Ch 7: Arrange Tables

Idiom: bar chart
• one key, one value
  • data
    • 1 categ attrib, 1 quant attrib
    • mark: lines
  • regions: contiguous bounded areas distinct from each other
    • express values
      • 0, 1, 11, 25, 50, 75, 100
  • some keys: Categorical regions
    • regions: contiguous bounded areas distinct from each other
      • express values
        • regions: contiguous bounded areas distinct from each other
          • express values
            • regions: contiguous bounded areas distinct from each other
              • express values
                • 0, 1, 2, 3, 5, 4

Idiom: stacked bar chart
• one more key
  • data
    • 2 categ attrib, 1 quant attrib
    • mark: vertical stack of lines
  • channels
    • length and color hue
    • spatial regions: one per mark
      • oriented by quant attrib
      • aligned by categ attrib
      • by label (alphabetical) by length attrib (data-driven)
  • task
    • compare, lookup values
    • scalability
    • dozens to hundreds of levels for key attrib

Some keys: Categorical regions
• regions: contiguous bounded areas distinct from each other
  • express values
    • regions: contiguous bounded areas distinct from each other
      • express values
        • regions: contiguous bounded areas distinct from each other
          • express values
            • regions: contiguous bounded areas distinct from each other
              • express values
                • 0, 1, 2, 3, 5, 4

Encoded tables: Arrange space
• Arrange
  • Express
    • Separate
  • Order
  • Align

Dense Arrangement
• 3 shorter in-class exercises
  • Two Numbers
  • Bars/Radial
  • Color Palettes

Separation, Order, Align Regions
• Separate
• Order
• Align

Arrangement
• Reverse
• Parallel
• Random
• Space Filling

Layout Density
• Compact
• General

Ch 7: Tables, Color
Paper: D3

Ch 7/10: Tables, Color
Paper: D3
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CPSC 547, Information Visualization
Week 5: 10 October 2017

Idiom: scatterplot
• Express Values
  • Express Values
    • 0, 1, 2, 3, 5, 4

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Idiom: stacked bar chart
• one more key
  • data
    • 2 categ attrib, 1 quant attrib
    • mark: vertical stack of lines
  • channels
    • length and color hue
    • spatial regions: one per glyph
      • aligned by quant attrib, lowest bar component
      • aligned by categ attrib, bottom bar component
  • task
    • part-to-whole relationship
    • scalability
    • several to one dozen levels for stacked attrib

LIMITATION: Hard to know rank. What's the 4th most? The 7th?

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Paper: D3

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LIMITATION: Hard to know rank. What's the 4th most? The 7th?
Many Keys
Recursive Subdivision

Idiom: line chart / dot plot
- one key, one value
  - data
  - 2 quant attributes
  - mark types
  - line connection marks between them
  - aligned lengths to express quant value
  - separated and ordered by key strata into horizontal regions
  - task:
  - find trend
  - connection marks emphasize ordering of items along key axis by explicitly drawing relationship between data and the axis
  - scalability
  - hundreds of key levels, hundreds of value levels

Idiom: Gantt charts
- one key, two (related) values
  - data
  - 1 categ strata, 2 quant strata
  - mark line
  - channels
  - horizon position starts/ends times
  - horizon length: duration
  - task:
  - emphasize temporal overlaps, highlighted dependencies between items
  - scalability
  - dozens of key levels
  - hundreds of value levels

Choosing bar vs line charts
- depends on type of key attrib
  - bar charts if categorical
  - line charts ordered
  - do not use line charts for categorical key attribs
  - violations expressions principle
  - implications of trend so strong that it overrules semantics!
  - The more rude a person is, the older he is!

Idiom: connected scatterplots
- scatterplot with line connection marks
  - popular in journalism
  - horz + vert axes: value attribs
  - line connection marks: temporal order
  - alternative to dual-axis charts
  - horizon time
  - vert: two-value attrib
  - empirical study
  - engaging but correlation unclear

Idiom: indexed line charts
- data: 2 quant attributes
  - connection
  - derived data: new quant value attrib
  - index plot instead of original value
  - task: show change over time
  - principle: normalized, not absolute
  - scalability
  - some as standard line chart

Idiom: clustered bar chart, star plot
- radial bar chart
  - radial bars meet at central ring, line mark
- star plot
  - radial axes, at central point, line mark
- bar chart
  - rectilinear axes, aligned vertically
- accuracy
  - length unaligned with radial
  - less accurate than aligned with rectilinear

Idiom: radial bar chart, star plot
- radial bar chart
  - radial bars meet at central ring, line mark
- star plot
  - radial axes, at central point, line mark
- bar chart
  - rectilinear axes, aligned vertically
- accuracy
  - length unaligned with radial
  - less accurate than aligned with rectilinear

Idiom: glyphmaps
- rectilinear good for linear vs nonlinear trends
- radial good for cyclic patterns

Chart axes
- labelled axis is critical
- avoid cropping y-axis
- include 0 at bottom left
- or slope misleads
- dual axes controversial
- acceptable if commensurate
- beware, very easy to mislead!

Idiom: bar chart
- data
  - 2 quant attribs (gene, experiment condition)
  - 1 quant attrib (expression level)
- mark: area: separate and align in 2D matrix
- channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels

Idiom: box chart
- data
  - 4 quant attribs, single quant attrib
  - channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels

Idiom: normal stacked bar chart
- task
  - part-whole judgements
- normalized stacked bar chart
  - normalized stacked bar chart, normalized to full vert height
  - single stacked bar equivalent to full pie
  - high information density: requires narrow rectangles
- pie chart
  - information density requires large circle

Idiom: idiom: pie chart, polar area chart
- pie chart
  - area marked with single channel
  - accuracy: angles less accurate than line length
  - arc length less accurate than straight line
- polar area chart
  - area marked with length channel
  - more direct analog to bar charts
- data
  - 1 categ key, 1 quant value attrib
  - task
  - part-whole judgements

Idiom: idiom:釉
- generalization of stacked graph
  - emphasizing horizontal continuity
  - vs vertical items
  - data
  - 1 categ key attrib (strip)
  - 1 ordered key attrib (line)
  - 1 quant value attrib (counts)
  - derived data
  - geometry layers, where height encodes counts
  - 1 quant attrib (layer ordering)
  - scalability
  - hundreds of tine keys
  - dozens to hundreds of artex keys
  - more than stacked bar, some main layers don't extend across whole chart

Idiom: clustered bar chart, star plot
- radial bar chart
  - radial bars meet at central ring, line mark
- star plot
  - radial axes, at central point, line mark
- bar chart
  - rectilinear axes, aligned vertically
- accuracy
  - length unaligned with radial
  - less accurate than aligned with rectilinear

Idiom: heatmap
- two keys, one value
  - data
  - 1 categ attrib (gene, experiment condition)
  - 1 quant attrib (expression level)
- mark: area
  - separate and align in 2D matrix
- channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels

Idiom: biplot
- data
  - 2 quant attribs (gene, experiment condition)
  - 1 quant attrib (expression level)
- mark: area: separate and align in 2D matrix
- channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels

Idiom: treemaps
- data
  - 3 quant attribs (gene, experiment condition)
  - 1 quant attrib (expression level)
- mark: area: separate and align in 2D matrix
- channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels

Idiom: radar chart
- data
  - 3 quant attribs (gene, experiment condition)
  - 1 quant attrib (expression level)
- mark: area: separate and align in 2D matrix
- channels
  - color: by quant attrib
  - (polar/emptying diameter)
  - task:
  - find clusters, outliers
  - scalability
  - 1M items, 100s of categ levels, ~10 quant attrib levels
Orientation limitations:
- rectilinear: scalability w.r.t. fluxes
  - 2 axes best
  - 3 problematic
  - more in number
  - 4 impossible
- radial: unfamiliarity, training time
  - radial perceptual limits
    - angles lower precision than lengths
    - symmetry between angle and length

- can be exploited!

Decomposing color:
- first rule of color: do not talk about color!
  - color is confusing if treated as monolithic
- decompose into three channels
  - ordered can show magnitude
  - saturation: how colorful
  - categorical can show identity
  - hue: what color
- channels have different properties
  - what they convey directly to perceptual system
  - how much they can convey: how many discriminable bins can we use?

Opponent color and color deficiency:
- perceptual processing before optic nerve
  - one achromatic luminance channel
  - 2 chromatic channels
  - red-green (r') and yellow-blue (b')
  - "color blind": one axis has degraded acuity
  - 8% of men are red-green color deficient
  - blue/yellow is rare

Color spaces:
- CIE L*a*b*: good for computation
  - L*: lightness (L) or value (V)
  - a* and b* axes: perceptually linear but nonintuitive
  - a*b* axes: perceptually linear but nonintuitive
  - L* intuitive: perceptually linear luminance
  - CIELAB: area under bell curve

Designing for color deficiency:
- Blue-Orange is safe
- Reduces color to 2 dimensions

Ch 10: Map Color and Other Channels

Spectral sensitivity

Luminance
- need luminance for edge detection
  - fine-grained detail only visible through luminance contrast
  - legible text requires luminance contrast!
- intrinsic perceptual ordering

Color encoding:
- Map
  - Categorical can show identity
  - Ordered can show magnitude

Designing for color deficiency: Avoid encoding by hue alone
- redundantly encode
  - vary luminance
  - change shape

Color deficiency: Blue-Orange is safe
- color constancy: simultaneous contrast effect

Bezold Effect: Outlines matter

Color/Lightness constancy: Illumination conditions

Image courtesy of John McCann

Visible Spectrum

Deuteranope simulation

Diverging

Normal vision

Protanope

Tritanope

Normalization Information

Color Information

Corners of the RGB color cube

Luminance Information

L from HLS

All the same

Layout Density

Dense

Chromatic Information

Color information

Dense software overviews

(Extracted from "Advanced Color Principles & Practices.
Stone.Tableau Customer Conference 2014")
Map other channels
- **Size**
  - length accurate, 2D area ok, 3D volume poor
  - nonlinear accuracy
  - horizontal, vertical, exact diagonal
- **Angle**
  - complex combination of lower-level primitives
  - many bins
  - highly separable against static
  - binary; good for highlighting
- **Shape**
  - motion
- **Color/Lightness constancy: Illumination conditions**
  - Color/Lightness constancy: Illumination conditions
  - Illumination conditions
  - Color/Lightness constancy: Illumination conditions
  - Color/Lightness constancy: Illumination conditions

**Ordered color:**
- **Light constancy:**
  - Rainbow is poor default
  - Highly separable against static
  - Good for highlighting
  - Use with caution!

**Colormaps**
- **Color/Lightness constancy: Illumination conditions**
  - Color/Lightness constancy: Illumination conditions
  - Illumination conditions
  - Color/Lightness constancy: Illumination conditions
  - Color/Lightness constancy: Illumination conditions

**Paper: D3**
- **Paper types**
  - Design studies
  - Technique/algorithm
  - Evaluation
  - Model/taxonomy
  - System
WebGL/OpenGL
• graphics library
  – pros
  – power and flexibility, control over WebGL
  – declarative
  – arbitrary interactive scene
  – arbitrary scene complexity

Processing / p5.js
• layer on top of WebGL
• visualization esp. for artists/designers
• pros
  – great sandbox for rapid prototyping
  – huge user community, great documentation
• cons
  – poor/wide library support
  – example app: MiBoe


prefuse
• infovis toolkit, in Java
• fine-grained building blocks for tailored visualizations
• pros
  – heavily used (previously)
  – very powerful abstractions
  – quickly implement most techniques covered so far
• cons
  – no longer active
  – non-trivial learning curve
• example app: DOI Tress Revisited

D3 Features
• document transformation as atomic operation
  – scene changes vs representation of scenes themselves
• declarative: what
  – Protovis, D3
• declarative: when
  – data joins bind input data to elements
• declarative: where
  – visual representation

[Fig 5. Munzner et al. TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed

InfoVis Reference Model
• conceptual model underlies design of prefuse and many other toolkits
  – data tables, networks
  – also infovis pipeline, data state model

[Fig 2. Interactions and Memory in Visual Information Seeking. Using Main Street, Chapter 1. Morgan-Kaufmann, 1999]

D3
• declarative infovis toolkit, in javascript
• D3 meets Document Object Model
  – pros
  – seamless interoperability with Web


Protovis
• declarative infovis toolkit, in Javascript
  – marks with inherited properties
• pros
  – runs in browser
  – familiar programming model
  – much more interaction, geospatial, trees,
• cons
  – not all kinds of operations supported
  • example app: NapkinVis (2009 course project)


Next Time
• to read
  – VAD Ch. 8: Arrange Spatial Data
  – VAD Ch. 9: Arrange Networks


Toolkits
• imperative: how
  – low-level rendering: Processing, OpenGL
  – parametrized visual objects: prefuse
  – also flare: prefuse for Flash

• declarative: what
  – Protovis, D3
  – separation of specification from execution

• considerations
  – expressiveness
  – can’t build it
  – efficiency
  – how long will it take?
• declarative: where
  – visual form: layout, color, size, ...

• declarative: when
  – data joins bind input data to elements
  – data binding to scenegraph elements
  – operators act on selections to modify content