- # Ejemplo 1.

0	0	0	0	0
0	0	1	1	0
0	0	1	1	0
0	0	0	0	0
0	0	0	0	0

0,0	0,1	0,2	0,3	0,4
1,0	1,1	1,2	1,3	1,4
2,0	2,1	2,2	2,3	2,4
3,0	3,1	3,2	3,3	3,4
4,0	4,1	4,2	3,4	4,4

$$M_{pq} = \sum_x \sum_y x^p\, y^q f(x,y)$$

$$M_{pq} = \begin{bmatrix} M_{00} & M_{10} \\ M_{01} & M_{11} \end{bmatrix} = \begin{bmatrix} 4 & 10 \\ 6 & 15 \end{bmatrix}$$

Para p,q = 0,1

$$M_{00} = \sum_x \sum_y f(x,y) = (1) + (1) + (1) + (1) = 4$$

$$M_{10} = \sum_x \sum_y x\, f(x,y) = (2)(1) + (3)(1) + (2)(1) + (3)(1) = 10$$

$$M_{01} = \sum_x \sum_y y\, f(x,y) = (1)(1) + (2)(1) + (1)(1) + (2)(1) = 6$$

$$M_{11} = \sum_x \sum_y x\, y\, f(x,y) = \underbrace{(2)(1)(1)}_{2} + \underbrace{(3)(1)(1)}_{3} + \underbrace{(2)(2)(1)}_{4} + \underbrace{(3)(2)(1)}_{6} = 15$$

- Ejemplo 2.

0	0	0	0	0
0	0	1	1	0
0	0	1	1	0
0	0	0	0	0
0	0	0	0	0

0,0	0,1	0,2	0,3	0,4
1,0	1,1	1,2	1,3	1,4
2,0	2,1	2,2	2,3	2,4
3,0	3,1	3,2	3,3	3,4
4,0	4,1	4,2	3,4	4,4

$\mu_{00} = M_{00},$
$\mu_{01} = 0,$
$\mu_{10} = 0,$
$\mu_{11} = M_{11} - \bar{x} M_{01} = M_{11} - \bar{y} M_{10}$

$$\mu_{pq} = \sum_x \sum_y (x - x_c)^p (y - y_c)^q f(x, y)$$

$$\mu = \begin{bmatrix} \mu_{00} & \mu_{10} \\ \mu_{01} & \mu_{11} \end{bmatrix} = \begin{bmatrix} 4 & 0 \\ 0 & 0 \end{bmatrix}$$

Centroide $\{\bar{x}, \bar{y}\} = \left\{\frac{M_{10}}{M_{00}}, \frac{M_{01}}{M_{00}}\right\} = \left\{\frac{10}{4}, \frac{6}{4}\right\} = 2.5, 1.5$

Para p,q = 0,1

$\mu_{00} = \sum_x \sum_y f(x,y) = 4$

$(-0.5)(1) + (0.5)(1) + (-0.5)(1) + (0.5)(1)$

$\mu_{10} = \sum_x \sum_y (x - x_c)^1 f(x,y) = (2-2.5)(1) + (3-2.5)(1) + (2-2.5)(1) + (3-2.5)(1) = 0$

$(-0.5)(1) + (0.5)(1) + (-0.5)(1) + (0.5)(1)$

$\mu_{01} = \sum_x \sum_y (y - y_c)^1 f(x,y) = (1-1.5)(1) + (2-1.5)(1) + (1-1.5)(1) + (2-1.5)(1) = 0$

$\mu_{11} =$

$\sum_x \sum_y (x - x_c)^1 (y - y_c)^1 f(x,y) = (2-2.5)(1-1.5)(1) +$
$(3-2.5)(1-1.5)(1) +$
$(2-2.5)(2-1.5)(1) +$
$(3-2.5)(2-1.5)(1) = 0.25 - 0.25 - 0.25 + 0.25 = 0$

Ejemplo 4.

- D=1, $\theta = 0$ (de izquierda a derecha)

La imagen:

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix}$$

Pixel vecino -> Pixel de referencia	0	1	2	3
0	2	2	1	0
1	0	2	0	0
2	0	0	3	1
3	0	0	0	1

(0,0) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 2$

(0,1) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 2$

(0,2) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 1$

(0,3) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(1,0) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(1,1) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 2$

(1,2) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(1,3) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(2,0) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(2,1) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$

(2,2) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 3$

(2,3) $\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 1$

(3,0)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3,1)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3,2)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3,3)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 3$$

- Pero conviene que la matriz sea simétrica respecto a su diagonal principal.

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix}$$

Pixel vecino -> Pixel de referencia ⬇	0	1	2	3
0	2	0	0	0
1	2	2	0	0
2	1	0	3	0
3	0	0	1	1

(0,0)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} =$$

(0,1)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(0,2)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(0,3)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(1,0)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 2$$

(1,1)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 2$$

(1,2)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(1,3)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(2, 0)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 1$$

(2, 1)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(2, 2)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 3$$

(2, 3)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3, 0)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3, 1)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 0$$

(3, 2)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 1$$

(3, 3)

$$\begin{matrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 2 & 2 & 2 \\ 2 & 2 & 3 & 3 \end{matrix} = 1$$