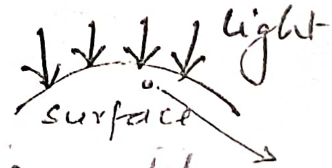
Basic Illumination Model

Differentiate between shading, illumination and intensity.

Shading	Illumination	Intensity
↓	↓	↓
portion shown by illumination	Brightness	Quantity of illumination

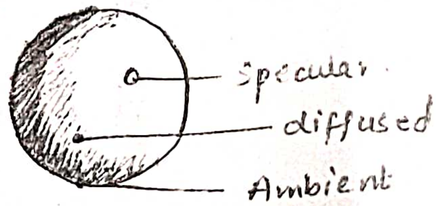
In Illumination model, we find out the intensity of illumination on a particular object/ object-surface at a particular point.



Also known as shading model or lighting model.

It has got 3 components.

1) Ambient illumination
2) Diffused Reflection
3) Specular Reflection



① Ambient Illumination / Diffused illumination

A surface that is not exposed to direct light may still be lit up by reflections from other nearby objects — ambient light.

The amount of incident light reflected by a surface depends on the type of material.

Shiny material reflect more of the incident light and dull surfaces absorb more of the incident light.

~~At~~ Ambient Component $= I_a K_a$

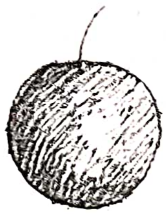
I_a = intensity of ambient light, K_a – % of light reflected by surface

Diffuse Reflection

- Surfaces that are rough / grainy, tend to reflect ly in all directions.
- This scattered light is called diffused reflection.
- Such surfaces are called ideal diffuse reflectors.
- Lambertian surface appears equally bright from all the viewing directions. Because they reflect light with equal intensity in all directions. Ex:- snow

Specular Reflection

In specular reflection, some portion of the surface generates more light or may produce a bright spot. This is called specular reflection. Example:- metal surfaces, shiny plastic, gold and silver coated surface.

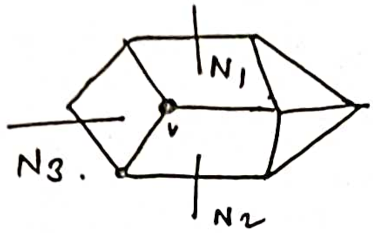


Phong shading

Specific type of shading technique in 3D-CG that is useful for smoothening out multi surface shapes and creating more sophisticated computer modeled images. This technique is called interpolation, where phong shading visualises a smoother surface for 3D model.

linearly interpolate vertex intensity over the surface of program.

1) $N_v = \dfrac{N_1 + N_2 + N_3}{|N_1 + N_2 + N_3|}$

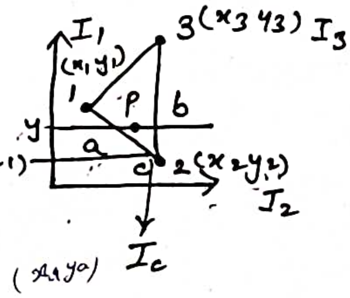


$= \dfrac{\sum_{i=1}^{n} N_i}{|\sum_{i=1}^{n} N_i|}$

where n = no. of surfaces in polygon sharing that vertex.

2) By applying illumination model we get intensity of each vertex.

3) Intensity of a point :-



$$I_a = \frac{y_a - y_2}{y_1 - y_2} I_1 + \frac{y_1 - y_a}{y_1 - y_2} I_2$$

Intensity of b point :-

$$I_b = \frac{y_b - y_2}{y_2 - y_3} I_3 + \frac{y_3 - y_b}{y_2 - y_3} I_2$$

Intensity of P point :-

$$I_p = \frac{x_b - x_p}{x_b - x_a} \cdot I_a + \frac{x_p - x_a}{x_b - x_a} \cdot I_b$$

Now intensity of point I_c

$$I_c = I_a + \frac{I_2 - I_1}{y_1 - y_2}$$ → term is constant

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Gouraud shading

method used in comp. Graphics to simulate the differing effects of light and colour across the surface of an object. In practice, it is used to achieve smooth lighting on low polygon surfaces without heavy computational requirements of calculating lighting for each pixel.

Basic Principle:- In this method, we calculate the surface normals at the vertices of a polygons in a 3D computer model. These normals are then averaged for all the polygons that meet at each point. Lighting computations are then performed to produce colour intensities at vertices. The lighting calculation used by Gouraud was based on the Lambertian diffuse lighting model.

Gouraud shading was used to remove the drawback of flat shading which says that for every face of a polygon, we need to multiply its Normal vector with the intensity to get the shade which actually had too much discontinuity.

Gouraud shading used intensity - interpolation method

Interpolation:- using known/ established values, we find unknown values.

3 Step of this shading

1.) find the avg. unit normal vector at each polygon
2.) apply illumination model to each polygon vector to determine polygon vector intensity.

Colors

The 3 primary colors used by artists are Red, yellow and blue but when examined scientif-ically it was found that the primary colors are actually Red, Green and Blue because their wavelengths are spread more evenly across the visible light spectrum.

Primary colors – Red, Green and Blue, they are also called additive primary colors because making their combination will generate other different colors.

Secondary colors:- Mixing the primary colors, produce three additional colors called secondary colors.

Red + Green = yellow
Red + Blue = magenta
Green + Blue = cyan

They are also called subtractive primary colors. You can see your toner cartridges of the printer which are yellow, magenta and cyan. (along with black)

Characterstics of Color.

1.) Dominant frequence (Hue)

The color that we see (red, green, purple etc.)

2.) Brightness

The total light energy which shows how much object is illuminating.

3.) Purity (Saturation)

how close a light appears to be a pure spectral Colour, ex. pink is less saturated then red.

4) Chromaticity

Purity and hue combined together.

A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as 3-4 values or color components.

Color Gamut → set of all colors that we can produce from primary colors.

Shade → a shade is produced by dimming a hue or adding black.

dark blue = pure blue + black.

Tint → tint is produced by "lightening" a hue or adding white.

pastel red = pure red + white.

Tone → refers to the effects of reducing the

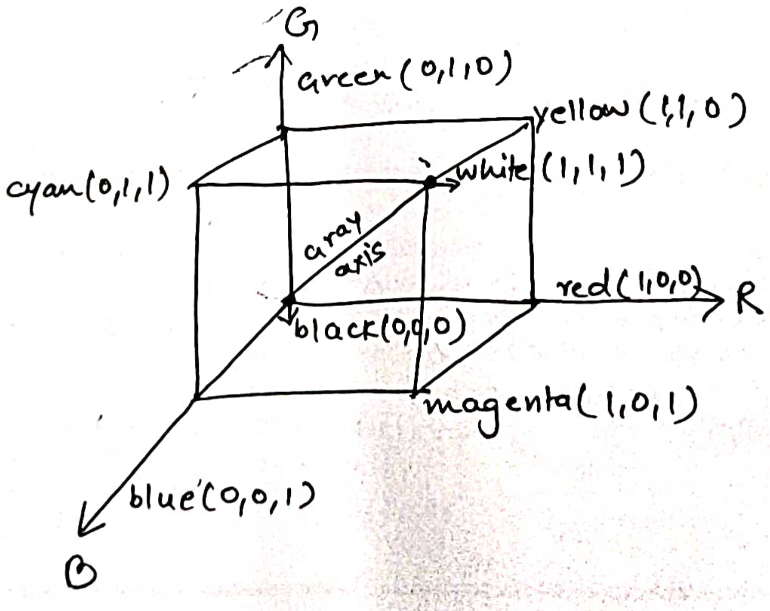
Ray tracing

It is a rendering technique in 3D CG for generating an image by tracing the path of light as pixels in an image plane and simulating the effects of its encounters with virtual objects.

Color Models

1) RGB (Red, Green, Blue) model

- most widely used in comp. graphics
- use color coordinate system with 3 primary colors Red, green, blue.
- each primary color can take an intensity value from 0 (lowest) to 1 (highest)
- Mixing these 3 colors at different intensity levels produces a variety of colors.
- The collection of all these colors obtained by linear combination of red, green and blue forms the cube shaped RGB color space.



- In RGB model, an arbitrary color within the cubic color space can be specified by its color coordinates (r, g, b)

It uses additive process, wherein we begin with an additive process of adding appropriate primary components to black color to yield desired color.

- This concept is used in Display monitor (LCD)
- considered to be vibrant.

The CMY model

- Stands for cyan-magenta-yellow color model.
- used for hardcopy devices.
- It uses subtractive process unlikely to RGB which use additive process.
- The C-M-Y coordinates are just the complement of the R-G-B coordinates.

$$\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

- Good for reading, not vibrant.
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Conversion Policy (RGB to CMYK) cyan-magenta-yellow-black key

- The black Key (K) color is calculated from Red, green and blue colors.

$$K = 1 - \max(R, G, B)$$

- The cyan color (C) is calculated from Red and Black color.

$$C = (1-R-K)/(1-K)$$

The magenta color (M) is calculated from Green and black colors.

$$M = (1-G-K)/(1-K)$$

- The yellow color (y) is calculated from the blue and black colors.

$$Y = (1-B-K)/(1-K)$$

Example:-

Lets assume there is a RGB value for violet color (100, 50, 150). Convert it into CMYK.

According to formula,

$$R' = 100/255 = 0.392$$
$$G' = 50/255 = 0.196$$
$$B' = 150/255 = 0.588.$$
$$K = (1-0.588) = 0.412$$

There is a core formula, RGB values are divided by 255 to change the range from 0...255 to 0...1

so = $R = R/255$, $G = G/255$, $B = B/255$

continue...

$$C = (1-R'-K)/(1-K) = 0.333$$
$$M = (1-G-K)/(1-K) = 0.667$$
$$Y = (1-B-K)/(1-K) = 0.$$

So, CMYK values for violet are (.333, .667, 0) colorfulness" of a hue or adding gray or black & white.

YIQ model

- used for US TV Broadcast
- designed to separate chrominance (I and Q) from luminance (Y)
- used in video system.

HSV model

Every color is represented by 3 components Hue (H) Saturation (S) and value (V). We have already seen hue and saturation earlier. V here is called lightness, which describes how dark the color is.