Conveying Shape: Lines

Maneesh Agrawala

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

	Antony and Cleopatra	Julius Caesar	The Tempest	Hamlet	Othello	Macbeth
Antony	157	73	0	0	0	0
Brutus	4	157	0	1	0	0
Caesar	232	227	0	2	1	1
Calpurnia	0	10	0	0	0	0
Cleopatra	57	0	0	0	0	0
mercy	2	0	3	5	5	1
worser	2	0	1	1	1	0

Keyword Weighting

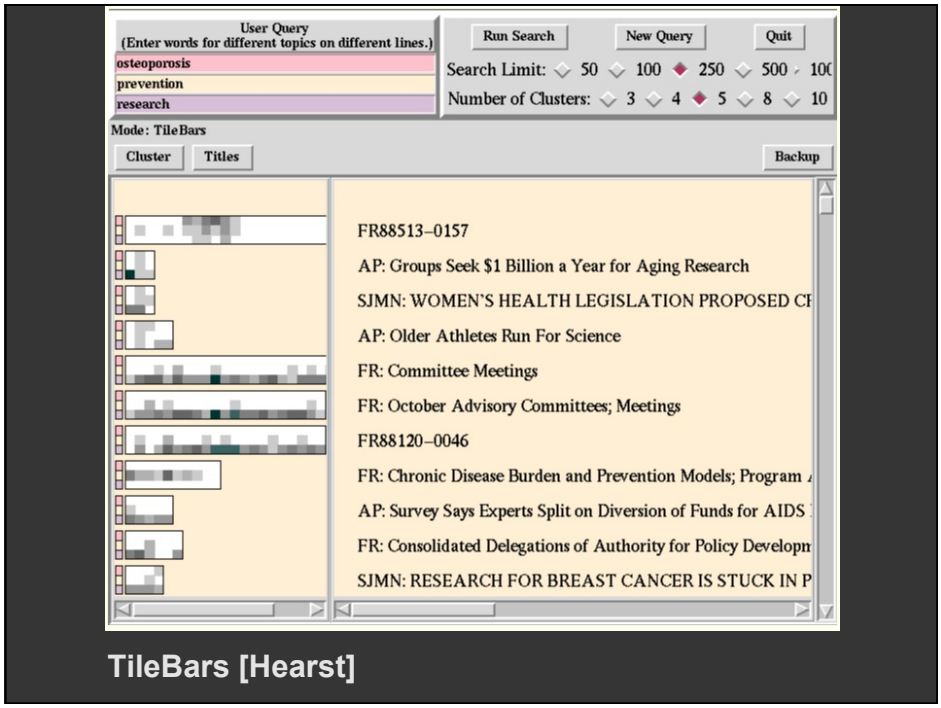
Term Frequency

tf_{td} = count(t) in d

TF.IDF: Term Freq by Inverse Document Freq

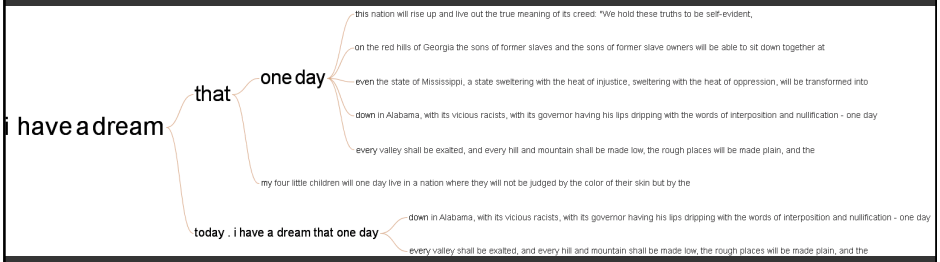
$tf.idf_{td} = \log(1 + tf_{td}) \times \log(N/df_t)$

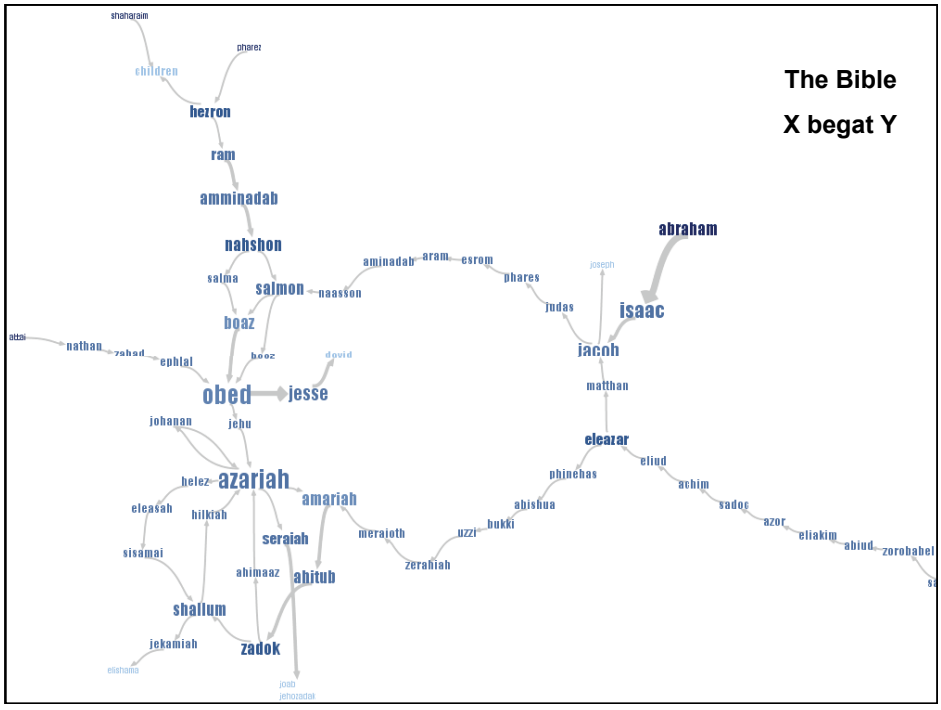
df_t = # docs containing t; N = # of docs



TileBars [Hearst]

Recurrent themes in speech





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) ??

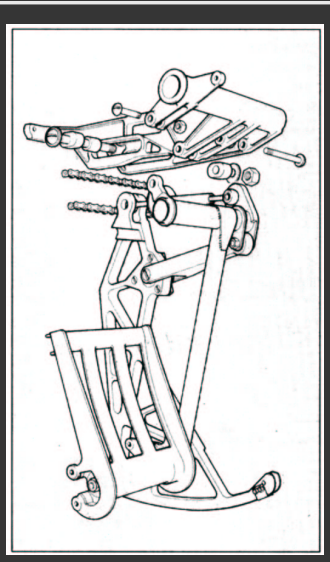
Grading

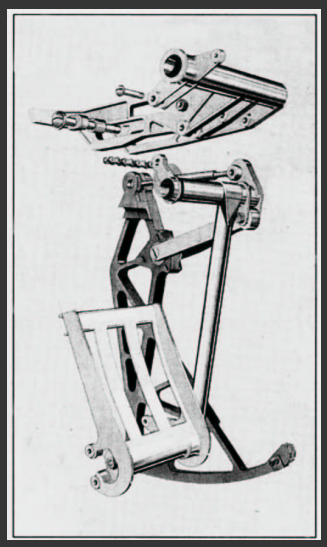
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Conveying Shape

Conveying shape

Lines
Shading



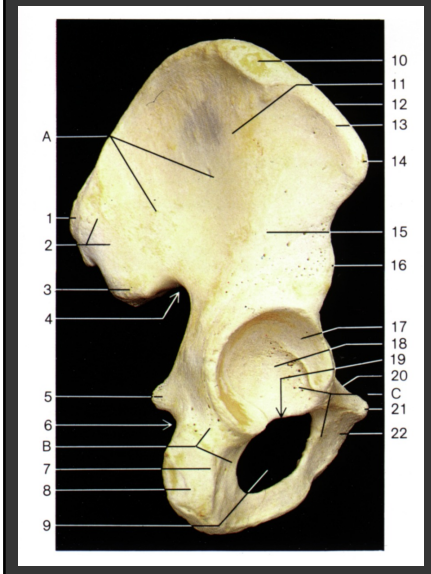


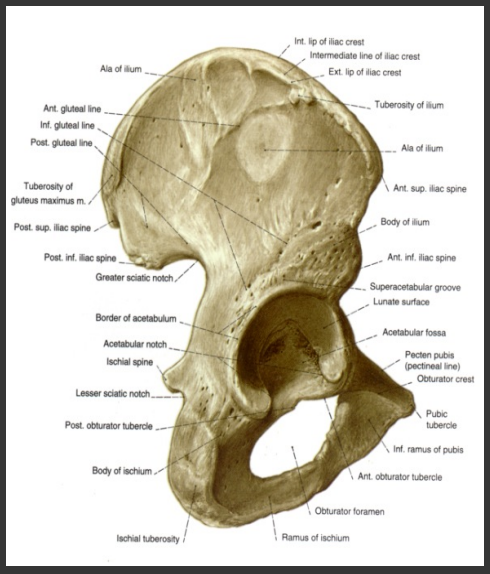
From Gooch[2]

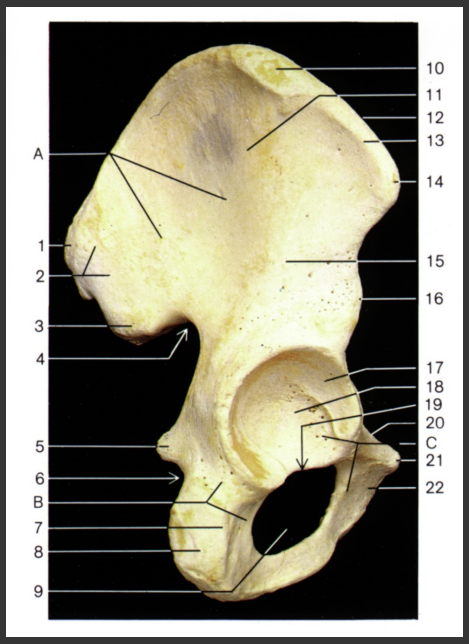
Topics

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

Photographs vs. Drawings



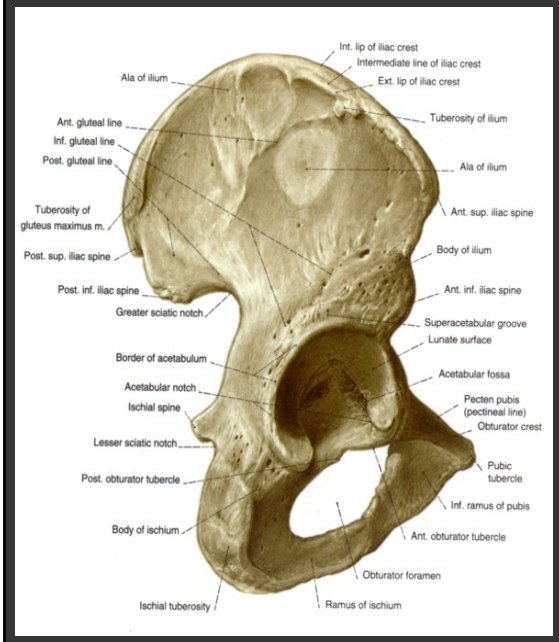




A photographic depiction captures the exact appearance of the object as we actually see it

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 Yokochi.
Color Atlas of Anatomy:
A Photographic Study of the Human Body,
Igaku-Shoin, 1993.



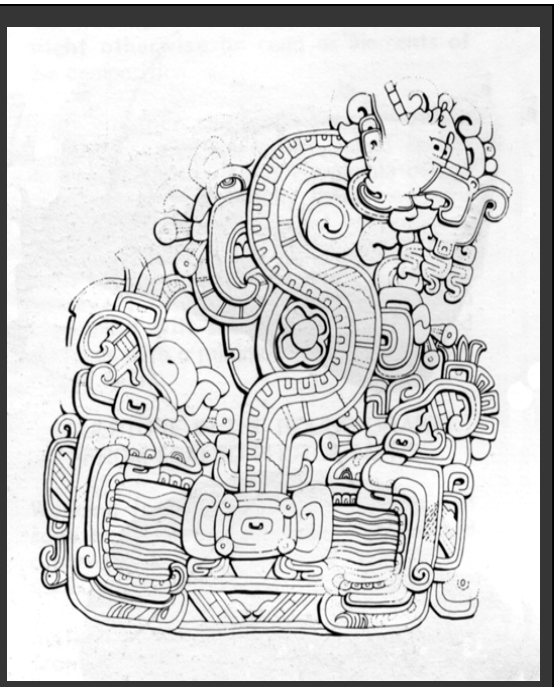
A drawing offers the possibility to clarify structural or conceptual information that may be difficult to perceive in even a very good photo.

Color drawing of the same subject.
Sobotta Atlas of Human Anatomy, 11th English edition, vol. 2, edited by Jochen Staubesand, translated and edited by Anna N. Taylor,
Urban & Schwarzenberg, 1990.

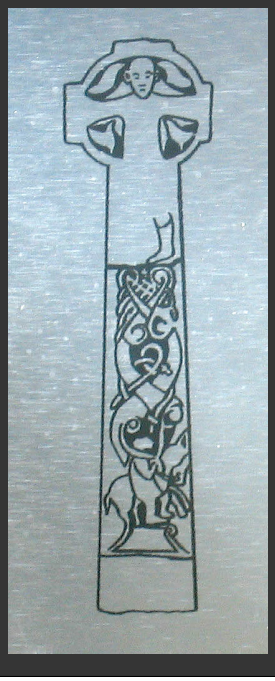
Photo vs. Drawing in Archaeology

James B. Porter. "Relief Monuments", in The Student's Guide to Archaeological Illustrating. Brian D. Dillon, ed., Institute of Archaeology, University of California, Los Angeles, 1981

Photo vs. Drawing in Archaeology



James B. Porter. "Relief Monuments", in The Student's Guide to Archaeological Illustrating. Brian D. Dillon, ed., Institute of Archaeology, University of California, Los Angeles, 1981



Doorty Cross,
Kilfenora Cathedral
12th Century

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

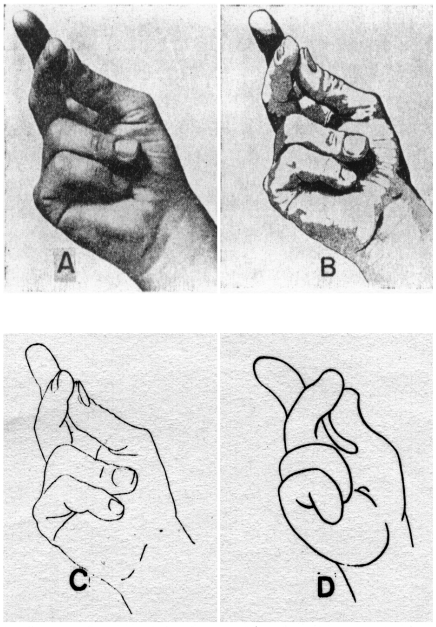


FIG. 1. FOUR REPRESENTATIONS OF THE HANDS IN POSITION 1
(A) Photograph; (B) Shaded Drawing; (C) Line Drawing; (D) Cartoon

T. A. Ryan and Carol B. Schwartz, "Speed of Perception as a Function of Mode of Representation", American Journal of Psychology, 69, pp. 60-69, 1956.

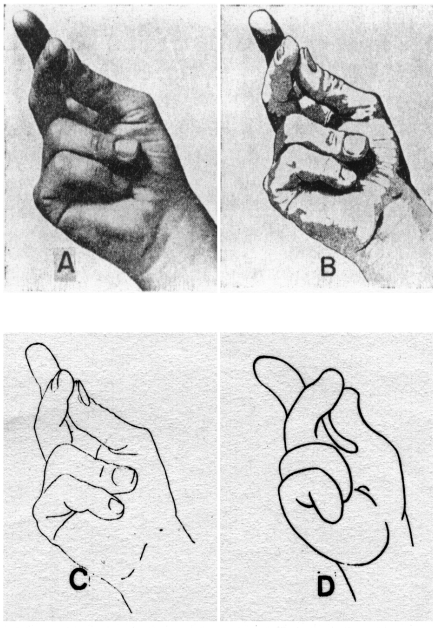


FIG. 1. FOUR REPRESENTATIONS OF THE HANDS IN POSITION 1
(A) Photograph; (B) Shaded Drawing; (C) Line Drawing; (D) Cartoon

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

T. A. Ryan and Carol B. Schwartz, "Speed of Perception as a Function of Mode of Representation", American Journal of Psychology, 69, pp. 60-69, 1956.

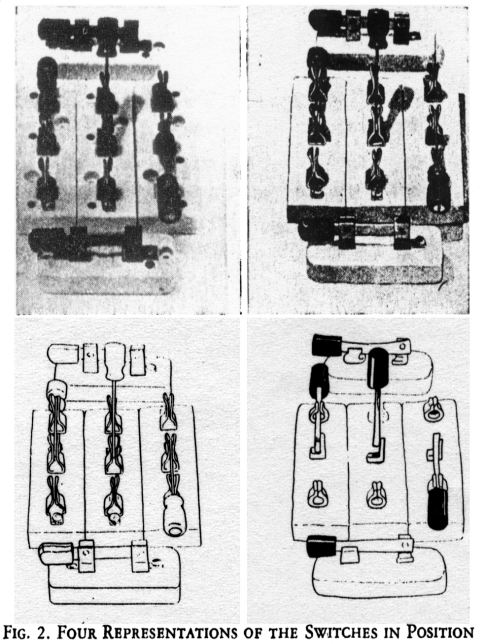


FIG. 2. FOUR REPRESENTATIONS OF THE SWITCHES IN POSITION 1

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

T. A. Ryan and Carol B. Schwartz, "Speed of Perception as a Function of Mode of Representation", American Journal of Psychology, 69, pp. 60-69, 1956.

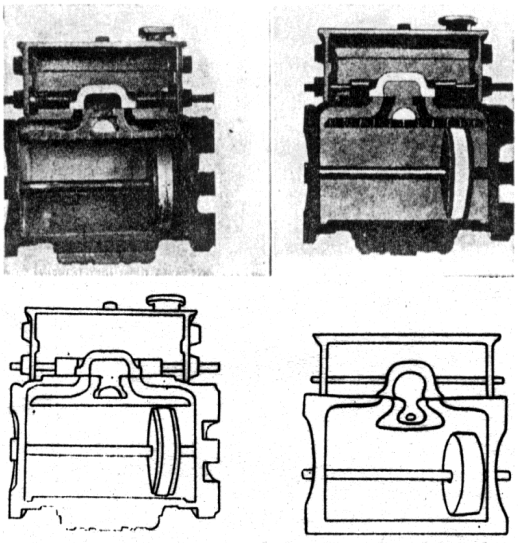


FIG. 3. FOUR REPRESENTATIONS OF THE STEAM VALVES IN POSITION 1

Speed of stating stage of cycle, in seconds (mean):

- 0.235 photo
- 0.316 shaded drawing
- 0.375 line drawing
- 0.262 cartoon

T. A. Ryan and Carol B. Schwartz, "Speed of Perception as a Function of Mode of Representation", American Journal of Psychology, 69, pp. 60-69, 1956.

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

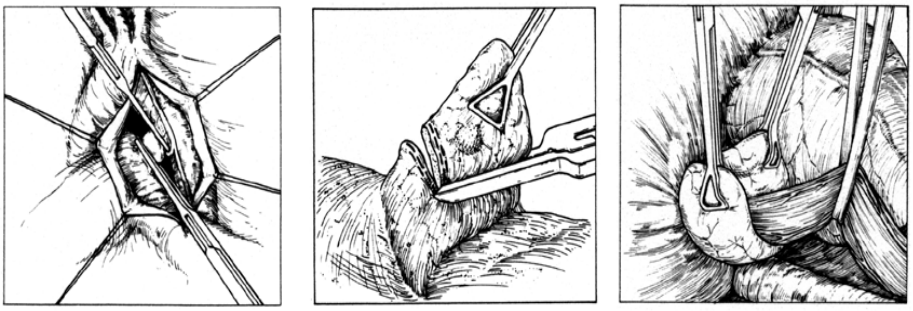
Realistic

Patent Ductus Arteriosus | Wedge Resection | Esophageal Fundoplication

K. Hirsch and D. A. McConathy, "Picture Preferences of Thoracic Surgeons", Journal of BioCommunications, Winter 1986, pp. 26-30.

Study of picture preferences

Semi-Schematic

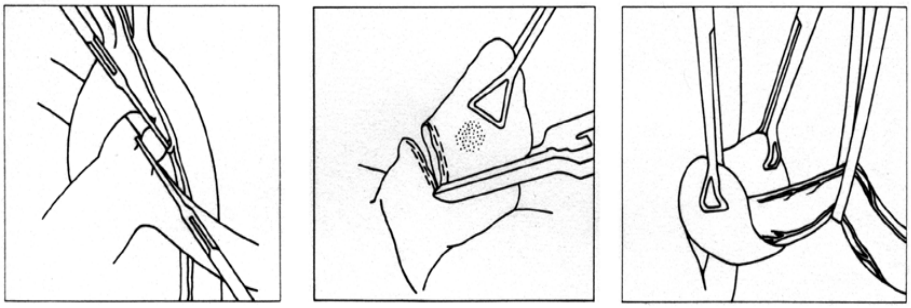


Patent Ductus Arteriosus | Wedge Resection | Esophageal Fundoplication

K. Hirsch and D. A. McConathy, "Picture Preferences of Thoracic Surgeons", Journal of BioCommunications, Winter 1986, pp. 26-30.

Study of picture preferences

Schematic



Patent Ductus Arteriosus | Wedge Resection | Esophageal Fundoplication

K. Hirsch and D. A. McConathy, "Picture Preferences of Thoracic Surgeons", Journal of BioCommunications, Winter 1986, pp. 26-30.

Results

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

Types of Lines

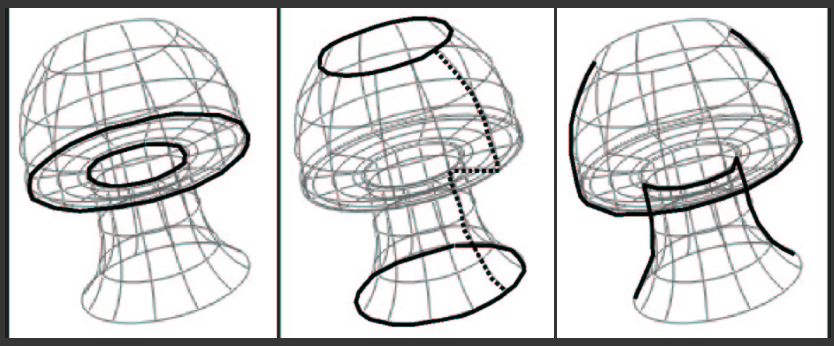
Lines signify features

Geometric features

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

Classic geometric line types

Isoparametric

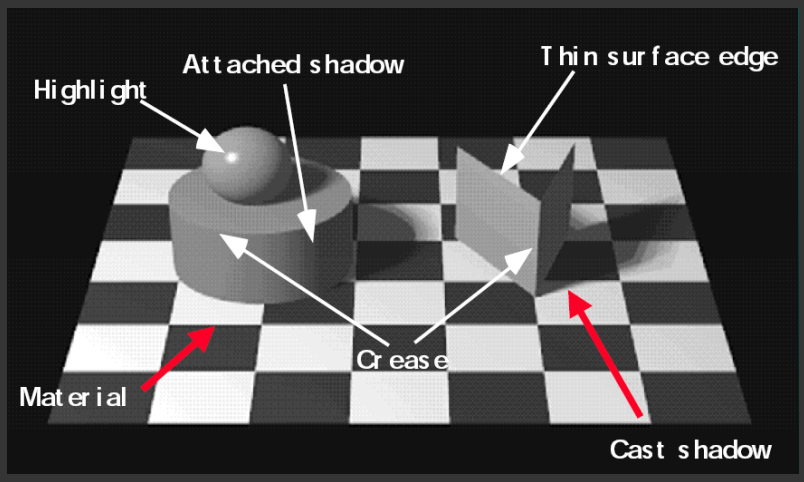


Discontinuities Boundaries Silhouettes

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?

Picasso, Portrait of Igor Stravinsky, 1920.

Graphite and charcoal, Musée Picasso, Paris, France

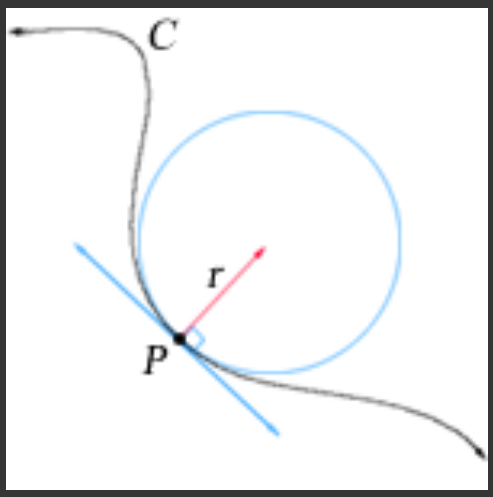
Two big issues

Which lines to draw?

How to draw the lines?

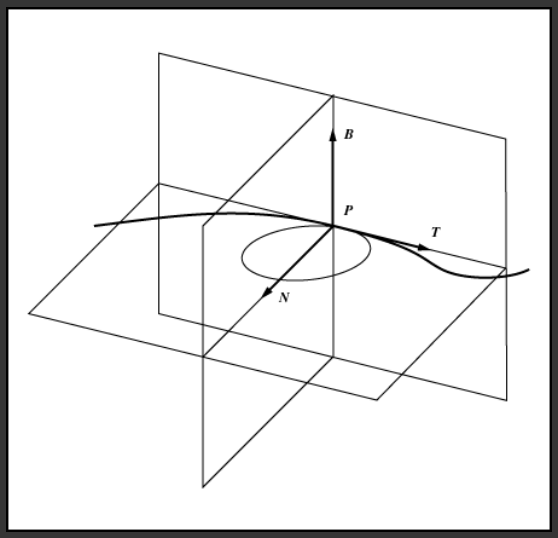
Lines of Curvature

Normal curvature

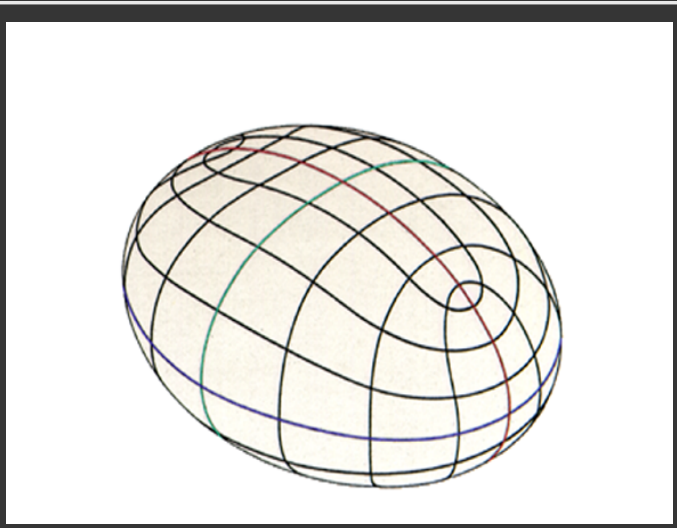


Curvature applet: http://www.ies.co.jp/math/java/calc/curve/curve.html

Space curve

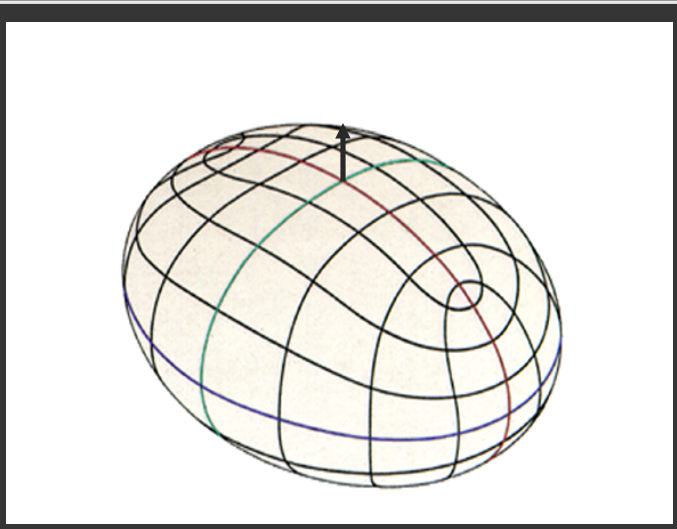


Curvature of surfaces



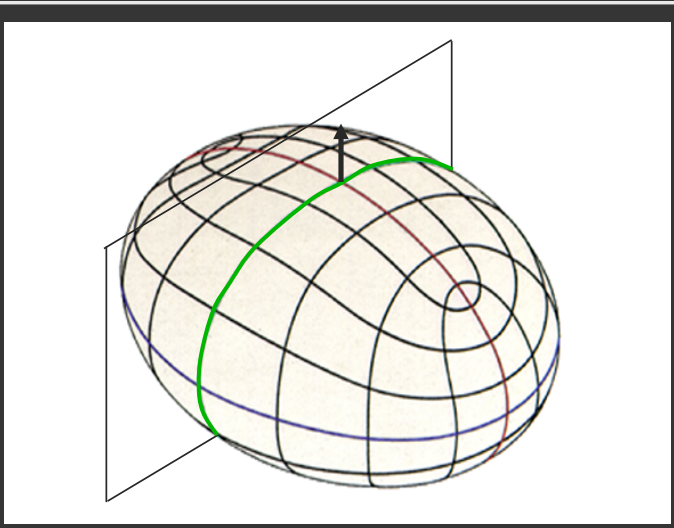
Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination

Curvature of surfaces



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

Curvature of surfaces



Hilbert and Cohn-Vossen [1952]
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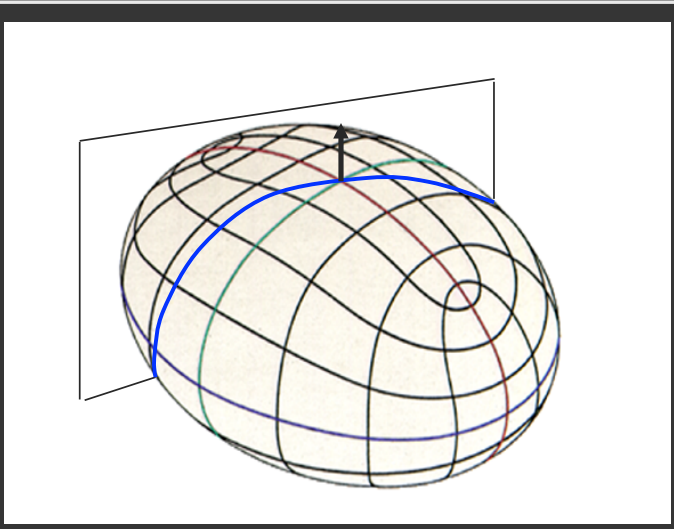

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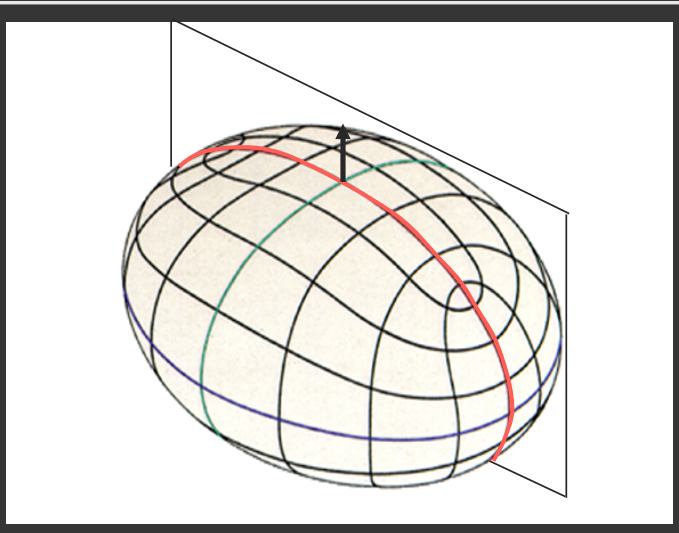
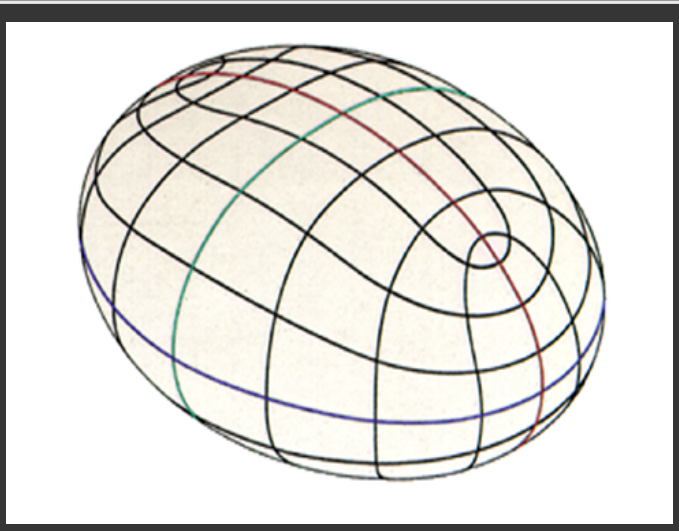
Curvature of surfaces

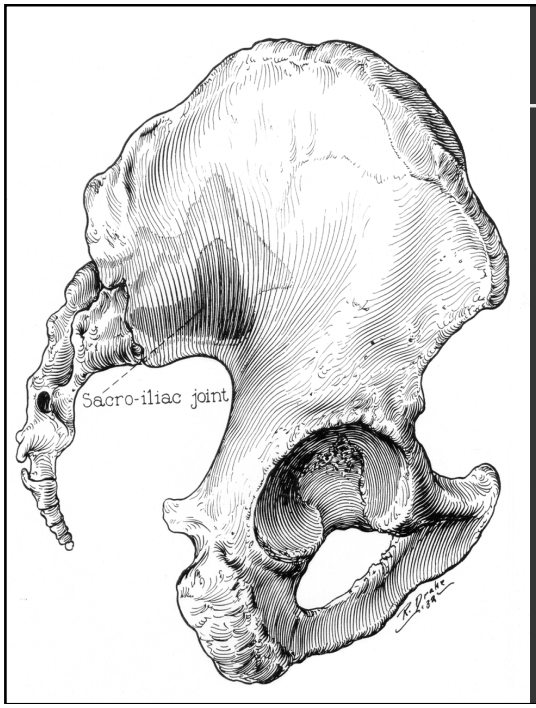


Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination

Principal curvatures



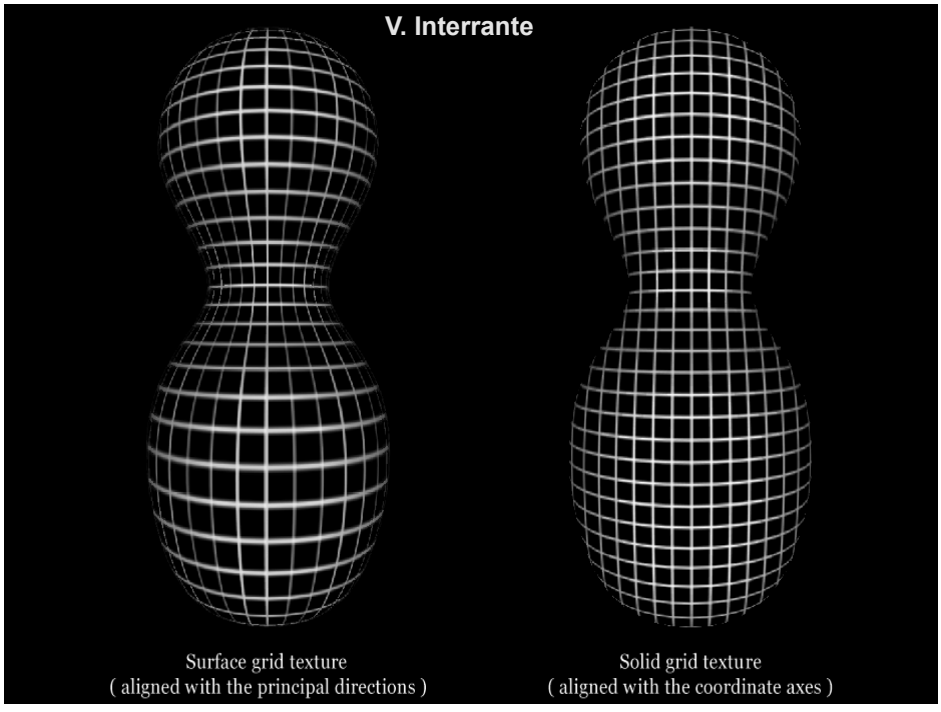
Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination



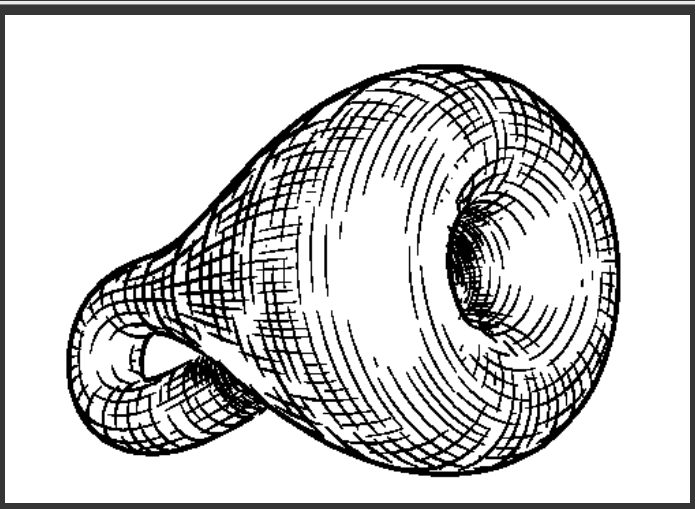
Artistic inspiration

- **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: $K = K_1 K_2$

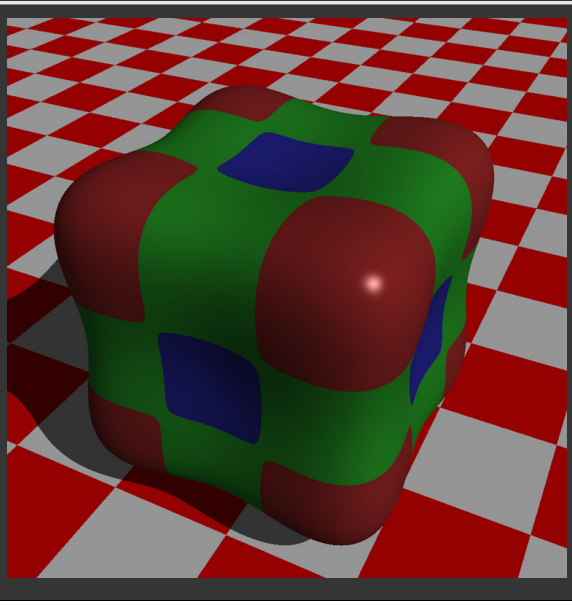
Mean curvature: $H = (K_1 + K_2) / 2$

$K > 0$: elliptic, convex or concave

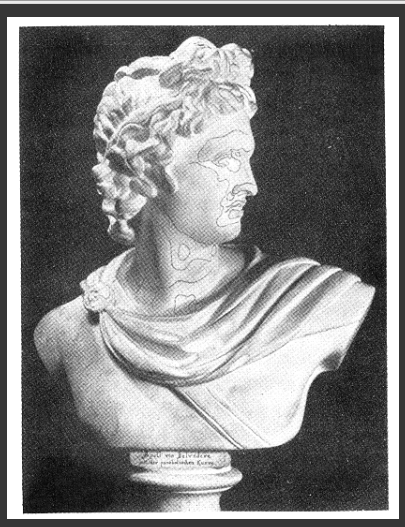
$K < 0$: hyperbolic, saddle-shaped

$K = 0$: parabolic, cylindrical or planar

Gaussian curvature



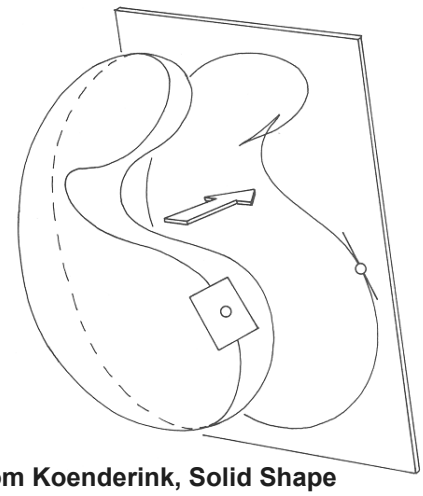
Parabolic lines



Felix Klein: Apollo

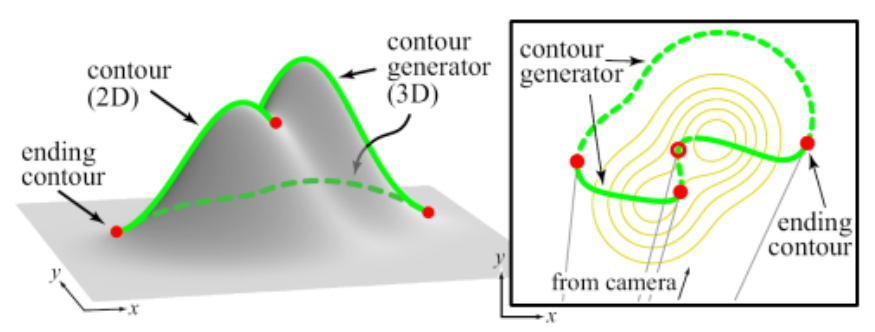
Silhouettes and Contours

Occluding contour



From Koenderink, Solid Shape

Occluding contour



[from DeCarlo et al. 03]

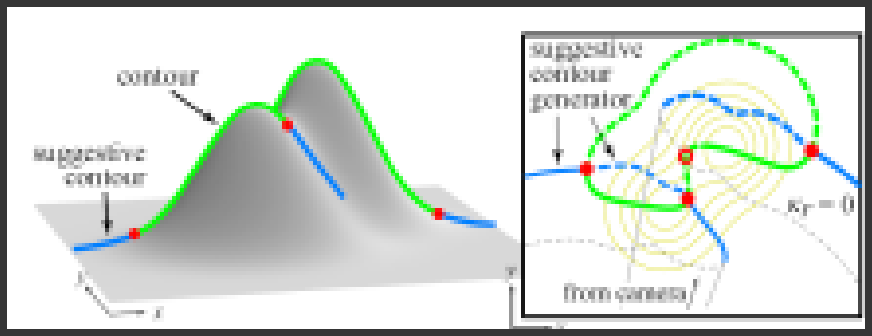
Definitions [Koenderink 84]

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

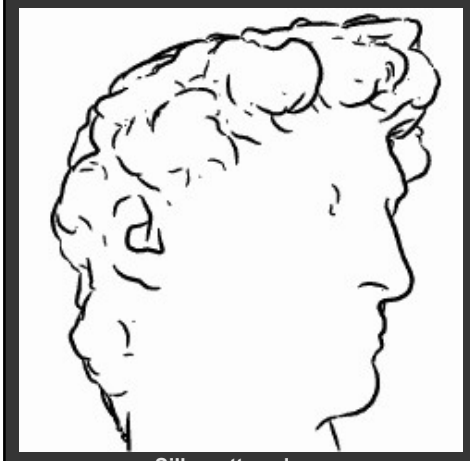
Silhouette – the visible part of the contour

Suggestive contours



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

Suggestive contours - DEMO



Silhouettes alone

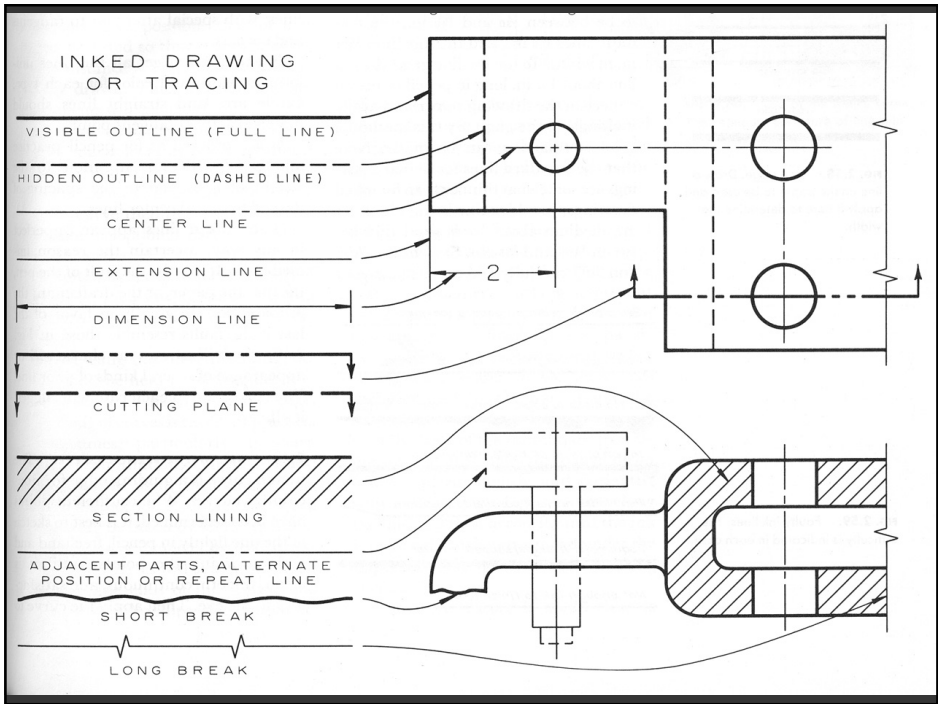
Silhouettes + suggestive contours

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


INKED DRAWING
OR TRACING
VISIBLE OUTLINE (FULL LINE)
HIDDEN OUTLINE (DASHED LINE)
CENTER LINE
EXTENSION LINE
DIMENSION LINE
CUTTING PLANE
SECTION LINING
ADJACENT PARTS, ALTERNATE
POSITION OR REPEAT LINE
SHORT BREAK
LONG BREAK
2

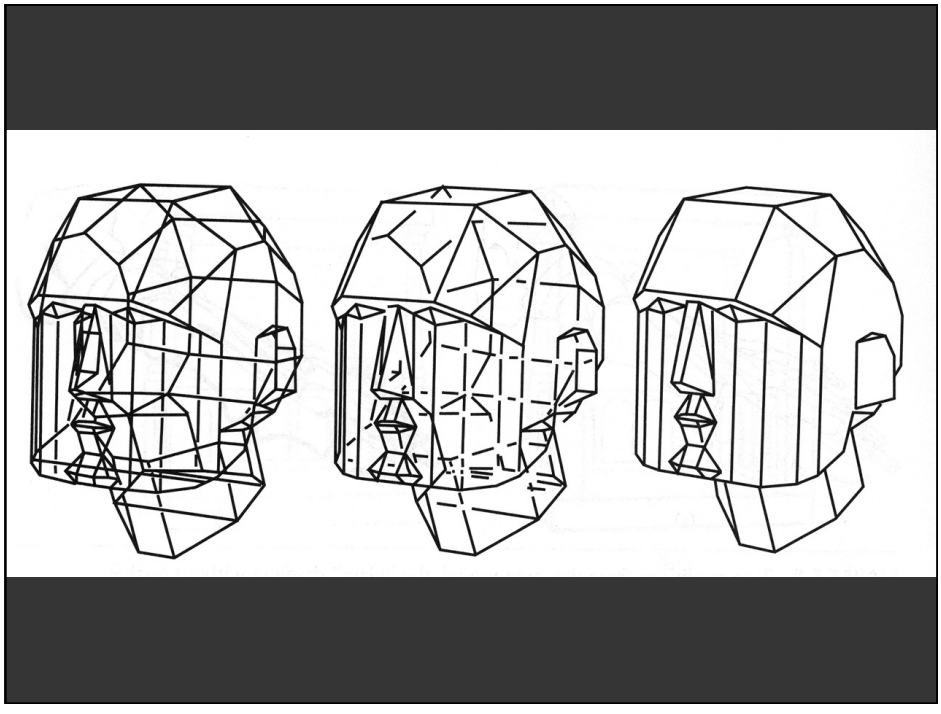
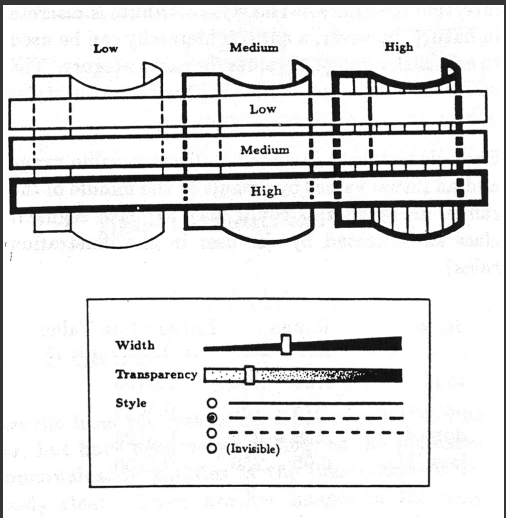


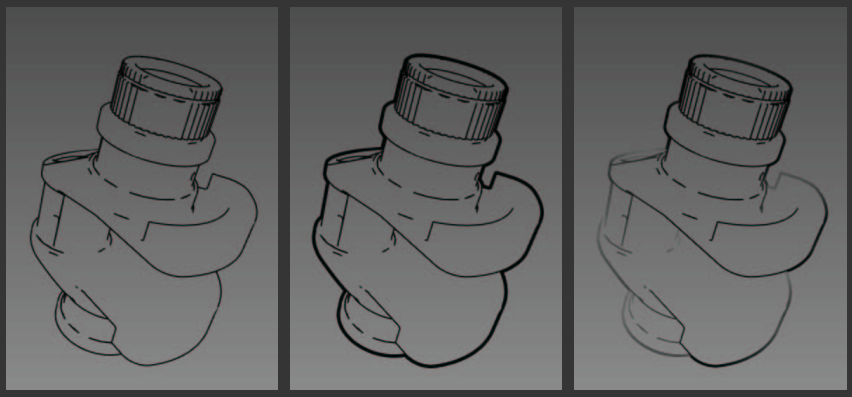
Illustration rules (Dooley & Cohen)



Importance
- Low
- Medium
- High

Types
- Boundaries
- Creases
- Silhouettes
- Isoparametric

Line weight



Single weight | Two weights | Distance weighting

From Martin (reproduced in Gooch and Gooch)

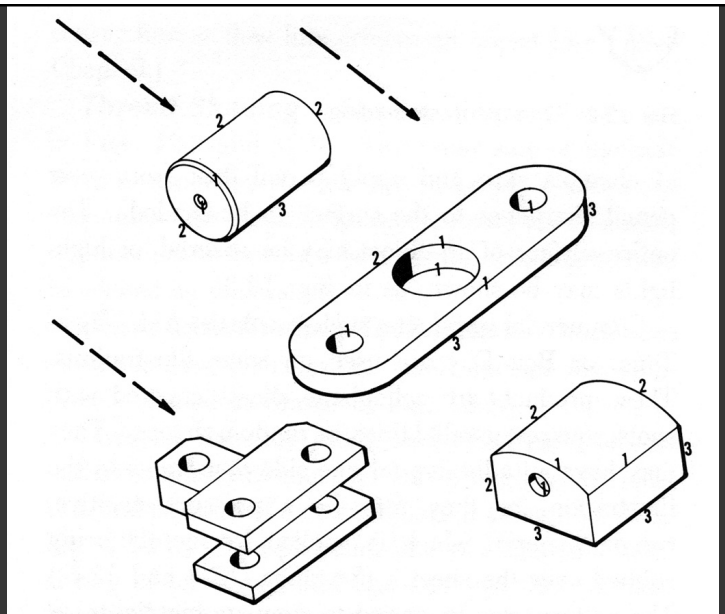
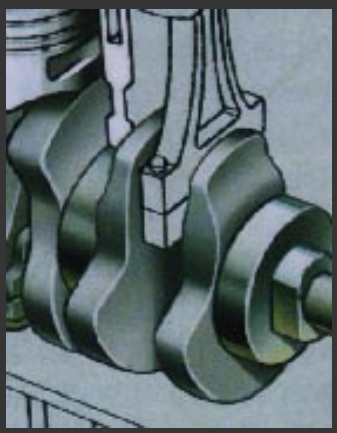
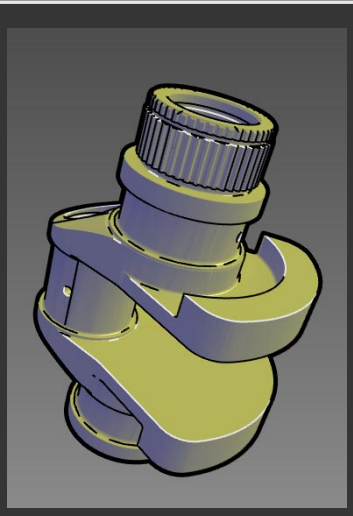
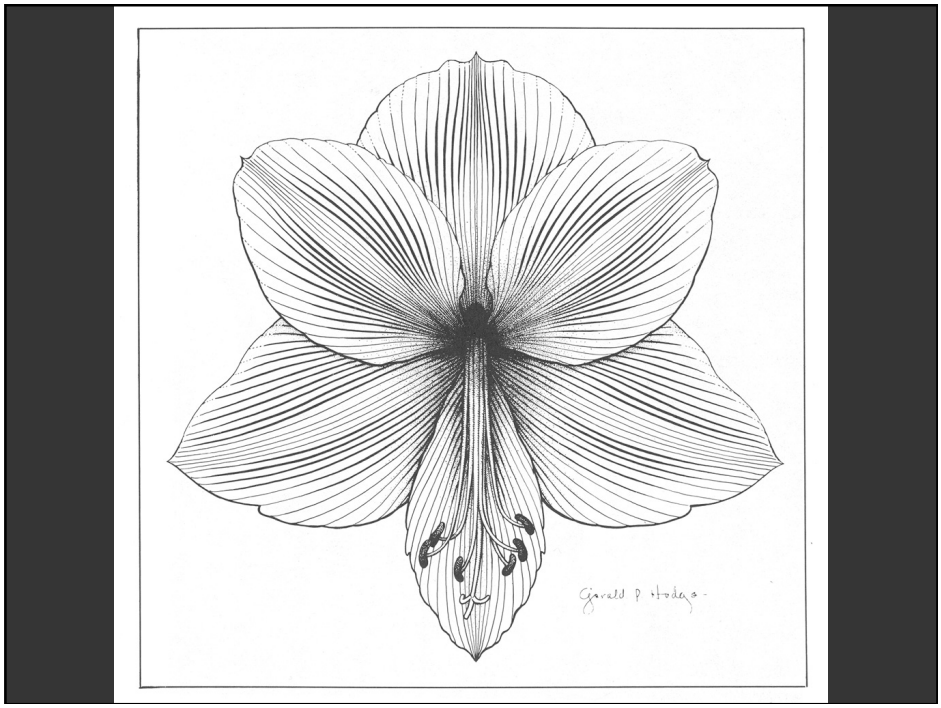


Fig. 12-1 Line contrast shading.

Highlighting



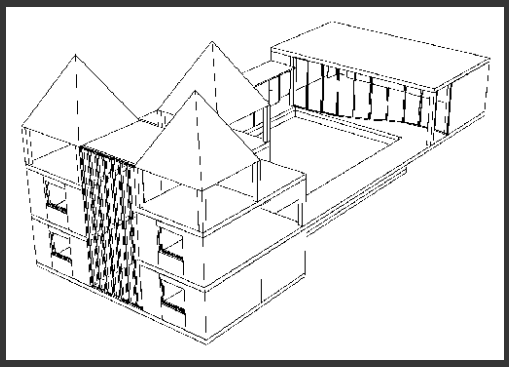




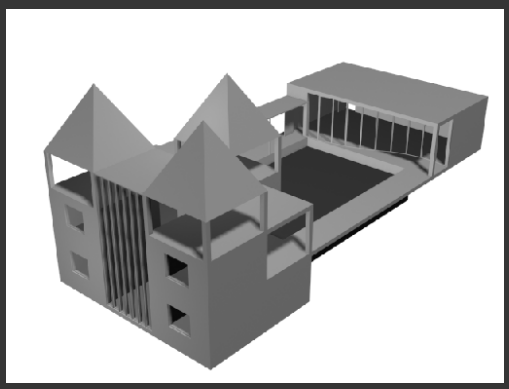
Effects of Drawing Style

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

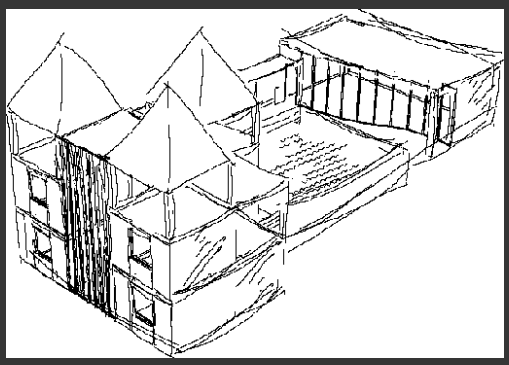
Comparison: CAD



Comparison: Shaded



Comparison: Sketch



Draft vs. presentation

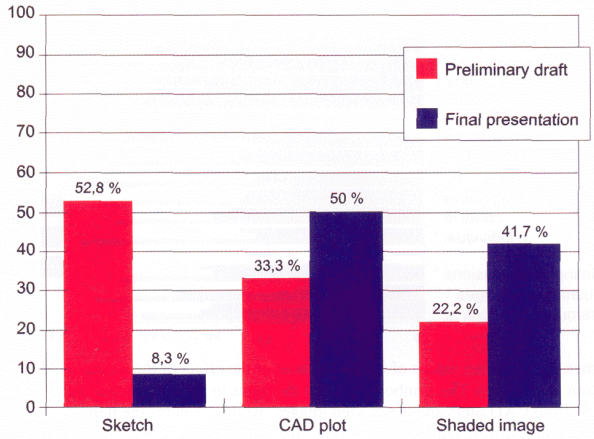


Figure 15.26: The use of sketches, CAD plots, and shaded images for the presentation of a first draft versus the presentation in a final presentation (Schumann et al. 1996)

Affect vs. cognition

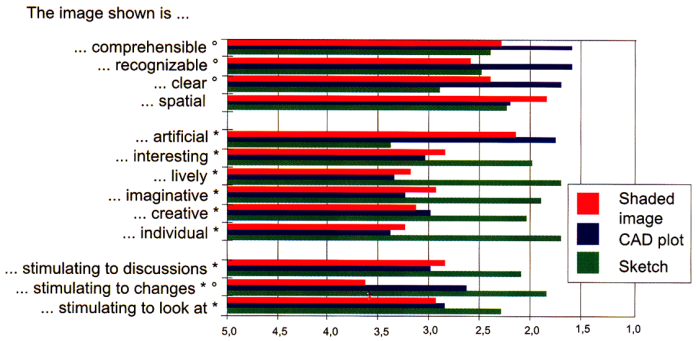


Figure 15.27: Mean values of the assessment of the effect of the media (CAD users) (Schumann et al. 1996). The symbol * denotes the items in which sketches differ significantly ($p<0.05$) from CAD plots and the shaded images, while ° denotes the items in which CAD plots differ significantly ($p<0.05$)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

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