Sam Saltwick
November 20th 2018
Fall 2018

Shape from Shading

Quantitative Shape Recovery

- Orthographic projection
- We have gray levels at pixels (x, y)
- We want to recover the orientations of the normals at points (x, y, z)
- By integration, we want to obtain $z = f(x, y)$

Radiance

- Radiance $L(\theta_1)$ is power emitted per unit area (flux) into a cone having unit solid angle

Reflectance

- Reflection is characterized by reflectance
- Ratio of radiance/irradiance
- Described by a function called Bidirectional Reflectance Distribution Function
- BRDF = $f(\theta_i, \phi_i, \theta_e, \phi_e) = \frac{L(\theta_e, \phi_e)}{dE(\theta_i, \phi_i)}$

Labertian Surfaces

- If BRDF is a constant K, surface is called a Lambertian surface

Simple Radiometric Modeling

- Pixel brightness is proportional to radiance of corresponding scene patch
- Pixel brightness is proportional to cosine of angle between normal to patch and direction of illumination source
- For a given pixel brightness, the locus of possible normals (p, q) in gradient space is a conic

Normals to $z = f(x, y)$

- Intersect surface plane $z = f(x, y)$ with red plane and blue plane
- Find tangents to red curve and blue curve
- Write that normal is perpendicular to 2 tangents and is in direction of cross-product

Gradient Space

- Orientations of normal can be represented by 2 parameters

$$p = \frac{\partial f}{dx}$$

$$q = \frac{\partial f}{dy}$$

- Components of p and q are called the gradient space coordinates of the normal
- Any direction (a, b, c) can be represented by $(-a/c, -b/c, -1)$ and by a point with 2 components in the same 2D gradient space

Geometric Interpretation of Gradient Space

- A direction (a, b, c) can be represented by a point on a plane $Z = -1$ by constructing the intersection between the vector of the same direction drawn from the origin, and the plane

Reflectance Map

- 2D lookup table that gives the pixel brightness as a function of the orientation of the scene surface in camera coordinates