Focus + Context

Lecture 12 CPSC 533C, Spring 2004
25 Feb 2003

Focus + Context

Leung and Apperly taxonomy

Nonlinear Magnification Fields

2D Hyperbolic Trees

3D Hyperbolic Graphs

TreeJuxtaposer

Intuition
move part of surface closer to eye

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

Bifocal

transformation magnification

transformation magnification

1D 2D

Perspective Wall

transformation magnification

transformation magnification

1D 2D

Polyfocal: Continuous Mag
**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 Functions**

- transformation
  - distortion
- magnification
  - derivative of transformation

- directionality
  - easy: compute transformation given magnification derivative
  - hard: compute magnification given 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**

- task
  - browsing large quasi–hierarchical graphs

Previous work: graph drawing

- scalability bottleneck
- layout
- avoiding disorientation

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 [Carey and Johnson 83]

- **incompatible**
  - [Brandenburg 88]

**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

**Avoiding disorientation**

- **problem**
  - maintain user orientation when showing detail
  - hard for big datasets

- exponential in depth: node count, space needed

**Overview and detail**

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

- **solution**
  - merge overview, detail
  - "focus+context"
Previous work: focus + context
fisheye views [Furnas 86], [Sarkar et al 94]

Previous work: focus + context
two-dimensional [Keahey 96]
nonlinear magnification [Keahey 96]
Hyperbolic space background

geometry with exponential "amount of room"
- good match for exponential node count of trees

2D hyperbolic plane
- hemisphere area
- hyperbolic: exponential
  \[ 2\pi \sinh^2(r) \]
- euclidean: polynomial
  \[ 2\pi r^2 \]

[Thurston and Weeks 84]

1D hyperbolic space
- hyperbola projects to line

2D hyperbolic space
- hyperboloid projects to disk

[1995 Lamping et al.]

3D hyperbolic space
- 3-hyperboloid projects to solid ball

webviz [Munzner and Burchard 95]
- straightforward cone tree + 3D hyperbolic space
- poor information density
Contribution: focus + context graphs

3D hyperbolic space
3-hyperboloid projects to solid ball
H3 layout
- circumference -> hemisphere

3D hyperbolic space
3-hyperboloid projects to solid ball
H3 layout
- bottom-up: allocate space for nodes
- top-down: place child on parent hemisphere

<table>
<thead>
<tr>
<th>Formula</th>
<th>Euclidean</th>
<th>Hyperbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>right-angle triangle</td>
<td>$\tan \theta = \frac{c}{b}$</td>
<td>$\tan \theta = \frac{\sinh(\theta)}{\cosh(\theta)}$</td>
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</tr>
<tr>
<td>circle area</td>
<td>$\pi r^2$</td>
<td>$2\pi \cosh(r) - 1$</td>
</tr>
<tr>
<td>hemisphere area</td>
<td>$2\pi r^2$</td>
<td>$2\pi \sinh(r)$</td>
</tr>
<tr>
<td>spherical cap area</td>
<td>$2\pi r^2(1 - \cos \phi)$</td>
<td>$2\pi \sinh^2(r(1 - \cos \phi))$</td>
</tr>
</tbody>
</table>

Progressive rendering
- want fast update during user interaction
  - fill in details when user is idle
- problem
  - dataset too big to draw in single frame
- solution
  - guaranteed frame rate algorithm
- progressive refinement
  - gradually improve image vs. standard Z-buffer
  - common in graphics [Bergman et al 86]
  - far less attention in infovis

H3Viewer algorithm
- drawing queue for nodes
- graph-theoretic
  - add parent, child nodes to queue
- view-dependent
  - sort queue by screen area

H3 video (excerpts)
**H3 results**

- scalability
  - performance
  - information density

**H3 results: scalability**

- performance
  - layout
    - 110K edges, 12 seconds (1997: SGI IR2)
    - 300K edges, 16 seconds (2002: Intel P3)
  - drawing
    - constant time: guaranteed frame rate
  - limited by main memory size

**H3 discussion: scalability**

- focus+context layout
  - success: large local neighborhood visible, 5–9 hops
  - cognitive limit: if graph diameter >> visible area

**TreeJuxtaposer**

- extend cognitive limit
  - move from local F+C to global F+C

**Noneuclidean geometry**

- Euclid's 5th Postulate
  - exactly 1 parallel line

- spherical
  - geodesic = great circle
  - no parallels

- hyperbolic
  - infinite parallels
Parallel vs. equidistant
- Euclidean: inseparable
- Hyperbolic: different

Exponential "amount of room"
- Good match for exponential node count of trees

2D hyperbolic plane embedded in 3D space
- Hemisphere area
- Hyperbolic: exponential
  \[ 2\pi \sinh^2(r) \]
- Euclidean: polynomial
  \[ 2\pi r^2 \]

Models, 2D
- Not just round!

Klein/projective
Poincare/conformal
Upper Half Space

Minkowski
- The hyperboloid itself embedded one dimension higher

1D Klein
- Hyperbola projects to line

2D Klein
- Hyperboloid projects to disk

[graphics.stanford.edu/papers/munzner_thesis/html/node8.html#fig]
[video: www.geom.uiuc.edu/~cises/htyper/hyper/lin/mkl/fig/fig]
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**Klein vs Poincare**

- stereographic projection
  - transparent sphere
  - plane at south pole
  - light at north pole
  
  [demo: torus.math.uiuc.edu/~jms/java/stereop/]

- transformation from Klein to Poincare
  - vertically project disc to hemisphere
  - stereographically project hemisphere to Poincare disc
  
  [video: www.geom.umn.edu/~crobles/hyperbolic/hypr/dbm/mkb/K2P.mpq]

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

**Models, 3D**

- Klein/projective
- Poincare/conformal
- "insider"

  [http://graphics.stanford.edu/papers/weitz/]

- Upper Half Space
- Minkowski

**3D Klein**

- 3-hyperboloid projects to solid ball

**Upper Half Space**

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

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

**3D Insider**

- insider: camera also moves by hyperbolic rules
  - cool, but limited visibility

  [demo]

**3D Minkowski**

- 3-hyperboloid embedded in 4D space
- light cone: special relativity
  - diagrams in 2D for clarity

- timelike: inside cone, speed < c
- lightlike: on cone, speed = c
- spacelike: outside cone, speed > c
- can't affect

  [appletree.mta.ca/courses/physics/4700/4700text/LightCone.html]