Second Test for Computer Vision (E1.216)
23 March 2022

Notes

- The duration of this exam is 3 hours.
- You **must** begin an answer on a new page. Failure to do so will incur penalties.
- The **first page** should **clearly indicate** your Name, S.R. No, Department, Program and IISc Email ID. **The rest of the first page should be kept empty.**
- Every page **must** contain the page number at the top right of the page.
- You will be graded for clarity and brevity of your solutions.

Q1: Epipolar Geometry

Consider a calibrated camera. Let the camera be translated forward (i.e. moved along the Z-axis, i.e. optical axis) between the two images.

A Derive the essential matrix for this camera configuration. [5 points]

B For correspondences (x_1, y_1) and (x_2, y_2) derive the relationship that they will satisfy. [5 points]

Q2: Stereo

Consider a 3D plane placed in front of a canonical stereo camera. Derive the expression for disparity $D(x, y)$ as a function of the pixel location (x, y). [10 points]

NOTE: In the first test, this plane had a specific orientation. But in this question it has an arbitrary orientation.

Q3: Photometric Stereo

Consider a 3D Lambertian sphere with albedo $\rho = 1$. Let it be illuminated from above as shown in Fig. 1, i.e. from a point source at infinity and the direction of lighting is along the vertical axis from above. Derive the intensity you would observe at any given location on the sphere in terms of its latitude and longitude. [10 points]

Q4: Epipolar Estimation

Consider a calibrated camera and assume that we know the rotation $\mathbf{R}$ from the first to the second image. Given N correspondences $\{(x_i, y_i) \leftrightarrow (x_i^{'}, y_i^{'}) | i = 1, \cdots, N\}$ derive an algorithm for accurate estimation of the epipolar geometry between the two images. Your method should clearly account for the fact that we know the rotation $\mathbf{R}$ and also use RANSAC to be robust to outliers in the correspondence. [10 points]

NOTE: I expect clear derivations/statements/justifications for key steps. Just stating the general approach will not be acceptable.

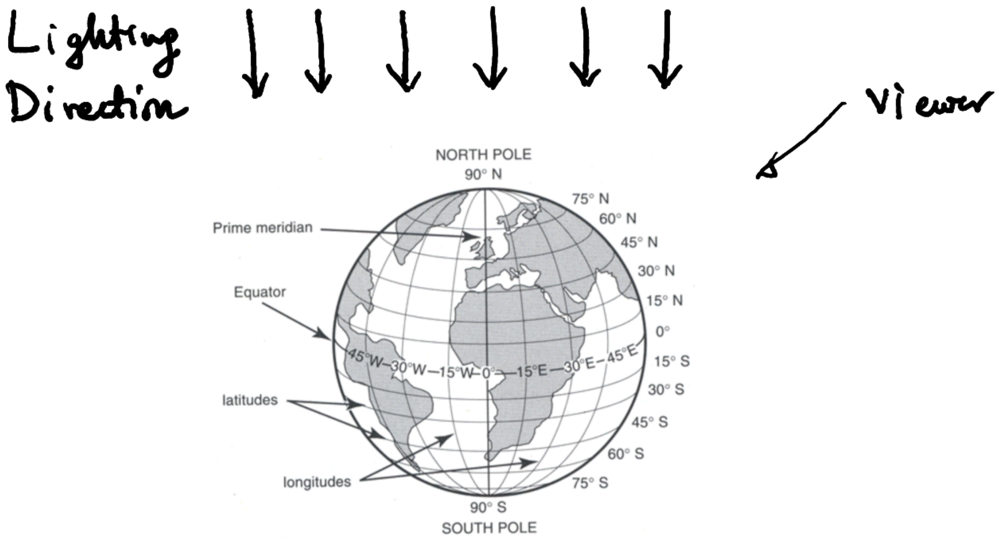

Figure 1: Illumination of a Lambertian sphere is from above as given.

Q5: Homography Induced by Plane

Let us consider a camera pair with a rotation $(\mathbf{R})$ and a translation $(\mathbf{T})$ between them. Let us place a 3D plane in front of this camera pair. Prove that the corresponding image points between the two cameras will satisfy a homography relationship. [10 points]

Q6: Epipolar Geometry

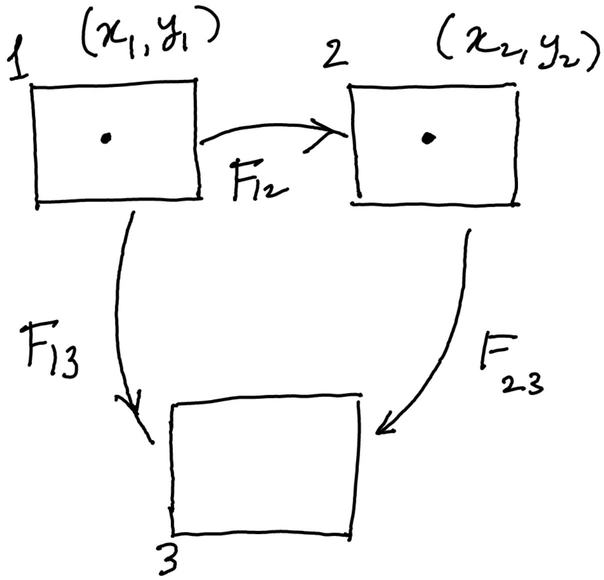

Figure 2: Three Camera Configuration

Consider a triplet of uncalibrated cameras as shown in Fig. 2. Assume we know the epipolar geometry between all pairs of cameras. Given a corresponding pair of points in images 1 and 2, i.e. $(x_1, y_1) \leftrightarrow (x_2, y_2)$, what can be say about the location of the correspondence in the third image (x_3, y_3). Explain your claim. [10 points]