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Selected Problems

1. What is the main advantage of performing feature descriptor matching in feature space rather than image space?

2. Given the following 5 by 5 image region:

$$\begin{bmatrix} 0 & 0 & 1 & 3 & 4 \\ 0 & 0 & 2 & 5 & 5 \\ 1 & 2 & 4 & 8 & 16 \\ 1 & 3 & 6 & 3 & 4 \\ 1 & 4 & 8 & 6 & 10 \end{bmatrix}$$

   compute the Hessian matrix and find its eigenvectors and eigenvalues. Use 5-tap central differences to obtain the necessary derivatives.

3. Show that the eigenvectors obtained in the previous question are orthogonal.

4. Given the following 3 by 3 image region containing pixel values (comprised between 0 and 7) in the left image of a stereo pair:

$$r_1 = \begin{bmatrix} 3 & 7 & 6 \\ 2 & 1 & 5 \\ 4 & 5 & 2 \end{bmatrix}$$

   and two other 3 by 3 image regions in the right image, such as:

$$r_2 = \begin{bmatrix} 6 & 5 & 1 \\ 2 & 2 & 1 \\ 7 & 3 & 5 \end{bmatrix} \qquad r_3 = \begin{bmatrix} 1 & 5 & 2 \\ 4 & 4 & 3 \\ 7 & 4 & 6 \end{bmatrix}$$

   Compute the histogram for each image region. Use these histograms to construct three descriptors $D(r_1)$, $D(r_2)$, and $D(r_3)$, and determine which descriptor among $\{D(r_2), D(r_3)\}$ is the most similar to $D(r_1)$ using Euclidian distance.

5. Explain why scale, rotation, and illumination invariance are important properties of image descriptors.