Nptel Online Certification Course
Indian Institute of Technology Kharagpur
Computer Vision
Assignment - Week 6

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

QUESTION 1: **Type: MCQ**

The histogram contains 9 bins corresponding to angles 0, 20, 40, 60, 80, 100, 120, 140, 160
Given gradient's magnitude and direction (in degrees) matrices as $\begin{bmatrix} 3 & 5 \\ 1 & 8 \end{bmatrix}$ and $\begin{bmatrix} 80 & 40 \\ 40 & 0 \end{bmatrix}$, respectively. Compute a vector representing histogram of gradients corresponding to the given details.

a) $(8, 1, 5, 0, 3, 0, 0, 0, 0)$

b) $(8, 1, 0, 0, 5, 0, 3, 0, 0)$

c) $(8, 0, 6, 0, 3, 0, 0, 0, 0)$

d) $(1, 0, 3, 0, 5, 0, 8, 0, 0)$

Correct Answer: c)
Detailed Solution:
Element in direction matrix corresponds to the bin, and the corresponding element in magnitude matrix corresponds to value of that bin. For example, 0 and 8 are corresponding elements in both matrices. So, bin 0 has element 8 in it. Since 40 degrees has both 5 and 1 in it, it sums up to give 6 at bin 40.

QUESTION 2: **Type: Numeric**

If an octave in SIFT operator has 12 images, then the scale factor by which each image in octave differs from the next image is (round off your answer to 4 places of decimal).

Correct Answer: 1.0650

Detailed Solution:

Within an octave, the adjacent scales differ by a constant factor k. If an octave contains $s + 1$ images, then $k = 2^{1/s}$. The scale factor is 2 in an octave. Therefore, $k = 2^{1/11}$.

<u>QUESTION 3:</u> **Type: MSQ**

Consider shifting a 3×3 window W by (u, v). Let $E(u, v)$ be the change function defined as the sum of squared differences (SSD) error, $E(u, v) = \sum_{(x,y)\in W} [I(x + u, y + v) - I(x, y)]^2$, where $I(x, y)$ is the intensity value of the pixel in (x, y) coordinates. $E(u, v)$ can be reduced to $E(u, v) = \sum_{(x,y)\in W} \begin{bmatrix} u & v \end{bmatrix} M \begin{bmatrix} u \\ v \end{bmatrix}$, where $M = \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix}$.

Considering score $R = \lambda_1\lambda_2 - (\lambda_1 + \lambda_2)^2$, where, λ_1 and λ_2 are eigen values of M, which of the following statements are correct?

a) When $|R|$ is small, the region is flat.

b) When $R < 0$, the region is an edge.

c) When $R < 0$, the region is a corner.

d) When $|R|$ is small, the region is corner.

Correct Answer: a, b

Detailed Solution:

When $|R|$ is small the region is flat. When $R < 0$, which happens when $\lambda_1 >> \lambda_2$ or vice versa, the region is an edge. When R is large, which happens when λ_1 and λ_2 are large and almost equal, it is a corner point.

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QUESTION 4: **Type: MSQ**

Which of the following are true?

a) FAST does not operate across scales.

b) Hough transform is used to determine edges.

c) RANSAC is robust to outliers.

d) ORB builds on FAST key point detector and the BRIEF descriptor.

Correct Answer: a, c, d

Detailed Solution:

Hough transform is a voting method to determine the best line of fit when multiple lines are present.

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FOR QUESTIONS 5 AND 6:

The top left corner of the matrix is considered as $(1, 1)$ and indices increment for x and y axes along horizontal right and vertical downward directions, respectively.

Consider a 3×3 matrix $A = \begin{bmatrix} 0.3 & 0.1 & 0.6 \\ 0.5 & 0.2 & 0.3 \\ 0.1 & 0.3 & 0.4 \end{bmatrix}$. Based on the given data solve the following questions 5 and 6:

QUESTION 5: **Type: Comprehensive**

Compute the magnitude using first order first difference operator at the center pixel. Round off your answer to 4 places of decimals.

Correct Answer: 0.1414

Detailed Solution:

Magnitude at a pixel location (x_i, y_i) is $\frac{\sqrt{(f(x_{i+1}, y_i) - f(x_{i-1}, y_i))^2 + (f(x_i, y_{i+1}) - f(x_i, y_{i-1}))^2}}{2}$.

QUESTION 6: **Type: Comprehensive**

Compute the orientation (in degrees) using first order first difference operator at the center pixel.

Correct Answer: -45

Detailed Solution:

Orientation is $tan^{-1}(f(x_i, y_{i+1}) - f(x_i, y_{i-1}))/(f(x_{i+1}, y_i) - f(x_{i-1}, y_i))$, where the function $f()$ gives out the intensity at that particular location.

QUESTIONS 7: **Type: MCQ**

Find the eigen values of the matrix $\begin{bmatrix} -5 & 2 \\ -7 & 4 \end{bmatrix}$.

a) $-3, 2$

b) $3, -2$

c) $-1, 3$

d) $1, -3$

Correct Answer: a)
Detailed Solution:
The eigen values are calculates as $\begin{vmatrix} -5-\lambda & 2 \\ -7 & 4-\lambda \end{vmatrix} = 0.$

QUESTIONS 8: **Type: MSQ**

Which of the following statements are true?

a) Harris corner assigns a feature descriptor to each corner points for feature matching.

b) Harris corner finds key points based on significant changes in intensity along all directions.

c) The dimension of the SIFT description vector is 128.

d) SIFT can handle changes in viewpoint, upto 20 degrees out of plane.

Correct Answer: b), c)

Detailed Solution:

Harris corner detector find key points based on maximum intensity changes along all directions around a small neighborhood. SIFT can handle changes in viewpoint, upto 60 degrees out of plane. The difference of gaussian is used to form a gaussian pyramid. A 128 dimensional description vector is formed from the 8 orientations in each of the 16 cells.

QUESTION 9: **Type: Numeric**

Given two features each of size 5 as $f(3, 2, 4, 5, 1)$ and $g(7, 2, 5, 3, 2)$. Compute L_1 norm between f and g.

Correct Answer: 8

Detailed Solution:

L_1 norm is $\sum_{i=0}^{n} |f - g|$.

QUESTION 10: **Type:MCQ**

Consider the following matrix representing 4 sample data points $(2,2), (1,1), (2,2), (3,3)$ as $X = \begin{bmatrix} 2 & 2 \\ 1 & 1 \\ 2 & 2 \\ 3 & 3 \end{bmatrix}$. Compute the covariance matrix using data points from X.

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

b) $\begin{bmatrix} 0.5 & 0.5 \\ 0.5 & 0.5 \end{bmatrix}$

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

d) $\begin{bmatrix} 2 & 2 \\ 2 & 2 \end{bmatrix}$

Correct Answer: b)

Detailed Solution:

Compute the mean vectors as $[\frac{2+1+2+3}{4}, \frac{2+1+2+3}{4}] = [2,2]$. Now compute $\tilde{X} = \begin{bmatrix} 2-2 & 2-2 \\ 1-2 & 1-2 \\ 2-2 & 2-2 \\ 3-2 & 3-2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ -1 & -1 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}$.

The covariance matrix is given by $\frac{\tilde{X}^T \tilde{X}}{4}$.
