University at Buffalo
Department of Computer Science and and Engineering
CSE 473/573 - Computer Vision and Image Processing

Fall 2024

Homework #2
Due Date: 10/8/2024, 11:59PM

Instructions

- Answer the questions below, and provide as much of your work as necessary.
- Export or scan your homework and store it as a PDF version before submitting online to UBLearns.

1 Harris Detector (40 points)

In Harris Corner Detection, it aims to find the difference in intensity for a displacement of (u, v) for all directions:$E(u,v) = \begin{bmatrix} u & v \end{bmatrix} \mathbf{M} \begin{bmatrix} u \\ v \end{bmatrix}$, where $\mathbf{M} = \sum_{x,y} \mathbf{W}(x,y) \begin{bmatrix} \mathbf{I}_X^2(x,y) & \mathbf{I}_X(x,y)\mathbf{I}_Y(x,y) \\ \mathbf{I}_X(x,y)\mathbf{I}_Y(x,y) & \mathbf{I}_Y^2(x,y) \end{bmatrix}$, and $\mathbf{W}$ is the window matrix. Assume that $\mathbf{W} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$, $\mathbf{I}_X = \begin{bmatrix} 0 & 0 \\ 1 & 2 \end{bmatrix}$, and $\mathbf{I}_Y = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$. We use threshold f to determine whether the window contains a corner, where $f = \frac{\lambda 1 \lambda 2}{\lambda 1 + \lambda 2}$, $\lambda 1, \lambda 2$ are the eigen values of $\mathbf{M}$. If $f > 1$, we determine that the window contains a corner; otherwise, it does not contain a corner. Please give a mathematical calculation and infer if this window contains a corner or not.

2 Optical Flow (10 points)

Provide examples of two scenarios where optical flow does not match the actual motion field i.e scenarios where the optical flow estimation is different from the actual motion of the objects.

Hint: Example Scenario where a stationary sphere with a texture less surface is illuminated by a moving light source, where the optical flow will predict the motion of the sphere due to change in illumination across the sphere(which can be detected using consecutive images), but in reality, the

sphere is stationary. On similar grounds think of other two such different cases apart from the one given above.
(5 points for each correct scenario and its proper justification)

3 Gaussian Filter Separability (20 points)

One of the characteristics of Gaussian filter is that a 2D filter can be expressed as the product of two 1D Gaussian filters. Please express the following 2D 5x5 Gaussian filter as the product of two 1D Gaussian filters.

$$G = \frac{1}{289}\begin{pmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 28 & 16 & 4 \\ 7 & 28 & 49 & 28 & 7 \\ 4 & 16 & 28 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{pmatrix}$$

Provide an example that demonstrates your answer is accurate.

4 Feature Matching (30 points)

Short Answer

- What is the value range for Sum of Squared Differences (SSD) and Cross-Correlation (CC)? (10 pts each)
- Explain the reasons for your answer. (5 pts each)