Final Exam for Computer Vision (E1.216)
21 April 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

1. Deep Learning

Let us consider a homography or projective transformation between point correspondences in two cameras, i.e. $\mathbf{q} = \mathbf{H}\mathbf{p}$ where $\mathbf{p}$ and $\mathbf{q}$ are the homogeneous forms of points (x_1, y_1) and (x_2, y_2) respectively. Provide an approach to train a deep neural network to estimate $\mathbf{H}$ given correspondences. I do not need any training methods. Instead you should clearly and succinctly specify the inputs and outputs along with the loss function to be minimised. You should do this for

a supervised, and [5 points]

b unsupervised learning scenarios. [5 points]

2. Radiometry

Consider the configuration shown in Fig. 1 where we have a cube and a sphere illuminated by a single point source at infinity. Each planar face of the cube will have a uniform intensity denoted as I_1, I_2 and I_3. Provide a qualitative sketch the iso-contours of values I_1, I_2 and I_3 on the sphere, i.e. indicate which points on the sphere will have intensity values of I_1, I_2 and I_3. Clearly and briefly explain your answer. [10 points]

3. Stereo

Consider a canonical stereo set up with $D = \frac{fB}{Z}$, where Z is the depth of a point and D is disparity. Assume that the estimate of D has a small amount of noise in it. How does this affect the uncertainty of depth estimate Z? What does it imply? [10 points]

Hint: Think of how changing or perturbing one variable affects another here and use differentiation.

4. Epipolar Geometry

Given two cameras with a homogeneous point correspondence $(\mathbf{p}, \mathbf{q})$ and known relative rotation $\mathbf{R}$ between the two cameras. Ignoring the unit-norm scale constraint, let the translation direction $\mathbf{t}$ have a probability distribution $\mathcal{N}\left(\mathbf{0}, \sigma^2\mathbf{I}\right)$. Derive the distribution for the epipolar error. [10 points]

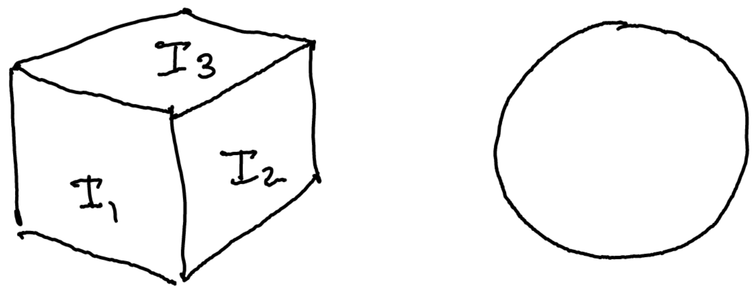

Figure 1: A cube and a sphere with uniform albedo $\rho = 1$ are illuminated by a point source at infinity

5. Structure Tensor

Consider a patch where the image derivatives I_x and I_y are drawn independently from a uniform distribution between $[-\frac{1}{2}, \frac{1}{2}]$. What is the expected ratio of the eigen-values λ_1 and λ_2 for the structure-tensor matrix as the patch grows to a very large size? Prove your answer. [10 points]

6. Segmentation

Consider a set of noise-free correspondences across two views. Let there be N_1 correspondences following the same motion and let there be N_2 correspondences belonging to a different motion. Assume we use RANSAC to group the points into two different motions. If we want correct segmentation or classification with probability p, how many trials do we need to carry out? Explain your answer which should be exact in its specification, not a vague restatement of RANSAC from the course slides. [10 points]

7. Epipolar Geometry

Consider a fundamental matrix of the form

$$\mathbf{F} = \begin{bmatrix} 0 & 0 & a \\ 0 & 0 & b \\ c & d & e \end{bmatrix}$$

a Where are the epipoles for this **F** ? [5 points]

b What can you say about the properties of the epipolar lines in this case. Prove your statement. [5 points]