

21-S1-Q1

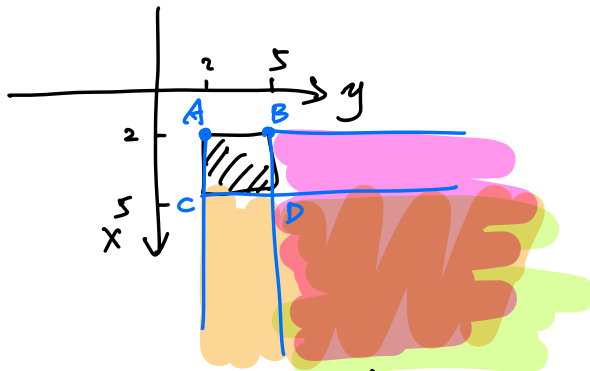
Q(a) $f(x,y)$ $h(x,y)$

Solution

(a) ① 2D unit step function

$$s(x,y) = \begin{cases} 1, & x \geq 0 \text{ and } y \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

②

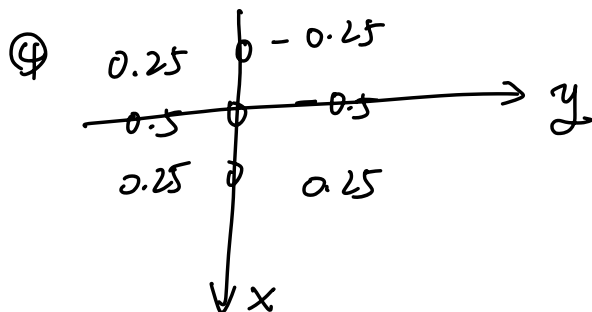


③ $f(x,y) = s(x-2, y-2)$

$$- [s(x-2, y-2) - s(x-5, y-2)]$$

$$- [s(x-2, y-2) - s(x-2, y-5)]$$

$$+ s(x-5, y-5)$$



$$\textcircled{5} h(x, y) = 0.25 \delta(x-1, y-1) + 0.25 \delta(x-1, y+1) \\ + 0.5 \delta(x, y+1) + 0.25 \delta(x+1, y+1) \\ - 0.25 \delta(x+1, y-1) - 0.5 \delta(x, y-1)$$

(b)

	0	1	2	3	4	5	6	7
0								
1		0	0	0	0	0	0	0
2		0	1	1	1	1	0	0
3		0	1	1	1	1	0	0
4		0	1	1	1	1	0	0
5		0	1	1	1	1	0	0
6		0	0	0	0	0	0	0
7		0	0	0	0	0	0	0

	0	1	2	3	4	5	6	7
0								
1		0.25	0	-0.25				
2		0.5	0	-0.5				
3		0.25	0	-0.25				
4								
5								
6								
7								

$$g(1,1) = 0.25 \quad g(1,2) = 0.25 \quad g(1,3) = 0 \quad g(1,4) = 0 \quad \dots$$

$$g(2,2) = 0.75 \quad g(2,3) = 0 \quad g(2,4) = 0 \quad g(2,5) = -0.75$$

similarly

output image

	0	1	2	3	4	5	6	7
0								
1		0.25	0.25	0	0	-0.25	-0.25	0
2		0.75	0.75	1	1	-0.75	-0.75	0
3		1	1	0	0	-1	-1	0
4		1	1	0	0	-1	-1	0
5		0.75	0.75	1	1	-0.75	-0.75	0
6		0.25	0.25	0	0	-0.25	-0.25	0
7		0	0	0	0	0	0	0

- (c) ① $h(x, y)$ acts as horizontal gradient operator
- ② $h(x, y)$ computes the weighted difference between the pixels on the left and right of each position
- ③ $h(x, y)$ effectively detect vertical edge in the image

Verification

- ① Along the left edge of the rectangle in $f(x, y)$, where there is a transition from 0 to 1
- ② Along the right edge of the rectangle in $f(x, y)$, where there is a transition from 1 to -1
- ③ This behavior confirms that the filter effectively detects vertical edges