EECS101 Discussion 7

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The Object

- A sphere centered at $(0, 0, z_0)$ given by

$$z(x, y) = z_0 + \sqrt{r^2 - (x^2 + y^2)}, (x^2 + y^2) \leq r^2$$

  ◦ Given the representation, we can derive (p,q). Therefore, we can compute the normal given by

$$N = (-p, -q, 1); \ \widehat{N} = \frac{(-p, -q, 1)}{\sqrt{p^2 + q^2 + 1}}$$

Imaging conditions

- $\hat{S}$: source direction,
- $\hat{V}$: viewing direction, always $(0,0,1)$

- $\widehat{H}$: angular bisector between $\hat{V}$ and $\hat{S}$

$$\widehat{H} = \frac{\hat{V} + \hat{S}}{\left|\hat{V} + \hat{S}\right|}$$

* Note all vectors are unit vectors

The Image Formation

- Scene radiance *L* is given by

$$L(x, y) = aL_l + (1 - a)L_s; \quad 0 \leq a \leq 1$$

Lambertian reflectance L_l and specular reflectance L_s

- Image irradiance is proportional to the scene radiance

- Range of L：[0,1]; range of image：[0,255]

The Image Formation

▸ Lambertian reflectance
$$L_l = \cos(\theta)$$
◦ Where θ is the angle between the source and the surface normal
▪ <u>Note only consider $\cos(\theta) \geq 0$</u>

▸ Specular reflectance
$$L_s = \exp(-(\alpha/m)^2)$$

◦ m is related to the surface roughness.
◦ α is the angle in radians between the surface normal $\widehat{N}$ and $\widehat{H}$

To obtain the angles

▸ Relationship between the dot product and the angle

$$\cos(\theta) = \frac{a \cdot b}{|a||b|} = a \cdot b$$

$$\theta = \arccos(a \cdot b)$$

◦ Where a and b are two unit vectors, and θ is the angle between the two

Configurations to Use

▸ Use at least the following 9 configurations and generate 9 images respectively
  ◦ a) S= [0, 0, 1], r = 50, a = 0.5, m = 1
  ◦ b) S = $[1/\sqrt{3}, 1/\sqrt{3}, 1/\sqrt{3}]$, r = 50, a = 0.5, m = 1
  ◦ c) S = [1, 0, 0], r = 50, a = 0.5, m = 1
  ◦ d) S= [0, 0, 1], r = 10, a = 0.5, m = 1
  ◦ e) S= [0, 0, 1], r = 100, a = 0.5, m = 1
  ◦ f) S= [0, 0, 1], r = 50, a = 0.1, m = 1
  ◦ g) S= [0, 0, 1], r = 50, a = 1, m = 1
  ◦ h) S= [0, 0, 1], r = 50, a = 0.5, m = 0.1
  ◦ i) S= [0, 0, 1], r = 50, a = 0.5, m = 10000

Grading Criteria

- Total 100 points
  - 20 points for written problem
  - 10 points for submitting program
  - 25 points for the report containing
    - 10 points for deriving the normal
    - 15 points for explaining the effect of each of the four variables: S, m, a and r
      - Use image a as reference, describe your observation and the reason why it is the case
  - 45 points for the nine images

Submission Guideline

> Put your images, your program and report in a single file. For each image, specify the configuration used to generate it.