EN.601.461/661

Computer Vision

Assignment #9

Due date: November 19th 11:59PM

5 marks (10% per day late submission)

Instructions: Answer your questions on paper or an electronic/printout document. Use a new sheet for each question (i.e. don't answer two questions on the same sheet). Scan/save your calculations as a pdf document or take pictures of your solution and submit it on Gradescope. You are encouraged to use a calculator or other software to help with math but you **must** include all the steps/printouts of the calculations in your submission. No need to submit code.

1. Projection of a 3D point (0pt).
   a. You have two cameras P and P' in a world frame W. Both cameras have the same calibration matrix
   $$K = \begin{bmatrix} 100 & 0 & 320 \\ 0 & 100 & 240 \\ 0 & 0 & 1 \end{bmatrix}.$$
   Both cameras have a rotation $R = I$. The camera P is at the origin and and ${}^{W}\boldsymbol{t}_{P,} = [1 \quad 0 \quad 0]^T$. You have three points $\boldsymbol{X_1} = [0 \quad 0 \quad 1]^T$, $\boldsymbol{X_2} = [1 \quad 0 \quad 1]^T$, $\boldsymbol{X_3} = [1 \quad 0 \quad 2]^T$. Calculate the inhomogeneous image coordinates $\boldsymbol{x}_i$ and $\boldsymbol{x}'_i$. To make things more exciting, add the following noise to your coordinates (each column is the noise of $\boldsymbol{x}_i$ and $\boldsymbol{x}'_i$).
   $$N = \begin{bmatrix} -0.1068 & 0.3714 & -1.0891 \\ 1.5326 & -0.2256 & 0.0326 \end{bmatrix}, N' = \begin{bmatrix} 1.1006 & -1.4916 & 2.3505 \\ 1.5442 & -0.7423 & -0.6156 \end{bmatrix}$$
2. Projective Reconstruction (2pt)
   a. Use the image coordinates of question 1 to construct the matrices A_i. Use 4 equations per point (two equations from each image) when building the matrix A_i. You can use the matrices P and P' from question 1 (you don't have to extract those from a fundamental matrix).
   b. Use the DLT algorithm to triangulate the points and calculate the projective reconstruction $(P, P', \boldsymbol{X})$.
3. Affine reconstruction (1.5pt)
   a. Calculate the plane at infinity π_∞. You can use any information available or derived from questions 1 and 2.
   b. Use π_∞ to calculate the affine reconstructions $(P_A, P'_A, \boldsymbol{X}_{Ai})$ from the projective reconstruction of question 2b).
4. Metric reconstruction (1.5pt)
   a. Calculate the image of the absolute conic ω. You can use any information available or derived from questions 1, 2 or 3.
   b. Use ω to calculate the metric reconstruction $(P_M, P'_M, \boldsymbol{X}_{Mi})$