EECS101 Discussion 7

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The Object

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

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

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

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

    - Note normal at points that satisfy $(x^2 + y^2) = r^2$ is a special case and should be treated separately:
    - $N = (\mathrm{x},\ y,\ 0)$ and remember to normalize it.

Imaging Conditions

- $\hat{S}$: source direction
- $\hat{V}$: viewing direction, always at (0,0,1)
- $\hat{H}$: angular bisector between $\hat{V}$ and $\hat{S}$

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

*Note all vectors are unit vectors

The Image Formation

- Scene radiance L is given by

$$L = aL_l + (1 - a)L_s\ ,\ where\ 0 \leq a \leq 1$$

  - It consists of two components: a Lambertian component L_l and a specular component L_s.
  - The overall effect is a weighted average between the two controlled by a.
- Image irradiance is proportional to the scene radiance
- Image irradiance to pixel value

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
  - Note only consider $\cos(\theta) \geq 0$
- Specular reflectance

$$L_s = e^{-\left(\frac{\alpha}{m}\right)^2}$$

  - m is related to the surface roughness
  - α is the angle in radians between the normal and H is given by

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

To obtain the angles

- Relationship between the dot product and the angle

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

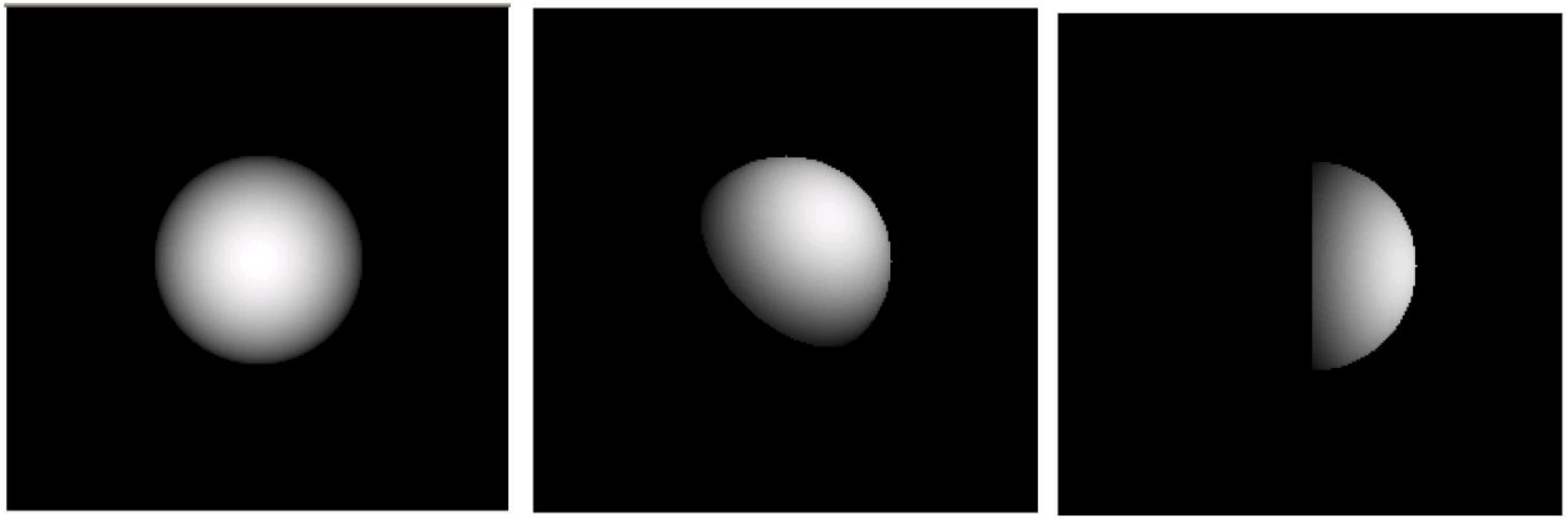
$$\theta = \arccos(\vec{a} * \vec{b})$$

  - Where $\vec{a}$ and $\vec{b}$ are unit vectors, and * denotes the dot product operation and θ is the angle between the two vectors

Configurations to Use

- You need to 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

Example



Grading Criteria

- Total 100 points
  - 10 points for submitting a program
  - 20 points for demo
  - 25 points for the report containing
    - 5 points for deriving the normal
    - 10 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
      - Vary S: a) b) c)
      - Vary r: d) e) f)
      - Vary a: c) f) g)
      - Vary m: c) h) i)
  - 45 points for the nine images

Submission Guideline

- Put your images, program and write-up in a single file.
- For each image, **specify the configuration** used to generate it. Submit it and your program to Canvas by Mar 3rd midnight.