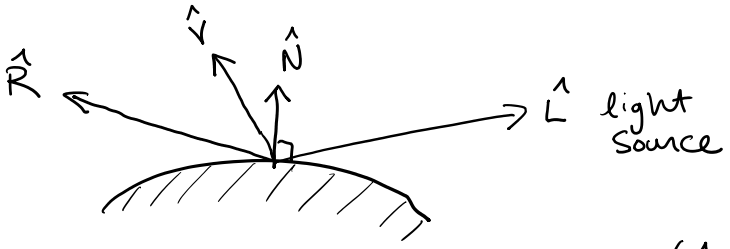
Ray Tracing - Phong Shading

Monday, 14 March 2022 10:10



Bright diffuse if $(\hat{L}\cdot\hat{N})$ large

Bright specular if $(\hat{R}\cdot\hat{V})$ large

- if "metalic" then specular color = light source
  else specular color $\approx$ material color

$$\rho = m_a \underline{C}\,\underline{A} + \sum_{m \in \text{lights}} \left[m_d \underline{C}\,\underline{I}_m \max(\hat{L}_m \cdot \hat{N}) + m_s \underline{S}\,\underline{I}_m \max(\hat{R}_m \cdot \hat{V})^{m_{sp}} \right]$$

$$\underline{S} = m_{sm}\underline{C} + (1 - m_{sm})(1,1,1)$$

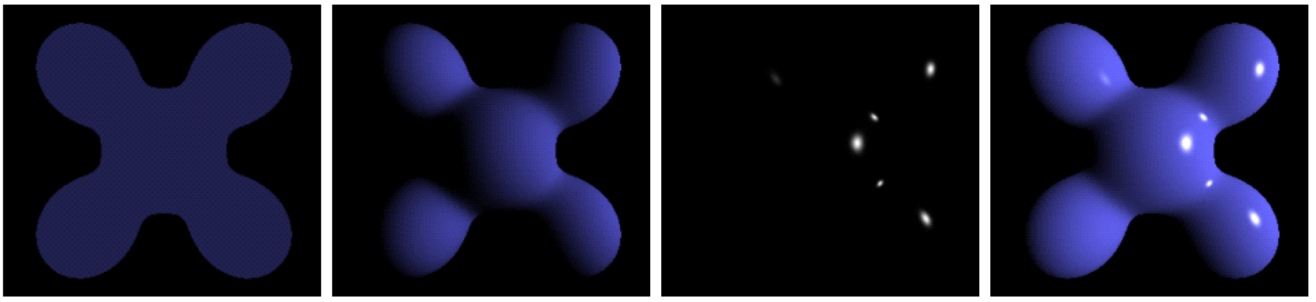
Note: $\underline{C}\,\underline{I} = \{C_r I_r, C_g I_g, C_b I_b\}$
component-wise multiplication

Light $\underline{I}_m = (R,G,B)$ intensity of infalling light
$\underline{A} = (R,G,B)$ intensity of ambient light

Object $\underline{C} = (R,G,B)$ is the color of the object
$\underline{S}$ specular highlight color, which is linearly interpolated according to m_{sm}.

Material m_a, m_d, m_s — ambient, diffuse (Lambertian) and specular reflection
m_{sp} Phong exponent
m_{sm} is the "metalness" of the material (0 → very metalic)

$$\hat{R}_m = 2(\hat{L}_m \cdot \hat{N})\hat{N} - \hat{L}_m$$



Ambient + Diffuse + Specular = Phong Reflection

Can we do it faster? Typical m_{sp} is large (like $m_{sp} = 40$)

$$\max(\hat{R}_m \cdot \hat{V})^{\alpha} = \max(1-\lambda)^{\beta\gamma} = (\max(1-\lambda)^{\beta})^{\gamma}$$
$$\approx \max(1-\beta\lambda)^{\gamma}$$

where $\lambda = 1 - \hat{R}_m \cdot \hat{V}$ and $\beta = \frac{\alpha}{\gamma}$ (small)

If γ is chosen to be an integer power of 2, i.e., $\gamma = 2^n$

$(1-\beta\lambda)^{\gamma}$ → square $(1-\beta\lambda)$ n times

$$(1-\beta\lambda)^{\gamma} = (1-\beta\lambda)^{2^n} = (1-\beta\lambda)^{2\cdot 2\cdot 2\cdot 2\cdots} = (\cdots((1-\beta\lambda)^2)^2\cdots)^2$$

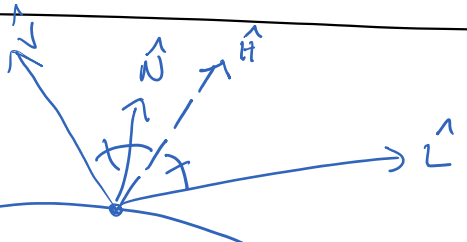
holds for sufficiently large γ (4 or 8)

$$\lambda = (\hat{R}_m - \hat{V}) \cdot (\hat{R}_m - \hat{V})/2$$

or

$$= (\hat{R}_m \times \hat{V}) \cdot (\hat{R}_m \times \hat{V})/2$$

Blinn-Phong



$(\hat{R} \cdot \hat{V})^{\alpha} \longmapsto (\hat{N} \cdot \hat{H})^{\alpha'}$ $\quad \alpha' > \alpha$

For a front lit surface $\alpha' = 4\alpha$

$\hat{H}$ is independent of position if $L \to$ "∞" $V \to$ "∞"

↑ calculate it once.

RASTER GRAPHICS