Shape Illustration and Visualization

Baoquan Chen

JPEG slides are from Pat Hanrahan

Lines

Reflection Lines

From Farin and Harnsford

Feature Detectors!

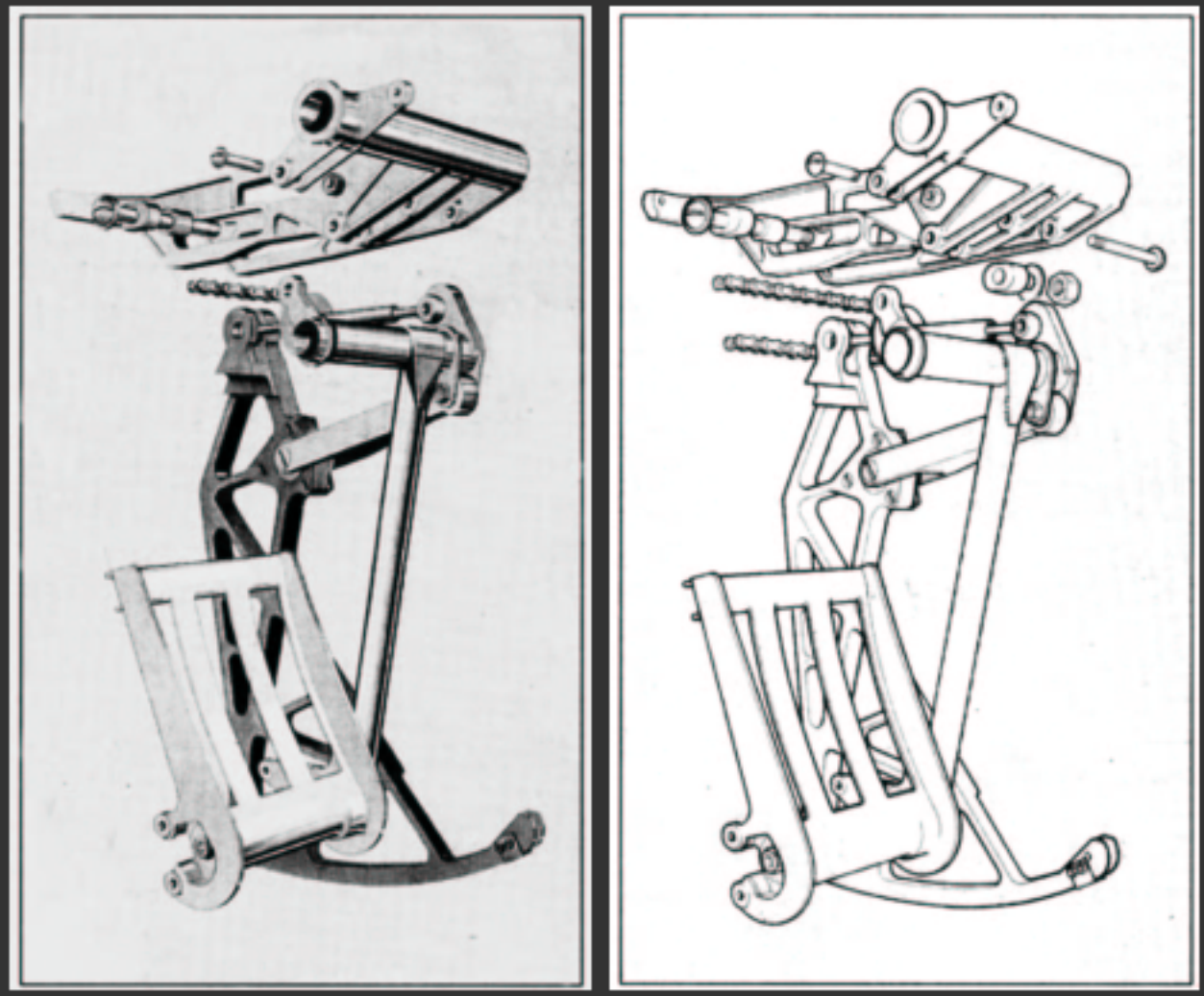
Picasso, Portrait of Igor Stravinsky, 1920.

Graphite and charcoal, Musée Picasso, Paris, France

Conveying Shape

Shading

Lines

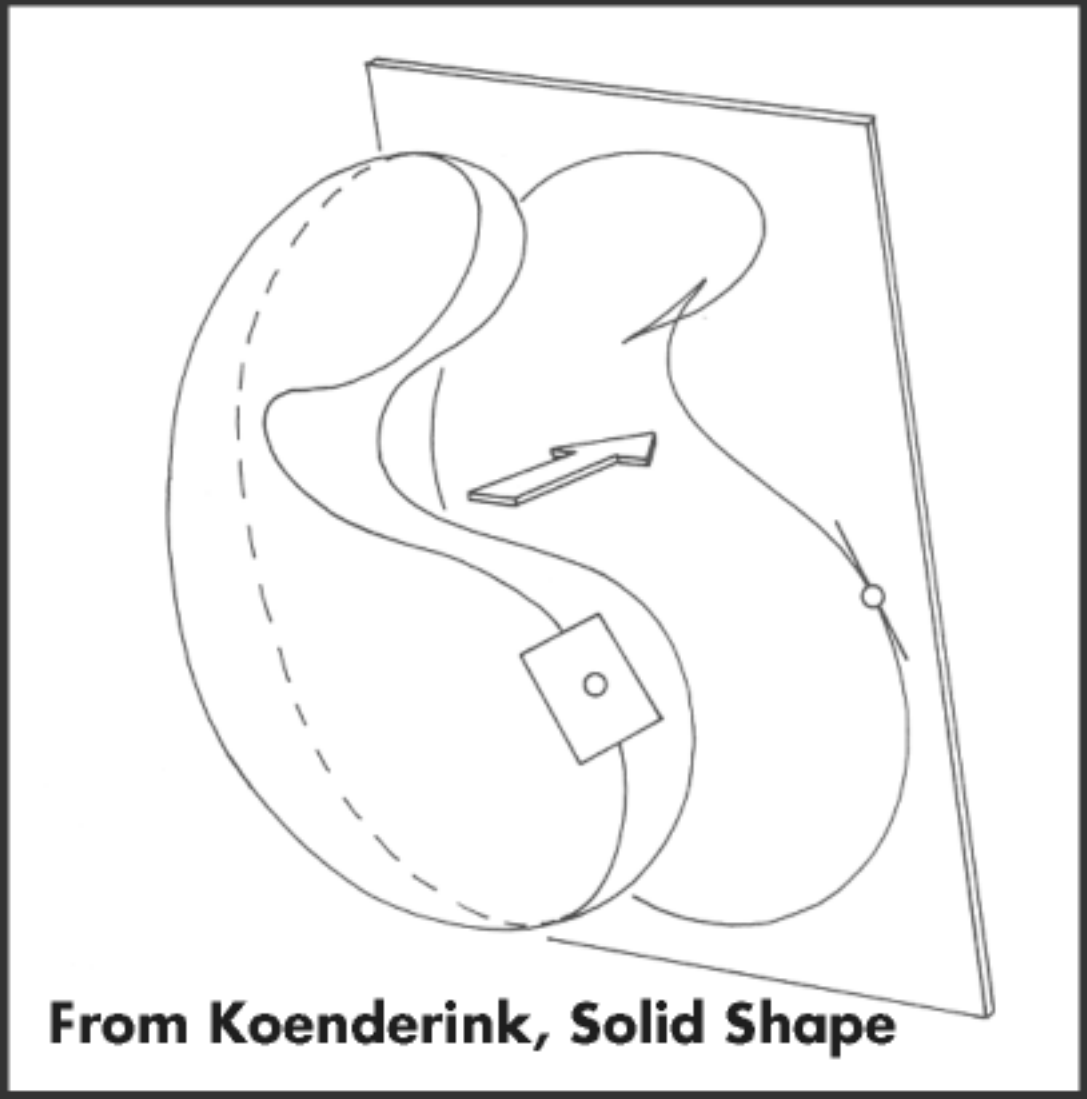


From Gooch[2]

Types of Lines

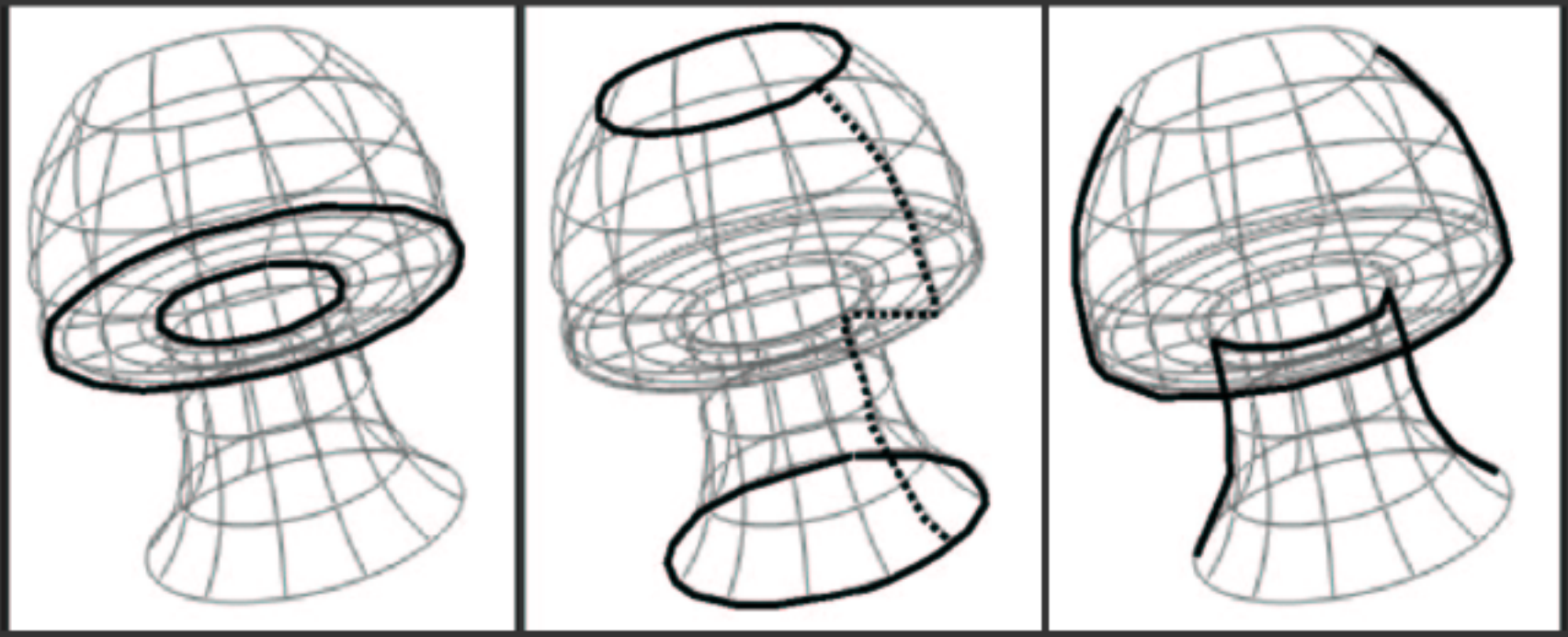
- Discontinuities: creases and self-intersections
- Boundaries between surface patches
- Silhouettes and contours and cusps
- Parabolic lines
- Isoparametric lines
- Lines of curvature
- Attached and unattached shadows
- Isoluminance and luminance extrema
- Highlights

Occluding Contour



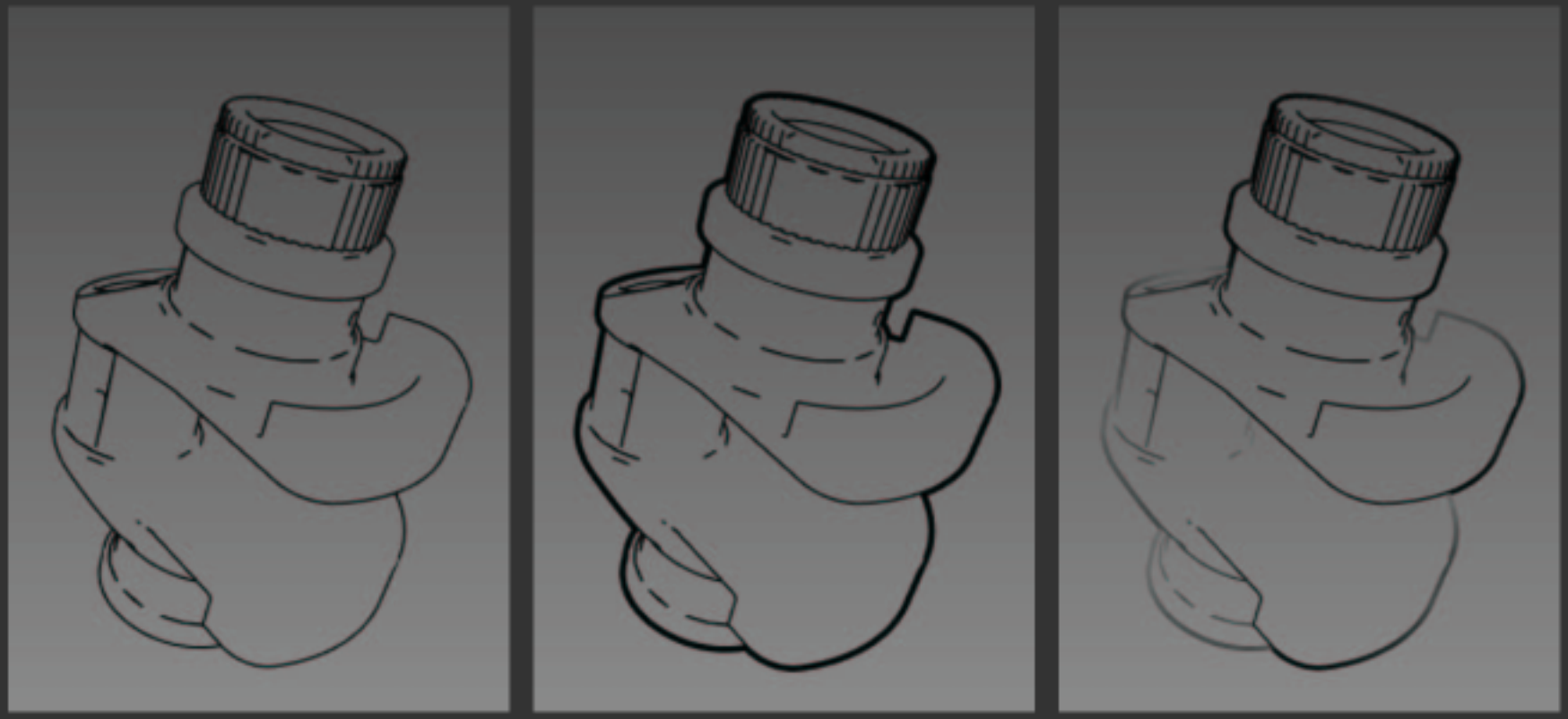
From Koenderink, Solid Shape

Examples of Line Types



Discontinuities Boundaries Silhouettes

Line Drawing Conventions



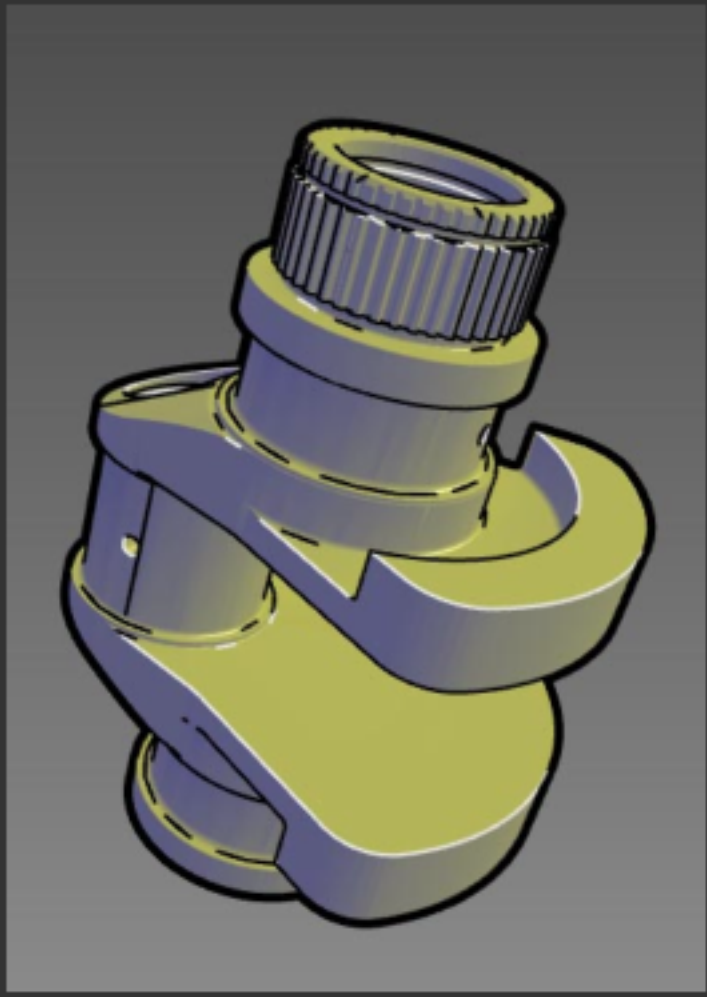
Single weight

Two weights

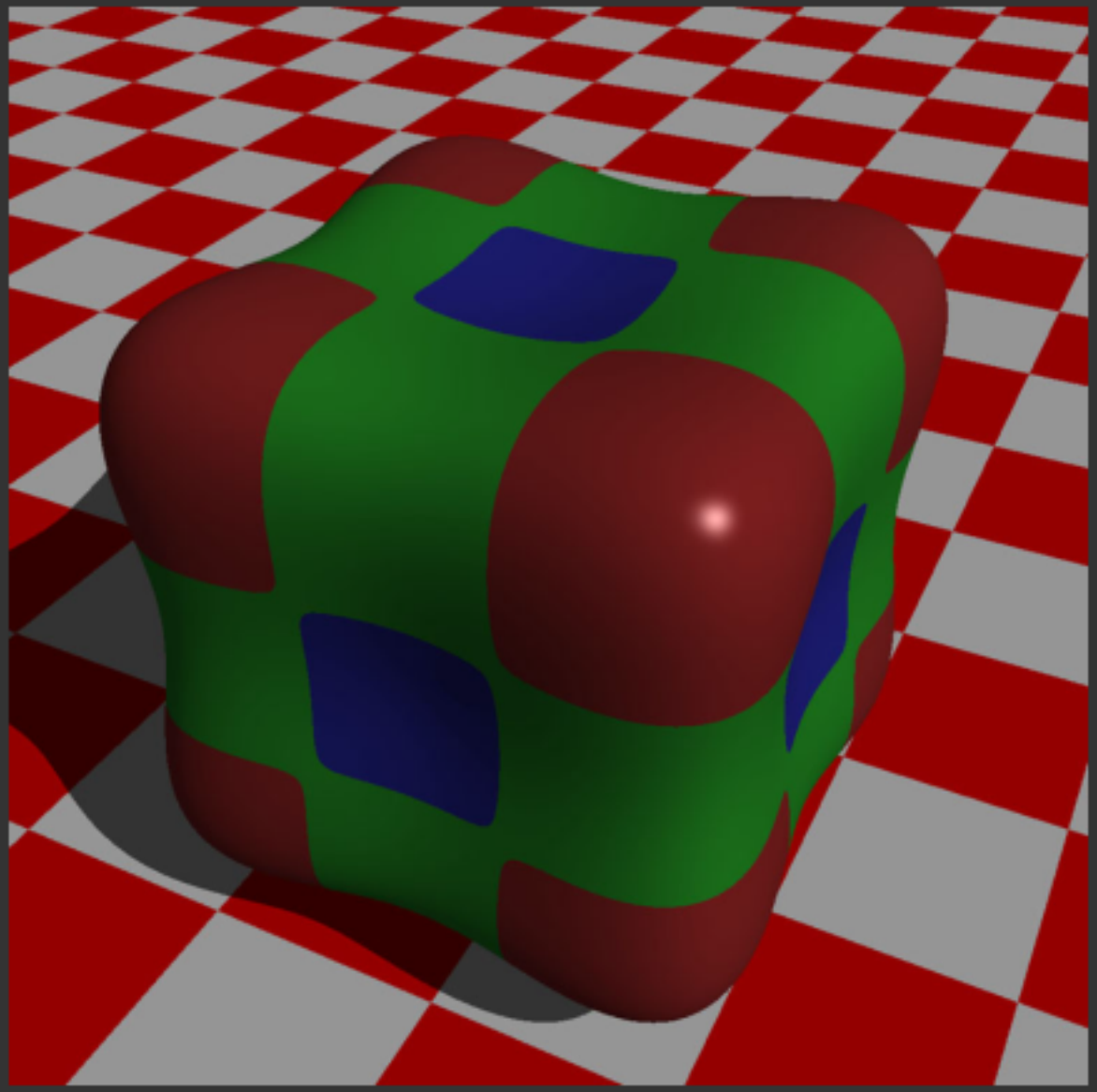
Distance weighting

From Martin (reproduced in Gooch and Gooch)

Highlighting



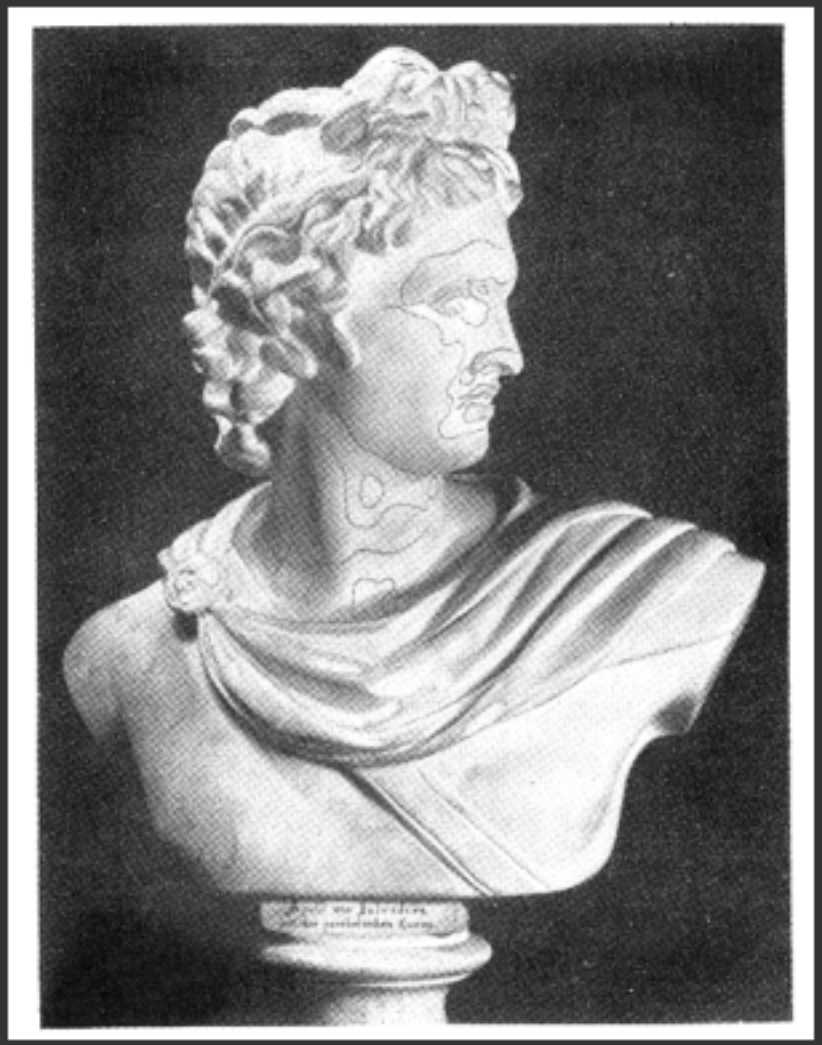
Gaussian Curvature



Parabolic Lines

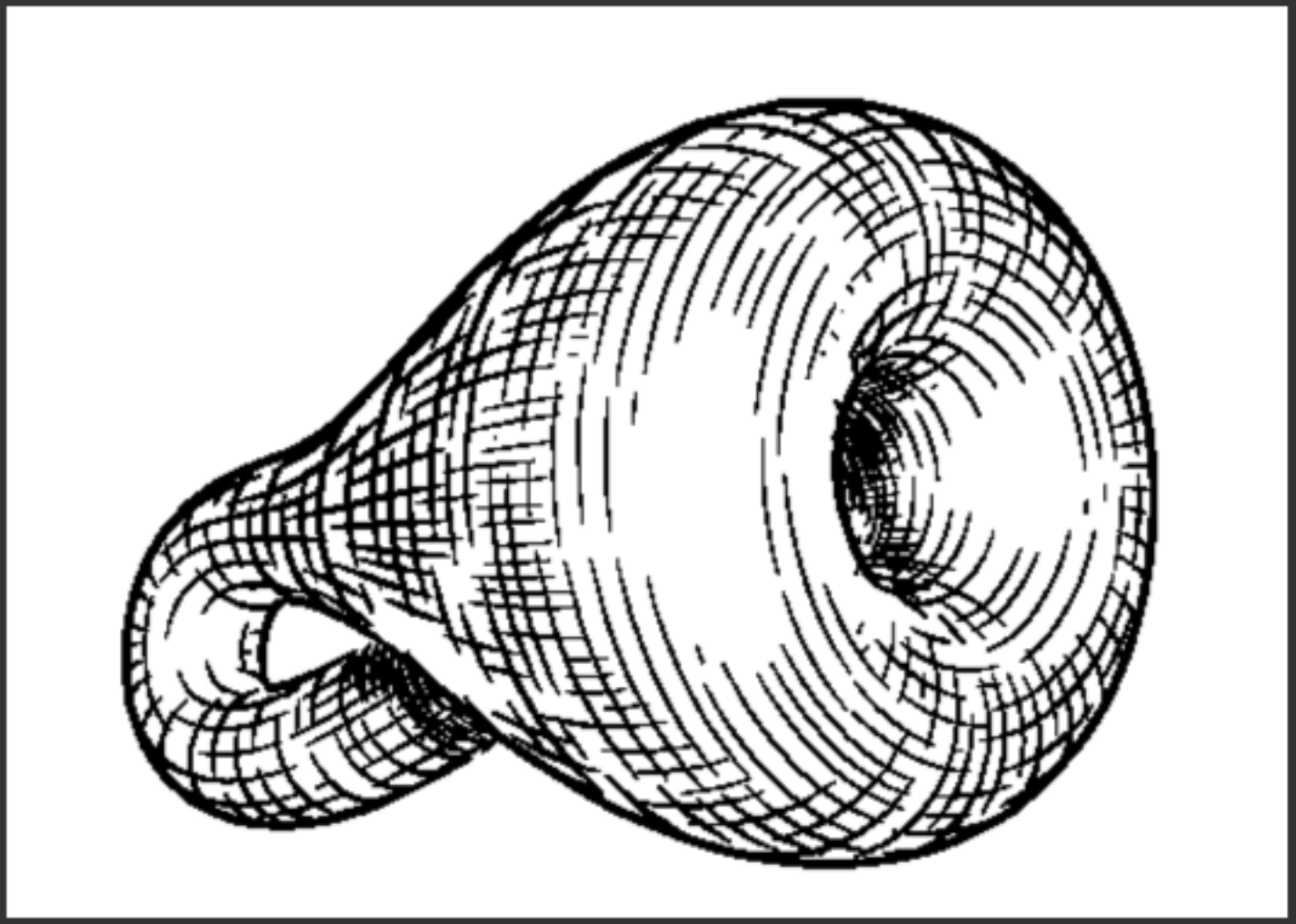
1. Segmentation of the object into convex, concave and saddle-shaped regions
2. Inflection points of the visual contour
3. Changes of topology of the contour with viewpoint changes
4. Qualitative structure of the illuminance distribution
5. Loci that create and annihilate highlights

Parabolic Lines



Felix Klein Apollo

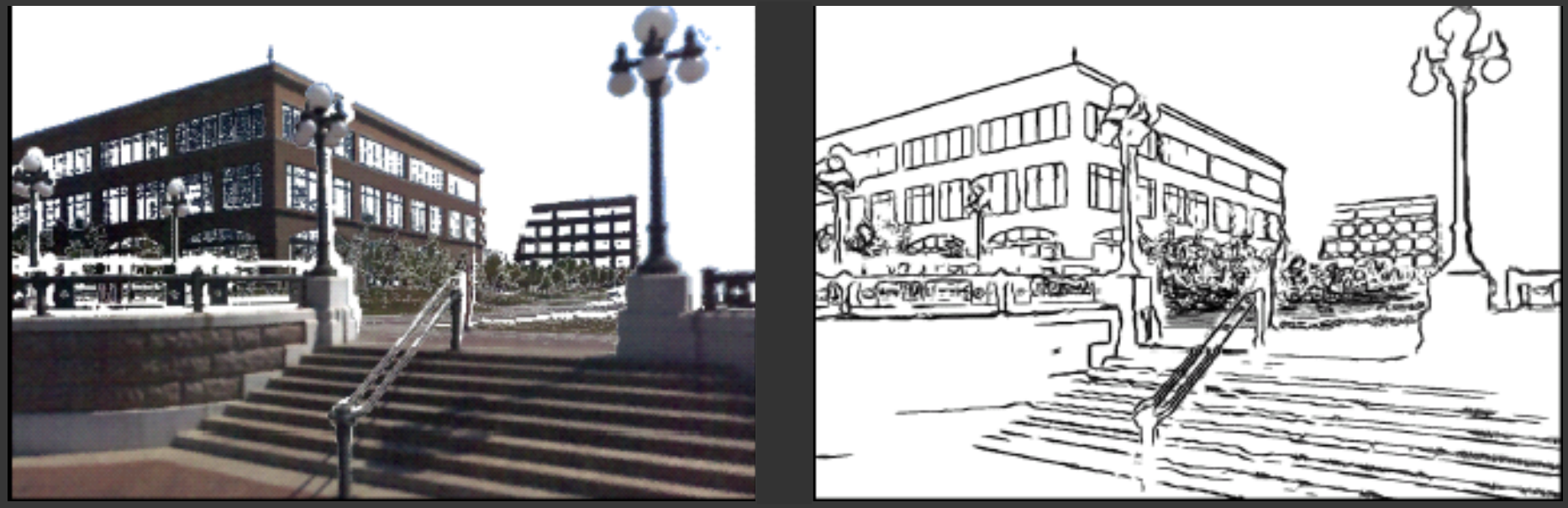
Curvature Direcctions



Klein bottle

From Hertzmann and Zorin

Photorealism vs. Non-Photorealism

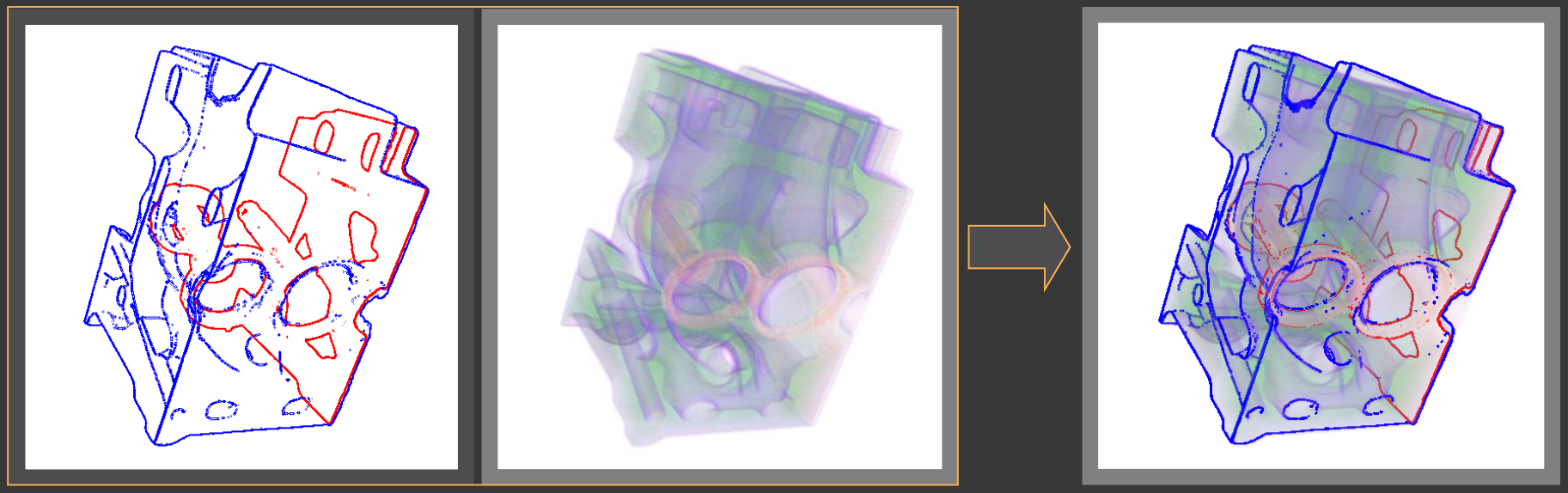


Mississippi River Bank, Saint Paul
From Hui Xu and Baoquan Chen

Photograph to Illustration

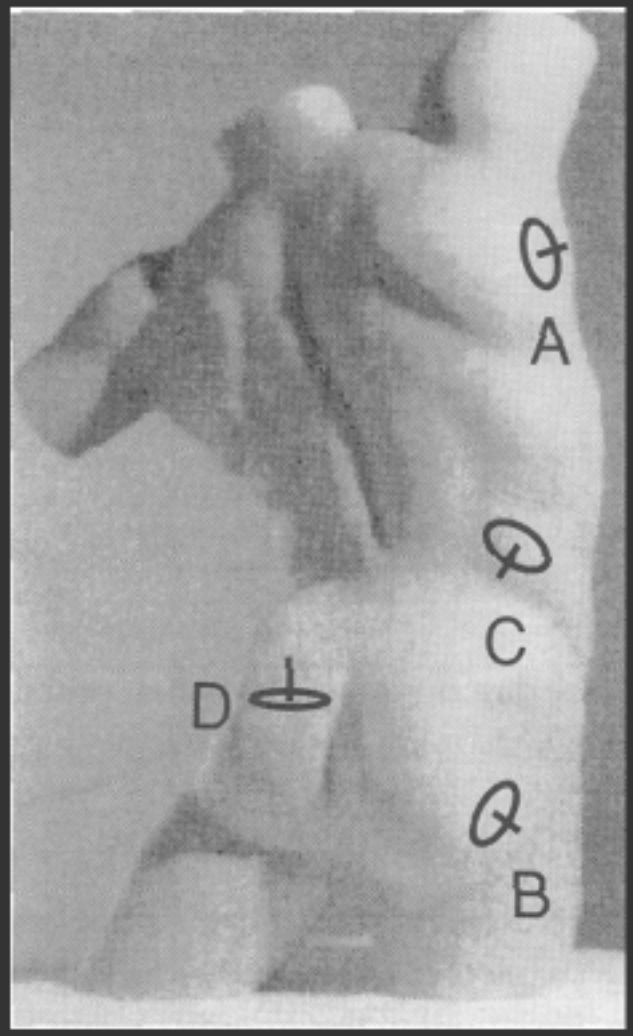
Raskar, et al. Non-photorealistic Camera …, SIGGRAPH'04

Mixing Surfaces with Volumes



shading

Estimating Orientation



From Koenderink, van Doorn, Kappers

Goals

- Show form and orientation of surface
- Maintain contrast with background
- Rake textural details
- Emphasize important features

Shading model developed by Gooch et al.

Learning from Technical Illustration

The non-photorealistic cool (blue) to warm (tan) transition on the skin of the garlic. Colored pencil drawing by Susan Ashurst.

Learning from Technical Illustration

Characteristics in many technical illustrations:

- edge lines, the set containing surface boundaries, silhouettes, and discontinuities, are drawn with black curves
- matte objects are shaded with intensities far from black or white with warmth or coolness of color indicative of surface normal; a single light source provides white highlights
- shadowing is not shown
- metal objects are shaded as if very anisotropic

Learning from Technical Illustration

Edward Tufte. *Visual Explanations*. Graphics Press, 1997:

Tufte advocates improving a computer graphics animation by lowering the contrast of the shading and adding black lines to indicate direction. He states that this is an example of the strategy of *the smallest effective difference* :

Make all visual distinctions as subtle as possible, but still clear and effective.

The principle provides a possible explanation of why cross-hatching is common in black and white drawings and rare in colored drawings: colored shading provides a more subtle, but adequately effective, difference to communicate surface orientation.

Traditional Shading of Matte Objects

$$I = k_d k_a + k_d \max\left(0, \hat{\mathbf{l}} \cdot \hat{\mathbf{n}}\right)$$

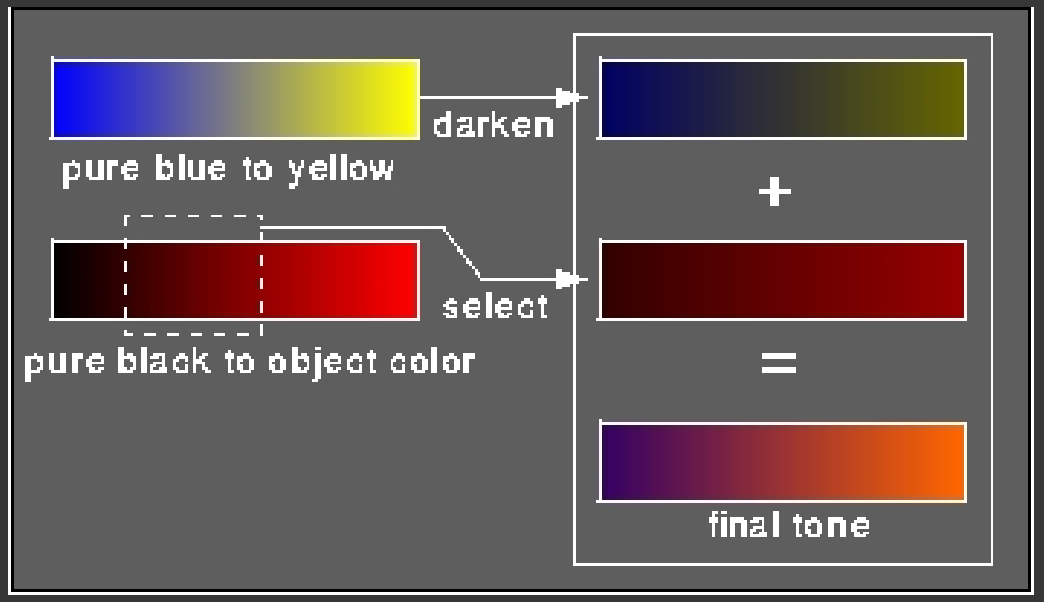
Tone-based Shading of Matte Objects

Adding blacks and whites to a given color results in what artists call *shades* in the case of black, and *tints* in the case of white. When color scales are created by adding grey to a certain color they are called *tones.*

The temperature of a color is defined as being warm (red, orange, and yellow), cool (blue, violet, and green), or temperate (red-violets and yellow-greens). The depth cue comes from the perception that cool colors recede while warm colors advance.

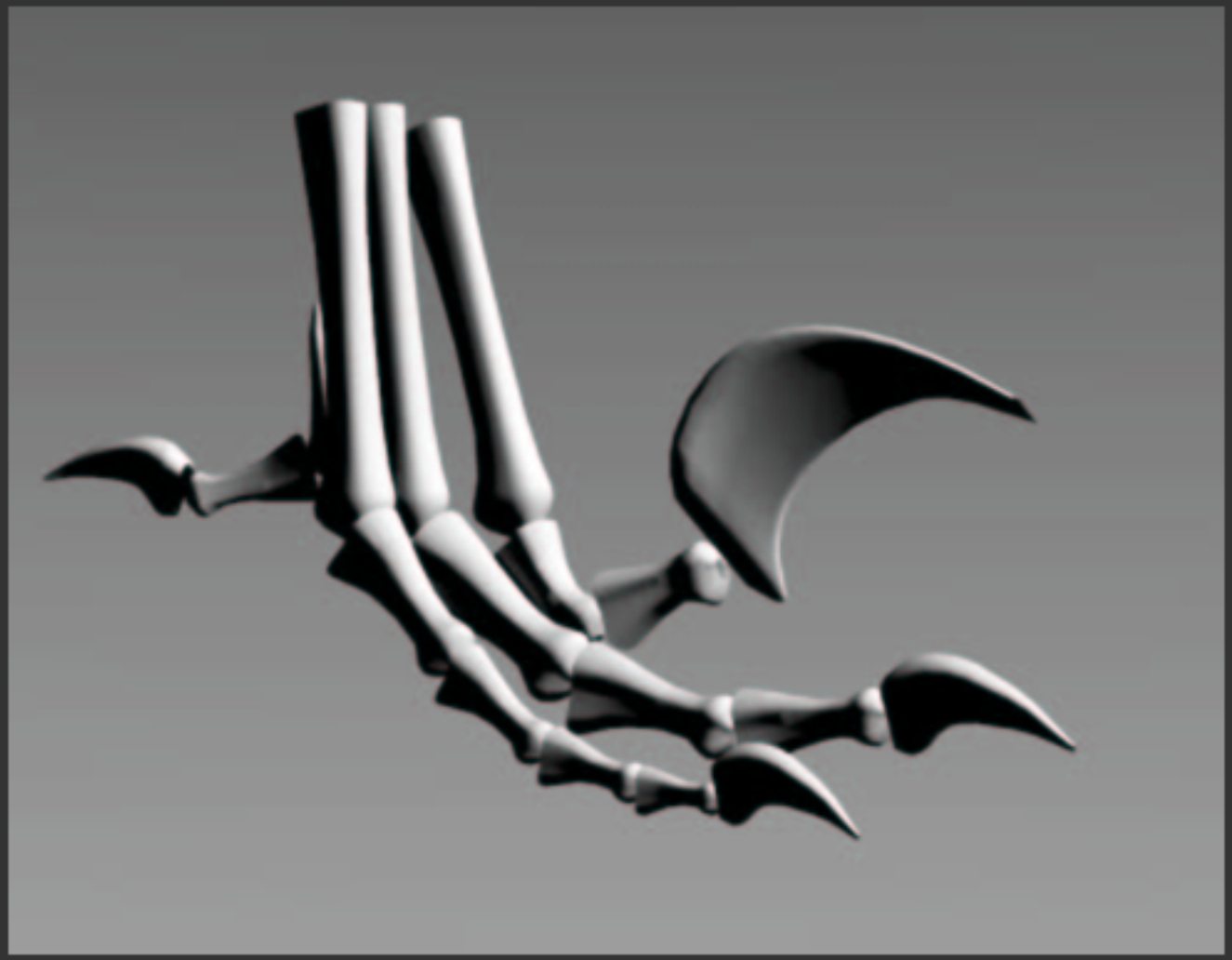
Tone-based Shading of Matte Objects

How the tone is created for a pure red object by summing a blue-to-yellow and a dark-red-to-red tone.

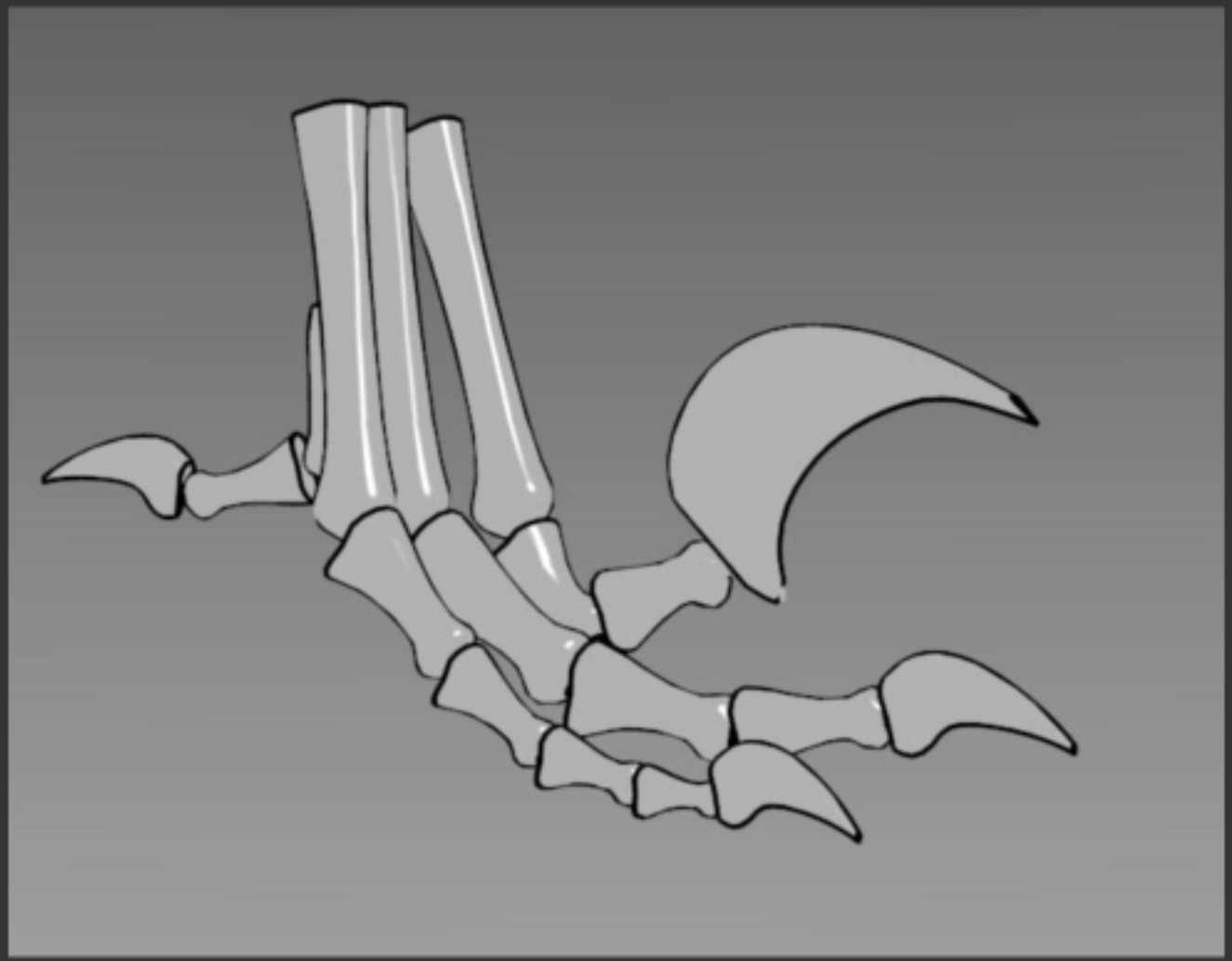


$$I = \left(\frac{1+\hat{\mathbf{l}}\cdot\hat{\mathbf{n}}}{2}\right)k_{cool} + \left(1-\frac{1+\hat{\mathbf{l}}\cdot\hat{\mathbf{n}}}{2}\right)k_{warm}$$

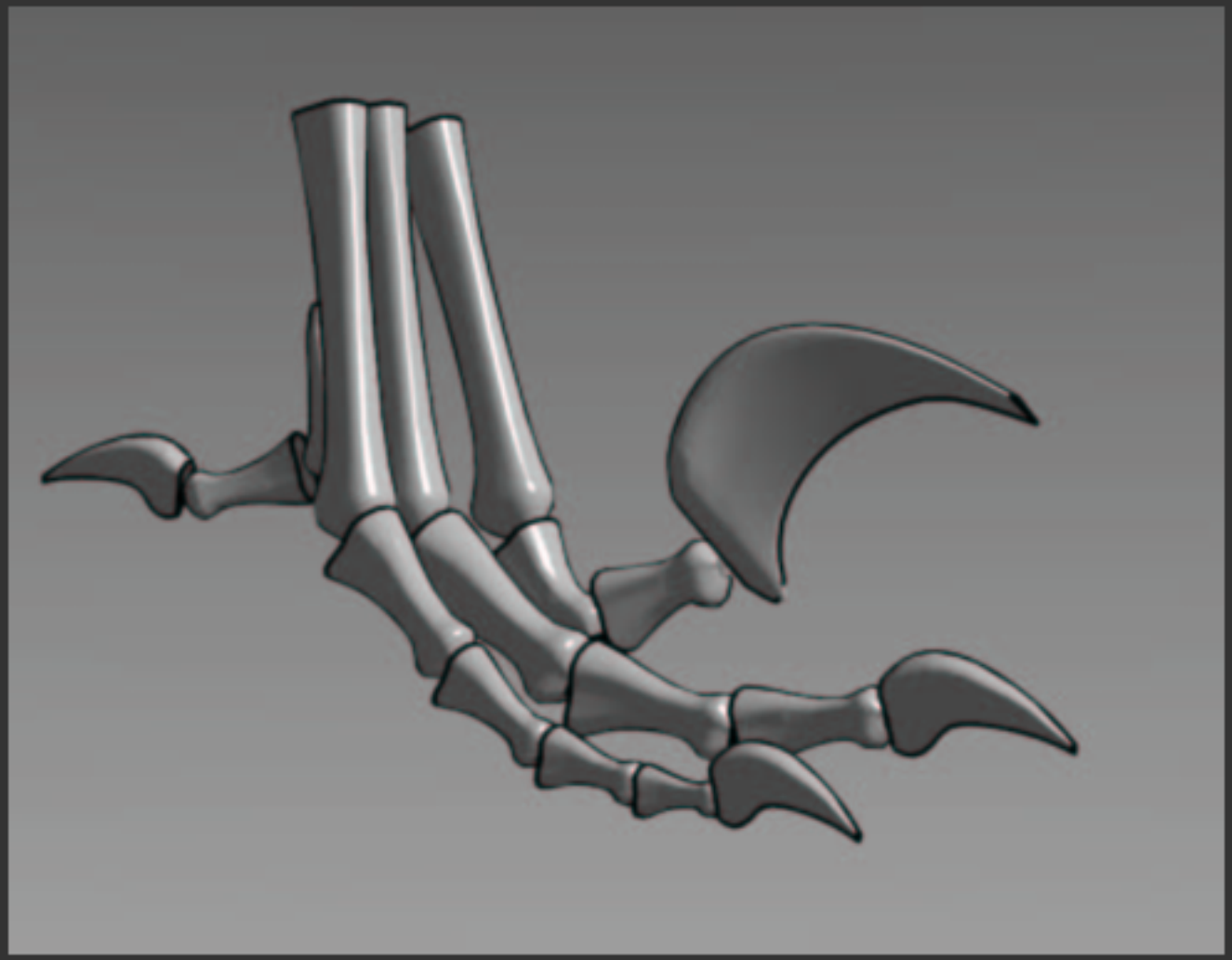
Diffuse + No Ambient



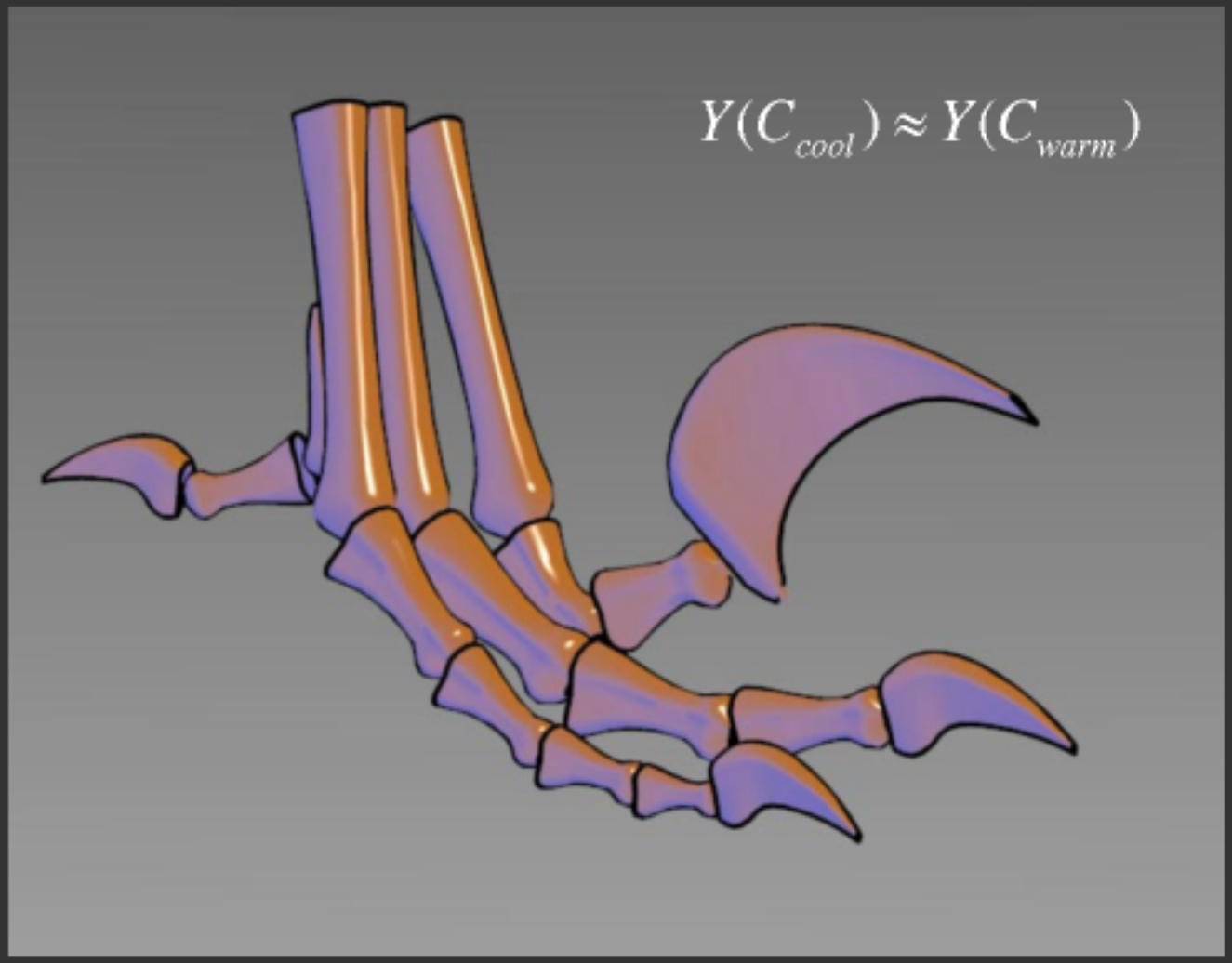
Edges + Highlights



Lower Diffuse; Add Ambient

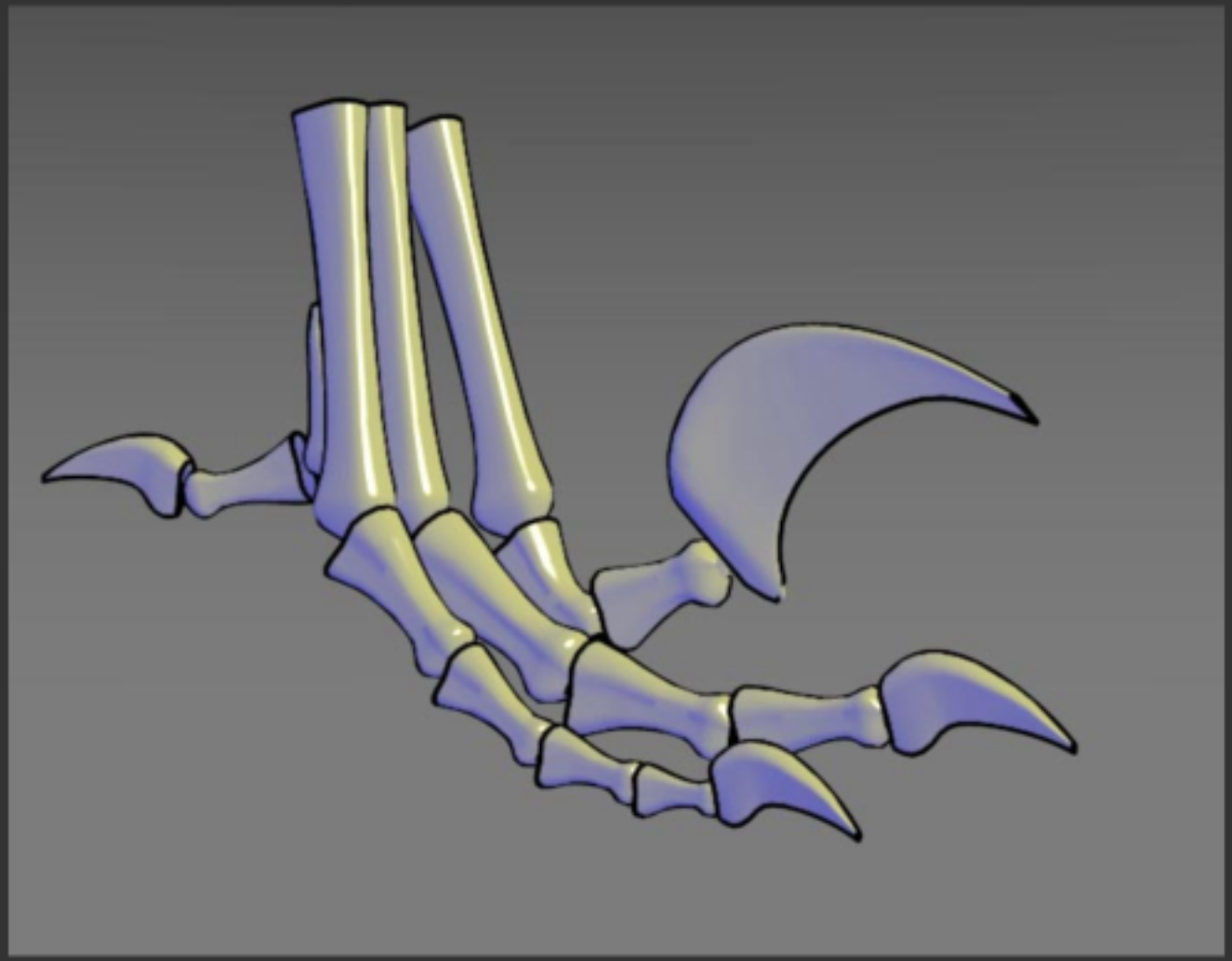


Tone-based Shading



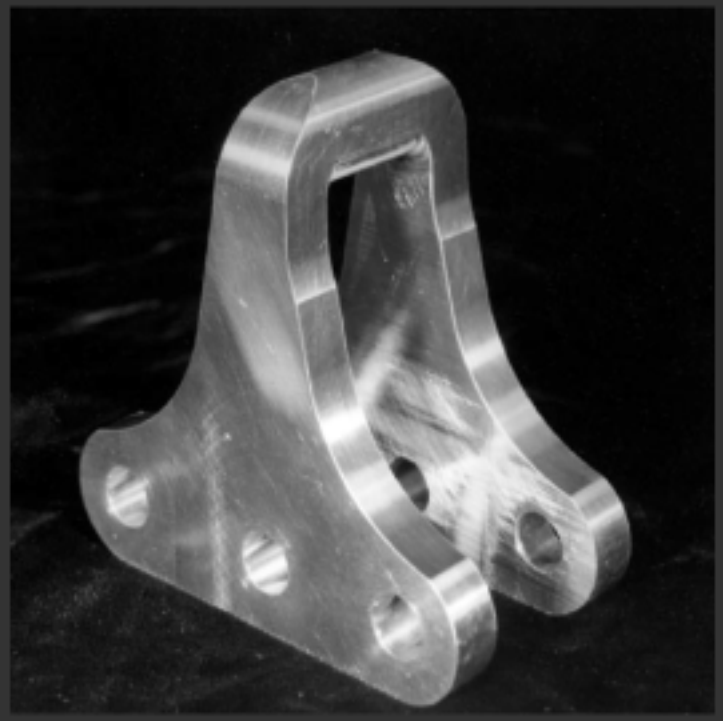
$$L = \text{lerp}(\frac{1 + \hat{\mathbf{N}} \bullet \hat{\mathbf{L}}}{2}, C_{cool}, C_{warm})$$

Tone-based Shading



Blue to yellow + object color

Anisotropic Metallic Objects

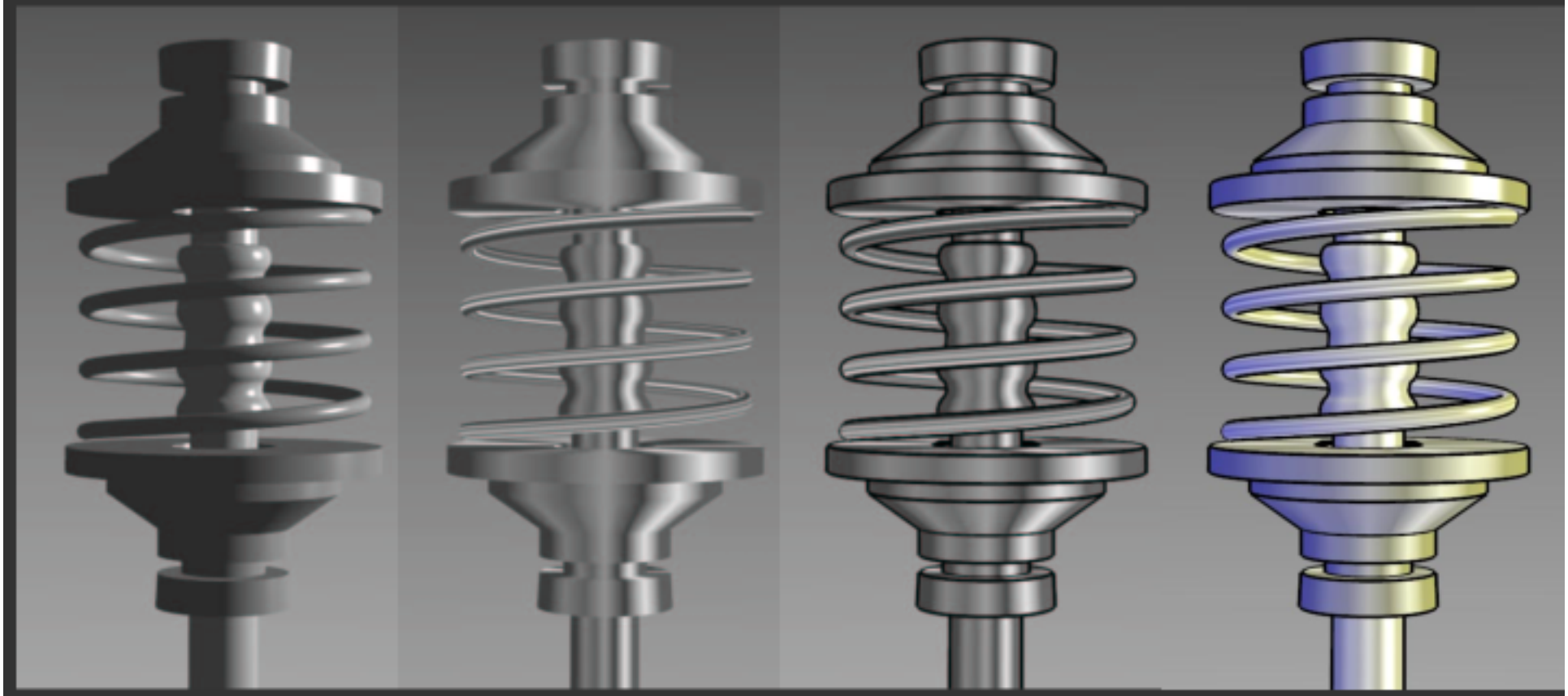


Shading of Metal Objects

In practice illustrators represent a metallic surface by alternating dark and light bands, what is known as "*anisotropic reflection*" on milled metal parts. Lines are streaked in the direction of the axis of minimum curvature,

To simulate a milled object, we map a set of 20 stripes of varying intensity along the parametric axis of maximum curvature. The stripes are random intensities between 0.0 and 0.5 with the stripe closest to the light source direction overwritten with white. Between the stripe centers the colors are linearly interpolated.

Metallic Shading



Phong Metal Metal+Edges Metal+Tone