CO2 AU4-1

01) What is surface reflectance albedo ? State the three factors it depends on, with the help of a suitable diagram of a surface normal and gradient space, derive / show step-by-step that the reflectance map R(p,q) is given by following equation

$$\frac{(pp_s + qq_s + 1)}{\sqrt{p^2+q^2+1}\sqrt{p_s^2+q_s^2+1}} = R(p,q)$$

Albedo is the percentage of solar energy striking a surface that is reflected away from the earth. Surface reflectance is ratio of the amount light not absorbed by a surface to the amount of light striking the surface. Albedo is a measure of energy and surface reflectance is a property of a material. The reflectance properties of an object depend on the material and its physical and chemical state the surface roughness as well as the geometric circumstance (ex incident angle of the sunlight). The reflectance of a material also varies with the wavelength of the electromagnetic energy.

A convinient representation for the relevant information is "reflectance map". The reflectance map, $R(p,q)$ gives scene radiance as a function of surface gradient (p,q) in a viewer centered coordinate system. If z is the elevation of the surface above a reference plane lying perpendicular to optical axis of imaging system.

$$p = \frac{\partial z}{\partial x} \quad \text{and} \quad q = \frac{\partial z}{\partial y}$$

The reflectance map $R(p,q)$ determines the proportion of light reflected as a function of p and q.

$$I(x,y) = R(p,q)$$

for $\cos(i)$, $\cos(e)$ and $\cos(g)$ can be derived using normalised dot products of the surface normal vector, $n = (p, q, -1)$, which points in the direction of light source and the vector $= (0,0,-1)$

$$X \cdot y = |x||y| \cos\theta$$ where θ is angle between the vectors

$$\cos(i) = \frac{1 + pp_s + qq_s}{\sqrt{1+p^2+q^2}\sqrt{1+p_s^2+q_s^2}}$$

$$\cos(e) = \frac{1}{\sqrt{1+p^2+q^2}} \qquad \cos(g) = \frac{1}{\sqrt{1+p_s^2+q_s^2}}$$

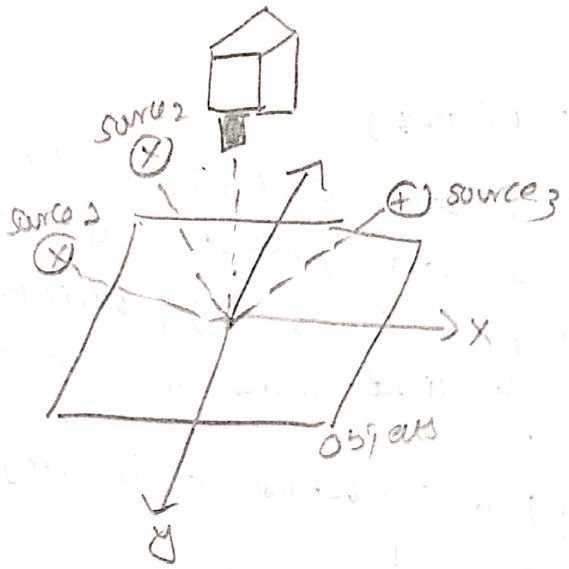
$$I(x,y) = I_0 \rho \cos(i) = I_0 \rho \left(\frac{pp_s + qq_s + 1}{\sqrt{p^2+q^2+1}\sqrt{p_s^2+q_s^2+1}} \right)$$

(Q2) Describe in detail the process of photometric stereo with a suitable diagram. How is the surface normal field/vectors $g(x,y)$ estimated?

Photometric stereo is a computer vision method of analyzing and detailing the contour and reflection of a surface in 3 dimensional space. The method involves shining an external light source on that surface moving the light and gathering multiple images based on the resulting illumination

Scenario

Photometric stereo has diverse applications most notably facial recognition, industrial product quality assurance control and an analyzing the surface of celestial objects notably moon.



We adapt a local shading model and assume that there is no ambient illumination

$$B(x) = \rho(x) N(x) \cdot S_1$$

where N is the unit surface normal and S_1 is the source vector. We assume that linear response of the camera is linear in surface radiosity and value of pixel at (x, y) is

$$\begin{aligned} I(x,y) &= kB(x) \\ &\approx kB(x,y) \\ &= k\rho(x,y) N(x,y) S_1 \\ &= g(x,y) \cdot v_1 \end{aligned}$$

where $g(x,y) = \rho(x,y) N(x,y)$ and $v_1 = kS_1$ where k is the constant connecting the Camera response to input radiance