EE-702 (Computer Vision)

Take-home mid-semester Examination

Total Credit = 30

- No discussion among students or with TAs
- You are free to consult books, papers and Internet.
- Last date of submission in EE office : March 3, 2025 by 5 pm.

Q1 : Consider the stereo vision problem where the cameras mimic the human eye. However, to simplify the problem, assume that the imaging surface (it is not planar as taught in the class) is hemispherical with radius r and the pin-hole (O_1 in fig.) is at the center of the sphere. Also assume at the optical axes (given by O_1O_1') for the cameras are parallel, baseline distance (O_1O_2) is b and the cross-sections $A_1O_1B_1$ and $A_1O_2B_2$ are co-planar.

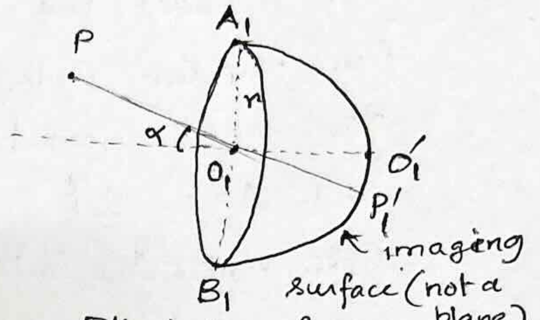

Illustration of the camera (Camera #1).

a) Explain the relationship between depth and the corresponding disparity and how it is different from the standard pair of stereo cameras taught in the class.

b) Suppose we have space varying resolution in this new camera system, ie, the CCD array is more compact (dense) near the optical center O_1' (and O_2') (fovea) with very high resolution near the optical center and radially gradually falling off as we move towards the equator along the retinal surface. How would the precision in depth perception change as a function of the angle α?

[5+4 = 9]

Q2 : Consider solving the structure from motion problem using the linearized 8-point algorithm. Suppose the object being imaged is known to be a planar one (ie, it satisfies $ax + by + cz = 1$ in the 3D coordinate (WCS) system), what advantage can you take about this prior knowledge while solving the 8-point algorithm? Do we face any difficulty in solving the problem?

[5+2 = 7]

Q3. For the shape from shading problem with a known source direction and for a Lambertian surface $z(x,y)$, one uses the following regularization (smoothness) term

$$\iint \left[(p_y - q_x)^2 + \left(p_x^2 + A p_y^2 + B q_x^2 + q_y^2 \right) \right] dx\,dy \quad \text{with } A = B$$

that includes the integrability condition also. Derive the corresponding Euler-Lagrange equation to solve for (p, q). How are the solutions different for the two cases $A = B = 0$ and $A = B = 1$? How is the solution different from the case when the integrability term is not used ? [4+2+2=8]

Q4: Consider a set of four points (A', B', C', D') on a 3D object but lying on a straight line. They are imaged (using perspective projection) by two different cameras having arbitrary relative pose (rotation R) and translation ($\underline{t}$) between them and the point set maps as (A_1, B_1, C_1, D_1) and (A_2, B_2, C_2, D_2), in respective image plane. Assuming both cameras having the same internal (intrinsic) camera parameters, compute the following quantity

$$\alpha_i = \frac{C_i A_i}{C_i B_i} \Big/ \frac{D_i A_i}{D_i B_i} \quad \text{for } i = 1, 2$$

where the terms like CA defines the length of the line joining the points C and A.

Find the relationship between α_1 and α_2. What does the relationship signify (also mention if there could be any practical application of the term α). [4+2=6]

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