Conveying Shape: Lines

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CS 294-10: Visualization
Fall 2013

Last Time: Text Layout
Document x Term matrix

Each document is a vector of term weights
Simplest weighting is to just count occurrences

<table>
<thead>
<tr>
<th></th>
<th>Antony and Cleopatra</th>
<th>Julius Caesar</th>
<th>The Tempest</th>
<th>Hamlet</th>
<th>Othello</th>
<th>Macbeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antony</td>
<td>157</td>
<td>73</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Brutus</td>
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<td>157</td>
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<td>1</td>
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<td>0</td>
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<tr>
<td>Caesar</td>
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<td>227</td>
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<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Calpurnia</td>
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<td>10</td>
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</tr>
<tr>
<td>Cleopatra</td>
<td>57</td>
<td>0</td>
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<td>0</td>
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<td>mercy</td>
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<td>0</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
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<tr>
<td>worser</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Keyword Weighting

Term Frequency
\[ tf_{td} = \text{count}(t) \text{ in } d \]

TF.IDF: Term Freq by Inverse Document Freq
\[ tf.idf_{td} = \log(1 + tf_{td}) \times \log(N/df_t) \]
\[ df_t = \# \text{ docs containing } t; \ N = \# \text{ of docs} \]
Recurrent themes in speech

The Bible
X begat Y

“Today, I have a dream that one day...”
Takeaways

Show (or provide access to) source text
Let readers assess model
Let readers use visualization as index into documents

Find meaningful abstractions for grouping docs
Are clusters interpretable?

Where possible use text to represent text... but which terms are the most descriptive?

Announcements
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
- 1 or 2 design discussion presentations

Schedule
- Project proposal: 10/28
- Project presentation: 11/13, 11/18 and 11/20
- Final paper and presentation: ?? 12/12 (3-5pm) ??

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

Conveying Shape
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. Rohde and Chihiro Yokochi.

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


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

Study of picture preferences


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
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

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

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

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.

V. Interrante

Surface grid texture (aligned with the principal directions)

Solid grid texture (aligned with the coordinate axes)
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

[from Koenderink 84]
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: CAD

Comparison: Shaded
Comparison: Sketch

Draft vs. presentation

Figure 15.26: The use of sketches, CAD plots, and shaded images for the presentation of a first draft versus the presentation in a final presentation (Schumam 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

Figure 15.27: Mean values of the assessment of the effect of the media (CAD users) (Schumann et al., 1996). The symbol * denotes the items in which sketches differ significantly (p<0.05) from CAD plots and the shaded images, while # denotes the items in which CAD plots differ significantly (p<0.05) from sketches and shaded images.