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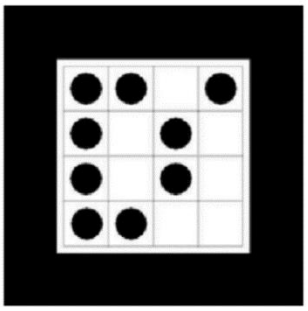
BLG453E – Midterm Exam 2 (CRN: 13633) – 19.12.2024

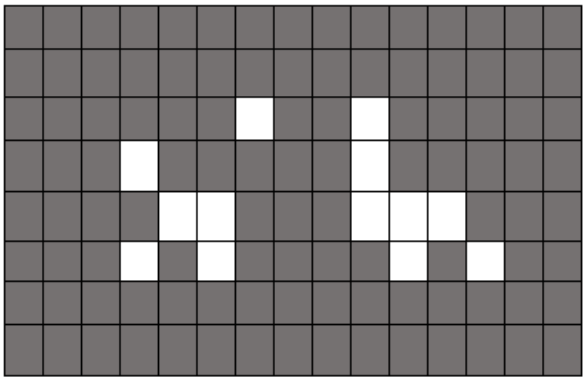


Q1) [10 pts] In early 2000s, Siemens Corporate Research developed a marker system called SCR, in which each marker has 16 slots for circle placement. An example SCR marker is given on the left. Suppose that, you are developing a mobile app which detects the marker and produces the SCR code (e.g. 1101 1010 1010 11 00 for left fig.). List the steps and methods to create the SCR code from a given image (e.g. figure on the right).

(Alternative solutions are acceptable)

- Thresholding the image to eliminate unnecessary details and obtain a B&W representation.
- Hough Line & Corner detection to find the polygons.
- Perspective transform of the rectangle to a frontal view.
- Hough Circle detection

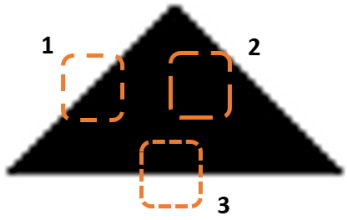
Q2) [10 pts] For the given image with white foreground pixels and black background pixels. Find the number of white pixels after (a) opening operation, (b) closing operation. Use a Square structuring element of size 3x3.



Opening: 0 pixels

Closing: 20 pixels

Q3 [10 pts] For the center pixels of windows 1, 2 and 3 shown in the figure, analyze the eigenvalues & draw the eigenvectors



For patches 1 and 3, $\lambda_1 \gg \lambda_2$.
For patch 2, $\lambda_1 \cong \lambda_2$ and very small.

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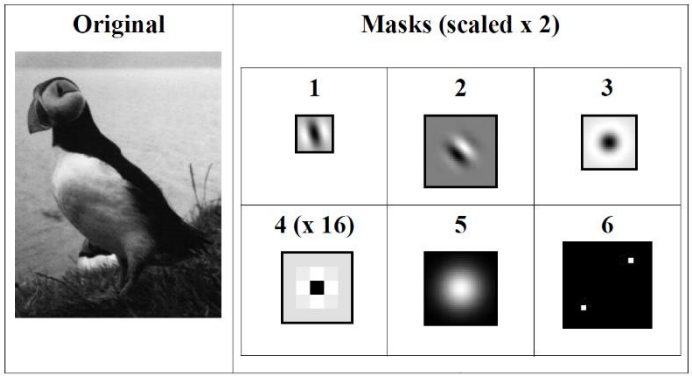
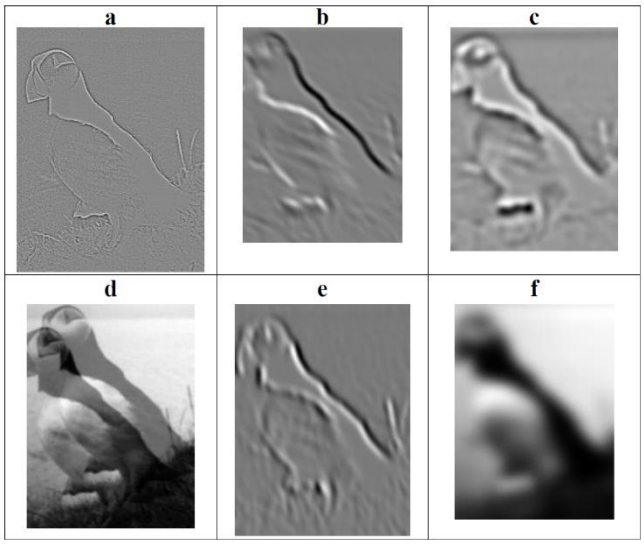
Q4) [10 pts] To calculate Laplacian of Gaussian for an image, the operations $J(x,y) = [\nabla^2 G(x,y)] * I(x,y)$ and $J(x,y) = \nabla^2[G(x,y) * I(x,y)]$ could be used equivalently. Explain ∇^2, $G(x,y)$ terms and the reason of the equivalency property.

$G(x,y)$: Gaussian Filter
∇^2: Laplacian Mask

Since convolution is a **linear** operator, we can use both.

Q5) [24 pts] The figure below shows an image together with 6 convolution masks. The result of convolving the image with each of the masks in turn is also shown, but the order has been randomised. State which mask was used to generate each output image. Note that the masks are shown at twice the spatial scale (twice as large) as the images, except for mask 4 which is shown at 16 times the spatial scale of the images. In both masks and images, the smallest or most negative grey level is shown as black, and the largest or most positive as white. In the masks, the grey-level at the outside boundary of the mask represents zero.

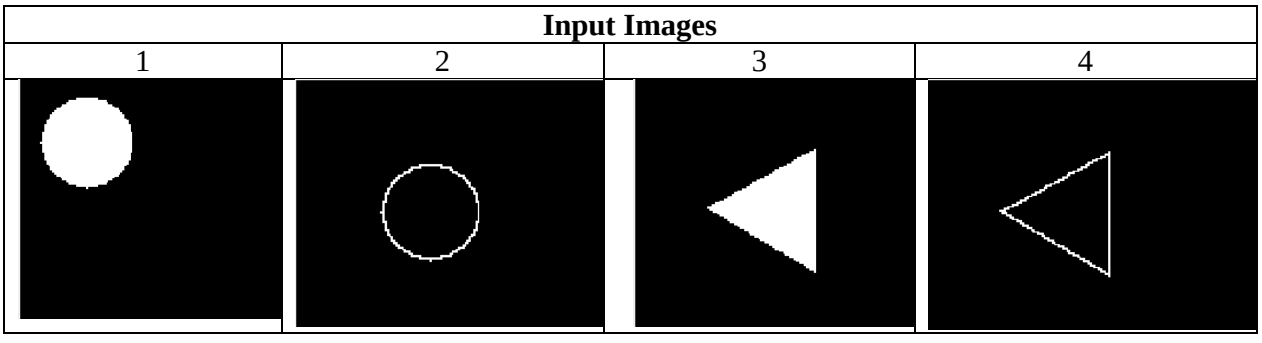




1-e, 2-b,3-c,4-a,5-f,6-d

(Full points were awarded for four correct answers.)

Q6) [16 pts] For Hough line detection, using $x\cos\theta + y\sin\theta = \rho$ equation on different input images, given accumulator visuals are obtained. Match the input images with $A(\theta, \rho)$ maps.



1-C, 2-A, 3-B, 4-D

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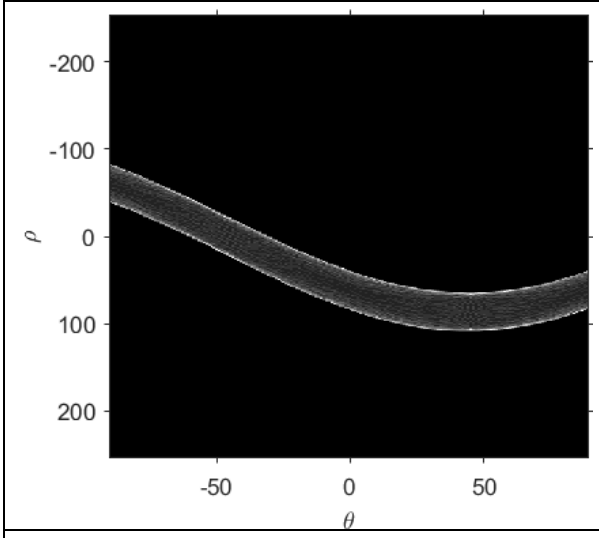
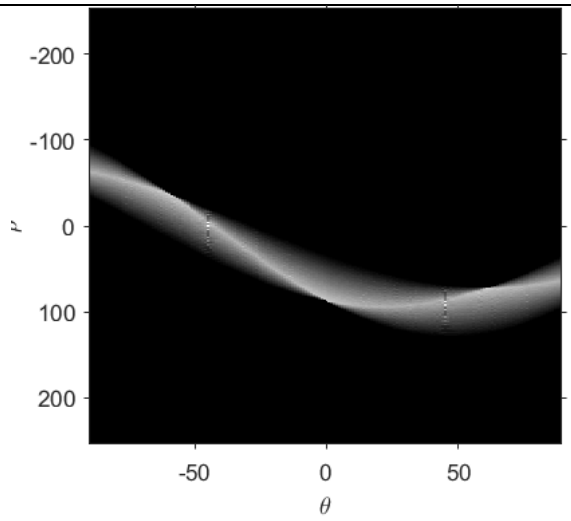
Accumulators

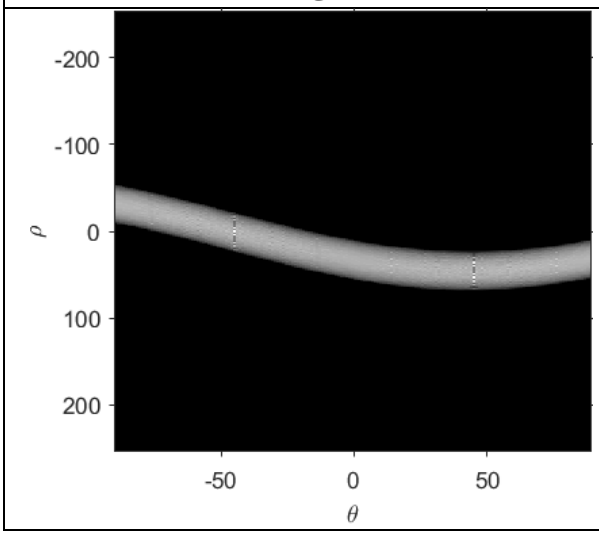
A



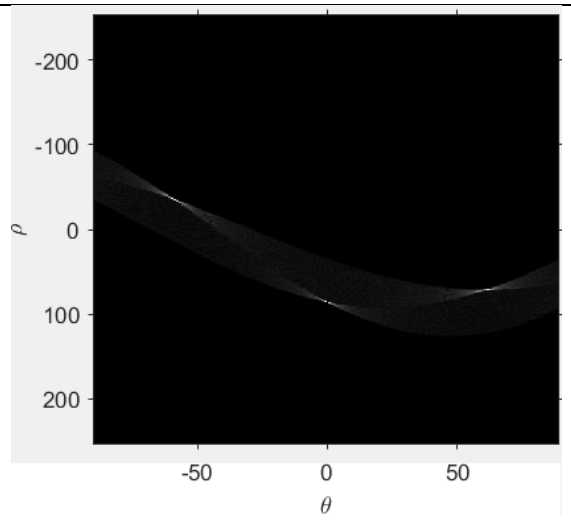
B



C



D



Q7) [10 pts] To detect 45° and 135° oriented edges, design two simple 3x3 filters. Explain how these filters could be used.

We could use Robinson Compass Masks as an example:

$$SE = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & 2 \end{bmatrix}, SW = \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$$

Q8) [10 pts] What kind of image features or properties could be explored by combining the two image filters given in Q7?

Combining the filters by addition: Edges in both diagonals are detected.
Combining the filters by convolution: The X shaped corners are detected.