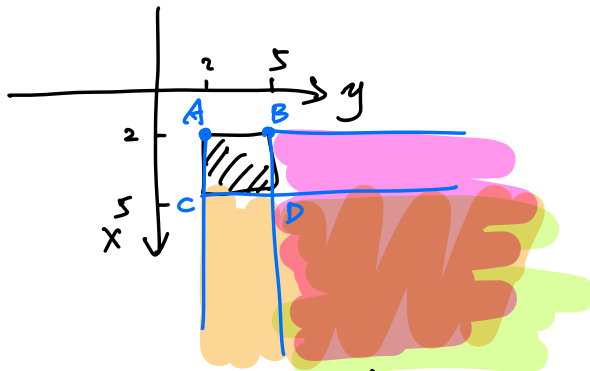21 - S1 - Q1

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

Solution

(a) ① 2D unit step function

$$S(x,y) = \begin{cases} 1, & x \geq 0 \text{ and } y \geq 0 \\ 0, & \text{otherwise} \end{cases}$$
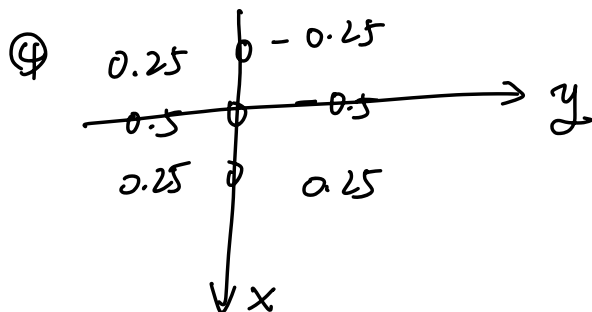
②

③ $f(x,y) = S(x-2, y-2)$

$$- \left[S(x-2, y-2) - S(x-5, y-2) \right]$$

$$- \left[S(x-2, y-2) - S(x-2, y-5) \right]$$

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

④

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)

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

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

similarly

output image

(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