Information Visualization

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Outline

Information Visualization

interactive visual representation of abstract data

Interactivity

static images
- 10,000 years
- art, graphic design

moving images
- 100 years
- cinematography

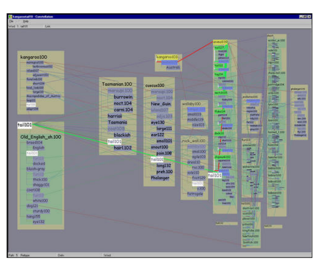
interactive graphics
- 20 years
- computer graphics, human-computer interaction

Information Visualization

interactive visual representation of abstract data
- help human perform some task more effectively

Task-Oriented Design: Constellation

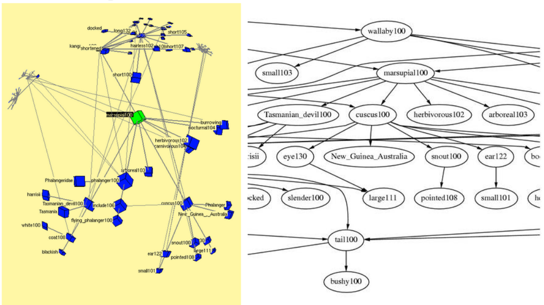
custom design for checking semantic networks
- reading definition subgraph labels
- following paths through network




[graphics.stanford.edu/papers/munzner_thesis/html/node10.html#layoutefffig]

Task-Oriented Design

previous general methods



[graphics.stanford.edu/papers/munzner_thesis/html/node10.html#dotconstfig]

Information Visualization

interactive visual representation of abstract data

- help human perform some task more effectively

bridging many fields

- graphics: interacting in realtime
- cognitive psych: finding appropriate representation
- HCI: using task to guide design and evaluation

external representation

- reduces load on working memory
- offload cognition

- familiar example: multiplication/division

External Representation: multiplication

paper mental buffer

```
  57
x 48
----
```


External Representation: multiplication

paper mental buffer

```
  57
x 48         [ 7*8=56 ]
----
```


External Representation: multiplication

paper mental buffer

```
   5
  57
x 48         [ 7*8=56 ]
----

   6
```


External Representation: multiplication

paper mental buffer

```
   5
  57
x 48       [5*8=40 + 5 = 45]
----

   6
```

External Representation: multiplication

paper mental buffer

```
  57
x 48      [5*8=40 + 5 = 45]
----

 456
```


External Representation: multiplication

paper mental buffer

```
  57
x 48      [7*4=28]
----

 456
```


External Representation: multiplication

paper mental buffer

```
   2
  57
x 48      [7*4=28]
----

 456
  8
```


External Representation: multiplication

paper mental buffer

```
   2
  57
x 48      [5*4=20 + 2 =22]
----

 456
  8
```


External Representation: multiplication

paper mental buffer

```
  57
x 48      [5*4=20 + 2 =22]
----

 456
228
```


External Representation: multiplication

paper mental buffer

```
  57
x 48
----

 456
228_
----
   6
```

External Representation: multiplication

paper mental buffer

```
  57
x 48
----
 456
228_       [8+5 = 13]
----
   6
```


External Representation: multiplication

paper mental buffer

```
  57
x 48
----
 1
 456
228_       [8+5 = 13]
----
  36
```


External Representation: multiplication

paper mental buffer

```
  57
x 48
----
 1
 456
228_       [4+2+1=7]
----
  36
```


External Representation: multiplication

paper mental buffer

```
  57
x 48
----
 456
258_       [4+2+1=7]
----
 736
```


External Representation: multiplication

paper mental buffer

```
  57
x 48
----
 456
258_
----
2736
```


Information Visualization

interactive visual representation of abstract data
- help human perform some task more effectively

bridging many fields
- graphics: interacting in realtime
- cognitive psych: finding appropriate representation
- HCI: using task to guide design and evaluation

external representation
- reduces load on working memory
- offload cognition

- familiar example: multiplication/division
- infovis example: topic graphs

External Representation: Topic Graphs

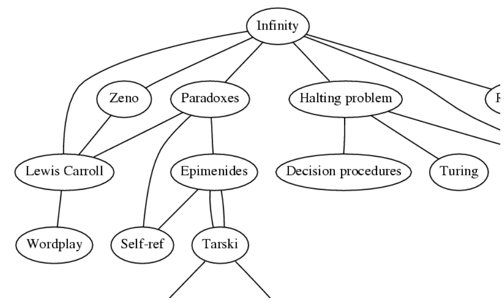
[Godel, Escher, Bach. Hofstadter 1979]

Paradoxes – Lewis Carroll
Turing – Halting problem
Halting problem – Infinity
Paradoxes – Infinity
Infinity – Lewis Carroll
Infinity – Unpredictably long searches
Infinity – Recursion
Infinity – Zeno
Infinity – Paradoxes
Lewis Carroll – Zeno
Lewis Carroll – Wordplay

Halting problem – Decision procedures
BlooP and FlooP – AI
Halting problem – Unpredictably long searches
BlooP and FlooP – Unpredictably long searches
BlooP and FlooP – Recursion
Tarski – Truth vs. provability
Tarski – Epimenides
Tarski – Undecidability
Paradoxes – Self-ref
[...]

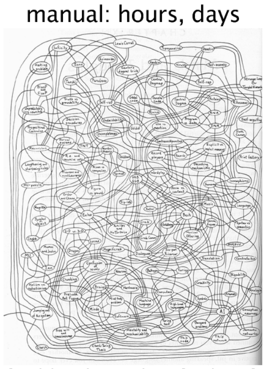
External Representation: Topic Graphs

offload cognition to visual systems
minimal attention to read answer



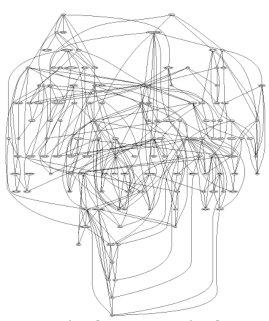
External Rep: Automatic Layout

manual: hours, days



[Godel, Escher, Bach. Hofstader 79]

automatic: seconds



dot, [Gansner et al 93]

InfoVis vs. SciVis

is spatialization given (scivis) or chosen (infovis)
- my definition

names are unfortunate historical accidents
- not scivis iff data generated by scientists
- infovis not unscientific
- scivis not uninformative
- but – too late to change

infovis: how to represent
- choosing, doing, evaluating
- huge space of possibilities: random walk ineffective
- need design guidelines

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Overviews
Focus+Context
Linked Views
Layers
Perception
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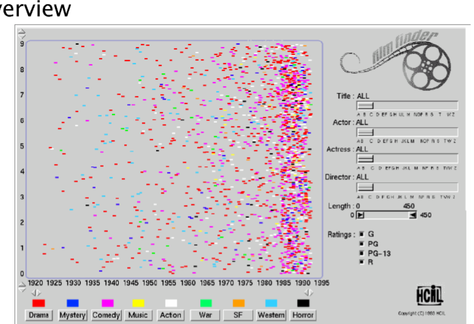
Overviews: Shneiderman mantra

overview

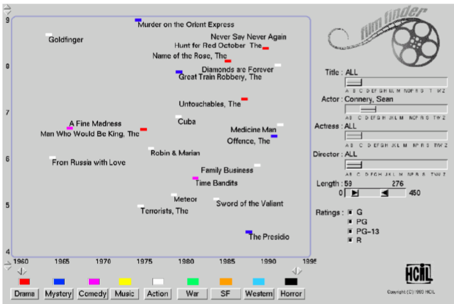


Ahlberg & Shneiderman, Color plate 1. The FilmFinder.

[Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays. Ahlberg and Shneiderman, Proc SIGCHI '94,

Overviews: Shneiderman mantra

overview, zoom and filter



Ahlberg & Shneiderman, Color plate 2. Categories have been selected, the displayed is zoomed

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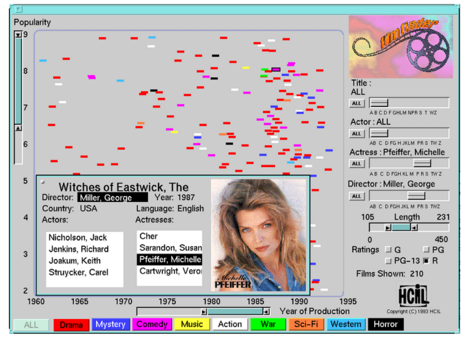
[Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays. Ahlberg and Shneiderman, Proc SIGCHI '94, citeseer.ist.psu.edu/ahlberg94visual.html]

Overviews: Shneiderman mantra

overview, zoom and filter, details-on-demand



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[Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays. Ahlberg and Shneiderman, Proc SIGCHI '94,

Overviews: Shneiderman mantra

overview first,
then zoom and filter,
details-on-demand

other tasks
- relate, history, extract

data types
- 1D, 2D, 3D, nD, temporal, tree, network

The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations.
Ben Shneiderman, Proc. 1996 IEEE Visual Languages, also Maryland HCIL TR 96-13
ftp://ftp.cs.umd.edu/pub/hcil/Reports-Abstracts-Bibliography/96-13html/96-13.html

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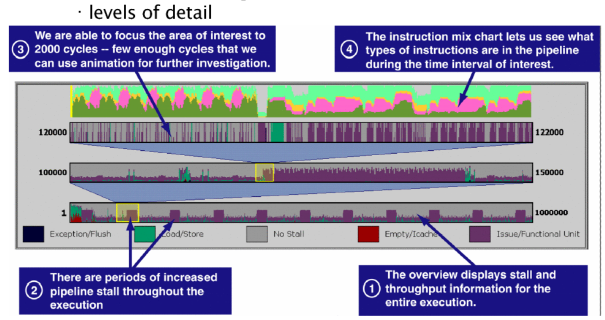
Overviews: Rivet

performance tuning
- levels of detail



[Stolte et al, Visualizing Application Behavior on Superscalar Processors, InfoVis 99, graphics.stanford.edu/papers/rivet_pipeline]

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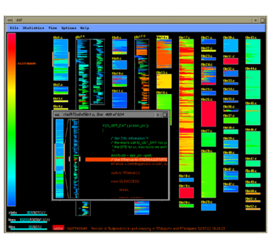
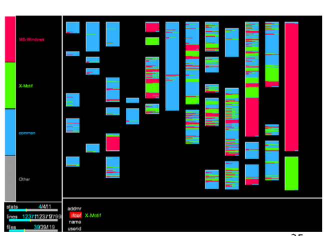
Overviews: SeeSoft

software maintenance
- colored lines of code -> lines one pixel high

code age



platform dependencies



[Ball and Eick, Software Visualization in the Large, Computer 29:4, 1996 citeseer.nj.nec.com/ball96software.html]

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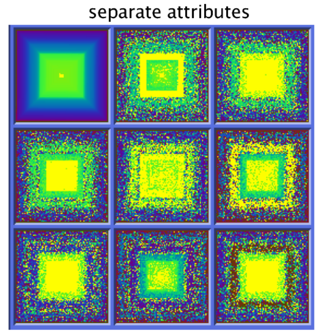
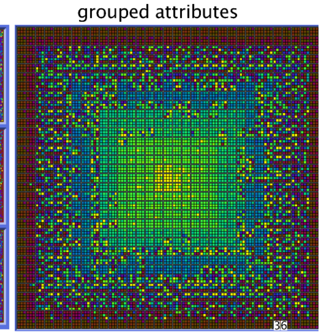
Overviews: VisDB

database queries

separate attributes



grouped attributes



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[Keim and Kriegel, VisDB: Database Exploration using Multidimensional Visualization, IEEE CG&A,

Overviews: Tree Skeletonization

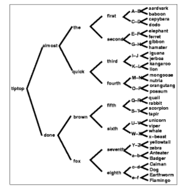
uses Strahler metric

[Graph Visualisation in Information Visualisation: a Survey.
Ivan Herman, Guy Melancon, M. Scott Marshall.
IEEE Transactions on Visualization and Computer Graphics, 6(1), pp. 24-44, 2000.
http://citeseer.nj.nec.com/herman00graph.html]

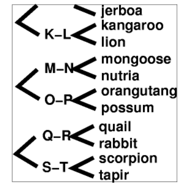
Overview+Detail

problem
- avoid user disorientation when inspecting detail
- hard for big datasets

bad: one window, must remember position



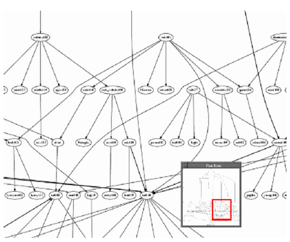
global overview



local detail

Overview+Detail

better: add linked overview window(s)
problem: still cognitive load to correlate



Single Merged View: Many Names

focus+context
- [Rao94]

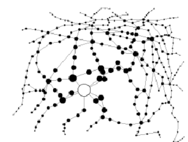
fisheye views
- [Furnas86,Sarkar94]

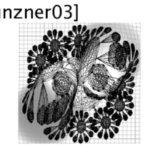
hyperbolic views
- [Rao95, Munzner97]

stretchable rubber sheet
- [Sarkar93, Robertson93, Munzner03]

nonlinear distortion
- [Keahey97]

pliable surfaces
- [Carpendale95]





distortion-oriented presentation techniques
- [Leung94]

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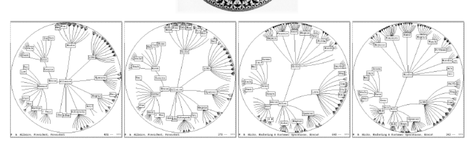
Focus+Context: Hyperbolic Trees

fisheye effect from 2D hyperbolic geometry
- [demo: www.lexisnexis.com/startree]



[The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John Lamping and Ramana Rao, Proc SIGCHI '95.]

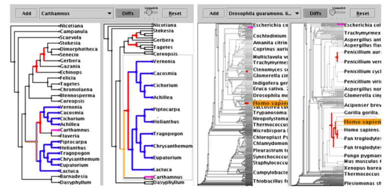
Focus+Context: H3

fisheye effect from 3D hyperbolic geometry
- [demo: graphics.stanford.edu/~munzner/h3]

[Tamara Munzner. H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space. Proc. InfoVis 1997. graphics.stanford.edu/papers/h3]

Focus+Context: TreeJuxtaposer

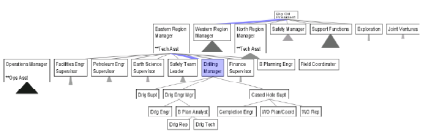
stretch and squish "rubber sheet"
guaranteed visibility
- keeping highlighted marks visible at all times
- [demo: olduvai.sf.net/tj]



[TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner et al. SIGGRAPH 2003. www.cs.ubc.ca/~tmm/papers/tj]

Focus+Context: SpaceTree

interactively expand/contract
- not stretching space
- [demo: www.cs.umd.edu/hcil/spacetree]



[SpaceTree. Catherine Plaisant, Jesse Grosjean and Ben B. Bederson. Proc. InfoVis 2002 ftp://ftp.cs.umd.edu/pub/hcil/Reports-Abstracts-Bibliography/2002-05html/2002-05.pdf]

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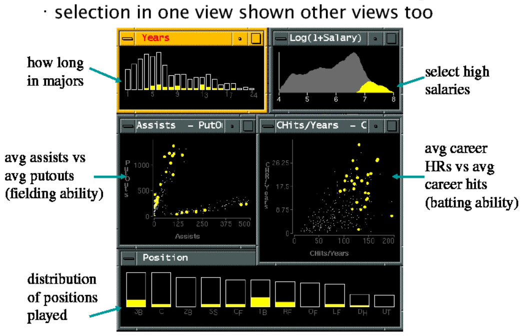
Linked Views: EDV

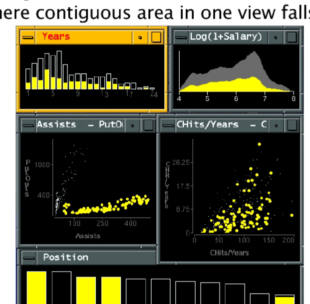
Exploratory Data Visualizer: statistical graphics
- selection in one view shown other views too



[Visual Exploration of Large Structured Databases, Graham J. Wills,

Linked Views: EDV

aka brushing, coordinated views
- see where contiguous area in one view falls in others



[Visual Exploration of Large Structured Databases, Graham J. Wills,

Linked Views: Time-Series Data Analysis

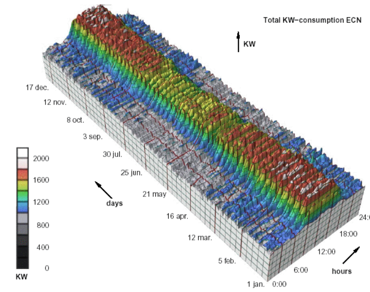
data: N pairs of (value, time)
- N large: 50K

tasks
- find standard day patterns
- find how patterns distributed over year, week, season
- find outliers from standard daily patterns
- want overview first, then detail on demand

[van Wijk and van Selow, Cluster and Calendar based Visualization of Time Series Data, InfoVis99, citeseer.nj.nec.com/vanwijk99cluster.html]

3D Extrusion: Obvious but Nonoptimal

perspective interferes with comparison
daily, weekly patterns hard to see



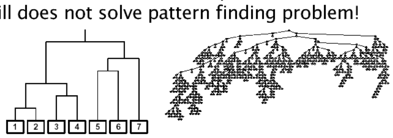
[van Wijk and van Selow, Cluster and Calendar based Visualization of Time Series Data, InfoVis99, citeseer.nj.nec.com/vanwijk99cluster.html]

Hierarchical Clustering

start with all M day patterns
- compute mutual differences, merge most similar
- continue up to 1 root cluster

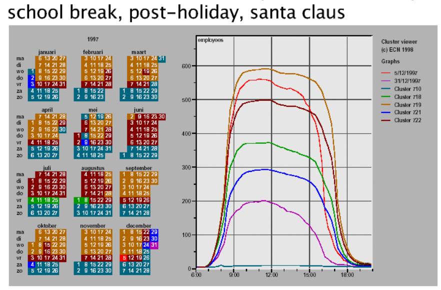
result: binary hierarchy of clusters
- choice of distance metrics

dendrogram display common
- shows structure of hierarchy
- still does not solve pattern finding problem!



Link Clusters and Calendar

2D linked clusters-calendars shows patterns
- office hours, weekend/holidays, summer/fridays
- school break, post-holiday, santa claus



[van Wijk and van Selow, Cluster and Calendar based Visualization of Time Series Data, InfoVis99, Figure 4, citeseer.nj.nec.com/vanwijk99cluster.html]

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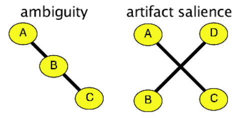
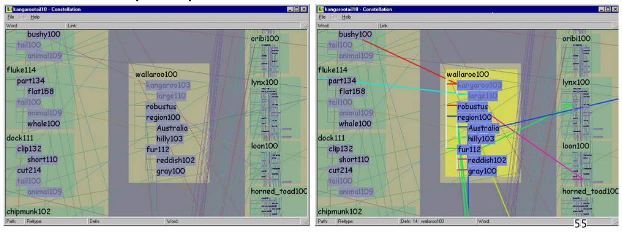
Layering: Cartography

Layering: Semantic Networks

edge crossing problem
- false attachments

layers to avoid perception
- vs. spatial position

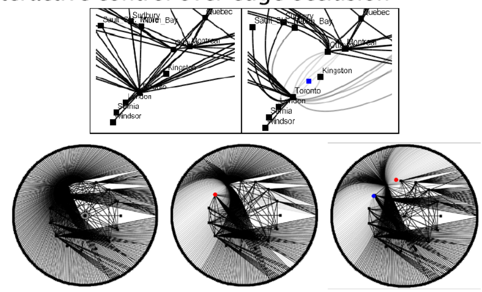




[Munzner et al, Constellation, Proc. InfoVis 99, graphics.stanford.edu/papers/const]

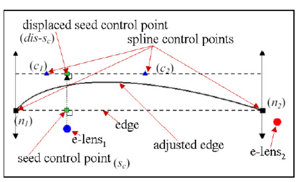
Layering: EdgeLens

interactive control over edge occlusion



[EdgeLens: An Interactive Method for Managing Edge Congestion in Graphs
Nelson Wong, M. Sheelagh T. Carpendale, Saul Greenberg, Proc. InfoVis03, pp 51-58
pages.cpsc.ucalgary.ca/~sheelagh/personal/pubs/2003/wong-carp-infovis03-submit.pdf]

EdgeLens Algorithm

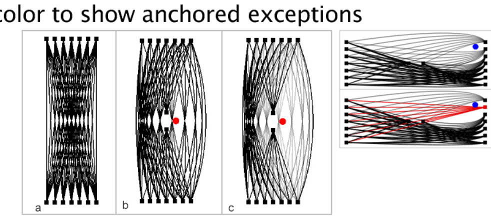


decide which edges affected
calculate displacements
calculate spline control points
draw curves

[EdgeLens: An Interactive Method for Managing Edge Congestion in Graphs
Nelson Wong, M. Sheelagh T. Carpendale, Saul Greenberg, Proc. InfoVis03, pp 51-58.
pages.cpsc.ucalgary.ca/~sheelagh/personal/pubs/2003/wong-carp-infovis03-submit.pdf]

EdgeLens Techniques

deformation, transparency
color to show anchored exceptions



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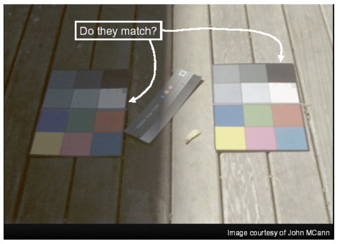
Human Perception

sensors/transducers
- psychophysics: determine characteristics
- eyes are not cameras

relative judgements: strong
absolute judgements: weak

Relative Judgements

color/brightness constancy



[Image: John McCann. from A Field Guide to Digital Color, Maureen C. Stone, AK Peters 2003; SIGGRAPH 2001 course notes; graphics.stanford.edu/courses/cs448b-02-spring/04cdrom.pdf]

Relative Judgements

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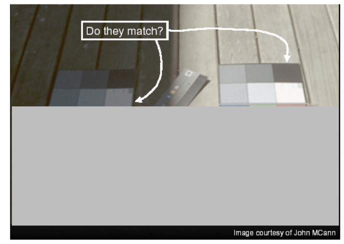

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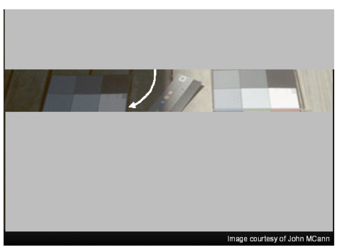

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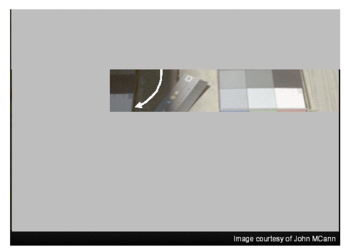

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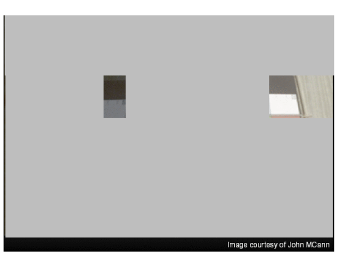

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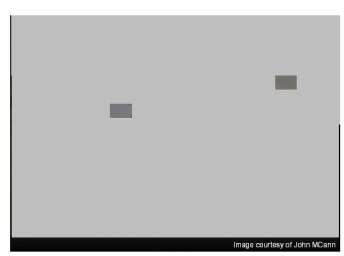
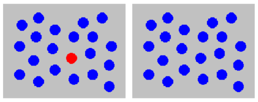
color/brightness constancy



[Image: John McCann. from A Field Guide to Digital Color, Maureen C. Stone, AK Peters 2003; SIGGRAPH 2001 course notes; graphics.stanford.edu/courses/cs448b-02-spring/04cdrom.pdf]

Preattentive Visual Channels: Popout

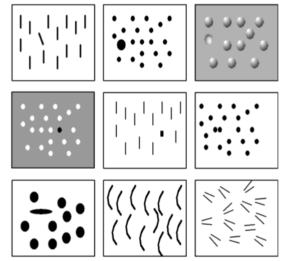
color (hue) alone: preattentive
- visual attentional system not invoked
- parallel search: speed independent of distractor count



[Chris Healey, Preattentive Processing, www.csc.ncsu.edu/faculty/healey/PP]

Preattentive Visual Channels: Popout

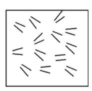
many preattentive channels of visual modality
- hue
- shape
- texture
- length
- width
- size
- orientation
- curvature
- intersection
- intensity
- flicker
- direction of motion
- stereoscopic depth
- lighting direction
- [and many more...]



[Chris Healey, Preattentive Processing, www.csc.ncsu.edu/faculty/healey/PP]

Non-preattentive: parallelism

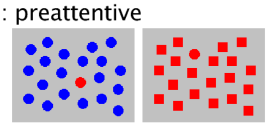
many preattentive channels of visual modality
- hue
- shape
- texture
- length
- width
- size
- orientation
- curvature
- intersection
- intensity
- flicker
- direction of motion
- stereoscopic depth
- lighting direction
- [and many more...]



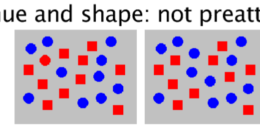
[Chris Healey, Preattentive Processing, www.csc.ncsu.edu/faculty/healey/PP]

Preattentive Visual Channels

color alone: preattentive
shape alone: preattentive



combined hue and shape: not preattentive



- requires attention
- sequential search: speed linear with distractor count

[Chris Healey, Preattentive Processing, www.csc.ncsu.edu/faculty/healey/PP]

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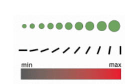
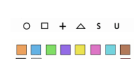
Data Types

continuous (quantitative)
- 10 inches, 17 inches, 23 inches



ordered (ordinal)
- small, medium, large

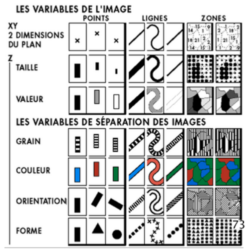
categorical (nominal)
- apples, oranges, bananas



Bertin: Semiology of Graphics

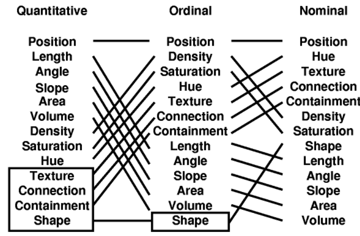
- geometric primitives: marks
  - points, lines, areas, volumes
- attributes: visual/retinal variables
  - parameters control mark appearance
  - separable channels flowing from retina to brain
  - [x,y]
    - position
  - [z]
    - size, shape, greyscale, color, texture, orientation
- data types
  - nominal, ordinal, quant

[Bertin, Semiology of Graphics, 1967 Gauthier-Villars, 1998 EHESS]



Data Type Affects Channel Ranking

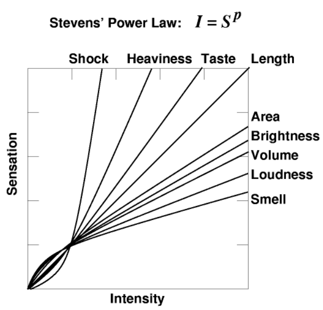
- spatial position best for all types
  - accuracy at judging magnitudes, from best to worst



[Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]
[Card, Mackinlay, and Shneiderman. Readings in Information Visualization: Using Vision to Think. Morgan Kaufmann 1999. Chapter 1]

Nonlinear Perception of Magnitudes

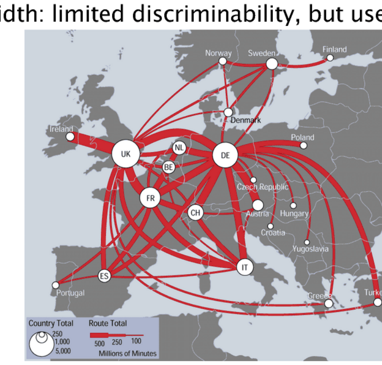
sensory channels not equally discriminable



[Stevens, On the Theory of Scales of Measurement, Science 103:2684, 1946]

Channel Dynamic Range

linewidth: limited discriminability, but useful



[mappa.mundi.net/maps/maps_014/telegeography.html]

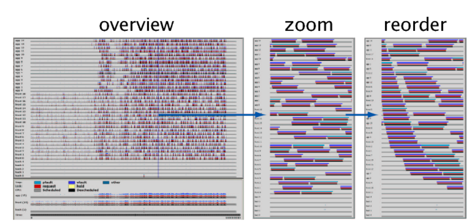
Integral vs. Separable Channels

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

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

Spatial Ordering: Rivet

performance analysis of parallel system



[Bosch, Performance Analysis and Visualization of Parallel Systems Using SimOS and Rivet: A Case Study, HPCA6, 2000. graphics.stanford.edu/papers/rivet_argus]

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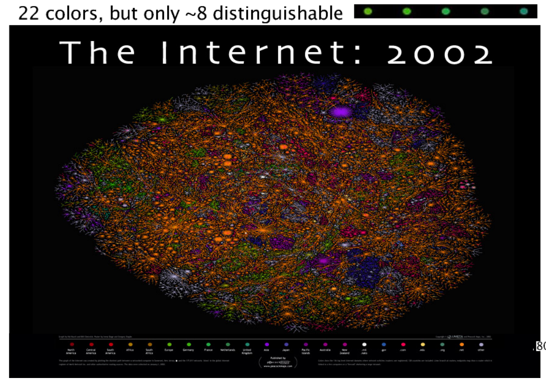
Coloring Categorical Data

22 colors, but only ~8 distinguishable

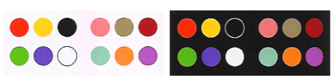


Coloring Categorical Data

discrete small patches separated in space

limited distinguishability: around 8-14
- channel dynamic range: low
- choose bins explicitly for maximum milage

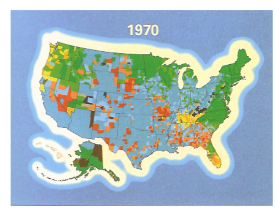
maximally discriminable colors from Ware
- maximal saturation for small areas



[Colin Ware, Information Visualization: Perception for Design. Morgan Kaufmann 1999. Figure 4.21]

Minimal Saturation for Large Areas

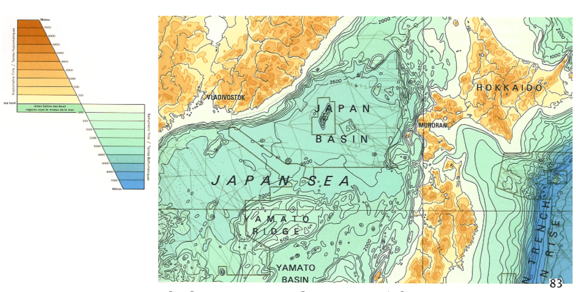
avoid saturated color in large areas
- "excessively exuberant"



[Edward Tufte, Envisioning Information, p.82]

Minimal Saturation for Large Areas

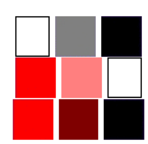
large continuous areas in pastel
- diverging colormap (bathymetric/hypsometric)



[Tufte, Envisioning Information, p. 91]

Coloring Ordered Data

innate visual order
- greyscale/luminance
- saturation
- brightness



debatable visual order
- hue

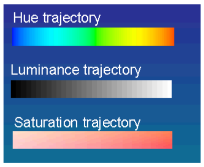
Coloring Quantitative Data

continuous field

side by side patches highly distinguishable
- channel dynamic range: high

mediocre
- hue (rainbow)

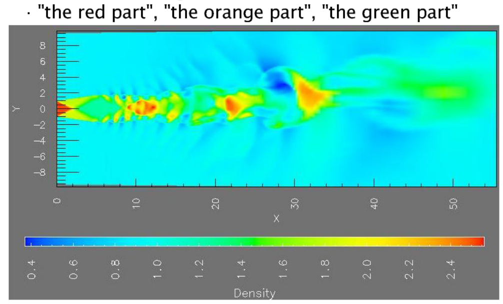
good
- greyscale/luminance
- saturation
- brightness



[www.research.ibm.com/visualanalysis/perception.html]

Rainbow Colormap Advantages

low-frequency segmentation
- "the red part", "the orange part", "the green part"

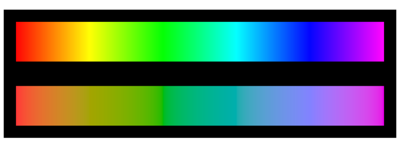


[Rogowitz and Treinish, Why Should Engineers and Scientists Be Worried About Color?
http://www.research.ibm.com/people/l/lloydt/color/color.HTM

Rainbow Colormap Disadvantages

segmentation artifacts
- popular interpolation perceptually nonlinear!

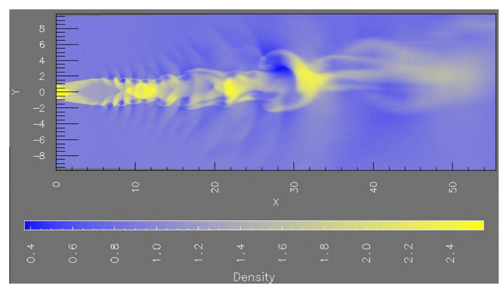
solution
- create perceptually isolinear map



[Kindlmann, Reinhard, and Creem.
Face-based Luminance Matching for Perceptual Colormap Generation. Proc. Vis 02
www.cs.utah.edu/~gk/lumFace]

Non-Rainbow Colormap Advantages

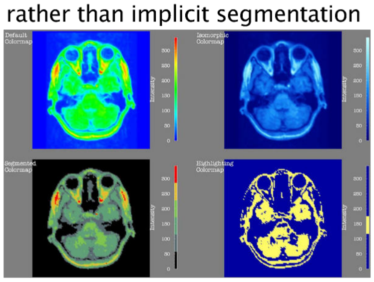
high-frequency continuity
- interpolating between just two hues



[Rogowitz and Treinish, How NOT to Lie with Visualization,

Segmenting Colormaps

explicit rather than implicit segmentation



[Rogowitz and Treinish, How NOT to Lie with Visualization,
www.research.ibm.com/dx/proceedings/pravda/truevis.htm

Color Deficiency

very low channel dynamic range for some!

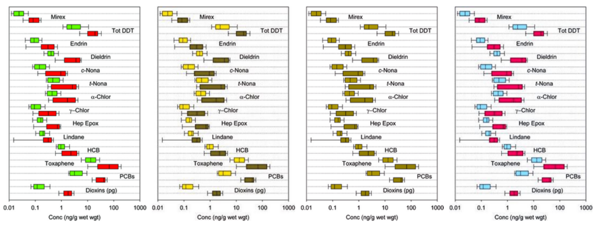
protanope
deutanope
- has red/green deficit
- 10% of males!

tritanope
- has yellow/blue deficit

http://www.vischeck.com/vischeck
- test your images

Color Deficiency Examples: vischeck

original protanope deuteranope tritanope

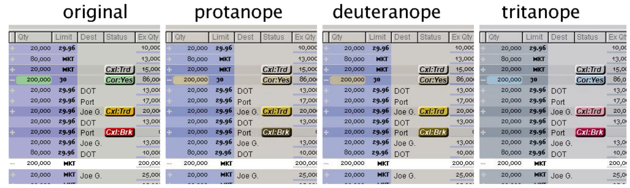


[www.cs.ubc.ca/~tmm/courses/cpsc533c-04-spr/a1/dmitry/533a1.html, citing Global Assessment of Organic Contaminants in Farmed Salmon, Ronald A. Hites, Jeffery A. Foran, David O. Carpenter, M. Coreen Hamilton, Barbara A. Knuth, and Steven J. Schwager, Science 2004 303: 226-229.]

Designing Around Deficiencies

red/green could have domain meaning
then distinguish by more then hue alone
- redundantly encode with saturation, brightness

original protanope deuteranope tritanope



[Courtesy of Brad Paley]

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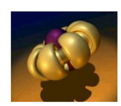
Space vs. Time: Showing Change

literal abstract
<--->
time for time space for time

animation: show time using temporal change
- good: show process



[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]

Space vs. Time: Showing Change

literal abstract
<--->
time for time space for time

animation: show time using temporal change
- good: show process
- good: compare by flipping between two things

[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]
[www.astroshow.com/ccdpho/pluto.gif]

Space vs. Time: Showing Change

literal abstract
<--->
time for time space for time

animation: show time using temporal change
- good: show process
- good: compare by flipping between two things
- bad: compare between many things

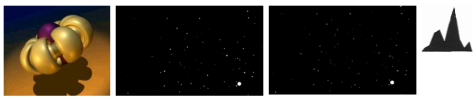
   

[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]
[www.astroshow.com/ccdpho/pluto.gif]
[Edward Tufte. The Visual Display of Quantitative Information, p 172]

Space vs. Time: Showing Change

literal abstract
<------------------------------------->
time for time space for time

animation: show time using temporal change
- good: show process
- good: compare by flipping between two things
- bad: compare between many things
  interference from intermediate frames

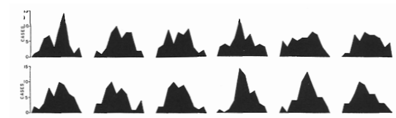


[Outside In excerpt. www.geom.uiuc.edu/docs/outreach/oi/evert.mpg]
[www.astroshow.com/ccdpho/pluto.gif]
[Edward Tufte. The Visual Display of Quantitative Information, p 172]

Space vs. Time: Showing Change

literal abstract
<------------------------------------->
time for time space for time

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



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

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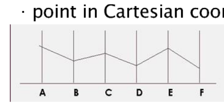
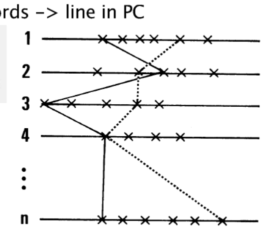
Parallel Coordinates

only 2 orthogonal axes in the plane
instead, use parallel axes!
- point in Cartesian coords -> line in PC

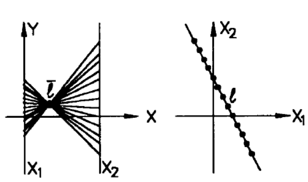




[Hyperdimensional Data Analysis Using Parallel Coordinates. Edward J. Wegman. Journal of the American Statistical Association, Vol. 85, No. 411. (Sep., 1990), pp. 664-675.]

Par Coords: Point-Line Duality

point in Cartesian coords -> line in PC
point in PC -> line in Cartesian n-space



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

Par Coords: Correllation

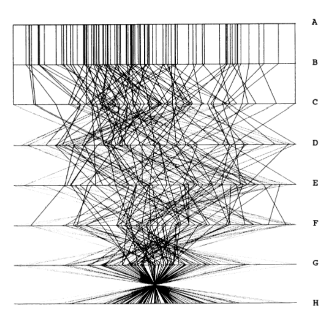


Figure 3. Parallel Coordinate Plot of Six-Dimensional Data Illustrating Correlations of ρ = 1, .8, .2, 0, −.2, −.8, and −1.

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

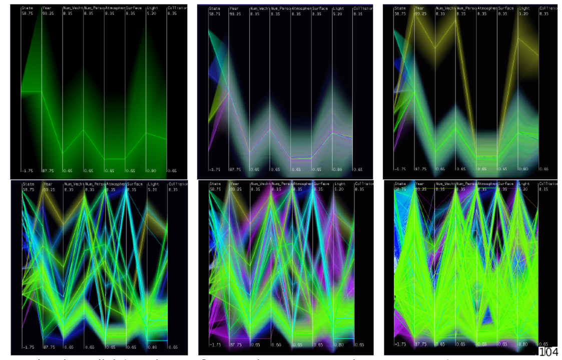
Par Coords: Axis Ordering

geometric interpretations
- hyperplane, hypersphere
- don't worry about point order

infovis
- no intrinsic order, what to do?
- indeterminate/arbitrary order
  - weakness of many techniques
  - downside: human-powered search
  - upside: powerful interaction technique
- most implementations
  - user can interactively swap axes

machine learning approach
- Automated Multidimensional Detective [Inselberg 99]

Hierarchical Parallel Coords: LOD



[Hierarchical Parallel Coordinates for Visualizing Large Multivariate Data Sets. Ying-Huey Fua, Matthew O. Ward, and Elke A. Rundensteiner. IEEE Visualization '99.]

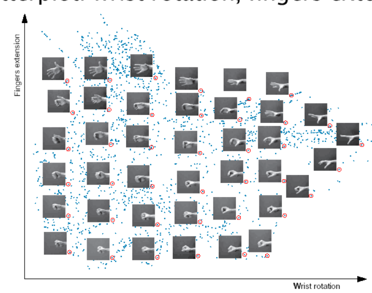
Dimensionality Reduction

mapping multidimensional space into space of fewer dimensions
- typically 2D for infovis
- keep/explain as much variance as possible
- show underlying dataset structure

multidimensional scaling (MDS)
- minimize differences between interpoint distances in high and low dimensions

Dimensionality Reduction: Isomap

4096 D: pixels in image
2D scatterplot: wrist rotation, fingers extension

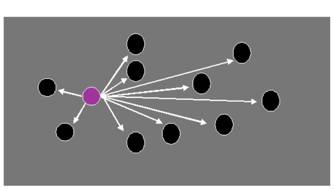


[A Global Geometric Framework for Nonlinear Dimensionality Reduction. J. B. Tenenbaum, V. de Silva, and J. C. Langford. Science 290(5500), pp 2319--2323, Dec 22 2000]

Naive Spring Model MDS

repeat for all points
- compute spring force to all other points
- difference between high dim, low dim distance
- move to better location using computed forces

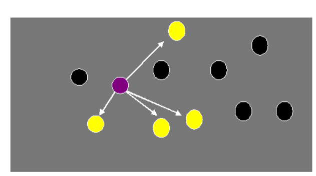
compute distances between all points
- O(n^2) iteration, O(n^3) algorithm



Faster Spring Model [Chalmers 96]

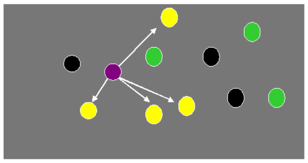
compare distances only with a few points
- maintain small local neighborhood set

A Linear Iteration Time Layout Algorithm for Visualising High-Dimensional Data. Matthew Chalmers, Proc. IEEE Visualization 96



Faster Spring Model [Chalmers 96]

compare distances only with a few points
- maintain small local neighborhood set
- each time pick some randoms, swap in if closer



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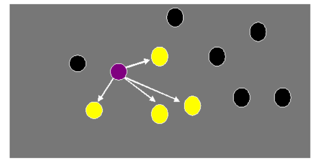
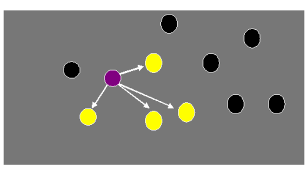


Faster Spring Model [Chalmers 96]

compare distances only with a few points
- maintain small local neighborhood set
- each time pick some randoms, swap in if closer

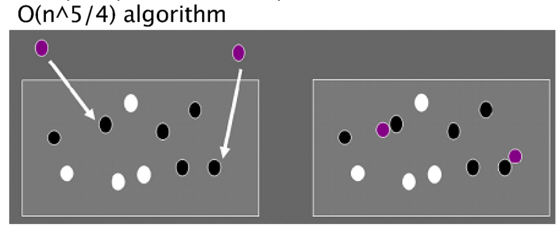
small constant: 6 locals, 3 randoms typical
- O(n) iteration, O(n2) algorithm



Parent Finding [Morrison 02, 03]

lay out a root(n) subset with [Chalmers 96]
for all remaining points
- find “parent”: laid-out point closest in high D
- place point close to this parent

O(n^5/4) algorithm

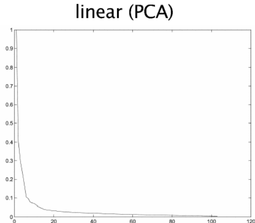


[Fast Multidimensional Scaling through Sampling, Springs and Interpolation
Alistair Morrison, Greg Ross, Matthew Chalmers
Information Visualization 2(1) March 2003, pp. 68–77.
http://www.dcs.gla.ac.uk/~matthew/papers/JInfoVis.pdf]

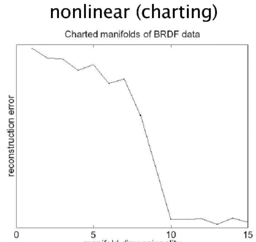
True Dimensionality

maybe need > 2D to show real structure
- find knee in error-dimensions curve
- show as multiple scatterplots

linear (PCA)

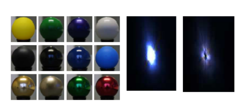


nonlinear (charting)



[A Data-Driven Reflectance Model, SIGGRAPH 2003, W Matusik, H. Pfister

True Dimensionality: BRDF example



measured material properties (BRDFs)

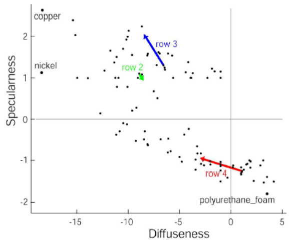
linear PCA: 25-45 dimensions needed
- interpolating gives impossible intermediate points: highlights with holes

nonlinear charting: 10-15 dimensions needed
- physically plausible highlights

[A Data-Driven Reflectance Model, SIGGRAPH 2003, W Matusik, H. Pfister
M. Brand and L. McMillan, graphics.lcs.mit.edu/~wojciech/pubs/sig2003.pdf]

True Dimensionality: BRDF example

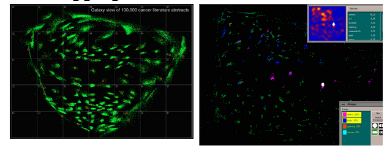
nonlinear charting
2D scatterplot axes categorizable by people
- red, green, blue, specular, diffuse, glossy, metallic, plastic-y, roughness, rubbery, greasiness, dustiness...



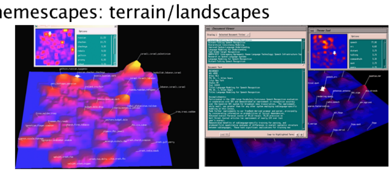
[A Data-Driven Reflectance Model, SIGGRAPH 2003, W Matusik, H. Pfister M. Brand and L. McMillan, graphics.lcs.mit.edu/~wojciech/pubs/sig2003.pdf]

MDS Output: Beyond Point Clouds

- galaxies: aggregation



- themescapes: terrain/landscapes



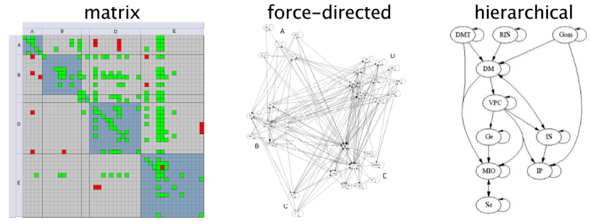
[Visualizing the non-visual: spatial analysis and interaction with information from text documents. James A. Wise et al, Proc. InfoVis 1995. www.pnl.gov/infoviz/graphics.html]

Outline

Introduction
Overviews
Focus+Context
Linked Views
Layers
Perception
Visual Encoding
Color
Space and Time
High Dimensionality
Trees and Graphs

Graphs: Matrix vs. Node-Link

matrix force-directed hierarchical

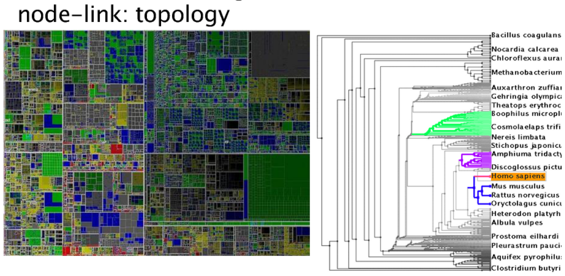


[Using Multilevel Call Matrices in Large Software Projects. Frank van Ham, Proc. InfoVis 2003, pp.227-232]

Trees: Treemap vs. Node-Link

treemaps: attribute values at leaves
- outlier detection: big files on disk

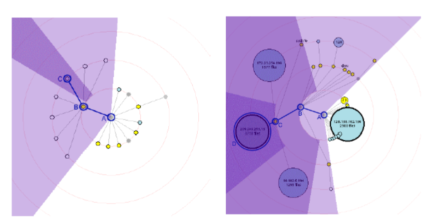
node-link: topology



[Interactive Information Visualization of a Million Items. Jean-Daniel Fekete and Catherine Plaisant, Proc InfoVis 2002. www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=2002-01]
[TreeJuxtaposer, Munzner et al. SIGGRAPH 2003. www.cs.ubc.ca/~tmm/papers/tj]

Animated Radial Layouts

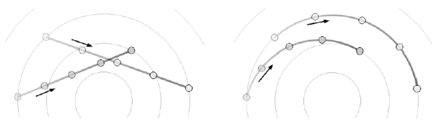
adapt radial layout for dynamic case
[video]



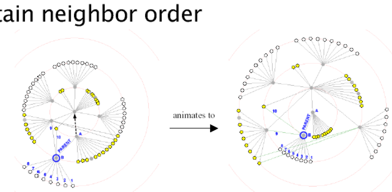
[Animated Exploration of Graphs with Radial Layout. Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst, Proc InfoVis 2001. http://bailando.sims.berkeley.edu/papers/infovis01.htm]

Animation

polar interpolation



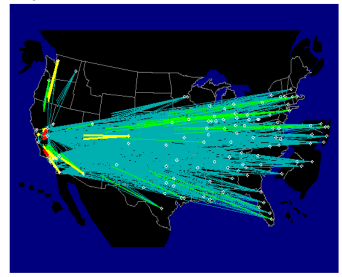
maintain neighbor order



[http://bailando.sims.berkeley.edu/papers/infovis01.htm]

Geographic Networks

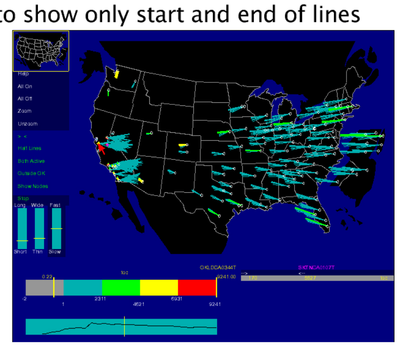
telephone network
post-earthquake Midwestern occlusion



[Becker, Eick, and Wilks. Visualizing Network Data, IEEE TVCG 1995
citeseer.nj.nec.com/becker95visualizing.html]

Geographic Networks

filter to show only start and end of lines



[Becker, Eick, and Wilks. Visualizing Network Data, IEEE TVCG 1995
citeseer.nj.nec.com/becker95visualizing.html]

More Information

http://www.cs.ubc.ca/~tmm
- talks, papers, projects: lots of pictures!

UBC Term 1 grad course
- CPSC 533C Visualization

current project domains
- bioinformatics, data mining, sustainability

past project domains
- topology, networking, computational linguistics, ...