A Non-Photorealistic Lighting Model for Automatic Technical Illustration

from Gooch, Gooch, Shirley, and Cohen, SIGGRAPH 98.

Technical Illustration Goals

Shape information more important than photorealism

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

• Tufte
Technical Illustration

Characteristics

Edge lines drawn with black curves
  • boundaries, silhouettes, discontinuities

White highlights from single light source

Shading stays far from black and white
  • limited intensity range

Hue changes (warm to cool) help to indicate surface normal

Phong Illumination

highlights lost
edge lines would be hard to see
no variation dark regions
Solid Color +
Highlights and Edges

Restricted Intensity Phong + Edges
Diffuse Illumination

Standard Lambertian Model

\[ I = k_d \cdot k_a + k_d \cdot \max(0, \ l.n) \]

- Points with normals away from light all constant color

Color Interpolation Model

\[ I = (1+ l.n)/2 \cdot k_1 + [1 - (1+ l.n)/2] \cdot k_2 \]

- Variation across entire range of normals

\[ l.n \in [-1, 1] \]

Color Temperature Principles

Warm colors approach

- Red, yellow, orange

Cool temperatures recede

- Blue, violet, green
Cool-to-Warm Illumination

Blue-to-yellow illumination

- $k_1 = \text{blue} = (0,0,b)$
- $k_2 = \text{yellow} = (y,y,0)$

Scaled object-color illumination

- $k_1 = \text{black} = (0,0,0)$
- $k_2 = \text{object color} = k_d$

Combined model

- $k_1 = k_{\text{cool}} = (0,0,b) + \alpha k_d$
- $k_2 = k_{\text{warm}} = (y,y,0) + \beta k_d$

Constant Luminance, Changing Hue
Changing Hue and Luminance

Approximating Cool-to-Warm Illumination in OpenGL

Two directional lights
- Direction $L$, intensity $(k_{\text{warm}} - k_{\text{cool}})/2$
- Direction $-L$, intensity $(k_{\text{cool}} - k_{\text{warm}})/2$
  — Negative intensities are legal!

Ambient light
- Intensity $(k_{\text{cool}} + k_{\text{warm}})/2$

White surface color
Add white highlights using second pass
Illustrative Metal Shading

Milled metals exhibit streaks along milling axis

Simulate this anisotropy using stripes of various intensities along milling axis

- Random stripe intensities from 0.0 to 0.5
- Stripe closest to light direction is white
- Linearly interpolate colors between stripes

Metal Shading + Edges

Phong Metal
Video