Nptel Online Certification Course
Indian Institute of Technology Kharagpur
Computer Vision
Assignment - Week 4

Number of questions: 10 **Total marks: 10x2=20**

FOR QUESTIONS 1 AND 2:

Consider a stereo imaging set up camera with left calibration matrix $K = \begin{bmatrix} 2 & 1 & 2 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$ and a right calibration matrix $K' = \begin{bmatrix} 0 & 1 & 3 \\ 1 & 2 & 2 \\ 0 & 0 & 1 \end{bmatrix}$. The right camera has $R = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$

Based on the given parameters, solve the following question 1 and 2:

QUESTION 1: **Type: Comprehensive**

Given translation vector t as $(1, 0, 1)$, compute the right epipole.

a) $(-3, -3, 1)$

b) $(3, 3, 1)$

c) $(4, 0, 2)$

d) $(4, 0, -2)$

Correct Answer: b)
Detailed Solution:
Right epipole is given by $e' = K't$.

QUESTION 2: **Type: Comprehensive**

Compute the fundamental matrix F.

a) $\begin{bmatrix} 0.5 & -1.5 & -1.5 \\ 0 & 0 & 0.5 \\ -1.5 & 4.5 & 3 \end{bmatrix}$

b) $\begin{bmatrix} 0 & -1.5 & -1.5 \\ 0 & 0 & 0.5 \\ 1.5 & 4.5 & 3.5 \end{bmatrix}$

c) $\begin{bmatrix} 0.5 & 1.5 & 1.5 \\ 0 & 0 & 0.5 \\ 1.5 & 4.5 & 3 \end{bmatrix}$

d) $\begin{bmatrix} 0.5 & -1.5 & 1.5 \\ 0 & 0 & 0.5 \\ 1.5 & 0.5 & 3 \end{bmatrix}$

Correct Answer: a)

Detailed Solution:

Fundamental matrix is given by $F = [e']_X H$, where Homography is given by $H = K'RK^{-1}$.

QUESTION 3: **Type: MCQ**

Consider a plane induced homography $H = \begin{bmatrix} 1 & 2 & 0 \\ -5 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ of a stereo imaging set up. Epipole $e'(3, 5)$ in right image plane and a point $x(2, 1)$ in left image plane are given. Compute the epipolar line (l') on which the corresponding point of x will lie in right image plane.

a) $(13, 1, 44)$

b) $(13, -1, -44)$

c) $(-13, 1, -44)$

d) $(13, 1, -44)$

Correct Answer: : d)
Detailed Solution: Epipolar line $l' = e' \times Hx$, e' and x are expressed in homogeneous coordinate system.

QUESTION 4: **Type: MCQ**

Given the right camera as $R = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$ and translation vector t as $(1, 0, 1)$, compute the Essential matrix E.

a) $\begin{bmatrix} 0 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$

b) $\begin{bmatrix} -1 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & 1 \end{bmatrix}$

c) $\begin{bmatrix} 0 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

d) $\begin{bmatrix} 0 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$

Correct Answer: c)
Detailed Solution:
Essential matrix is given by $E = [t']_X R$.

QUESTION 5: **Type: MCQ**

Consider a stereo imaging set up with two cameras $P = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$ (left camera) and $P' = \begin{bmatrix} 2 & 1 & 2 & 3 \\ 1 & 3 & 0 & 2 \\ 1 & 0 & 1 & 1 \end{bmatrix}$ (right camera), find the Fundamental matrix.

a) $\begin{bmatrix} 2 & 0 & 2 \\ 1 & 0 & -1 \\ -2 & -2 & -4 \end{bmatrix}$

b) $\begin{bmatrix} 1 & 0 & 2 \\ -2 & 0 & -1 \\ -1 & 2 & -3 \end{bmatrix}$

c) $\begin{bmatrix} 1 & 0 & 2 \\ -1 & 1 & -1 \\ -1 & -2 & -4 \end{bmatrix}$

d) $\begin{bmatrix} 1 & -3 & 2 \\ -1 & 1 & -1 \\ -1 & 7 & -4 \end{bmatrix}$

Correct Answer: d)
Detailed Solution:
Fundamental matrix $F = [m']_X M'$, where m' is the last column of P' and M' is the left 3x3 matrix of P'.

QUESTION 6: **Type: MCQ**

Given fundamental matrix $F = \begin{bmatrix} -2 & 1 & 2 \\ 1 & 2 & 0 \\ 1 & 2 & 0 \end{bmatrix}$. Given two points $p_1 = (1, 3)$ and $p_2 = (3, 2)$ in the left image, find the right epipole e'.

a) $(0, -35, 35)$

b) $(35, 0, 35)$

c) $(0, 35, 35)$

d) $(-35, 0, 35)$

Correct Answer: a)
Detailed Solution:
Right epipole is given by $e' = l'_1 \times l'_2$, where $l'_2 = Fp_2$ and $l'_1 = Fp_1$.

QUESTION 7: **Type: MCQ**

Assume that a stereo imaging setup has two image planes, left and right. Which of the following could be a possible right null vector (or left epipole for the corresponding stereo imaging setup) of the given fundamental matrix $F = \begin{bmatrix} -1 & 3 & 2 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \end{bmatrix}$

a) $(1, -1, 2)$

b) $(-1, 1, 2)$

c) $(-1, 1, -2)$

d) $(1, 1, 2)$

Correct Answer: : c)

Detailed Solution: Check for $Fe = 0$, where e is the left epipole or right null vector of F.

QUESTION 8: **Type: MCQ**

Consider a stereo imaging set up with two cameras $P = \begin{bmatrix} 2 & 0 & 3 & 1 \\ 0 & 5 & 0 & 1 \\ 1 & 2 & 1 & 2 \end{bmatrix}$ (left camera) and $P' = \begin{bmatrix} 3 & 2 & 1 & 1 \\ 2 & 0 & 0 & 2 \\ 0 & 3 & 2 & 1 \end{bmatrix}$ (right camera). Find the right epipole e'. Answer till two decimal places.

a) $(9.6, -7.6, -3.8)$

b) $(-9.6, -7.6, 3.8)$

c) $(-1.6, -7.6, 2.8)$

d) $(1.6, -7.6, -2.8)$

Correct Answer: b)

Detailed Solution:

Compute the camera centre first as $C = -M^{-1}p_4$, where M is the left 3×3 matrix of the left camera projection matrix P and p_4 is the last column of P.

The right epipole is now calculated as $e' = P'C$, where P' is the right camera projection matrix.

QUESTION 9: **Type: MCQ**

Compute the essential matrix E, provided calibration matrices of two cameras in stereo set up as K (left camera) = $\begin{bmatrix} 2 & 3 & 2 \\ 0 & 4 & 3 \\ 0 & 0 & 0 \end{bmatrix}$ and K' (right camera) = $\begin{bmatrix} 1 & 1 & 2 \\ 0 & 5 & 3 \\ 0 & 0 & 1 \end{bmatrix}$ along with fundamental matrix $F = \begin{bmatrix} 4 & 2 & 3 \\ 1 & 1 & 1 \\ 4 & 2 & 3 \end{bmatrix}$.

a) $\begin{bmatrix} 8 & 7 & 7 \\ 18 & 20 & 22 \\ 30 & 30 & 30 \end{bmatrix}$

b) $\begin{bmatrix} 26 & 57 & 47 \\ 34 & 85 & 57 \\ 8 & 20 & 14 \end{bmatrix}$

c) $\begin{bmatrix} 6 & 8 & 7 \\ 8 & 3 & 22 \\ 30 & 33 & 3 \end{bmatrix}$

d) $\begin{bmatrix} 26 & 67 & 47 \\ 34 & 95 & 67 \\ 8 & 20 & 14 \end{bmatrix}$

Correct Answer: : d)

Detailed Solution: Essential matrix $E = K'^T F K$.

QUESTION 10: **Type:Numeric**

Consider a stereo imaging set up with two cameras $P = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$ (left camera) and $P' = \begin{bmatrix} 2 & 0 & 0 & 3 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$ (right camera). If the image coordinates of a 3-D point are $(3, 3)$ and $(0, 3)$ in left and right cameras, compute its depth (z-coordinate) in the 3D.

Correct Answer: 1

Detailed Solution:

The depth is given by $Z = \frac{Kt}{x'-x} = \frac{2\times\frac{3}{2}}{3-0}$.
