Conveying Shape: Lines

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CS 294-10: Visualization
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Final project

Design new visualization method
- Pose problem, Implement creative solution

Deliverables
- Implementation of solution
- 8-12 page paper in format of conference paper submission
- 2 design discussion presentations

Schedule
- Project proposal: 10/24
- Initial problem presentation: 10/24, 10/29 or 10/31
- Midpoint design discussion: 11/19, 11/21 or 11/26
- Poster Presentation: 12/10, Final Paper: 12/14

Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member
Conveying Structure: Exploded Views

Exploded views

Goal: Show overall structure

Direction
- Principal axes
- Sometimes zigzag to reduce occlusions

Distance
- Reduce / eliminate occlusions

Axonometric projection
- Reduces distortion

Guidelines
- When?
- Where?

Train [from Mijksenaar 99]
Principal Axes

Pivot hanger [French & Vierck 60]

Manual steering gear [from Ferguson 92]

Leonardo Da Vinci

Ratchet device
Radial exploded views

3D Distortion Viewing [Carpendale 97]

3D Explosion Probe [Sonnet 04]

Zigzag layout

Camping Stove [from Mijksenaar 99]
Occlusion and guidelines

Cutaways, sections, exploded view

Strange immersion of torus in 3-space
[Curris 92]
Sections and exploded view

IBM building plan [from Holmes 93]

Generating an Exploded View

1. Geometric analysis - Find downward facing ceiling polygons
2. Place sectioning planes below ceilings
3. Multi-pass render each story separately

[Niederauer 03]
Works with Existing 3D Applications

Quake III Arena by Id Software

Intercept and modify OpenGL stream
- Non-invasive [Mohr 01]
- Apply to existing OpenGL application without modification

[Niederauer 03]

Interactive exploded views

Interactive Image-Based Exploded View Diagrams [Li 04]
Authoring Pipeline

Segmentation
Stacking

Fragmentation and depth assignment
Annotation

Interactive viewing
Interactive deformation

Using deformation for browsing volume data [McGuffin 03]

Summary

Choosing important internal features is challenging
- Requires semantic knowledge
- Are there domain-independent principles?

Choosing good views
- Avoid accidental views
- Use canonical views if possible

Finding blockers – Visibility analysis

Transforming blockers
- Few basic choices (cull, move, transparency, modify drawing style)
Conveying Shape: Lines

Conveying shape

Lines
Shading

From Gooch²
Topics

Photographs vs. drawings
Types of lines
Lines of curvature
Silhouettes and contours
Graphical drawing conventions
Effects of drawing style

Photographs vs. Drawings
A photographic depiction captures the exact appearance of the object as we actually see it.

Subtle, complex details of coloration and texture are fully represented, with great accuracy.

Photograph of the right hip bone (lateral aspect).
Johannes W. Rohen and Chihiro Yokocchi.

A drawing offers the possibility to clarify structural or conceptual information that may be difficult to perceive in even a very good photo.

Color drawing of the same subject.

Photo vs. Drawing in Archaeology

Hand-drawn illustrations are routinely used to emphasize important features that are difficult to capture in a photograph, while minimizing secondary detail.

Drawings are also useful to portray information that cannot be captured or represented photographically, such as hidden surfaces.
Perception of the 3D configuration of familiar objects

Speed of imitation of position, in seconds (mean):
- 0.039 photo
- 0.044 shaded drawing
- 0.070 line drawing
- 0.046 cartoon


Perception of the 3D configuration of familiar objects

Speed of naming open switch, in seconds (mean)
- 0.690 photo
- 0.719 shaded drawing
- 1.169 line drawing
- 0.288 cartoon


Speed of stating stage of cycle, in seconds (mean):
- 0.235 photo
- 0.316 shaded drawing
- 0.375 line drawing
- 0.262 cartoon

Their conclusion

Superiority of performance (photo vs. drawing) varies with the application

Response times were consistently longest for the basic line drawing images
Study of picture preferences


Results

Surgeons rated the ‘schematic’ representation least preferable; the ‘semi-schematic’ and ‘realistic’ representations were preferred in equivalent numbers.
Types of Lines

Classic geometric line types

- Discontinuities
- Boundaries
- Silhouettes
Lines signify features

Geometric features
- Creases
- Boundaries
- Self-intersections
- Silhouettes
- Isoparametric lines
- Parabolic lines
- Principal directions of curvature

Lines in images

Photoshop “Find Edges …”
Causes of image discontinuities

Lines signify features

Material features
- Texture features
- Material boundaries

Lighting features
- Attached and unattached shadows
- Highlights and highlight boundaries
- Isoluminance contours
- Luminance extrema
How to create drawings?

Graphite and charcoal, Musée Picasso, Paris, France

Two big issues

Which lines to draw?

How to draw the lines?
Lines of Curvature

Normal curvature

Curvature applet: http://www.ies.co.jp/math/java(calc)/curve/curve.html
Space curve

Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination

Curvature of surfaces

Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination
Curvature of surfaces

Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination
Principal curvatures

Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination

Artistic inspiration

Russell Drake’s “single line system of shading”
- the flow of the shape is conveyed through the directions of the carefully drawn strokes

Lumbosacral and Sacro-iliac fusion.
Russell Drake, medical illustrator, Mayo Foundation, 1932.
Principal directions

Klein bottle
From Hertzmann and Zorin
Gaussian curvature

\( K_1 = \) curvature in first principal direction
\( K_2 = \) curvature in second principal direction
Gaussian curvature: \( K = K_1 \cdot K_2 \)
Mean curvature: \( H = (K_1 + K_2) / 2 \)

\( K > 0 \) : elliptic, convex or concave
\( K < 0 \) : hyperbolic, saddle-shaped
\( K = 0 \) : parabolic, cylindrical or planar
Parabolic lines

Felix Klein: Apollo

Silhouettes and Contours
Occluding contour

From Koenderink, Solid Shape

Occluding contour

[from DeCarlo et al. 03]
Definitions [Koenderink 84]

Rim – the closed space curve on the shape that makes up the silhouette; the space curve is smooth and has no discontinuities except when the surface is discontinuous; the rim is not a plane curve!

Contour – the projection of the rim; the projection may have singularities

Silhouette – the visible part of the contour

Suggestive contours

DeCarlo, Finkelstein, Rusinkiewicz, Santella, Suggestive contours for conveying shape, SIGGRAPH 2003
Suggestive contours - DEMO

DeCarlo, Finkelstein, Rusinkiewicz, Santella, Suggestive contours for conveying shape, SIGGRAPH 2003