Introduction to Biology Visualization

G. Elisabeta Marai

Electronic Visualization Lab
University of Illinois at Chicago
A 45-minute tutorial

- What is (electronic) visualization
- Understanding color
- Visual design principles
- Visualization software
- A few BioVis examples at EVL

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Data Visualization Beginnings

The Ptolemy world map (circa 150), indicating the countries of China at the extreme right, beyond the island of Sri Lanka (oversized) and the Southeast Asian peninsula

Scientific drawings, data plots

Some of our more interesting charts this year...

...forecast a successful 2009!

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## Anscombe’s Quartet

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Visualizing Anscombe’s Quartet

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Electronic Visualization

- Electronic visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Visualization of human development
http://tools.google.com/gapminder/

- Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

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II. Understanding Color: Make Me Look, But Be Responsible
All You Need to Know About Color 😊

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Color Is a Perception

- Color is a perception and *not* visible EM radiation (light waves are not colored)
- Wavelengths don’t look the same to everyone
  - *most* people experience the sensation “blue” with wavelengths near 400nm
Perceived color depends on the human visual system (eye-brain mechanism)
– color perception strongly influenced by context, training, etc.,
abnormalities such as color blindness (affects about 8% of males, 0.4% of females)
Color Blindness: BioVis

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http://www.vischeck.com/daltonize/
Luminance vs. “Color”

- Human vision much more sensitive to slight changes in luminance (intensity or value) of light than slight changes in color (hue)
  - "Colors are only symbols. Reality is to be found in luminance alone..." (Pablo Picasso)
Grayscale vs. Color

M. Livingstone’08

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Luminance: How Many 3’s?

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
How Many 3’s?

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
Bad Luminance (Value) Difference

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Contrast

- Contrast: difference of value between text and background
- Foreground-background colors should differ in value

Use colors that have greatest contrast with the background for most important items

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Mapping Color to Data

1. Sequential: ordered data that progress from low to high.

2. Diverging: ordered data with equal emphasis on mid-range critical values and extremes at both ends of the data range.

3. Qualitative: nominal or categorical data.

http://colorbrewer2.org/

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Tufte, Visual Explanations
Number of data classes: 5
Nature of your data: qualitative
Pick a color scheme:
Only show: colorblind safe, print friendly, photocopy safe
Context: roads, cities, borders
Background: solid color, terrain
Color transparency

5-class Set1
HEX:
-e41a1c #377eb8 #4daf4a #984ea3 #ff7f00

© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Source code and feedback
Back to Flash version
Back to ColorBrewer 1.0

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Source code and feedback
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Number of data classes: 5
Nature of your data:
- sequential
- diverging
- qualitative

Pick a color scheme:

Only show:
- colorblind safe
- print friendly
- photocopy safe

Context:
- roads
- cities
- borders

Background:
- solid color
- terrain
- color transparency

5-class BrBG

Export your selected color scheme:

HEX:
- #a6611a
- #dfc27d
- #f5f5f5
- #80cdc1
- #018571
Use Less Color, Not More

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Felice Frankel
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Act Responsibly

- Don’t use more colors than necessary (when in doubt use less color)
- Make sure your visualization looks good in grayscale first
- Ensure contrast of color between text and background (especially of value)
- Use colors that have greatest contrast with the background for most important items
- Be aware of color-blindness (red-green, but also yellow-blue)
- Be aware of green/blue key encodings (most people have trouble telling them apart)
III. Tufte’s Visual Design Principles

E. Tufte, statistician, graphic designer, and author
Maintain Graphical Integrity

Graphics shd not be used to deceive. Deceptive graphics may:

- Compare full time periods with smaller time periods
- Make use of design variation to obscure or exaggerate data variation

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E.g., broken graphical integrity

- note the vertical jump from $12 to $13.3
- note the time jump from yearly to quarterly
- note the jump from 2D to 3D

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Tufte, Visual Display
Reduce Chartjunk

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Tufte, Visual Display
Maximize Data-Ink Ratio

Data Ink Ratio = (data-ink) / (total ink in the plot)

Avoid heavy grids and enclosing boxes; Prune graphics
Concentrate on data and NOT on data containers

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Tukey and Tukey, VD-114
Use Small Multiples

- to show variation

Tufte, Envisioning Information

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Jackson Practical Fly-Fisher, from Tufte
E.g., small multiple chromosome
E.g., small multiples as opposed to animation

Image from the video “Study of a numerically simulated severe storm”, UIUC

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Tufte, Visual Explanations
E.g., small multiples as opposed to animation
Use Parallel Sequencing

- to show temporal variation
Use Narratives of Space and Time

- tell a story of position and chronology through visual elements

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Avoid Separate Legends and Keys

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Tufte, Visual Explanations
Use Color Effectively

**Above all, do no harm**
Proper color uses:
- to label (nominal)
- to measure (quantitative)
- to represent or imitate reality
- to enliven or decorate (modestly)

Quiet the backgrounds
- to allow brighter colors to stand out

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Tufte, Visual Explanations
Use Layering & Separation

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Tufte, Envisioning Information
E.g., layering and separation
Provide Both Overview and Detail

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Mizbee, by Meyer et al
Summary: Some of Tufte’s Principles

• Maintain graphical integrity
• Reduce chartjunk
• Maximize data-ink ratio
• Use small multiples
• Use parallel sequencing
• Use narratives of space and time
• Avoid separate keys and legends
• Use color effectively
• Use layering and separation
• Show both overview and detail

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IV. Visualization Software
For 2D visualization

- D3.js, R, Processing, Prefuse

Multeesum, Meyer et all

Prodigen, Ma et al (D3)

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For 3D visualization

- javascript, WebGL/Three.js

- Maya, Blender, Unity3

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Aquaria, Stolte et al

FixingTIM, Luciani et al
BioVis tools

- biovis.net (@ISMB)
- bivi.co
Wrap-Up

• Electronic visualization augments the human brain
• Color is a perception, hence difficult
• Visual design: simplicity rules
• Software tools: most are web-based
Further reading

Tufte’s books

Munzner’s Visual Analysis & Design

BioVis.net

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Questions?

- G. Elisabeta Marai
- [http://evl.uic.edu/marai](http://evl.uic.edu/marai)
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