Data Types
- quantitative
  - lengths: 10 inches, 17 inches, 23 inches
- ordered
  - sizes: small, medium, large
  - days: Mon, Tue, Wed, ...
- categorical
  - fruit: apples, oranges, bananas

Channel Ranking Varies By Data Type
- quantitative
- ordered
- categorical

Integral vs. Separable Dimensions
- not all dimensions separable

Preattentive Visual Channels
- color alone, shape alone: preattentive
- combined color and shape: requires attention
- search speed linear with distractor count

External Representation: Topic Graphs
- hard to find topics two hops away from target
- Paradoxes - Lewis Carroll
- Turing - Halting problem
- Paradoxes - Infinity
- Infinity - Lewis Carroll
- Infinity - Unpredictably long searches
- Infinity - Recursion
- Infinity - Zeno
- Infinity - Paradoxes
- Lewis Carroll - Zeno
- Lewis Carroll - Workplay

Visual Encoding Example: Scatterplot
- x position
- y position
- hue
- size

Visual Encoding
- attributes
  - parameters
  - control mark appearance
  - separable channels flowing from retina to brain

Visual Encoding
- marks: geometric primitives
- points, lines, areas
- attributes
  - position
  - size
  - grey level
  - texture
  - color
  - orientation
  - shape

Visual Encoding
- [Colin Ware, Information Visualization: Perception for Design. Morgan Kaufmann 1999.]

Preattentive Visual Channels
- color alone, shape alone: preattentive

Automatic Node-Link Graph Layout
- manual: hours, days
- automatic: seconds

Why Do Visualization?
- pictures help us think
  - substitute perception for cognition
  - external memory: free up limited cognitive/memory resources for higher-level problems

Reading
- FCG Chap 27

Visualization Design Layers
- depends on both data and task
- Anscornbe’s quartet:
  - same
  - mean
  - variance
  - correlation coefficient
  - linear regression line

Visualization
- interactive visual representation of abstract data
  - help human perform some task more effectively
  - bridging many fields
  - computer graphics: interact in realtime
  - cognitive psychology: find appropriate representation
  - HCI: use task to guide design and evaluation
  - external representation
  - reduces load on working memory
  - offload cognition
  - familiar example: multiplication/division
  - infovis example: topic graphs

Information Visualization
- interactive visual representation of abstract data
- help human perform some task more effectively
- bridging many fields
- computer graphics: interact in realtime
- cognitive psychology: find appropriate representation
- HCI: use task to guide design and evaluation
- external representation
- reduces load on working memory
- offload cognition
- familiar example: multiplication/division
- infovis example: topic graphs
Preattentive Visual Channels
- preattentive channels include
  - hue
  - shape
  - texture
  - length
  - size
  - orientation
  - curvature
  - intensity
  - flicker
  - direction of motion
  - stereoscopic depth
  - lighting direction
  - many more...

(Coloring Categorical Data)
- 22 colors, but only ~8 distinguishable

(Coloring Categorical Data)
- discrete small patches separated in space
- limited distinguishability: around 8-14
- channel dynamic range low
- best to choose bins explicitly
- maximal saturation for small areas

(Quantitative Colormaps)
- dangers of rainbows
  - perceptually nonlinear
  - arbitrary not innate ordering
- other approaches
  - explicitly segmented colormaps
  - monotonically increasing/decreasing luminance, plus hue to semantically distinguish regions

(3D vs 2D Representations)
- curve comparison difficult; perspective distortion, occlusion
- dataset is abstract, not inherently spatial
- after data transformation to clusters, linked 2D views of representative curves show more

(Space vs Time: Showing Change)
- animation: show time using temporal change
- good: show process
- good: flip between two things
- bad: flip between many things
- interference between intermediate frames

(Space vs Time: Showing Change)
- small multiples: show time using space
- overview: show each time step in array
- compare: side by side easier than temporal
- external cognition vs internal memory
- general technique, not just for temporal changes

(Composite Views: Glyphs)
- internal structure where subregions have different visual channel encodings

(Adjacent Multiple Views)
- different visual encodings show different aspects of the data
- linked highlighting to show where contiguous in one view distributed within another

(Adjacent Views)
- overview and detail
- same visual encoding, different resolutions
- small multiples
- same visual encoding, different data

(Data Reduction)
- overviews as aggregation
- focus+context
- show details embedded within context
- distortion: TreeJuxtaposer video
- filtering: SpaceTree demo

(Dimensionality Reduction)
- mapping from high-dimensional space into space of fewer dimensions
- generate new synthetic dimensions
- why is lower-dimensional approximation useful?
- assume true/intrinsic dimensionality of dataset is (much) lower than measured dimensionality!
- only indirect measurement possible?
  - fisheries: want spawn rates.
  - X-ray: CT scan, MRI
  - sparse data in verbose space?
  - documents: word occurrence vectors, 10K+ dimensions, want dozens of topic clusters

(DR Example: Image Database)
- 4096 D (pixels) to 2D (hand gesture)
- no semantics of new synthetic dimensions from alg.
- assigned by humans after inspecting results

(DR Technique: MDS)
- multidimensional scaling
  - minimize differences between interpoint distances in high and low dimensions
  - minimize objective function: stress
    \[
    \text{stress}(D, \Delta) = \frac{1}{N} \sum_{i,j} (d_{ij} - \Delta_{ij})^2
    \]
  - D: matrix of low D distances
  - \( \Delta \): matrix of high distances

(Parallel Coordinates)
- only two orthogonal axes in the plane
- instead, use parallel axes!

(Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg)

[Edward Tufte. The Visual Display of Quantitative Information, p 172]
Parallel Coordinates

- point in Cartesian coords is line in par coords
- point in par coords is line in Cartesian n-space

[Inselberg and Dindele. Parallel Coordinates: A Tool for Visualizing Multi-Dimensional Geometry. IEEE Visualization '90.]

Hierarchical Parallel Coords: LOD

- minimize
  - crossings, area, bends/curves
  - angular resolution, symmetry
- most criteria individually NP-hard
- cannot just compute optimal answer
- heuristics: try to find something reasonable
- criteria mutually incompatible

Node-Link Graph Layout

- minimize
  - crossings, area, bends/curves
- maximize
  - angular resolution, symmetry
- criteria mutually incompatible

Cushion Treemaps

- show structure with shading
- single parameter controls global vs local view

van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999

Beyond 314: Other Graphics Courses

- 424: Geometric Modelling
  - was offered this year
- 426: Computer Animation
  - will be offered next year
- 514: Image-Based Rendering - Heidrich
- 526: Algorithmic Animation - van de Panne
- 533A: Digital Geometry - Shaffer
- 533B: Animation Physics - Bridson
- 547: Information Visualization - Munzner

Beyond UBC CS

- SIGGRAPH conference back in Vancouver August 2014!
  - 19K-20K people: incredible combination of research, entertainment, art
  - Electronic Theater, Exhibit, ETech, ...
  - pricey: but student rate, student volunteer program
  - local SIGGRAPH chapter
    - talk series, SPARK FX festival, ...
  - http://siggraph.ca

Now What?