Lecture 3: Focus+Context

Information Visualization
CPSC 533C, Fall 2006

Tamara Munzner

UBC Computer Science

19 September 2006

Papers Covered

A Review and Taxonomy of Distortion-Oriented Presentation Techniques. Y.K. Leung and M.D. Apperley, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 2, June 1994, pp. 126-160. [http://www.ai.mit.edu/people/jimmylin/papers/Leung94.pdf]

Nonlinear Magnification Fields. Alan Keahey, Proc InfoVis 1997 [http://citeseer.nj.nec.com/keahey97nonlinear.html]

The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John Lamping and Ramana Rao, Proc SIGCHI '95. [http://citeseer.nj.nec.com/lamping95focuscontext.html]

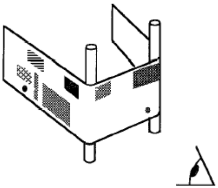
H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space. Tamara Munzner, Proc InfoVis 97 [http://graphics.stanford.edu/papers/h3/]

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner, Guimbretiere, Tasiran, Zhang, and Zhou. SIGGRAPH 2003. [http://www.cs.ubc.ca/˜tmm/papers/tj/]

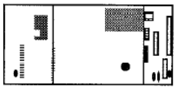
hyperbolic geometry background, if time

Focus+Context Intuition

- move part of surface closer to eye



(a)

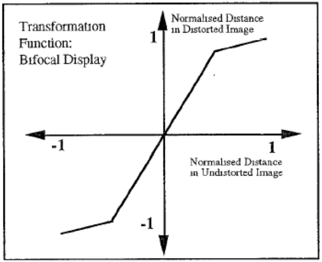


(b)

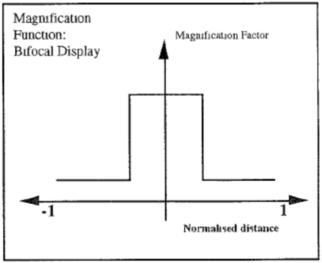
- stretchable rubber sheet
- borders tacked down
- merge overview and detail into combined view

Bifocal Display

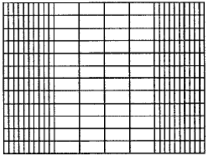
transformation



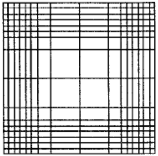
magnification



1D

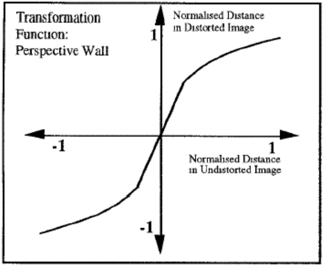


2D

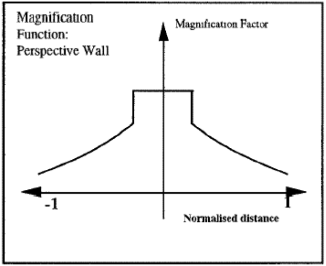


Perspective Wall

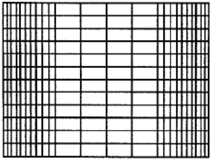
transformation



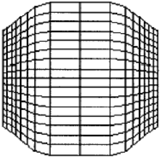
magnification



1D

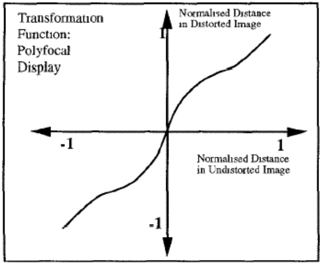


2D

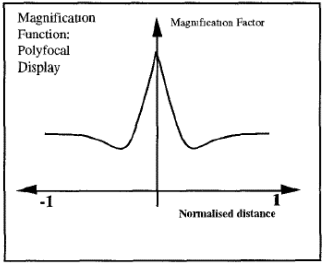


Polyfocal: Continuous Magnification

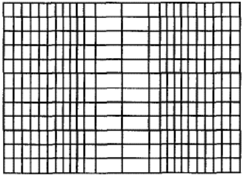
transformation



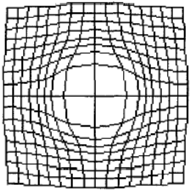
magnification



1D

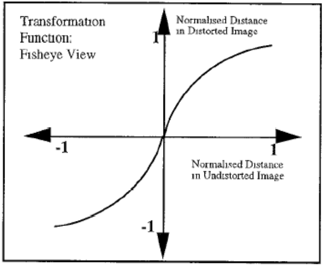


2D

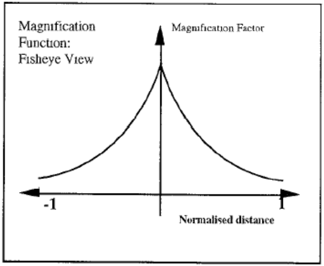


Fisheye Views: Continuous Mag

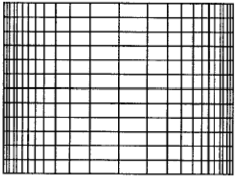
transformation



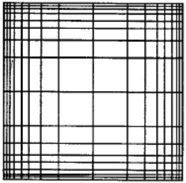
magnification



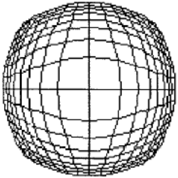
1D



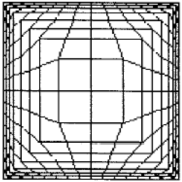
2D rect



polar

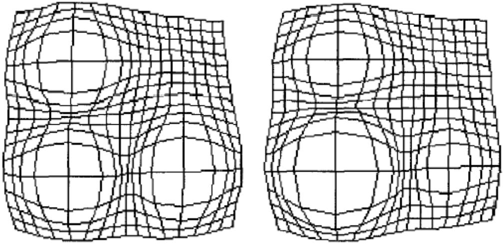


norm polar

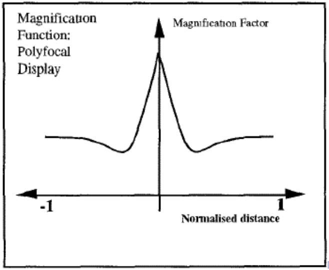


Multiple Foci

same params diff params



polyfocal magnification function dips allow this

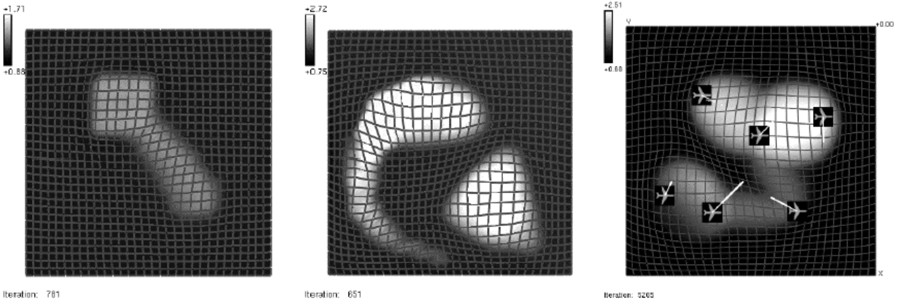


Nonlinear Magnification

- transformation
  - distortion
- magnification
  - derivative of transformation
- directionality
  - easy: given transformation, compute magnification
    - differentiation
  - hard: given magnification, compute transformation
    - integration
- new mathematical framework
  - approximate integration, iterative refinement
  - minimize error mesh

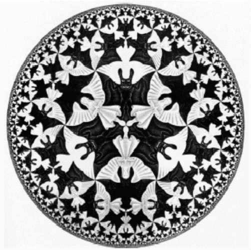
Expressiveness

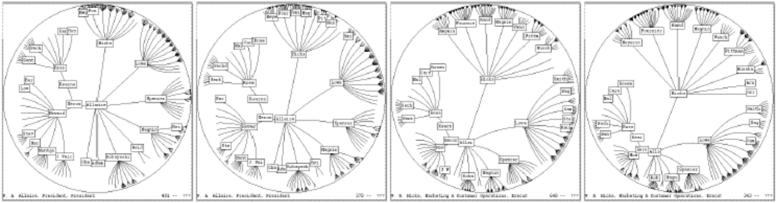
- magnification is more intuitive control
  - allow expressiveness, data-driven expansion



2D Hyperbolic Trees

- fisheye effect from hyperbolic geometry





[video]

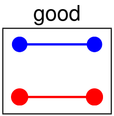
3D Hyperbolic Graphs: H3

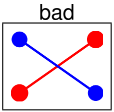
- spanning tree backbone for quasi-hierarchical graphs

video

Graph Layout Criteria

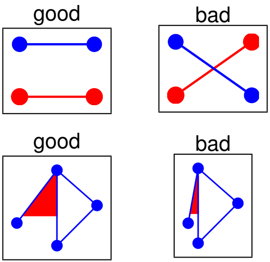
- minimize
  - crossings, area, bends/curves





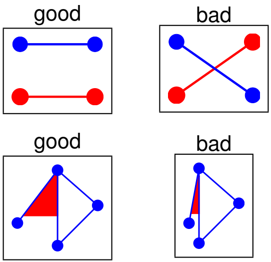
Graph Layout Criteria

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



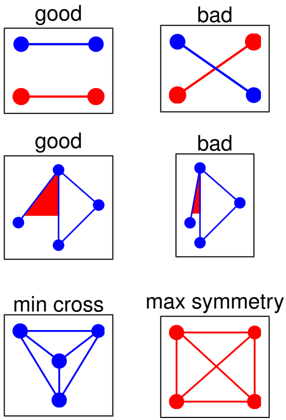
Graph Layout Criteria

- minimize
  - crossings, area, bends/curves
- maximize
  - angular resolution, symmetry
- most criteria NP-hard
  - edge crossings (Garey and Johnson 83)



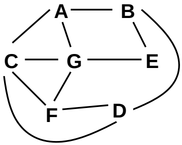
Graph Layout Criteria

- minimize
  - crossings, area, bends/curves
- maximize
  - angular resolution, symmetry
- most criteria NP-hard
  - edge crossings (Garey and Johnson 83)
- incompatible
  - (Brandenburg 88)



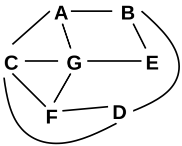
Layout

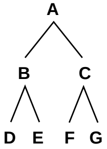
- problem
  - general problem is NP-hard



Layout

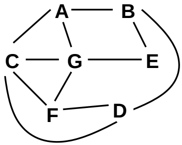
- problem
  - general problem is NP-hard
- solution
  - tractable spanning tree backbone
  - match mental model
    - quasi-hierarchical
  - use domain knowledge to construct
    - select parent from incoming links

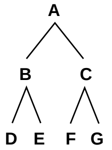


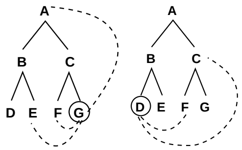


Layout

- problem
  - general problem is NP-hard
- solution
  - tractable spanning tree backbone
  - match mental model
    - quasi-hierarchical
  - use domain knowledge to construct
    - select parent from incoming links
  - non-tree links on demand



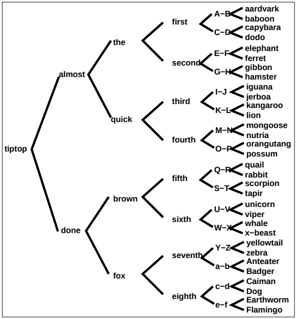




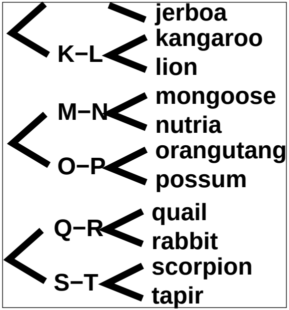
Avoiding Disorientation

- problem
  - maintain user orientation when showing detail
  - hard for big datasets
- exponential in depth
  - node count, space needed

global overview

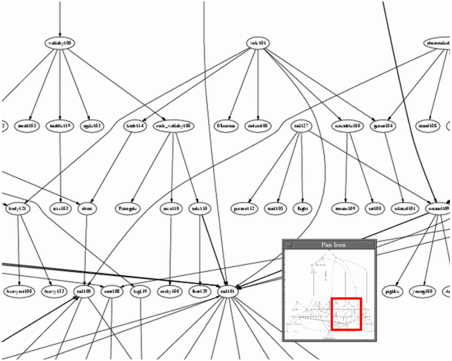


local detail



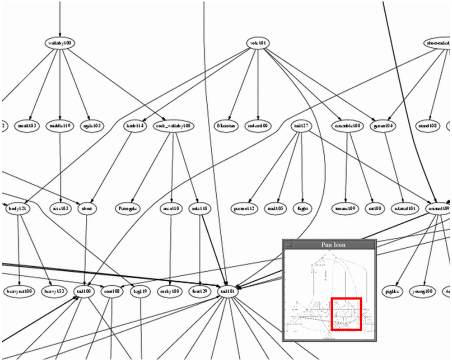
Overview and detail

- two windows: add linked overview
  - cognitive load to correlate



Overview and detail

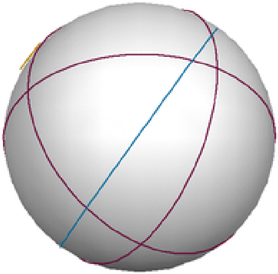
- two windows: add linked overview
  - cognitive load to correlate



- solution
  - merge overview, detail
  - focus+context

Noneuclidean Geometry

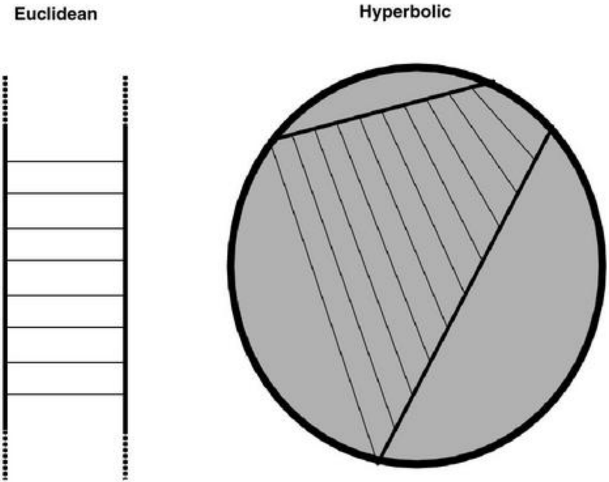
- Euclid's 5th Postulate
  - exactly 1 parallel line
- spherical
  - geodesic = great circle
  - no parallels
- hyperbolic
  - infinite parallels



(torus.math.uiuc.edu/jms/java/dragsphere)

Parallel vs. Equidistant

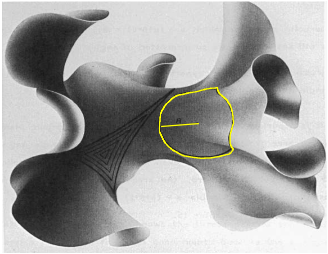
- euclidean: inseparable
- hyperbolic: different



Exponential Amount Of Room

room for exponential number of tree nodes

2D hyperbolic plane
embedded in 3D space



[Thurston and Weeks 84]

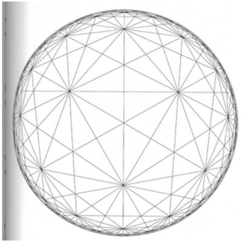
hemisphere area

hyperbolic: exponential
$2\pi \sinh^2 r$

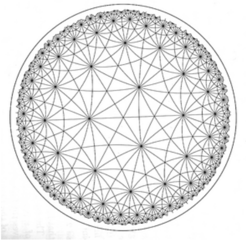
euclidean: polynomial
$2\pi r^2$

Models, 2D

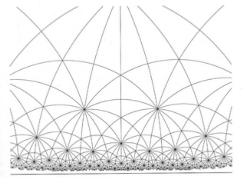
Klein/projective



Poincare/conformal

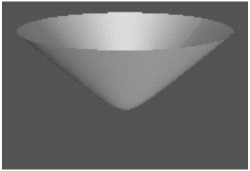


Upper Half Space



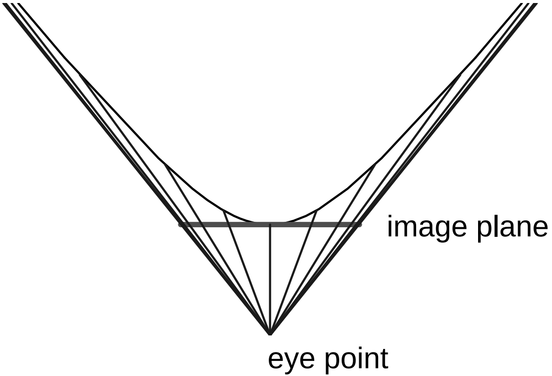
[Three Dimensional Geometry and Topology, William Thurston, Princeton University Press]

Minkowksi



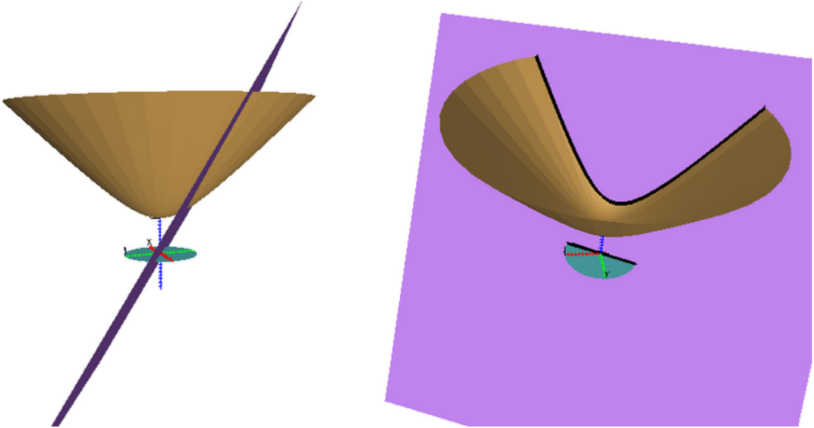
1D Klein

hyperbola projects to line



2D Klein

hyperbola projects to disk



(graphics.stanford.edu/papers/munzner_thesis/html/node8.html#hyp2Dfig)

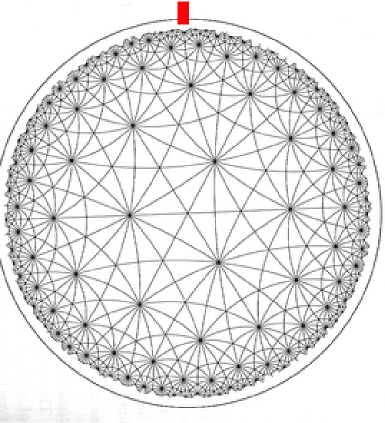
Klein vs Poincare

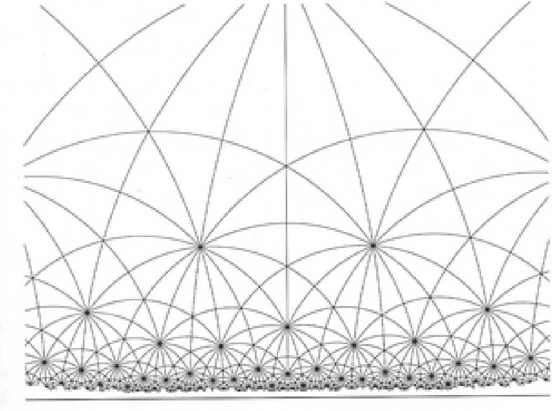
- Klein
  - straight lines stay straight
  - angles are distorted
- Poincare
  - angles are correct
  - straight lines curved

- graphics
  - Klein: 4x4 real matrix
  - Poincare: 2x2 complex matrix

Upper Half Space

- cut and unroll Poincare
  - one point on circle goes to infinity

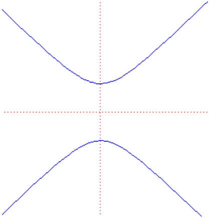




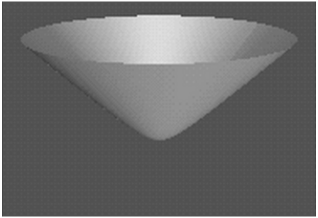
[demo: www.geom.umn.edu/˜crobles/hyperbolic/hypr/modl/uhp/uhpjava.html]

Minkowski

1D



2D



[www-gap.dcs.st-and.ac.uk/~history/Curves/Hyperbola.html]

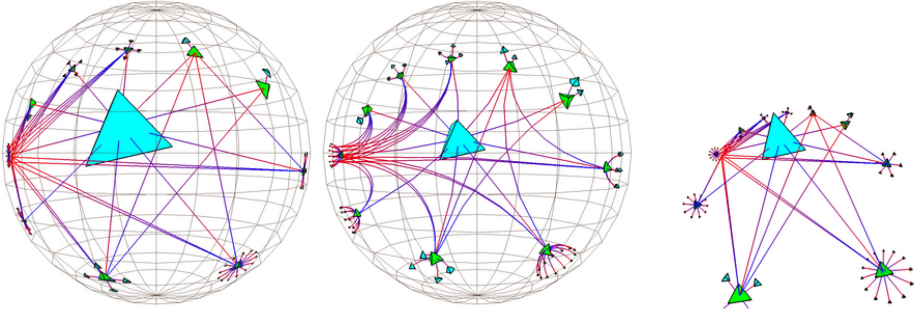
[www.geom.umn.edu/~crobles/hyperbolic/hypr/modl/mnkw/]

the hyperboloid itself embedded one dimension higher

Models, 3D

- 3-hyperbola projects to solid ball
  - Upper Half Space
  - Minkowski

Klein/projective Poincare/conformal insider

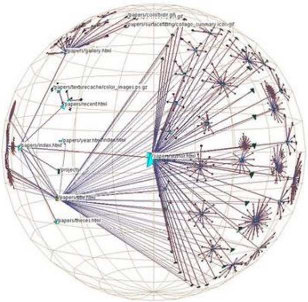


[graphics.stanford.edu/papers/webviz/]

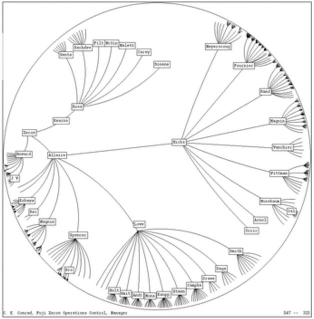
3D vs. 2D Hyperbolic Scalability

- information density: 10x better

H3



PARC Tree



	center	fringe
3D	**dozens**	**thousands**
2D	**dozens**	**hundreds**

Scalability

- success: large local neighborhood visible, 5-9 hops
- limit: if graph diameter >> visible area
  - TreeJuxtaposer: global vs. local F+C