Paramater	Type	Default	Description
a_{cm}	Color	(.2, .2, .2, 1)	ambient color of material
d_{cm}	Color	(.8, .8, .8, 1)	diffuse color of material
s_{cm}	Color	(0, 0, 0, 1)	specular color of material
e_{cm}	Color	(0, 0, 0, 1)	emissive color of material
s_{rm}	double	0	specular exponent of material (range: [0.0, 128.0])
a_{cli}	Color	(0, 0, 0, 1)	ambient color of light i
d_{cli}	Color	(1, 1, 1, 1)	diffuse color of light i
s_{cli}	Color	(1, 1, 1, 1)	specular color of light i
P_{pli}	double[4]	(0, 0, 1, 0)	position of light i
s_{dli}	double[3]	(0, 0, -1)	spotlight direction of light i
s_{rli}	double	0	spotlight exponent for light i (range: [0.0, 128.0])
c_{rli}	double	180	spotlight cutoff angle for light i (range: [0.0,90.0],180.0)
k_{0li}	double	1	constant attenuation factor for light i (range: [0.0,∞))
k_{1li}	double	0	linear attenuation factor for light i(range: [0.0,∞))
k_{2li}	double	0	quadratic attenuation factor for light i(range: [0.0,∞))
a_{cs}	Color	(.2, .2, .2, 1)	ambient color of scene

Define:
$d_1 \odot d_2 = \max d_1 \cdot d_2, 0$
If c_1 and c_2 are colors, then $c_1 * c_2$ is the color $(r_1r_2, g_1g_2, b_1b_2, a_1a_2)$.

If P_1 and P_2 are homogeneous points, then let $\overrightarrow{P_1P_2}$ be the unit vector that points from P_1 to P_2. Note that if P_2 has a zero w coordinate and P_1 does not, then $\overrightarrow{P_1P_2}$ is the unit vector corresponding to the direction specified by the x, y, and z coordinates of P_2. If P_1 has a zero w coordinate and P_2 does not, then $\overrightarrow{P_1P_2}$ is the unit vector that is the negative of that correspoinding to the direction specified by P_1. If both P_1 and P_2 have zero w coordinates, then $\overrightarrow{P_1P_2}$ is the unit vector obtained by normalizing the direction corresponding to $P_2 - P_1$.

If d is a direction, $\hat{d}$ is the unit vector in d's direction. Let $||P_1P_2||$ be the distance between P_1 and P_2. Let V be the point being lit, and n be the corresponding normal. Let P_e be the eyepoint. Finally, let nl be the number of lights.

Then, the color c produced by lighting a point is:

$$
\begin{aligned}
c \quad &= \quad e_{cm} && (1)\\
&+ \quad a_{cm} * a_{cs} && (2)\\
&+ \quad \sum_{i=0}^{nl-1} (\mathrm{att}_i)(\mathrm{spot}_i)[a_{cm} * a_{cli} && (3)\\
&\quad + \quad (n \odot \overrightarrow{VP_{pli}}) d_{cm} * d_{cli} && (4)\\
&\quad + \quad (f_i)(n \odot \hat{h}_i)^{s_{rm}} s_{cm} * s_{cli}] && (5)
\end{aligned}
$$

where

$f_i = \begin{cases} 1 & n \odot \overrightarrow{VP_{pli}} \neq 0 \\ 0 & \text{otherwise} \end{cases}$

$h_i = \overrightarrow{VP_{pli}} + \overrightarrow{VP_e}$

$\mathrm{att}_i = \begin{cases} \frac{1}{k_{0i} + k_{1i}\|VP_{pli}\| + k_{2i}\|VP_{pli}\|^2} & \text{if } P_{pli}\text{'s } w \neq 0 \\ 1.0 & \text{otherwise} \end{cases}$

$\mathrm{spot}_i = \begin{cases} \left(\overrightarrow{P_{pli}V} \odot \hat{s}_{dli}\right)^{s_{rli}} & c_{rli} \neq 180 \text{and} \overrightarrow{P_{pli}V} \odot \hat{s}_{dli} \geq \cos(c_r li) \\ 0.0 & c_{rli} \neq 180 \text{and} \overrightarrow{P_{pli}V} \odot \hat{s}_{dli} < \cos(c_r li) \\ 1.0 & c_{rli} = 180 \end{cases}$