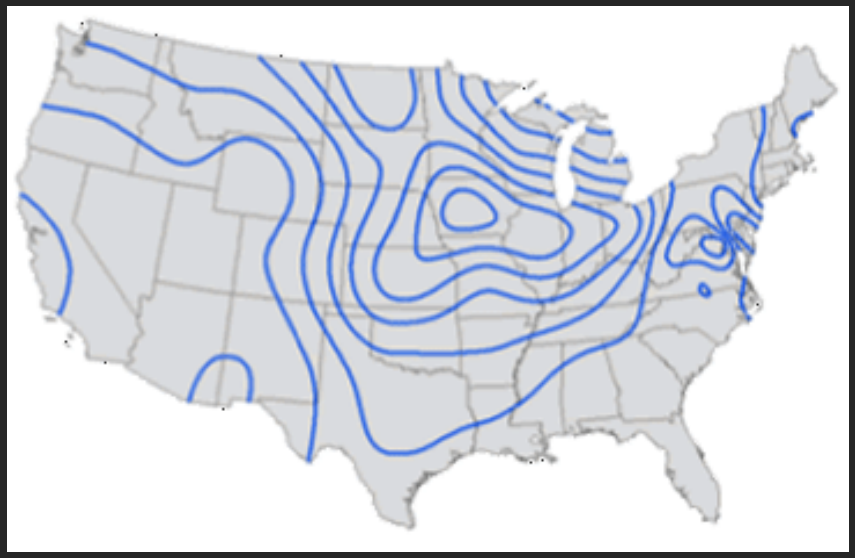
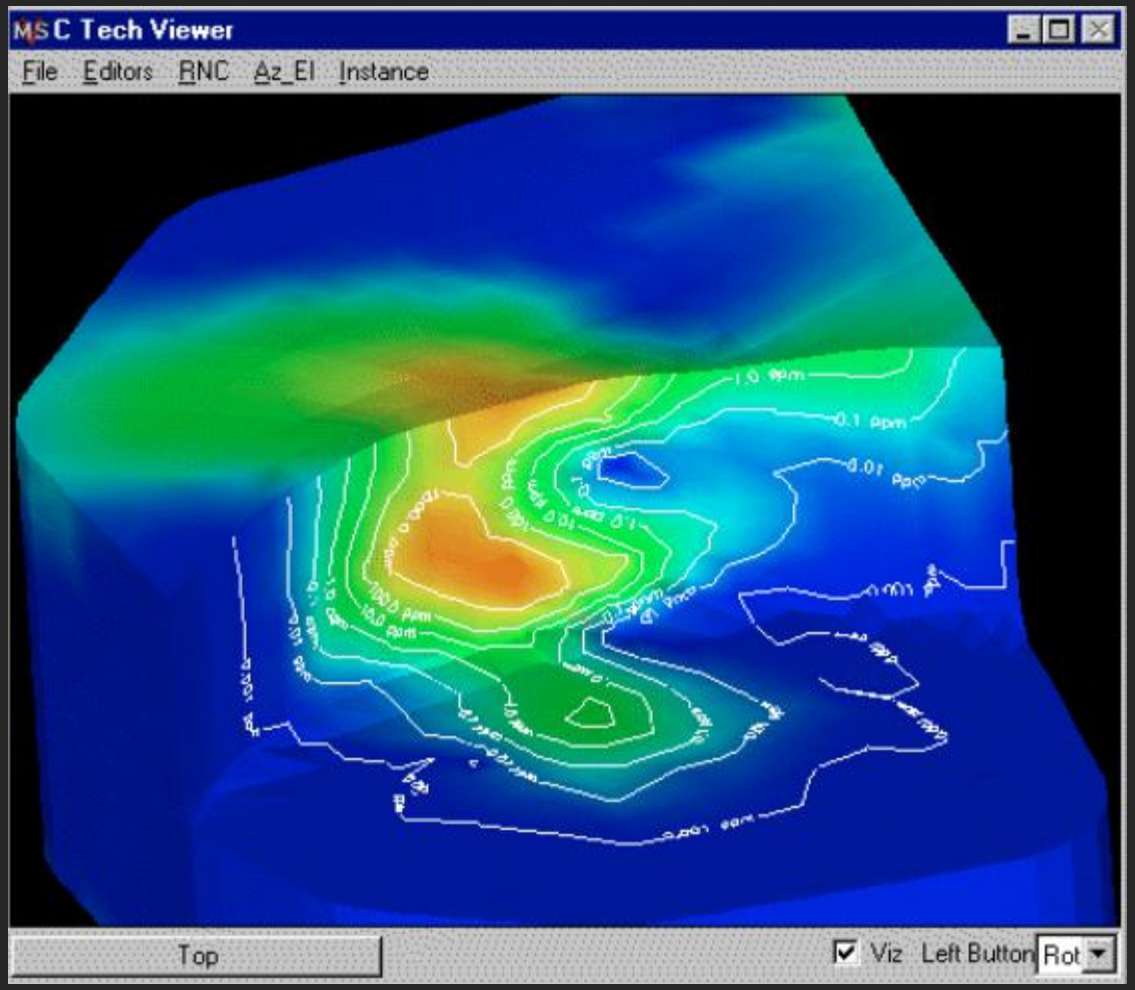


Image credits: http://giscommons.org/?page_id=18

Isolines


MSC Tech Viewer
File Editors RNC Az_El Instance
1.0 ppm
0.1 ppm
0.01 ppm
Top
Viz Left Button Rot

Isolines

- Pixel by pixel contouring
- Straightforward approach: scan all pixels for equivalence with isovalue
- Input: $f: (1, \ldots xmax) * (1, \ldots, ymax) \rightarrow R$
- Isovalues $I_1,\ldots I_n$ and isocolors $c_1,\ldots, c_n$
- Algorithm:

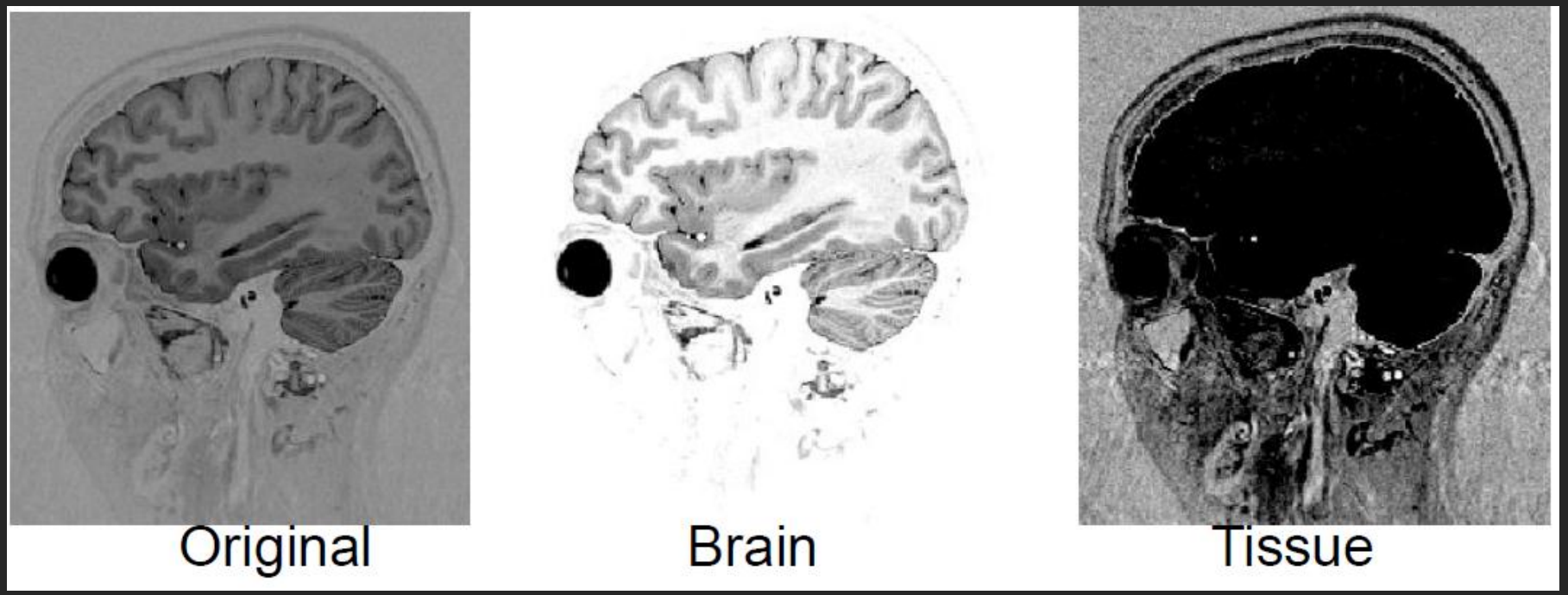
```
for all (x,y) ∈ (1,...,x_max) x (1,...,y_max) do
    for all k∈ { 1,...,n } do
        if |f(x,y)-I_k| < ε then
            draw (x,y,c_k)
```

Color coding

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

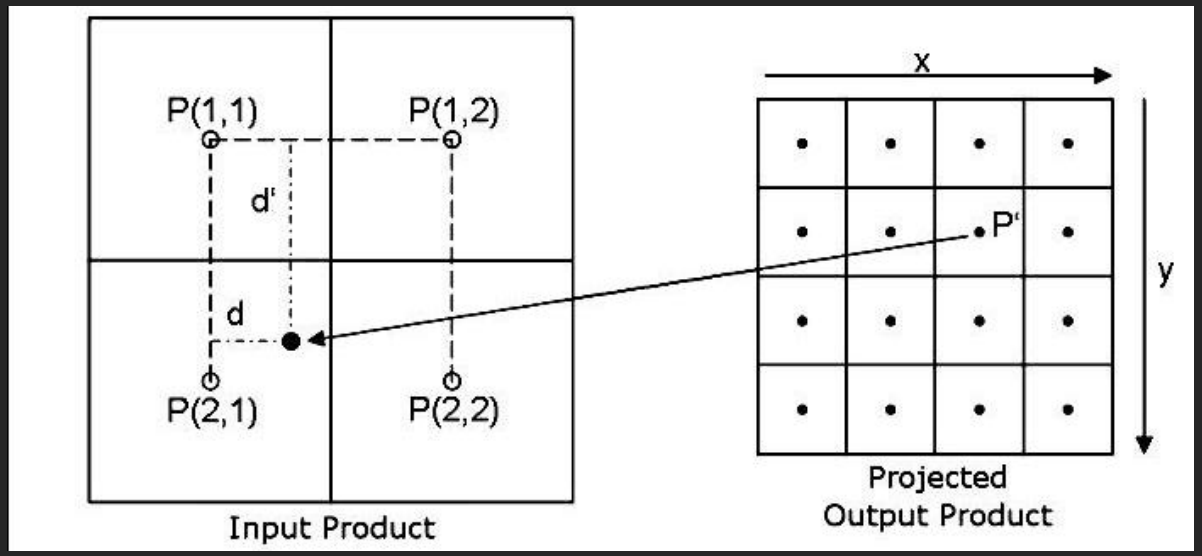
Color coding

- Example:
  - Separate color table to visualize the brain
  - Separate color table to visualize the tissue

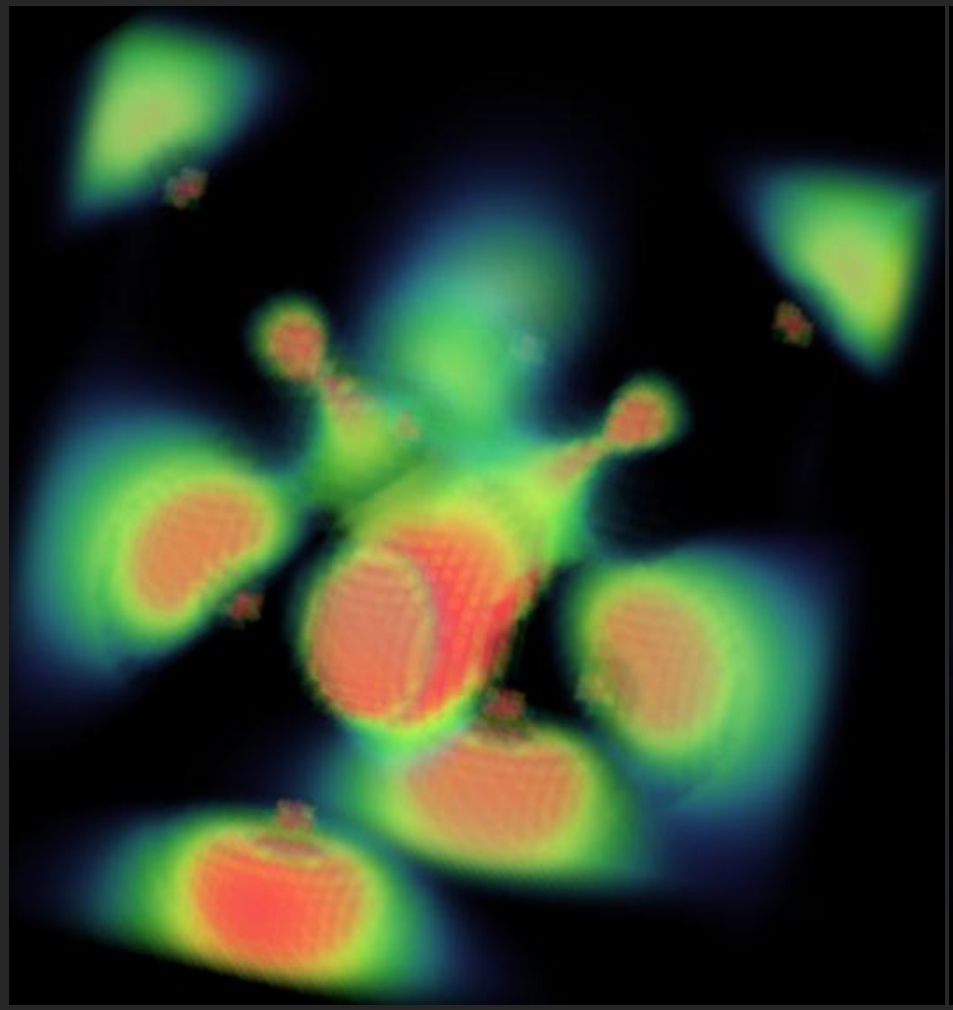


Interpolation

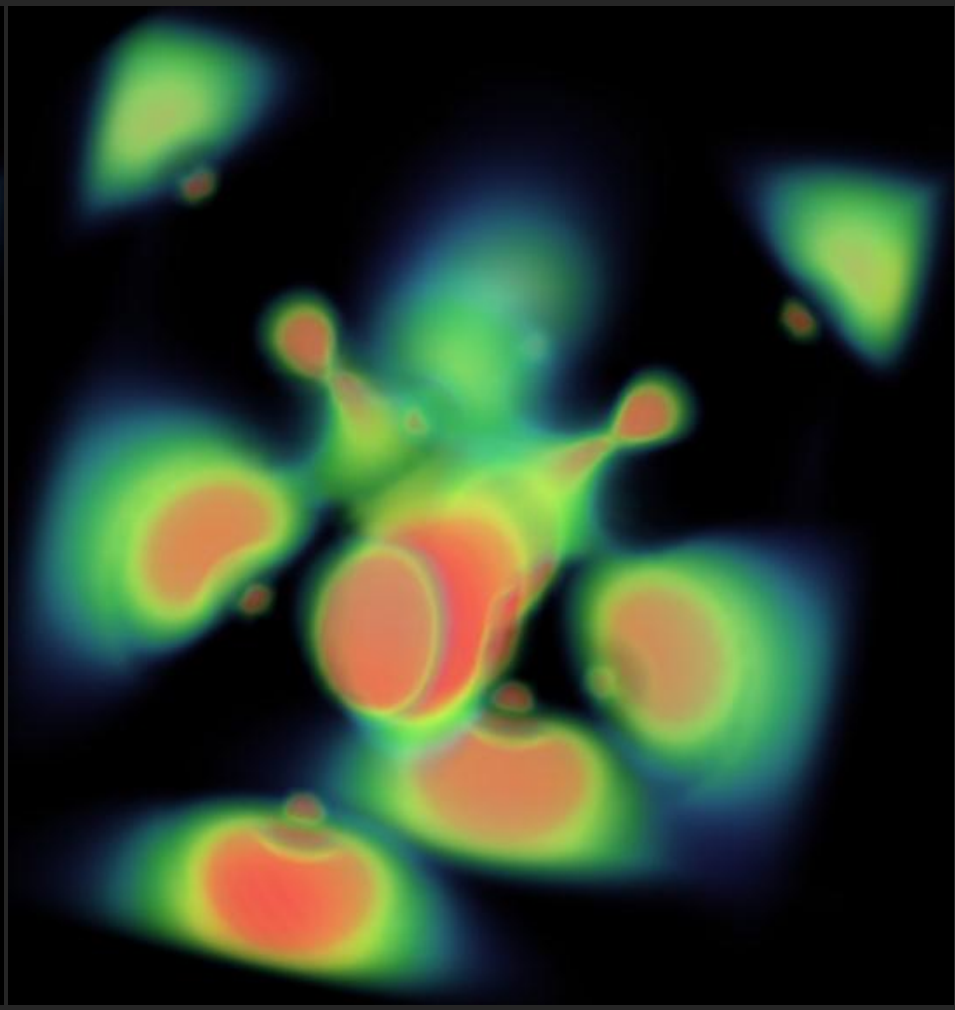
- Linear interpolation $x = x_1 * \frac{x - x_0}{x_1 - x_0} + x_0 * \frac{x_1 - x}{x_1 - x_0}$
- Bilinear interpolation
- $P'(x, y) = P(1,1) * (1 - d) * (1 - d') + P(1,2) * d * (1 - d') + P(2,1) * d' * (1 - d) + P(2,2) * d * d'$



Interpolation



Nearest Neighbor
Binary



Trilinear Interpolation
Smooth/Weighted