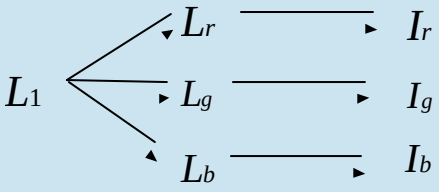
Lighting and Shading

Shading - recap

- Adding colour

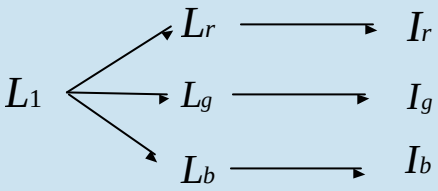


$$I_r = K_{ar}L_{ar} + K_{dr}(l \cdot n)L_{dr} + K_{sr}(r \cdot v)^{a_r}$$
$$I_g = K_{ag}L_{ag} + K_{dg}(l \cdot n)L_{dg} + K_{sg}(r \cdot v)^{a_g}$$
$$I_b = K_{ab}L_{ab} + K_{db}(l \cdot n)L_{db} + K_{sb}(r \cdot v)^{a_b}$$

- Combine $I_r + I_g + I_b$

Shading - recap

- Adding colour



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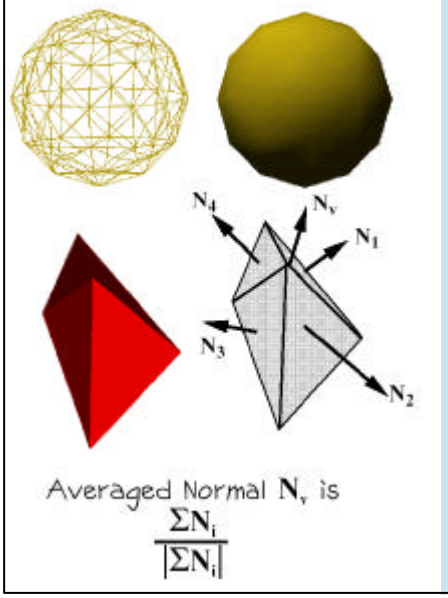
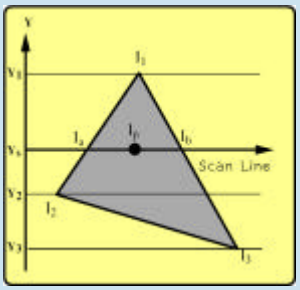
- Combine $I_r + I_g + I_b$

Gouraud Shading (intensity interpolation)



Intensity interpolation along each scan line and along polygon edges.

$$I_a = I_1 - (I_1 - I_2)\frac{Y_1 - Y_s}{Y_1 - Y_2}$$
$$I_b = I_1 - (I_1 - I_3)\frac{Y_1 - Y_s}{Y_1 - Y_3}$$
$$I_p = I_b - (I_b - I_a)\frac{X_b - X_p}{X_b - X_a}$$



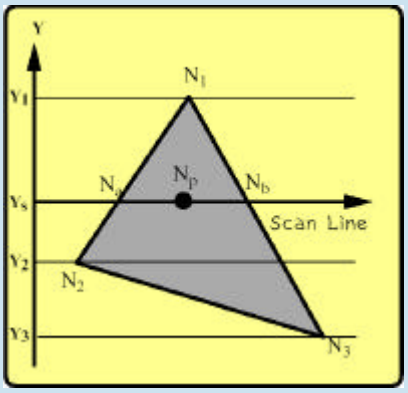
Phong Shading (normal vector interpolation)

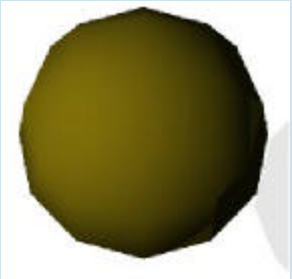
- Normal vector interpolation along each edge and each scan line

$$N_a = N_1 - (N_1 - N_2)\frac{Y_1 - Y_s}{Y_1 - Y_2}$$

$$N_b = N_1 - (N_1 - N_3)\frac{Y_1 - Y_s}{Y_1 - Y_3}$$

$$N_p = N_b - (N_b - N_a)\frac{X_b - X_p}{X_b - X_a}$$





Shading comparisons

Flat

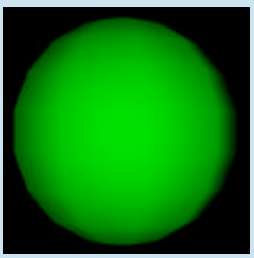
- single colour to each polygon
- fast
- facetted look

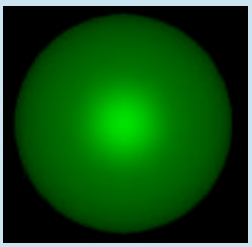
Gouraud

- intensity interpolation
- smoother effect
- some mach banding
- specular highlights handled poorly
- more computation

Phong

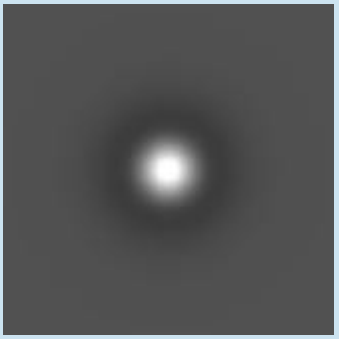
- vector normal interpolation
- more accurate
- more realistic highlights
- much less Mach banding
- much more computation





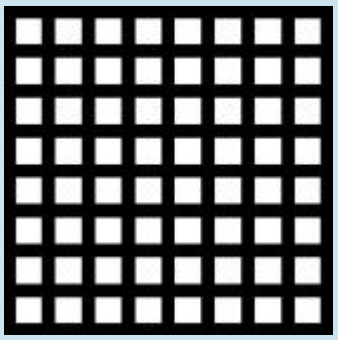
Human Perception and Light

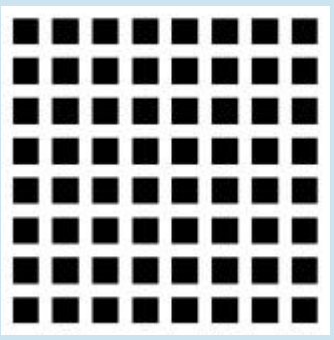
- Difference Signaling
  - Contrast vs. value information
  - Light value information vs. object information.
- cell has normal rate
  - light in centre excites
  - light in surrounds inhibits
- Colour and Lightness Constancy



Consequences

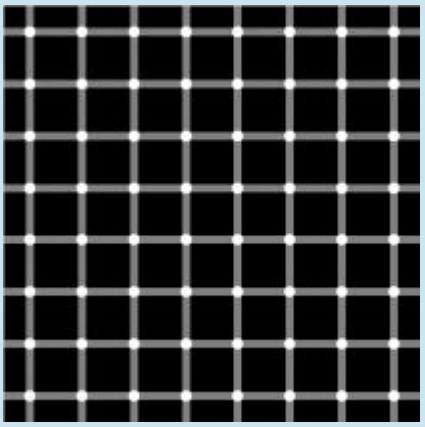
- Hermann Grid Illusion





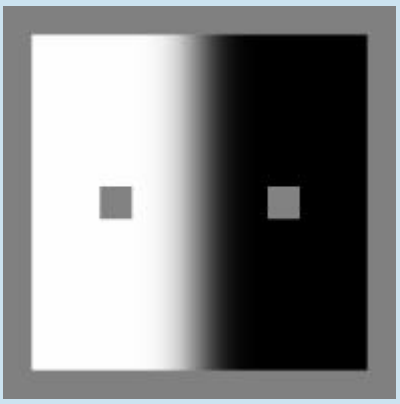
Consequences

- Scintillating Grid



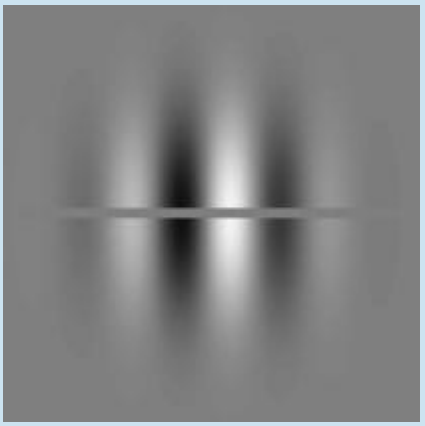
Consequences

- Simultaneous Brightness Contrast



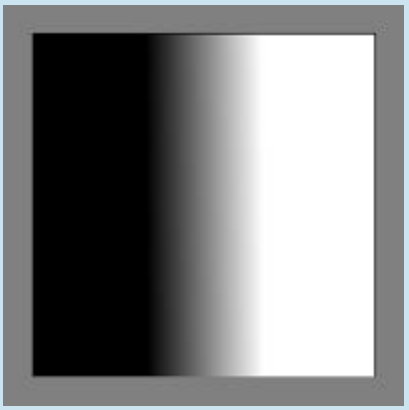
Consequences

- Grating Induction Effect



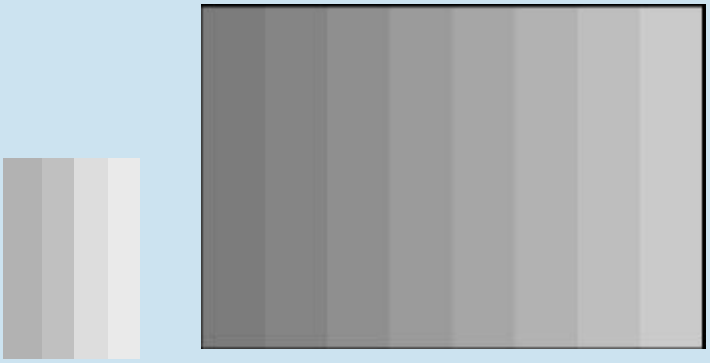
Consequences

- Mach Banding



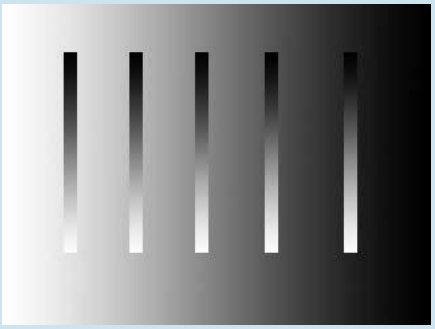
Consequences

- Chevreul Illusion



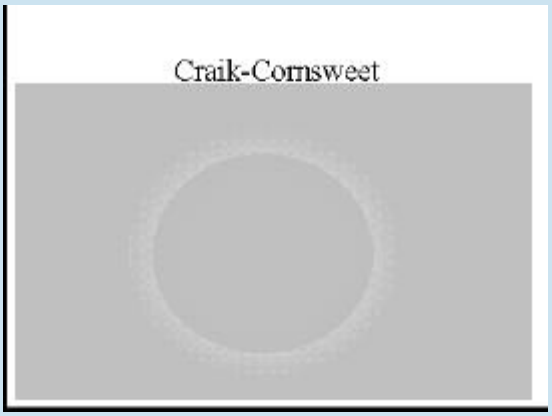
Consequences

- Crispening



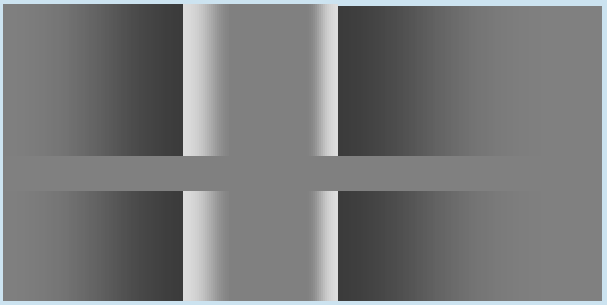
Consequences

- Craik-Cornsweet Effect



Consequences

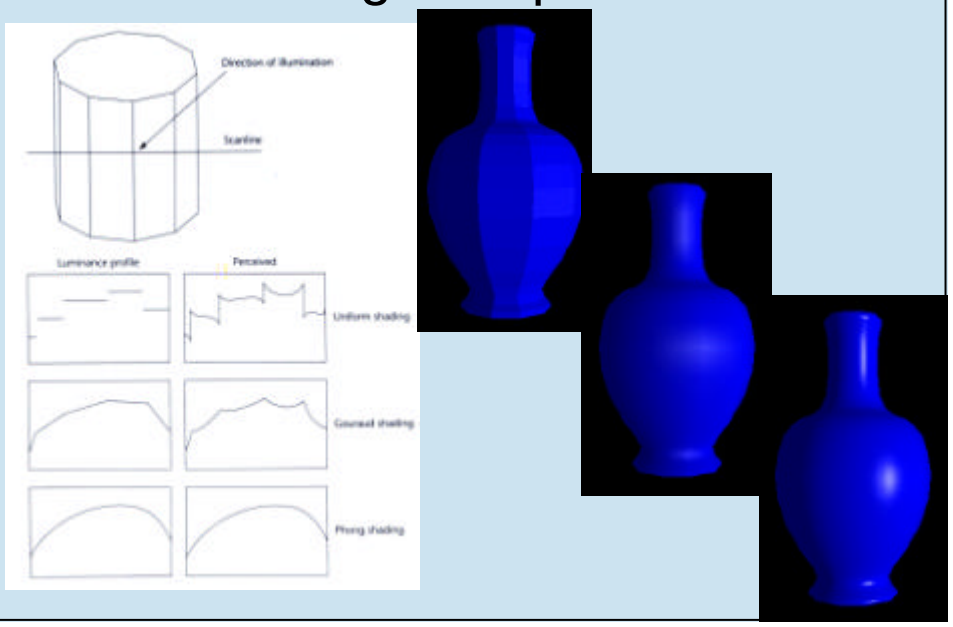
- Craik-Cornsweet Effect



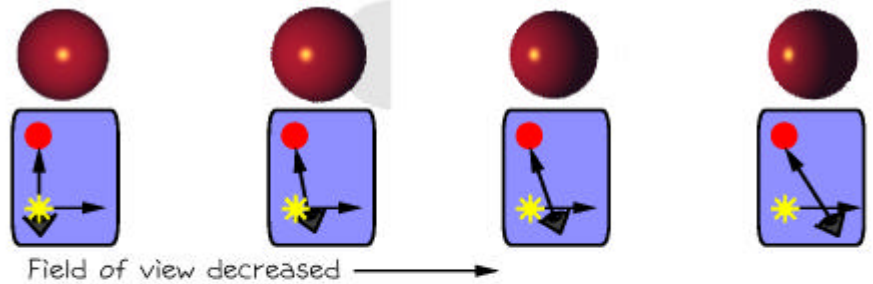
Seurat: The Bathers

- Craik-Cornsweet Effect

Shading Comparisons

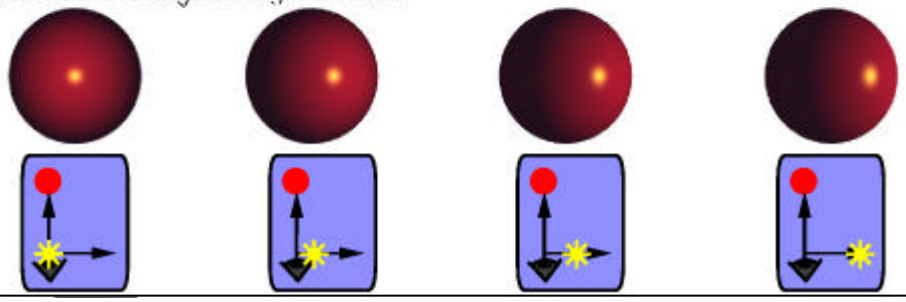


Phong Model – Effect of moving the eye



Field of view decreased →

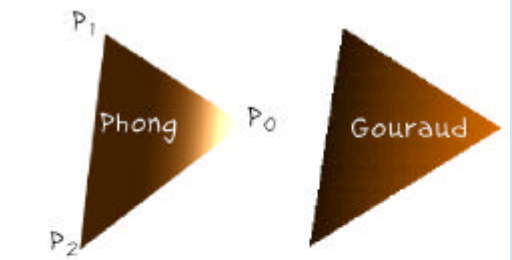
Effect of moving the light source



Specular Colour

small specpower no reflection white specular	large specpower no reflection white specular	large specpower low reflection white specular	large specpower higher reflection yellow specular	large specpower low reflection yellow specular
surface ebrass ambient 0.17 0.10 0.01 diffuse 0.45 0.29 0.04 specular .1 .1 .1 specpow 2 reflect 0	surface dbrass ambient 0.17 0.10 0.01 diffuse 0.45 0.29 0.04 specular .3 .3 .3 specpow 10 reflect 0	surface cbrass ambient 0.17 0.10 0.01 diffuse 0.45 0.29 0.04 specular .9 .9 .9 specpow 35 reflect 0.1	surface abrass ambient 0.17 0.10 0.01 diffuse 0.45 0.29 0.04 specular .9 .9 0.2 specpow 35 reflect 0.1	surface bbrass ambient 0.17 0.10 0.01 diffuse 0.45 0.29 0.04 specular .9 .9 0.2 specpow 35 reflect 0.4

More on Phong shading



The normal vectors have been adjusted to give a highlight at P_0 but not at the other vertices. In the Goraud interpolation scheme the highlight is lost, averaged out with the other vertex intensities. The Phong interpolation finds the correct highlight.

Problems with interpolation methods

- **Expensive:** since illumination calculation is repeated for every pixel. Also calculating and normalising new normal. (Schlick equation and table look up methods).
- **Silhouette edge:** Attempts have been made to modify normals to match a curve fitted to the edge. (see Van Overveld and Wyvill)
- **Perspective distortion:** Intensity interpolation is performed in screen space. The z has undergone a non-linear transformation.

Problems with interpolation methods

- **Orientation Dependence:** The results of an interpolation model are not independent of the projected polygons orientation. Results may differ when the polygon is rotated affecting animations.
- **Problems at Shared Vertices:** This problem is analagous to the cracks problem in subdivided meshes. The undivided edge is interpolated differently to the two divided edges.
- **Unrepresentative Vertex Normals:** Pathalogical cases where interpolated normals give poor results. Examples are staircase example and mobius strip.