Conveying Shape: Lines

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CS 294-10: Visualization
Fall 2008

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: 10/27
- Initial problem presentation: 10/27, 10/29 or 11/3
- Midpoint design discussion: 11/19, 11/24 or 11/26
- Final paper and presentation: 12/10

Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member
Conveying shape

Lines
Shading

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.


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

Photo vs. drawing

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

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


Perception of the 3D configuration of familiar objects

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

<table>
<thead>
<tr>
<th></th>
<th>Patent Ductus Arteriosus</th>
<th>Wedge Resection</th>
<th>Esophageal Fundoplication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realistic</td>
<td></td>
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</table>

Study of picture preferences

Semi-Schematic

Patent Ductus Arteriosus  Wedge Resection  Esophageal Fundoplication


Study of picture preferences

Schematic

Patent Ductus Arteriosus  Wedge Resection  Esophageal Fundoplication

Results

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

Types of Lines
Lines signify features

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

Classic geometric line types

- Isoparametric
- Discontinuities
- Boundaries
- Silhouettes
Lines in images

Photoshop “Find Edges …”

Causes of image discontinuities

From Dan Kersten
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](http://www.ies.co.jp/math/java/calc/curve/curve.html)

Space curve
Curvature of surfaces

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

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**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

\[ K_1 = \text{curvature in first principal direction} \]
\[ K_2 = \text{curvature in second principal direction} \]

Gaussian curvature: \( K = K_1 K_2 \)
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
Gaussian curvature

Parabolic lines

Felix Klein: Apollo
Silhouettes and Contours

Occluding contour

From Koenderink, Solid Shape
Occluding contour

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
Graphical Drawing Conventions

Drawing parameters

- Haloed lines
- Taper near t-junction
- Control of line weight
- Highlighting
- Eye-lashing
- Sketchiness
Illustration rules (Dooley & Cohen)

Importance
- Low
- Medium
- High

Types
- Boundaries
- Creases
- Silhouettes
- Isoparametric

Line weight

Single weight  Two weights  Distance weighting

From Martin (reproduced in Gooch and Gooch)
Highlighting

Fig. 12-1  Line contrast shading.
Effects of Drawing Style

Assessing the effect of non-photorealistic rendered images in CAD, Schumann, Strothotte, Raab, Laser, CHI 96
Comparison: Sketch

Draft vs. presentation

Figure 15.24: The use of sketches, CAD plots, and shaded images for the presentation of a first draft versus the final presentation (Schumans et al. 1996)
Affect vs. cognition

**Summary**

Illustrations often better than photographs

- Enhance important features
- Deemphasize unimportant detail

Grand challenge

- Produce a good line drawing
- What lines, not just how to draw lines