Lecture 6: Interaction Principles

Information Visualization
CPSC 533C, Fall 2011

Tamara Munzner

UBC Computer Science

Mon, 26 September 2011

Required Readings

Chapter 3: Visual Encoding Principles
(this time: last 11 pages, Sec 3.5)

Chapter 4: Interaction Principles

Interactive Visualization of Genealogical Graphs. Michael J. McGuffin, Ravin Balakrishnan. Proc. InfoVis 2005, pp 17-24.

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Tamara Munzner, Francois Guimbretiere, Serdar Tasiran, Li Zhang, and Yunhong Zhou. SIGGRAPH 2003.

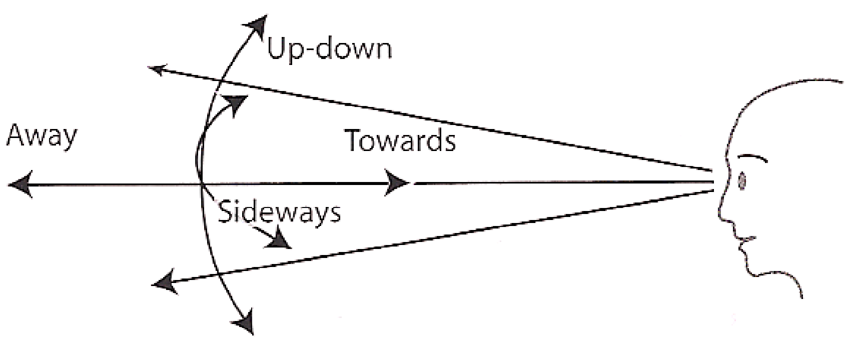
Further Reading

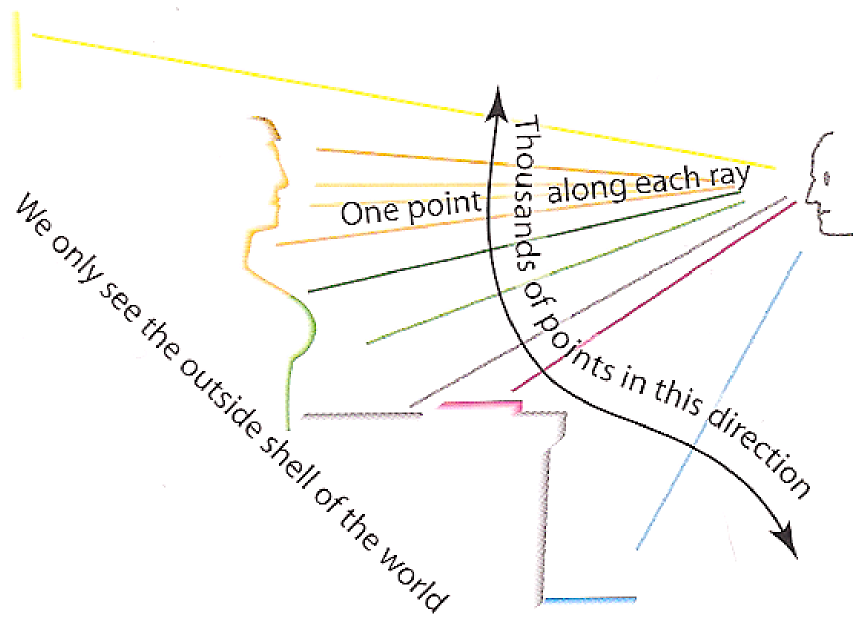
Animation: Can It Facilitate? Barbara Tversky, Julie Morrison, Mireille Betrancourt. International Journal of Human Computer Studies 57:4, pp 247-262, 2002.

Animated Transitions in Statistical Data Graphics¡/a¿ Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.

Dangers of Depth vs Position

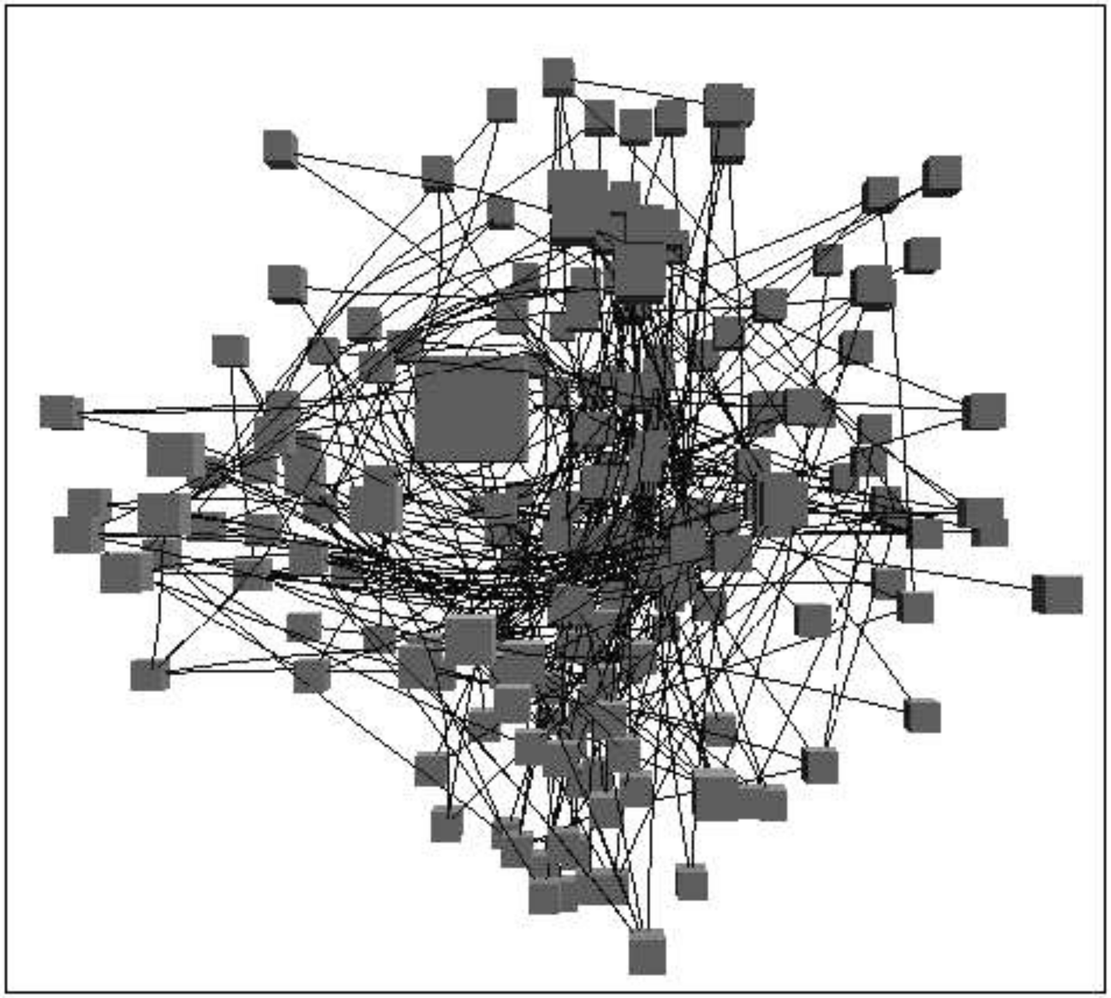
- rankings for **planar** spatial position, not depth!
- we don't really live in 3D; we see in 2.05D
  - up/down and sideways: image plane
  - acquire more info quickly from eye movements
- away: depth into scene
  - only acquire more info from head/body motion





[Ware. Visual Thinking For Design. 2008. (p 44)]

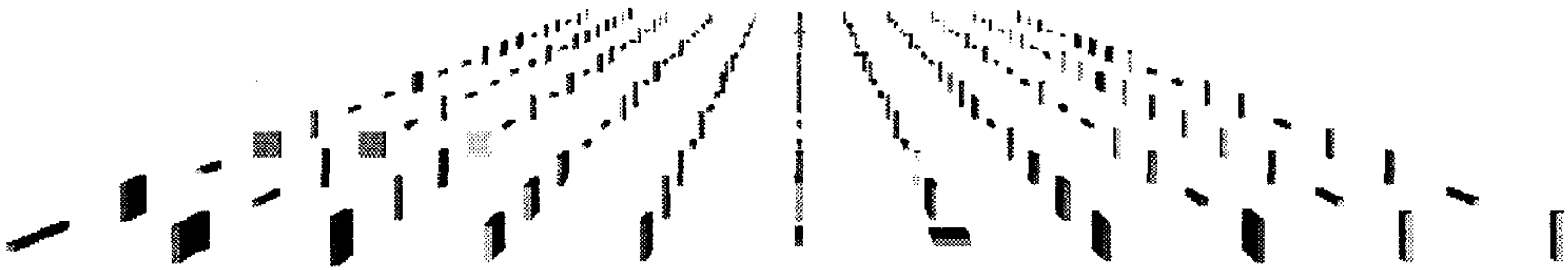
Occlusion and Motion Parallax



[Fig 21. Carpendale et al. Distortion Viewing Techniques for 3D Data. InfoVis 1996.]

Perspective Distortion

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



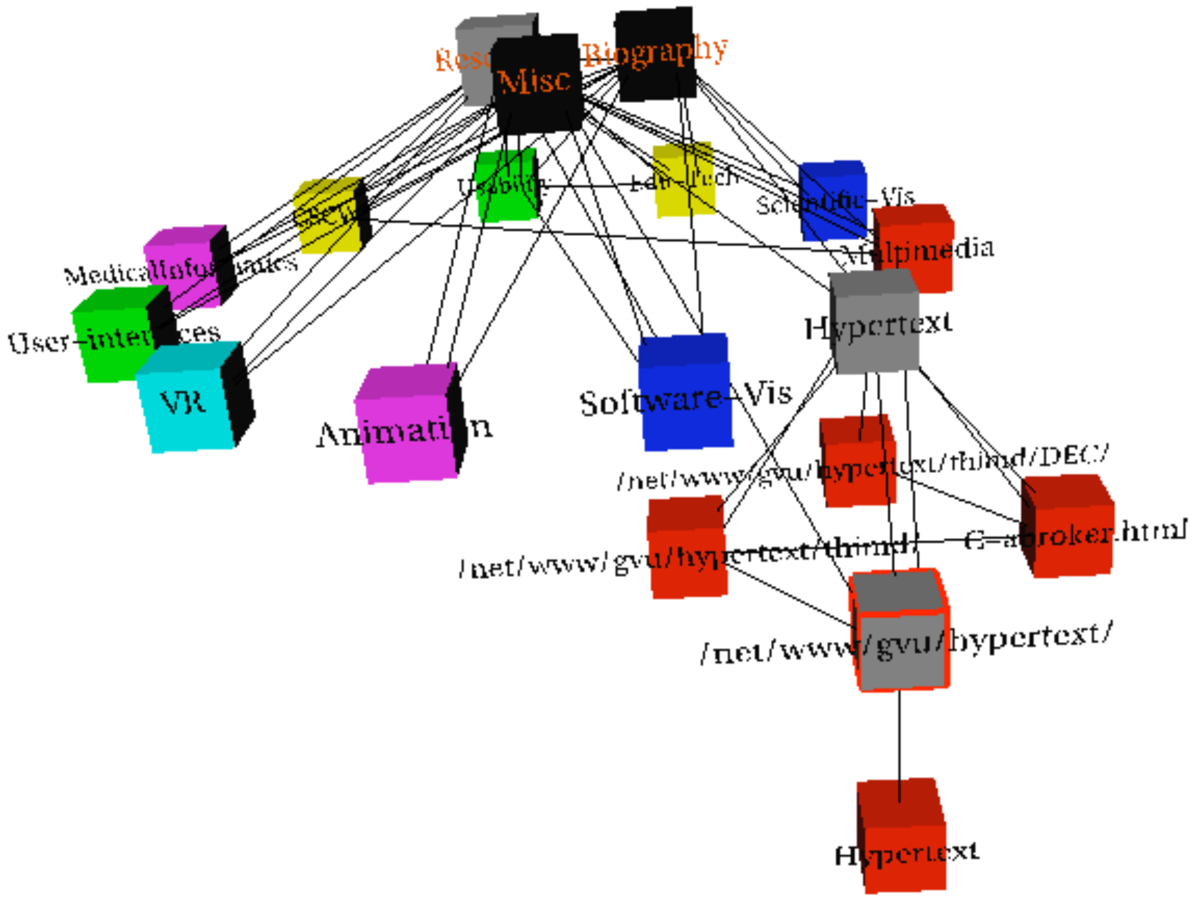
[Fig 1. Visualizing the Results of Multimedia Web Search Engines. Mukherjea, Hirata, and Hara. InfoVis 96]

Other Cues

- familiar size
- shadows and shading
- stereo
- atmospheric perspective

Text Legibility

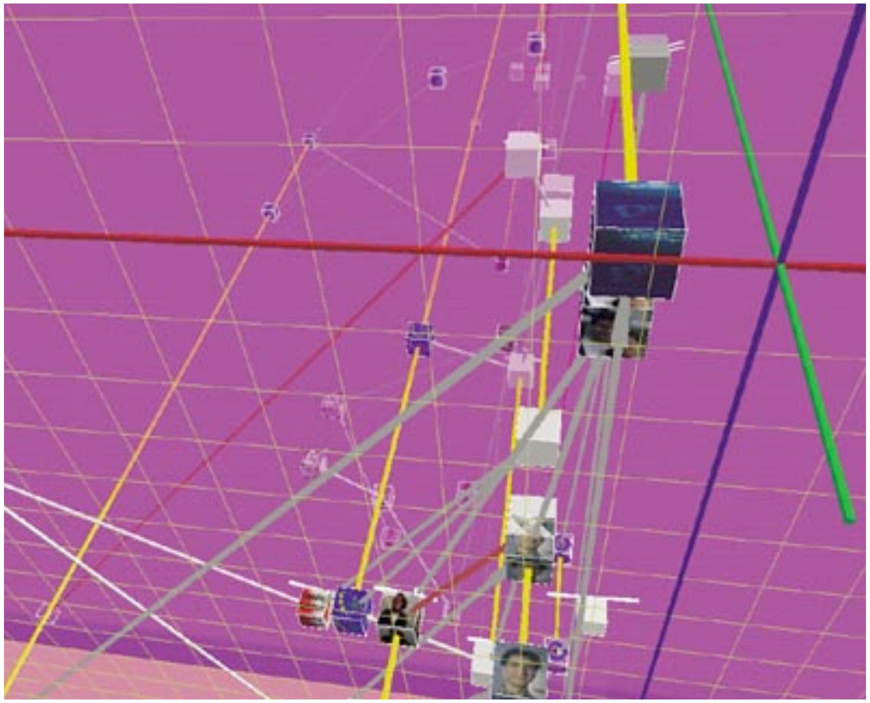
- far worse when tilted from image plane



[Visualizing the World-Wide Web with the Navigational View Builder. Mukherjea and Foley. Computer Networks and ISDN Systems, 1995.]

Need to Justify 3D

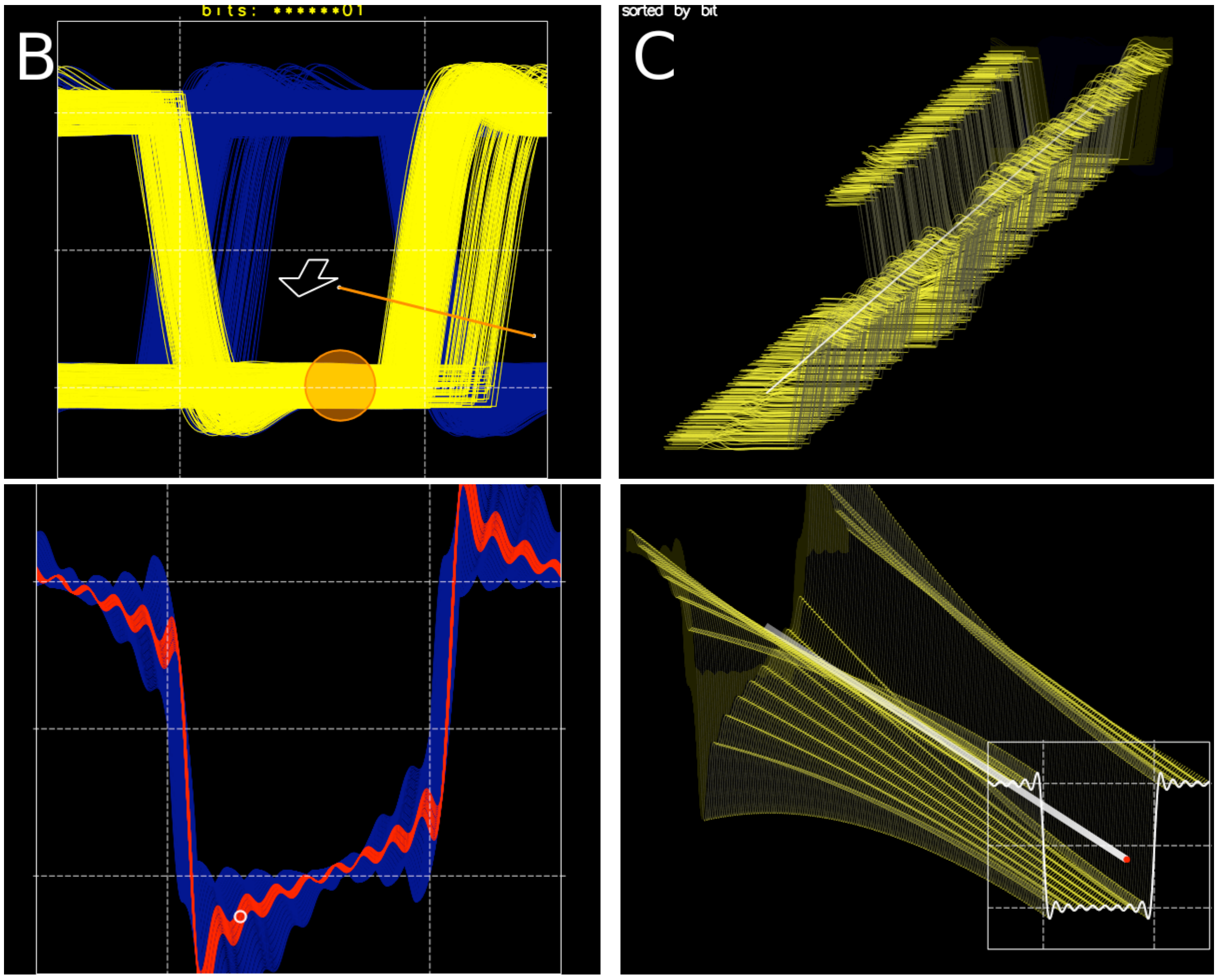
- 3D legitimate for true 3D spatial data
- 3D needs very careful justification **for abstract data**
  - enthusiasm in 1990s, but now skepticism
  - be especially careful with 3D point clouds or networks



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

Abstract 3D Can Be Justified

- constrained navigation
- drawer opening metaphor



[Fig 3 and 7. Lopez-Hernandez et al. A Layer-Oriented Interface for Visualizing Time-Series Data from Oscilloscopes. Proc. PacificVis 2010, p 41-48.]

Classes of Change

- changing selection
- changing highlighting
- changing viewpoint: navigating
- changing spatial order: sorting
- changing visual encoding

Latency and Feedback

- .1 sec: perceptual processing
- 1 sec: immediate response
- 10 sec: unit tasks

More Interaction Principles

- interaction costs
  - interplay between automatic and interactive
- spatial cognition
  - systematic distortions: hierarchical
  - landmarks for spatial memory

Animation

- narrative storytelling
  - careful choreography to direct eyes to right spot
  - vs datasets with simultaneous change many places
- transitions between configurations
  - powerful technique, very common
- video-style playback of multiframe sequence

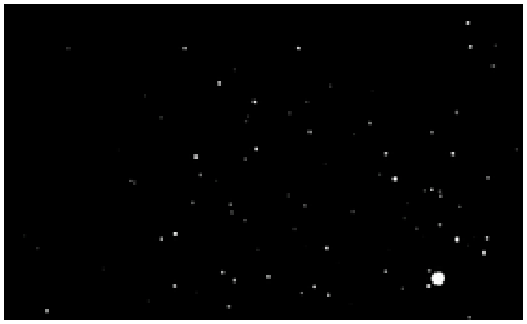
Animation

- narrative storytelling
  - careful choreography to direct eyes to right spot
  - vs datasets with simultaneous change many places
  - possibility: show process
- transitions between configurations
  - powerful technique, very common
- video-style playback of multiframe sequence

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

Animation

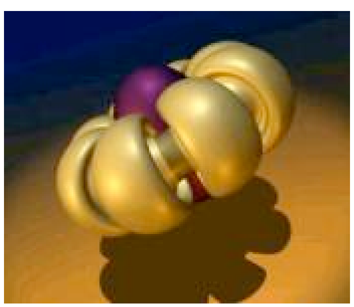
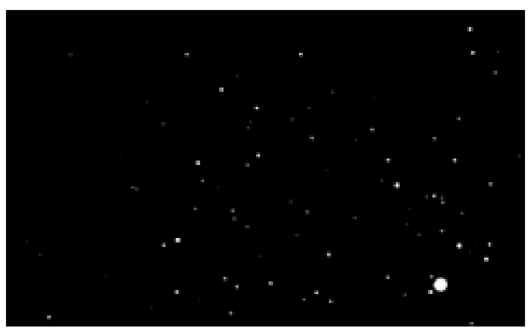
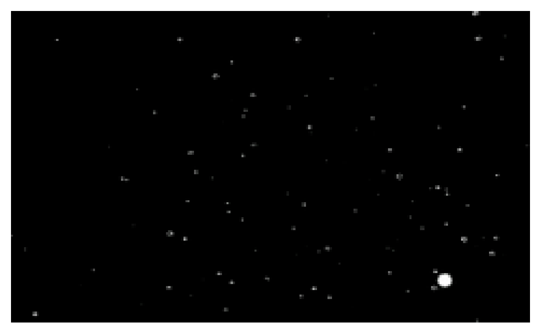
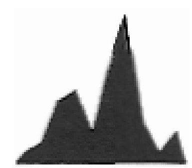
- narrative storytelling
  - careful choreography to direct eyes to right spot
  - vs datasets with simultaneous change many places
  - possibility: show process
- transitions between configurations
  - powerful technique, very common
- video-style playback of multiframe sequence
  - good: compare by flipping between two things


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

Animation

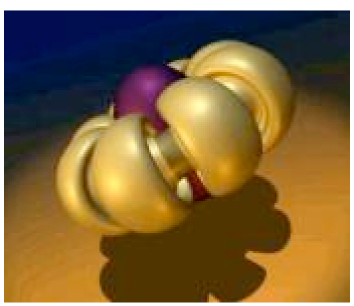
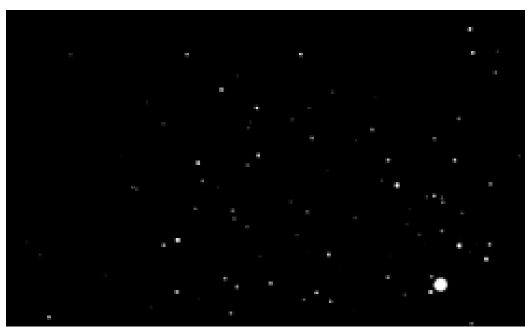
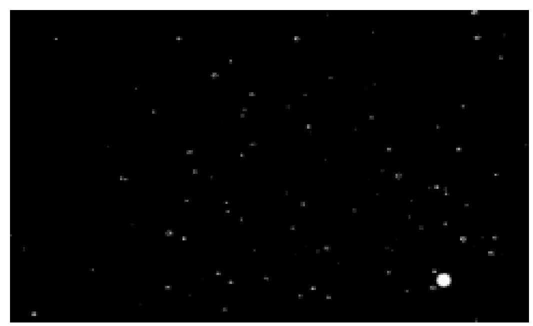
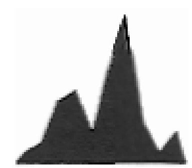
- narrative storytelling
  - careful choreography to direct eyes to right spot
  - vs datasets with simultaneous change many places
  - possibility: show process
- transitions between configurations
  - powerful technique, very common
- video-style playback of multiframe sequence
  - good: compare by flipping between two things
  - bad: compare between many things

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

Animation

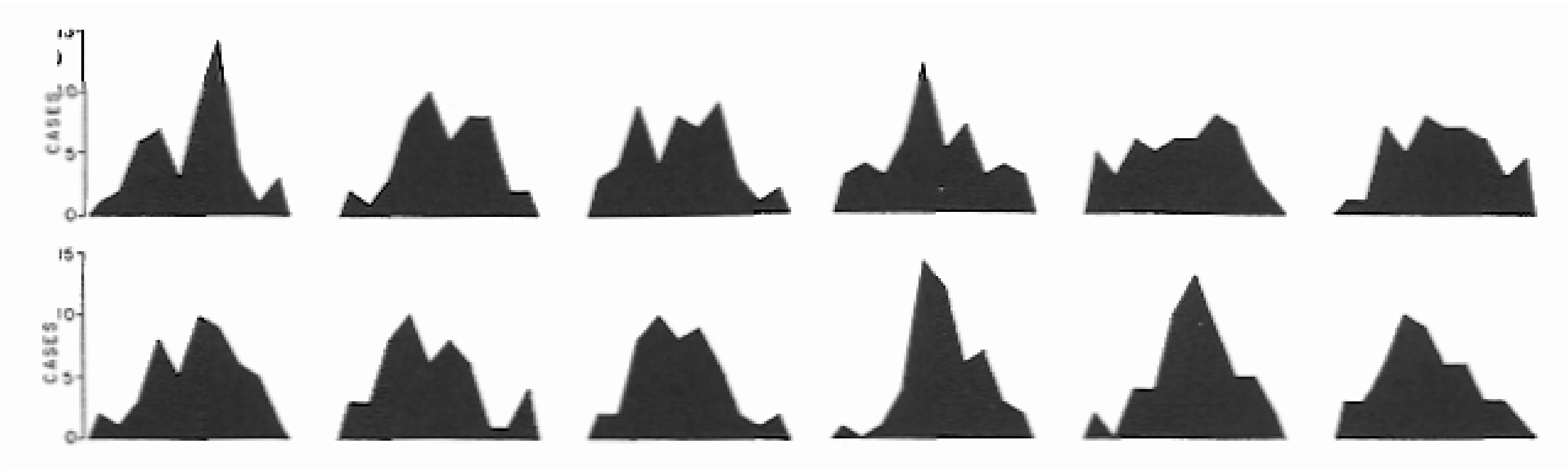
- narrative storytelling
  - careful choreography to direct eyes to right spot
  - vs datasets with simultaneous change many places
  - possibility: show process
- transitions between configurations
  - powerful technique, very common
- video-style playback of multiframe sequence
  - good: compare by flipping between two things
  - bad: compare between many things
    - interference from intermediate frames

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

Animation

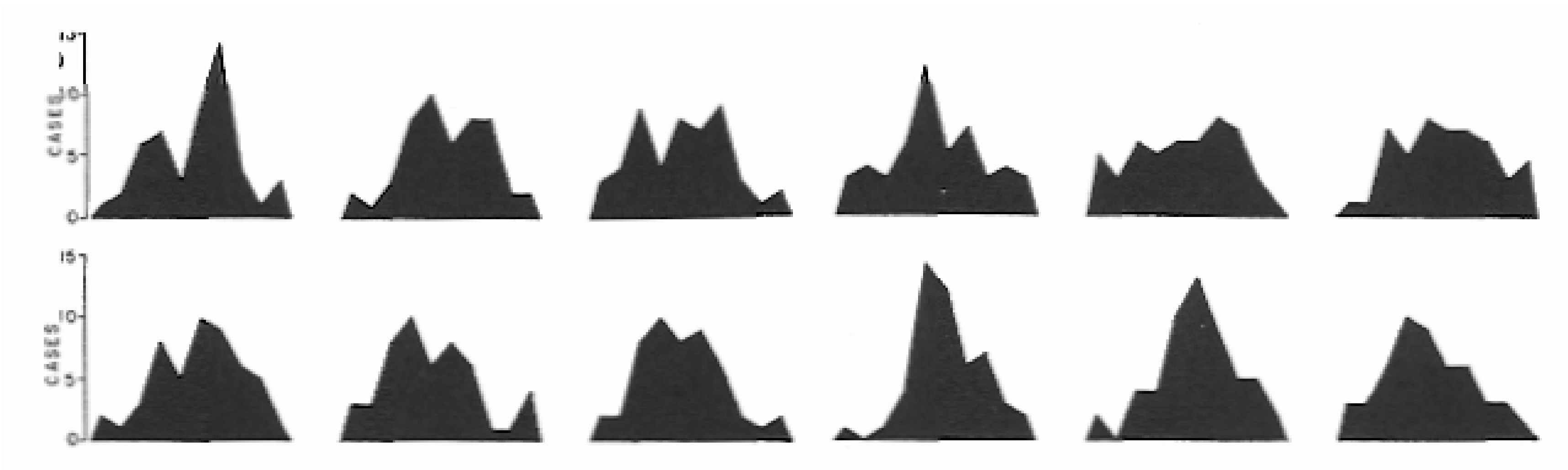
- small multiples: show time using space
  - overview: show each time step in array
  - compare: side-by-side easier than temporal
    - external cognition instead of internal memory



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

Animation

- 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]

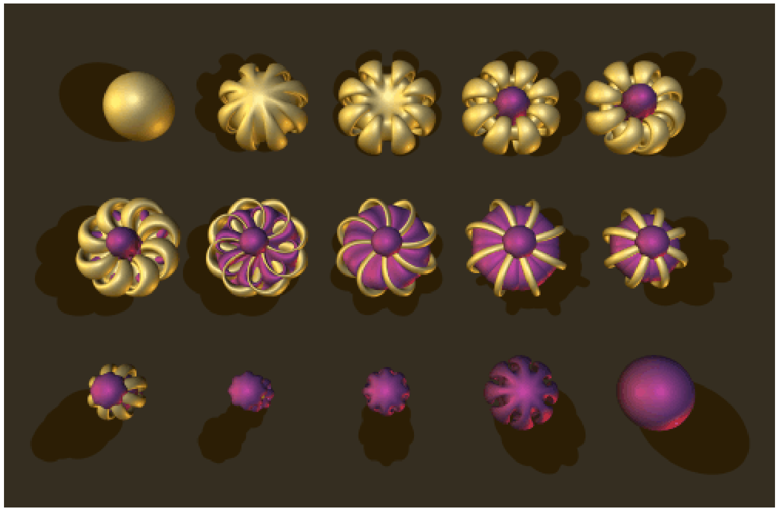
Animation

literal | abstract

⟵ . . . . ⟶

time for time | space for time

- small multiples: show time using space
  - also can be good for showing process



[www.geom.uiuc.edu/graphics/pix/Video_Productions/Outside_In/postcard.comp.html]

Animation vs. Small Multiples

- Tversky argument: intuition that animation helps is wrong
  - meta-review of previous studies
  - often more info shown in animation view so not a fair comparison

  - carefully chosen segmentation into small multiples better than animation if equivalent information shown

[Animation: Can It Facilitate? Barbara Tversky, Julie Morrison, Mireille Betrancourt. International Journal of Human Computer Studies 57:4, pp 247-262, 2002.]

Animated Transitions

- general and powerful idea
  - transitions, not motion as visual encoding
- benefits
  - attracts attention
  - facilitates object constancy
  - implies causality
  - emotionally engaging
- this paper: statistical graphics
  - design principles
  - controlled experiments

[Animated Transitions in Statistical Data Graphics. Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.]

Transition Taxonomy

- change viewpoint
- change spatial substrate
- filter
- reorder
- change time
- change visual mapping
- change data schema

Congruence Principles

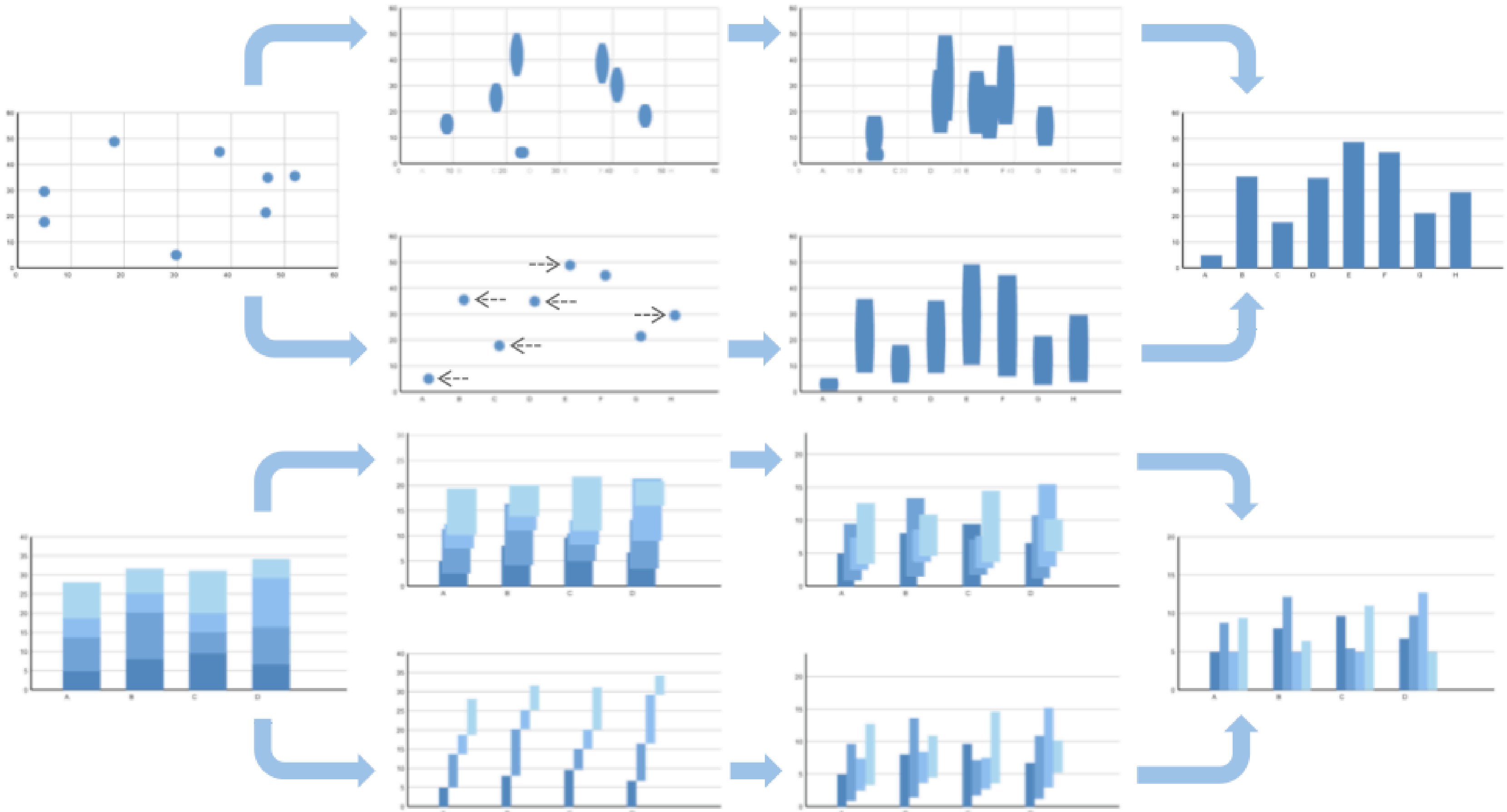
- internal and external representations should match
    - both structure and content
- principles
    - maintain valid data graphics during transitions
    - use consistent mappings (semantic-syntactic)
    - respect semantic correspondences
    - avoid ambiguity

Apprehension Principles

- external representation structure and content should be readily and accurately perceived and comprehended

- principles
  - group similar transitions
    - gestalt common fate
  - minimize occlusion
  - maximize predictability
    - slow-in, slow-out
  - use simple transitions
  - use staging for complex transitions
  - make transitions as long as needed, but no longer

Staging



[Animated Transitions in Statistical Data Graphics. Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.]

Experiments

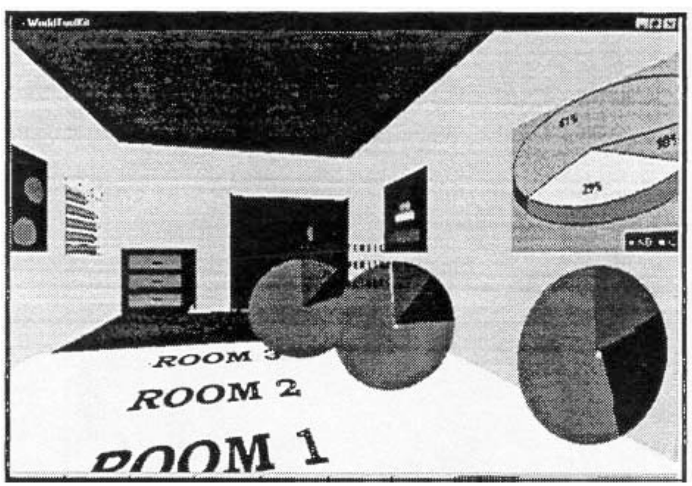
- study 1: object location tracking
  - animation always helped
  - staged animation almost always helped
- study 2: value change estimation
  - animation helps in some cases
  - staging not significant help
- preference: staged anim mostly, anim always
- guideline: avoid overly complex multi-staging

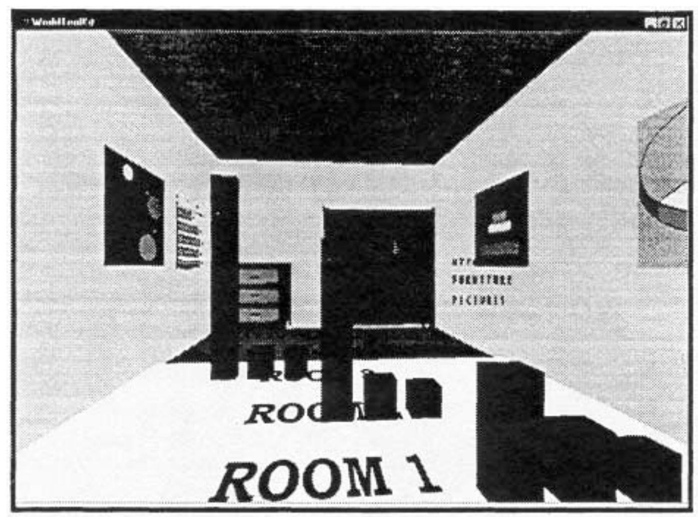
Change Blindness

- don't see changes if attention directed elsewhere
- even if they're very drastic!
- demo

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

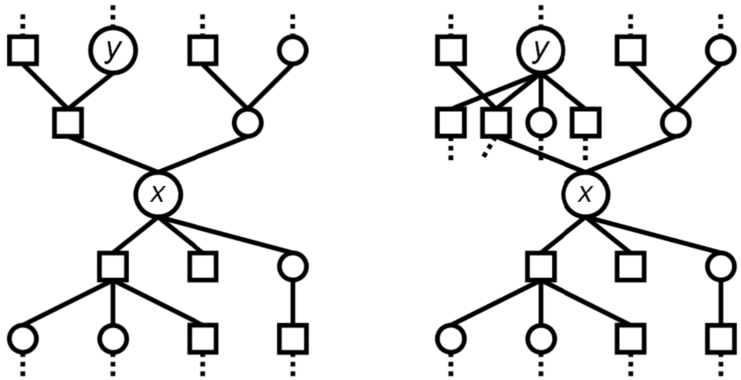




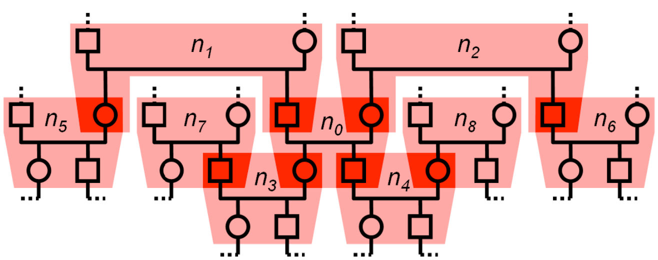
[Development of an information visualization tool using virtual reality.Kirner and Martins. Symp Applied Computing 2000]

Genealogical Graphs

- family trees not actually trees
- single person has tree of ancestors, tree of descendants
    - pedigree collapse inevitable: diamond in ancestor graph



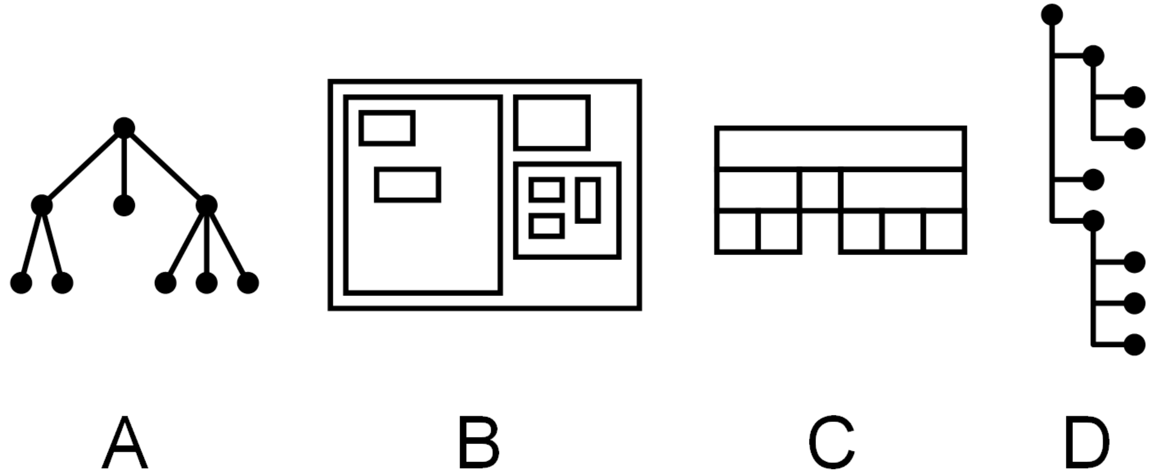
- exponential crowding problem



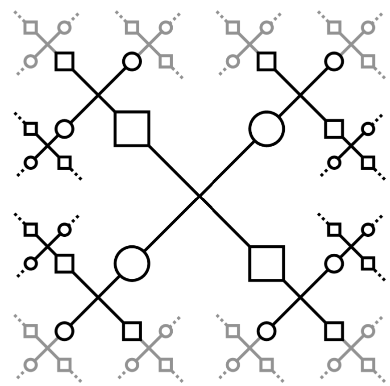
[Fig 2/6, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Visual Encoding Alternatives

- rooted: node-link, enclosure, adjacent/align, indent



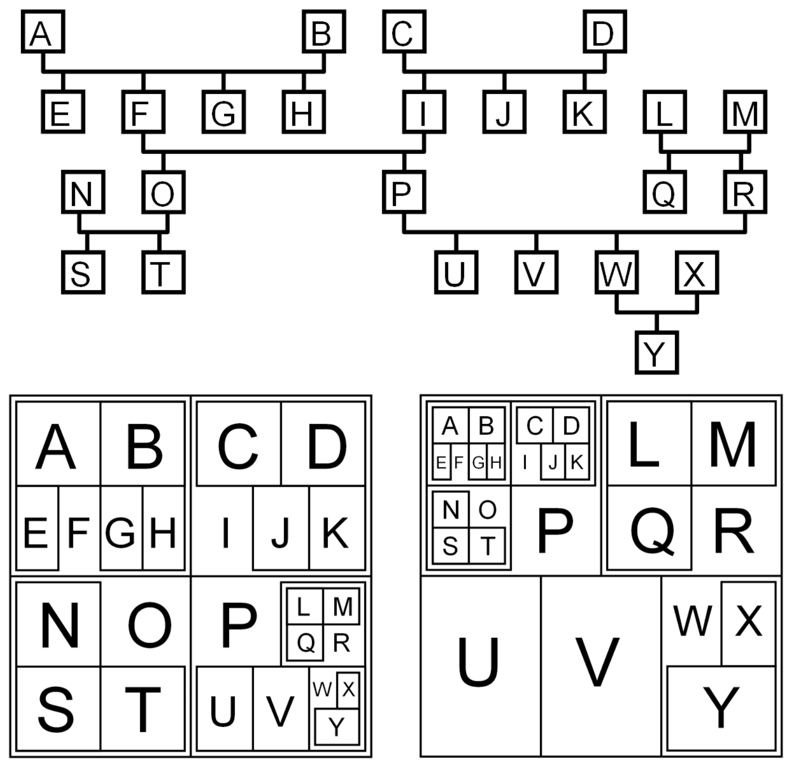
- fractal: no crossings, but lose ordering by generation



[Fig 8/7, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Visual Encoding Alternatives

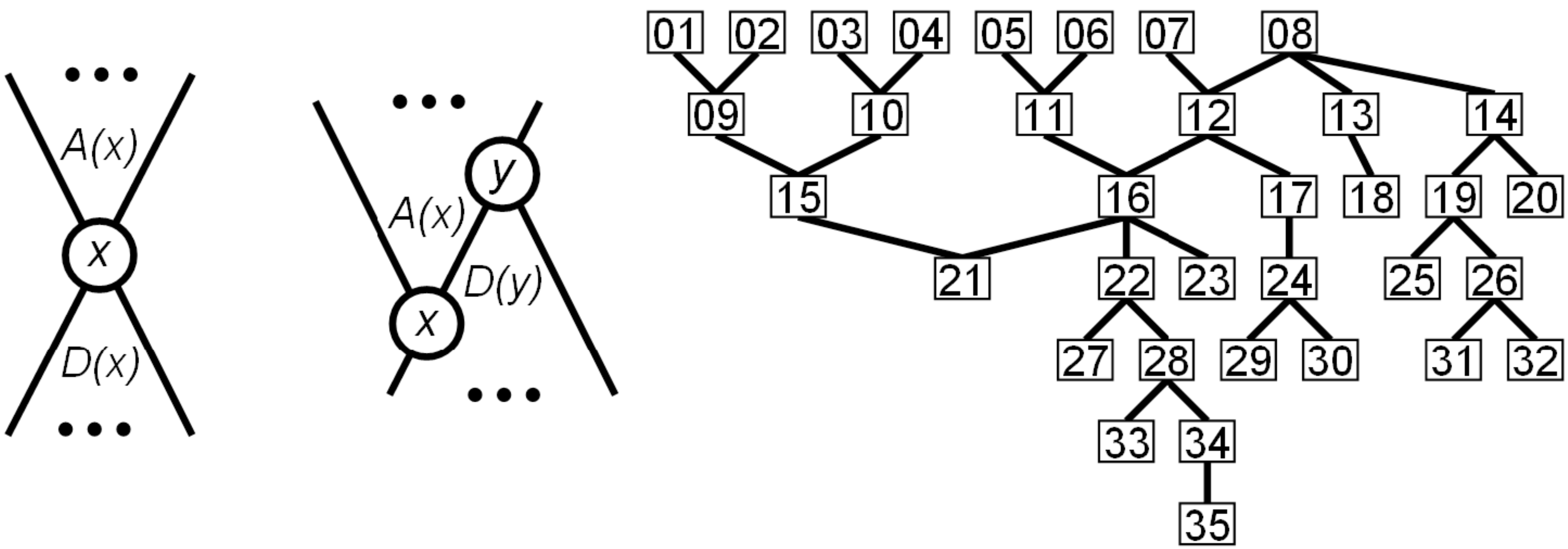
- free trees
  - node-link
  - enclosure changing root: current focus set
    - FIOP, then PRUVW
    - generation order still lost



[Fig 9, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Dual Trees

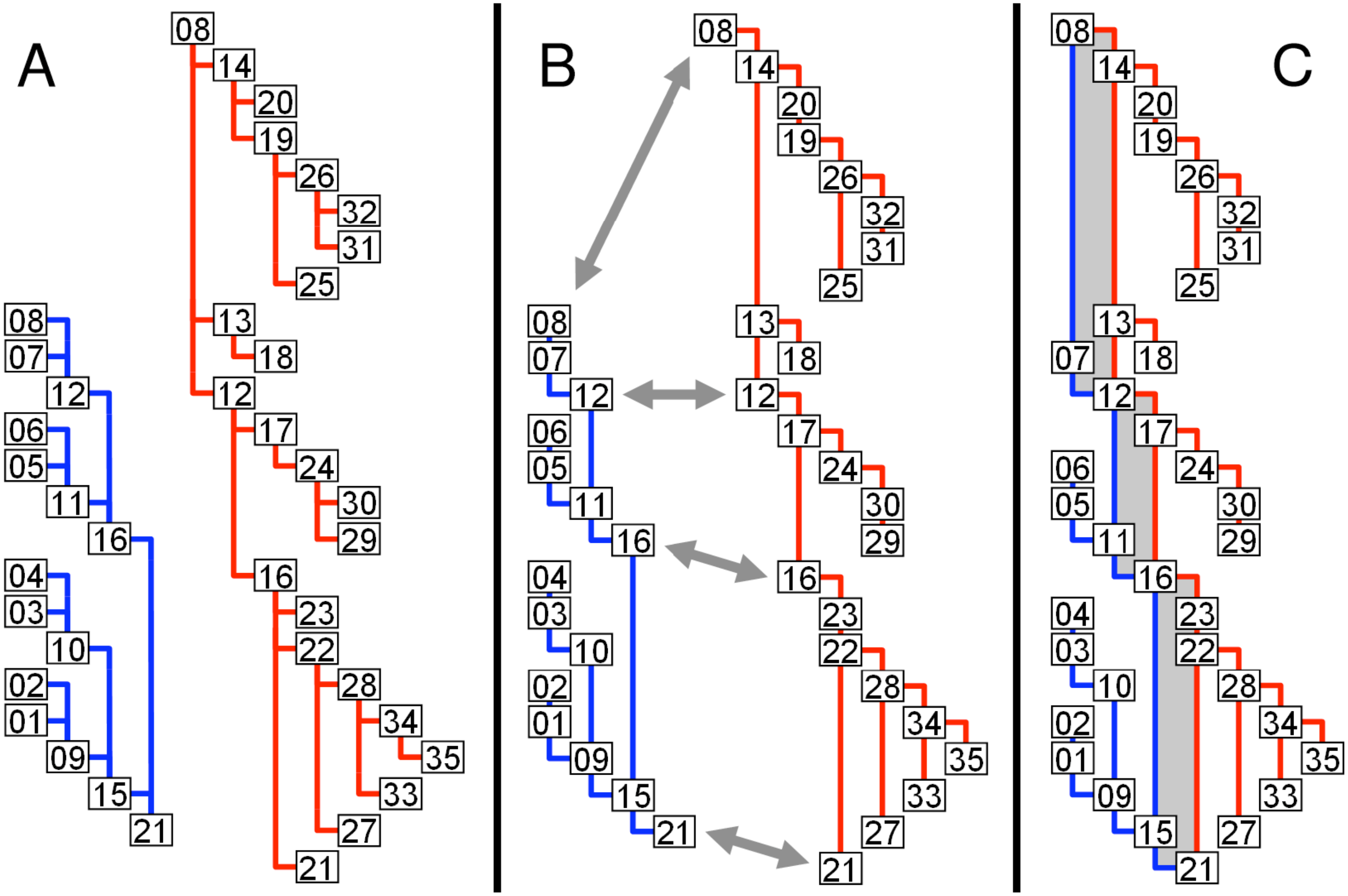
- abstraction requirements
  - explore canonical subsets and combinations
  - easy to interpret, scales well
  - no crossings, nodes ordered by generation
- doubly rooted: x leftmost descend, y rightmost ancest



[Fig 10, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

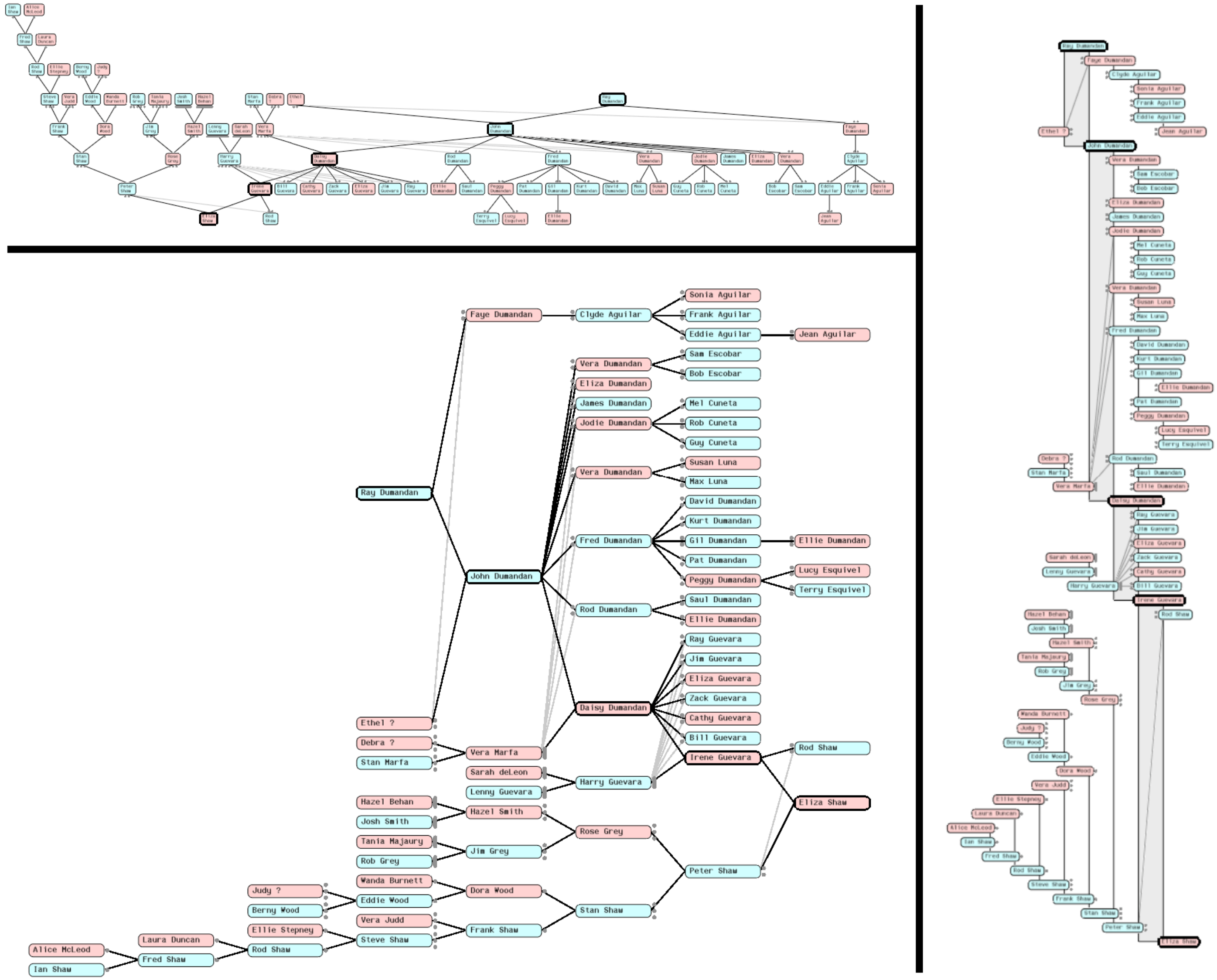
Drawing Dual Trees

- indented, flipped, combined



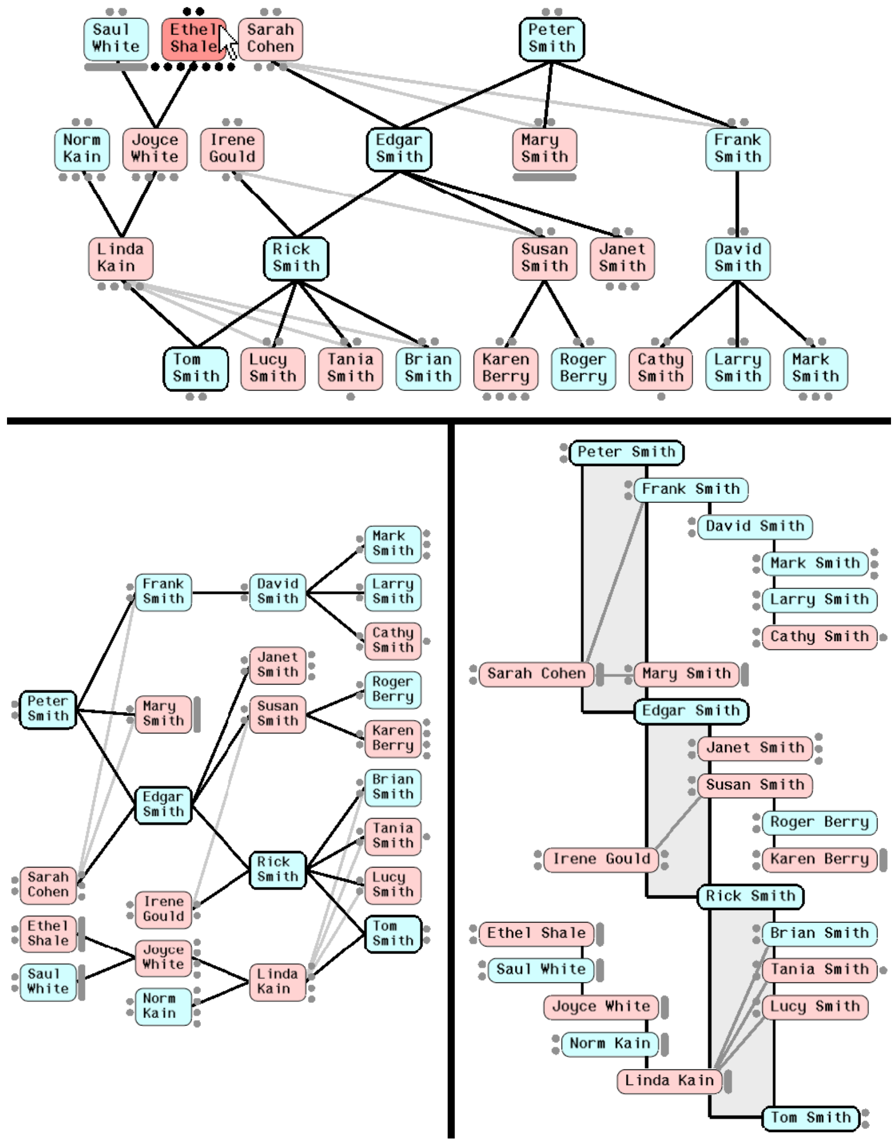
[Fig 11, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Three Layouts



[Fig 12, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Three Layouts

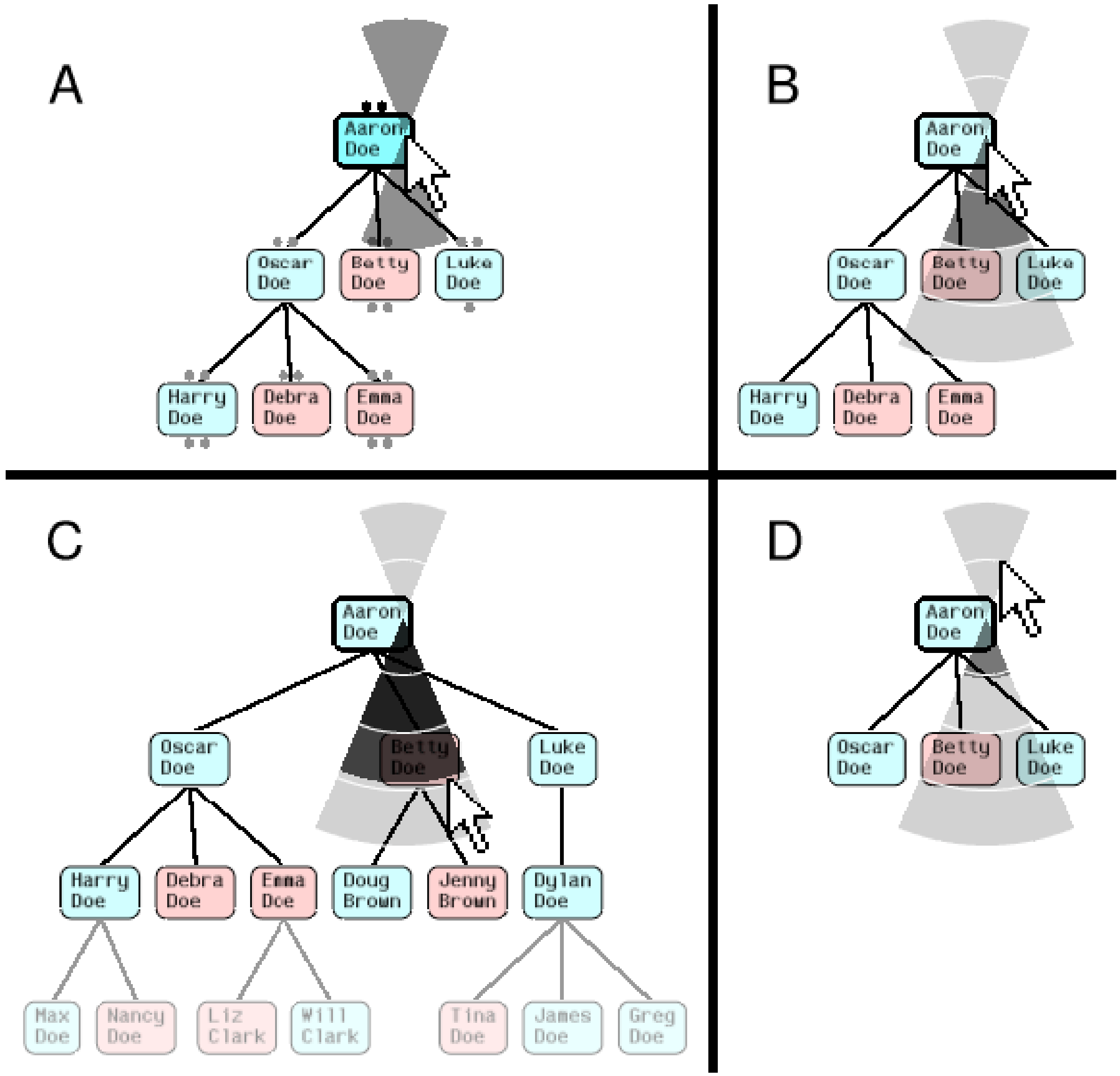


[Fig 13, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Interaction

- expand/collapse parents or children
  - expand: automatic rotation, collapse
  - three-stage animated transition
    - fade out old nodes to hide
    - move nodes to new positions
    - fade in new nodes to show
  - 2-item marking menu: flick up or down
    - popup menu, allows ballistic gestures
- mouseover hover
  - preview dots: collapsed are expanded

Subtree Drag-out Widget



[Fig 14, McGuffin and Balakrishnan. Interactive Visualization of Genealogical Graphs. Proc. InfoVis 2005, p. 17-24]

Latency Classes

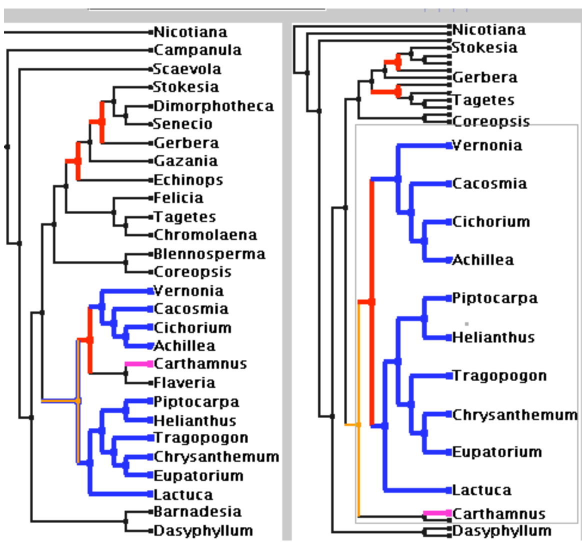
- popup menus
  - appear at current focus point of eye/click
  - gestures
  - perceptual processing: subsecond update
- mouseover hover
  - preview dots
  - perceptual processing: subsecond update
- animated transitions
  - immediate response: 1 second

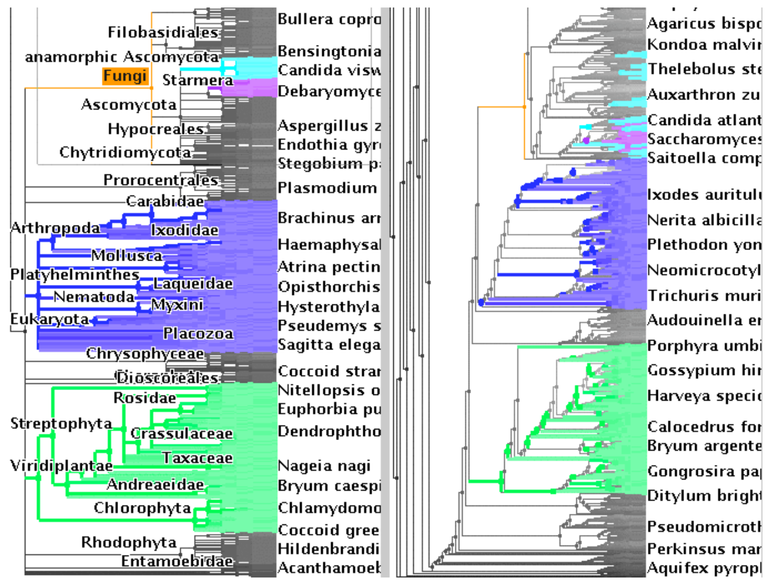
Critique

- strengths
  - identified right abstraction
  - careful visual encoding design, considered many alternatives
  - careful interaction design

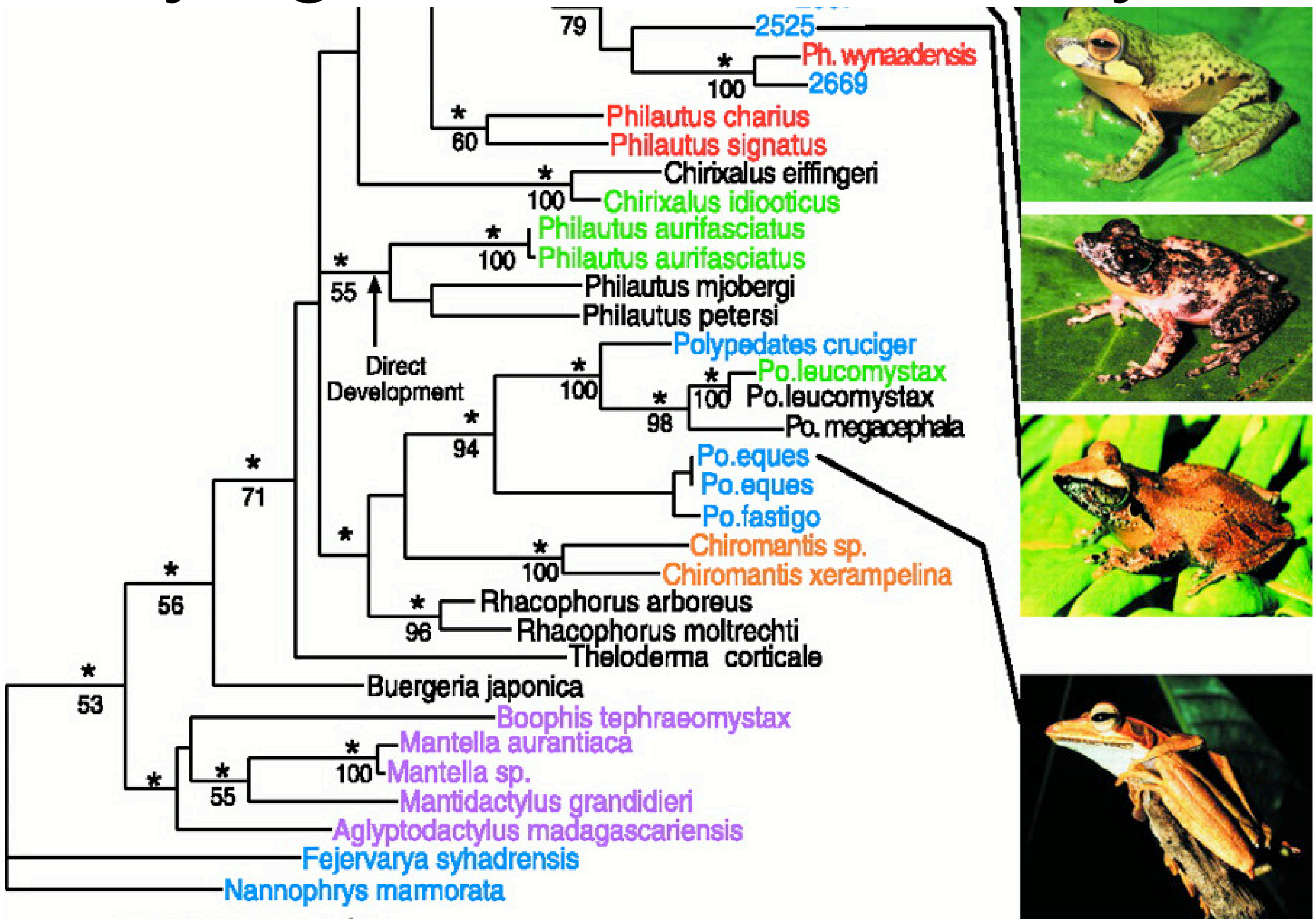
TreeJuxtaposer

- side by side comparison of evolutionary trees



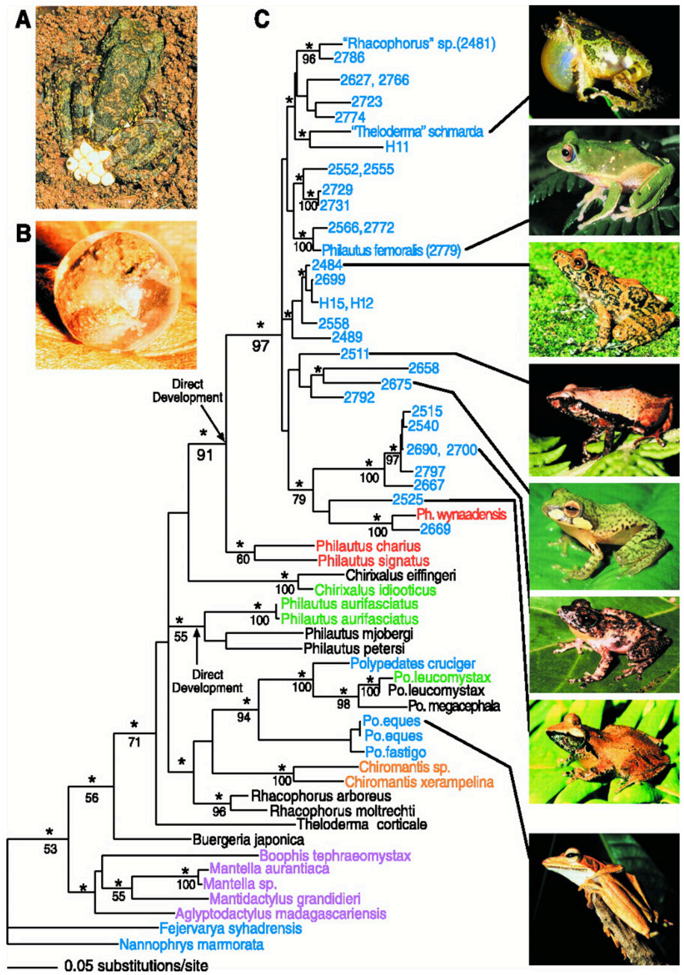


Phylogenetic/Evolutionary Tree



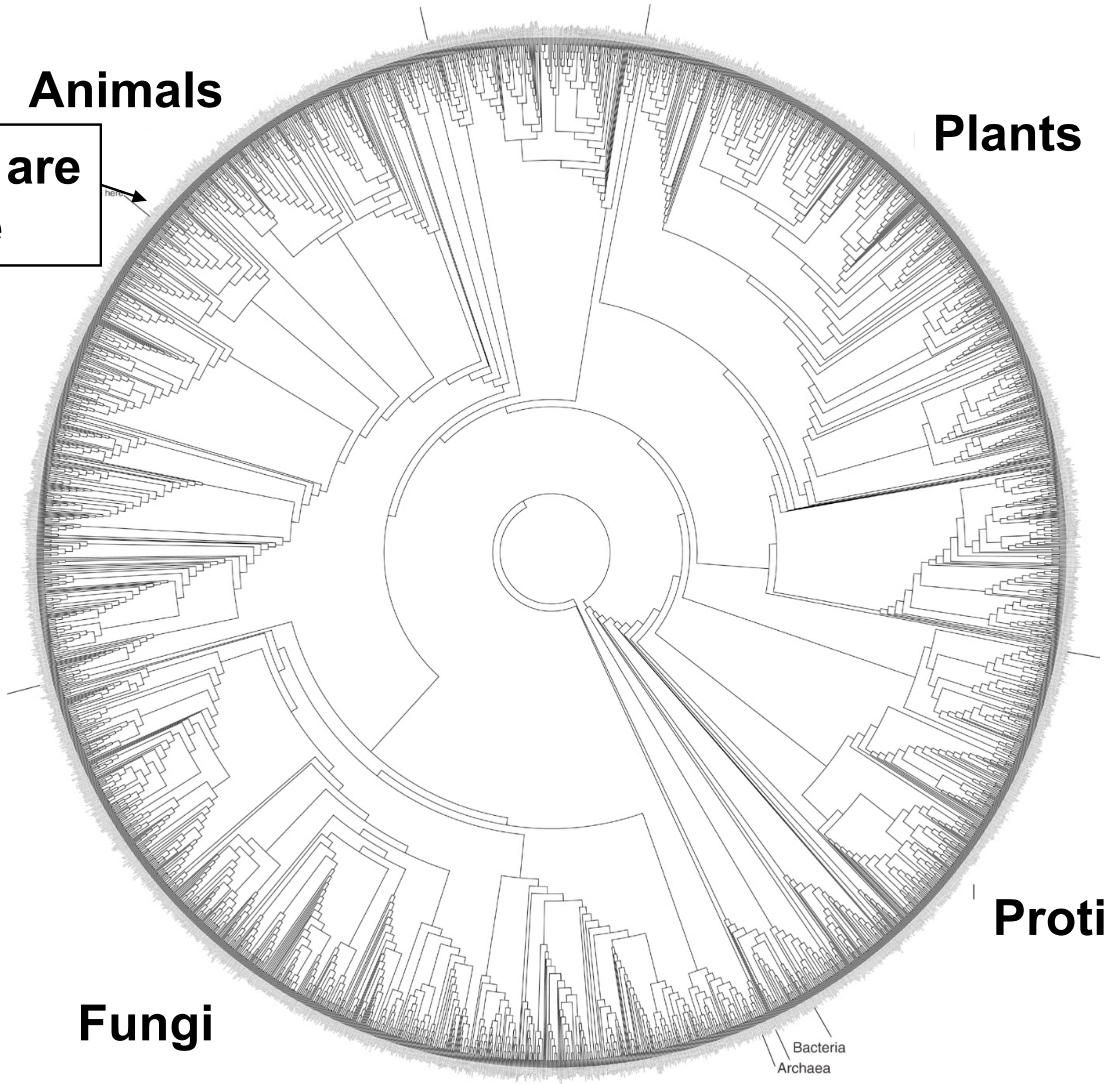
M Meegaskumbura et al., Science 298:379 (2002)

Common Dataset Size Today



M Meegaskumbura et al., Science 298:379 (2002)

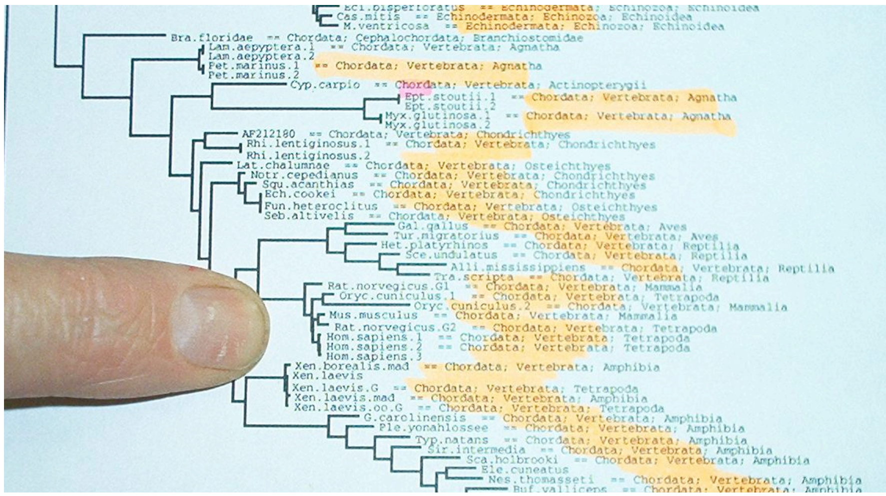
Future Goal: 10M node Tree of Life

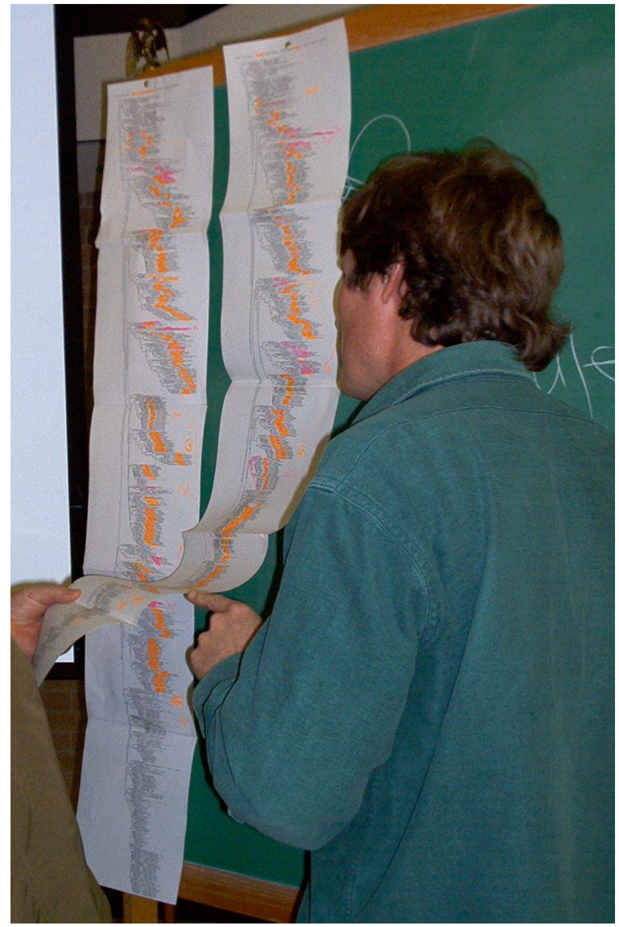


David Hillis, Science 300:1687 (2003)

Paper Comparison: Multiple Trees

focus

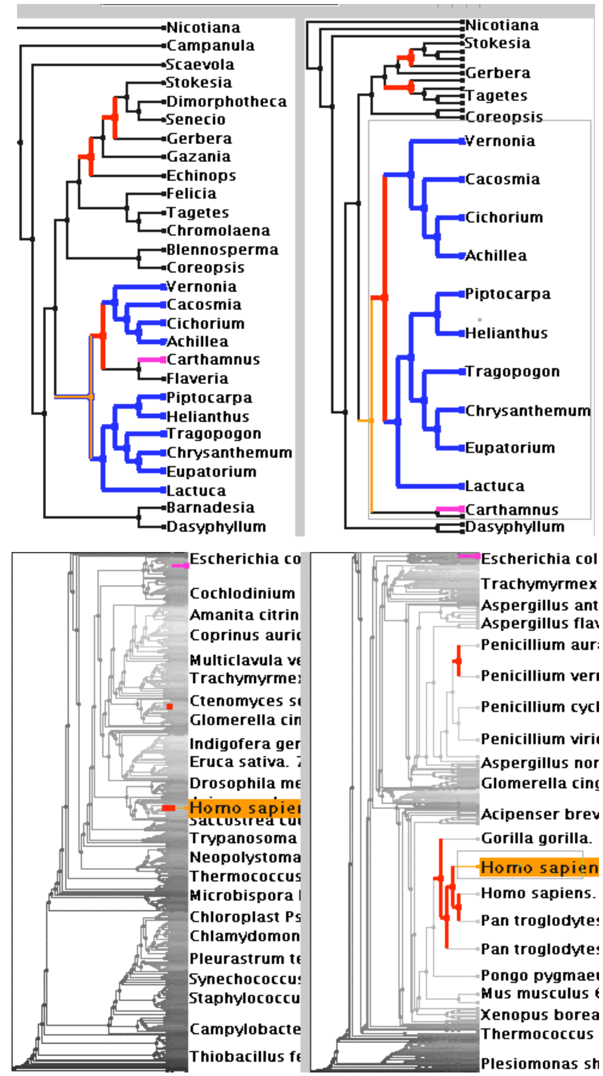




context

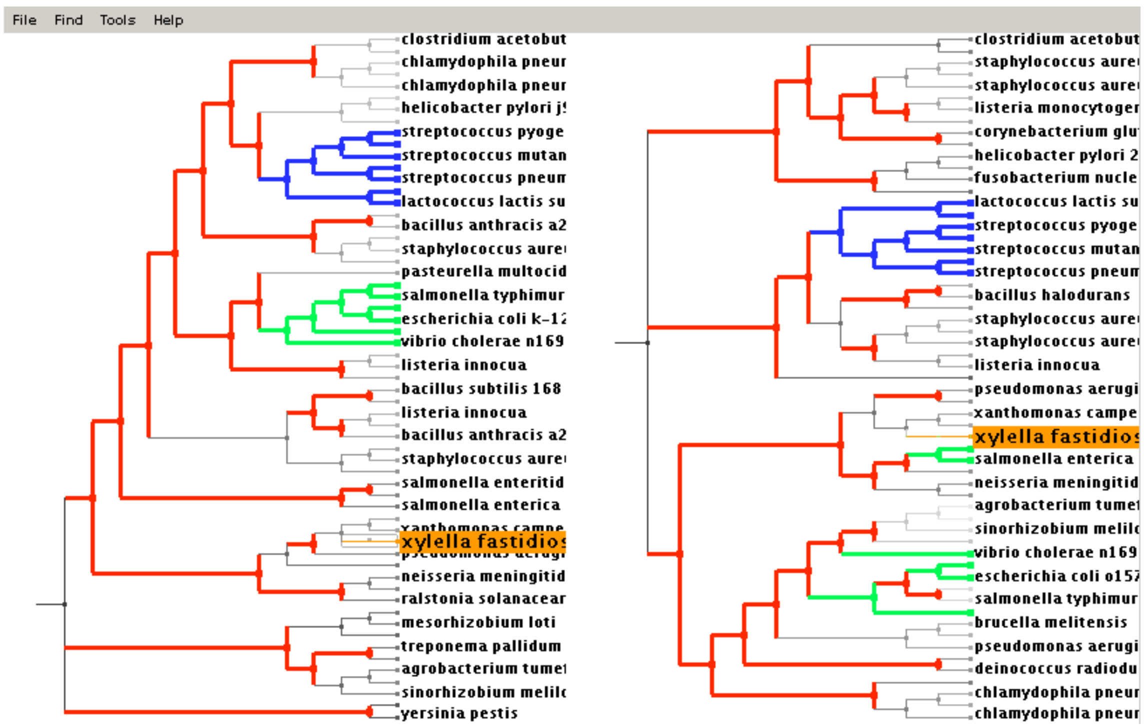
Accordion Drawing

- rubber-sheet navigation
  - stretch out part of surface, the rest squishes
  - borders nailed down
  - Focus+Context technique
    - integrated overview, details
  - old idea
    - [Sarkar et al 93], [Robertson et al 91]
- guaranteed visibility
  - marks always visible
  - important for scalability
  - new idea
    - [Munzner et al 03]

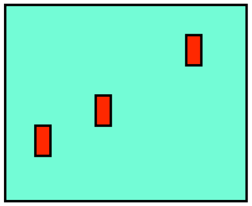


Guaranteed Visibility

- marks are always visible
- easy with small datasets



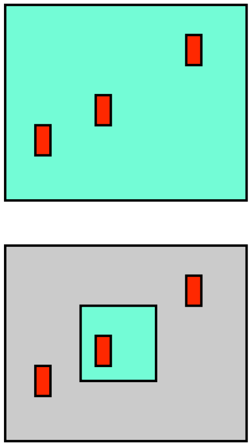
Guaranteed Visibility Challenges



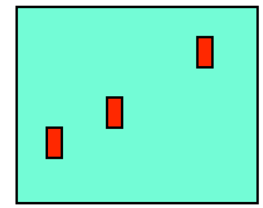
- hard with larger datasets
- reasons a mark could be invisible

Guaranteed Visibility Challenges

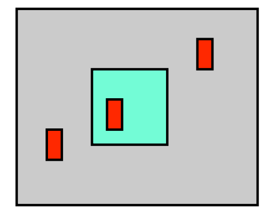
- hard with larger datasets
- reasons a mark could be invisible
  - – outside the window
    - AD solution: constrained navigation



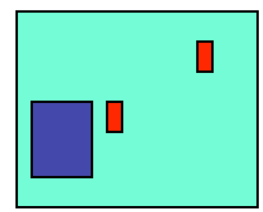
Guaranteed Visibility Challenges



- hard with larger datasets
- reasons a mark could be invisible
  - outside the window
    - AD solution: constrained navigation

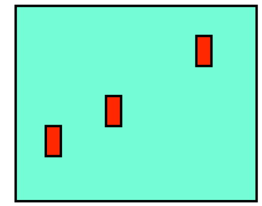


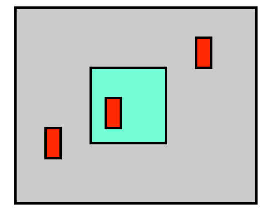
  - underneath other marks
    - AD solution: avoid 3D



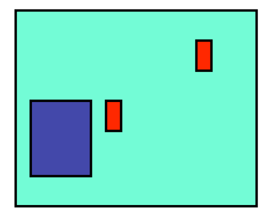
Guaranteed Visibility Challenges

- hard with larger datasets
- reasons a mark could be invisible

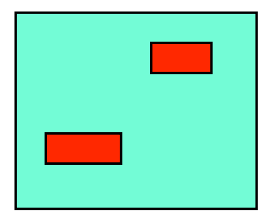




  - outside the window
    - AD solution: constrained navigation



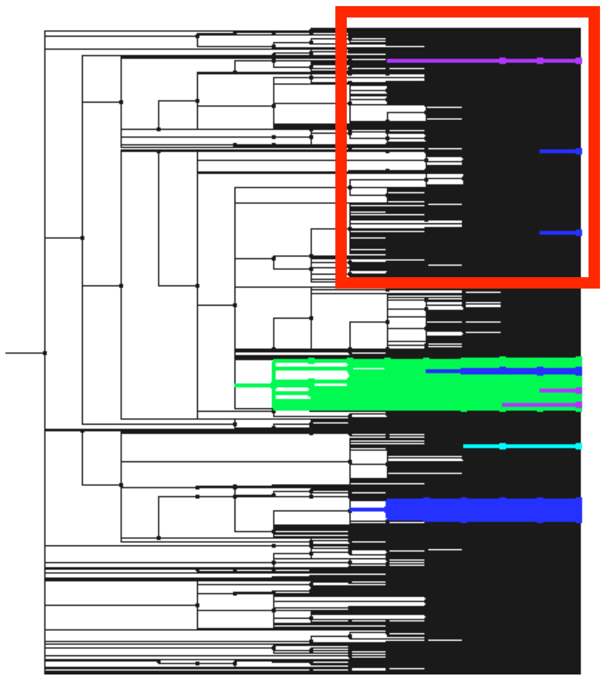
  - underneath other marks
    - AD solution: avoid 3D



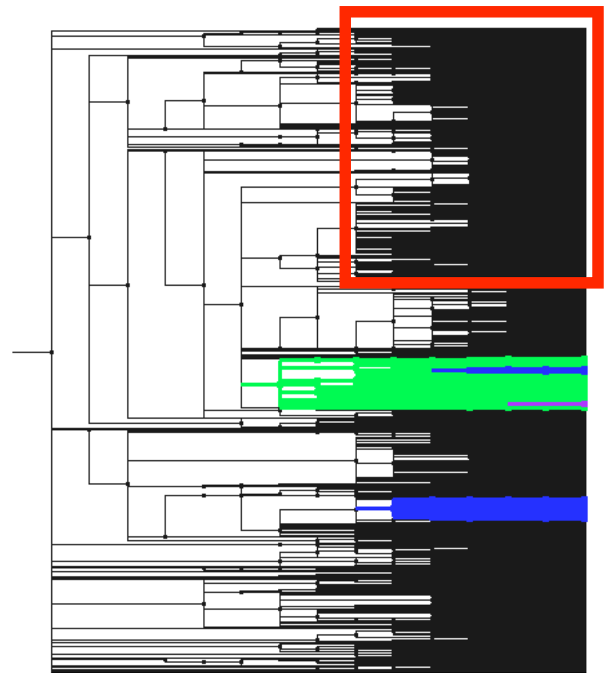
  - smaller than a pixel
    - AD solution: smart culling

Guaranteed Visibility: Small Items

- Naïve culling may not draw all marked items



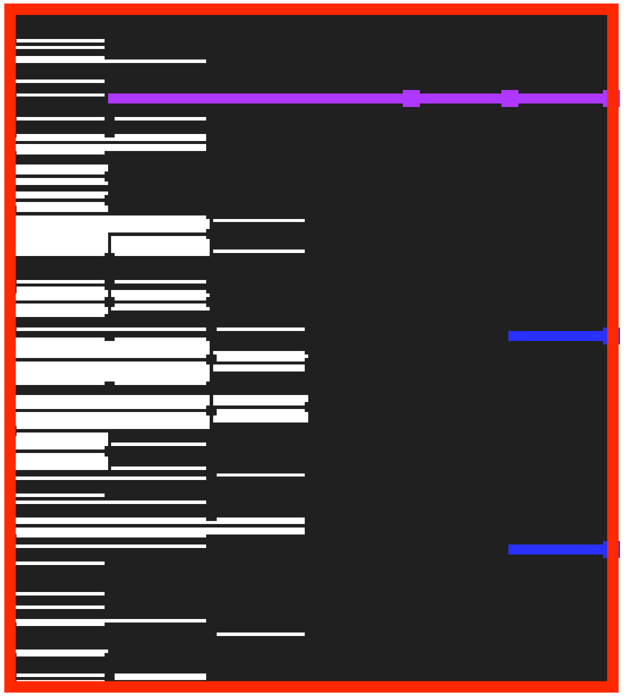
Guaranteed visibility of marks



No guaranteed visibility

Guaranteed Visibility: Small Items

- Naïve culling may not draw all marked items



Guaranteed visibility of marks

No guaranteed visibility

Stretch and Squish Scalability

- later algorithms for render and navigate
  - scale up to many million nodes

Composite Rectilinear Deformation for Stretch and Squish Navigation. James Slack and Tamara Munzner. IEEE Trans. Visualization and Computer Graphics (Proc. Visualization 2006) 12(5), September 2006, p 901-908.

Partitioned Rendering Infrastructure for Scalable Accordion Drawing (Extended Version). James Slack, Kristian Hildebrand, and Tamara Munzner . Information Visualization, 5(2), p. 137-151, 2006.

Latency Classes

- mouseover hover (subsecond)
- guaranteed frame rate (subsecond)
- animated transitions (1 second)

Reading For Next Time

Chapter 5: Single View Methods

The Visual Design and Control of Trellis Display R. A. Becker, W. S. Cleveland, and M. J. Shyu (1996). Journal of Computational and Statistical Graphics, 5:123-155.