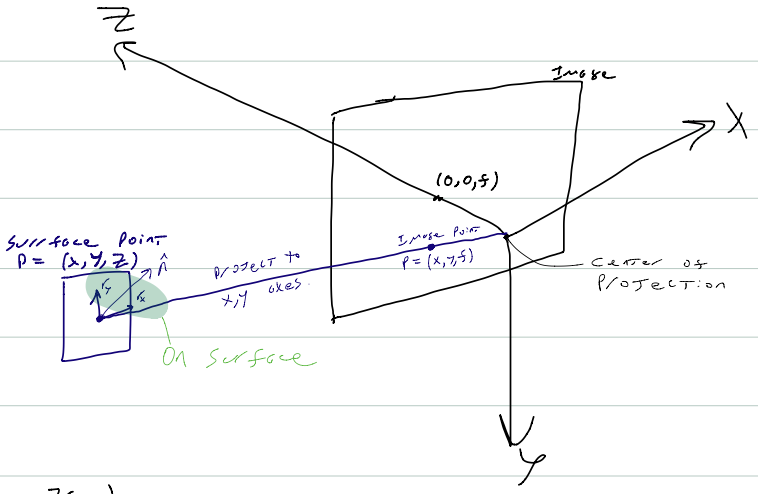
Assignment #1 Questions

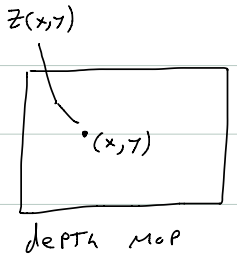
Tutorial - Monday 5-6+ pm.

Projects (due one week) (end of month)

- research topic
- "hacker" projects
- Standard algorithms
  - → structure from motion
  - → image stiching
  - → deformable models

Shape from Shading (Horn 1970, Szeliski: pp. 508)





Gradient space (derivative of depth)

Let $(p, q) \triangleq \left(\frac{\partial z}{\partial x}, \frac{\partial z}{\partial y}\right)$

Let $r_x = \left(1, 0, \frac{\partial z}{\partial x}\right) = (1, 0, p)$

$r_y = \left(0, 1, \frac{\partial z}{\partial y}\right) = (0, 1, q)$

$\hat{n} = \text{unit}(r_x \times r_y)$

$= \text{unit}((1,0,p) \times (0,1,q))$

$$a \times b = \begin{vmatrix} i & j & k \\ a_i & a_j & a_k \\ b_i & b_j & b_k \end{vmatrix}; \quad r_x \times r_y = \begin{vmatrix} i & j & k \\ 1 & 0 & p \\ 0 & 1 & q \end{vmatrix}$$

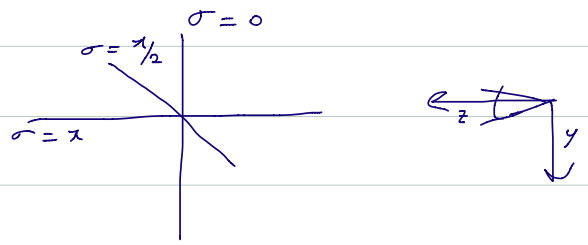
$= (-p, -q, 1)$

Thus $\hat{n} = \frac{(p, q, -1)^T}{\sqrt{1+p^2+q^2}}$ — Convention: normal points towards viewer

Define:

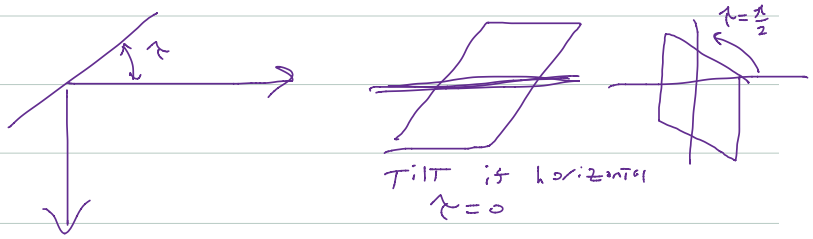
Slant: σ

angle with viewing plane



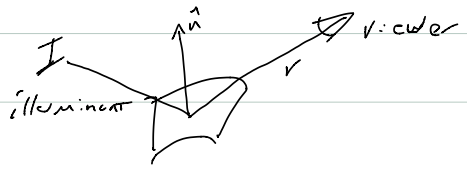
Tilt: τ

Rotation about z axis

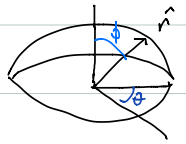


$E(x,y) = \rho \, I \cdot \hat{n}(x,y)$

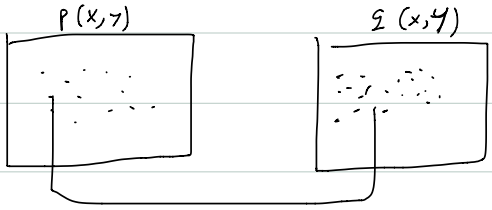
E: Image; ρ: surface albedo; $\hat{n}(x,y)$: surface normal



- How many measurements (@ each point)?
  - 1 (grey scale)



Unknowns: $\hat{n}$ or each pixel = 2 unknowns.



- Smoothness Constraint

$$E_s = \int \left(p_x^2 + p_y^2 + z_x^2 + z_y^2 \right) dx\,dy = \int \left(\|\nabla p\|^2 + \|\nabla z\|^2 \right) dx\,dy$$

Simple case: Photometric Stereo

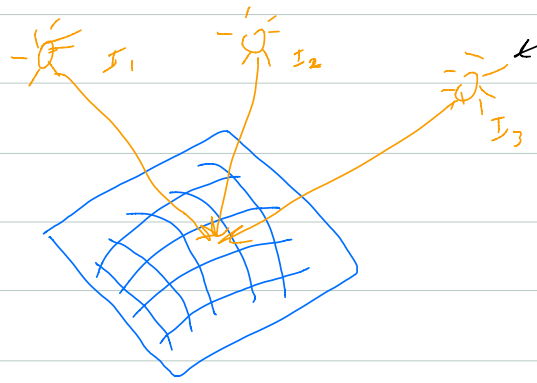
Multiple images of same scene with different lighting.

3 measurements

$$E_1(x,y) = \rho(x,y) I_1 \cdot \hat{n}(x,y)$$
$$E_2(x,y) = \rho(x,y) I_2 \cdot \hat{n}(x,y)$$
$$E_3(x,y) = \rho(x,y) I_3 \cdot \hat{n}(x,y)$$

1 unknown, 2 unknowns

3 unknowns



← 3 independent lights (or even 3 different coloured lights))

Reflectance Map

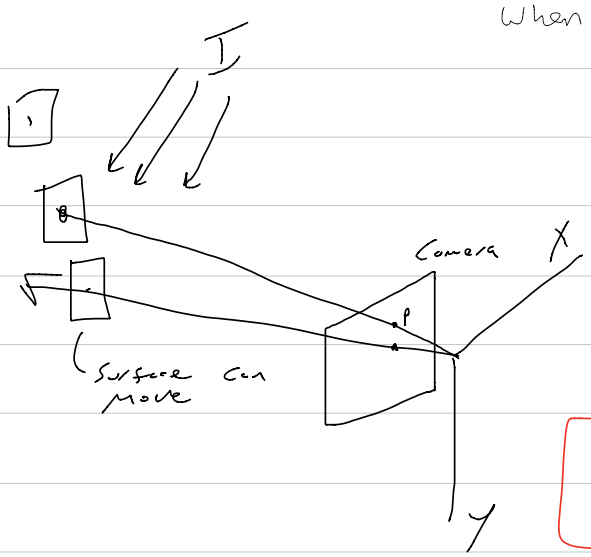
$$E(x,y) = R\left(p(x,y), \Sigma(x,y); I\right)$$

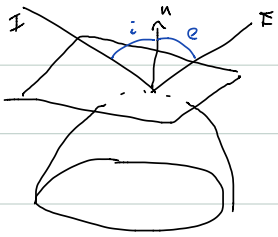
I: illumination direction

$E(x,y)$: image irradiance

R: reflectance function

R is a fn of surface orientation only when I is fixed.



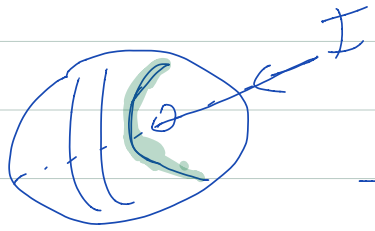


$$R(p,\Sigma,I) = I \cdot \hat{n}$$

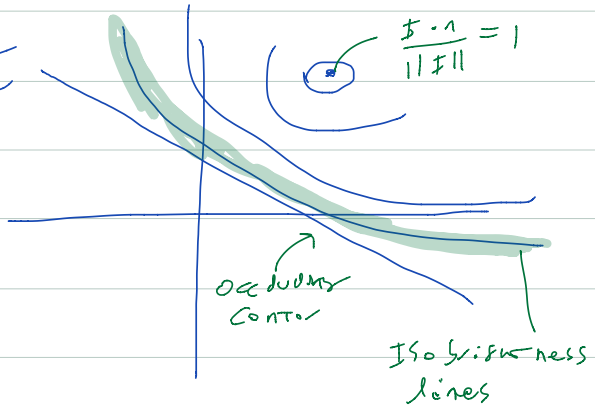
Lambertian

Assume Lambertian on asst #1

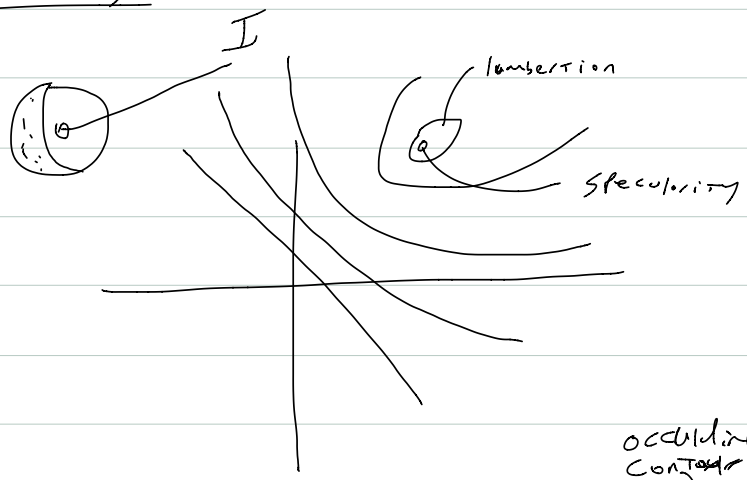
Lambertian Surface

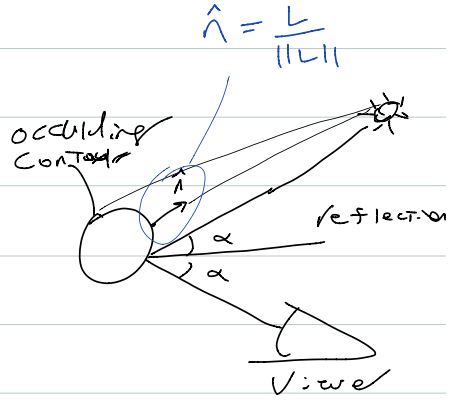


Viewer on z axis



Specularity





Interacting properties (Adelson. MIT.)

$$E(x,y) \propto L(x,y) R(x,y)$$

E(x,y): image
L(x,y): lighting
R(x,y): Reflectance