University of British Columbia
CPSC 314 Computer Graphics
Jan-Apr 2010

Tamara Munzner

Nonspatial/Information Visualization II

Week 13, Wed Apr 14

http://www.ugrad.cs.ubc.ca/~cs314/Vjan2010

Assignments

- project
  - P4 due today 5pm (plus grace/late days)
  - project 4 demo signup sheet, for last time
    - I will scan and post so you can check your time
    - you must contact me by Fri to schedule if you weren't in class to sign up
      - otherwise 2% huntdown penalty
    - email me in advance if you need to change
      - otherwise 2% noshow penalty
- homework
  - H4 solutions released Friday
    - homeworks not accepted after Thu 5pm
    - again: if you hand in late, do include time/date at top
  - H4 will be graded before exam
    - stay tuned, I'll announce on discussion group when they're ready to pick up

Office Hours

- extra TA office hours in lab 005 for P4/H4
  - Wed 4/14 2-4, 5-7 (Shailen)
  - Thu 4/15 3-5 (Kai)
  - Fri 4/16 11-4 (Garrett)
- my office hours for rest of term
  - Fri 4/16 4pm
  - by appointment - send me email to book
  - (I'm out of town 4/24-4/27, right after exam)

Graded Work

- still have some marked work not picked up, come grab it!
  - homeworks, midterms
- some extra handouts in lab
  - or print out yourself, everything posted on web site

- don't forget to check ugrad account for grading updates
  - find out what you got
  - also cross-check our records against yours

Final Exam

- Apr 23 8:30-11:30am, location DMP 310
  - across the hall
  - exam will be 2.5 hrs
  - extra 30 min in case of fire alarms, etc
- closed book
- one page notes, 8.5"x11", handwritten
  - both sides allowed, fine to reuse one side from midterm
- calculator is a good idea
- IDs out and face up
- bags/coats in front - phones off!

Final Emphasis

- covers entire course
- includes material from midterm
  - transformations
  - viewing
- more than half of exam will be on material not covered in midterm
  - color
  - rasterization
  - lighting/shading
  - advanced rendering
  - clipping
  - hidden surfaces
  - blending
  - textures
  - procedural approaches
  - picking
  - collision
  - antialiasing
  - modern hardware
  - curves
  - visualization

Exam Prep

- another sample final just posted
  - from Jan 2007
- homeworks are good practice
  - especially old homeworks from when I taught the course

Grading Reminder

- Original grading scheme for course
  - 20% midterm and 25% final
- New grading scheme for course
  - 12% midterm and 33% final

- Your course grade will automatically be the max of new and old schemes.

Correction: Premultiplying Colors

- specify opacity with alpha channel: (r,g,b,α)
  - α=1: opaque, α=.5: translucent, α=0: transparent
- **A** *over* **B**
  - **C** = α**A** + (1-α)**B**
- but what if **B** is also partially transparent**?**
  - **C** = α**A** + (1-α) β**B** = β**B** + α**A** + β**B** - α β**B**
  - $\gamma = \beta + (1-\beta)\alpha = \beta + \alpha - \alpha\beta$
    - 3 multiplies, different equations for alpha vs. RGB
- premultiplying by alpha
  - **C'** = γ **C, B'** = β**B, A'** = α**A**
  - **C' = B' + A' -** α**B'**
  - $\gamma = \beta + \alpha - \alpha\beta$
    - 1 multiply to find C, same equations for alpha and RGB

Clarification: Midpoint Check

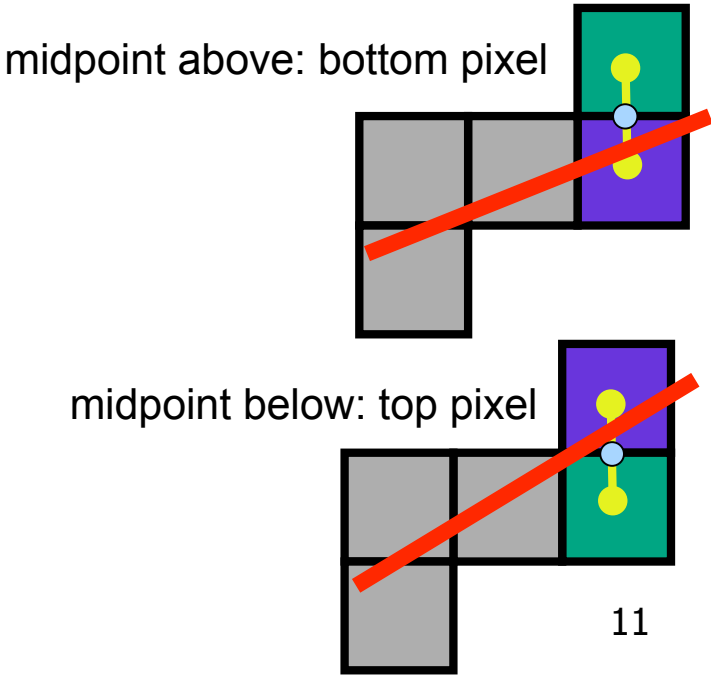
- $f(x,y) = (y_0 - y_1)\,x + (x_1 - x_0)\,y + x_0\,y_1 + x_1\,y_0$
  - implicit equation: on line when f(x,y) = 0
  - above line when f(x,y) < 0
  - below line when f(x,y) > 0
- check midpoint against line
  - midpoint to check is at x+1, y+.5
  - if f(x+1, y+5) < 0 then midpoint is below line

```
y=y0
for (x=x0; x <= x1; x++) {
  draw(x,y);
  if (f(x+1, y+.5) < 0) then {
   y = y + 1;
}
```

Clarification: Making It Incremental

- d: midpoint. build off previous computation
- if we stayed at same level, midpoint above line (d<0)
  - new midpoint check to set up is f(x+1, y) = f(x,y) + (y_0-y_1)
- if we moved up one level, midpoint below line (d>0)
  - new midpoint check set up is f(x+1, y+1) = f(x,y) + $(y_0- y_1)$ + $(x_1- x_0)$

```
y=y0
d = f(x0+1, y0+.5)
for (x=x0; x <= x1; x++) {
  draw(x,y);
  if (d<0) then {
   y = y + 1;
   d = d + (x1 - x0) + (y0 - y1)
  } else {
   d = d + (y0 - y1)
}
```



Clarification/Correction: Integer Only

- avoid dealing with non-integer values by doubling both sides
  - from f(x,y) = 0 to 2f(x,y) = 0
  - $f(x,y) = (y_0 - y_1)\,x + (x_1 - x_0)\,y + x_0\,y_1 + x_1\,y_0$

```
y=y0
d = f(x0+1, y0+.5)
for (x=x0; x <= x1; x++)
  {
  draw(x,y);
  if (d<0) then {
   y = y + 1;
   d = d + (x1 - x0) +
           (y0 - y1)
  } else {
   d = d + (y0 - y1)
}
```

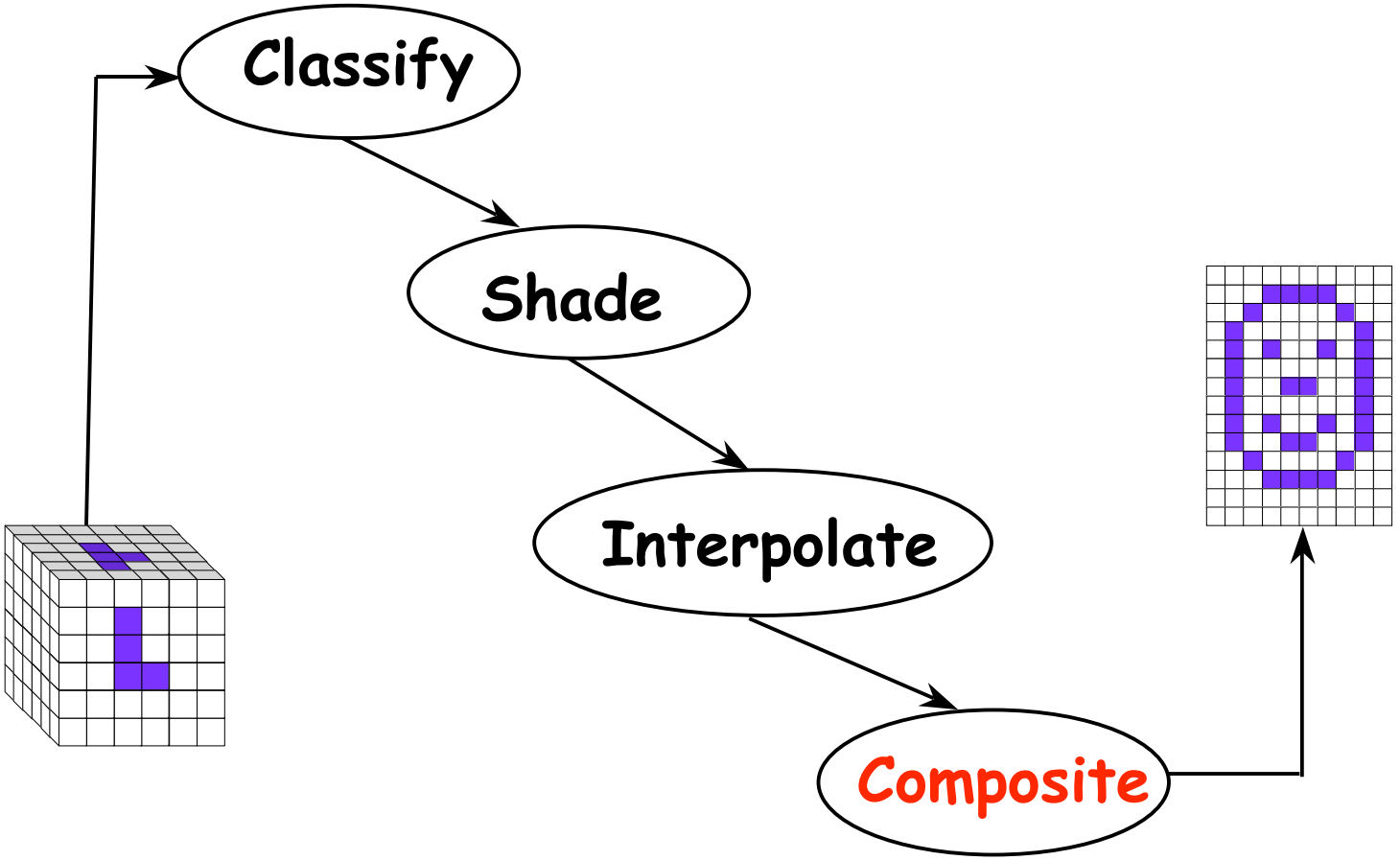
```
y=y0
d = 2*(y0-y1)(x0+1) +
    (x1-x0)(2*y0+1) +
    2*x0y1 - 2*x1y0
for (x=x0; x <= x1; x++) {
  draw(x,y);
  if (d<0) then {
   y = y + 1;
   d = d + 2(x1 - x0) +
           2(y0 - y1)
  } else {
   d = d + 2(y0 - y1)
}
```

Evaluations - Right Now

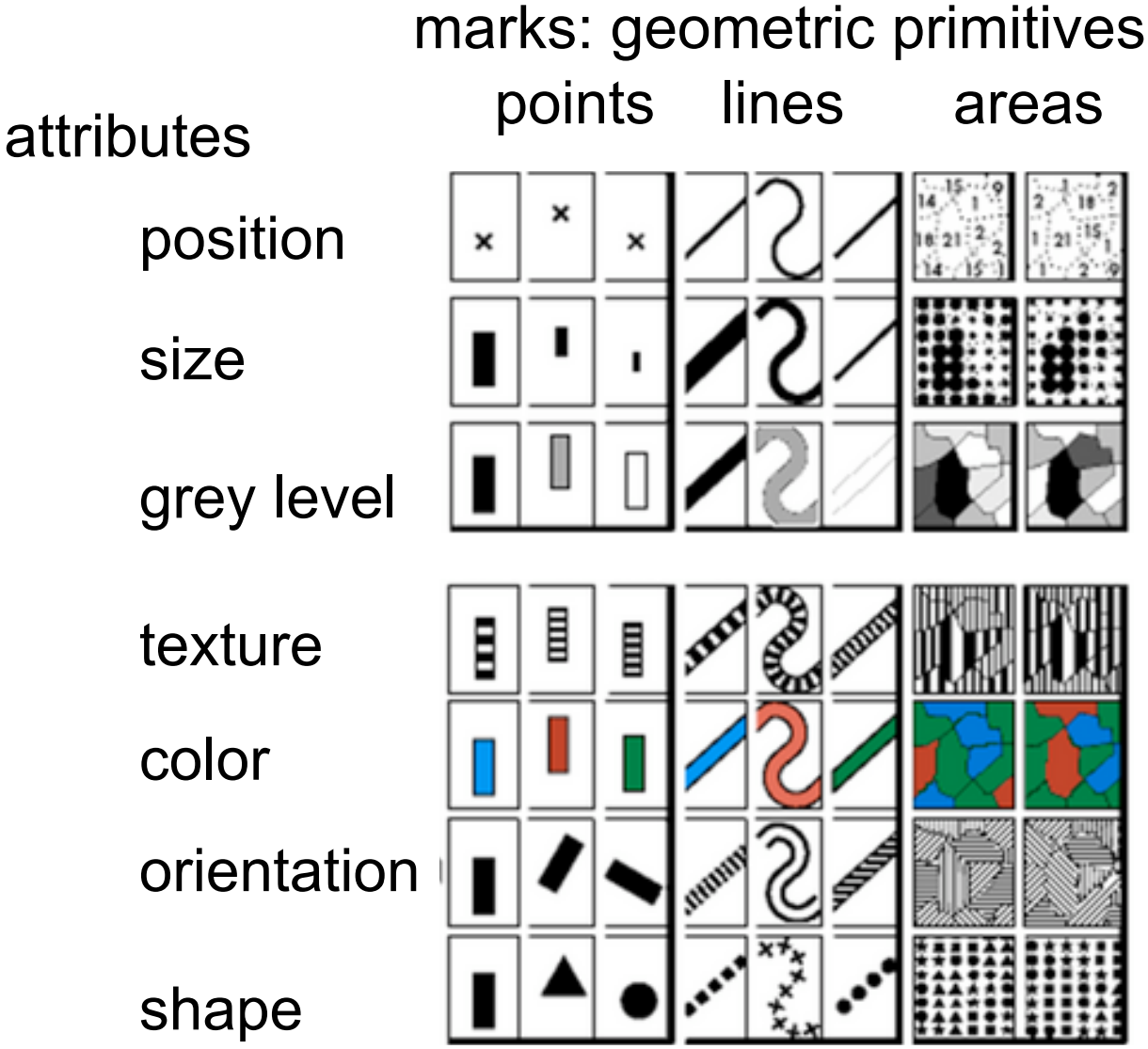
- official TA evaluations
  - still on paper, not online yet
- unofficial course evaluations - my custom form
  - much more specific questions than the official ones
  - I do not look at these until after official ones returned, long after grades are out
  - if you missed class, blanks will be in extra handouts container in lab, can turn in anonymously to the front desk on 2nd floor
  - your feedback helps me improve the course in later years

- **please also** fill out official teaching surveys for instructor (me!) at the CoursEval website https://eval.olt.ubc.ca/science

Review: Direct Volume Rendering



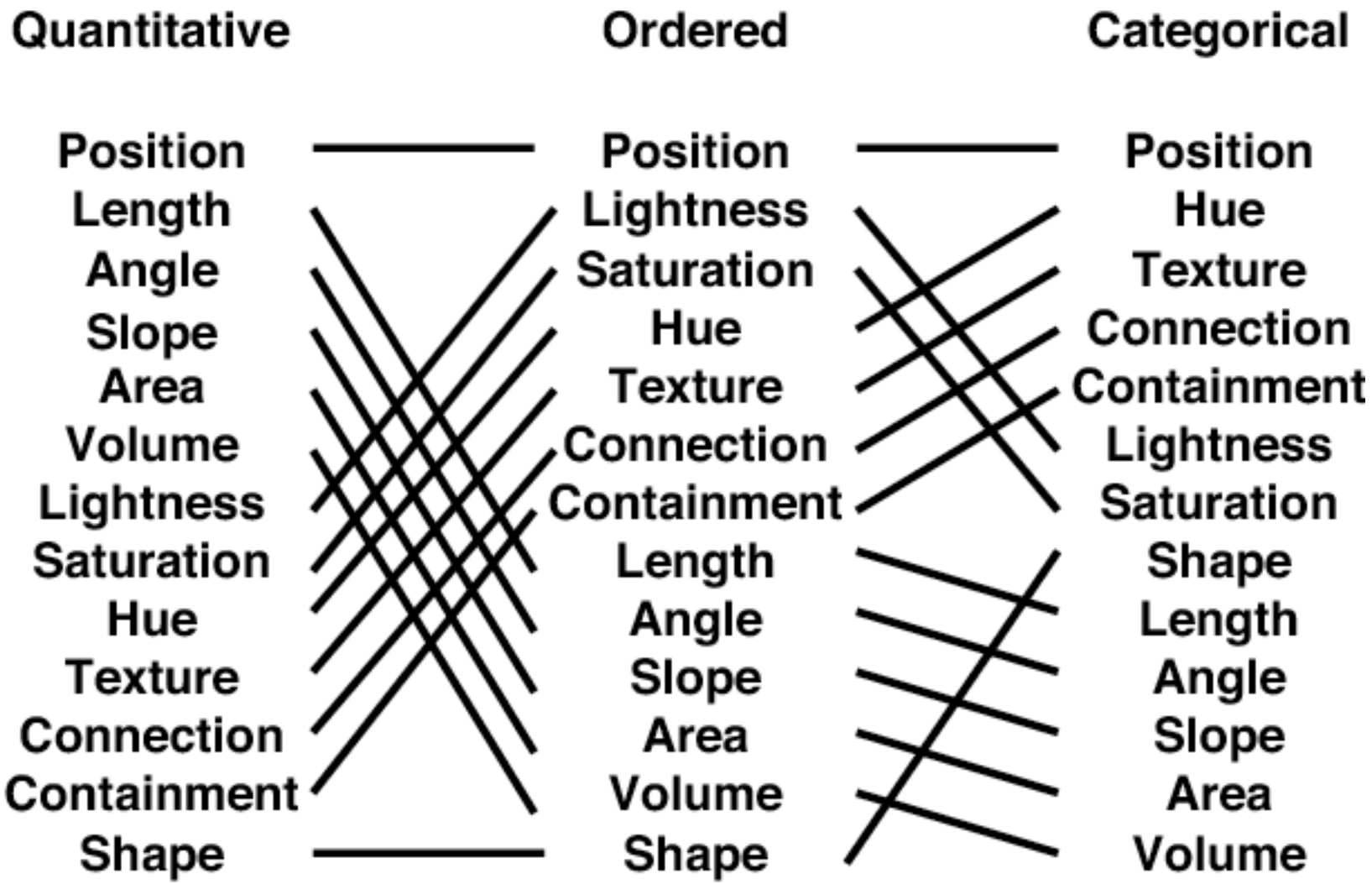
Review: Visual Encoding



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

Semiology of Graphics. Jacques Bertin, Gauthier-Villars 1967, EHESS 1998

Review: Channel Ranking By Data Type



[Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]

Review: Integral vs. Separable Channels

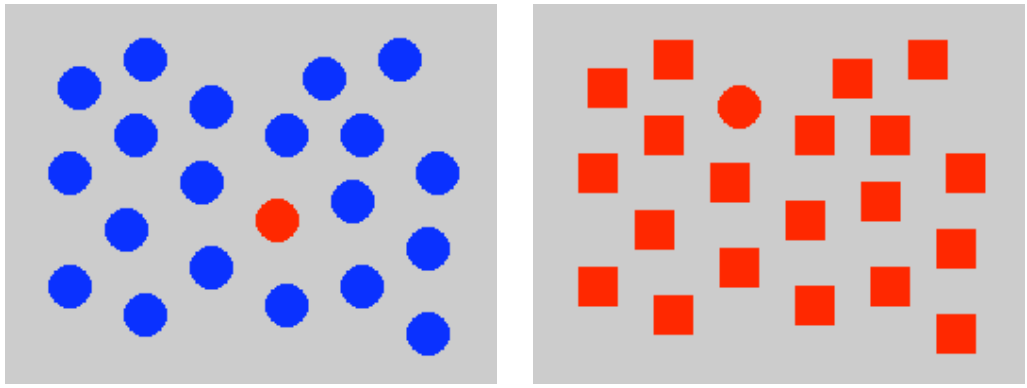
- not all channels separable

color location | color motion | color shape | size orientation | x-size y-size | red-green yellow-blue

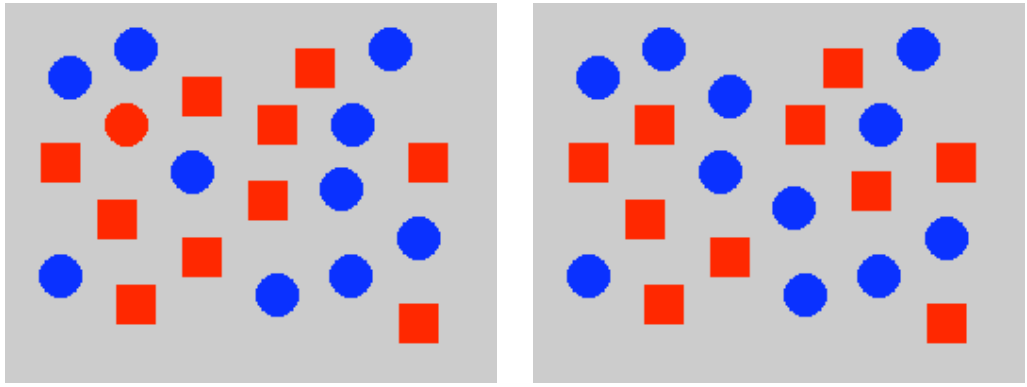
[Colin Ware, Information Visualization: Perception for Design. Morgan Kaufmann 1999.]

Review: Preattentive Visual Channels

- color alone, shape alone: preattentive



- combined color and shape: requires attention
  - search speed linear with distractor count

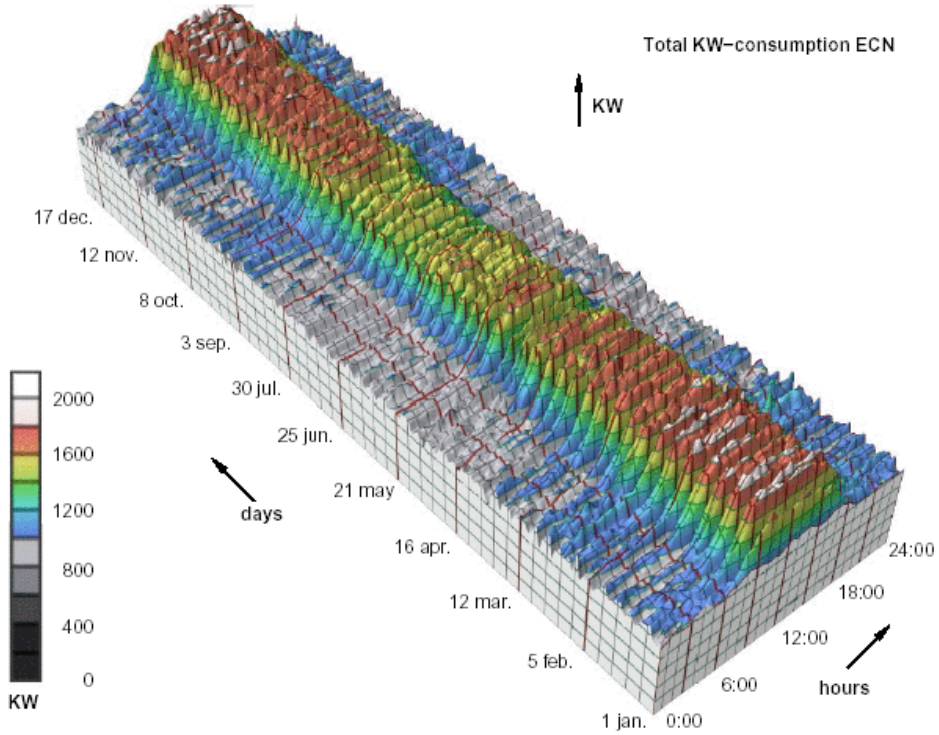


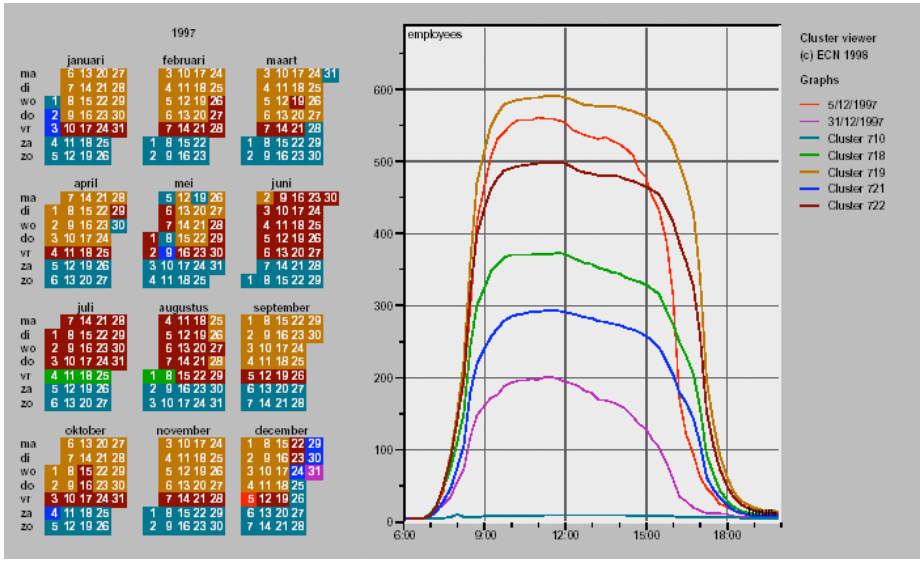
[Christopher Healey, [www.csc.ncsu.edu/faculty/healey/PP/PP.html]

Nonspatial/Information Visualization II

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





[van Wijk and van Selow, Cluster and Calendar based Visualization of Time Series Data, InfoVis99

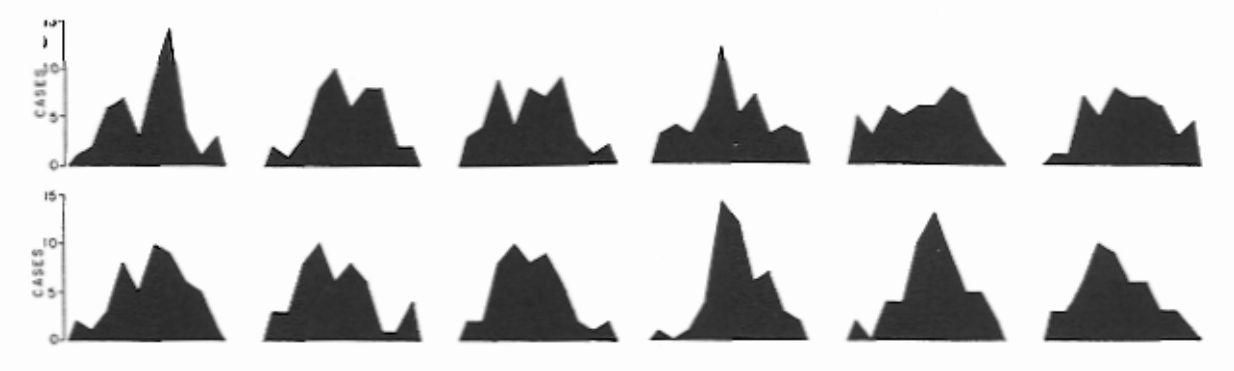
Space vs Time: Showing Change

- animation: show time using temporal change
  - good: show process
  - good: flip between two things
  - bad: flip between between many things
    - interference between intermediate frames

[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]
[www.astroshow.com/ccdpho/pluto.gif]
[Edward Tufte. The Visual Display of Quantitative Information, p 172]

Space vs Time: Showing Change

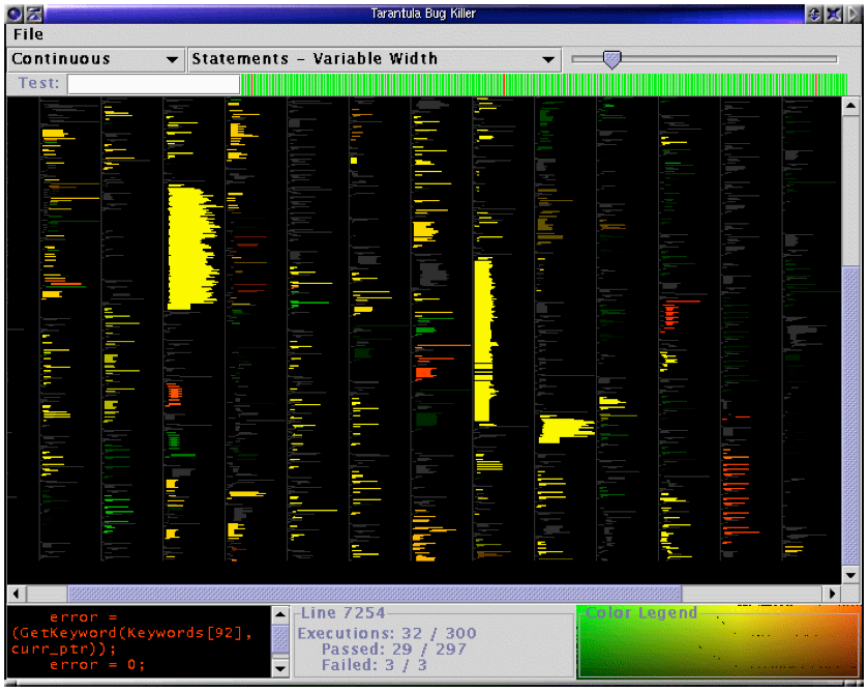
- small multiples: show time using space
  - overview: show each time step in array
  - compare: side by side easier than temporal
    - external cognition vs internal memory
  - general technique, not just for temporal changes



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

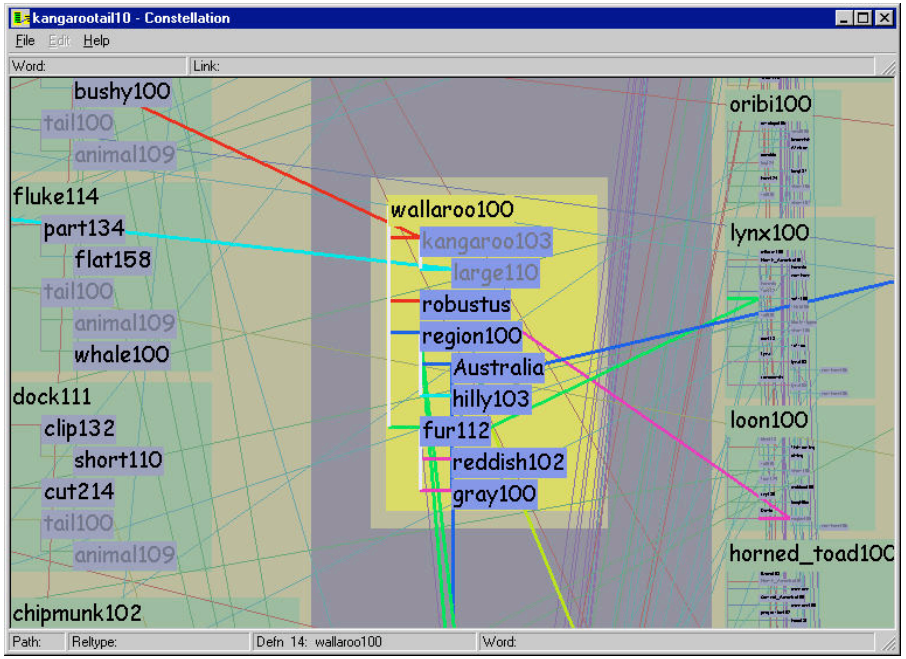
Composite Views

- pixel-oriented views
  - overviews with high information density



[Jones, Harrold, and Stasko. Visualization of Test Information to Assist Fault Localization. Proc. ICSE 2002, p 467-477.]

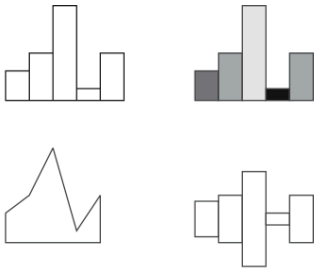
- superimposing/layering
  - shared coordinate frame
  - redundant visual encoding



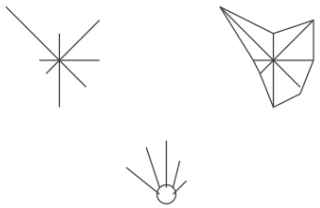
[Munzner. Interactive Visualization of Large Graphs and Networks. Stanford CS, 2000]

Composite Views: Glyphs

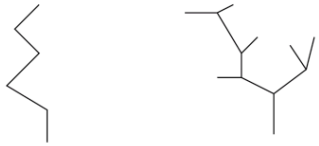
- internal structure where subregions have different visual channel encodings



Variations on Profile glyphs

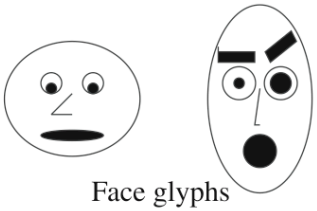


Stars and Anderson/metroglyphs

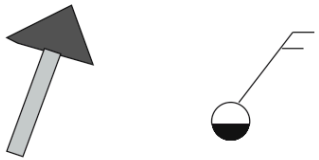


Sticks and Trees

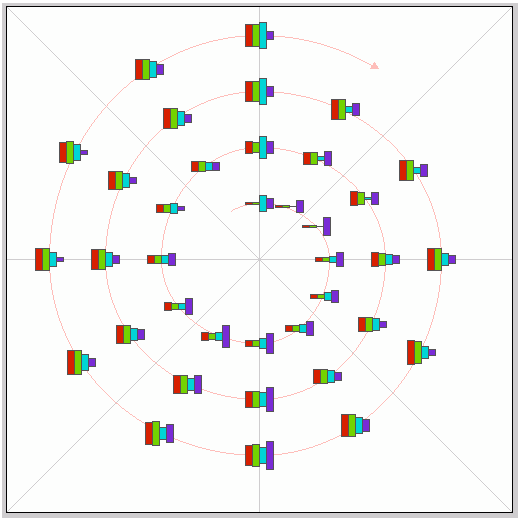
Autoglyph and box glyph

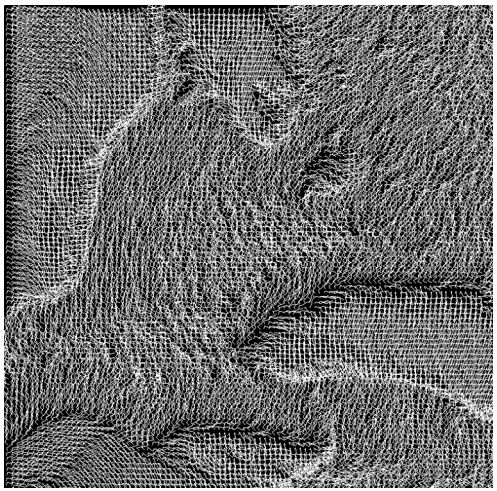


Face glyphs



Arrows and Weathervanes



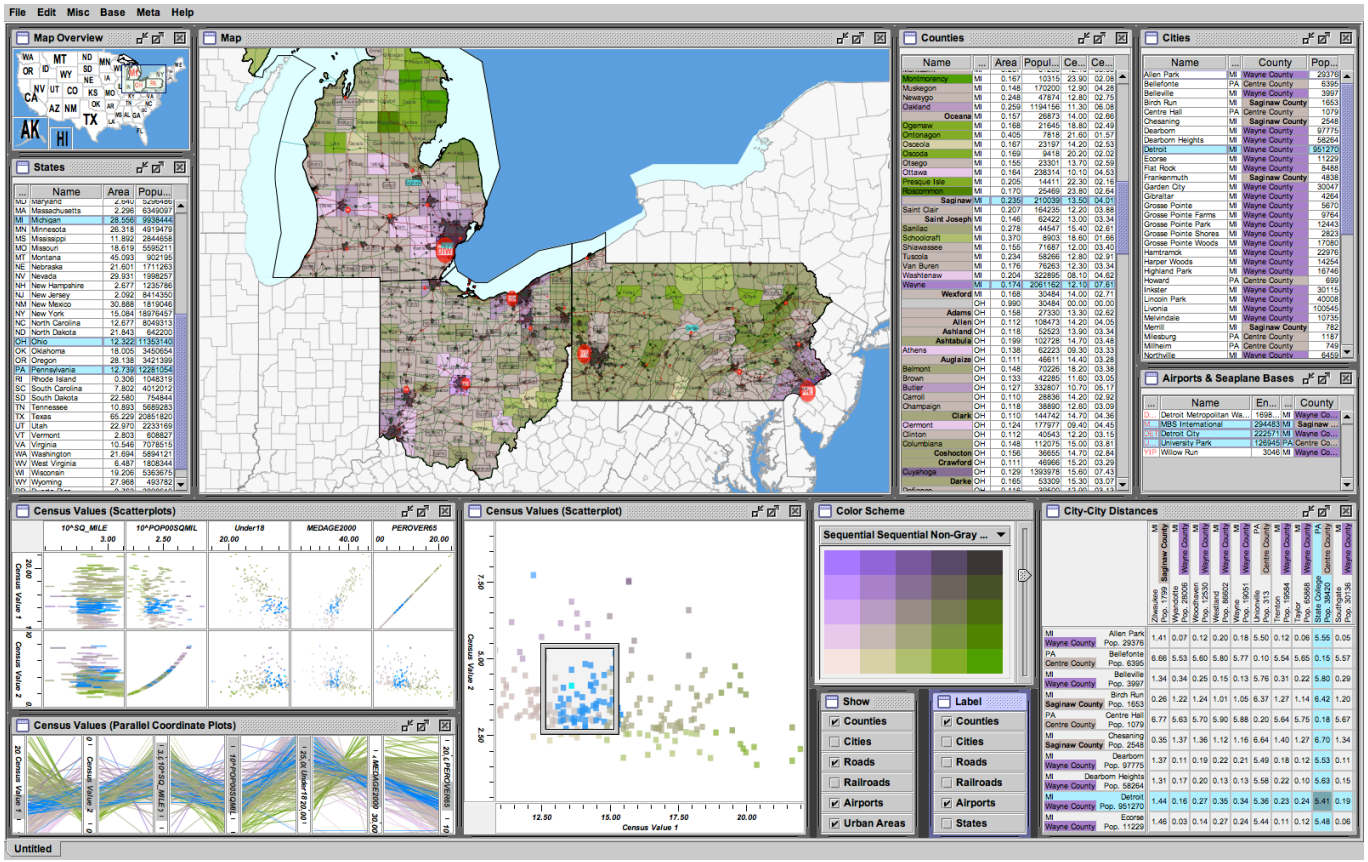


[Ward. A Taxonomy of Glyph Placement Strategies for Multidimensional Data Visualization. Information Visualization Journal 1:3-4 (2002), 194--210.]

[Smith, Grinstein, and Bergeron. Interactive data exploration with a supercomputer. Proc. IEEE Visualization, p 248-254, 1991.]

Adjacent: Multiple Views

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



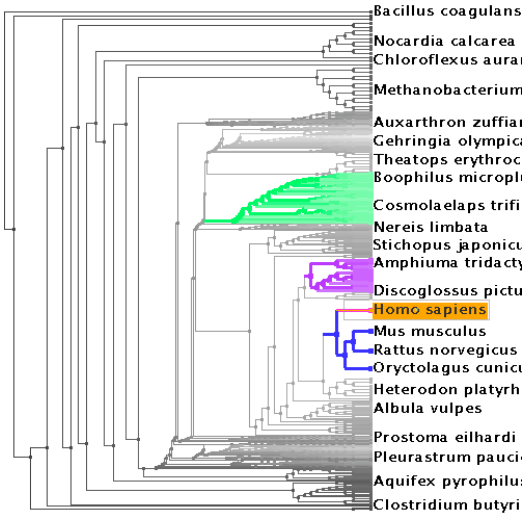
[Weaver. http://www.personal.psu.edu/cew15/improvise/examples/census]

Adjacent Views

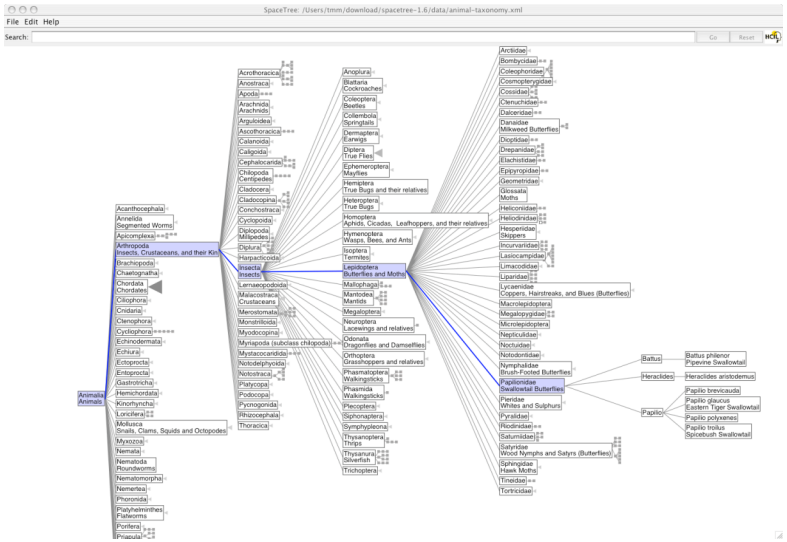
- overview and detail
  - same visual encoding, different resolutions
- small multiples
  - same visual encoding, different data

Data Reduction

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



[Munzner et al. TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Proc SIGGRAPH 2003, p 453-462]



[Plaisant, Grosjean, and Bederson. SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation. Proc. InfoVis 2002

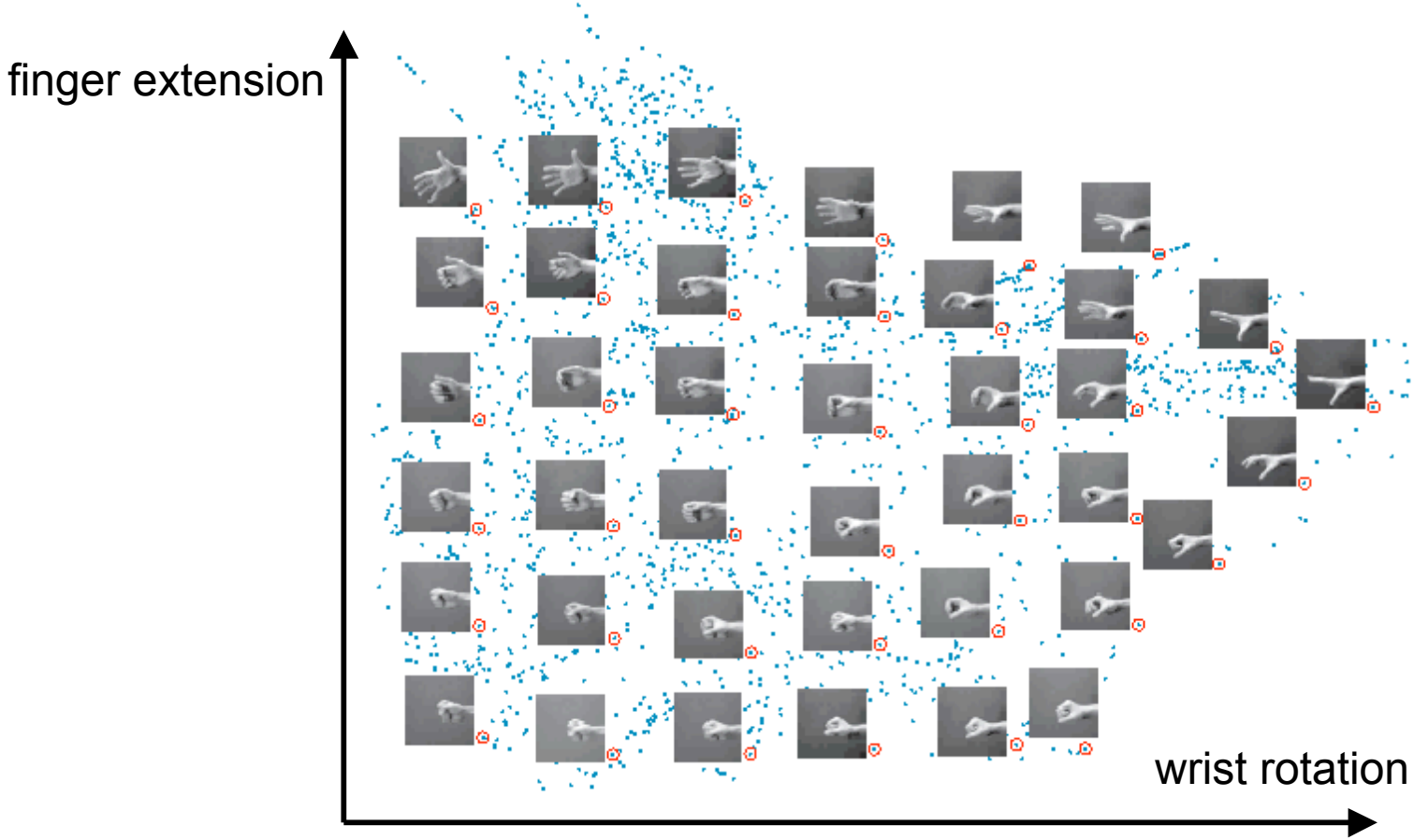
Dimensionality Reduction

- 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.
        have water color, air temp, catch rates...
    - 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



[A Global Geometric Framework for Nonlinear Dimensionality Reduction. Tenenbaum, de Silva and Langford. *Science* 290 (5500): 2319-2323, 2000, isomap.stanford.edu]

DR Technique: MDS

- multidimensional scaling
  - minimize differences between interpoint distances in high and low dimensions
- minimize objective function: stress

$$stress(D,\Delta) = \sqrt{\frac{\sum_{ij}(d_{ij}-\delta_{ij})^2}{\sum_{ij}\delta_{ij}^2}}$$

D: matrix of lowD distances d_{ij}

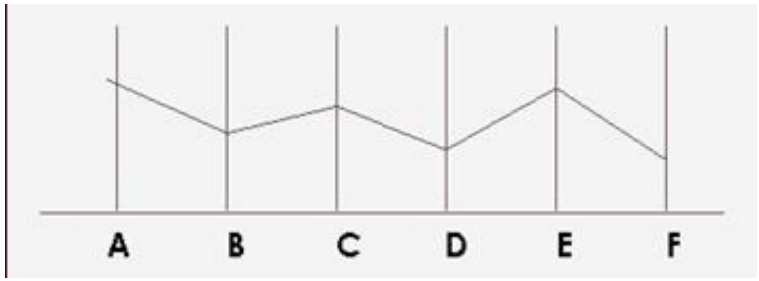
Δ: matrix of hiD distances δ_{ij}

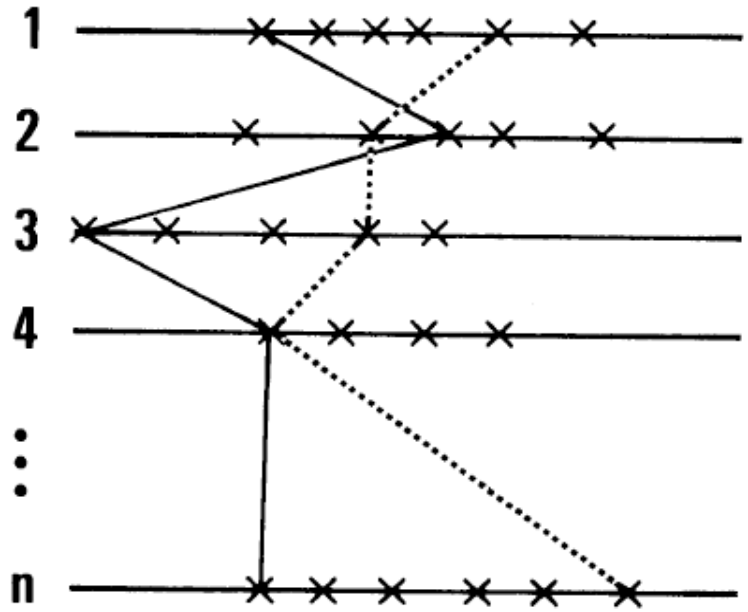
- Glimmer: MDS on the GPU

[Ingram, Munzner, Olano. Glimmer: Multiscale MDS on the GPU. IEEE TVCG 15(2):249-261, 2009.

Parallel Coordinates

- only two orthogonal axes in the plane
- instead, use parallel axes!

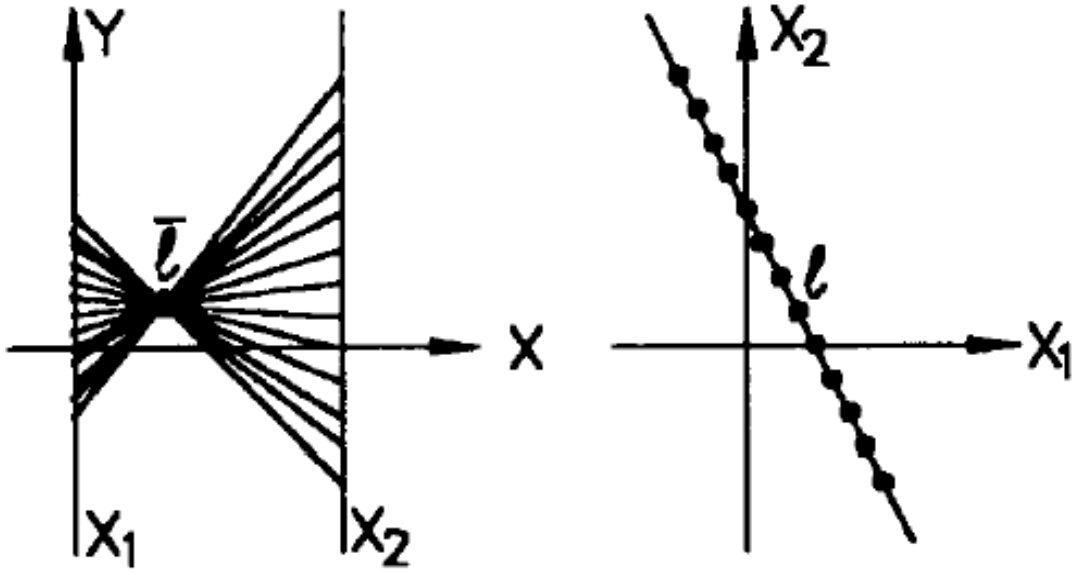




[Hyperdimensional Data Analysis Using Parallel Coordinates. Edward J. Wegman. Journal of the American Statistical Association, Vol. 85, No. 411. (Sep., 1990), pp. 664-675.]

Parallel Coordinates

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



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

Par Coords: Correllation

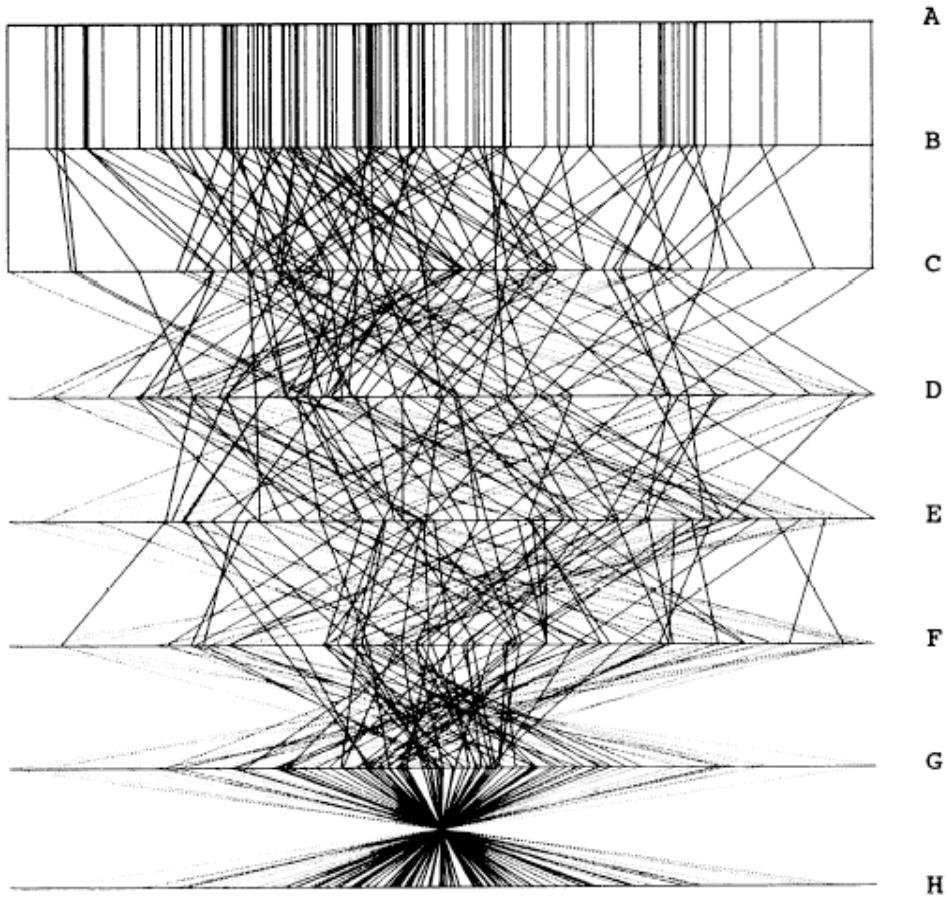
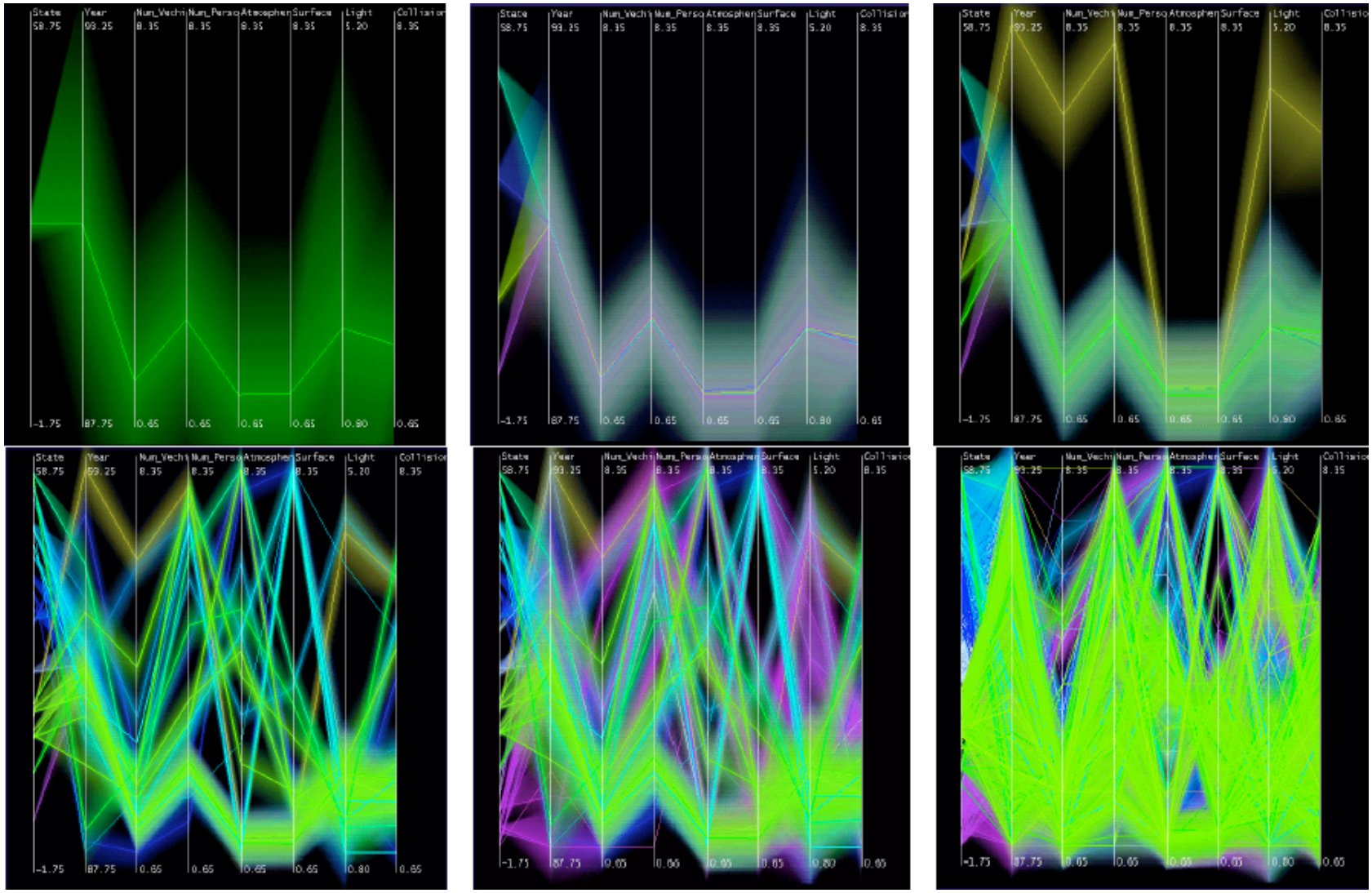


Figure 3. Parallel Coordinate Plot of Six-Dimensional Data Illustrating Correlations of $\rho = 1, .8, .2, 0, -.2, -.8,$ and -1.

[Hyperdimensional Data Analysis Using Parallel Coordinates. Wegman. Journal of the American Statistical Association, Vol. 85, No. 411. (Sep., 1990), pp. 664-675.]

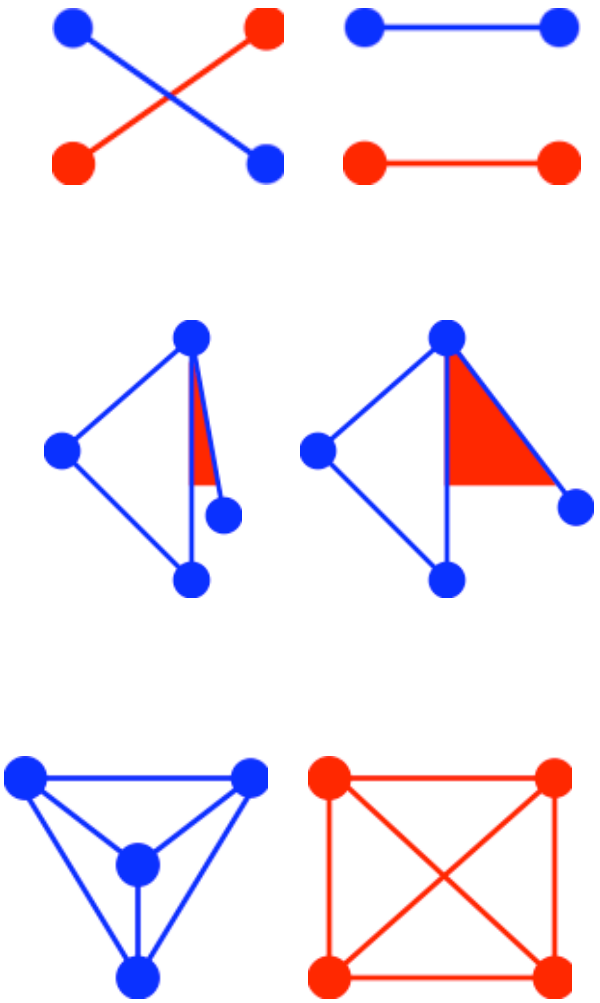
Hierarchical Parallel Coords: LOD



[Hierarchical Parallel Coordinates for Visualizing Large Multivariate Data Sets. Fua, Ward, and Rundensteiner. IEEE Visualization '99.]

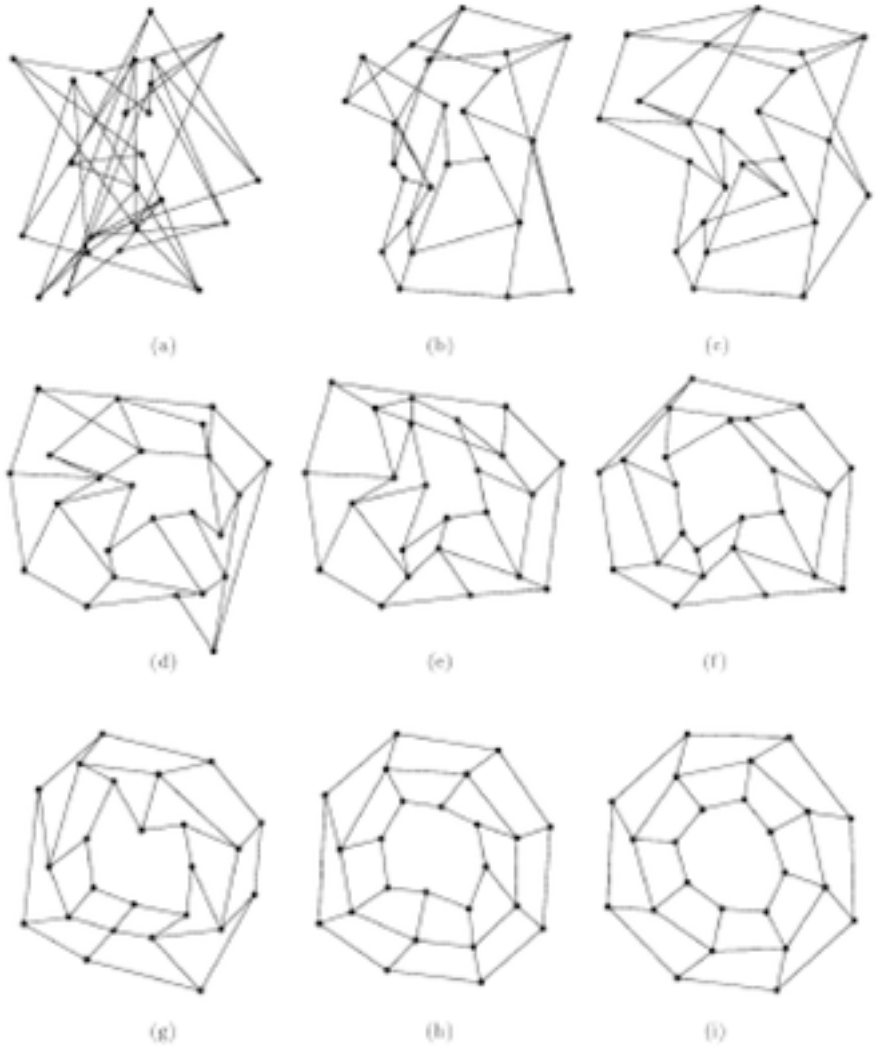
Node-Link Graph Layout

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



Force-Directed Placement

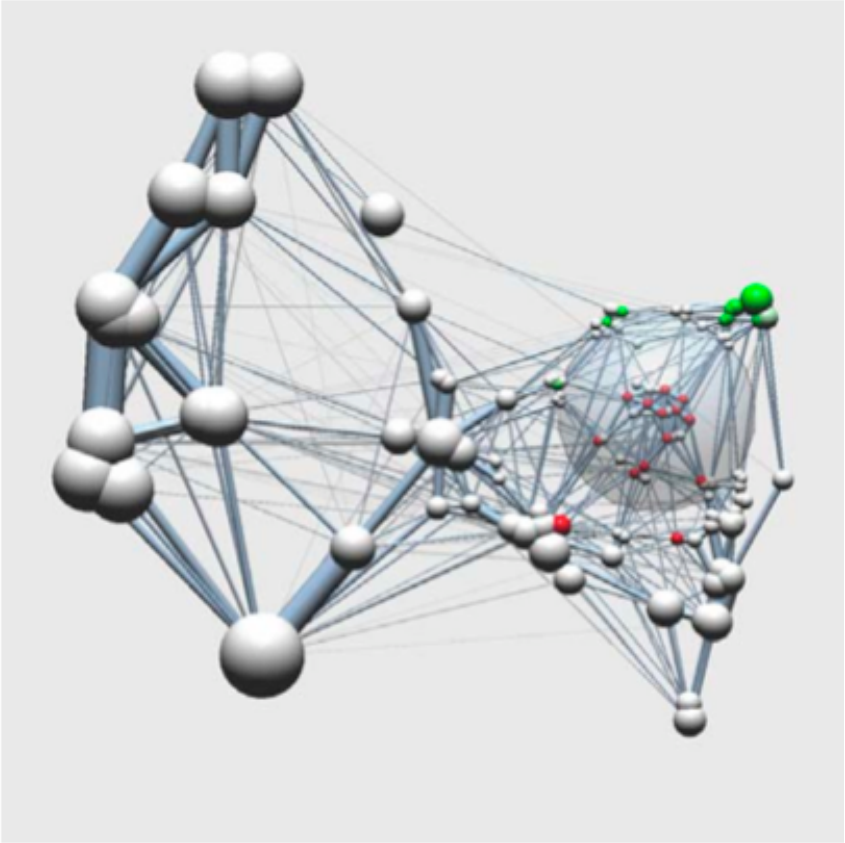
- nodes: repel like magnets
- edges: attract like springs
  - start from random positions, run to convergence
- very well studied area!
  - many people reinvent the wheel



[www.csse.monash.edu.au/~berndm/CSE460/Lectures/cse460-7.pdf]

Interactive Graph Exploration

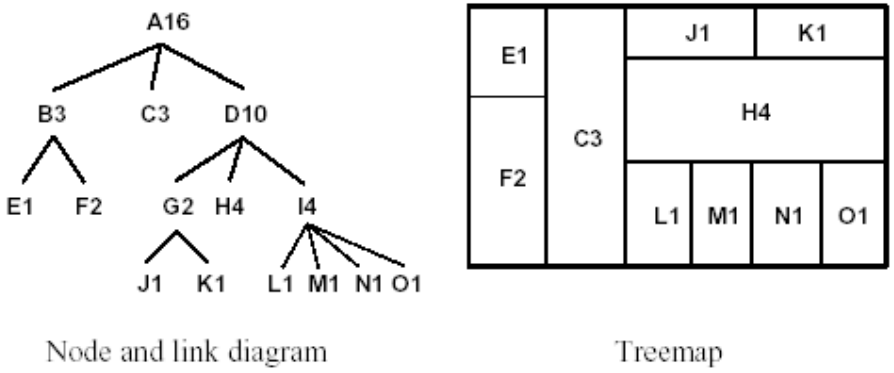
- geometric and semantic fisheye



van Ham and van Wijk. Interactive Visualization of Small World Graphs. Proc. InfoVis 2005

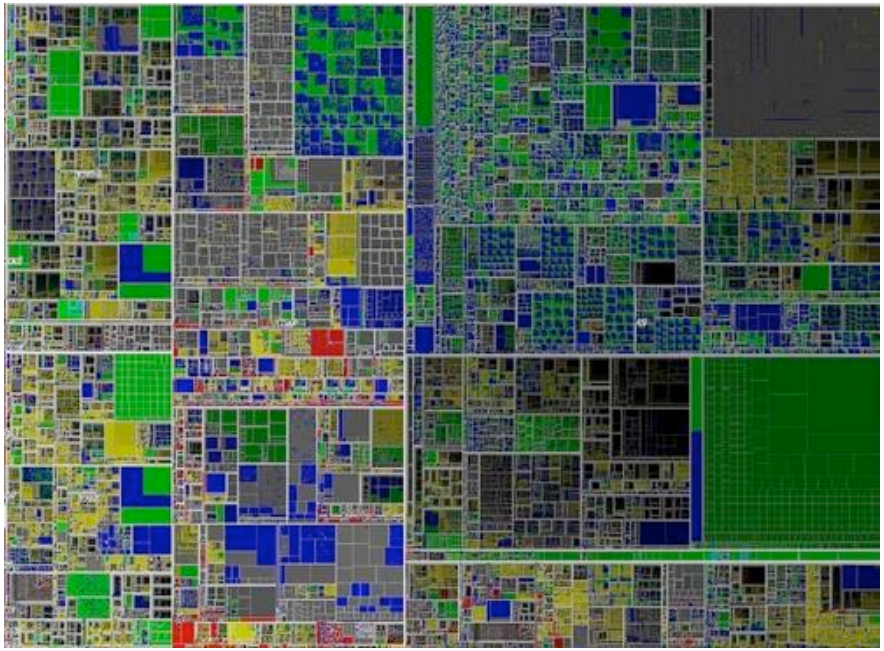
Treemaps

- containment rather than connection
  - emphasize node attributes, not topological structure



Node and link diagram

Treemap

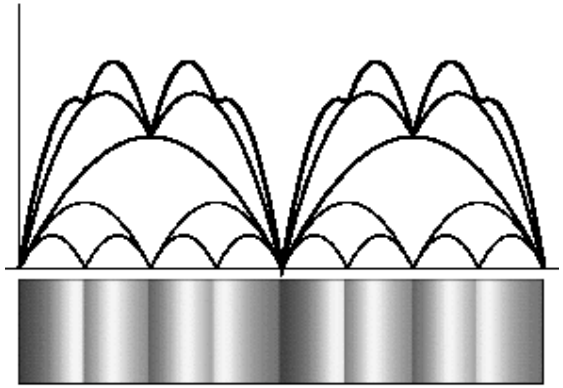


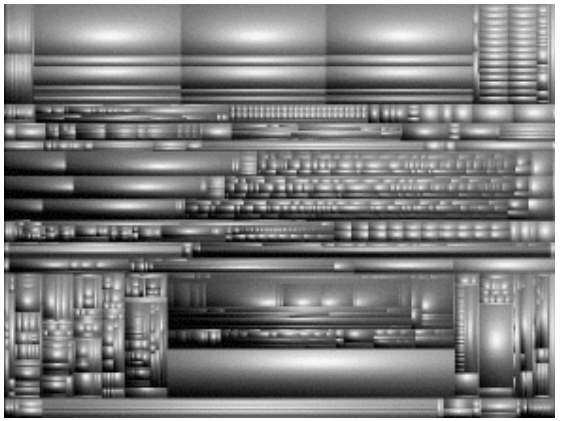
[van Wijk and van de Wetering. Cushion Treemaps. Proc InfoVis 1999]

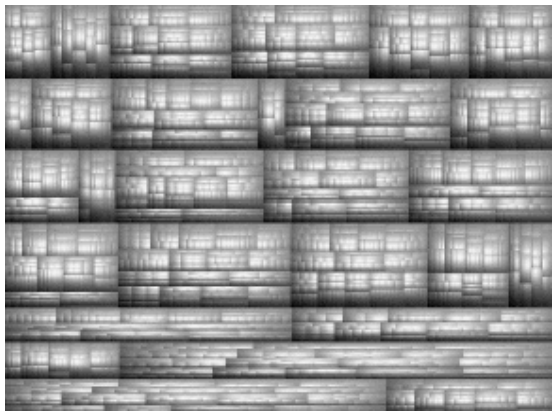
[Fekete and Plaisant. Interactive Information Visualization of a Million Items. Proc InfoVis 2002.

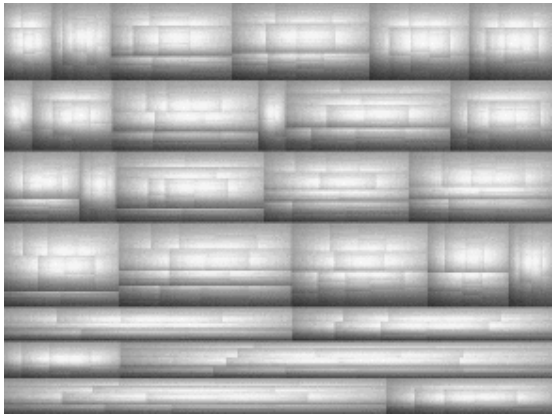
Cushion Treemaps

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









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

Now What?

Beyond 314: Other Graphics Courses

- 424: Geometric Modelling
  - will be offered next year
- 426: Computer Animation
  - was offered this year

- 514: Image-Based Rendering - Heidrich
- 526: Algorithmic Animation - van de Panne
- 533A: Digital Geometry - Sheffer
- 533B: Animation Physics - Bridson
- 533C: Information Visualization - Munzner

Beyond UBC CS

- SIGGRAPH conference in Vancouver next year!
  - August 7 - August 11 2011
  - ~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