Conveying Shape: Lines

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CS 294-10: Visualization
Fall 2007

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

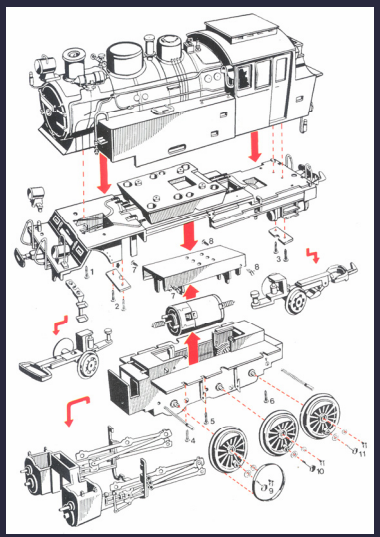
- Reduce / eliminate occlusions

Axonometric projection

- Reduces distortion

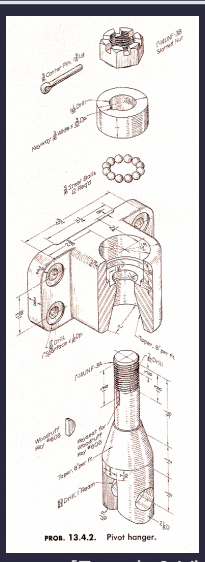
Guidelines

- When?
- Where ?

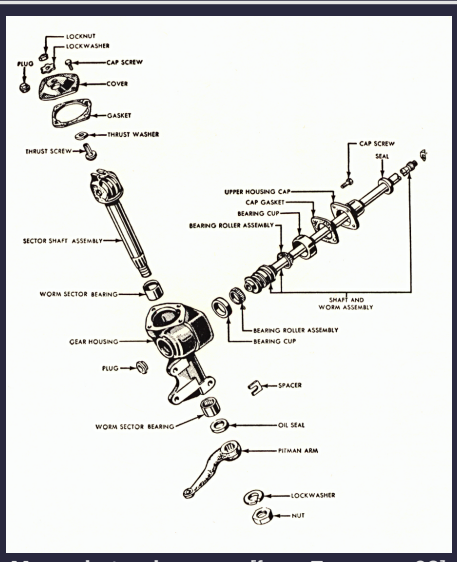


Train [from Mijksenaar 99]

Principal Axes

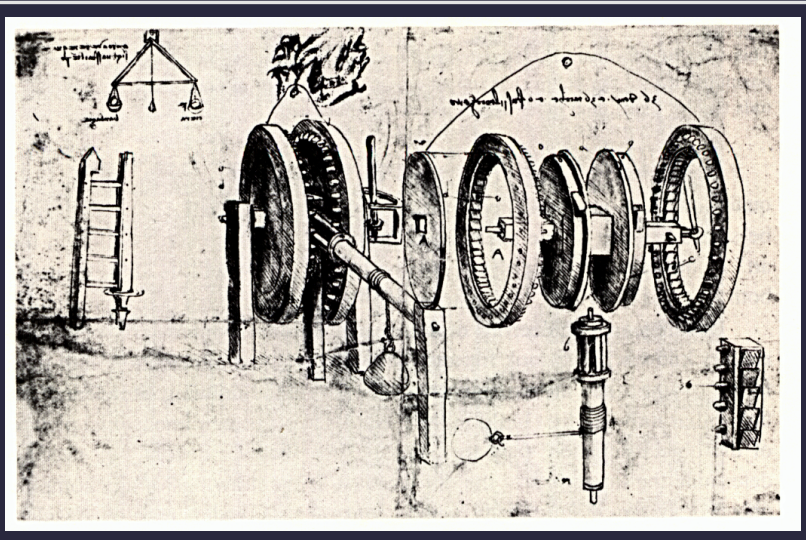


Pivot hanger [French & Vierck 60]



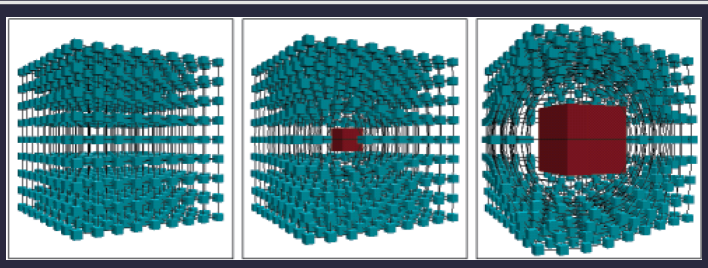
Manual steering gear [from Ferguson 92]

Leonardo Da Vinci

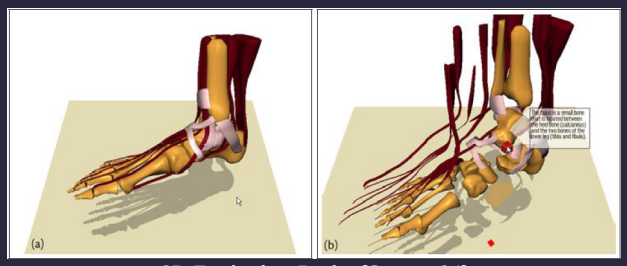


Ratchet device

Radial exploded views

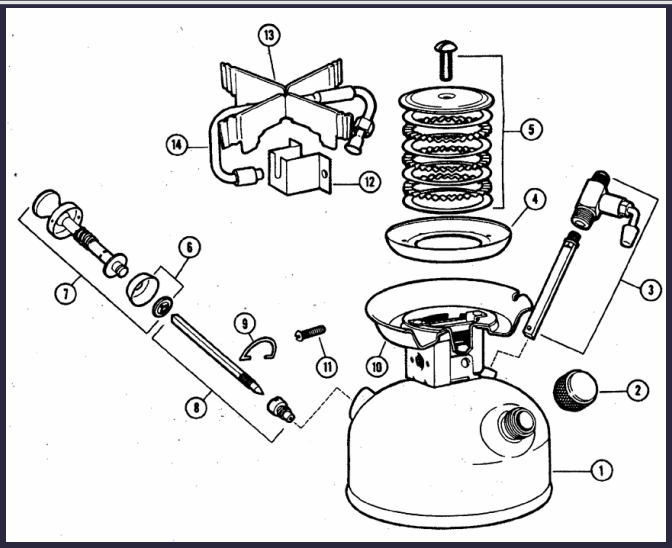


3D Distortion Viewing [Carpendale 97]



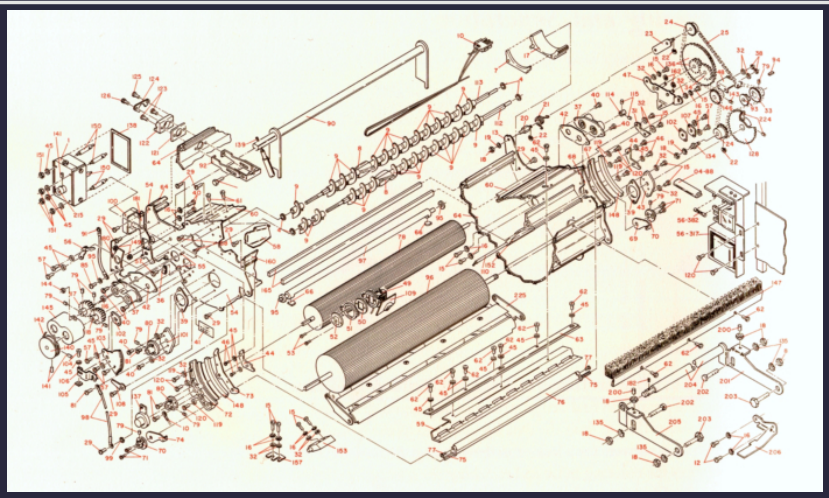
3D Explosion Probe [Sonnet 04]

Zigzag layout



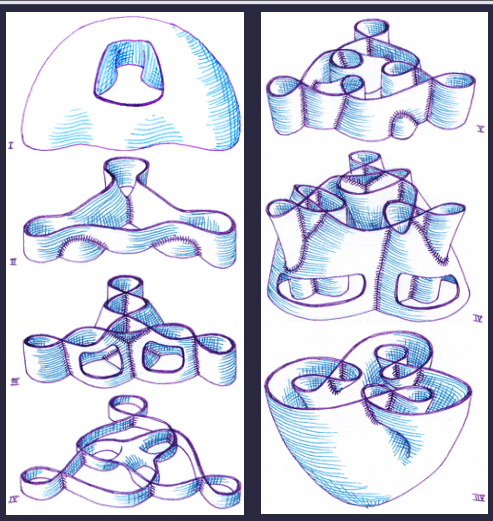
Camping Stove [from Mijksenaar 99]

Occlusion and guidelines



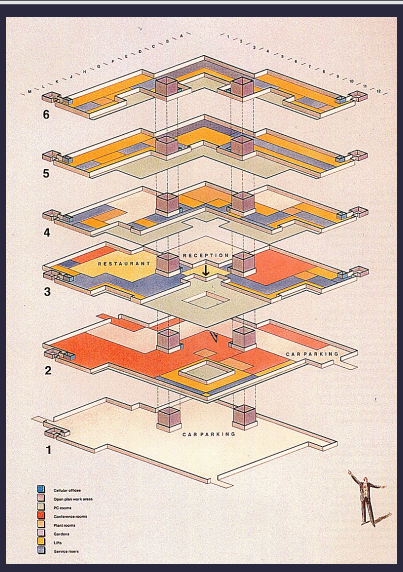
IBM Series III Copies/Duplicator Adjustment Parts Manual [Graham 76]

Cutaways, sections, exploded view



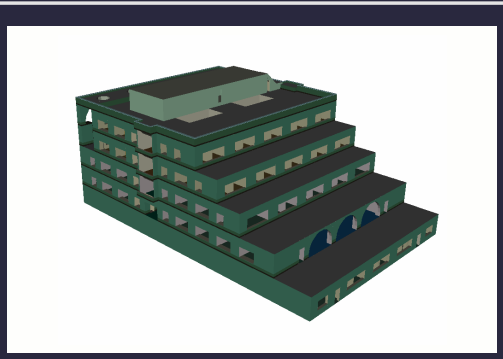
Strange immersion of torus in 3-space
[Curtis 92]

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

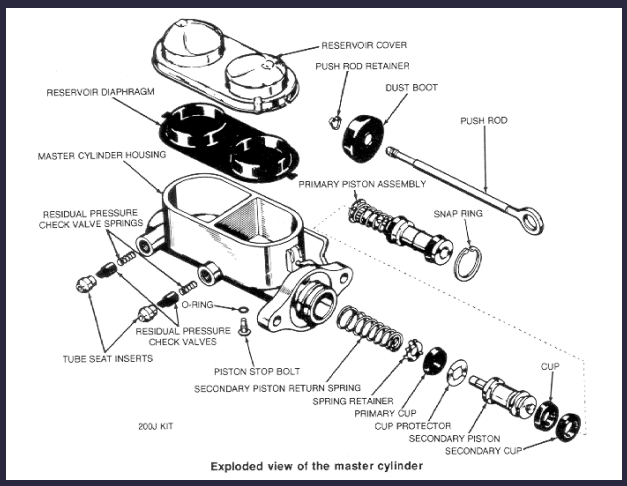
Quake III Arena by Id Software

Intercept and modify OpenGL stream

- Non-invasive [Mohr 01]
- Apply to existing OpenGL application without modification

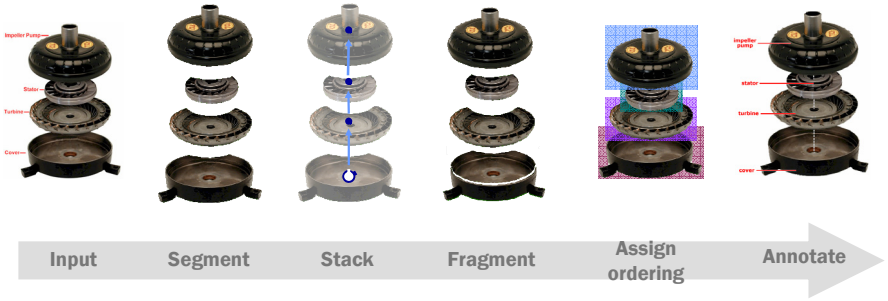
[Niederauer 03]

Interactive exploded views



Interactive Image-Based Exploded View Diagrams [Li 04]

Authoring Pipeline



Segmentation

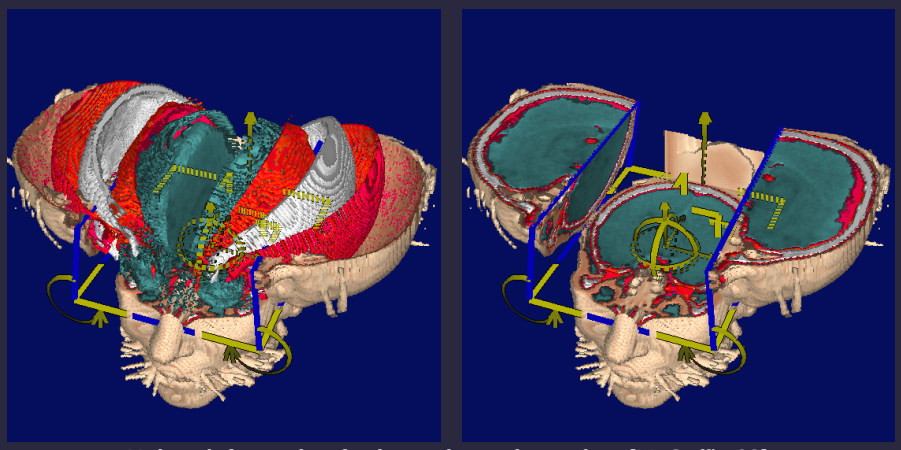
Stacking

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

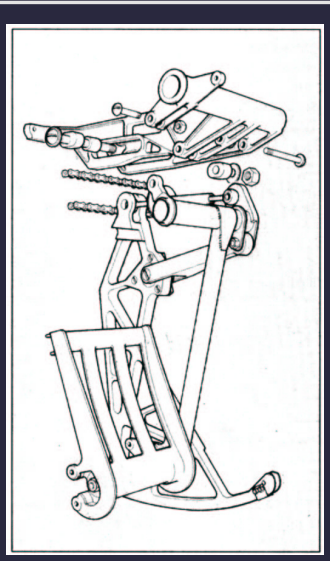
- Few basic choices (cull, move, transparency, modify drawing style)

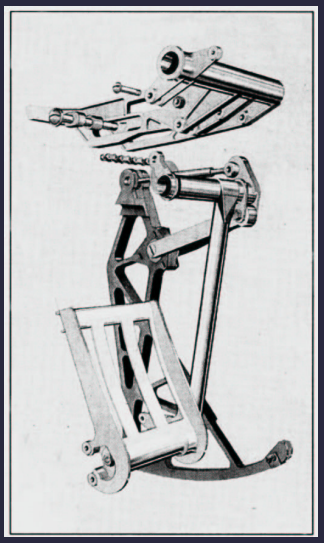
Conveying Shape: Lines

Conveying shape

Lines

Shading



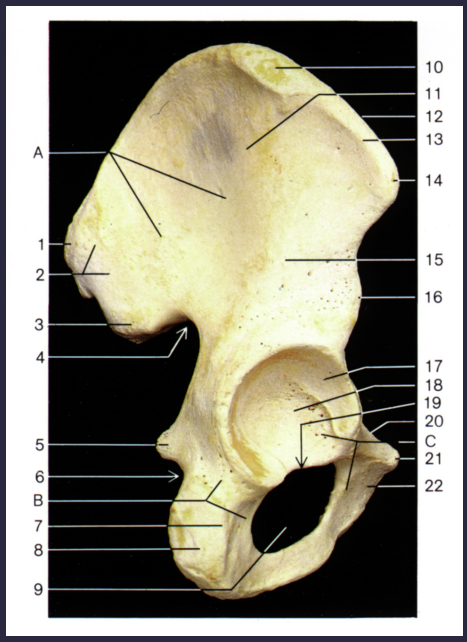


From Gooch[2]

Topics

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

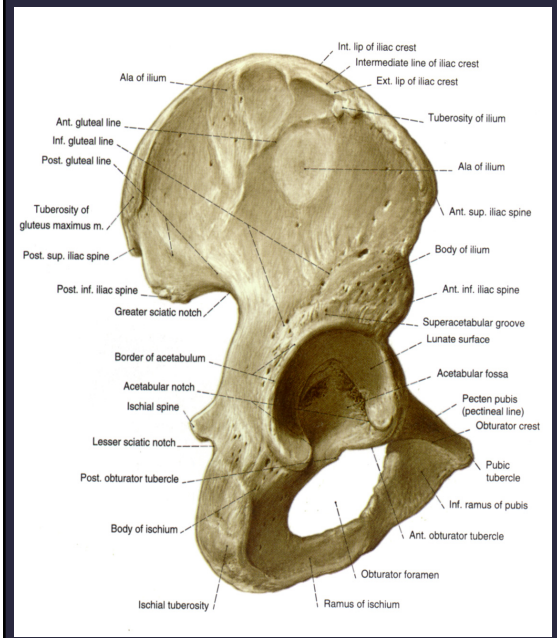
Photographs vs. Drawings



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.



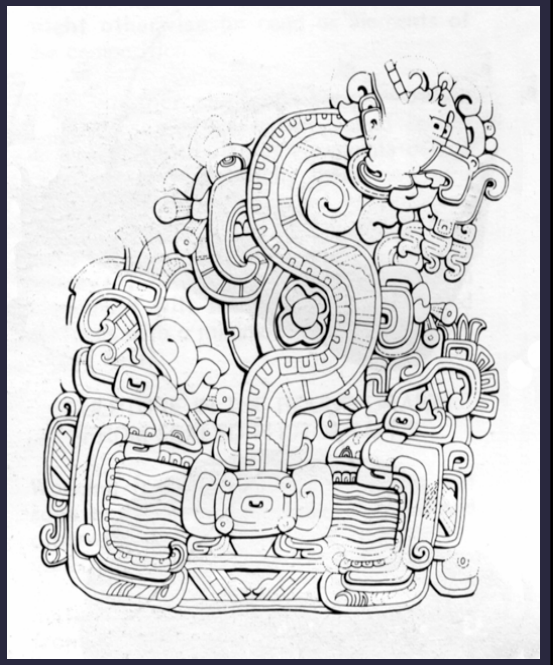
A drawing offers the possibility to clarify structural or conceptual information that may be difficult to perceive in even a very good photo.

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

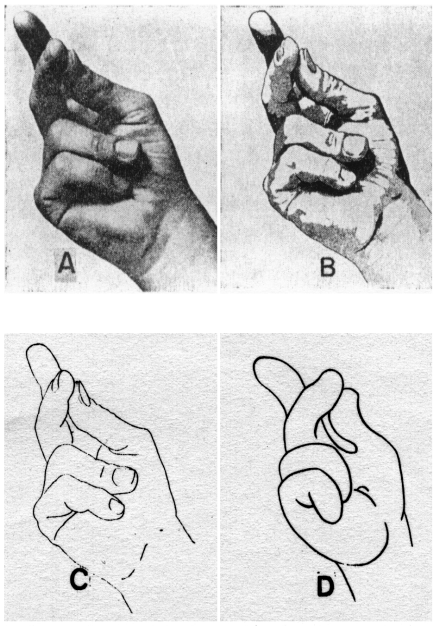


FIG. 1. FOUR REPRESENTATIONS OF THE HANDS IN POSITION 1
(A) Photograph; (B) Shaded Drawing; (C) Line Drawing; (D) Cartoon

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.

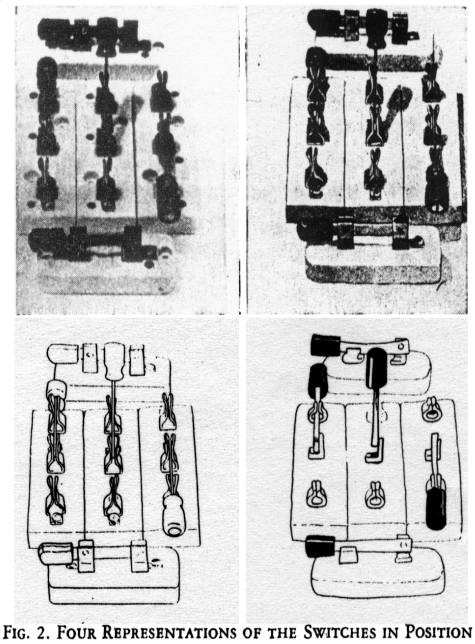


FIG. 2. FOUR REPRESENTATIONS OF THE SWITCHES IN POSITION 1

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.

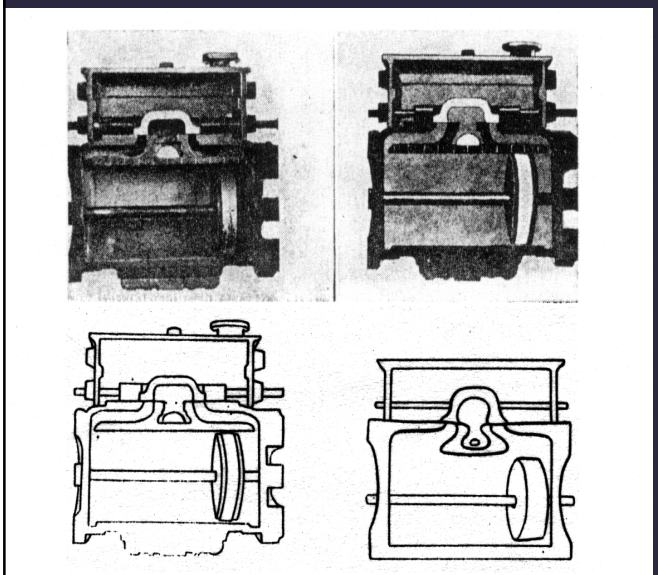


FIG. 3. FOUR REPRESENTATIONS OF THE STEAM VALVES IN POSITION 1

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

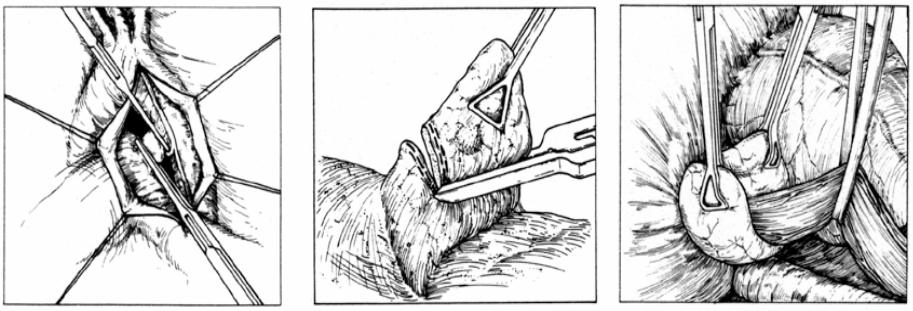
Realistic

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

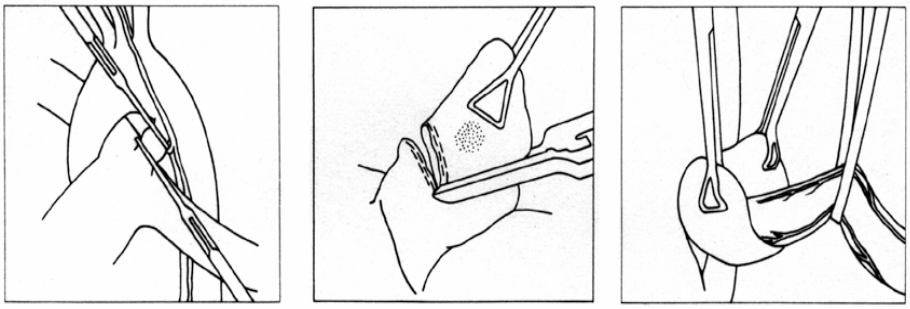


Patent Ductus Arteriosus | Wedge Resection | Esophageal Fundoplication

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.

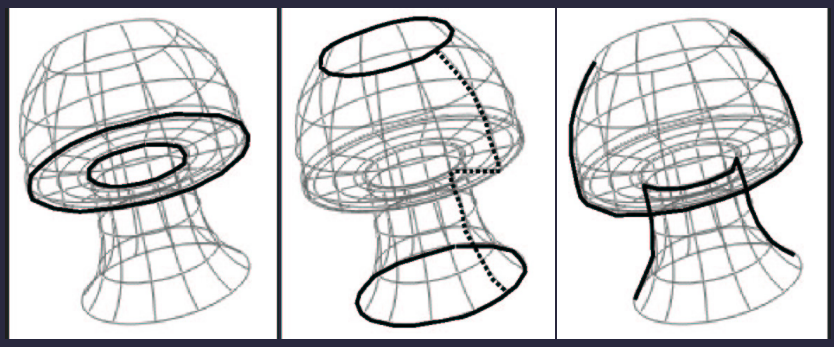
Results

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

Types of Lines

Classic geometric line types

Isoparametric



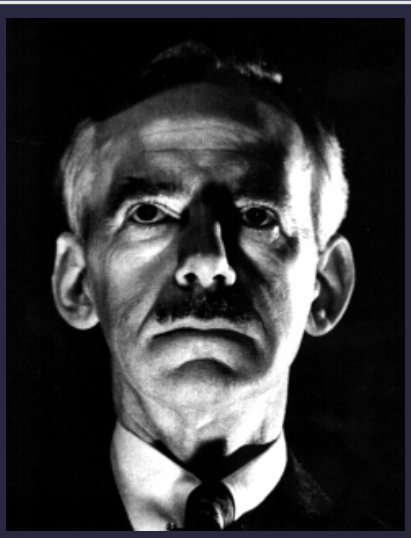
Discontinuities | Boundaries | Silhouettes

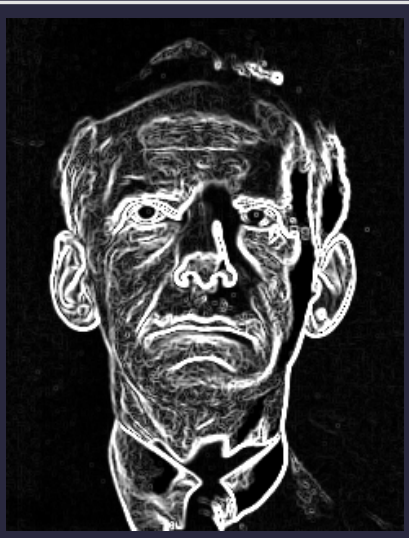
Lines signify features

Geometric features

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

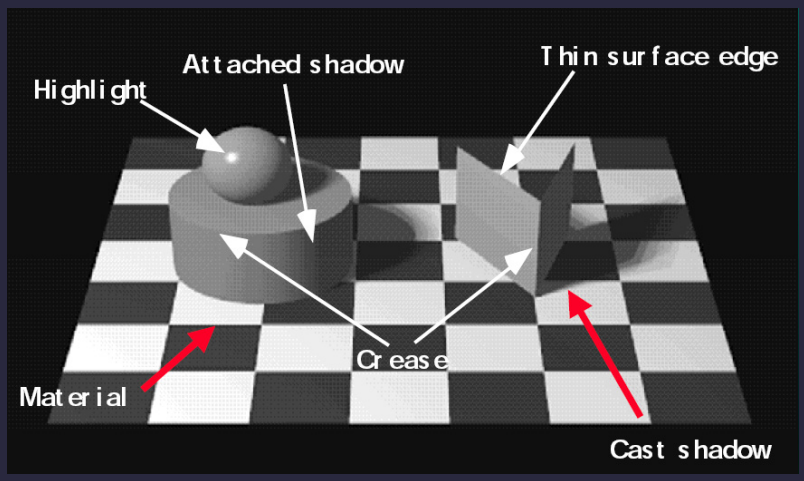
Lines in images





Photoshop “Find Edges …”

Causes of image discontinuities



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

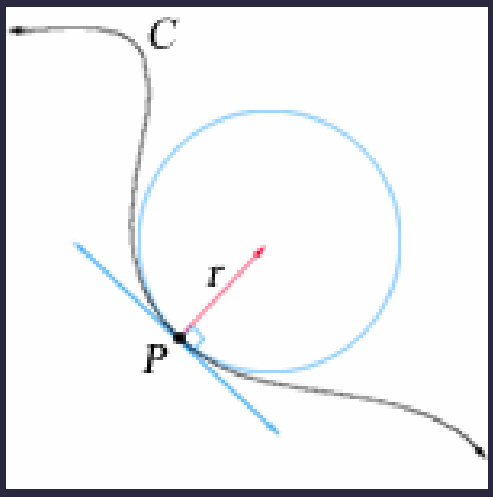
Two big issues

Which lines to draw?

How to draw the lines?

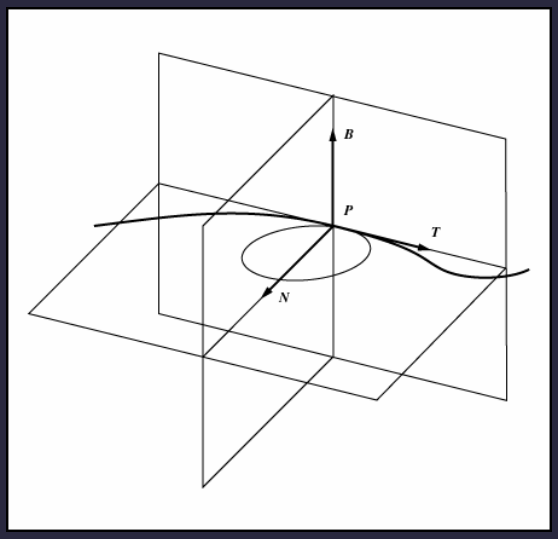
Lines of Curvature

Normal curvature

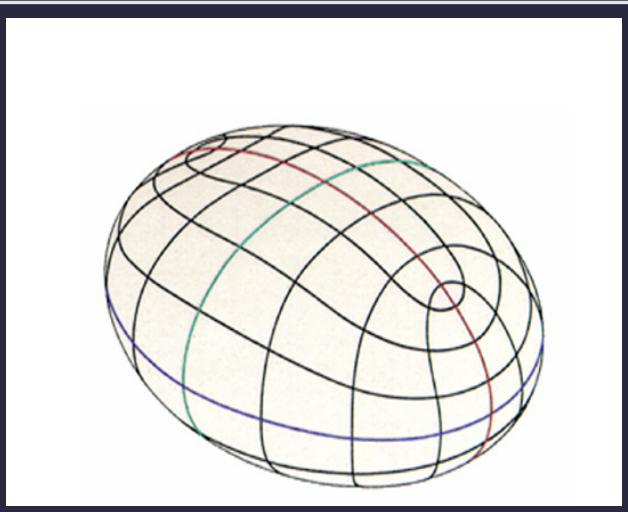


Curvature applet: http://www.ies.co.jp/math/java/calc/curve/curve.html

Space curve

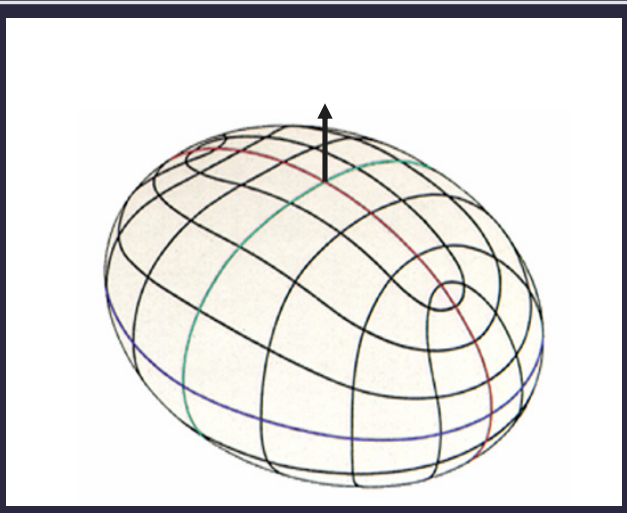


Curvature of surfaces



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

Curvature of surfaces



Hilbert and Cohn-Vossen [1952]
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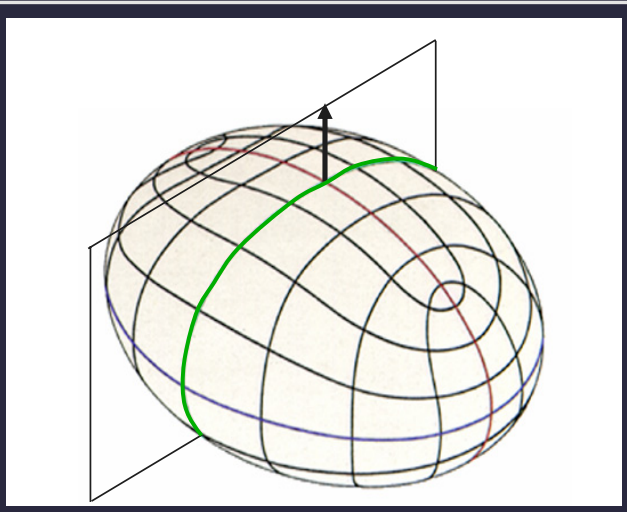

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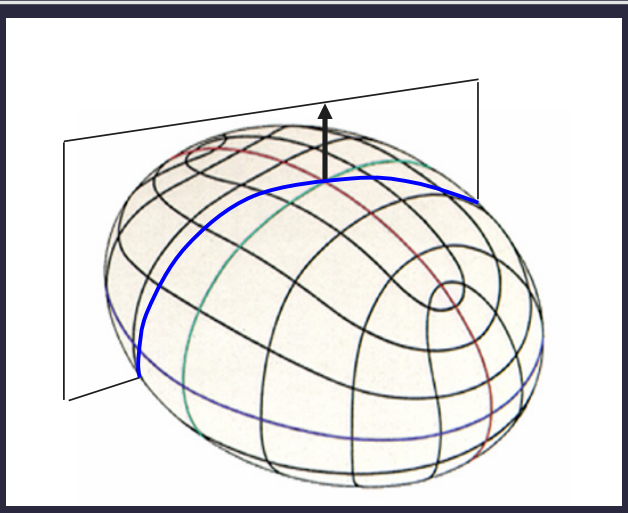

Hilbert and Cohn-Vossen [1952]
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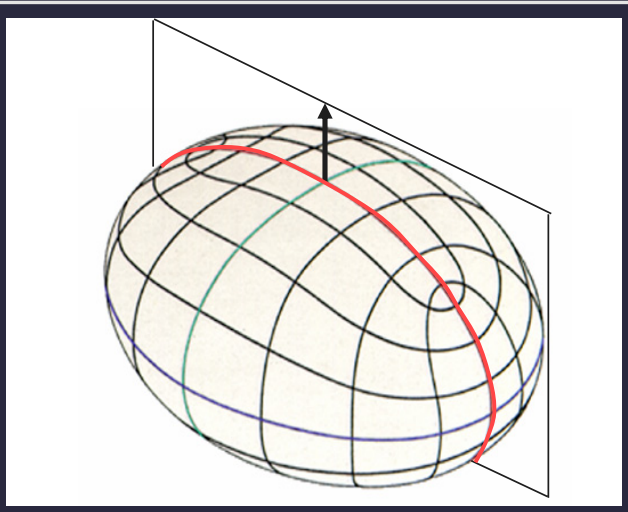
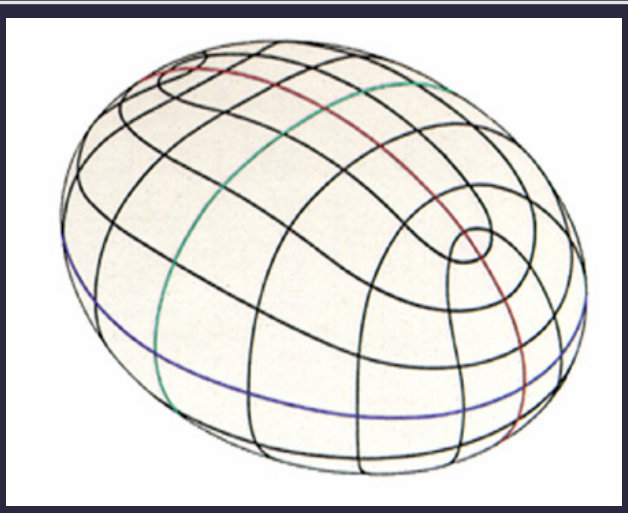
Curvature of surfaces

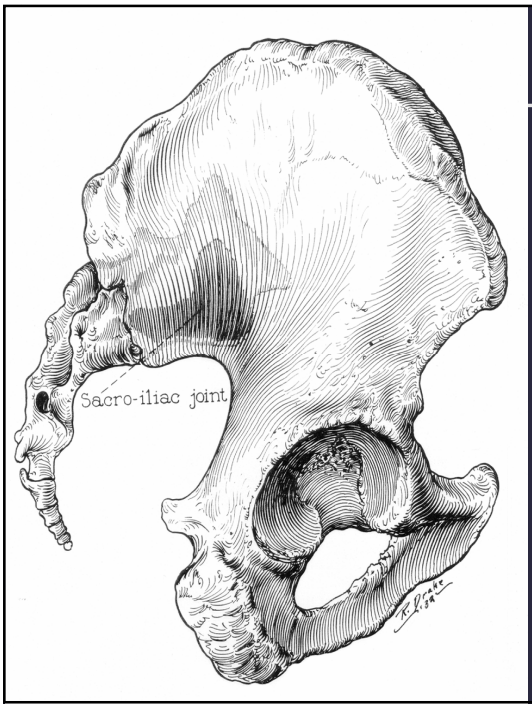


Hilbert and Cohn-Vossen [1952]
Geometry and the Imagination

Principal curvatures



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

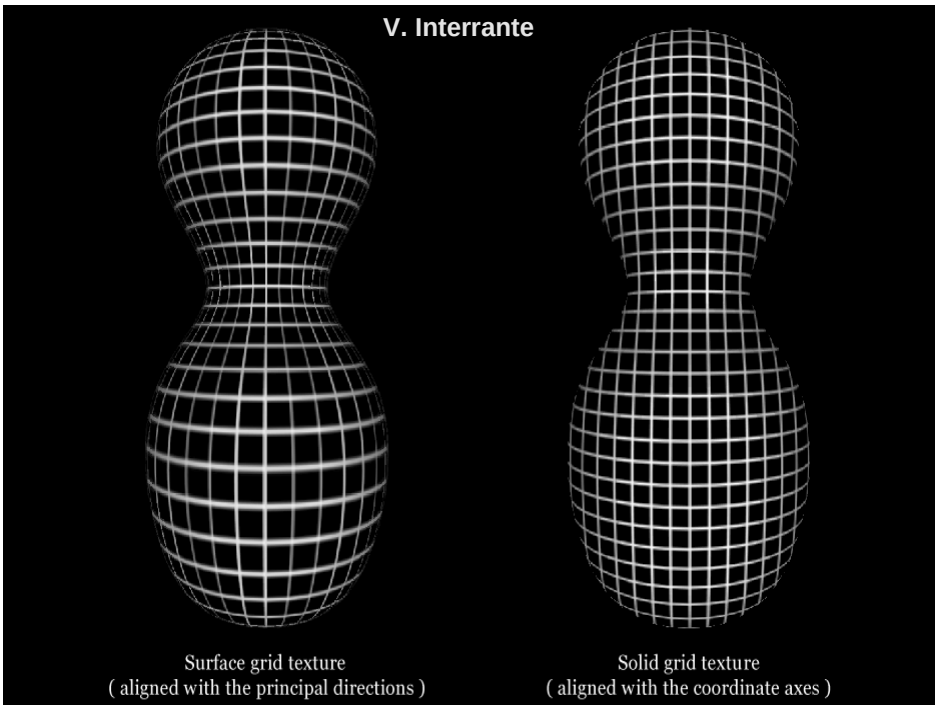


Artistic inspiration

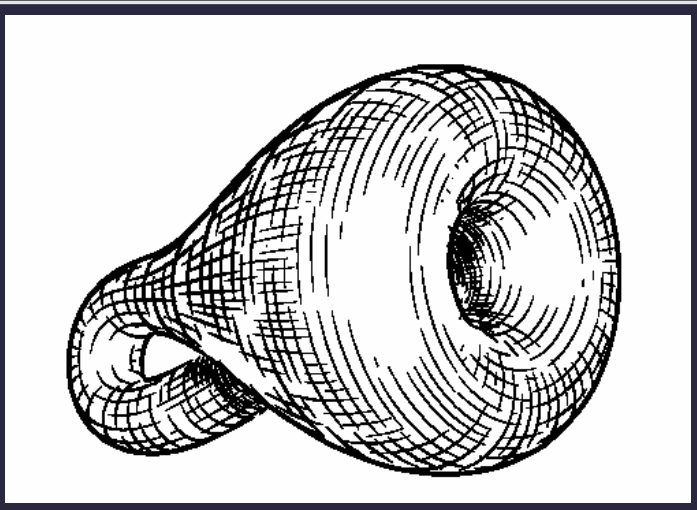
Russell Drake's "single line system of shading"

- **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

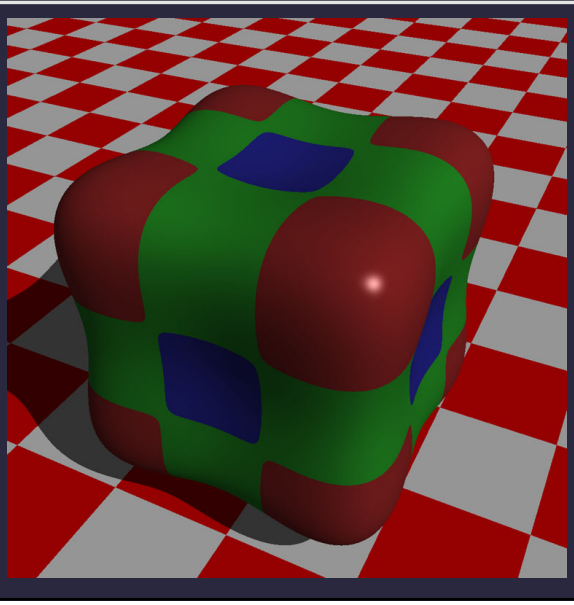
From Hertzmann and Zorin

Gaussian curvature

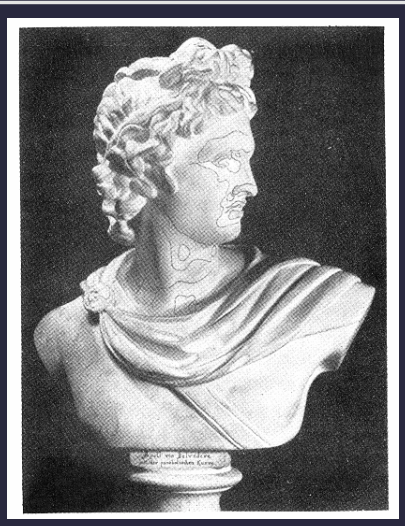
K_1 = curvature in first principal direction
K_2 = curvature in second principal direction
Gaussian curvature: $K = K_1 K_2$
Mean curvature: $H = (K_1 + K_2) / 2$

$K > 0$: elliptic, convex or concave
$K < 0$: hyperbolic, saddle-shaped
$K = 0$: parabolic, cylindrical or planar

Gaussian curvature



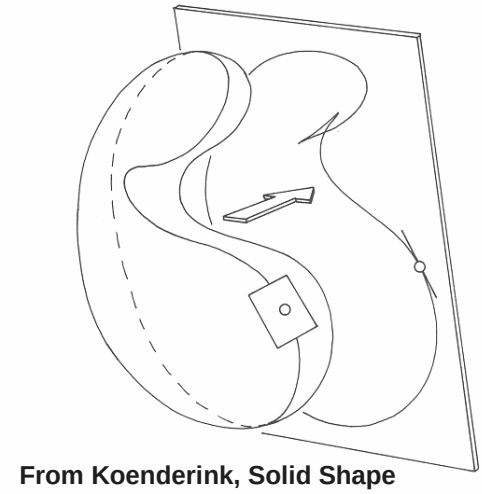
Parabolic lines



Felix Klein: Apollo

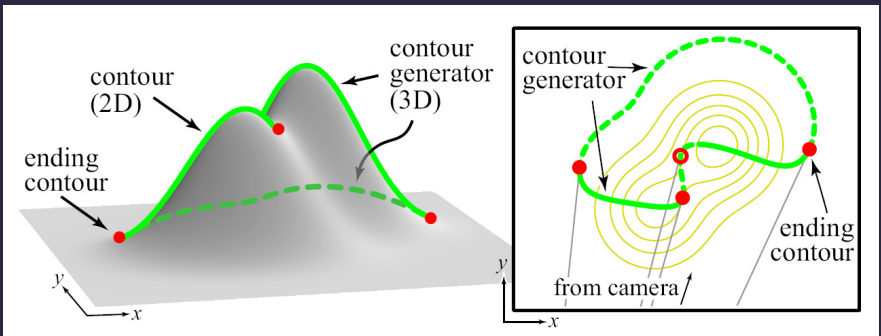
Silhouettes and Contours

Occluding contour



From Koenderink, Solid Shape

Occluding contour



[from DeCarlo et al. 03]

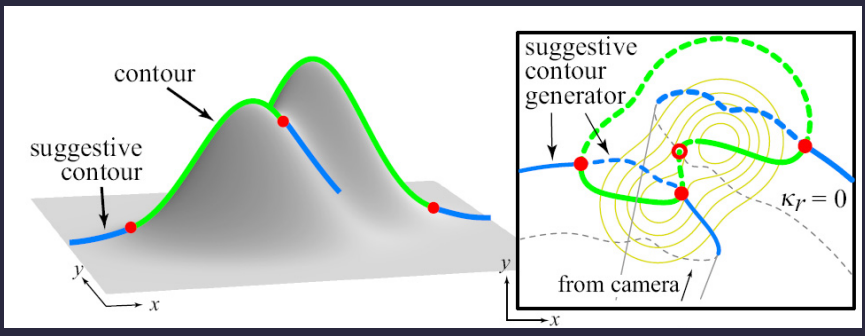
Definitions [Koenderink 84]

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