Conveying Shape: Lines

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CS 294-10: Visualization
Spring 2010

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: 3/29
- Initial problem presentation: 3/31 (Wed)
- Midpoint design discussion: TBD
- Final paper and presentation: TBD

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

Authoring Pipeline

Interactive deformation

Using deformation for browsing volume data [McGuin 03]
Conveying shape

Lines
Shading

From Gooch

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.

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


Study of picture preferences


Their conclusion

Superiority of performance (photo vs. drawing) varies with the application.
Response times were consistently longest for the basic line drawing images.

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


Fig. 2: Four Representations of the Switches in Position 1

Fig. 3: Four Representations of the Steam Valves in Position 1
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

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

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: $H = (K_1 + K_2) / 2$

$K > 0 : \text{elliptic, convex or concave}$
$K < 0 : \text{hyperbolic, saddle-shaped}$
$K = 0 : \text{parabolic, cylindrical or planar}$
Gaussian curvature

Parabolic lines

Felix Klein: Apollo

Silhouettes and Contours

Occluding contour

From Koenderink, Solid Shape
Occluding contour

Definitions

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

Suggestive contours - DEMO
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
Effects of Drawing Style

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

Comparison: CAD

Comparison: Shaded
Comparison: Sketch

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