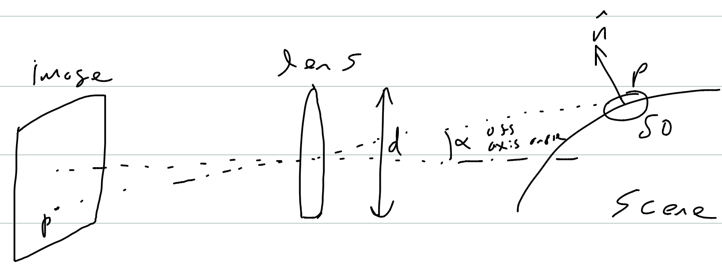
Lecture # 4 Shape from Shading

Nalwa "A guided tour of Computer Vision"

Marr "Vision



$$E(p) = L(p)\frac{\pi}{4}\left(\frac{d}{f}\right)^2 \cos^4 \alpha$$

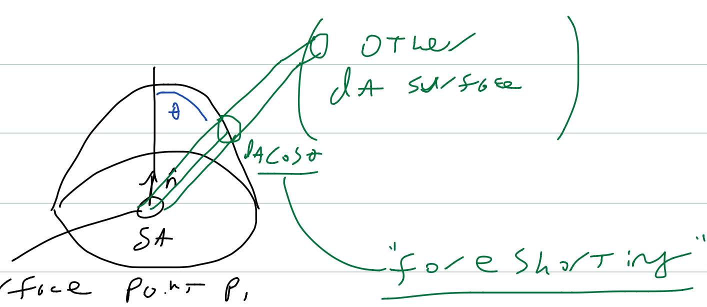
→ 1 is α is small

image irradiance — Scene radiance

1) irradiance (E) light incident on surface

$$E = \frac{\delta P}{\delta A}$$ — P – Power, A – area

2) radiance (L) light emitted from surface

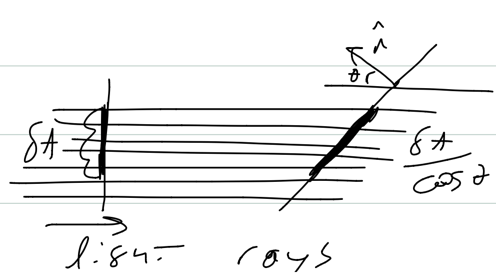


$$L = \frac{\delta P}{\delta A \, \delta \omega}$$

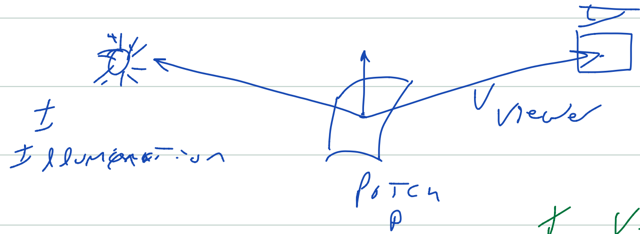
δP – energy power; δA – Area; δω – Solid Angle

Sphere = 4π sr

hemisphere = 2π sr



Simplest case for computer vision



I vector
$\|I\|$ brightness

$$E(x,y) \propto \rho(x,y)\, I \cdot A$$

image position

$0 \le \rho \le 1$
surface shading
"albedo"

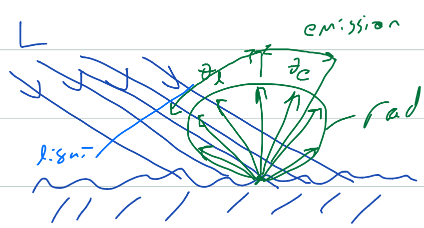
does not depend on viewing angle V

Lambertian Surface

matte paint, paper ✓

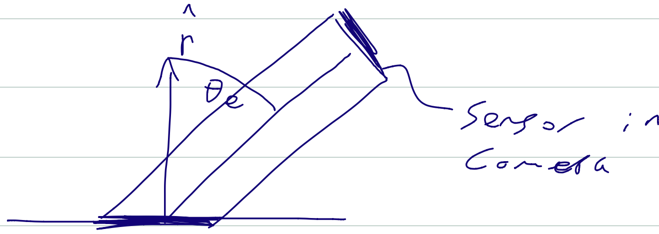
plastic, metal ✗

rough, non reflective surface.



radiate as $\cos\theta_e$

L: distant compact light source
(i.e. parallel rays)

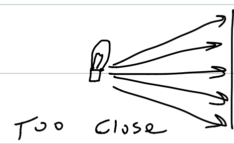


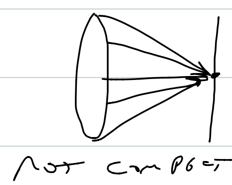
$$\frac{L(\theta_e)}{\cos\theta_e}$$

$$L(p) = \frac{L(\theta_e)}{\cos\theta_e} = \frac{L\cos\theta_e}{\cos\theta_e} = L$$

Assumptions

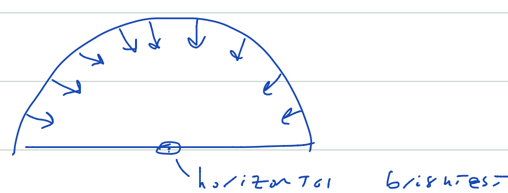
1) Single distant compact light source





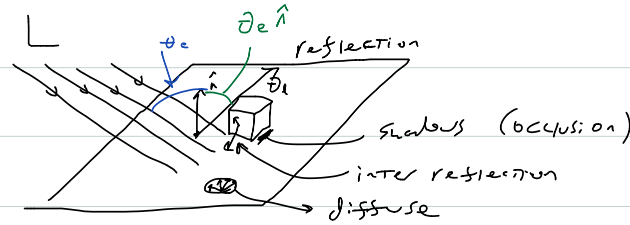
Mike Lange, McGill

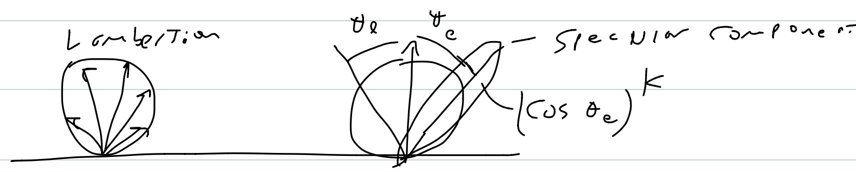
- What is a light source
- Shape from Shading on a Cloudy day



reflection — Lambertian

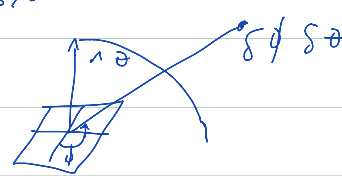
In general, specular & diffuse components

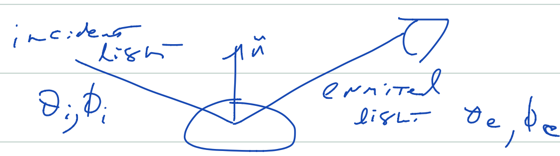




Bidirectional Reflectance Difusion function (BRDF, Horn ch10)

Spherical Coord





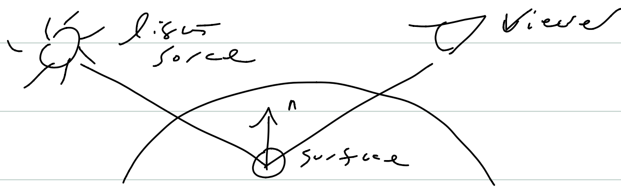
$$H(\theta_i, \phi_i, \theta_e, \phi_e) = \frac{\delta L(\theta_e, \phi_e)}{\delta E(\theta_i, \phi_i)}$$

emmited light

incident light

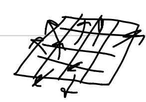
does not account for colour or colour shift (e.g. reflection in metal)

Shape from shading



Problem # 1 — Surface found depends on light source (numerical instability)

Problem # 2 — Need to integrate surface normals



(Horn "Robot Vision")