Information Visualization at UBC

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Information Visualization

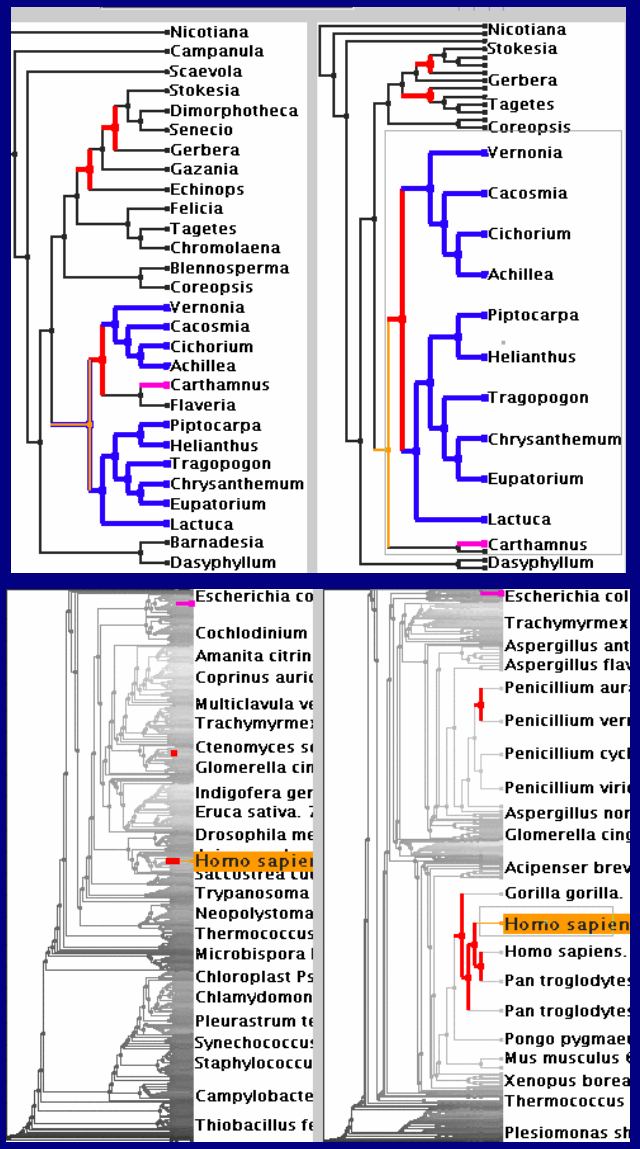
- visual representation of abstract data
  - computer-based
  - interactive
  - goal of helping human perform some task more effectively
- bridging many fields
  - cognitive psych: finding appropriate representation
  - HCI: using task to guide design and evaluation
  - graphics: interacting in realtime
- external representation reduces load on working memory

Current Projects

- accordion drawing
  - TreeJuxtaposer, SequenceJuxtaposer, TJC, PRISAD, PowerSetViewer
- evaluation
  - Focus+Context, Transformations
- graph drawing
  - TopoLayout
- dimensionality reduction
  - MDSteer, PBSteer

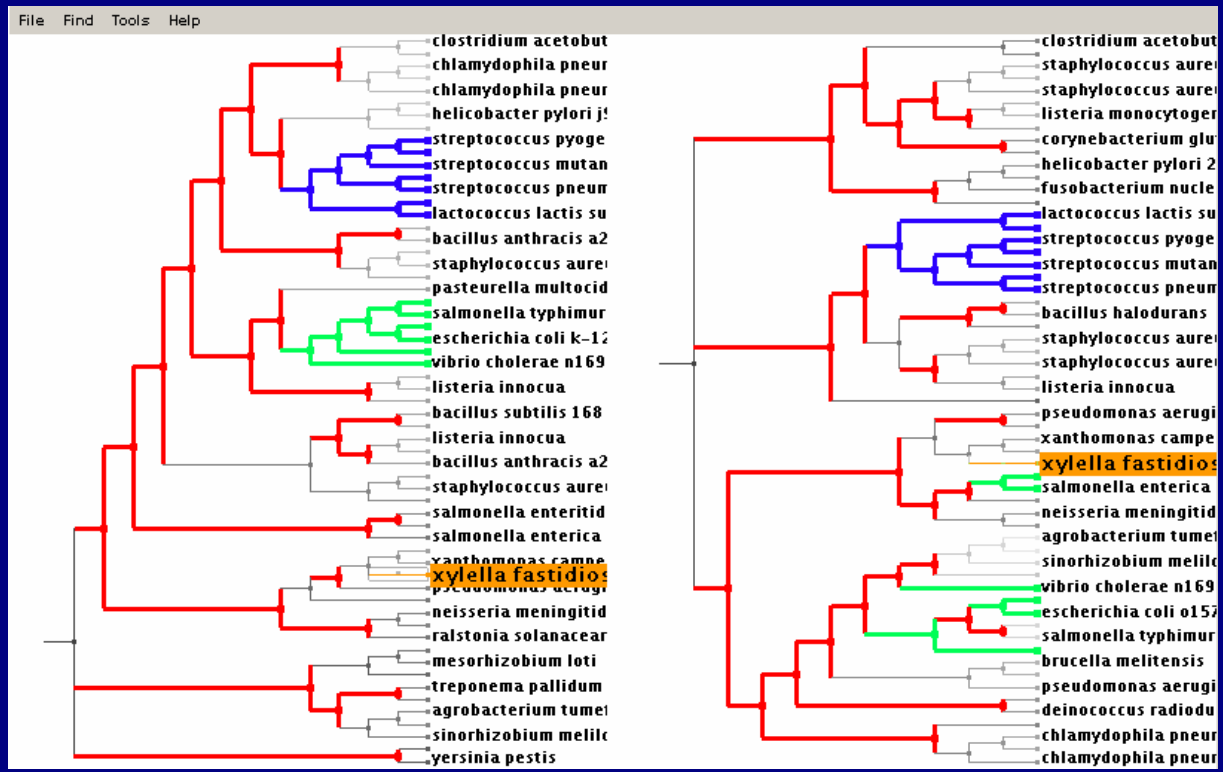
Accordion Drawing

- 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], ...
- guaranteed visibility
  - marks always visible
  - important for scalability
  - new idea
    - [Munzner et al 03]



Guaranteed Visibility

- easy with small datasets



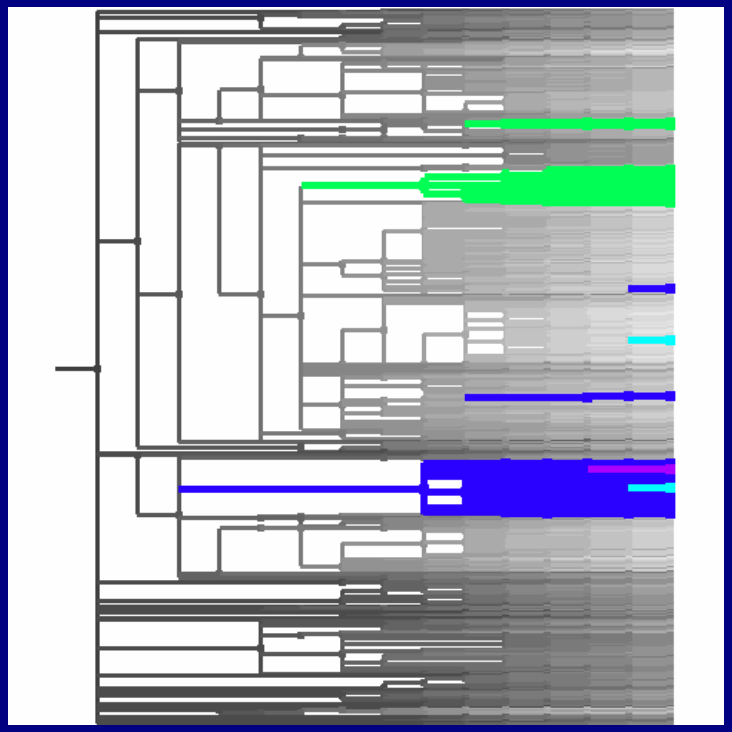
Guaranteed Visibility Challenges

- 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

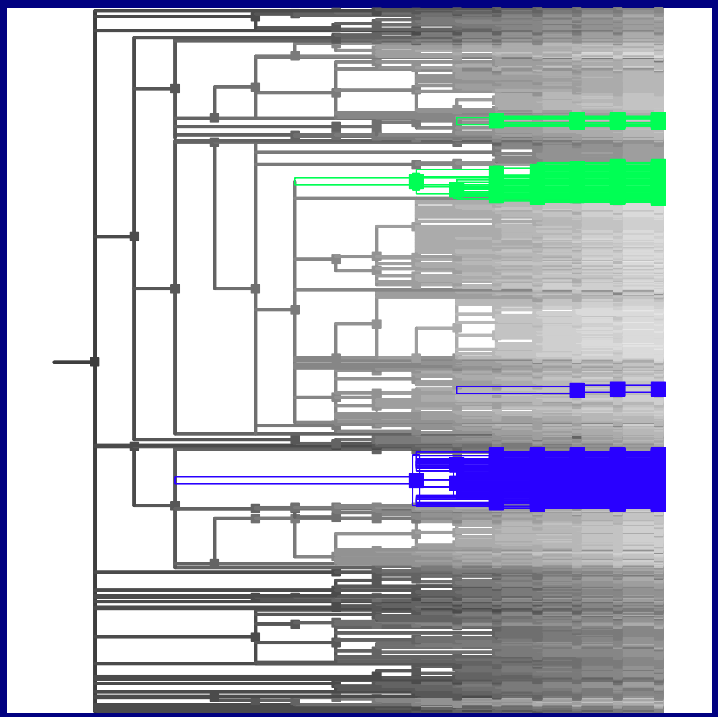
Guaranteed Visibility: Culling

- naive culling may not draw all marked items

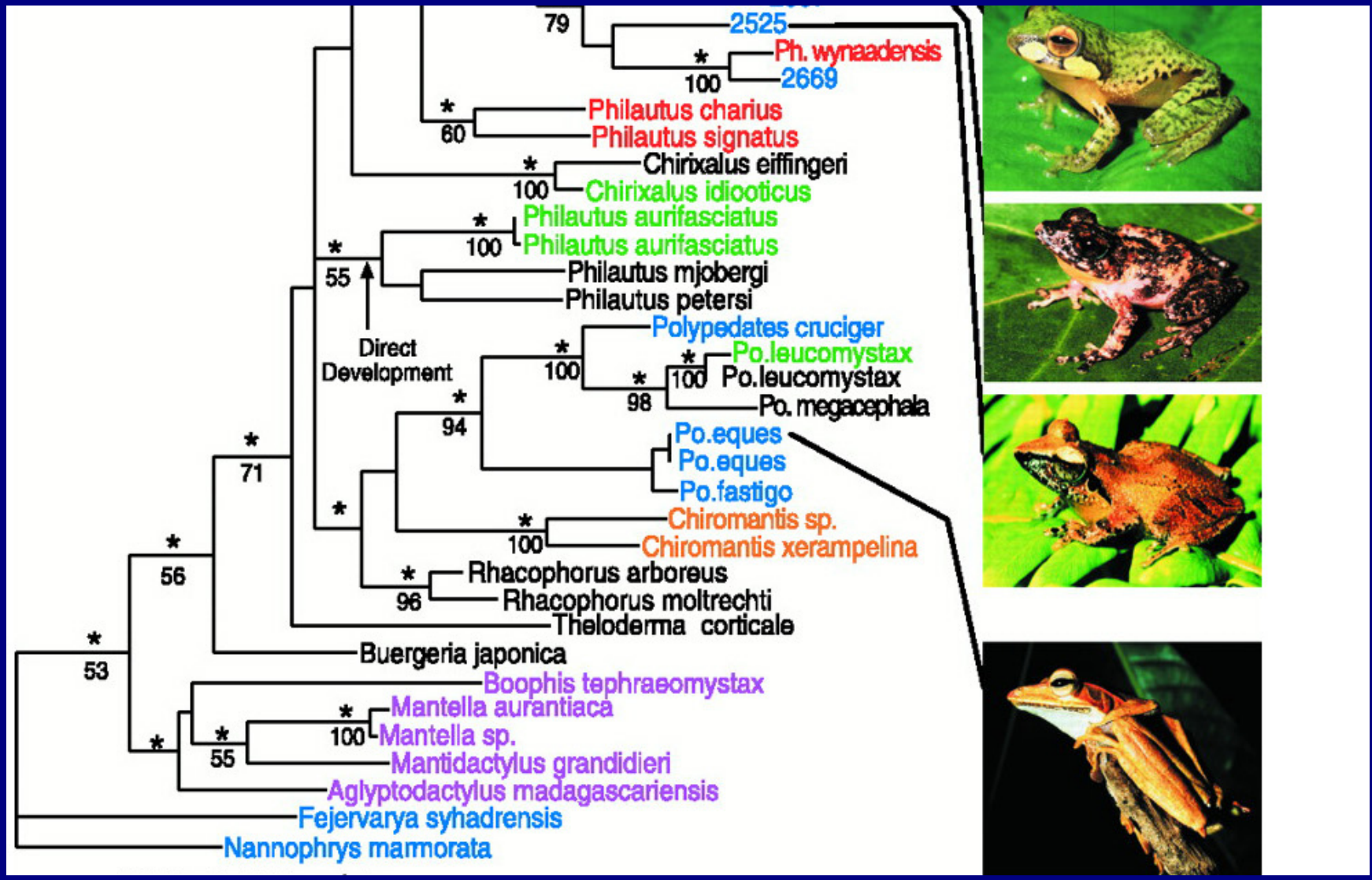
GV



no GV

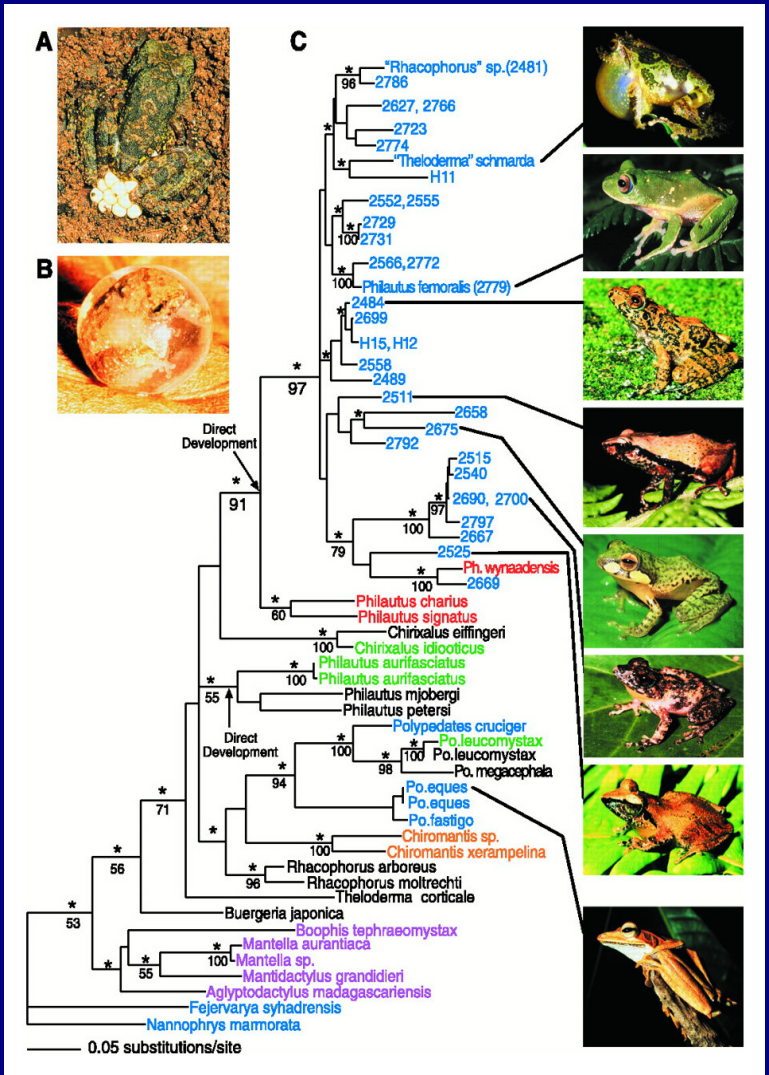


Phylogenetic/Evolutionary Tree



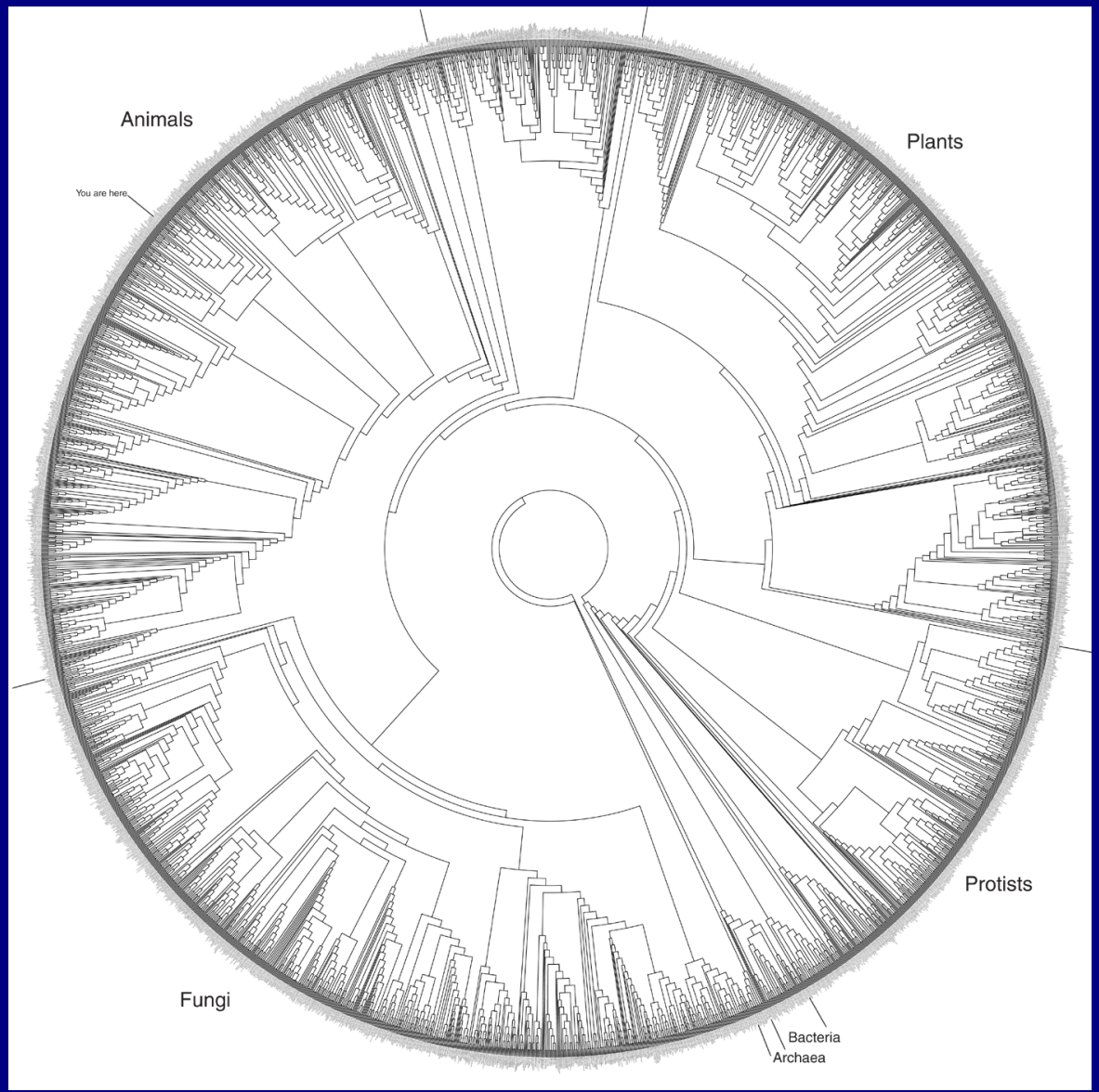
M Meegaskumbura et al., Science 298:379 (2002)

Common Dataset Size Today



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

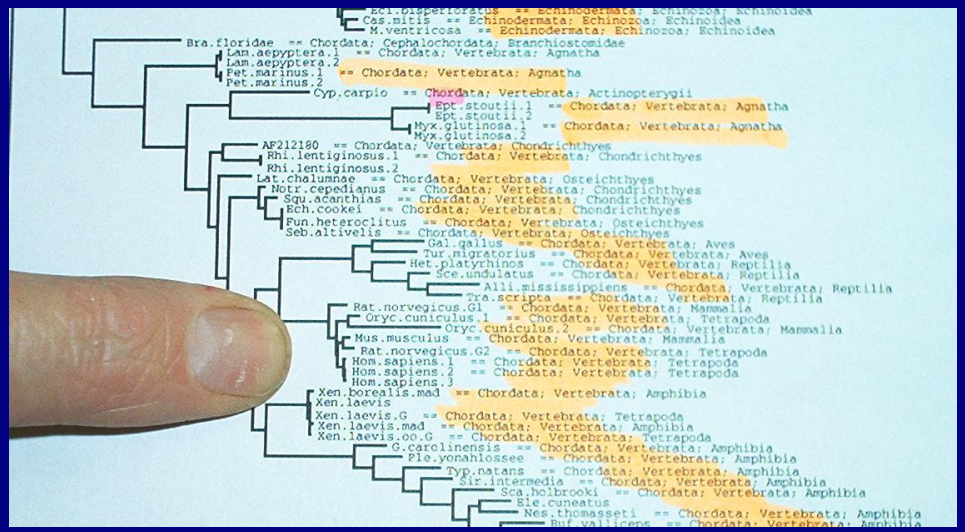
Future Goal: 10M Node Tree of Life



David Hillis, Science 300:1687 (2003)

Paper Comparison: Multiple Trees

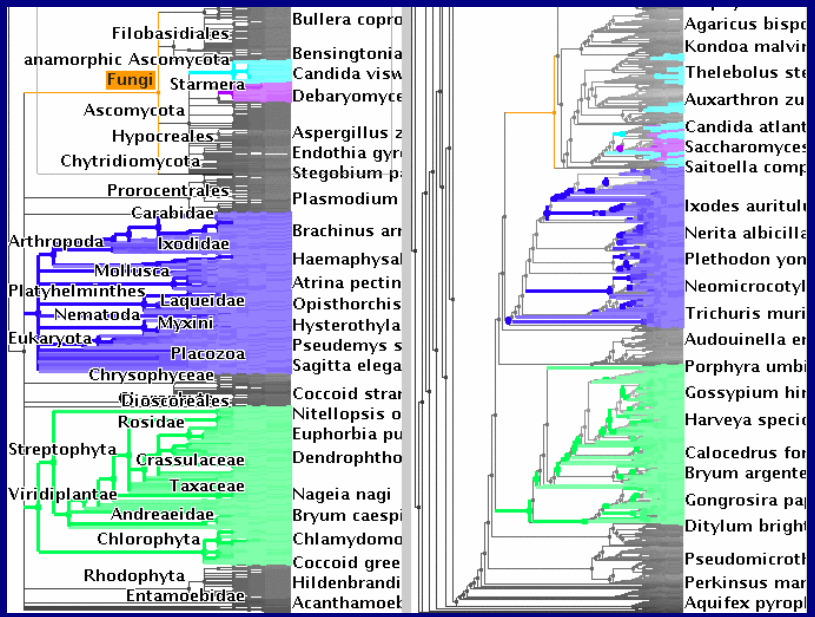
focus



context

TreeJuxtaposer

- comparison of evolutionary trees
  - side by side
- [demo: olduvai.sourceforge.net/tj]



TJ Contributions

- first interactive tree comparison system
  - automatic structural difference computation
  - guaranteed visibility of marked areas
- scalable to large datasets
  - 250,000 to 500,000 total nodes
  - all preprocessing subquadratic
  - all realtime rendering sublinear
- introduced accordion drawing (AD)
- introduced guaranteed visibility (GV)

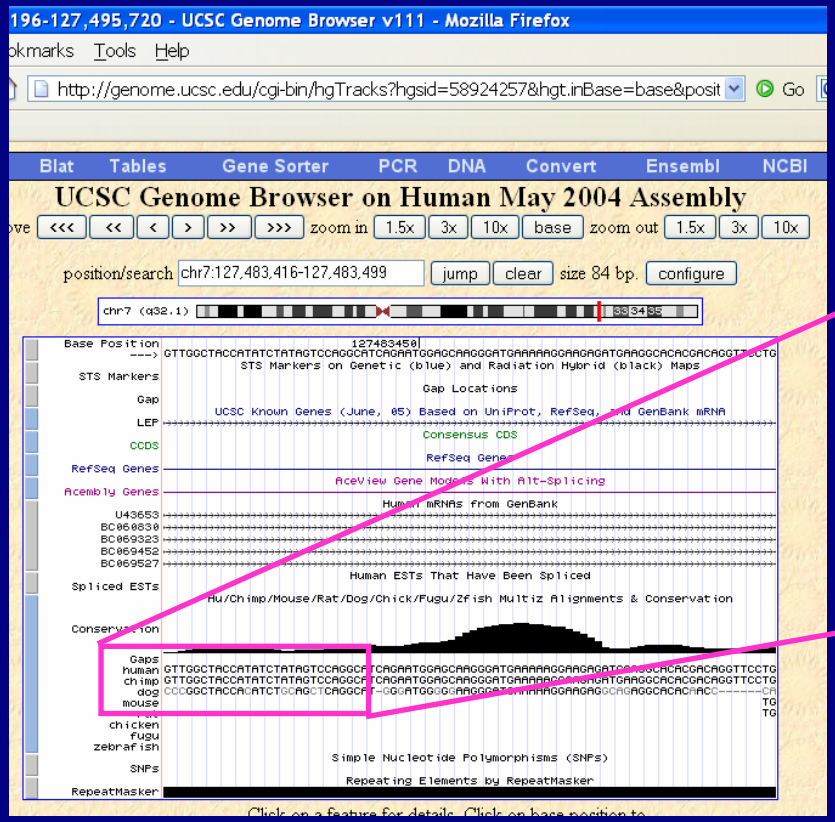
Joint Work: TJ Credits

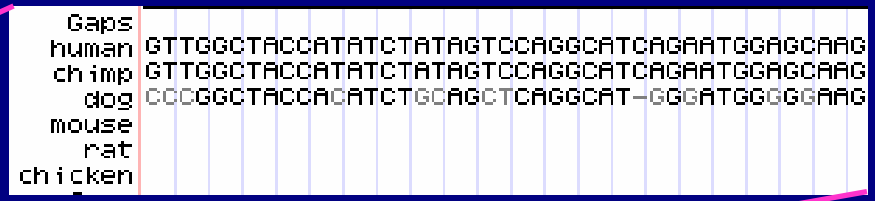
- Tamara Munzner (UBC prof)
- Francois Guimbretiere (Maryland prof)
- Serdar Tasiran (Koc Univ, prof)
- Li Zhang, Yunhong Zhou (HP Labs)
  - TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility
  - Proc. SIGGRAPH 2003
  - www.cs.ubc.ca/~tmm/papers/tj

- James Slack (UBC PhD)
- Tamara Munzner (UBC prof)
- Francois Guimbretiere (Maryland prof)
  - TreeJuxtaposer: InfoVis03 Contest Entry. (Overall Winner)
  - InfoVis 2003 Contest
  - www.cs.ubc.ca/~tmm/papers/contest03

Genomic Sequences

- multiple aligned sequences of DNA
- now commonly browsed with web apps
  - zoom and pan with abrupt jumps





SequenceJuxtaposer

- dense grid, following conventions
  - rows of sequences, typically species
  - columns of partially aligned nucleotides
  - [video: www.cs.ubc.ca/~tmm/papers/sj]

SJ Contributions

- accordion drawing for gene sequences
  - smooth, fluid transitions between states
  - guaranteed visibility for globally visible landmarks
  - difference thresholds changeable on the fly
- 2004 paper results: 1.7M nucleotides
  - current with PRISAD: 40M nucleotides
- future work
  - hierarchical structure from annotation dbs
  - editing

Joint Work: SJ Credits

- James Slack (UBC PhD)
- Kristian Hildebrand (Weimar Univ MS)
- Tamara Munzner (UBC prof)
- Katherine St. John (CUNY prof)

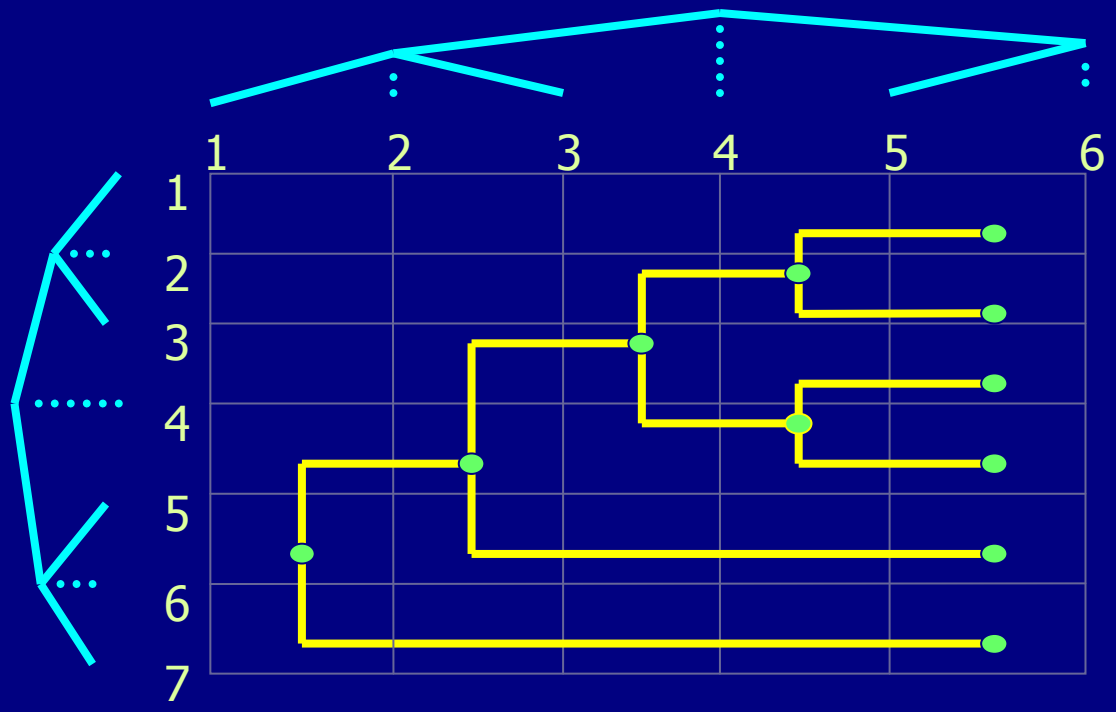
  – SequenceJuxtaposer: Fluid Navigation For Large-Scale Sequence Comparison In Context
  – Proc. German Conference Bioinformatics 2004
  – www.cs.ubc.ca/~tmm/papers/sj

Scaling Up Trees

- TJ limits: 500K nodes
  - large memory footprint
  - CPU-bound, far from achieving peak rendering performance of graphics card
- in TJ, quadtree data structure used for
  - placing nodes during layout
  - drawing edges given navigation
  - culling edges with GV
  - picking edges during interaction

New Data Structures, Algorithms

- new data structures
  - two 1D hierarchies vs. one 2D quadtree
- new drawing/culling algorithm



TJC/TJC-Q Results

- TJC
  - no quadtree
  - picking with new hardware feature
    - requires HW multiple render target support
  - 15M nodes
- TJC-Q
  - lightweight quadtree for picking support
  - 5M nodes
- both support tree browsing only
  - no comparison data structures

Joint Work: TJC, TJC-Q Credits

- Dale Beermann (Virginia MS alum)
- Tamara Munzner (UBC prof)
- Greg Humphreys (Virginia prof)

  – Scalable, Robust Visualization of Large Trees
  – Proc. EuroVis 2005
  – www.cs.virginia.edu/~gfx/pubs/TJC

PRISAD

- generic accordion drawing infrastructure
  - handles many application types
- efficient
  - guarantees of correctness: no overculling
  - tight bounds on overdrawing
    - handles dense regions efficiently
  - new algorithms for rendering, culling, picking
    - exploit application dataset characteristics instead of requiring expensive additional data structures

PRISAD Results

- trees
  - 4M nodes
  - 5x faster rendering, 5x less memory
  - order of magnitude faster for marking
- sequences
  - 40M nucleotides
- power sets
  - 2M to 7M sets
  - alphabets beyond 20,000

Joint Work: PRISAD Credits

- James Slack (UBC PhD)
- Kristian Hildebrand (Weimar MS)
- Tamara Munzner (UBC prof)

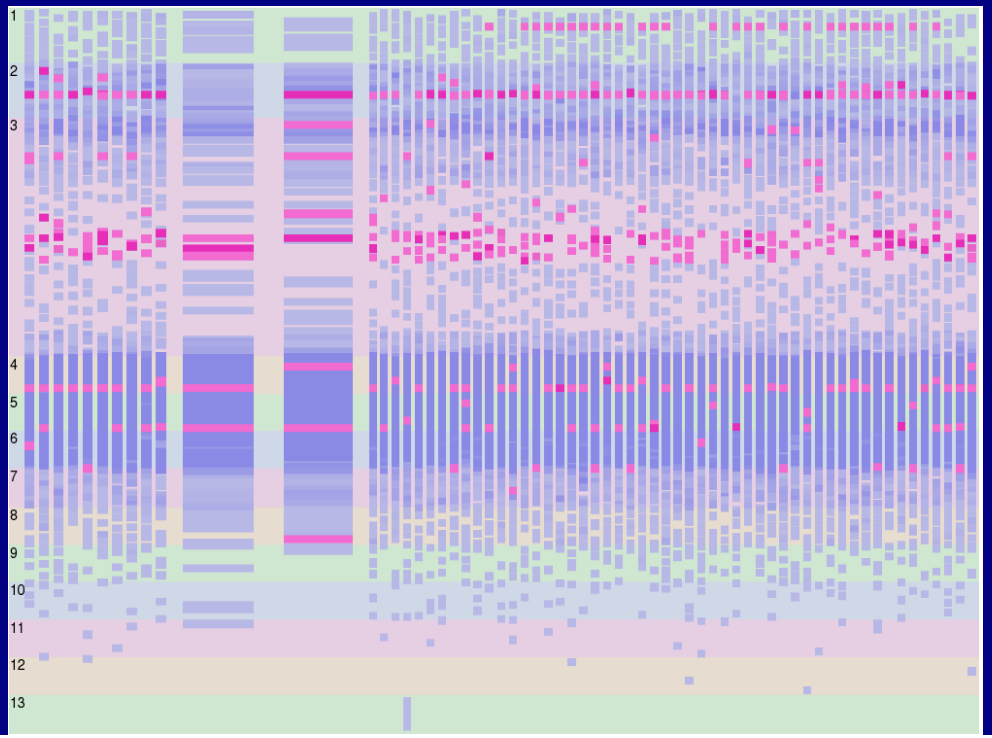
  – PRISAD: A Partitioned Rendering Infrastructure for Scalable Accordion Drawing.
  – Proc. InfoVis 2005, to appear

PowerSetViewer

- data mining of market-basket transactions
  - show progress of steerable data mining system with constraints
  - want visualization “windshield” to guide parameter setting choices on the fly
- dynamic data
  - all other AD applications had static data
- transactions as sets
  - items bought together make a set
  - alphabet is items in stock at store
  - space of all possible sets is power set

PowerSetViewer

- show position of logged sets within enumeration of power set
  - very long 1D linear list
  - wrap around into 2D grid of fixed width
  - [video]



Joint Work: PSV Credits

- work in progress

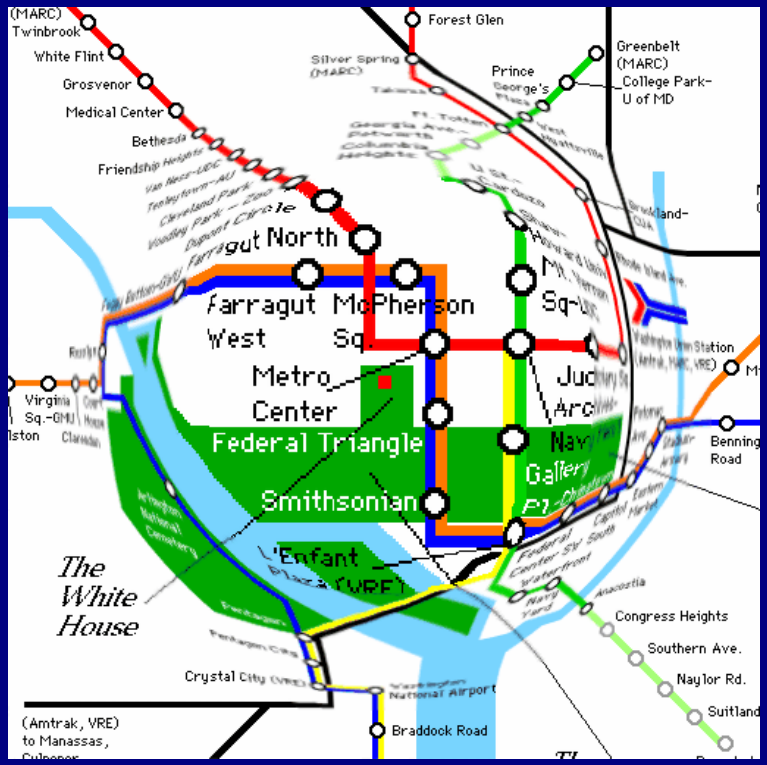
- Tamara Munzner (UBC prof)
- Qiang Kong (UBC MS)
- Raymond Ng (UBC prof)

Current Projects

- accordion drawing
  - TreeJuxtaposer, SequenceJuxtaposer, TJC, PRISAD, PowerSetViewer
- Focus+Context evaluation
  - system, perception
- graph drawing
  - TopoLayout
- dimensionality reduction
  - MDSteer, PBSteer

Focus+Context

- integrating details and overview into single view
  - carefully chosen nonlinear distortion
  - what are costs? what are benefits?



Focus+Context System Evaluation

- how focus and context are used with
  - rubber sheet navigation vs. pan and zoom
  - integrated scene vs. separate overview

- user studies using modified TJ
  - abstract tasks derived from biologists' needs based on interviews

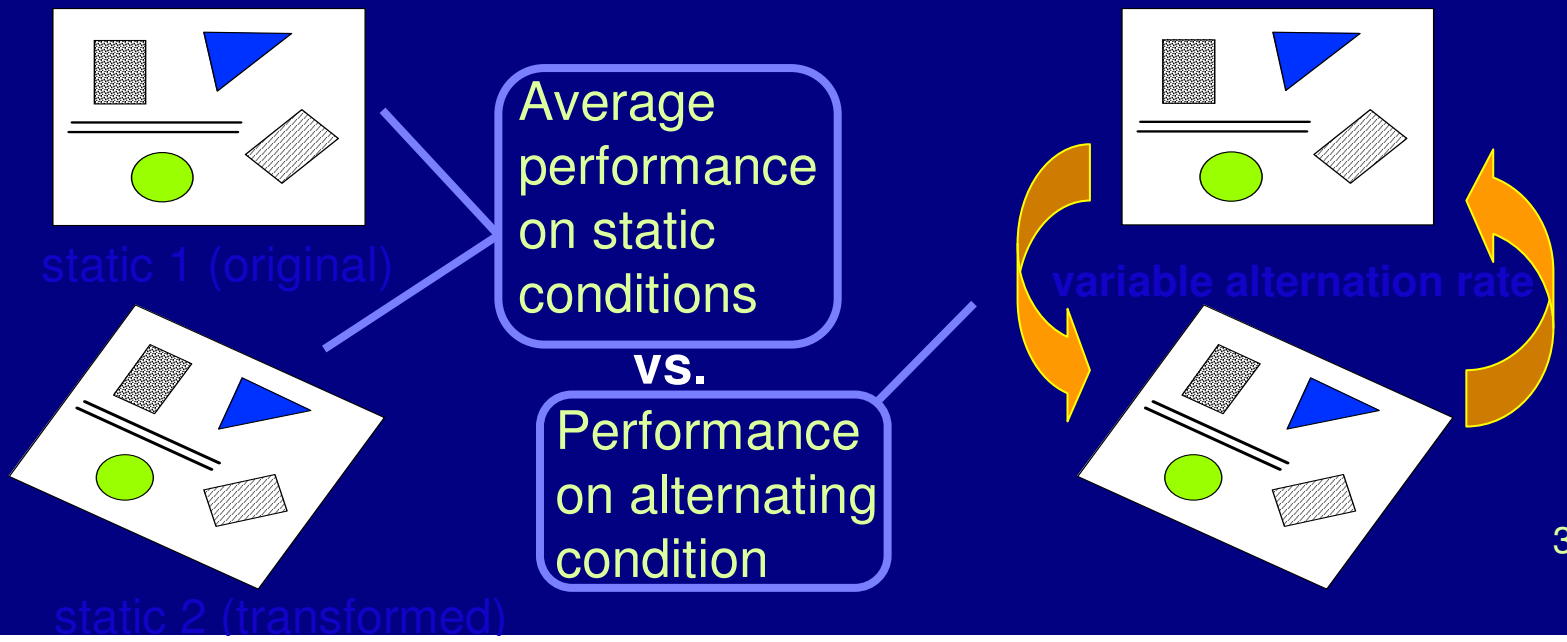
Joint Work: F+C System Eval Credits

- work in progress

- Adam Bodnar (UBC MS)
- Dmitry Nekrasovski (UBC MS)
- Tamara Munzner (UBC prof)
- Joanna McGrenere (UBC prof)
- Francois Guimbretiere (Maryland prof)

F+C Perception Evaluation

- understand perceptual costs of transformation
  - find best transformation to use
- visual search for target amidst distractors
  - shaker paradigm



F+C Perception Evaluation

- understand perceptual costs of transformation
  - deterioration in performance
    - time, effort, error
  - static costs: caused by crowding, distortion of static transformation itself
    - high static cost
  - dynamic costs: reorienting and remapping when transformation applied or focus moved
    - low dynamic cost
    - large no-cost zone

Joint Work: F+C Perceptual Eval

- Keith Lau (former UBC undergrad)
- Ron Rensink (UBC prof)
- Tamara Munzner (UBC prof)
  - Perceptual Invariance of Nonlinear Focus+Context Transformations
  - Proc. First Symposium on Applied Perception in Graphics and Visualization, 2004

- work in progress: continue investigation
- Heidi Lam (UBC PhD)
- Ron Rensink (UBC prof)
- Tamara Munzner (UBC prof)

Current Projects

- accordion drawing
  - TreeJuxtaposer, SequenceJuxtaposer, TJC, PRISAD, PowerSetViewer
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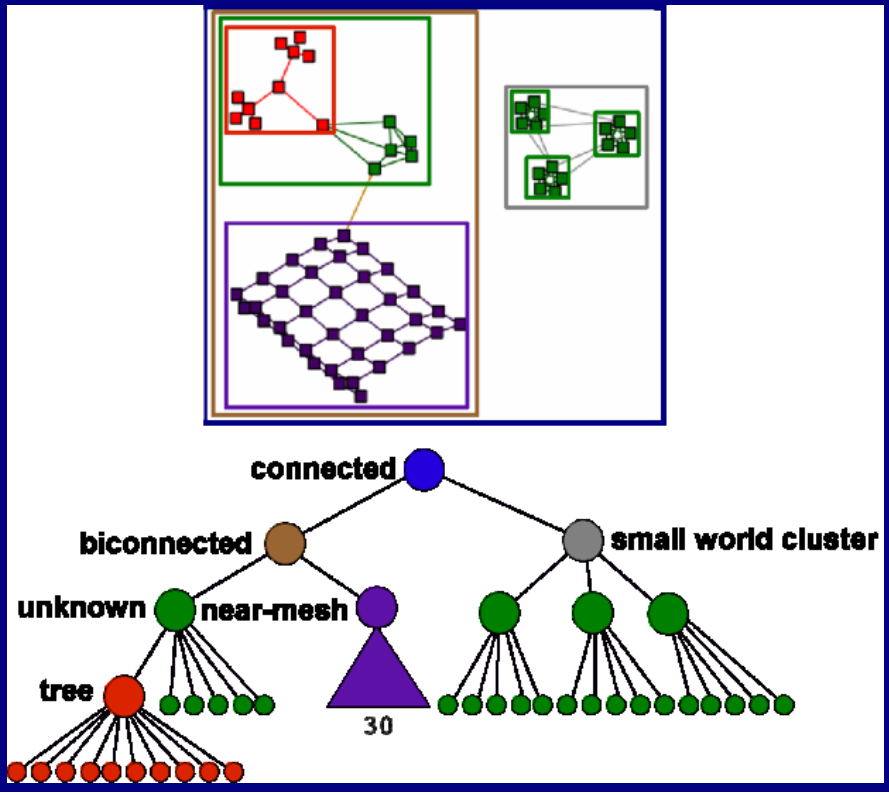
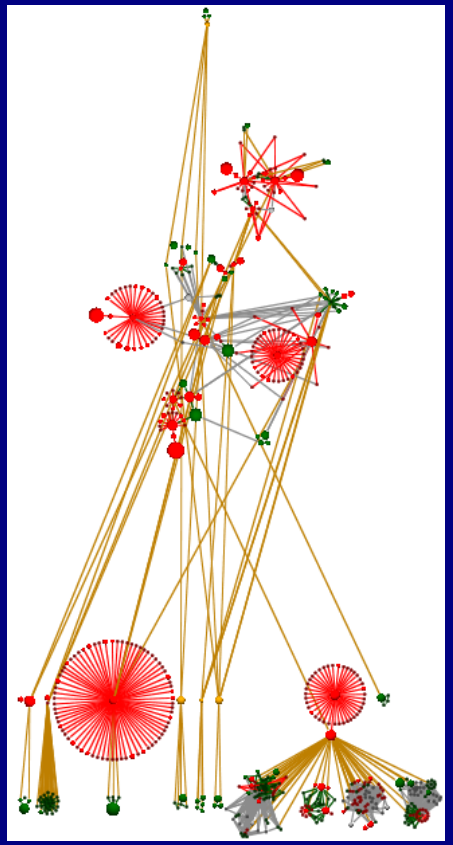
TopoLayout

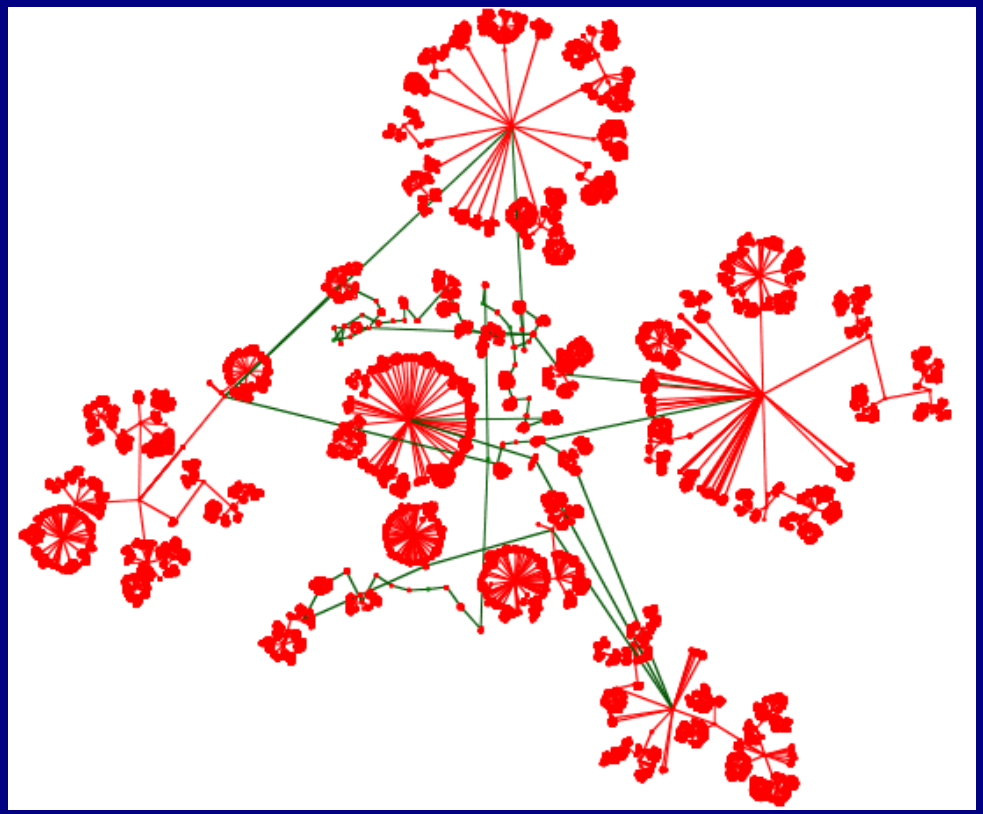
- multilevel decomposition and layout
  - automatic detection of topological features
- chop into hierarchy of manageable pieces
  - lay out using feature-appropriate algorithms



Multilevel Hierarchies

- strengths: handles large class of graphs
  - previous work mostly good with near-meshes
- weaknesses: poor if no detectable features





Joint Work: TopoLayout Credits

- work in progress

- Dan Archambault (UBC PhD)
- Tamara Munzner (UBC prof)
- David Auber (Bordeaux prof)

Current Projects

- accordion drawing
  - TreeJuxtaposer, SequenceJuxtaposer, TJC, PRISAD, PowerSetViewer
- Focus+Context evaluation
  - system, perception
- graph drawing
  - TopoLayout
- dimensionality reduction
  - MDSteer, PBSteer

Dimensionality Reduction

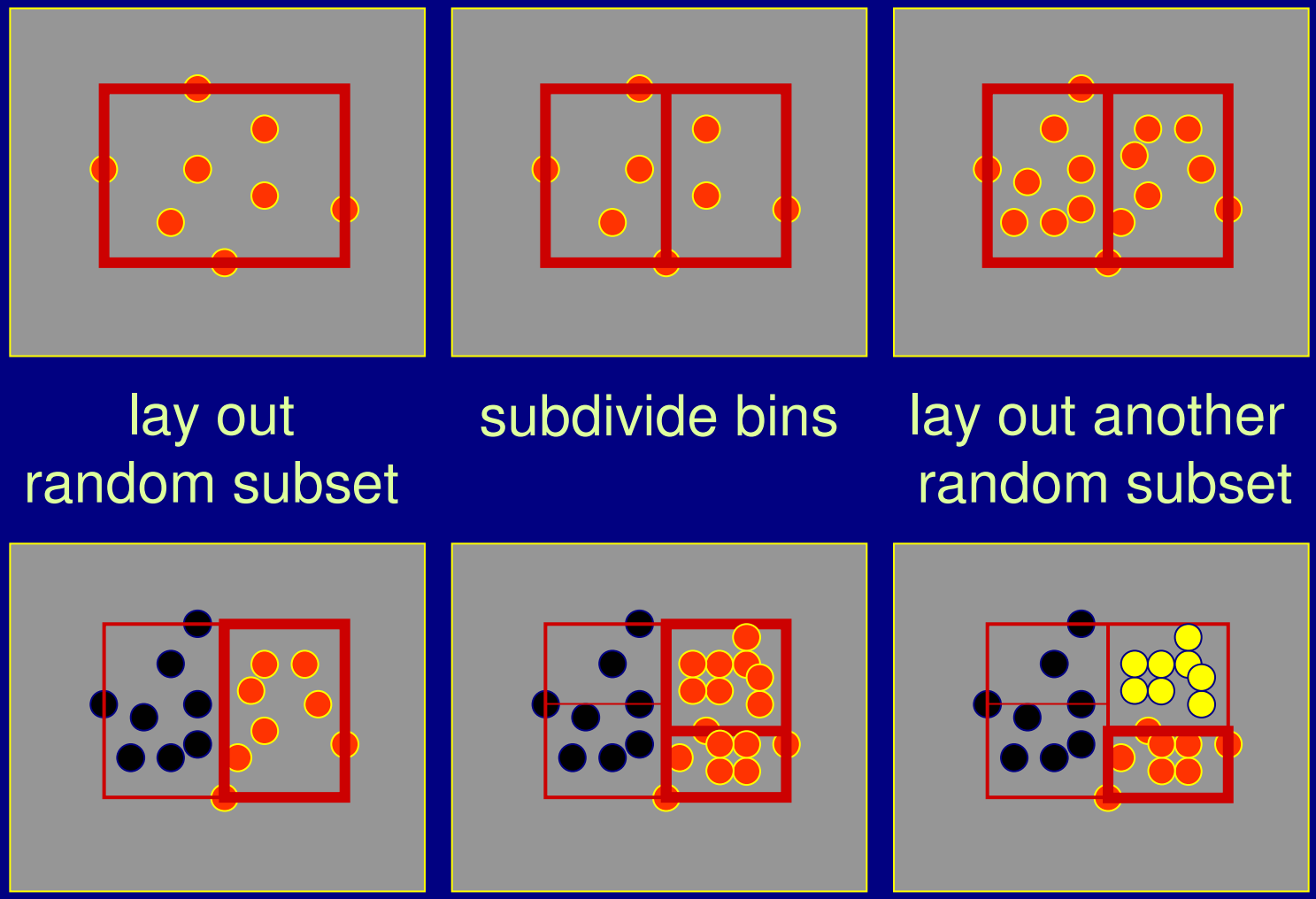
- mapping multidimensional space into space of fewer dimensions
  - typically 2D for infovis
  - keep/explain as much variance as possible
  - show underlying dataset structure

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

Scalability Limitations

- high cardinality and high dimensionality: slow
  - motivating dataset: 120K points, 300 dimensions
  - most existing software could not handle at all
  - 2 hours to compute with $O(n^{5/4})$ HIVE [Ross 03]
- real-world need: exploring huge datasets
  - people want tools for millions of points
- strategy
  - start interactive exploration immediately
    - progressive layout
  - concentrate computational resources in interesting areas
    - steerability
  - often partial layout is adequate for task

MDSteer Overview



lay out random subset

subdivide bins

lay out another random subset

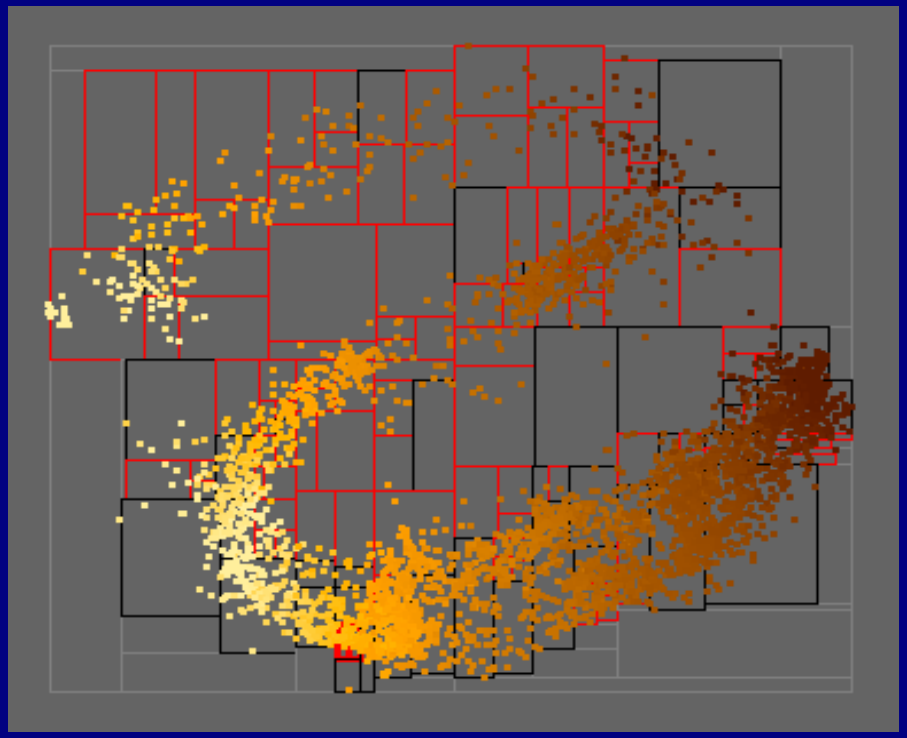
user selects active region of interest

more subdivisions and layouts

user refines active region

MDSteer Contributions

- first steerable MDS algorithm
  - progressive layout allows immediate exploration
  - allocate computational resources in lowD space
  - [video: www.cs.ubc.ca/~tmm/papers/mdsteer]



Joint Work: MDSteer Credits

- Matt Williams (former UBC MS)
- Tamara Munzner (UBC prof)
  - Steerable Progressive Multidimensional Scaling
  - Proc. InfoVis 2004
  - www.cs.ubc.ca/~tmm/papers/mdsteer

- work in progress: PBSteer for progressive binning
  - David Westrom (former UBC undergrad)
  - Tamara Munzner (UBC prof)
  - Melanie Tory (UBC postdoc)

Summary

- broad array of infovis projects at UBC
- theme: scalability
  - size of dataset
  - number of available pixels

InfoVis Service

- IEEE Symposium on Information Visualization (InfoVis) Papers/Program Co-Chair 2003, 2004
- IEEE Executive Committee, Technical Committee on Visualization and Graphics
- Visualization Research Challenges
  - report commissioned by NSF/NIH

More Information

- papers, videos, images
  - www.cs.ubc.ca/~tmm
- free software
  - olduvai.sourceforge.net/tj
  - olduvai.sourceforge.net/sj