Week 2:
Chart Types and Best Practices

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JRNL 520H, Special Topics in Contemporary Journalism: Data Visualization
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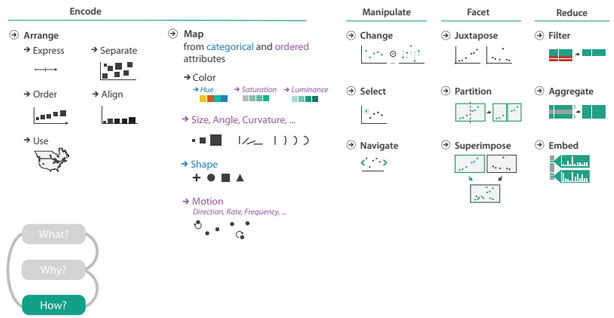
www.cs.ubc.ca/~tmm/courses/journ17

How?

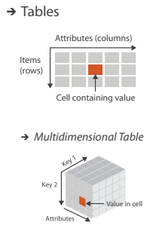


How?

Encode tables: Arrange space

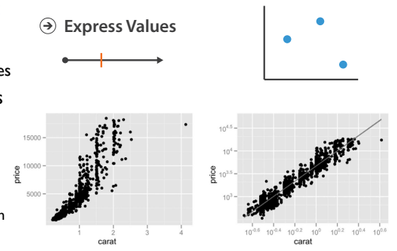
Keys and values

- key
  - –independent attribute
  - –used as unique index to look up items
  - –simple tables: 1 key
  - –multidimensional tables: multiple keys
- value
  - –dependent attribute, value of cell
- classify arrangements by key count
  - –0, 1, 2, many...



Idiom: **scatterplot**

- ***express*** values
  - –quantitative attributes
- no keys, only values
  - –data
    - 2 quant attribs
  - –mark: points
  - –channels
    - horiz + vert position
  - –tasks
    - find trends, outliers, distribution, correlation, clusters
  - –scalability
    - hundreds of items



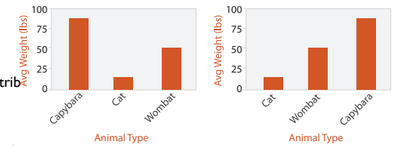
[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

Some keys: Categorical regions

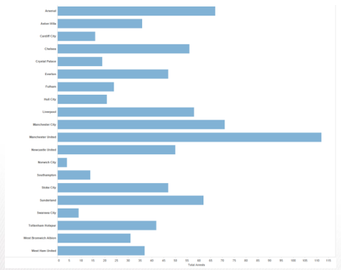
- **regions**: contiguous bounded areas distinct from each other
  - –using space to ***separate*** (proximity)
  - –following expressiveness principle for categorical attributes
- use ordered attribute to ***order*** and ***align*** regions

Idiom: **bar chart**

- one key, one value
  - –data
    - 1 categ attrib, 1 quant attrib
  - –mark: lines
  - –channels
    - length to express quant value
    - spatial regions: one per mark
      - – separated horizontally, aligned vertically
      - – ordered by quant attrib
        - » by label (alphabetical), by length attrib (data-driven)
  - –task
    - compare, lookup values
  - –scalability
    - dozens to hundreds of levels for key attrib



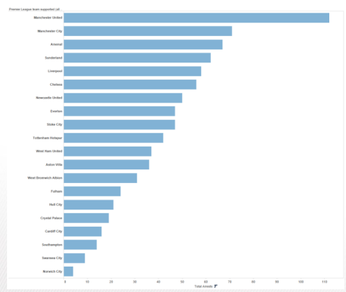
Separated and Aligned but not Ordered



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

[Slide courtesy of Ben Jones]

Separated, Aligned and Ordered



[Slide courtesy of Ben Jones]

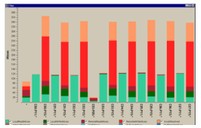
Separated but not Ordered or Aligned

LIMITATION: Hard to make comparisons

[Slide courtesy of Ben Jones]

Idiom: **stacked bar chart**

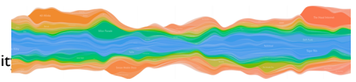
- one more key
  - –data
    - 2 categ attrib, 1 quant attrib
  - –mark: vertical stack of line marks
    - **glyph**: composite object, internal structure from multiple marks
  - –channels
    - length and color hue
    - spatial regions: one per glyph
      - – aligned: full glyph, lowest bar component
      - – unaligned: other bar components
  - –task
    - part-to-whole relationship
  - –scalability
    - several to one dozen levels for stacked attrib



[Using Visualization to Understand the Behavior of Computer Systems. Bosch. Ph.D. thesis, Stanford Computer Science, 2001.]

Idiom: **streamgraph**

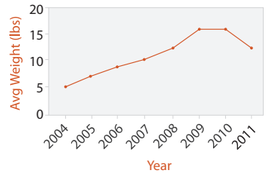
- generalized stacked graph
  - –emphasizing horizontal continuit
    - vs vertical items
  - –data
    - 1 categ key attrib (artist)
    - 1 ordered key attrib (time)
    - 1 quant value attrib (counts)
  - –derived data
    - geometry: layers, where height encodes counts
    - 1 quant attrib (layer ordering)
  - –scalability
    - hundreds of time keys
    - dozens to hundreds of artist keys
      - – more than stacked bars, since most layers don't extend across whole chart



[Stacked Graphs Geometry & Aesthetics. Byron and Wattenberg. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14(6): 1245–1252, (2008).]

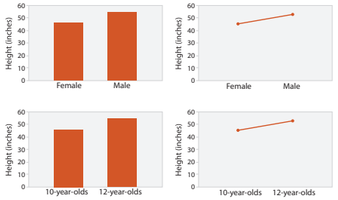
Idiom: **line chart**

- one key, one value
  - –data
    - 2 quant attribs
  - –mark: points
    - line connection marks between them
  - –channels
    - aligned lengths to express quant value
    - separated and ordered by key attrib into horizontal regions
  - –task
    - find trend
      - – connection marks emphasize ordering of items along key axis by explicitly showing relationship between one item and the next



Choosing bar vs line charts

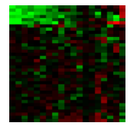
- depends on type of key attrib
  - –bar charts if categorical
  - –line charts if ordered
- do not use line charts for categorical key attribs
  - –violates expressiveness principle
    - implication of trend so strong that it overrides semantics!
      - – "The more male a person is, the taller he/she is"

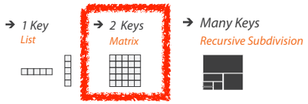


after [Bars and Lines: A Study of Graphic Communication. Zacks and Tversky. Memory and Cognition 27:6 (1999), 1073–1079.]

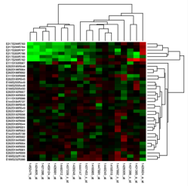
Idiom: **heatmap**

- two keys, one value
  - –data
    - 2 categ attribs (gene, experimental condition)
    - 1 quant attrib (expression levels)
  - –marks: area
    - separate and align in 2D matrix
      - – indexed by 2 categorical attributes
  - –channels
    - color by quant attrib
      - – (ordered diverging colormap)
  - –task
    - find clusters, outliers
  - –scalability
    - 1M items, 100s of categ levels, ~10 quant attrib levels





Idiom: **cluster heatmap**



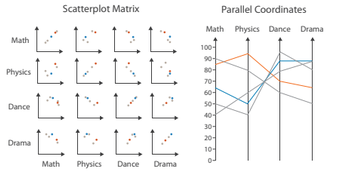
- in addition
  - –derived data
    - 2 cluster hierarchies
  - –dendrogram
    - parent-child relationships in tree with connection line marks
    - leaves aligned so interior branch heights easy to compare
  - –heatmap
    - marks (re-)ordered by cluster hierarchy traversal

Axis Orientation

- Rectilinear
- Parallel
- Radial

Idioms: **scatterplot matrix, parallel coordinates**

- scatterplot matrix (SPLOM)
  - –rectilinear axes, point mark
  - –all possible pairs of axes
  - –scalability
    - one dozen attribs
    - dozens to hundreds of items
- parallel coordinates
  - –parallel axes, jagged line representing item
  - –rectilinear axes, item as point
    - axis ordering is major challenge
  - –scalability
    - dozens of attribs
    - hundreds of items



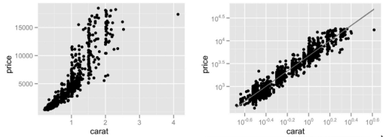
Table

Math	Physics	Dance	Drama
85	95	70	65
90	80	60	50
65	50	90	90
50	40	95	80
40	60	80	90

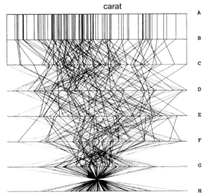
after [Visualization Course Figures. McGuffin, 2014. http://www.michaelmcguffin.com/courses/vis/]

Task: Correlation

- scatterplot matrix
  - –positive correlation
    - diagonal low-to-high
  - –negative correlation
    - diagonal high-to-low
  - –uncorrelated
- parallel coordinates
  - –positive correlation
    - parallel line segments
  - –negative correlation
    - all segments cross at halfway point
  - –uncorrelated
    - scattered crossings



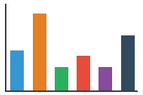
[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]



[Hyperdimensional Data Analysis Using Parallel Coordinates. Wegman. Journ. American Statistical Association 85:411 (1990), 664–675.]

Figure 3. Parallel Coordinate Plot of Six-Dimensional Data Illustrating Correlations of $\rho = 1, .8, .2, 0, -.2, -.8$, and -1.

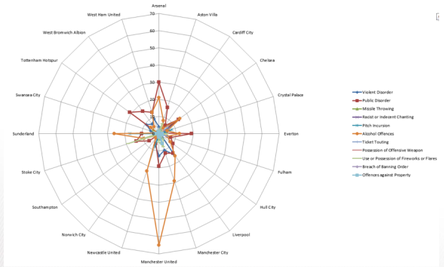
Idioms: **radial bar chart, star plot**



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

[Vismon: Facilitating Risk Assessment and Decision Making In Fisheries Management. Booshehrian, Möller, Peterman, and Munzner. Technical Report TR 2011-04, Simon Fraser University, School of Computing Science, 2011.]

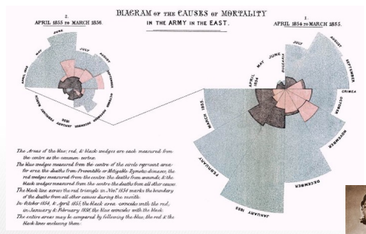
Radial Orientation: Radar Plots



LIMITATION: Not good when categories aren't cyclic

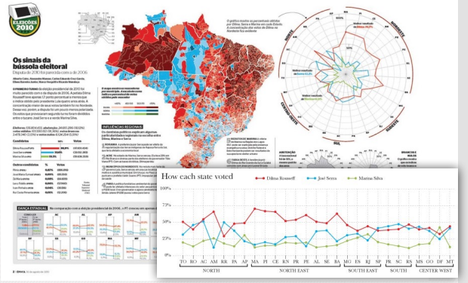
[Slide courtesy of Ben Jones]

"Diagram of the causes of mortality in the army in the East" (1858)



[Slide courtesy of Ben Jones]

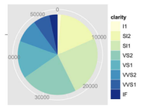
"Radar graphs: Avoid them (99.9% of the time)"

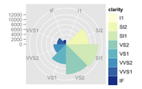


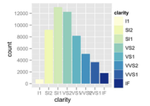
http://www.thefunctionalart.com/2012/11/radar-graphs-avoid-them-999-of-time.html

[Slide courtesy of Ben Jones]

Idioms: **pie chart, polar area chart**





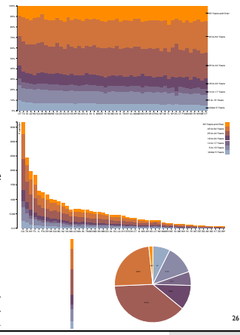


- pie chart
  - –area marks with angle channel
  - –accuracy: angle/area much less accurate than line length
- polar area chart
  - –area marks with length channel
  - –more direct analog to bar charts
- data
  - –1 categ key attrib, 1 quant value attrib
- task
  - –part-to-whole judgements

[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

Idioms: **normalized stacked bar chart**

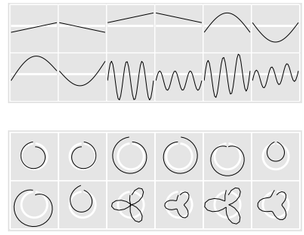
- task
  - –part-to-whole judgements
- normalized stacked bar chart
  - –stacked bar chart, normalized to full vert height
  - –single stacked bar equivalent to full pie
    - high information density: requires narrow rectangle
- pie chart
  - –information density: requires large circle



http://bl.ocks.org/mbostock/3887235,
http://bl.ocks.org/mbostock/3886208,
http://bl.ocks.org/mbostock/3886394

Idiom: **glyphmaps**

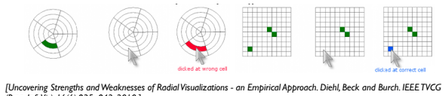
- rectilinear good for linear vs nonlinear trends
- radial good for cyclic patterns



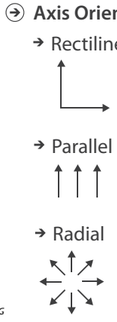
[Glyph-maps for Visually Exploring Temporal Patterns in Climate Data and Models. Wickham, Hofmann, Wickham, and Cook. Environmetrics 23:5 (2012), 382–393.]

Orientation limitations

- rectilinear: scalability wrt #axes
  - 2 axes best
  - 3 problematic
    - – more in afternoon
  - 4+ impossible
- parallel: unfamiliarity, training time
- radial: perceptual limits
  - –asymmetry: angles lower precision than lengths



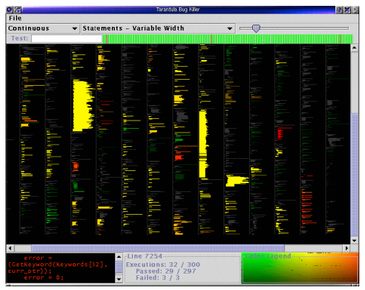
[Uncovering Strengths and Weaknesses of Radial Visualizations - an Empirical Approach. Diehl, Beck and Burch. IEEE TVCG (Proc. InfoVis) 16(6):935–942, 2010.]



Layout Density

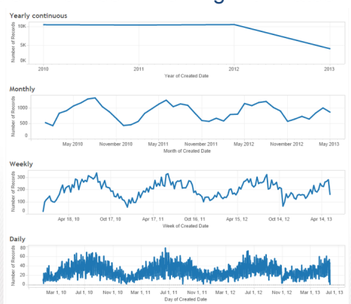
- Dense

dense software overviews



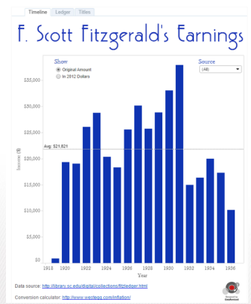
[Visualization of test information to assist fault localization. Jones, Harrold, Stasko. Proc. ICSE 2002, p 467-477.]

Basic Timelines – Working with Dates



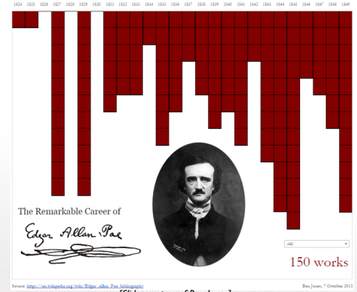
[Slide courtesy of Ben Jones]

Column Charts



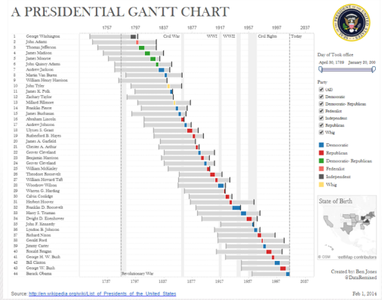
[Slide courtesy of Ben Jones]

Inverted Column Charts



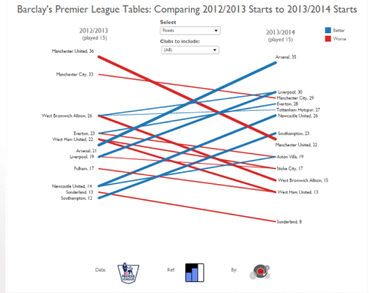
[Slide courtesy of Ben Jones]

Gantt Charts



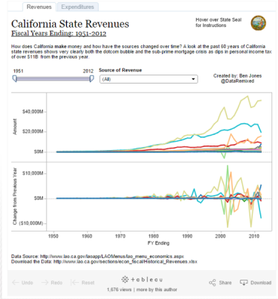
[Slide courtesy of Ben Jones]

Slopegraphs



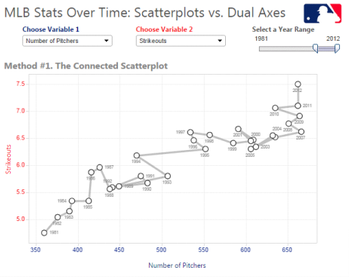
[Slide courtesy of Ben Jones]

Change from Previous



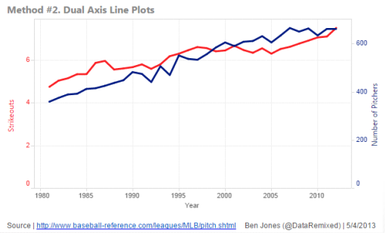
[Slide courtesy of Ben Jones]

Connected Scatterplots



[Slide courtesy of Ben Jones]

Dual Axis Line Plots



[Slide courtesy of Ben Jones]

Best Practices

- meaningful title
- axis labels
- include legend when necessary

Rules of Thumb

- No unjustified 3D

- Resolution over immersion
- Overview first, zoom and filter, details on demand
- Responsiveness is required
- Function first, form next

No unjustified 3D: Power of the plane

- high-ranked spatial position channels: **planar** spatial position
  - not depth!

Magnitude Channels: Ordered Attributes

Position on common scale

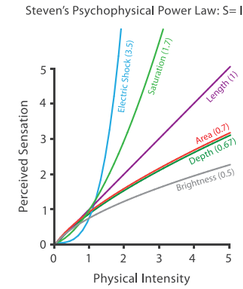
Position on unaligned scale

Length (1D size)

Tilt/angle

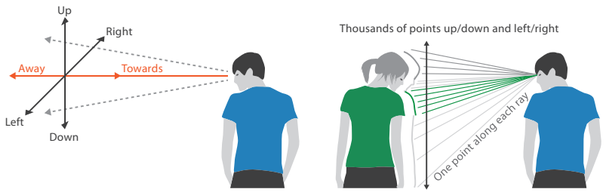
Area (2D size)

Depth (3D position)



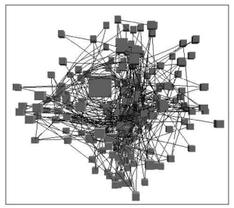
No unjustified 3D: Danger of depth

- we don't really live in 3D: we see in 2.05D
  - acquire more info on image plane quickly from eye movements
  - acquire more info for depth slower, from head/body motion



Occlusion hides information

- occlusion
- interaction complexity



[Distortion Viewing Techniques for 3D Data. Carpendale et al. InfoVis1996.]

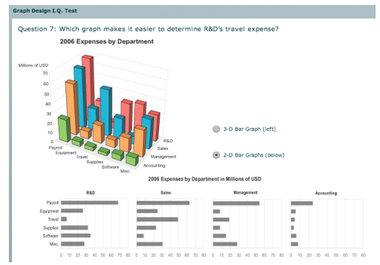
Perspective distortion loses information

- perspective distortion
  - interferes with all size channel encodings
  - power of the plane is lost!

[Visualizing the Results of Multimedia Web Search Engines. Mukherjea, Hirata, and Hara. InfoVis 96]

3D vs 2D bar charts

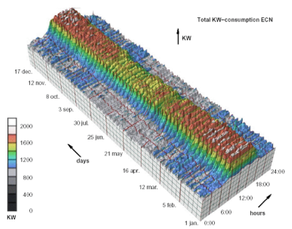
- 3D bars never a good idea!



[http://perceptualedge.com/files/GraphDesignIQ.html]

No unjustified 3D example: Time-series data

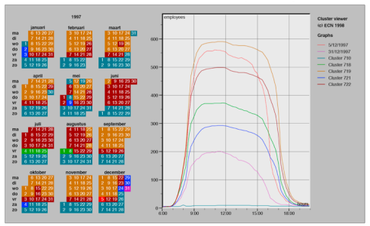
- extruded curves: detailed comparisons impossible



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

No unjustified 3D example: Transform for new data abstraction

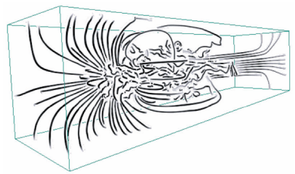
- derived data: cluster hierarchy
- juxtapose multiple views: calendar, superimposed 2D curves



[Cluster and Calendar based Visualization of Time Series Data. van Wijk and van Selow, Proc. InfoVis 99.]

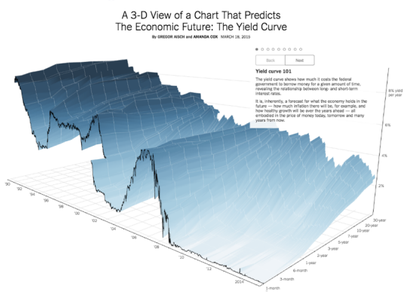
Justified 3D: shape perception

- benefits outweigh costs when task is shape perception for 3D spatial data
  - interactive navigation supports synthesis across many viewpoints



[Image-Based Streamline Generation and Rendering. Li and Shen. IEEE Trans. Visualization and Computer Graphics (TVCG) 13:3 (2007), 630–640.]

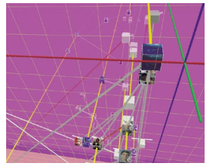
Justified 3D: Economic growth curve



http://www.nytimes.com/interactive/2015/03/19/upshot/3d-yield-curve-economic-growth.html

No unjustified 3D

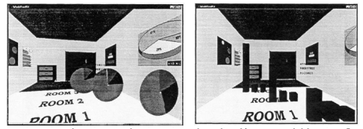
- 3D legitimate for true 3D spatial data
- 3D needs very careful justification for abstract data
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D for point clouds or networks



[WEBPATH-a three dimensional Web history. Frecon and Smith. Proc. InfoVis 1999]

Resolution beats immersion

- immersion typically not helpful for abstract data
  - do not need sense of presence or stereoscopic 3D
- resolution much more important
  - pixels are the scarcest resource
  - desktop also better for workflow integration
- virtual reality for abstract data very difficult to justify



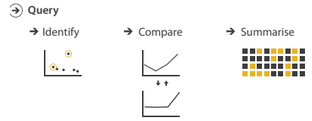
[Development of an information visualization tool using virtual reality. Kirner and Martins. Proc. Symp. Applied Computing 2000]

Overview first, zoom and filter, details on demand

- influential mantra from Shneiderman

[The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Shneiderman. Proc. IEEE Visual Languages, pp. 336–343, 1996.]

- overview = summary
  - microcosm of full vis design problem



Responsiveness is required

- three major categories
  - 0.1 seconds: perceptual processing
  - 1 second: immediate response
  - 10 seconds: brief tasks
- importance of visual feedback

Function first, form next

- start with focus on functionality
  - straightforward to improve aesthetics later on, as refinement
  - if no expertise in-house, find good graphic designer to work with
- dangerous to start with aesthetics
  - usually impossible to add function retroactively