EECS 4422/5323 Midterm Sample Answers

Question 1

Let

$$\mathbf{x} = \begin{bmatrix} x_{-1,-1} & x_{0,-1} & x_{1,-1} \\ x_{-1,0} & x_{0,0} & x_{1,-1} \\ x_{-1,1} & x_{0,1} & x_{1,1} \end{bmatrix}$$

be a structure element kernel anchored at $x_{0,0}$.

Let $\mathbf{b}$ be a binary image with width w and height h, where $b_{i,j}$ is the pixel located at position (i, j).

Write the mathematical expression for generating $\mathbf{d}$, the dilation of $\mathbf{b}$ with $\mathbf{x}$. For the purposes of this expression you can assume your image has been appropriately padded.

Answer:

$$\forall i \in [1, w], \forall j \in [1, h], \quad d_{i,j} = \bigvee_{p=-1}^{p=1} \bigvee_{q=-1}^{q=1} (x_{p,q} \wedge b_{i+p,i+q})$$

Question 2

To normalize the matrix, we find the global current maximum and minimum: $P_{max} = 7$, $P_{min} = -6$

We then compute pixel-wise equation:

$$P'_{i,j} = (P_{i,j} + 6)\frac{2}{13} - 1$$

which gives us:

$$\mathbf{P'} = \frac{1}{13} \begin{bmatrix} -11 & -1 & -3 & 11 \\ 9 & -7 & -5 & 11 \\ -1 & -3 & 13 & -9 \\ -1 & -7 & 9 & -13 \end{bmatrix}$$

Question 3

Applying wrap padding to our image patch (we need to pad by one number since our convolution kernel is 3×3), we get:

$$\begin{bmatrix} 51 & 4 & 8 & 51 & 4 \\ 53 & 10 & 15 & 53 & 10 \\ 67 & 72 & 44 & 67 & 72 \\ 51 & 4 & 8 & 51 & 4 \\ 53 & 10 & 15 & 53 & 10 \end{bmatrix}$$

Computing the kernel cross-correlation with this matrix, we get the following output:

$$\begin{bmatrix} (19-125) & (61-54) & (61-82) \\ (54-71) & (82-80) & (125-95) \\ (80-61) & (95-19) & (71-61) \end{bmatrix} = \begin{bmatrix} -106 & 7 & -21 \\ -17 & 2 & 30 \\ 19 & 76 & 10 \end{bmatrix}$$

Question 4

See slide 5 in Feature Detection 2 lecture. Any of the characteristics listed there would be acceptable (with explanation).

Question 5

Ellipses are parameterized by four variables, whereas lines are parameterized by two variables. Therefore, the accumulator space for a Hough Transform at equivalent spatial resolution must be much larger for ellipses.

Question 6

$$y = \max(0, \left(\sum_{i=1}^{3} w_i x_i \right) + b)$$

Note: we didn't really discuss the offset value, b, in class; if this was left out of your answer you would not be penalized.

Question 7

When supplying input with a person holding a cat near her face, it is possible that cross-talk between the cat and human face will cause Yulong's network to behave unpredictably.