CPSC 425 | **Practice Problems (Midterm) Solutions** | **15W (term 2)**

Multiple Part True/False Questions. For each question, indicate which of the statements, (A)–(C), are **true** and which are **false**? Note: Questions may have zero, one or multiple statements that are true.

Question 1:

Which of the following statements are **true** of a pinhole camera? Which are **false**?

(A) Images in a pinhole camera are upside down.
(B) A pinhole camera has a fixed focal length, f.
(C) Images in a pinhole camera are a perspective projection.

Solution : (A) True, (B) False, (C) True.

Question 2:

Consider Snell's law. Which of the following statements are **true**? Which are **false**?

(A) It describes how light bends when passing from one material into another.
(B) It describes how fast light travels in one material compared to another.
(C) It describes how much light is reflected and how much passes through the boundary between two materials.

Solution : (A) True, (B) True, (C) False.

Question 3:

Lens vignetting is a type of image distortion. Which of the statements are **true** of lens vignetting and which are **false**?

(A) Vignetting is a shift in colour owing to the varying refraction of light at different wavelengths.
(B) Vignetting is a darkening of an image towards its edges.
(C) Vignetting makes it difficult to bring all parts of an image into focus at the same time.

Solution : (A) False, (B) True, (C) False.

Question 4 Two thresholds are used when linking edge points in Canny edge detection. Which of the statements are **true** of Canny edge detection and which are **false**?

(A) Different thresholds are needed to select edge points when linking edges forward or backward from the starting location.

(B) The use of two thresholds prevents gaps that would otherwise appear in the linked edge points.

(C) The X and Y directional derivatives each require a threshold when linking to new edge points.

Solution : (A) False, (B) True, (C) False,

Question 5 The Harris corner detector is stable under some image transformations. For which of the image transformations is it **true** that the Harris corner detector is stable? For which is it **false**? Hint: Features are considered stable if the same locations on an object are typically selected in the transformed image.

(A) Image scaling.

(B) Image rotation.

(C) Image translation.

Solution : (A) False, (B) True, (C) True.

Question 6 Texture representation is hard. Which of the following statements are **true** of texture? Which are **false**?

(A) To date, texture analysis has proven more tractable than texture synthesis.

(B) The "spots" and (oriented) "bars" approach to texture representation described in Forsyth and Ponce is motivated, in part, by properties of human vision.

(C) If we process each layer of the Laplacian pyramid further with a set of oriented filters then we can represent energy at distinct scales and orientations as an "oriented pyramid."

Solution : (A) False, (B) True, (C) True.

Question 7 The Efros and Leung texture synthesis method uses a degree of randomization to select a match from among the good patch matches. What can be expected if we **increase** the degree of randomization for selecting patches? (Indicate which of the following statements are **true** and which are **false**).

(A) Unrealistic repeating patterns may appear in the texture.

(B) The accuracy of selected patches from the sample texture may decrease, leading to unrealistic textures.

(C) The method can run faster since we no longer need to compute the actual best match.

Solution: (A) False, (B) True, (C) False

Question 8 Which of the following statements about colour are **true**? Which are **false**?

(A) Modern, high quality computer monitors can display all the visible colours of the CIE XYZ colour system.

(B) In the human eye, the rods are cells that are used for sensing very low light levels and the cones are used for sensing under normal illumination. Only cones contribute to the perception of colour.

(C) A colour constancy algorithm corrects the colours of an image so that the brightest patch is normalized to white.

Solution : (A) False, (B) True, (C) False

Short Answer Questions. Answer each question clearly and concisely.

Question 9:

(A) Give a 3×3 linear filter that shifts an image 1 pixel downwards and also reduces the image brightness by 50%. Assume the filter is to be implemented as a correlation.

(B) Using your answer to part (a), what is the 3×3 linear filter if it is to be implemented as a convolution?

Solution :

As correlation	As convolution
$\begin{bmatrix} 0 & \frac{1}{2} & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \frac{1}{2} & 0 \end{bmatrix}$

Question 10:

Digital filtering in computer vision often includes some form of normalization of the filter values. In a sentence or two for each, describe a situation (or task) where the filter values are

(A) normalized to sum to one.

(B) normalized to sum to zero.

(C) normalized so that the sum of the squared values is one (i.e., the filter has magnitude one).

Solution :

(A) Normalization of filter values to sum to one guarantees that the overall brightness level of the image is unchanged. This typically is what we want when the filter is used for smoothing.

(B) Normalization of filter values to sum to zero means that the output is zero when the input image is constant. This typically is what we want when the filter is used for some kind of differentiation.

(C) Normalization of filter values so that the sum of the squared values is one means that, as a 1D vector, the filter is a unit vector. This typically is what we want when the filter is used for template matching (and we'd like to interpret/compare matches absolutely, as a cosine).

Question 11:

We can smooth an image by convolving the 1D vector $[0.25, 0.5, 0.25]$ with the rows and then the columns of the image. Instead, give the 2D matrix that combines these row and column operations into a single 3×3 filter that can be convolved with the image. Hint: The calculation is easier if you represent the 1D vector with fractions, as in $[1/4, 1/2, 1/4]$.

Solution : The 3×3 filter is

$$\begin{bmatrix} \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \\ \frac{1}{8} & \frac{1}{4} & \frac{1}{8} \\ \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \end{bmatrix}$$

Note: the filter is symmetric about its center row and column so that here correlation and convolution are equivalent.

Question 12 List three scene properties that would cause an edge (brightness discontinuity) in an image.

Solution:

- a depth discontinuity (i.e., a foreground/background segmentation)
- a surface orientation discontinuity (e.g., two intersecting planar surfaces)
- a reflectance discontinuity (i.e., a change in surface colour/material on an otherwise smooth surface)
- illumination boundaries (e.g., cast shadows, light sources, specularities)

Question 13 Consider the matrix, $\mathbf{M}$, defined at each image point where

$$\mathbf{M} = \begin{bmatrix} {I_x}^2 & I_x I_y \\ I_x I_y & {I_y}^2 \end{bmatrix}$$

(A) Write expressions for the eigenvalues, λ_1 and λ_2, of $\mathbf{M}$.

Solution:

$$\begin{aligned} \lambda_1 &= {I_x}^2 + {I_y}^2 \\ \lambda_2 &= 0 \end{aligned}$$

(B) Could the computation of $\mathbf{M}$ at each image point be used for edge detection? Briefly justifiy your answer.

Solution: Yes it could. The non-zero eigenvalue, λ_1, of $\mathbf{M}$ is the square of the magnitude of the image gradient, $[I_x, I_y]$, at each image point. It is a 1st derivative based computation. One could compare λ_1 to a threshold to suggest the presence of an edge point.

Question 14 If you were asked to develop a computer vision system to help a paint store match the colours of paints for customers, would it be best to use the standard CIE XYZ colour space or a uniform colour space? Explain your answer with just one or two sentences.

Solution : You should use a uniform colour space because it measures which differences in colour will be perceptible to human vision.