UNIVERSITÄT HEIDELBERG
HEIDELBERG CENTER LATEINAMERIKA

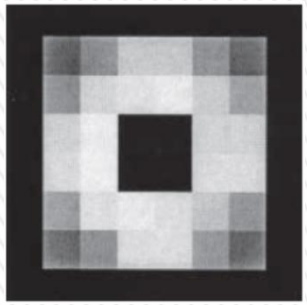
Prepaso práctico N°4

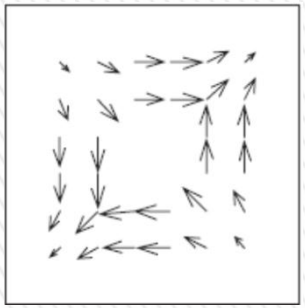
Filtros de borde, gaussiano y morfológico

Valentina Lagos Herrera (1), Daniel Karmelic (2), Germán Fernández (2)

(1) *Programa de Magister en Informática Médica, Universidad de Chile/Universidad de Heidelberg*

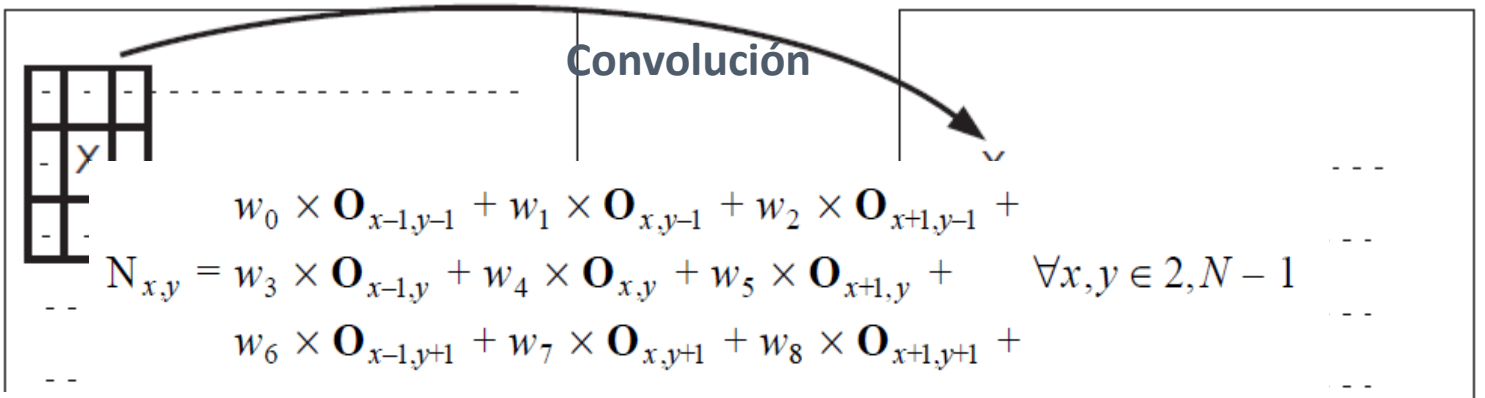
(2) Programa de Doctorado en Ciencias con Mención en Biología Molecular, Celular y Neurociencias, Universidad de Chile.





Kernel y operaciones de grupo
(Plantilla, matriz, template, etc)

Group operations calculate new pixel values from pixels' neighbourhoods by using a 'grouping' process. The group operation is usually expressed in terms of template convolution where the template is a set of weighting coefficients. The template is usually square, and its size is usually odd to ensure that it can be positioned appropriately. The size is normally used to describe the template; a 3 × 3 template is three pixels wide by three pixels long



$$N_{x,y} = \begin{aligned} & w_0 \times \mathbf{O}_{x-1,y-1} + w_1 \times \mathbf{O}_{x,y-1} + w_2 \times \mathbf{O}_{x+1,y-1} + \\ & w_3 \times \mathbf{O}_{x-1,y} + w_4 \times \mathbf{O}_{x,y} + w_5 \times \mathbf{O}_{x+1,y} + \\ & w_6 \times \mathbf{O}_{x-1,y+1} + w_7 \times \mathbf{O}_{x,y+1} + w_8 \times \mathbf{O}_{x+1,y+1} + \end{aligned} \qquad \forall x,y \in 2,N-1$$

w_0	w_1	w_2
w_3	w_4	w_5
w_6	w_7	w_8

*

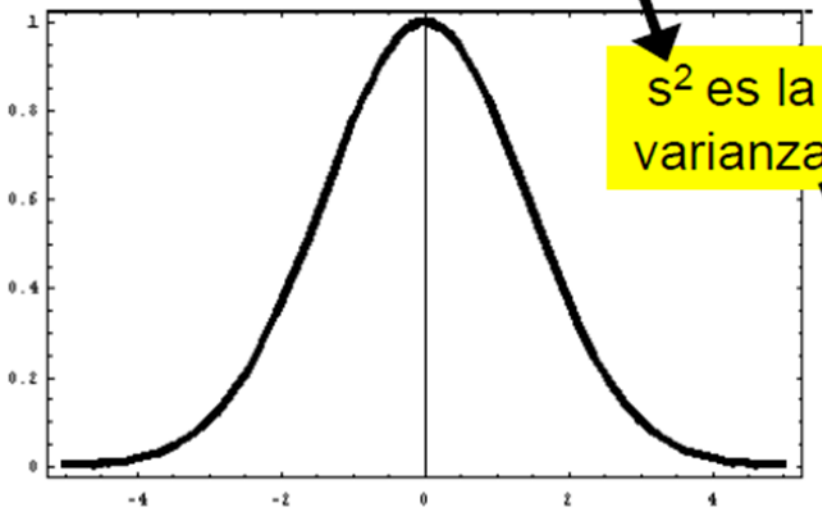
x-1,y+1	x,y+1	x+1,y+1
x-1,y	x,y	x+1,y
x-1,y-1	x,y-1	x+1,y-1

Operadores de suavizado.

- **Suavizado gaussiano:** media ponderada, donde los pesos toman la forma de una campana de Gauss.
- **Ejemplo.** Suavizado gaussiano horizontal.

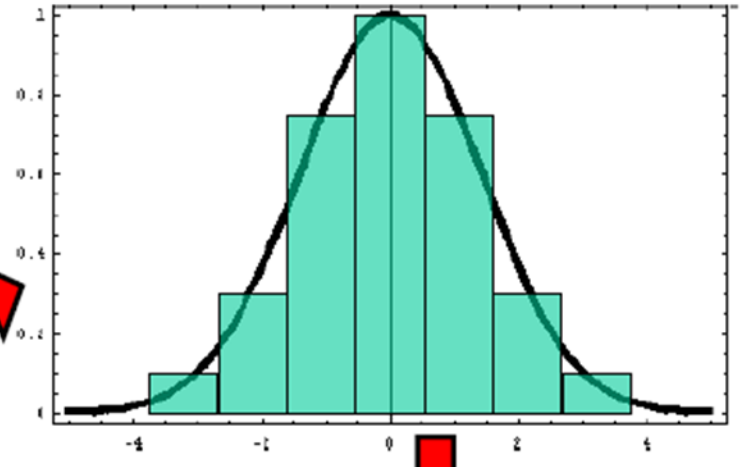
Campana de Gauss

$$f(x) = e^{-x^2/s^2}$$



s^2 es la varianza

Campana discreta

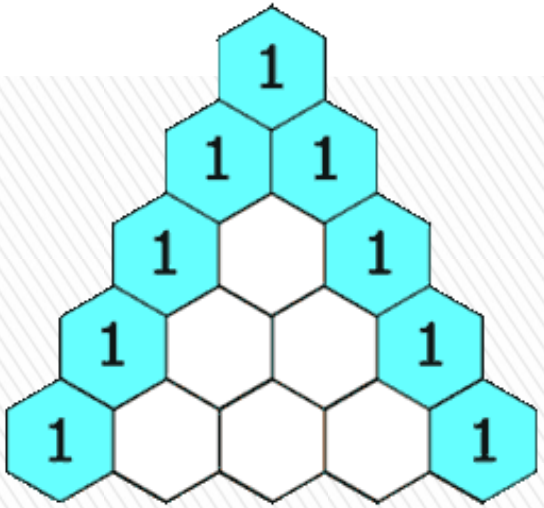


1/64 · | 1 | 6 | 15 | 20 | 15 | 6 | 1 |

Operadores de suavizado.

- La **varianza**, s^2, indica el nivel de suavizado.
  - **Varianza grande:** campana más ancha, más suavizado.
  - **Varianza pequeña:** campana más estrecha, menos suavizado.
  - Se mide en píxeles.
- **Cálculo de la máscara gaussiana (1D):** calcular la función, discretizar en el rango, discretizar en el valor y calcular el multiplicador...

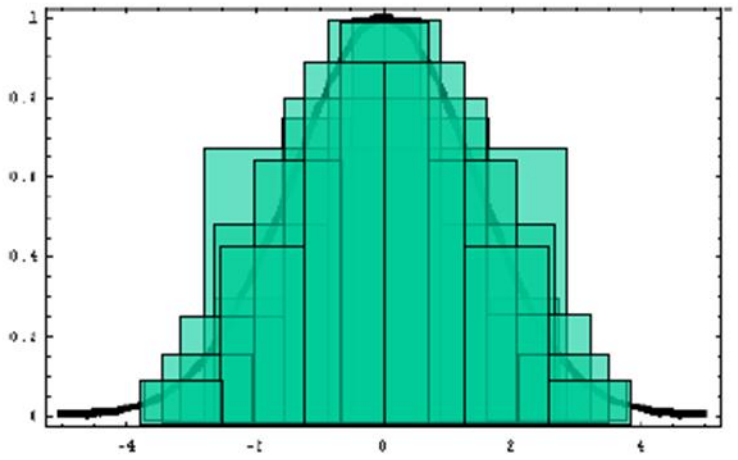
- ¿No existe una forma más rápida?
- **Idea:** el triángulo de Pascal.



Operadores de suavizado.

- **¡Magia!** Las filas del triángulo de Pascal forman discretizaciones de la campana de Gauss.

1/2·	1	1				
1/4·	1	2	1			
1/8·	1	3	3	1		
1/16·	1	4	6	4	1	
1/32·	1	5	10	10	5	1
1/64·	1	6	15	20	15	6	1

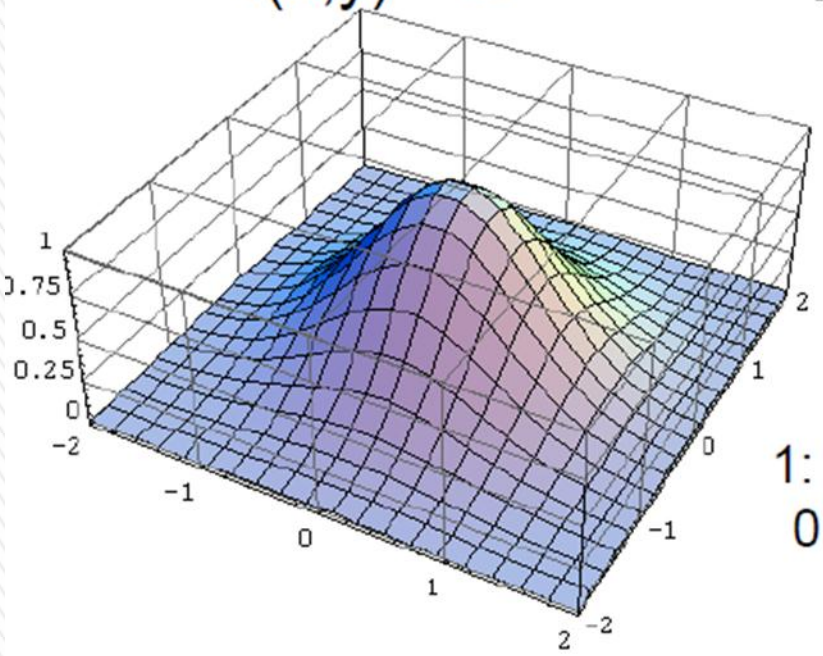


Operadores de suavizado.

- Normalmente, el suavizado gaussiano se aplica en dos dimensiones. Los pesos de la máscara dependen de la **distancia al píxel central**.

Campana de Gauss 2D

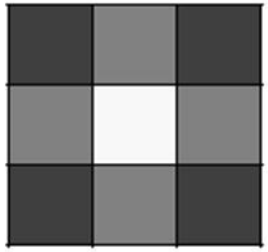
$$f(x,y) = e^{-(x^2+y^2)/s^2}$$

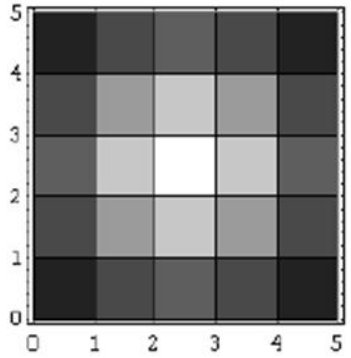


Máscara gaussiana de 3x3

$$1/16 \cdot \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

1: blanco
0: negro





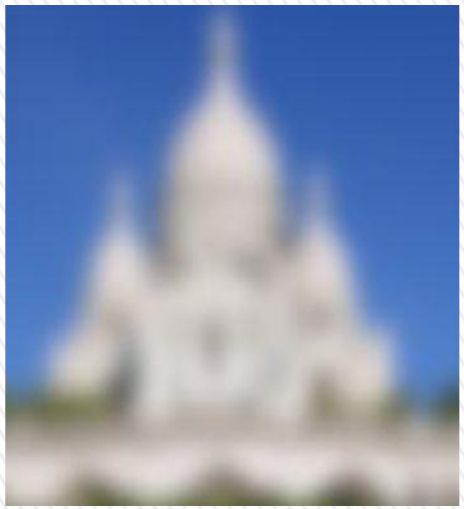
EJEMPLO

Operadores de suavizado.

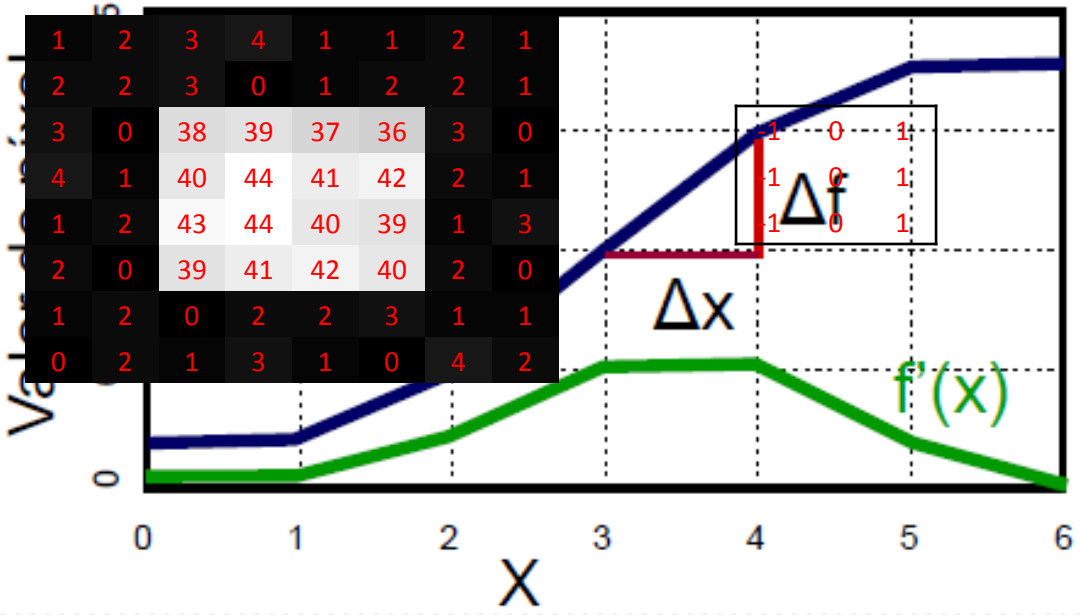
- **Efecto de niebla.** Dada una imagen bien definida, queremos simular una niebla (objetivo *empañado*).
- **Idea:** calcular una media ponderada entre la imagen original y un suavizado gaussiano de la imagen.

A Imagen original

B. Suaviz. gauss. 40x40

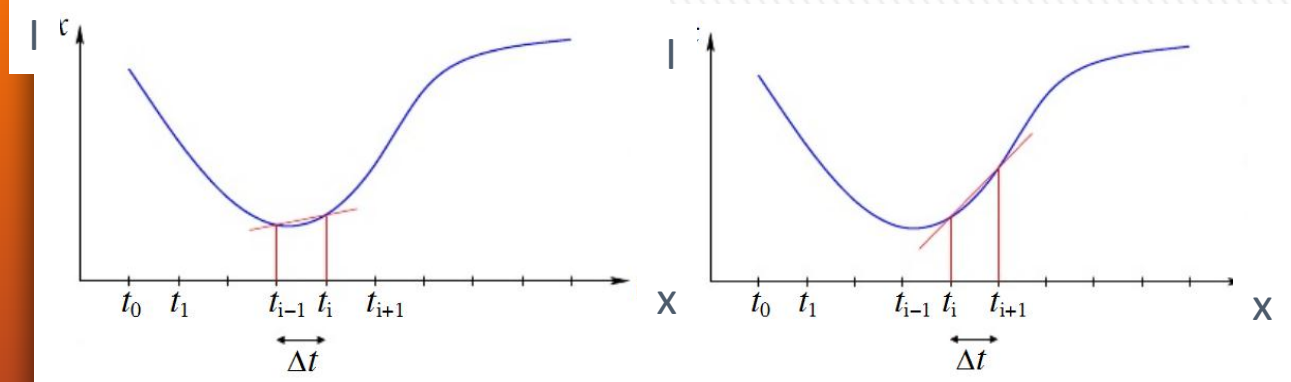


Detectores de Borde



4	3	0	-4	-1	2	-1	-4
4	38	39	-5	-4	-32	-37	-7
3	72	80	-2	-3	-72	-78	-7
3	113	124	-3	-10	-112	-113	-6
3	115	126	1	-8	-118	-117	-5
4	78	83	2	-5	-80	-78	-4
4	37	42	5	-3	-38	-40	-7
4	0	1	2	-2	2	0	-5

Derivada



$$\approx \frac{I_i - I_{i-1}}{\Delta x}$$

$$\approx \frac{I_{i+1} - I_i}{\Delta x}$$

$\Delta x = 1$

-1	0	+1
-1	0	+1
-1	0	+1

Operador Sobel

Filtro capaz de determinar los bordes por la determinación de un gradiente de intensidad.
Este gradiente se calcula utilizando una aproximación de una diferencial discreta.
Utilización de dos Kernels.

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A}$$

Horizontal

$$\mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A}$$

Vertical

$$\mathbf{G} = \sqrt{{\mathbf{G}_x}^2 + {\mathbf{G}_y}^2}$$

Intensidad

$$\mathbf{\Theta} = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x)$$

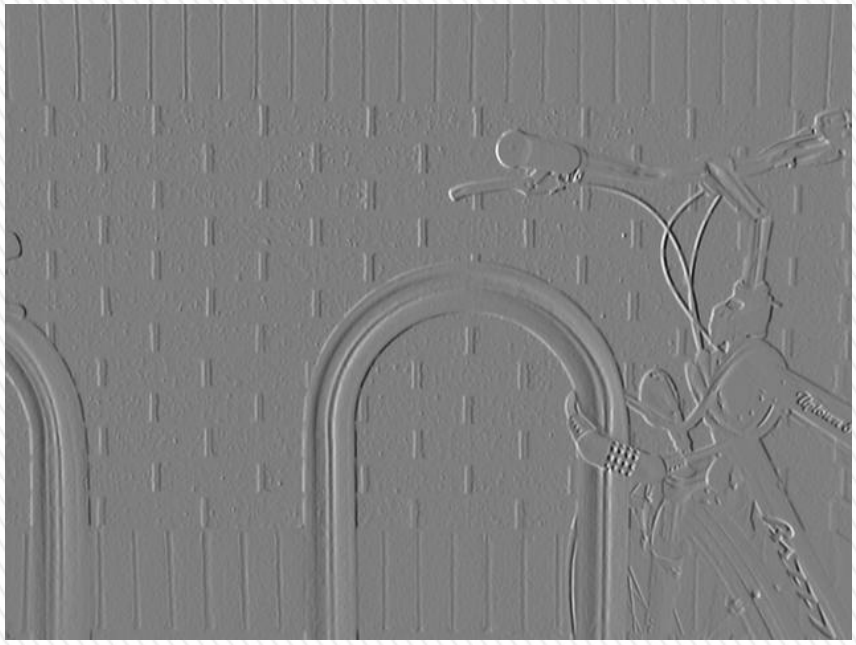
Dírección del cambio

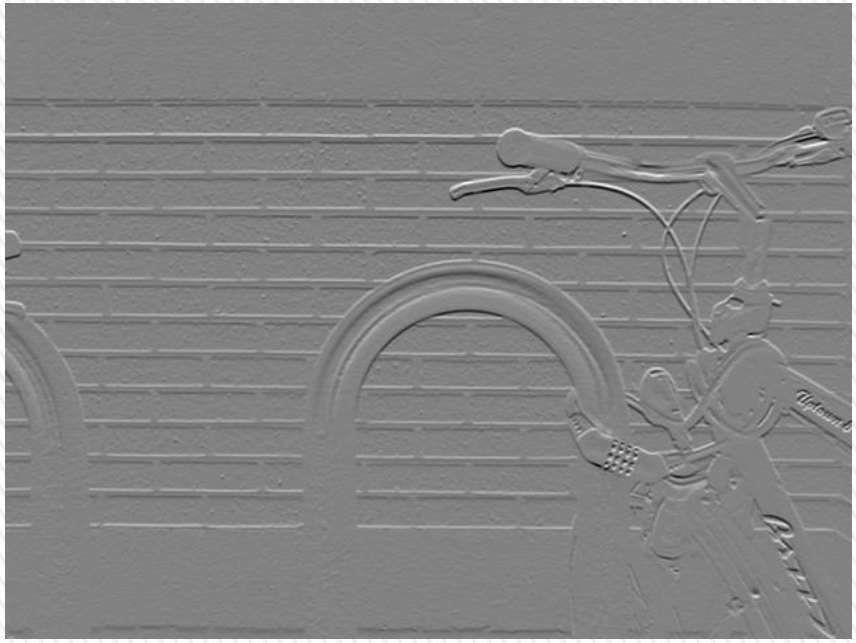
Operador Sobel

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A}$$

$$\mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A}$$

Operador Sobel





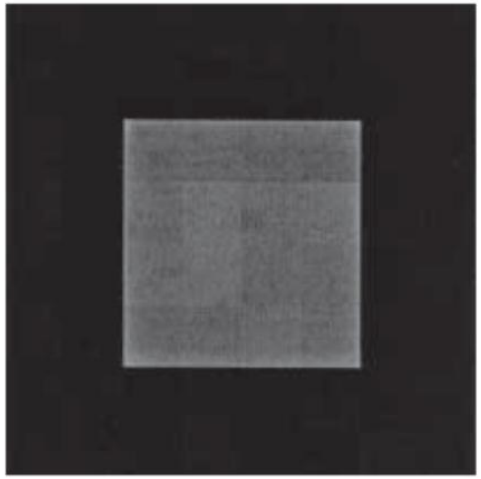
$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A}$$

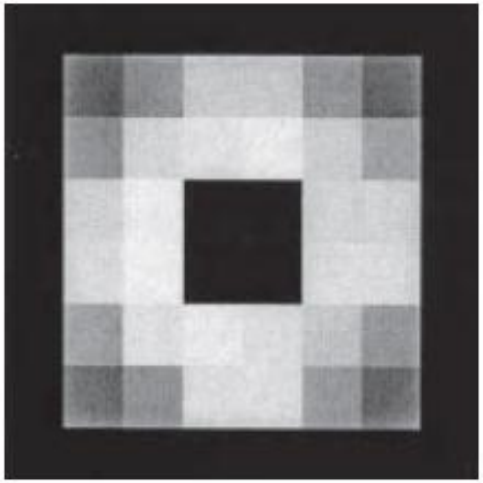
$$\mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A}$$

Operador Sobel

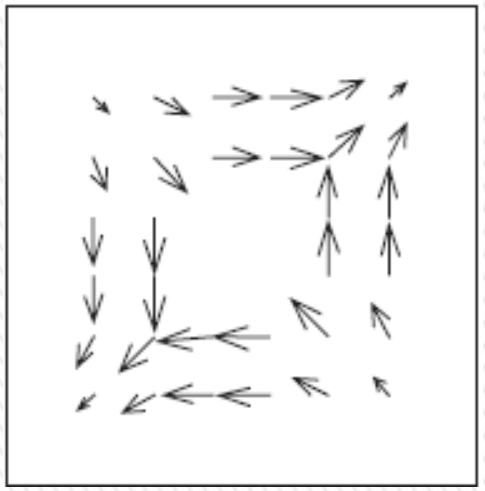
$$\mathbf{G} = \sqrt{\mathbf{G}_x^{\,2} + \mathbf{G}_y^{\,2}}$$

Operador Sobel



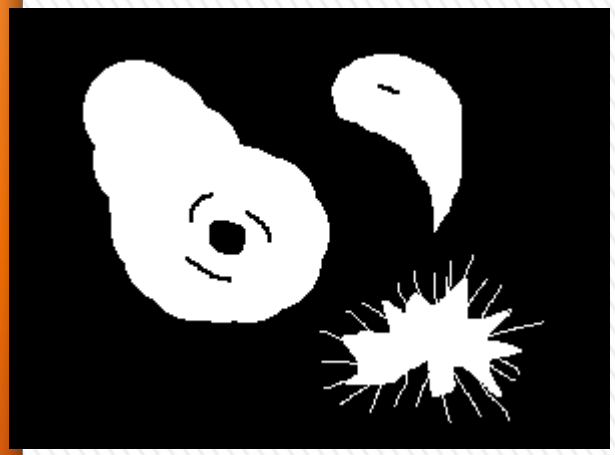


$$\mathbf{G} = \sqrt{\mathbf{G}_x^{\,2} + \mathbf{G}_y^{\,2}}$$

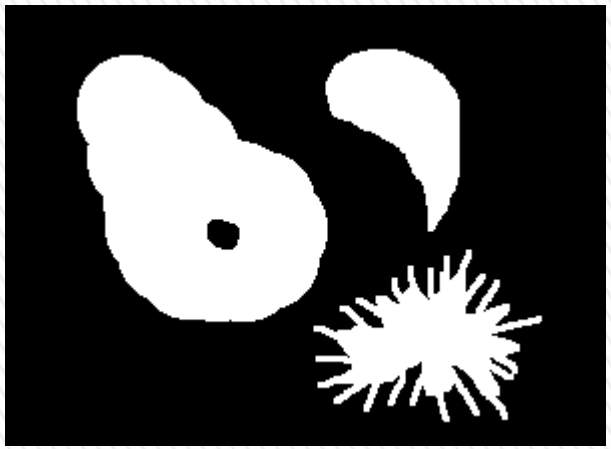


$$\mathbf{\Theta} = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x)$$

Operadores morfológicos



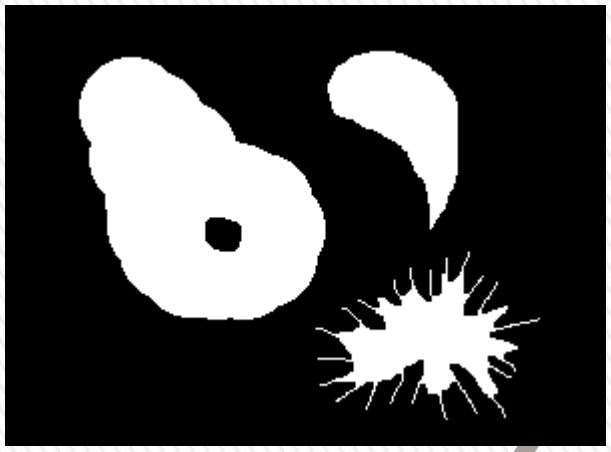
Dilatación



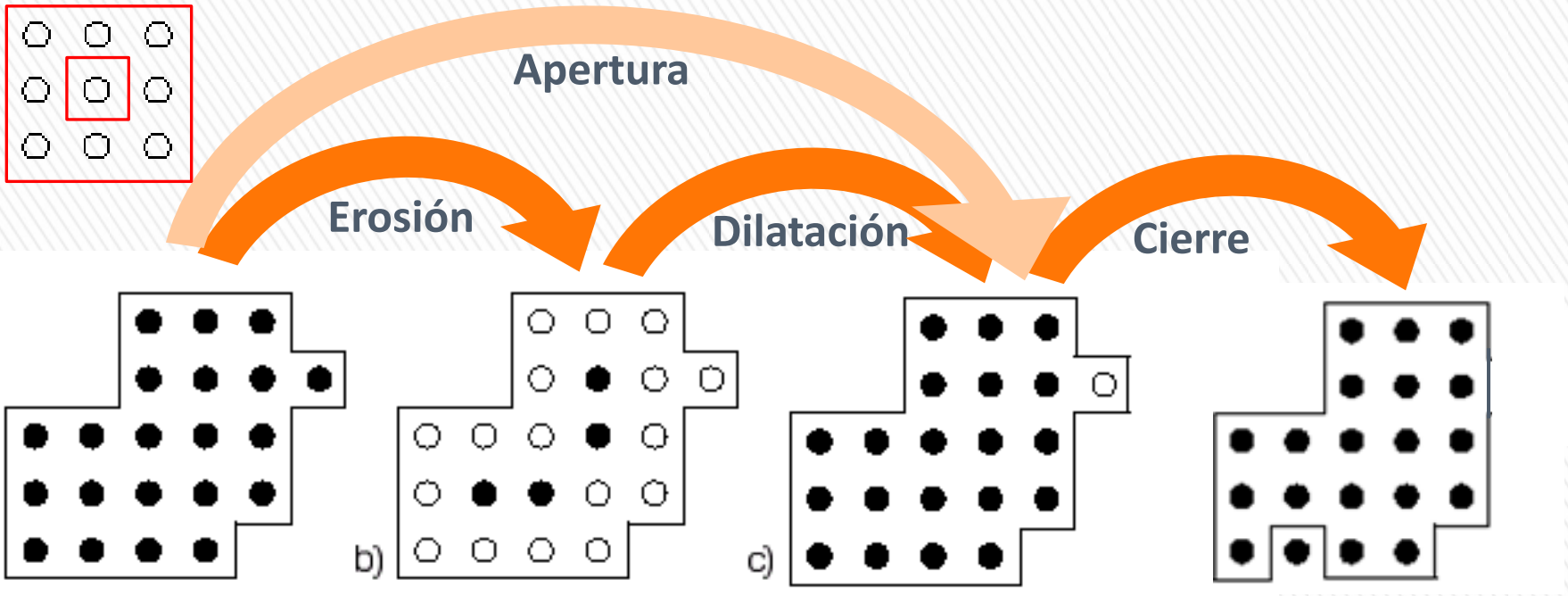
Apertura

Erosión

Cierre



Apertura



Notación

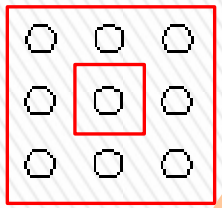
Dilatación $A \oplus B$

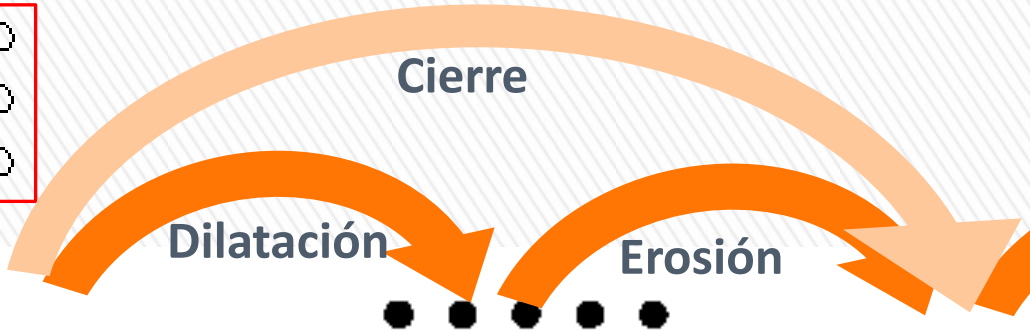
Erosión $A \ominus B$

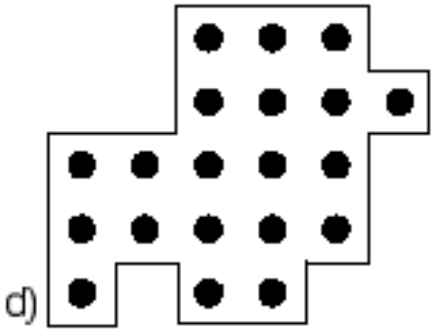
Apertura $A \circ B = (A \ominus B) \oplus B,$

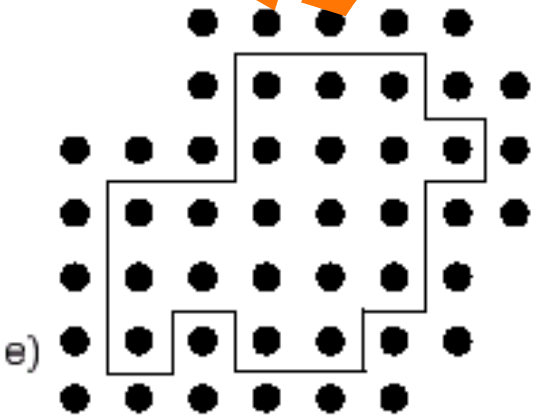
Cierre $A \bullet B = (A \oplus B) \ominus B,$

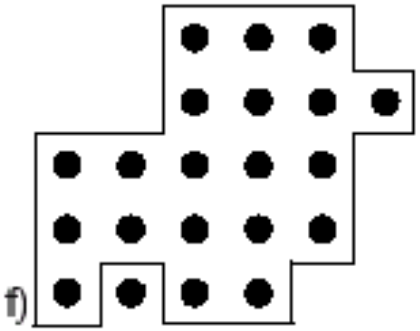
Cierre

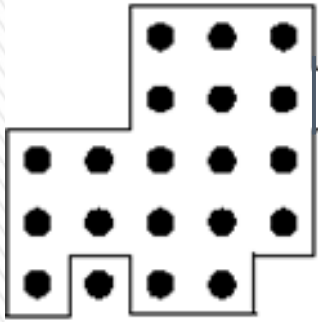




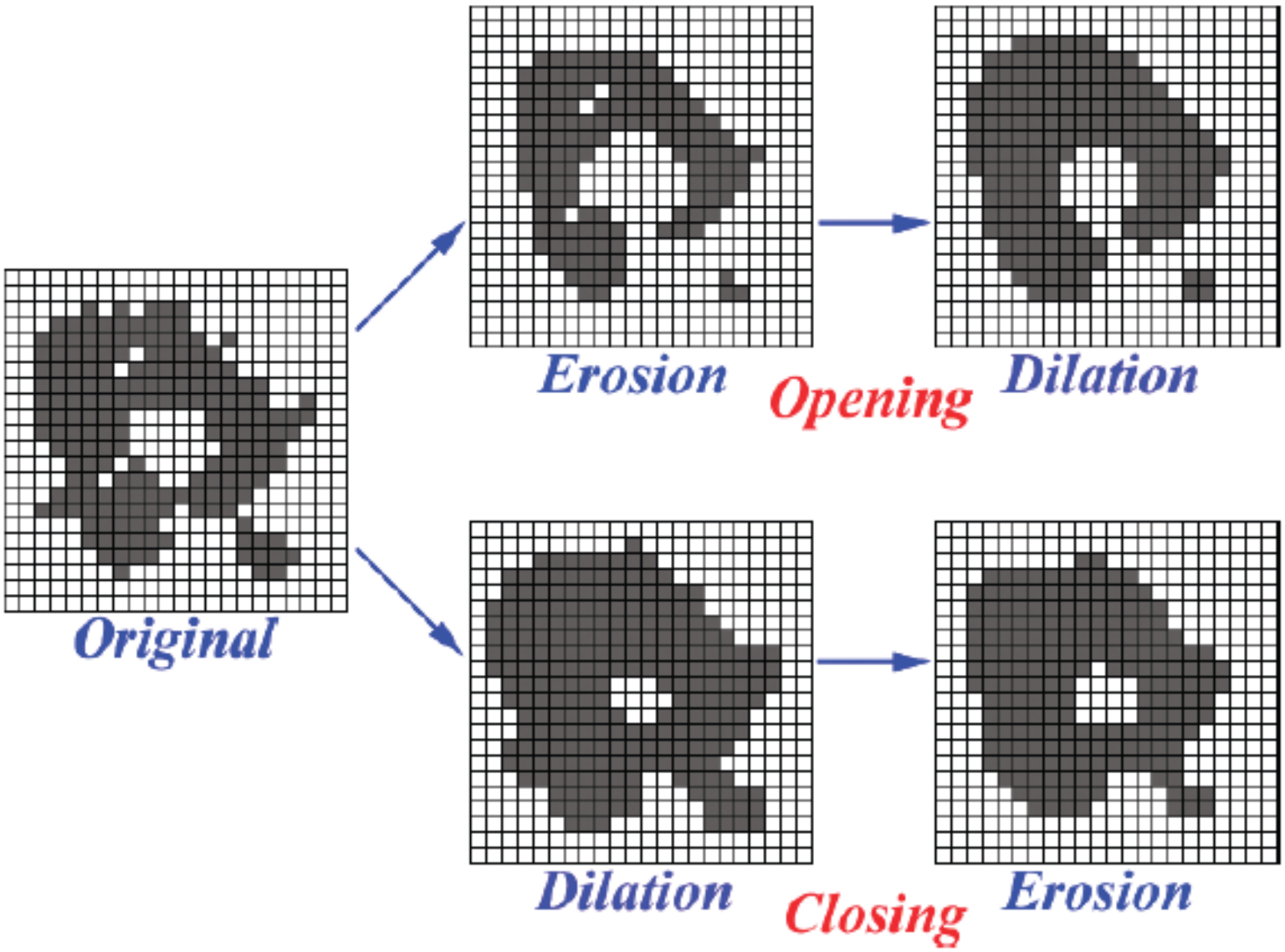


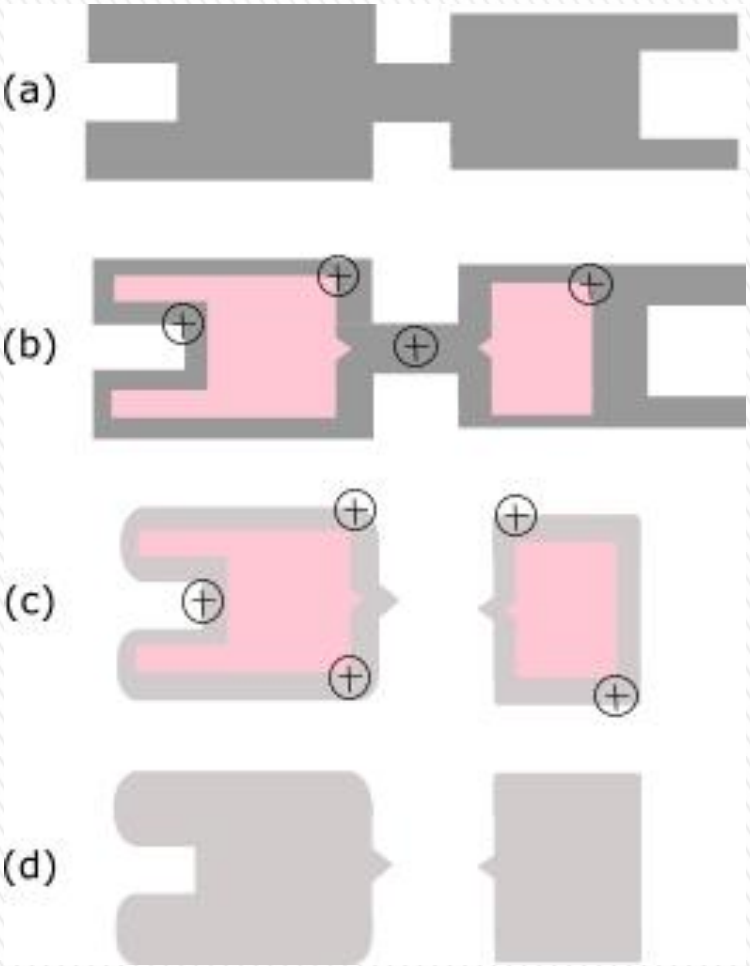






Open-Close

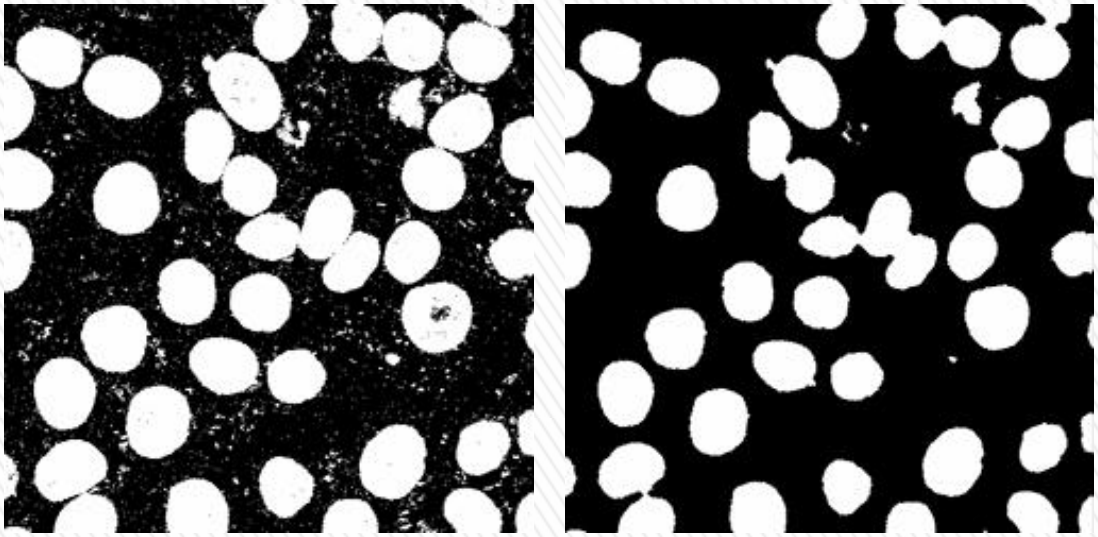

Original
Erosion
Opening
Dilation
Dilation
Closing
Erosion



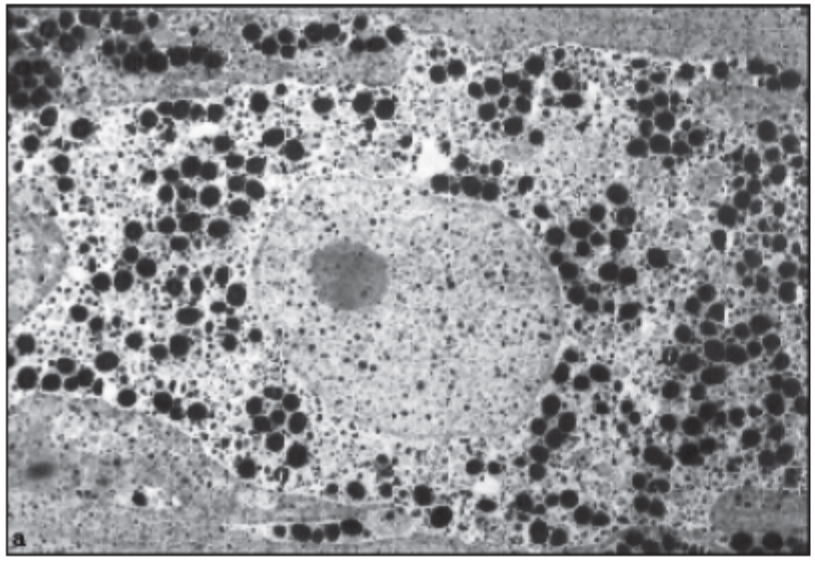
Erosión

Dilatación

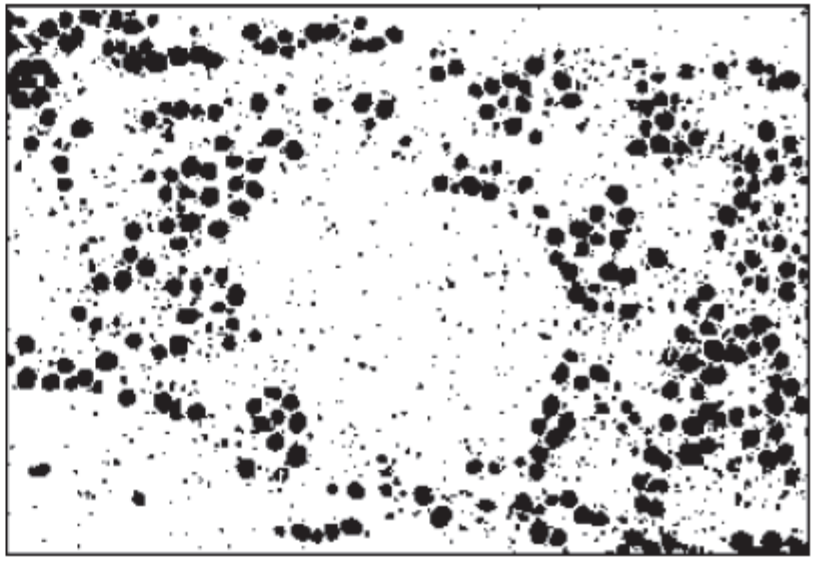
Ejemplo Open-Close



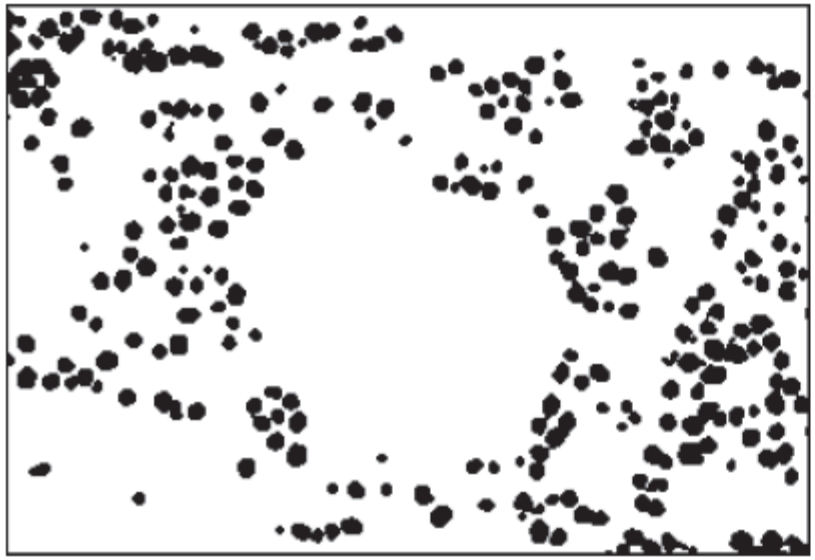
Aplicaciones de operadores morfológicos binarios



(a)



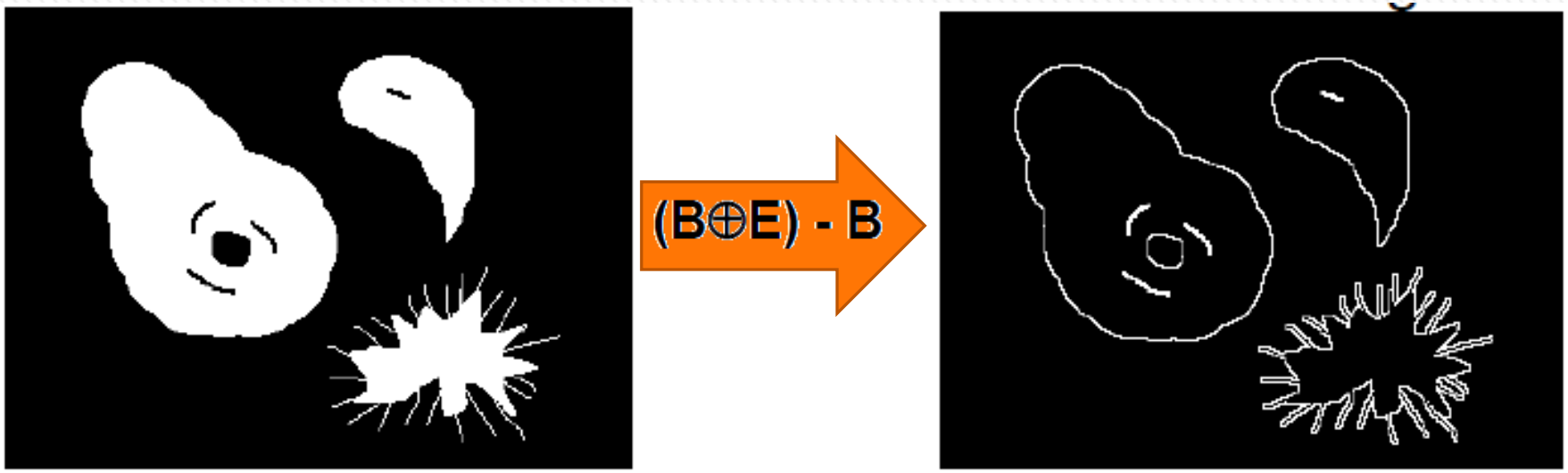
(b)



(c)

Otros usos de operadores morfológicos elementales

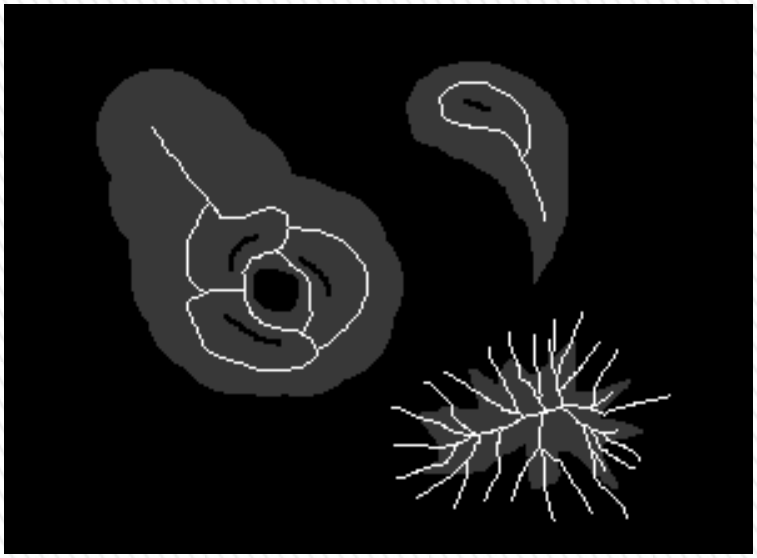
Borde morfológico



Thinning (Skeleton)

Erosiones sucesivas, excepto:

- si se pierde continuidad o
- hay un único punto

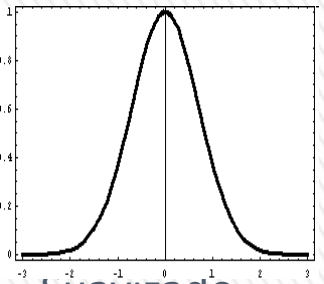


Operadores de bordes.

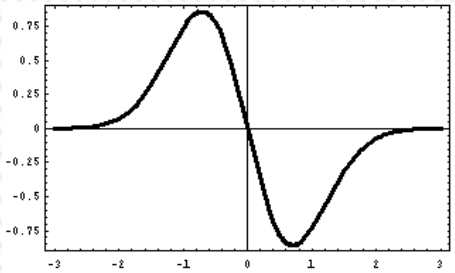
- Otra forma más sencilla (aproximada) es usar máscaras de convolución adecuadas, por ejemplo de **Laplace**.
- La **función de Laplace**es la segunda derivada de la gaussiana.

f(

M

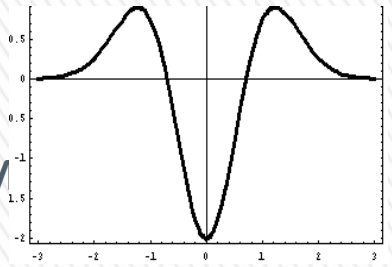


Suavizado



derivacion

M



gradiente