COMS30030 – Image Processing and Computer Vision

Problem Sheet MM03

Edges & Hough

1- Which of the following statements is(are) true about the Hough transform?

A- When detecting circles, normally a 3D accumulator array has to be used.
B- When detecting a circle with a known radius, still a 3D accumulator array is used.
C- It can only detect lines and circles.
D- It can detect partially visible circles.
E- All of the above are true.

Answer:
A and D – Given the equation of a circle (look it up if you don't recall), then there are 3 unknowns, a,b, and radius r. The parameter space would be three dimensional, (a, b, r). Partially visible circles still give enough evidence to locate the centre and radius of a circle.

2- Which statement is FALSE about the Sobel operator?

A- It is invariant to rotations, providing the same edge detection results regardless of image orientation.
B- It is more sensitive to vertical and horizontal edges than to diagonal edges.
C- It calculates the gradient in both the x and y directions to find the edges.
D- It uses weighted pixel values to calculate the gradient.
E- Both statements B and C are TRUE.

Answer:
A

3- You are performing shape recognition using the Hough Transform. The accumulator array shows a peak at ($\rho = 10,\ \theta = 45°$) What does this peak represent?

A- A line with slope tan (45°) passing through the origin.
B- A line with a distance of 10 units from the origin, inclined at 45° to the x-axis.
C- A circle with radius 10 units detected at an angle of 45°.
D- A line passing through the point (10,10) inclined at 45°.
E- A point in the image space corresponding to coordinates ($\rho = 10,\ \theta = 45°$).

Answer:
B

4- Consider a 3x3 image region where pixel intensity values are given as follows:

$$\begin{pmatrix} 10 & 10 & 10 \\ 20 & 20 & 20 \\ 30 & 30 & 30 \end{pmatrix}$$

Using the Sobel filter, what is the magnitude of the gradient at the centre pixel?

A- 0
B- 20
C- 40
D- 60
E- 80

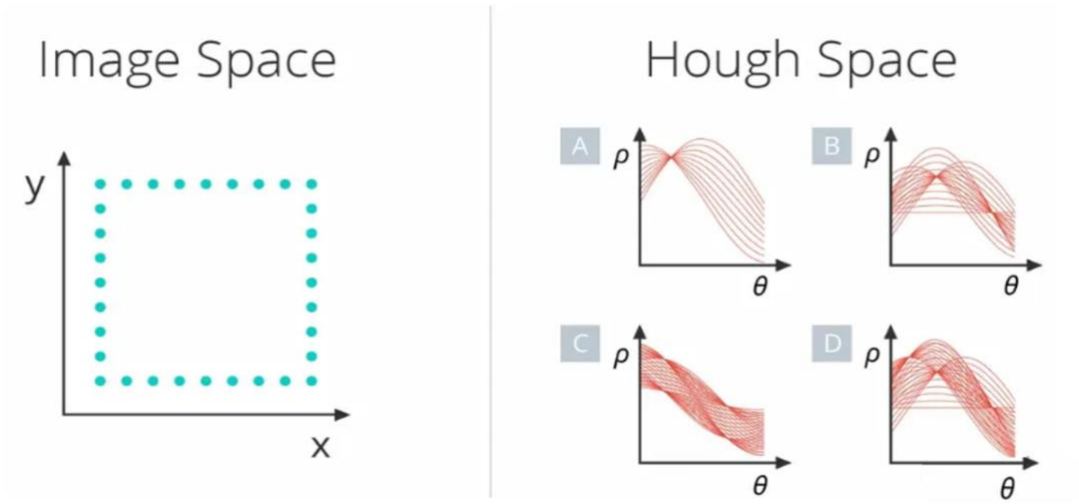
Answer:
E

5- In the context of gradient-based edge detection, which of the following describes the relationship between the gradient direction and the edge?

A- The gradient direction is always parallel to the edge.
B- The gradient direction points in the direction of the edge.
C- The gradient direction is always perpendicular to the edge.
D- The gradient direction points toward the region of maximum intensity.
E- The gradient direction varies randomly based on noise in the image.

Answer:
C

6- Which plot on the right is the Hough space of the square blue-dot image on the left?



Answer: C

7- Consider the following row of pixels: 5, 10, 15, 20, 25, 30, 35

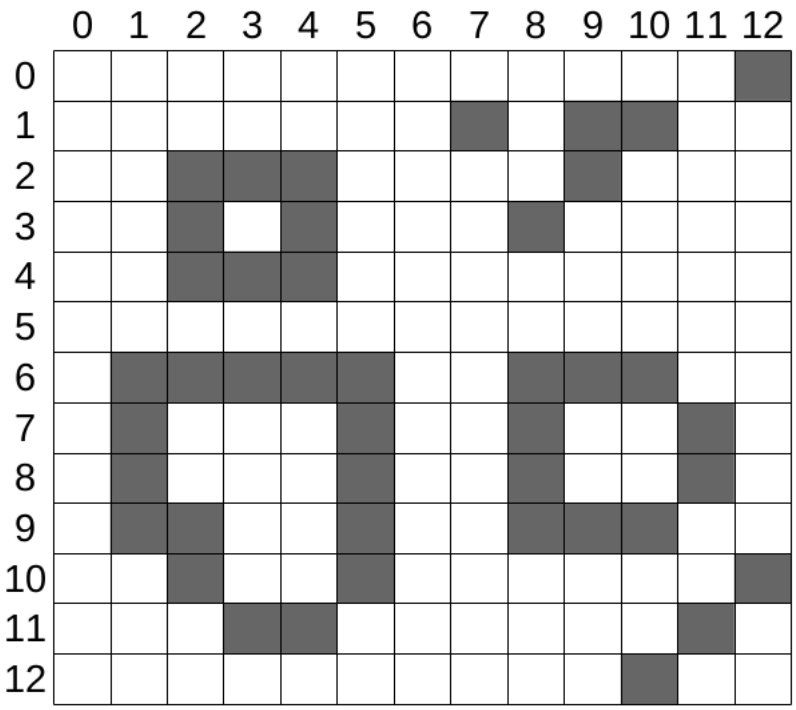
You are asked to calculate the gradient at the pixel with value 20 using a simplified version of the Prewitt operator with the horizontal mask: [-1, 0, 1]

Which of the following steps are correct for computing the gradient at the pixel with value 20 in this 1D scenario?

A- The Prewitt operator compares the centre pixel value directly to its neighbours, which gives $(25-15)/2 = 5$ as the gradient.
B- The gradient magnitude is computed as $\sqrt{(-15)^2 + (25)^2} = 29.15$
C- Applying the Prewitt operator results in a gradient of 0 at the pixel with value 20 because the central pixel contributes nothing to the result.
D- The Prewitt mask is applied to the window [15, 20, 25] and the result is: $-15+0+25=10$
E- The Prewitt operator detects vertical edges, and the gradient is not applicable for horizontal analysis in this case.

Answer:
D

8- Suppose that the Hough transform is applied to the image shown below.



Black and white image in the spatial domain

What is the maximum value in the accumulator cells? What are the corresponding values of $(\rho; \theta)$? Note, the origin lies at the top left corner.

Answer:

The maximum value is 8 and corresponds to the horizontal line where there are 8 pixels in that line.
By simple inspection, the values are $\rho = 6$ *and* $\theta = 0$

9- A Sobel kernel can be written as

$$S_x = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix} (1 \quad 2 \quad 1)$$

Which of the following statements are TRUE:

A- Separating the filter in the above manner, reduces the number of computations.
B- It is similar to applying a Gaussian filter followed by a derivative.
C- Separation leads to spurious edge artifacts.
D- Separation approximates the second derivative of a Gaussian.
E- A and D are both TRUE.

Answer:
A and B