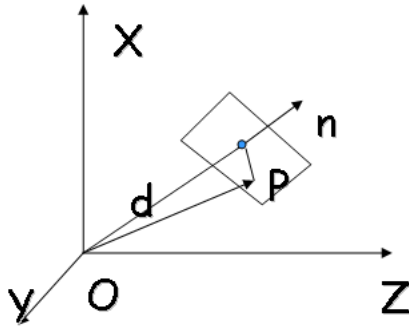


CSE 152 - Introduction to Computer Vision

Assignment 4

Due Thursday, May 27

Reading. Trucco and Verri: Chapter 8,9.



Question 1

Figure 1: Figure

Consider a plane with surface normal \mathbf{n} and distance \mathbf{d} from the origin and given by equation $\mathbf{n} \cdot \mathbf{p} = \mathbf{d}$ where $\mathbf{n} = (n_x, n_y, n_z)$ and $\mathbf{p} = (x, y, z)$. Let the camera have an optical axis in the z direction and focal length f . Let the camera be moving with translation $\mathbf{T} = (T_x, T_y, T_z)$ and angular velocity $(\omega_x, \omega_y, \omega_z)$. Show that the optical flow field is the following quadratic function of (x, y)

$$\begin{aligned} v_x &= \frac{1}{fd} (a_1 x^2 + a_2 xy + a_3 fx + a_4 fy + a_5 f^2) \\ v_y &= \frac{1}{fd} (a_1 xy + a_2 y^2 + a_6 fy + a_7 fx + a_8 f^2) \end{aligned}$$

where

$$\begin{aligned} a_1 &= -d\omega_y + T_z n_x & a_2 &= d\omega_x + T_z n_y \\ a_3 &= T_z n_z - T_x n_x & a_4 &= d\omega_z - T_x n_y \\ a_5 &= -d\omega_y - T_x n_z & a_6 &= T_z n_z - T_y n_y \\ a_7 &= -d\omega_z - T_y n_x & a_8 &= d\omega_x - T_y n_z \end{aligned}$$

Question 2 Photometric Stereo: Consider a Lambertian surface of constant albedo and a unit strength light source so that the image formation equation is $E = \mathbf{n} \cdot \mathbf{s}$. Suppose that two measurements, E_1 and E_2 are taken with two light source positions, \mathbf{s}_1 and \mathbf{s}_2 , determine the two possible solutions for the unit surface normal. When is there only one solution?

Question 3 Optical flow: Consider a camera modelled by orthographic projection and a piece of paper parallel to the image plane with an albedo pattern illuminated so that: $E(x, y) = \sin(2y) \cos(x)$. Let the camera translate parallel to the image plane with velocity vector $\mathbf{v} = (vx, vy)$.

1. Using the brightness constancy assumption, what is the normal component of the optical flow? (i.e., $\mathbf{v} \cdot \mathbf{n}$ in equation (8.18) in the text?)
2. Is there a point (x, y) where the normal component is zero?
3. For what values of (x, y) does it equal v ?