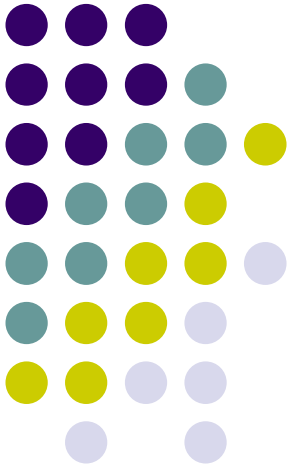
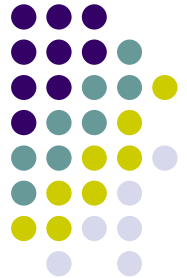
Procesamiento Digital de Imágenes

Pablo Roncagliolo B.

Nº 12

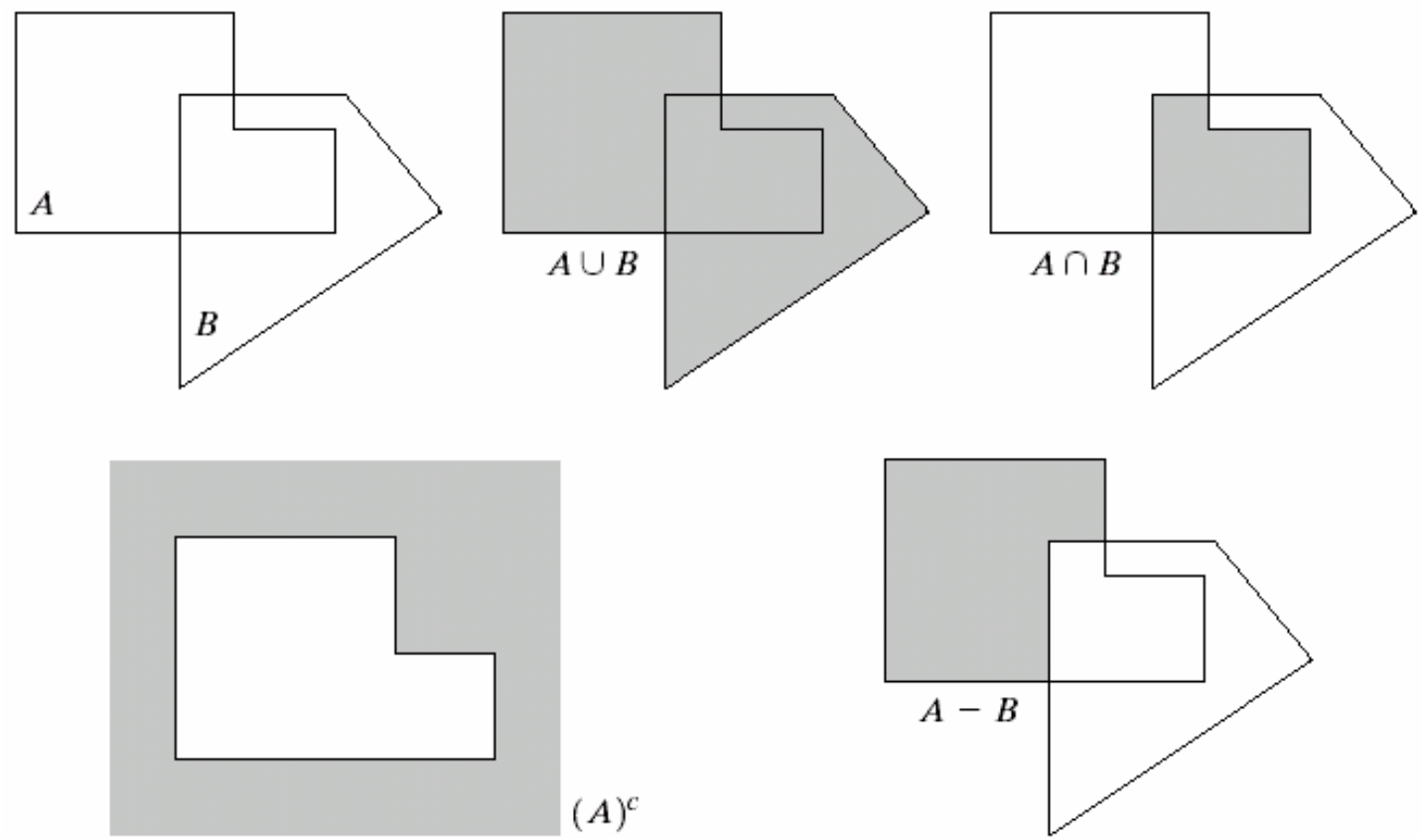


Operaciones Morfológicas



- Conceptos y algoritmos relevantes:
  - Operaciones lógicas
  - Dilatación
  - Erosión
  - Open (erosión+dilatación)
  - Close (dilatación+erosión)
  - Bordes utilizando op. Morfológicas
  - Fill Hole (Relleno de regiones)
  - Esqueleto de objetos
  - Etiquetado

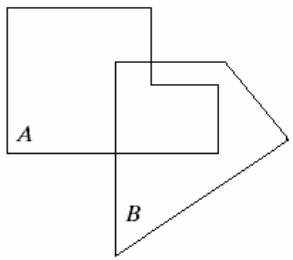
Operaciones Morfológicas

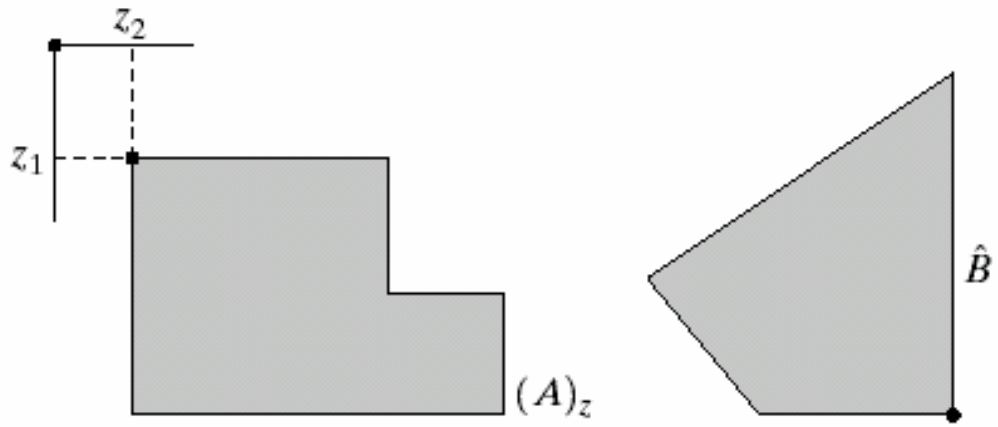


a b c
d e

FIGURE 9.1
(a) Two sets A and B. (b) The union of A and B. (c) The intersection of A and B. (d) The complement of A. (e) The difference between A and B.

Operaciones Morfológicas





a b

FIGURE 9.2
(a) Translation of A by z.
(b) Reflection of B. The sets A and B are from Fig. 9.1.

Operaciones Morfológicas

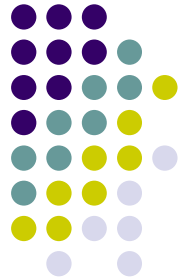


TABLE 9.1
The three basic logical operations.

p	q	p AND q (also $p \cdot q$)	p OR q (also $p + q$)	NOT (p) (also $\bar{p}$)
0	0	0	0	1
0	1	0	1	1
1	0	0	1	0
1	1	1	1	0

Operaciones Morfológicas

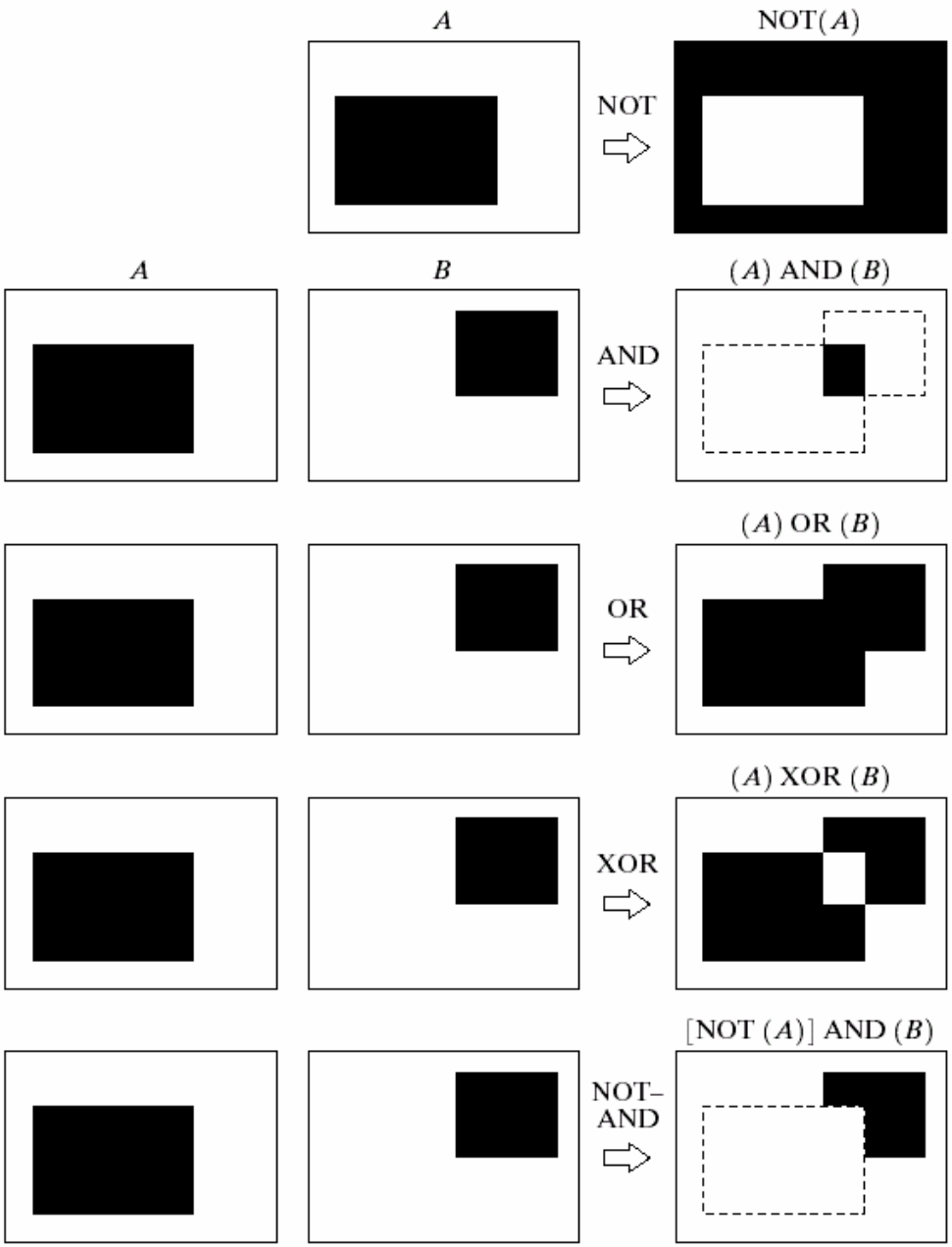
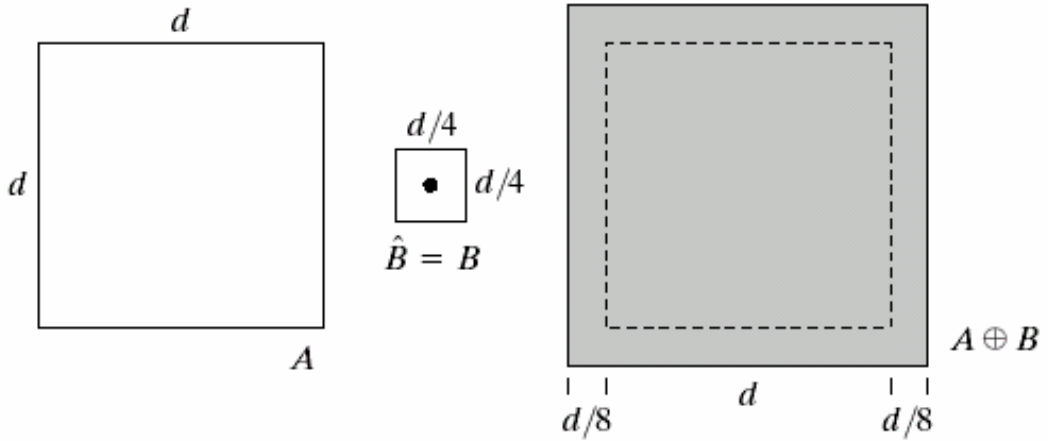


FIGURE 9.3 Some logic operations between binary images. Black represents binary 1s and white binary 0s in this example.

Operaciones Morfológicas: Dilatación

a b c
d e

FIGURE 9.4
(a) Set A.
(b) Square structuring element (dot is the center).
(c) Dilation of A by B, shown shaded.
(d) Elongated structuring element.
(e) Dilation of A using this element.

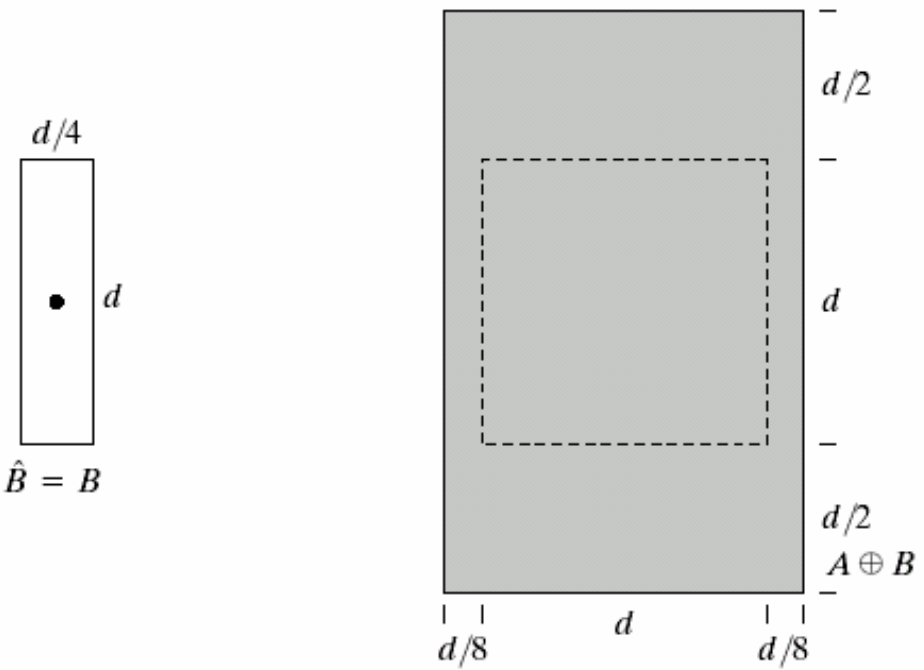


"Deja el centro, si el AND de algún elemento de B es 1"

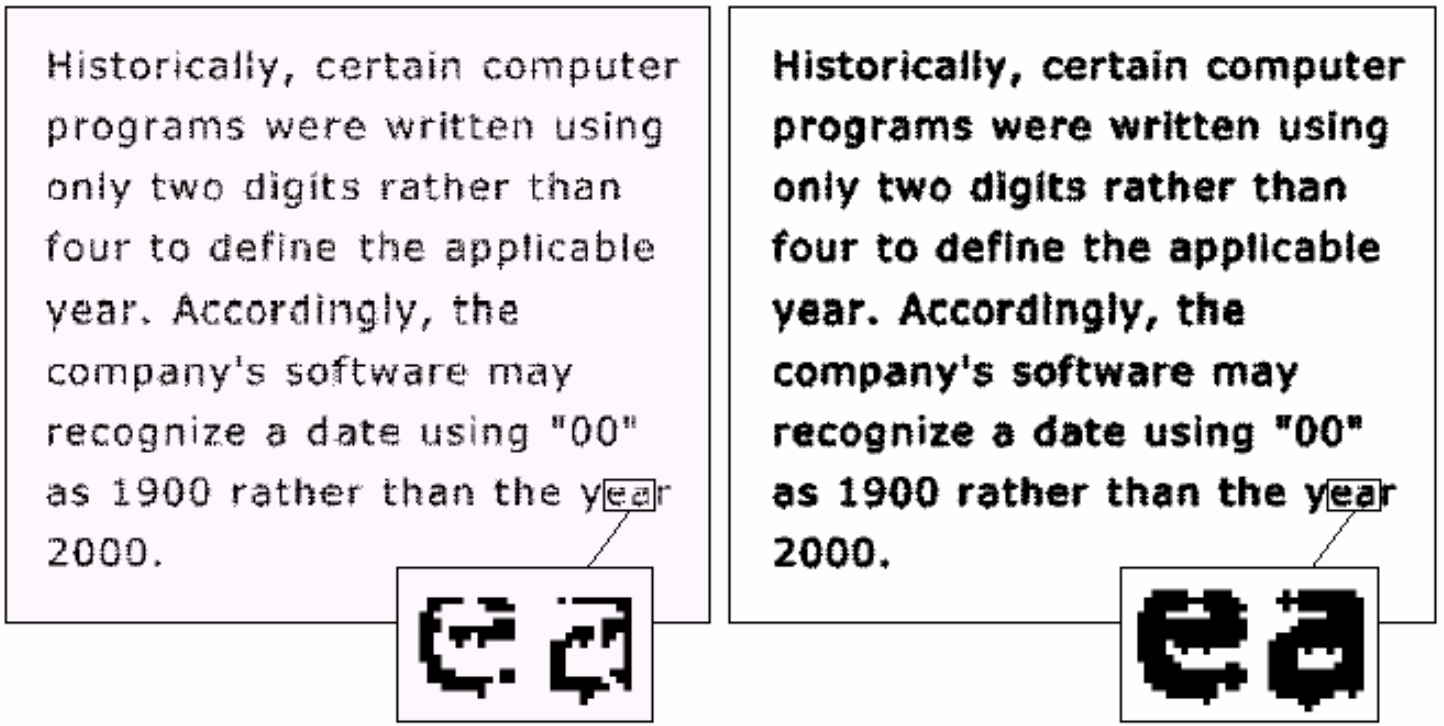
$$A \oplus B \approx A(and)B$$

```
% Dilatación
A2=imdilate(A,B)
```

Es conmutativa y asociativa



Operaciones Morfológicas: Dilatación



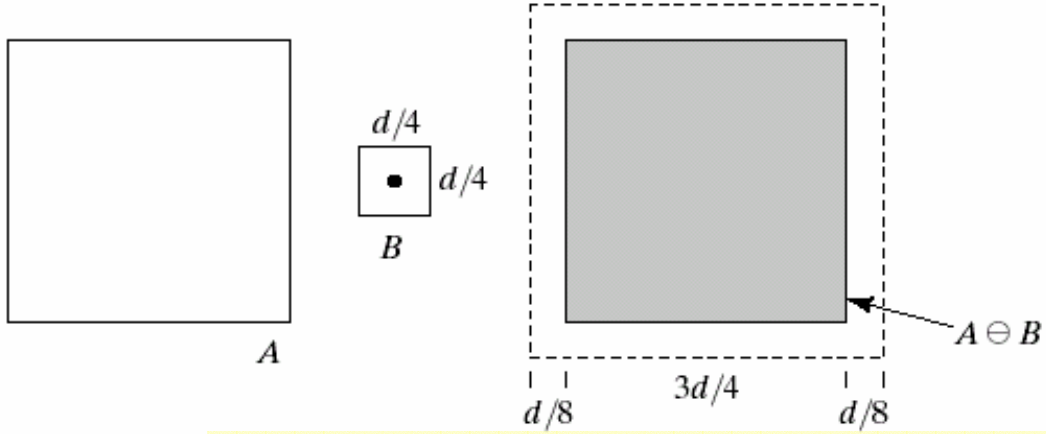
a c
b

FIGURE 9.5
(a) Sample text of poor resolution with broken characters (magnified view). (b) Structuring element. (c) Dilation of (a) by (b). Broken segments were joined.

```
% Elementos Estructurantes
B=strel('diamond',1);
```

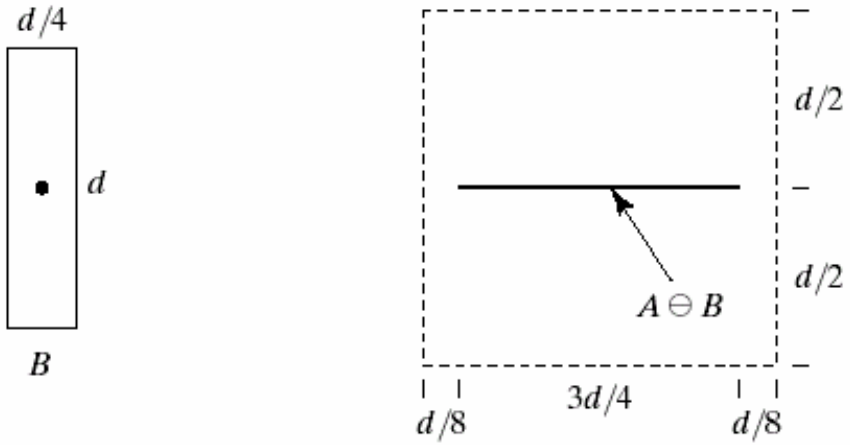
0	1	0
1	1	1
0	1	0

Operaciones Morfológicas: Erosión



$$A \Theta B \approx A(or)B$$

"Deja el centro, si el OR de todo B es 1"




```
% Erosión
A2=imerode(A,B);
```

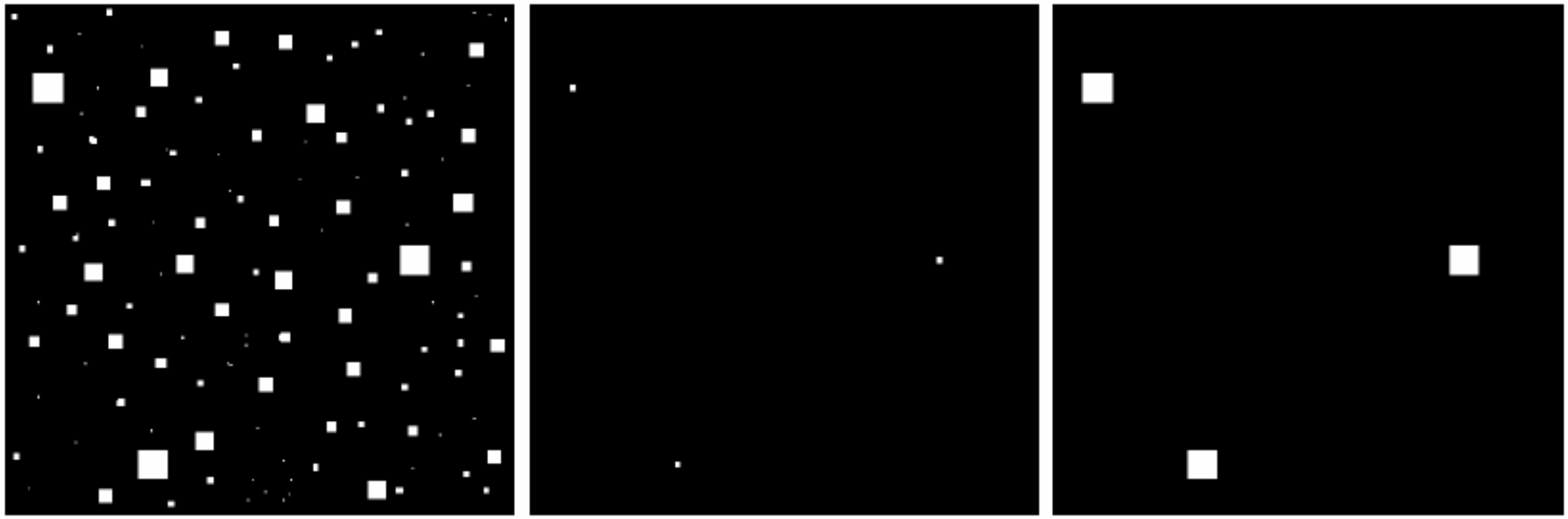
a b c
d e

FIGURE 9.6 (a) Set A. (b) Square structuring element. (c) Erosion of A by B, shown shaded. (d) Elongated structuring element. (e) Erosion of A using this element.

Operaciones Morfológicas

Erosión+Dilatación: Open

$$A \circ B$$

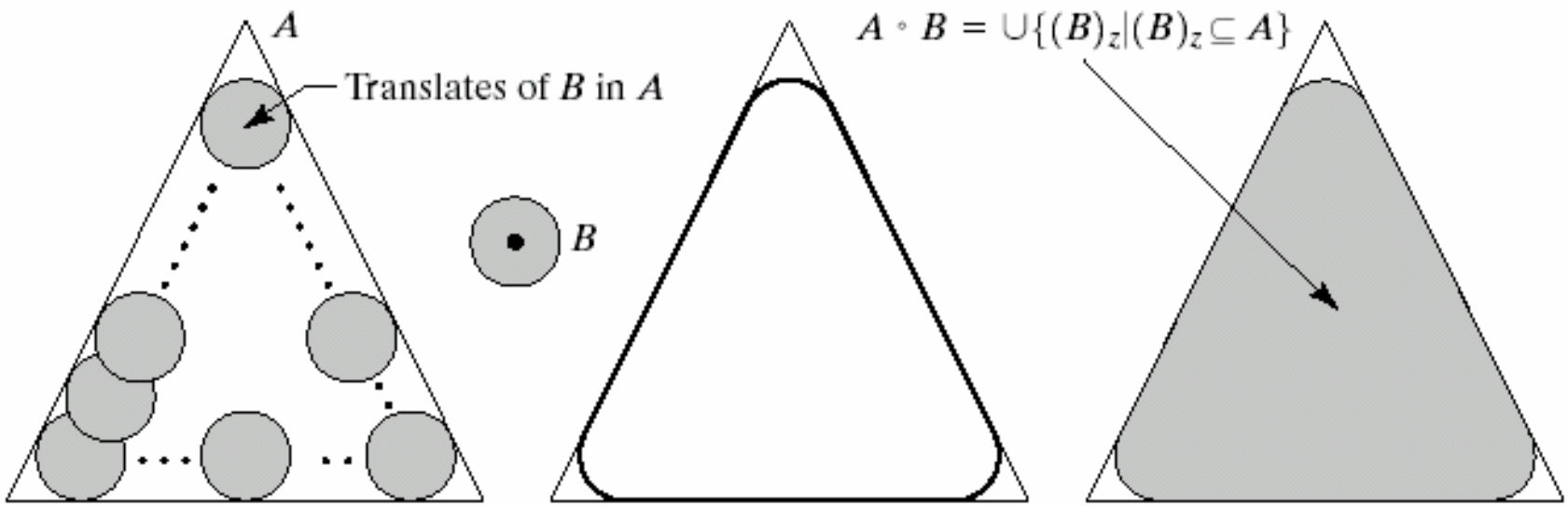


a b c

FIGURE 9.7 (a) Image of squares of size 1, 3, 5, 7, 9, and 15 pixels on the side. (b) Erosion of (a) with a square structuring element of 1's, 13 pixels on the side. (c) Dilation of (b) with the same structuring element.

```
% Open
A2=imopen(A,B);
```

Operaciones Morfológicas: Open

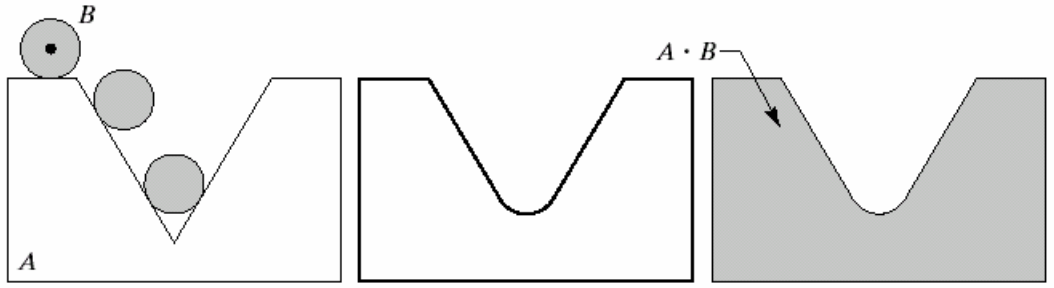


a b c d

FIGURE 9.8 (a) Structuring element B "rolling" along the inner boundary of A (the dot indicates the origin of B). (c) The heavy line is the outer boundary of the opening. (d) Complete opening (shaded).

Operaciones Morfológicas:
Dilatación+Erosión: Close

$$A \bullet B$$

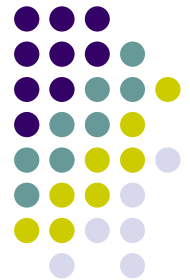


a b c

FIGURE 9.9 (a) Structuring element B "rolling" on the outer boundary of set A. (b) Heavy line is the outer boundary of the closing. (c) Complete closing (shaded).

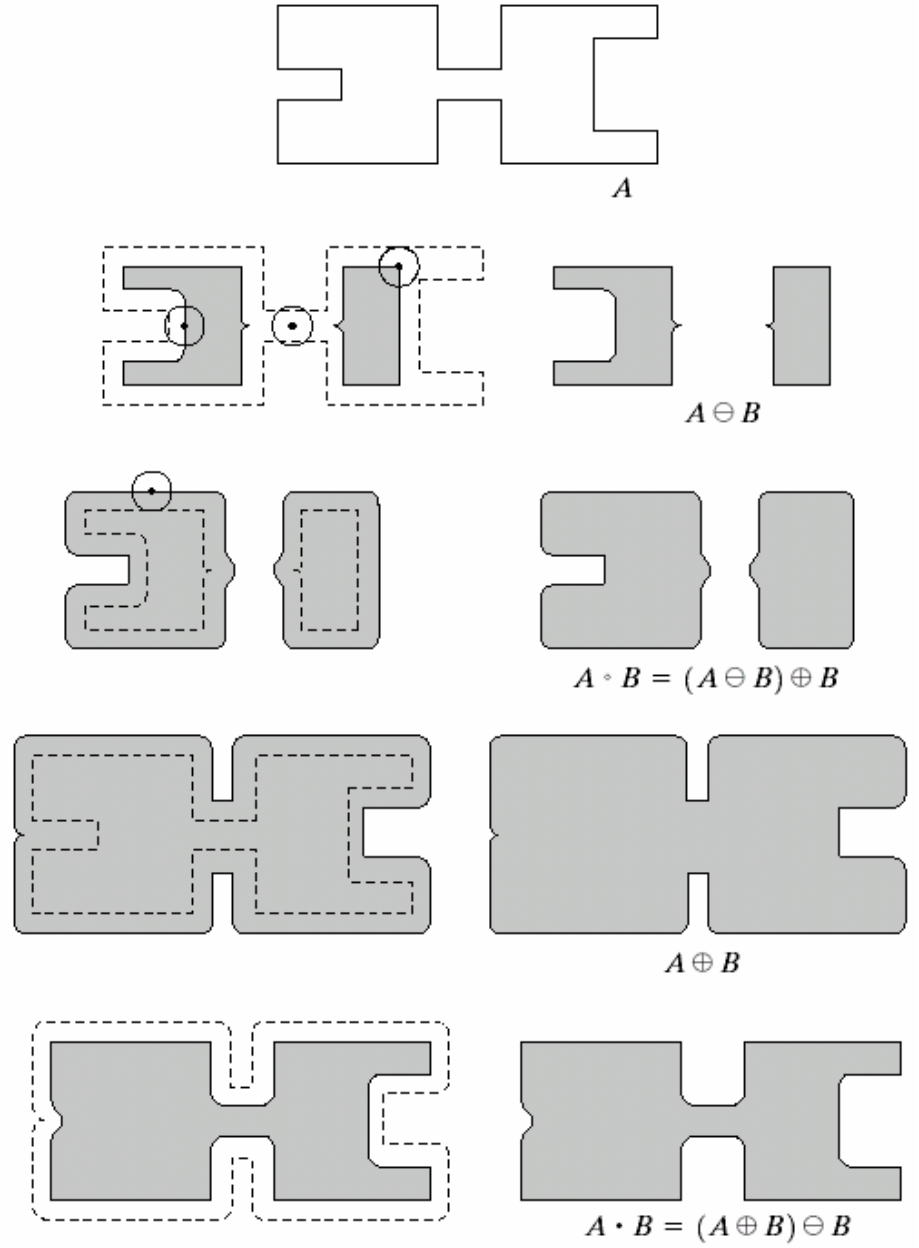
```
% Close
A2=imclose(A,B);
```

Operaciones Morfológicas

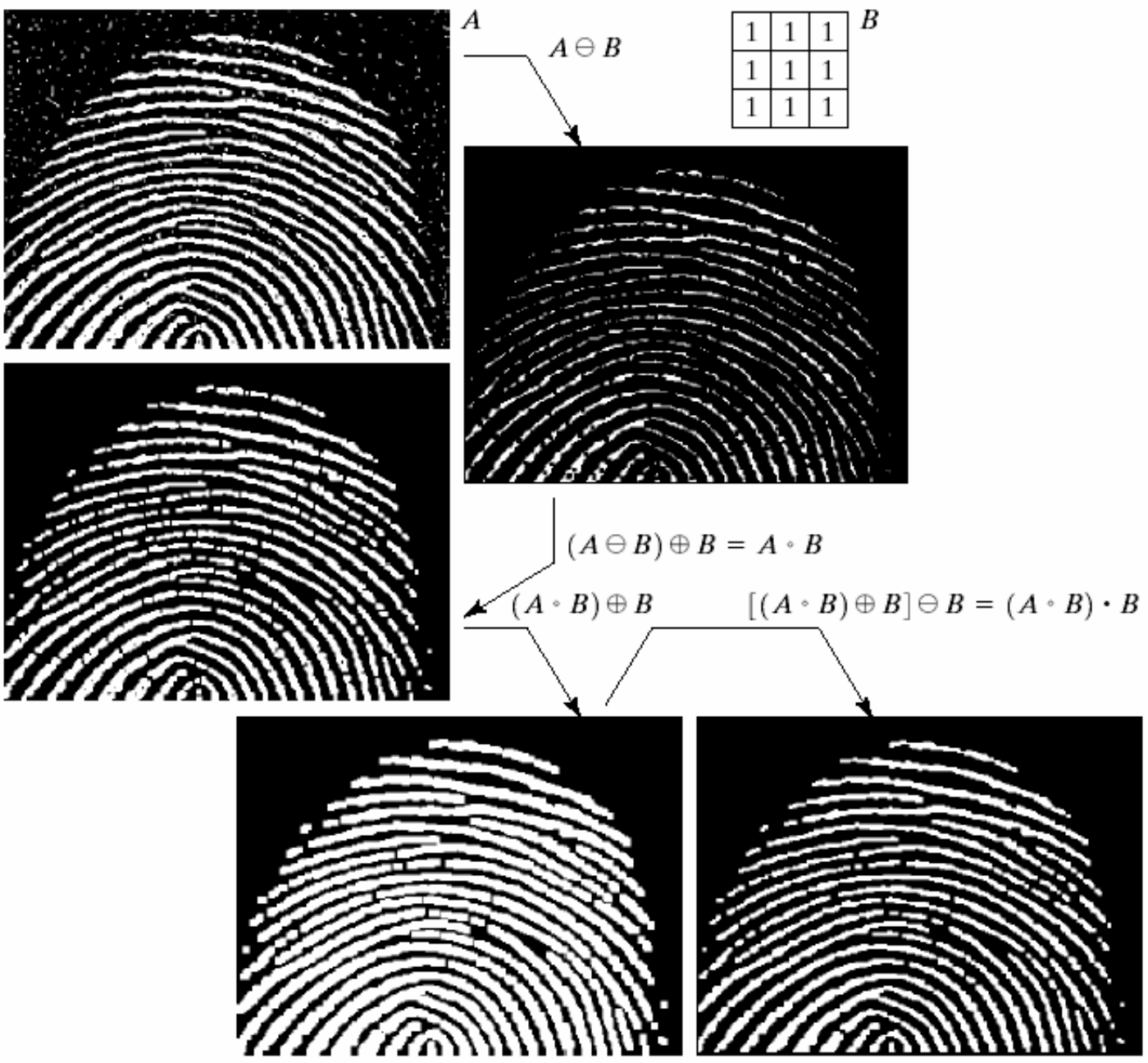


a
b c
d e
f g
h i

FIGURE 9.10 Morphological opening and closing. The structuring element is the small circle shown in various positions in (b). The dark dot is the center of the structuring element.



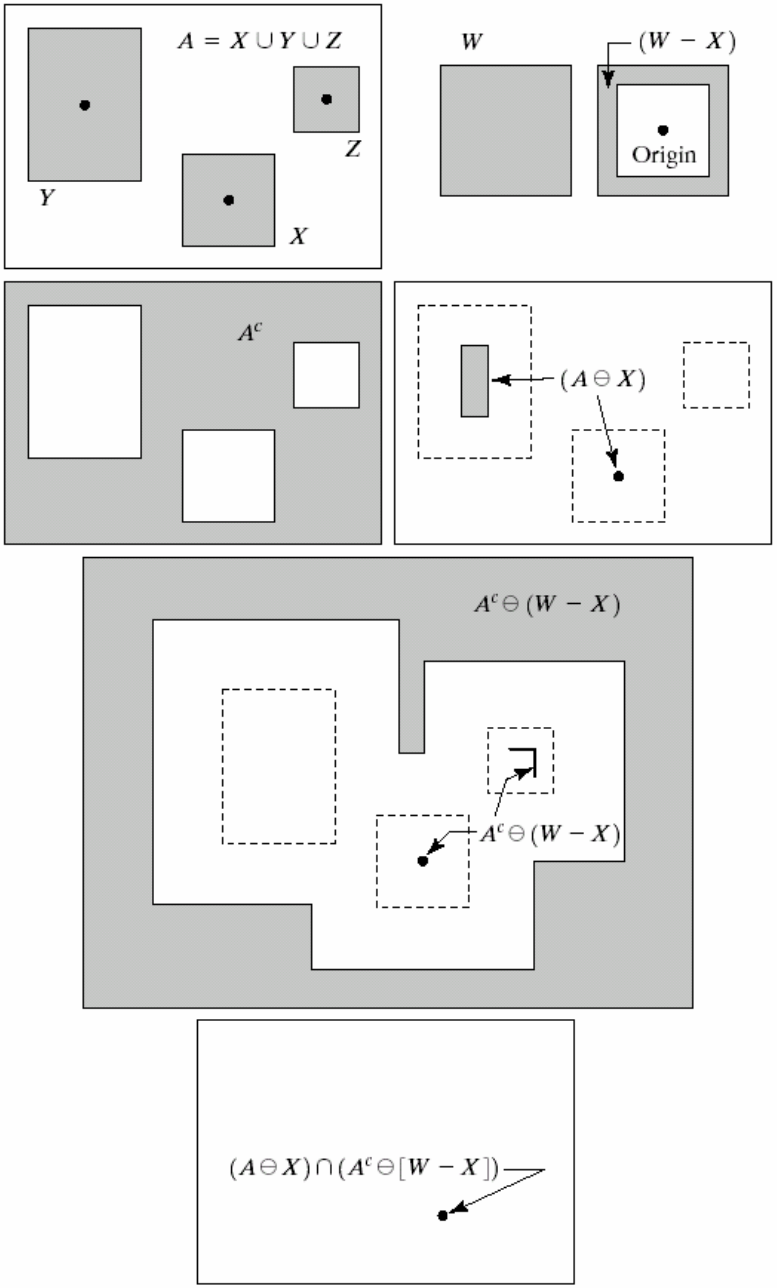
Operaciones Morfológicas



a b
d c
e f

FIGURE 9.11
(a) Noisy image. (c) Eroded image. (d) Opening of A. (d) Dilation of the opening. (e) Closing of the opening. (Original image for this example courtesy of the National Institute of Standards and Technology.)

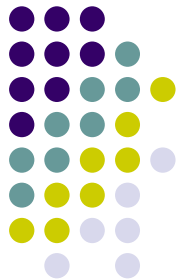
Operaciones Morfológicas



a b
c d
e
f

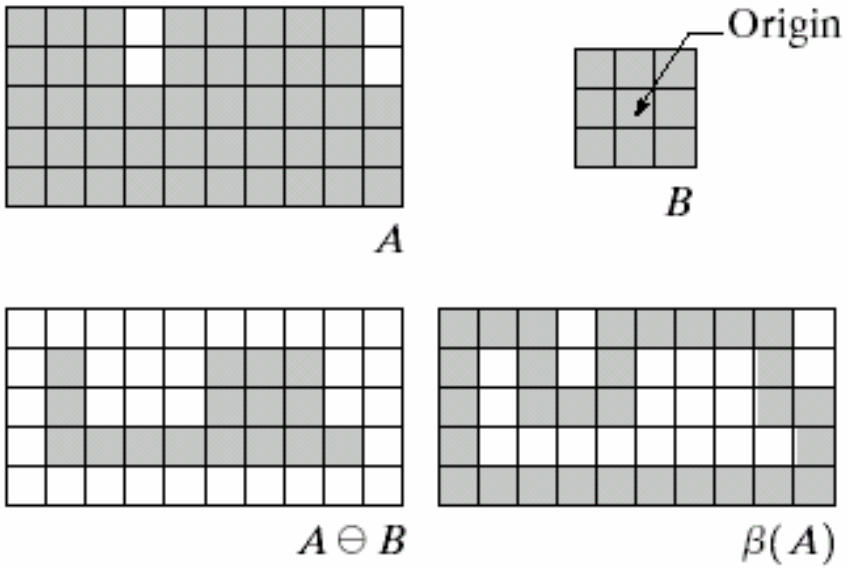
FIGURE 9.12
(a) Set A. (b) A window, W, and the local background of X with respect to W, $(W - X)$. (c) Complement of A. (d) Erosion of A by X. (e) Erosion of A^c by $(W - X)$. (f) Intersection of (d) and (e), showing the location of the origin of X, as desired.

Operaciones Morfológicas: Bordes mediante erosión:

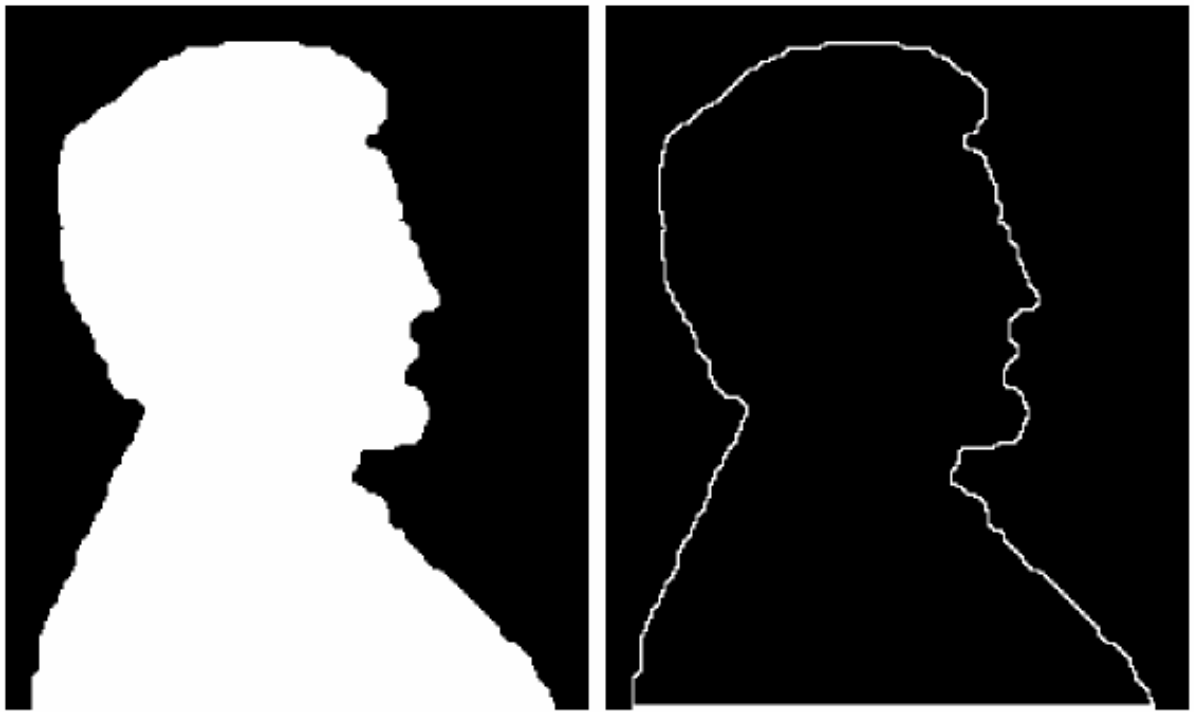


a b
c d

FIGURE 9.13 (a) Set A. (b) Structuring element B. (c) A eroded by B. (d) Boundary, given by the set difference between A and its erosion.



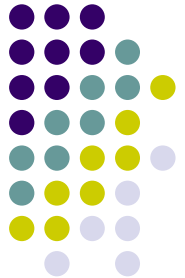
Operaciones Morfológicas



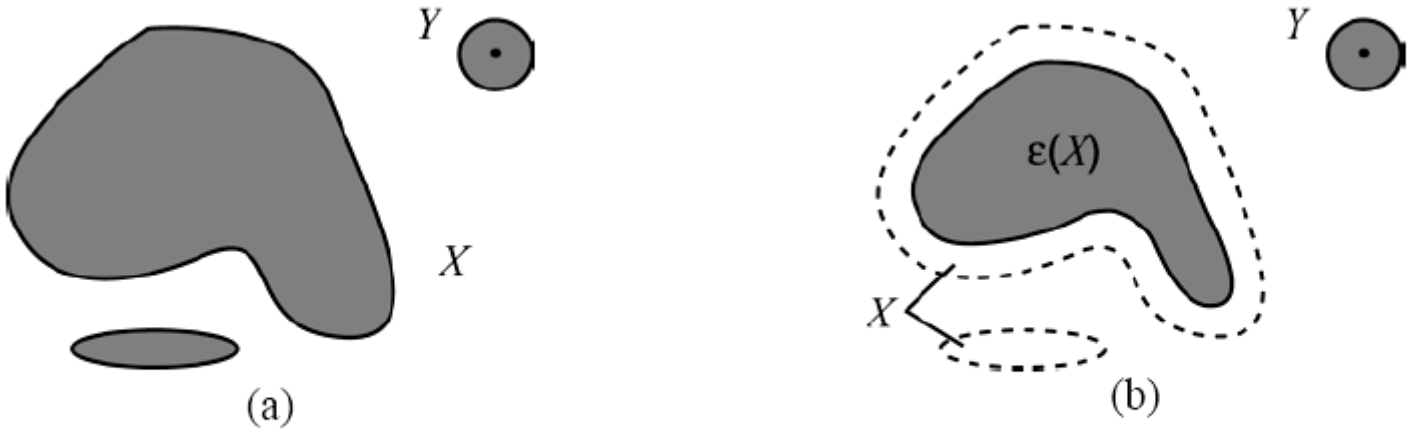
a b

FIGURE 9.14
(a) A simple binary image, with 1's represented in white. (b) Result of using Eq. (9.5-1) with the structuring element in Fig. 9.13(b).

Operaciones Morfológicas



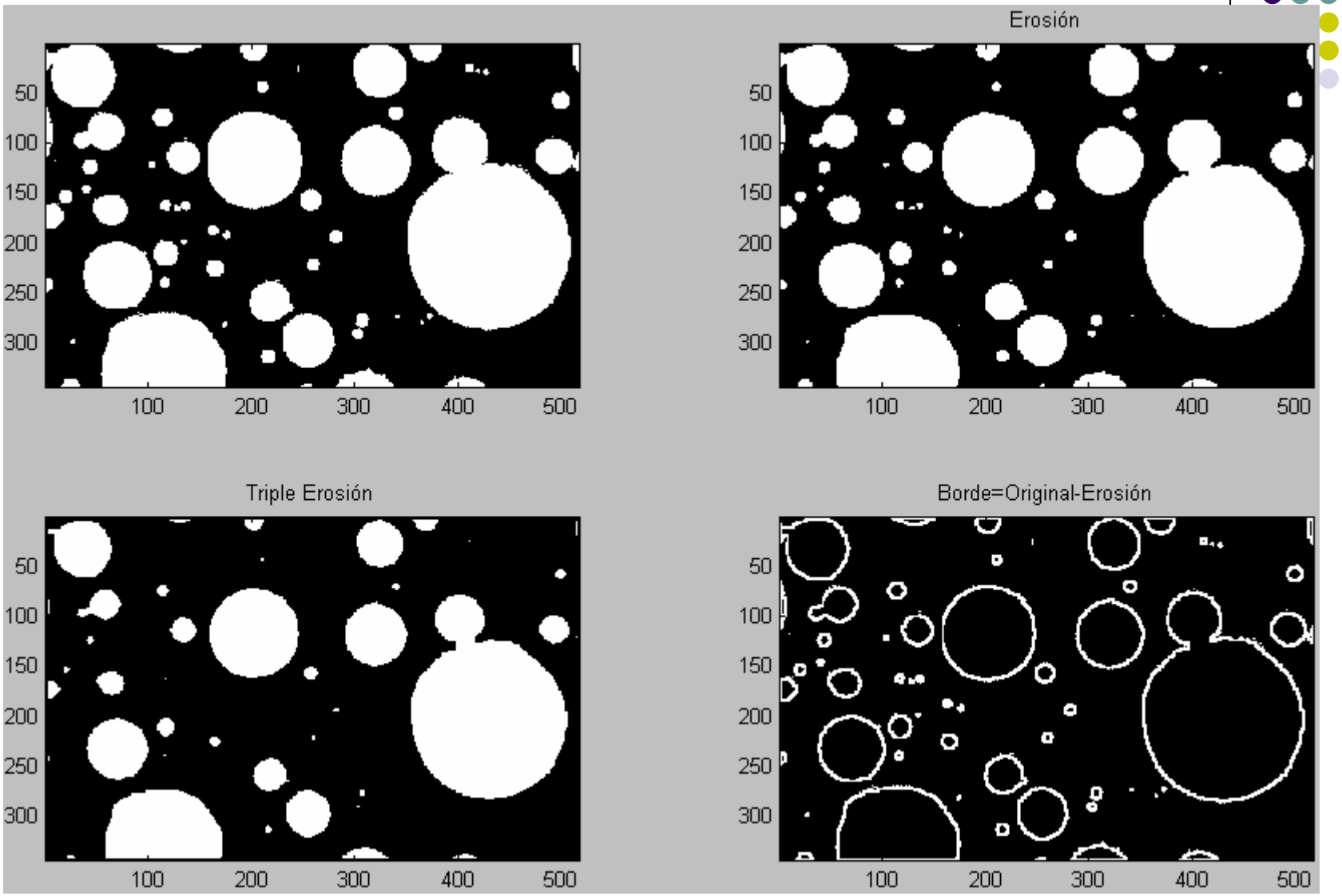
Ej. Erosión:



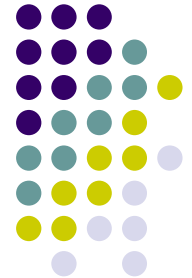
Erosión de X por el elemento estructurante Y. Los elementos conectados del conjunto X más pequeños que Y son eliminados.

El elemento estructurante debe estar contenido completamente.

Ej. Erosión

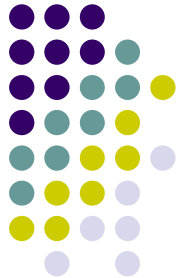

Erosión
Triple Erosión
Borde=Original-Erosión
50
100
150
200
250
300
100
200
300
400
500

Ej. Erosión

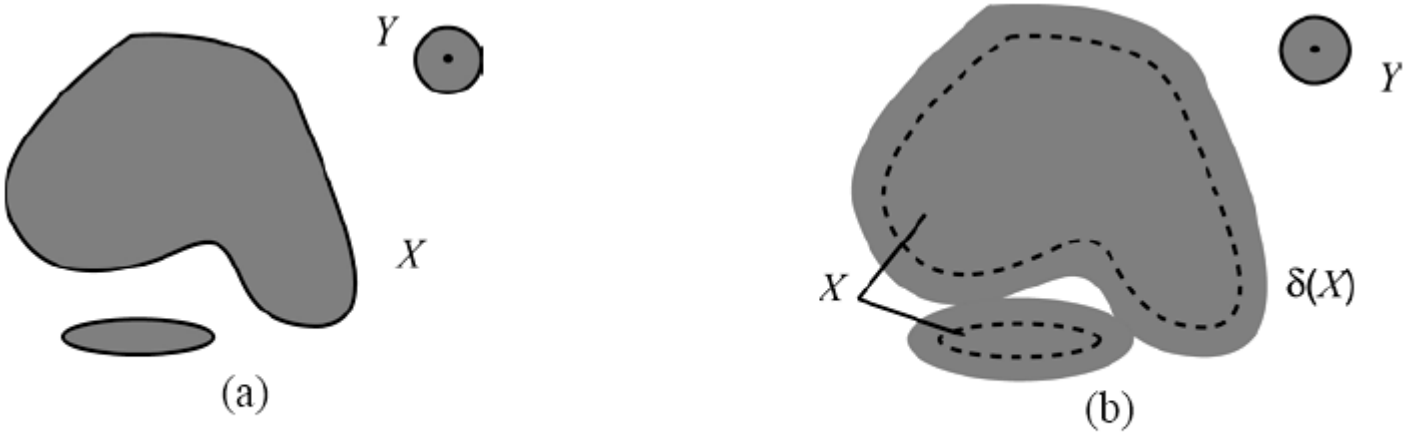


```
function B=erosion(A)
  [H W Z]=size(A);
  B=zeros(H,W);
  K=[1 1 1;
     1 1 1;
     1 1 1];

  for f=(1+1):(H-1)
     for c=(1+1):(W-1)
        suma=0;
        for ff=-1:1
           for cc=-1:1
              suma=suma+K(ff+2,cc+2)*A(f+ff,c+cc)/255;
           end;
        end;
        if suma==sum(sum(K))
           B(f,c)=255;
        else
           B(f,c)=0;
        end;
     end;
  end;
```

Operaciones Morfológicas



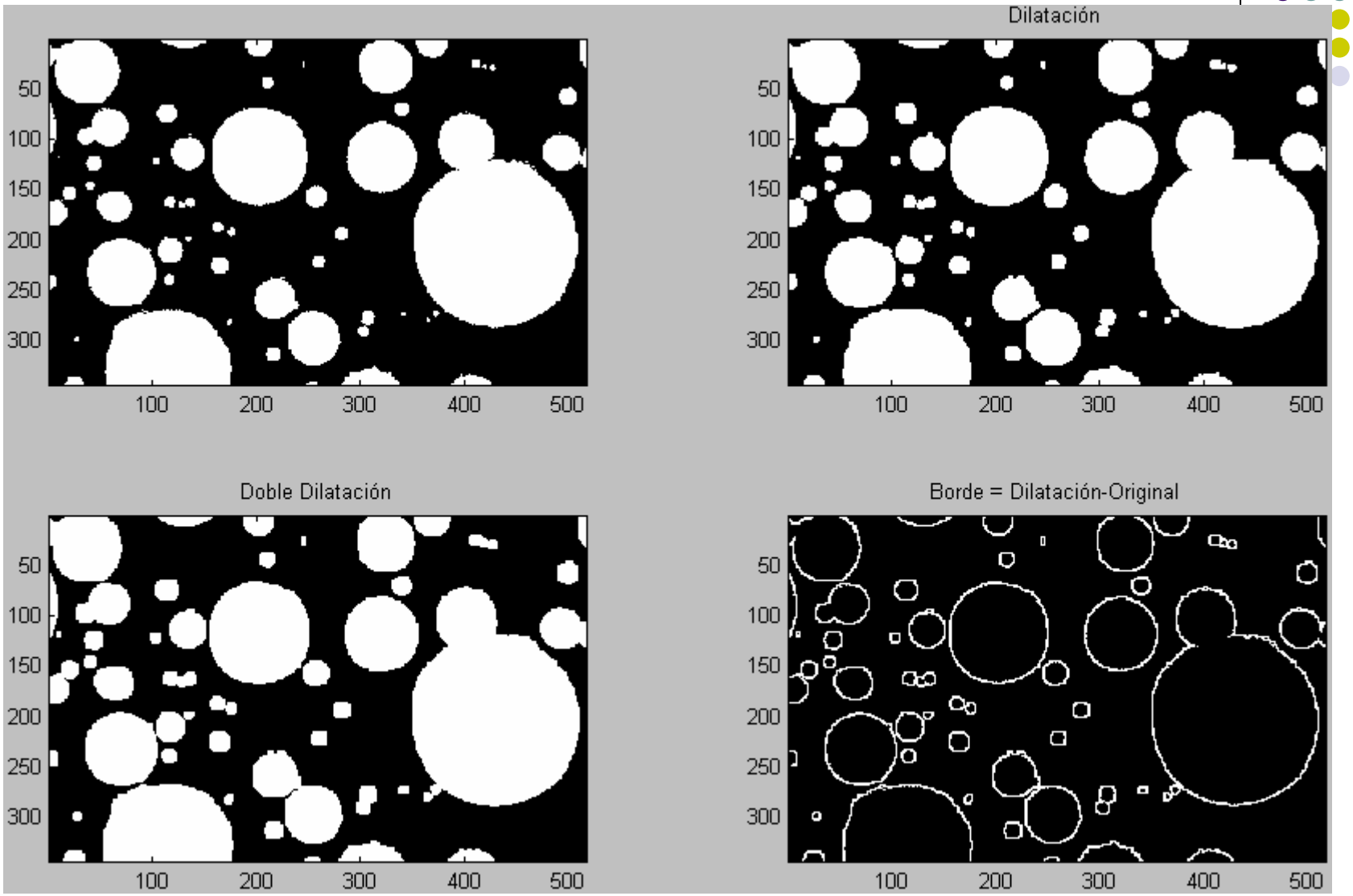
Dilatación:



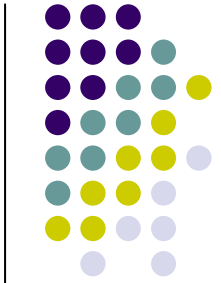
Dilatación de X por el elemento estructurante Y. El conjunto X aumenta su definición.

El centro del elemento estructurante Y debe estar contenido en la imagen X.

Ej. Dilatación

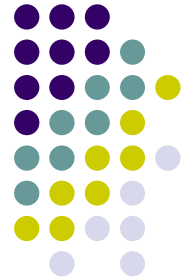


Ej. Dilatación



```
function B=dilatacion(A)
  [H W Z]=size(A);
  B=zeros(H,W);
  K=[1 1 1;
     1 1 1;
     1 1 1];

  for f=(1+1):(H-1)
     for c=(1+1):(W-1)
        suma=0;
        for ff=-1:1
           for cc=-1:1
              suma=suma+K(ff+2,cc+2)*A(f+ff,c+cc)/255;
           end;
        end;
        if suma>=1
           B(f,c)=255;
        else
           B(f,c)=0;
        end;
     end;
  end;
```

Operaciones Morfológicas

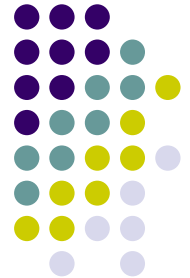


Ej. Apertura Morfológica: erosión+dilatación

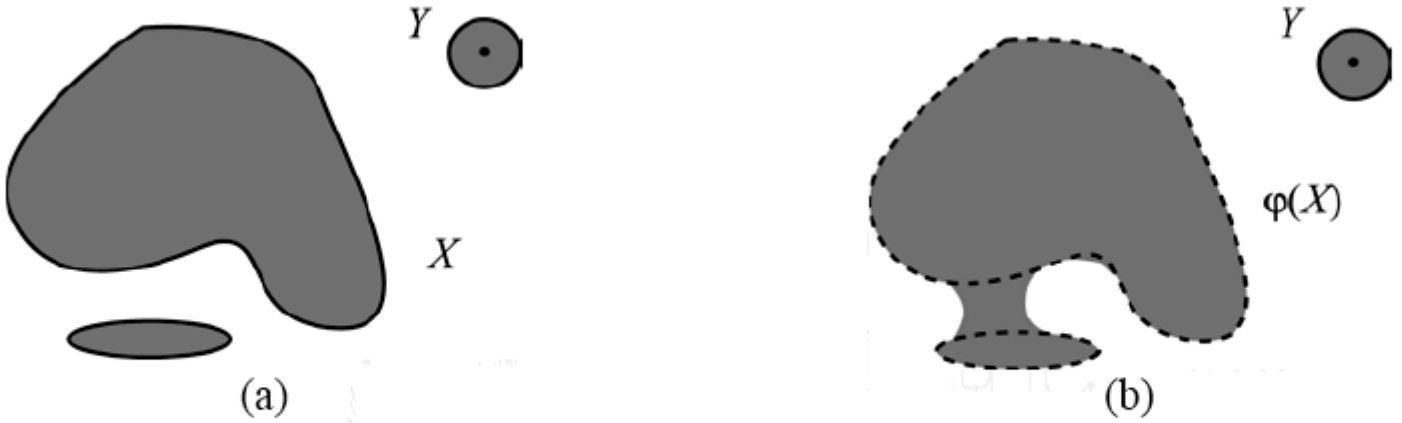
Apertura morfológica del conjunto X por el elemento estructurante Y. Eliminación de objetos menores en tamaño al elemento estructurante. La apertura redondea las convexidades importantes.

La apertura permite “recuperar” los elementos “mayores”, redondeando sus contornos.

Operaciones Morfológicas



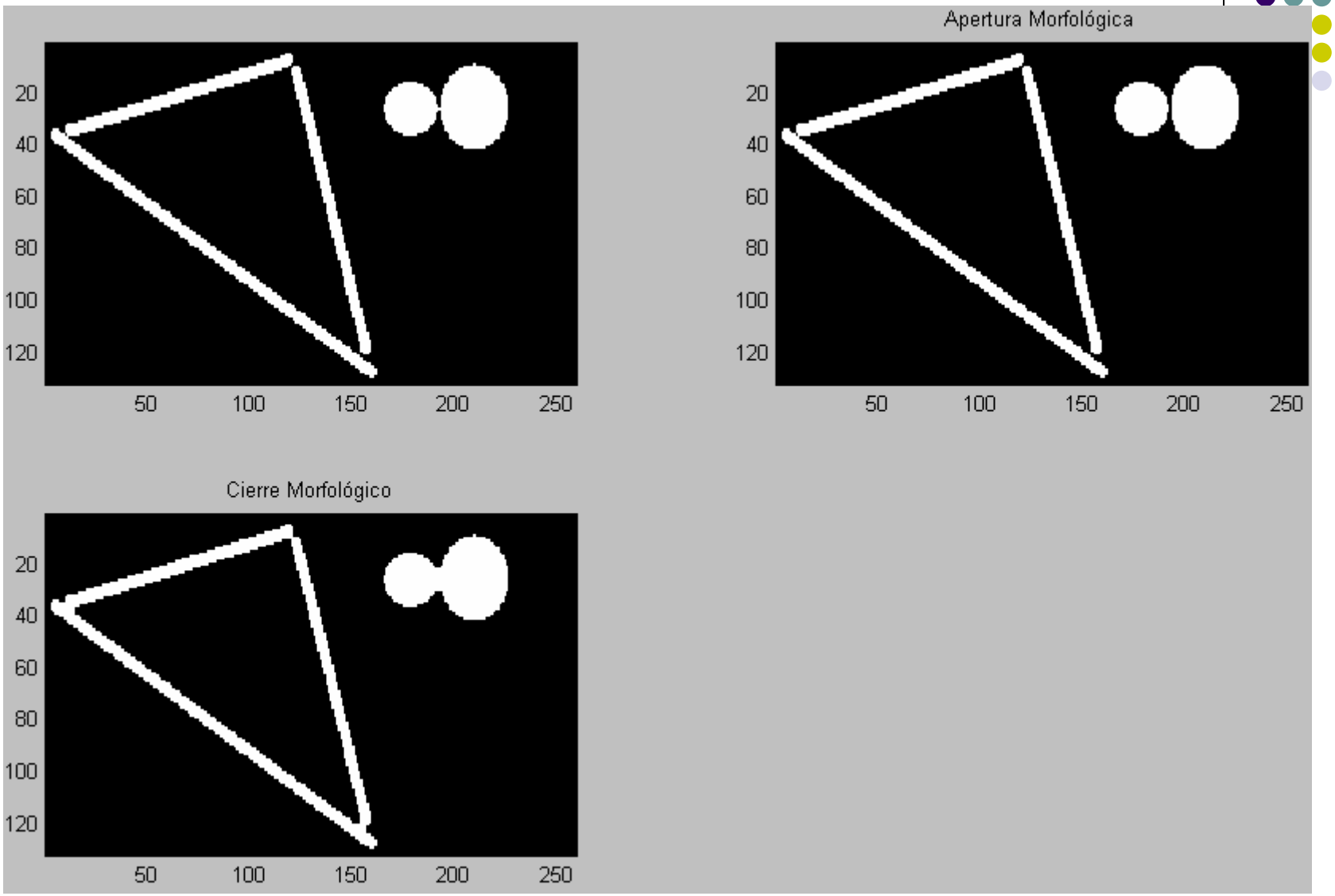
Ej. Cierre Morfológico: dilatación+erosión



Apertura morfológica del conjunto X por el elemento estructurante Y. El cierre redondea las concavidades importantes.

Permite “unir” elementos cercanos.

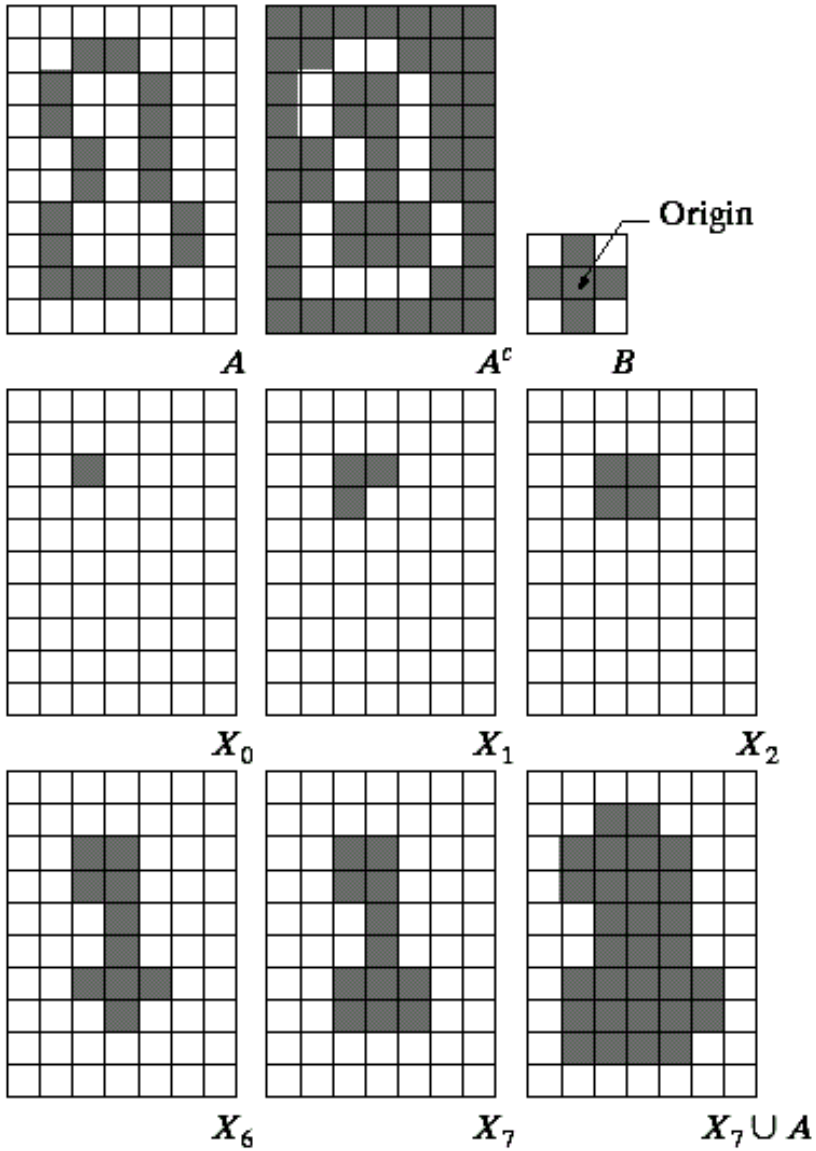
Ej. Apertura y Cierre



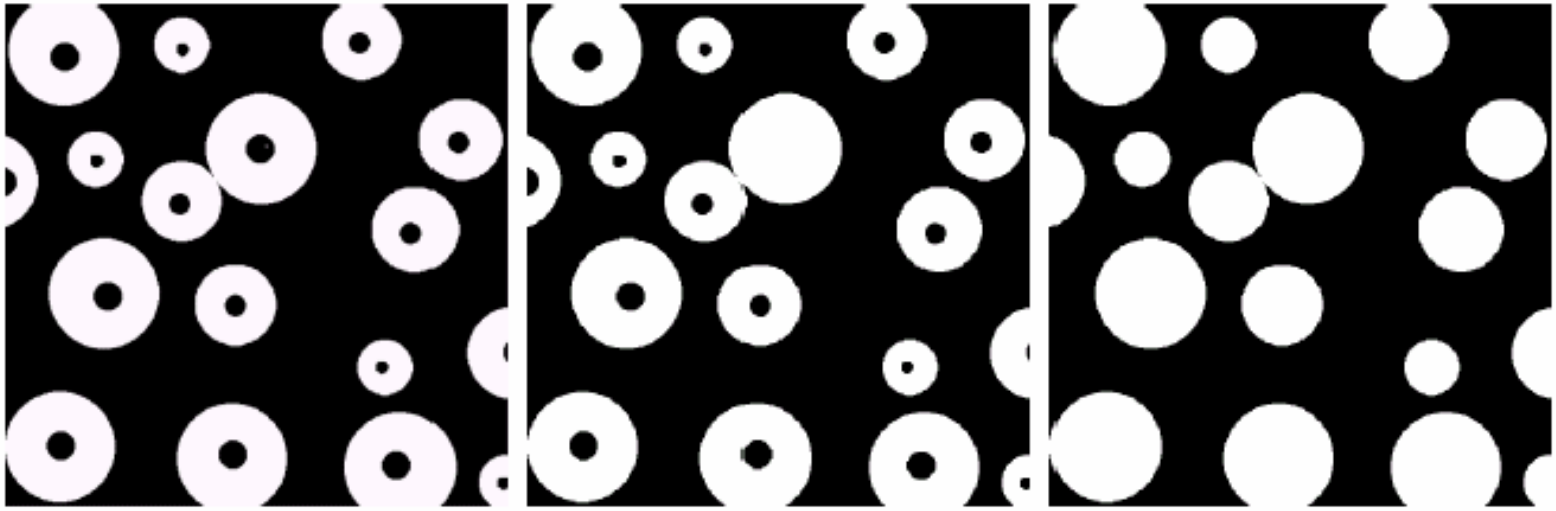
Operaciones Morfológicas: “Fill Hole”

FIGURE 9.15
Region filling.
(a) Set A.
(b) Complement of A.
(c) Structuring element B.
(d) Initial point inside the boundary.
(e)–(h) Various steps of Eq. (9.5-2).
(i) Final result [union of (a) and (h)].

$$X^k = \left(X^{k-1} \oplus B\right) \cup \forall_c : X^0 = b$$



Operaciones Morfológicas



a b c

FIGURE 9.16 (a) Binary image (the white dot inside one of the regions is the starting point for the region-filling algorithm). (b) Result of filling that region (c) Result of filling all regions.

Operaciones Morfológicas: Componentes conectados

Connected components	$X_k = (X_{k-1} \oplus B) \cap A;\ X_0 = p$ and $k = 1, 2, 3, \ldots$	Finds a connected component Y in A, given a point p in Y. (I)

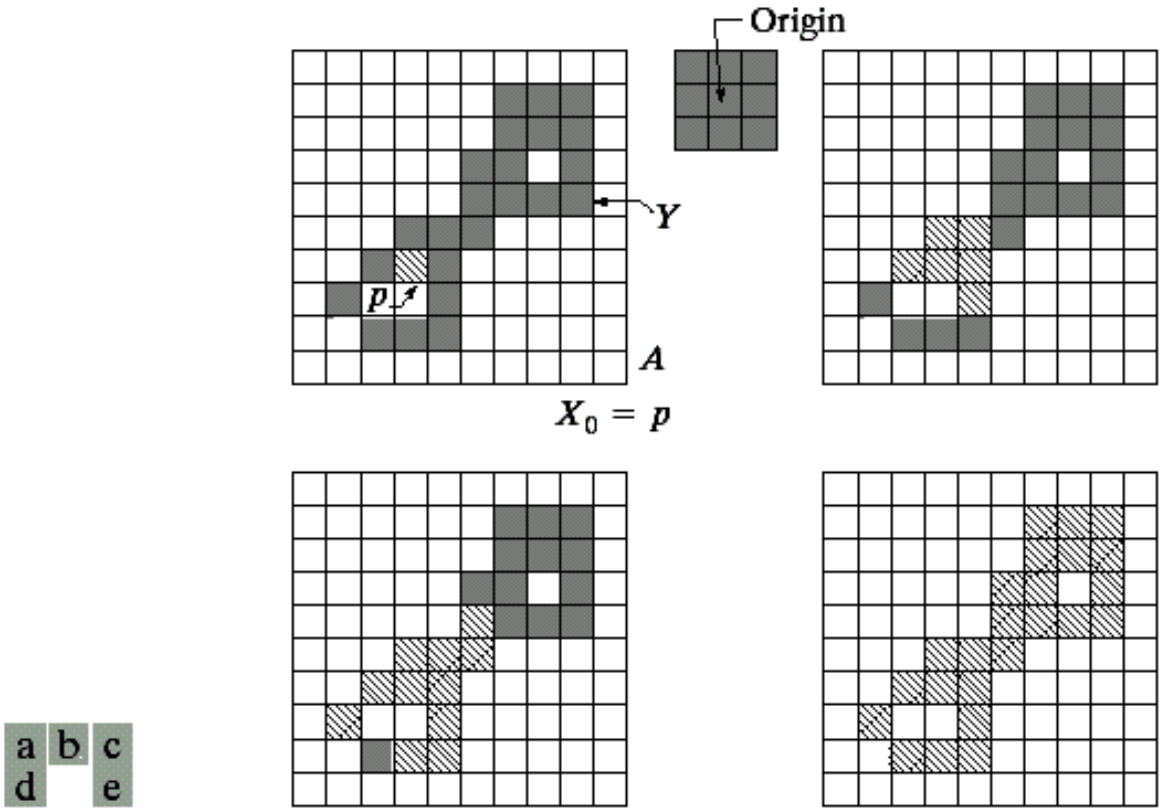
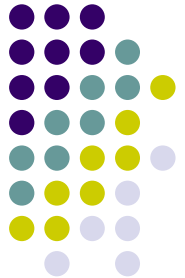


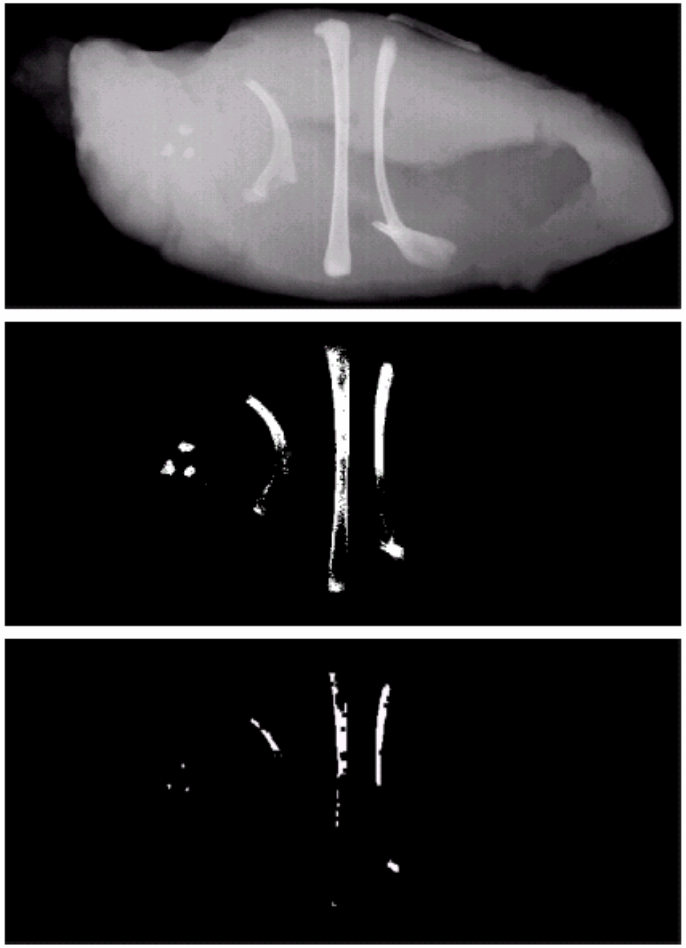
FIGURE 9.17 (a) Set A showing initial point p (all shaded points are valued 1, but are shown different from p to indicate that they have not yet been found by the algorithm). (b) Structuring element. (c) Result of first iterative step. (d) Result of second step. (e) Final result.

Operaciones Morfológicas



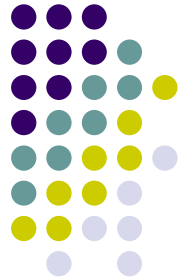
a
b
c d

FIGURE 9.18
(a) X-ray image of chicken filet with bone fragments. (b) Thresholded image. (c) Image eroded with a 5×5 structuring element of 1's. (d) Number of pixels in the connected components of (c). (Image courtesy of NTB Elektronische Geraete GmbH, Diepholz, Germany, www.ntbxray.com.)



Connected component	No. of pixels in connected comp
01	11
02	9
03	9
04	39
05	133
06	1
07	1
08	743
09	7
10	11
11	11
12	9
13	9
14	674
15	85

Operaciones Morfológicas



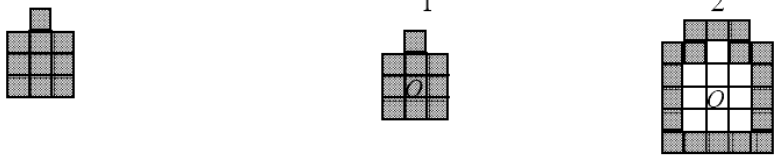
Transformación Hit-or-Miss:

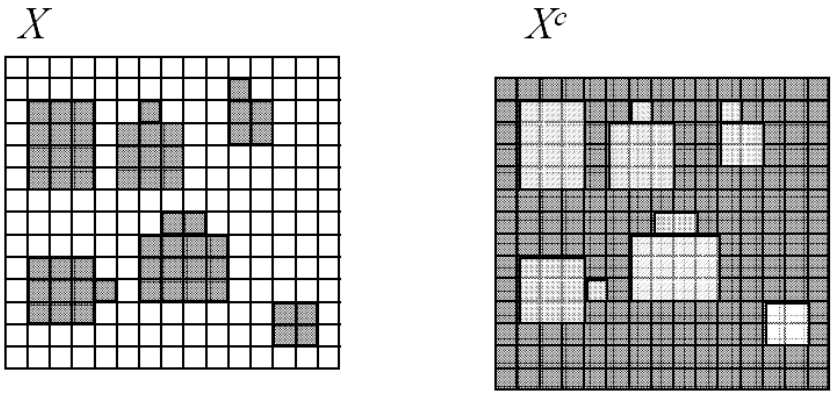
Hit-or-miss transform

$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$$
$$= (A \ominus B_1) - (A \oplus \hat{B}_2)$$

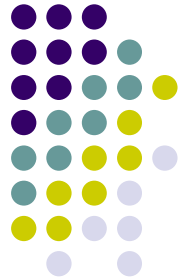
The set of points (coordinates) at which, simultaneously, B_1 found a match ("hit") in A and B_2 found a match in A^c.

Search for:

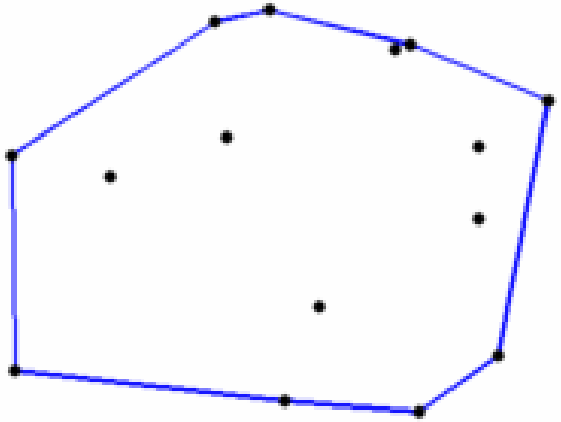




Operaciones Morfológicas



“Envoltura convexa” (convex hull): Conjunto de píxeles (polígono) convexos que contienen a un objeto binarizado.



Operaciones Morfológicas

Ejemplo: “Envoltura convexa”

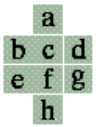
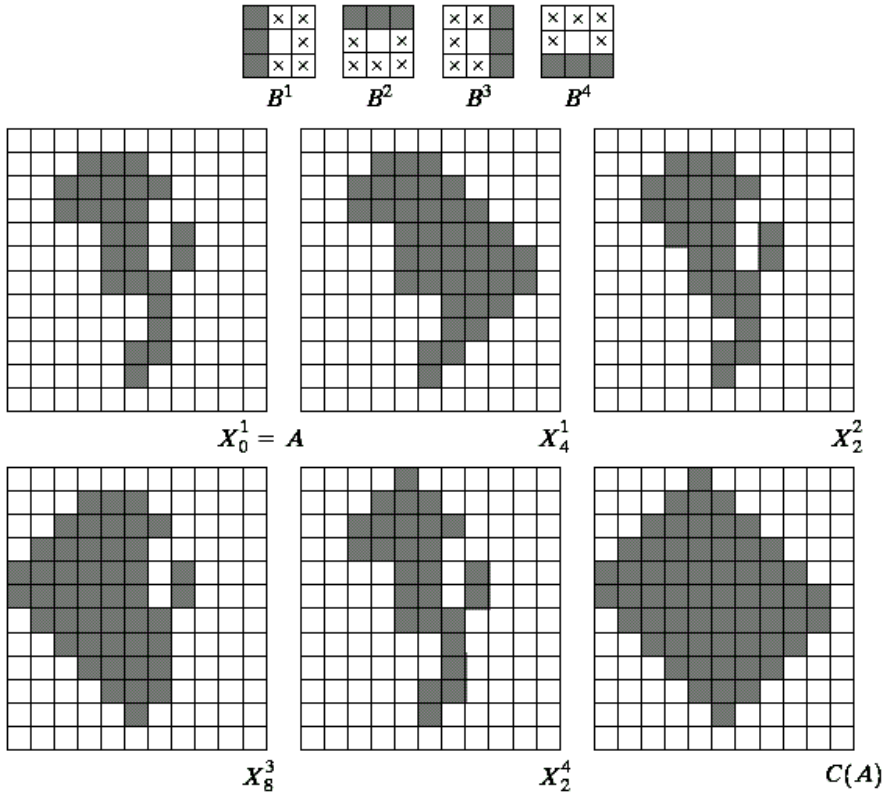
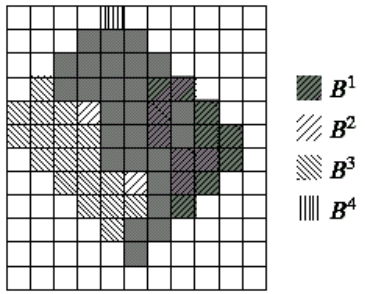


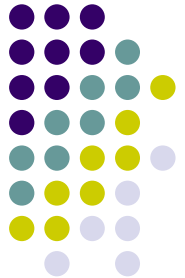
FIGURE 9.19
(a) Structuring elements. (b) Set A. (c)–(f) Results of convergence with the structuring elements shown in (a). (g) Convex hull. (h) Convex hull showing the contribution of each structuring element.



Convex hull	$X_k^i = (X_{k-1}^i \circledast B^i) \cup A; i = 1, 2, 3, 4;$ $k = 1, 2, 3, \ldots; X_0^i = A;$ and $D^i = X_{\text{conv}}^i.$	Finds the convex hull $C(A)$ of set A, where “conv” indicates convergence in the sense that $X_k^i = X_{k-1}^i$. (III)



Operaciones Morfológicas



Resultado final, limitando a las dimensiones máximas del objeto inicial.

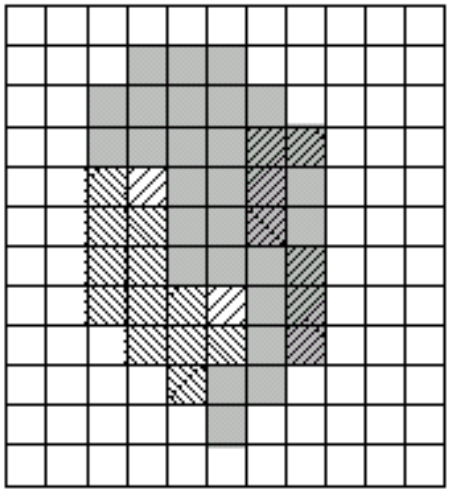
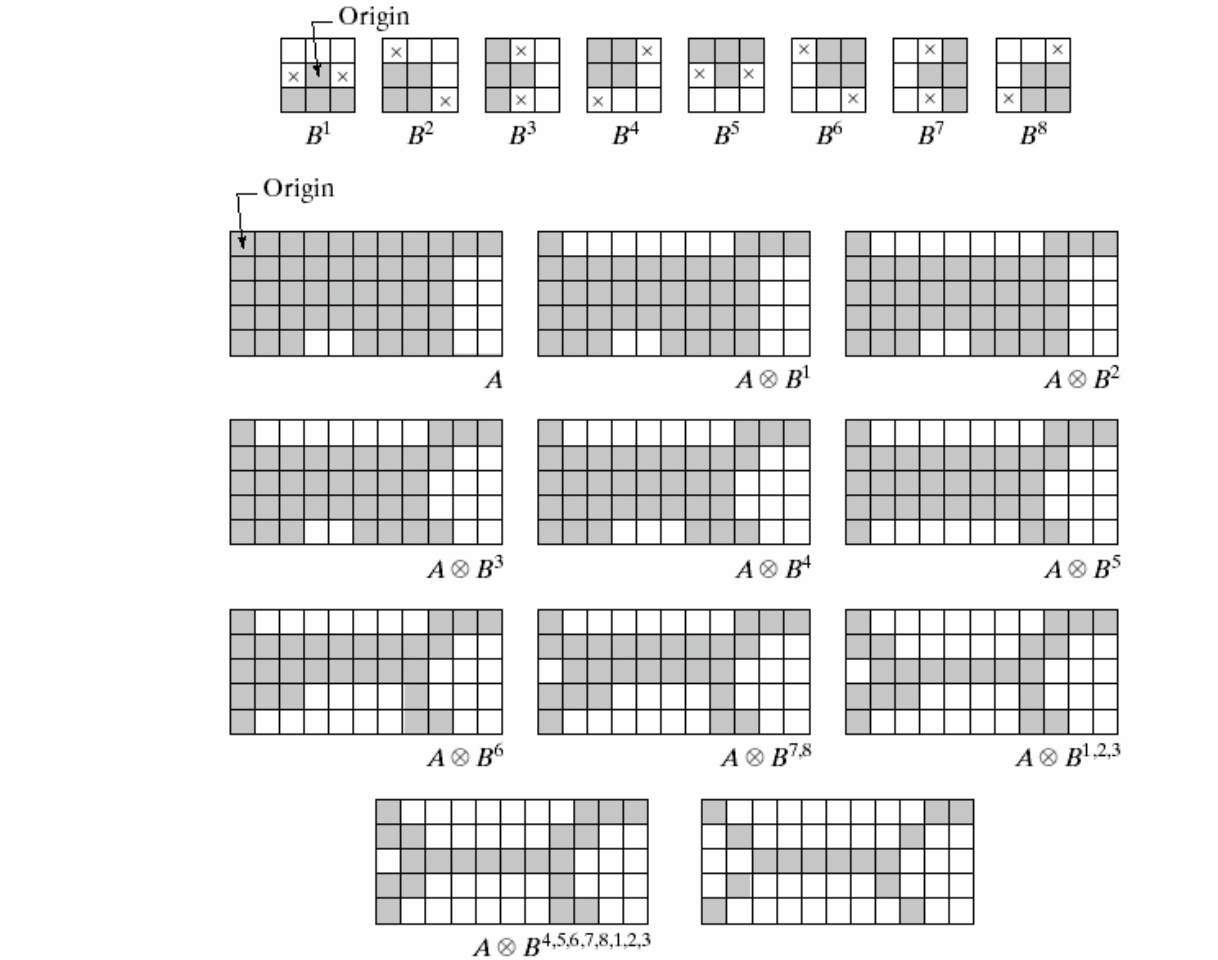


FIGURE 9.20 Result of limiting growth of convex hull algorithm to the maximum dimensions of the original set of points along the vertical and horizontal directions.

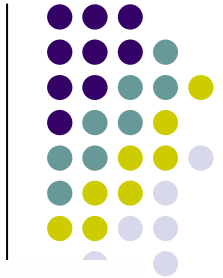
Operaciones Morfológicas

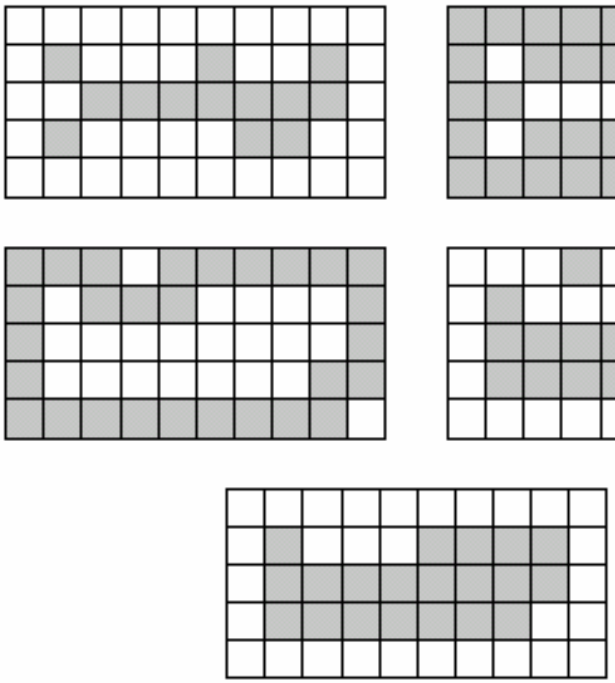


a
b c d
e f g
h i j
k l

FIGURE 9.21 (a) Sequence of rotated structuring elements used for thinning. (b) Set A. (c) Result of thinning with the first element. (d)–(i) Results of thinning with the next seven elements (there was no change between the seventh and eighth elements). (j) Result of using the first element again (there were no changes for the next two elements). (k) Result after convergence. (l) Conversion to m-connectivity.

Operaciones Morfológicas

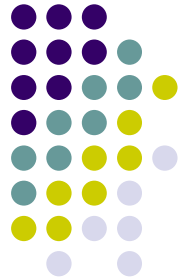




a b
c d
e

FIGURE 9.22 (a) Set A. (b) Complement of A. (c) Result of thinning the complement of A. (d) Thickened set obtained by complementing (c). (e) Final result, with no disconnected points.

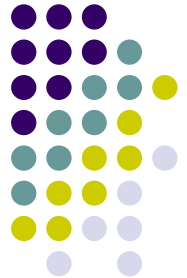
Operaciones Morfológicas: Esqueleto



Un esqueleto intenta representar la forma de un objeto con un número relativamente pequeño de píxeles. De esta forma, todos los píxeles del esqueleto son estructuralmente necesarios.

La posición, orientación y longitud de las líneas del esqueleto se corresponden con aquellas equivalentes de la imagen original. La tarea de sacar características de una imagen queda simplificada al obtener su esqueleto.

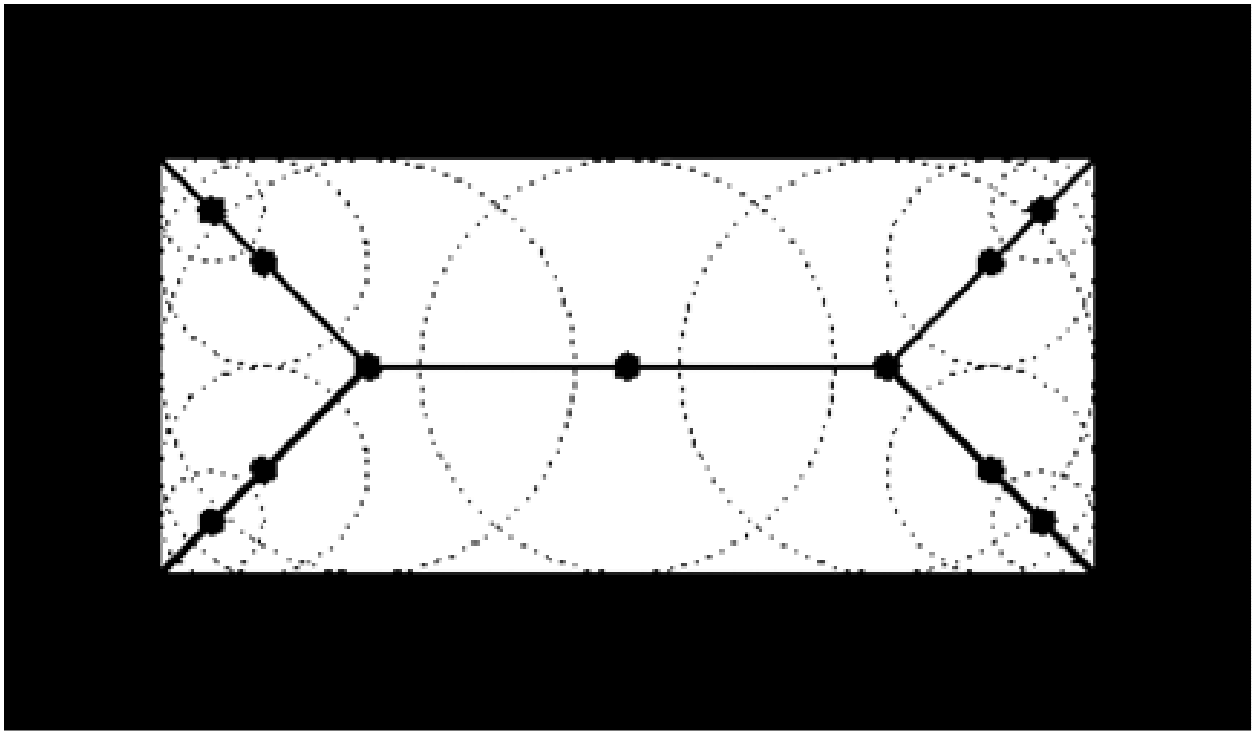
Operaciones Morfológicas: Esqueleto



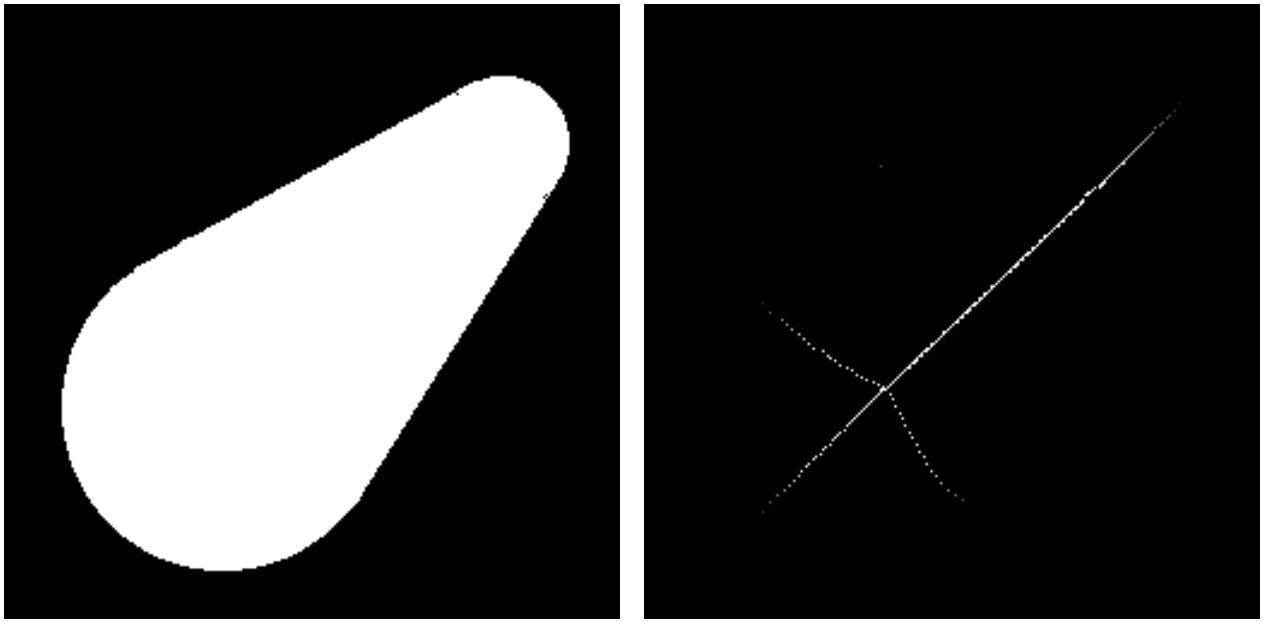
Transformación de eje central
(MAT, Medial Axis Transform)

Se denomina eje central (medial axis) al esqueleto. La forma de obtener el eje central es calcular, para cada píxel, la distancia más corta hasta el borde del objeto. Si el píxel tiene más de una distancia mínima es que forma parte del eje central.

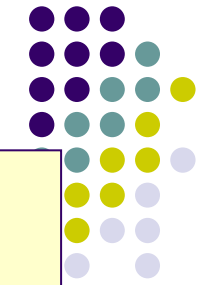
Operaciones Morfológicas: Esqueleto



Operaciones Morfológicas: Esqueleto



Operaciones Morfológicas: Esqueleto



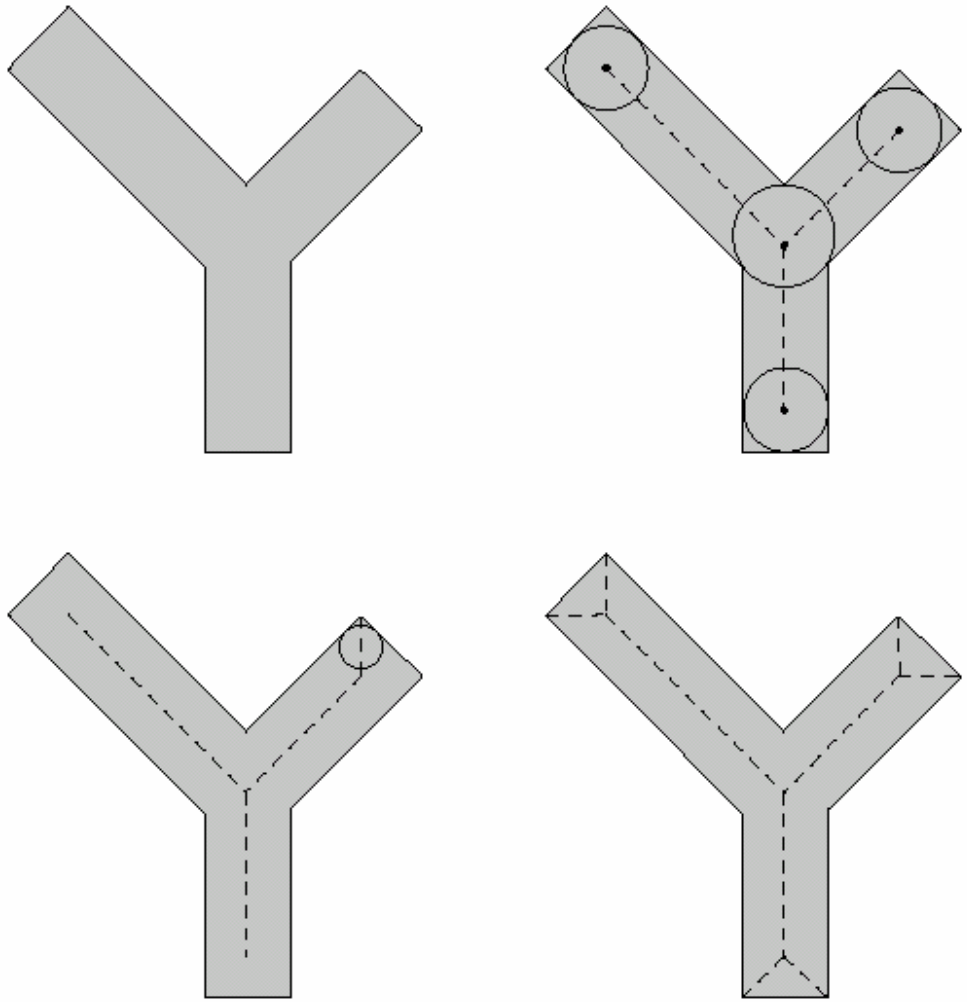
Algoritmo Básico

```
A1=erosion(A);

 Borde=A-A1;

 for f=1:H
    for c=1:W
       if A(f,c)>0
          n=0;
          min=H*W;
          for ff=1:H
              for cc=1:W
                 if Borde(ff,cc)>0
                    d=(f-ff)^2 + (c-cc)^2;
                    if d==min, n=n+1; end;
                    if d<min, min=d; n=1; end;
                 end;
              end;
           end;
           if n>1, B(f,c)=255; end;
       end;
    end;
 end;
```

If abs(d-min)<*delta* ...

delta **puede ser 1, 2 o más, lo que permite mayor flexibilidad en la búsqueda del eje central, sobre todo para objetos con anchos o altos "pares"**

Operaciones Morfológicas



a b
c d

FIGURE 9.23
(a) Set A.
(b) Various positions of maximum disks with centers on the skeleton of A.
(c) Another maximum disk on a different segment of the skeleton of A.
(d) Complete skeleton.

Operaciones Morfológicas

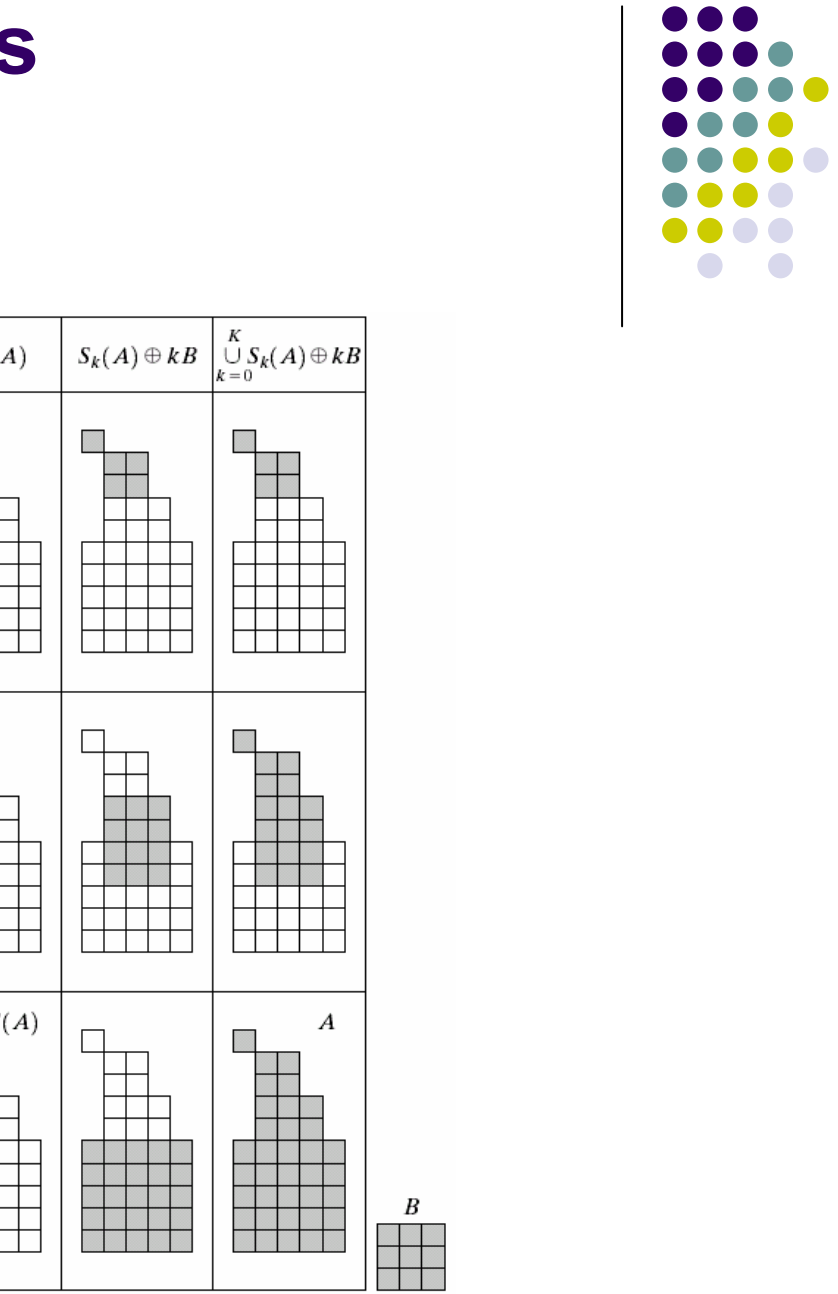
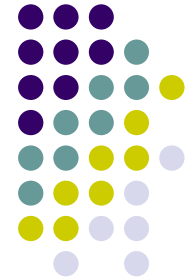
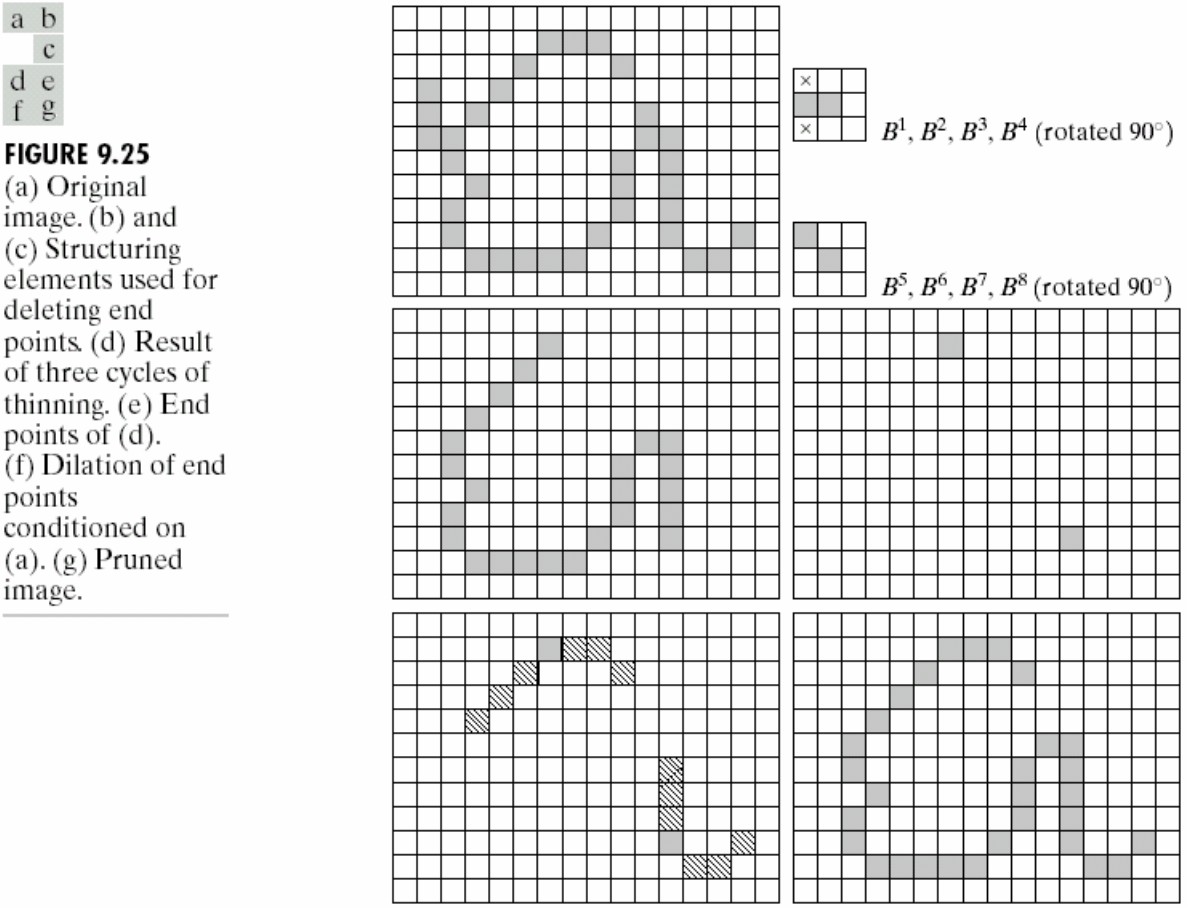


FIGURE 9.24 Implementation of Eqs. (9.5-11) through (9.5-15). The original set is at the top left, and its morphological skeleton is at the bottom of the fourth column. The reconstructed set is at the bottom of the sixth column.

Operaciones Morfológicas





a b
c
d e
f g

FIGURE 9.25
(a) Original image. (b) and (c) Structuring elements used for deleting end points. (d) Result of three cycles of thinning. (e) End points of (d). (f) Dilation of end points conditioned on (a). (g) Pruned image.

Operaciones Morfológicas

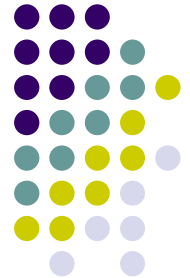
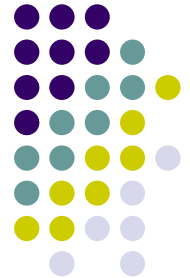


TABLE 9.2 Summary of morphological operations and their properties.

Operation	Equation	Comments (The Roman numerals refer to the structuring elements shown in Fig. 9.26).
Translation	$(A)_z = \{w \mid w = a + z, \quad \text{for } a \in A\}$	Translates the origin of A to point z.
Reflection	$\hat{B} = \{w \mid w = -b, \quad \text{for } b \in B\}$	Reflects all elements of B about the origin of this set.
Complement	$A^c = \{w \mid w \notin A\}$	Set of points not in A.
Difference	$A - B = \{w \mid w \in A, w \notin B\} = A \cap B^c$	Set of points that belong to A but not to B.
Dilation	$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \varnothing\}$	"Expands" the boundary of A. (I)
Erosion	$A \ominus B = \{z \mid (B)_z \subseteq A\}$	"Contracts" the boundary of A. (I)
Opening	$A \circ B = (A \ominus B) \oplus B$	Smoothes contours, breaks narrow isthmuses, and eliminates small islands and sharp peaks. (I)
Closing	$A \bullet B = (A \oplus B) \ominus B$	Smoothes contours, fuses narrow breaks and long thin gulfs, and eliminates small holes. (I)

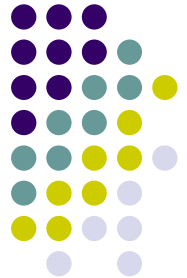
Operaciones Morfológicas



Hit-or-miss transform	$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$ $= (A \ominus B_1) - (A \oplus \hat{B}_2)$	The set of points (coordinates) at which, simultaneously, B_1 found a match ("hit") in A and B_2 found a match in A^c.
Boundary extraction	$\beta(A) = A - (A \ominus B)$	Set of points on the boundary of set A. (I)
Region filling	$X_k = (X_{k-1} \oplus B) \cap A^c; X_0 = p$ and $k = 1, 2, 3, \ldots$	Fills a region in A, given a point p in the region. (II)
Connected components	$X_k = (X_{k-1} \oplus B) \cap A; X_0 = p$ and $k = 1, 2, 3, \ldots$	Finds a connected component Y in A, given a point p in Y. (I)
Convex hull	$X_k^i = (X_{k-1}^i \circledast B^i) \cup A; i = 1, 2, 3, 4;$ $k = 1, 2, 3, \ldots; X_0^i = A;$ and $D^i = X_{\text{conv}}^i$.	Finds the convex hull $C(A)$ of set A, where "conv" indicates convergence in the sense that $X_k^i = X_{k-1}^i$. (III)

TABLE 9.2 Summary of morphological results and their properties. *(continued)*

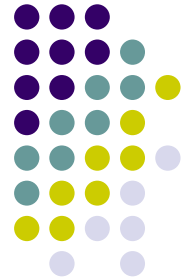
Operaciones Morfológicas



Operation	Equation	Comments (The Roman numerals refer to the structuring elements shown in Fig. 9.26).
Thinning	$A \otimes B = A - (A \circledast B)$ $= A \cap (A \circledast B)^c$ $A \otimes \{B\} =$ $((\ldots((A \otimes B^1) \otimes B^2)\ldots) \otimes B^n)$ $\{B\} = \{B^1, B^2, B^3, \ldots, B^n\}$	Thins set A. The first two equations give the basic definition of thinning. The last two equations denote thinning by a sequence of structuring elements. This method is normally used in practice. (IV)
Thickening	$A \odot B = A \cup (A \circledast B)$ $A \odot \{B\} =$ $((\ldots(A \odot B^1) \odot B^2 \ldots) \odot B^n)$	Thickens set A. (See preceding comments on sequences of structuring elements.) Uses IV with 0's and 1's reversed.

TABLE 9.2 Summary of morphological results and their properties. *(continued)*

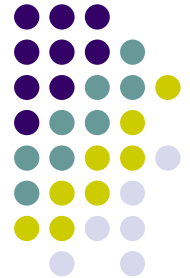
Operaciones Morfológicas



Skeletons	$S(A) = \bigcup_{k=0} S_k(A)$ $S_k(A) = \bigcup_{k=0}^{K} \{(A \ominus kB) - [(A \ominus kB) \circ B]\}$ Reconstruction of A: $A = \bigcup_{k=0}^{K} (S_k(A) \oplus kB)$	Finds the skeleton $S(A)$ of set A. The last equation indicates that A can be reconstructed from its skeleton subsets $S_k(A)$. In all three equations, K is the value of the iterative step after which the set A erodes to the empty set. The notation $(A \ominus kB)$ denotes the kth iteration of successive erosion of A by B. (I)
Pruning	$X_1 = A \otimes \{B\}$ $X_2 = \bigcup_{k=1}^{8} (X_1 \circledast B^k)$ $X_3 = (X_2 \oplus H) \cap A$ $X_4 = X_1 \cup X_3$	X_4 is the result of pruning set A. The number of times that the first equation is applied to obtain X_1 must be specified. Structuring elements V are used for the first two equations. In the third equation H denotes structuring element I.

TABLE 9.2
Summary of morphological results and their properties.
(continued)

Operaciones Morfológicas



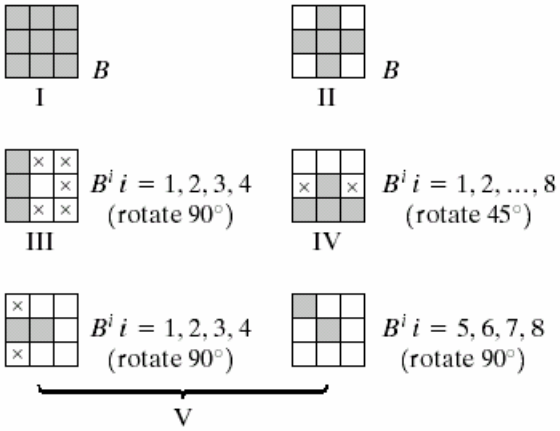
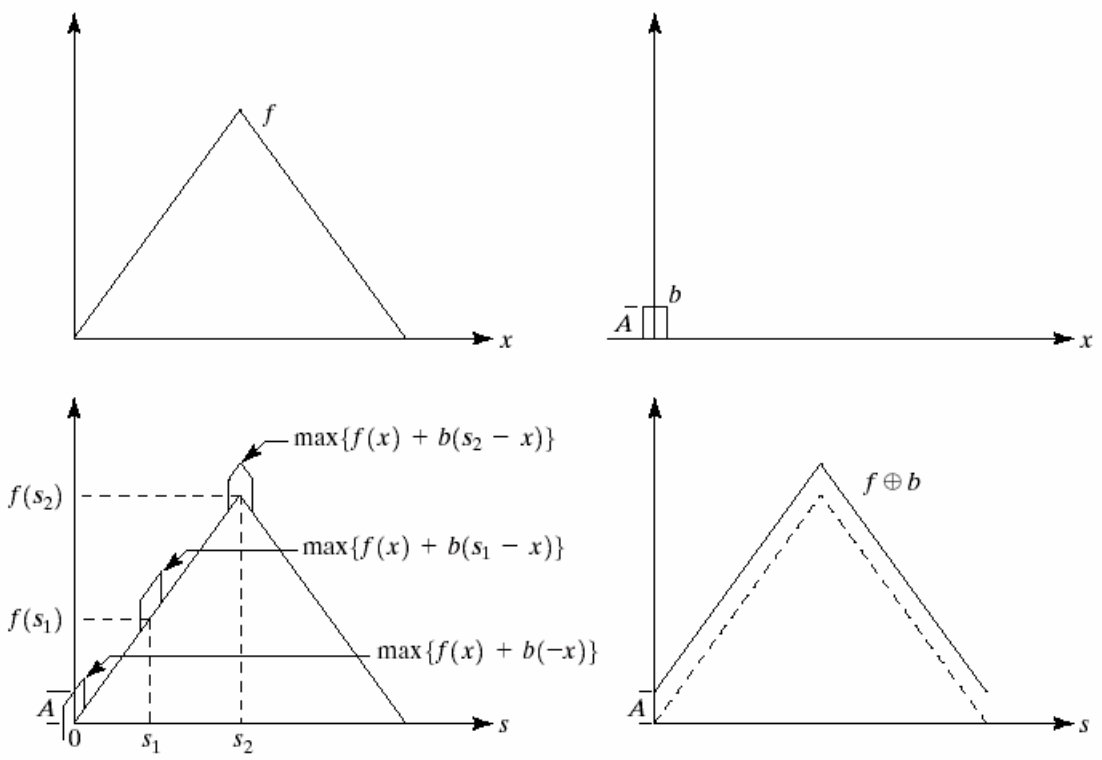


FIGURE 9.26 Five basic types of structuring elements used for binary morphology. The origin of each element is at its center and the ×'s indicate "don't care" values.

Operaciones Morfológicas



a b
c d

FIGURE 9.27 (a) A simple function. (b) Structuring element of height A. (c) Result of dilation for various positions of sliding b past f. (d) Complete result of dilation (shown solid).

Operaciones Morfológicas

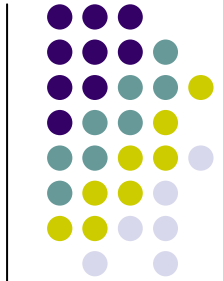
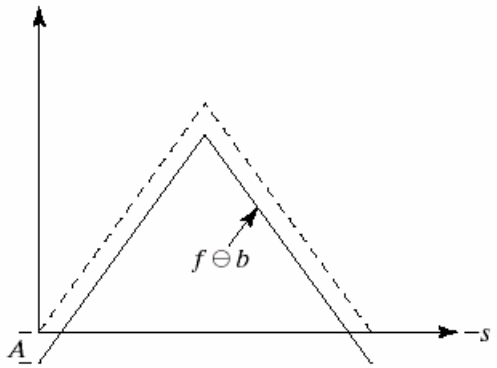
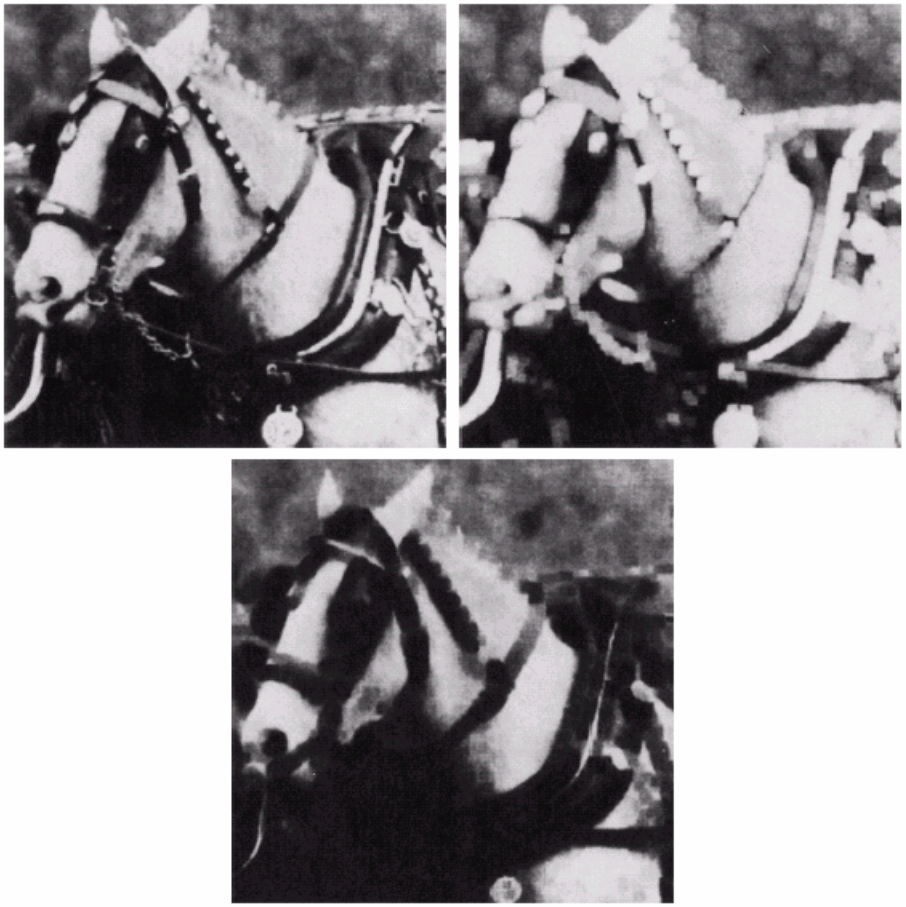


FIGURE 9.28
Erosion of the function shown in Fig. 9.27(a) by the structuring element shown in Fig. 9.27(b).



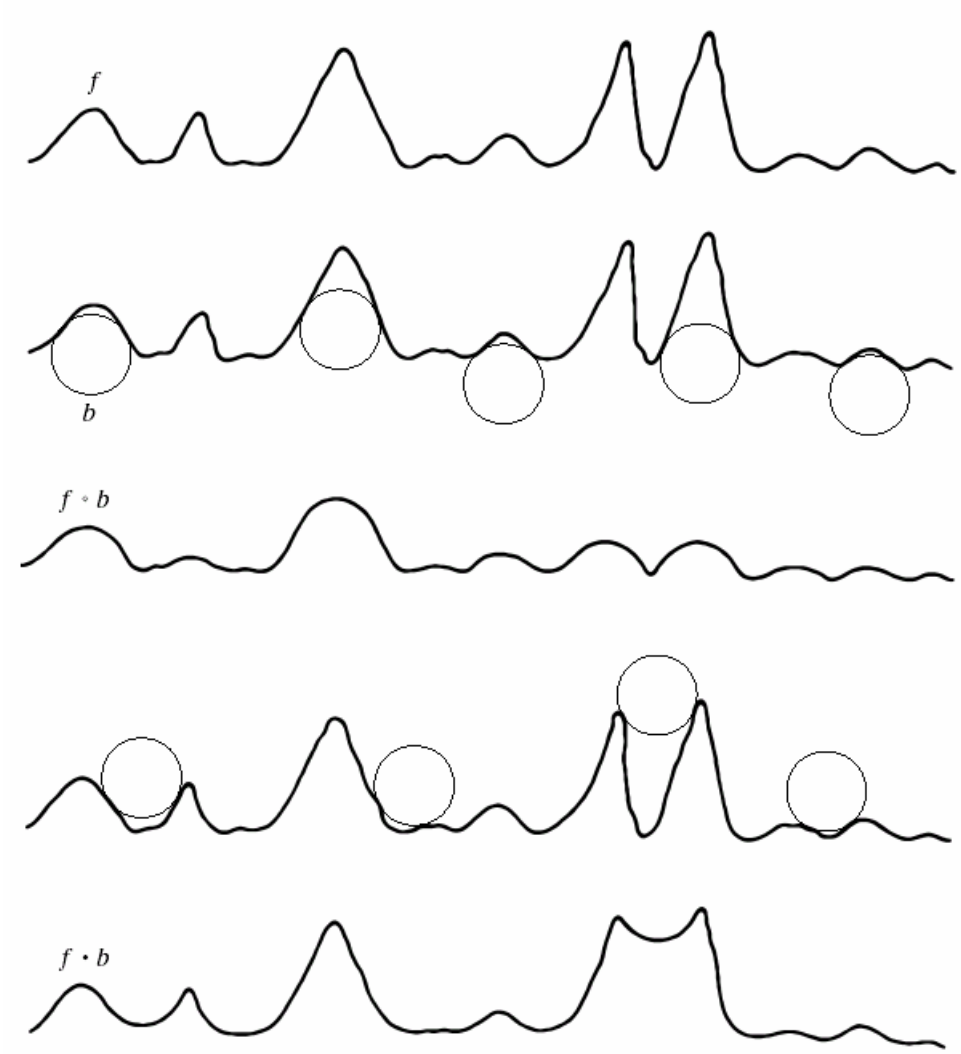
Operaciones Morfológicas



a b
c

FIGURE 9.29
(a) Original image. (b) Result of dilation. (c) Result of erosion. (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Operaciones Morfológicas



a
b
c
d
e

FIGURE 9.30
(a) A gray-scale scan line.
(b) Positions of rolling ball for opening.
(c) Result of opening.
(d) Positions of rolling ball for closing. (e) Result of closing.

Operaciones Morfológicas

a b

FIGURE 9.31 (a) Opening and (b) closing of Fig. 9.29(a). (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Operaciones Morfológicas

FIGURE 9.32 Morphological smoothing of the image in Fig. 9.29(a). (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Operaciones Morfológicas

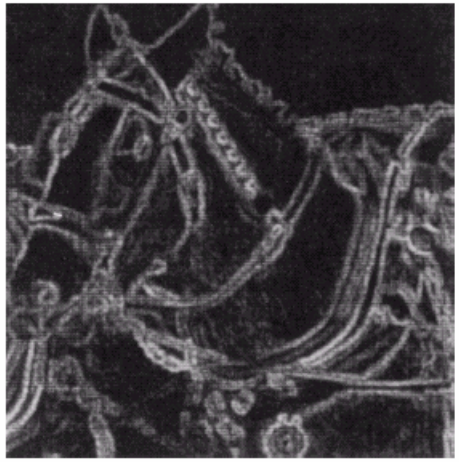


FIGURE 9.33 Morphological gradient of the image in Fig. 9.29(a). (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Operaciones Morfológicas

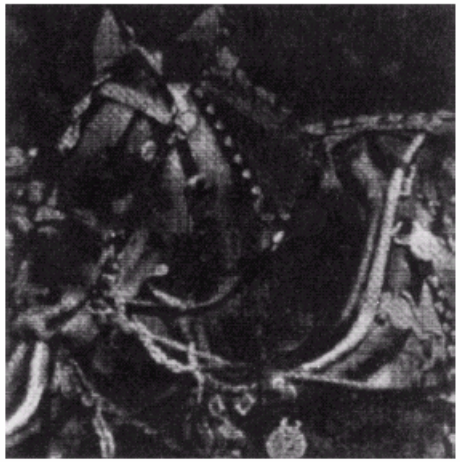
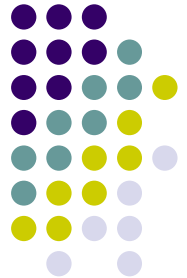


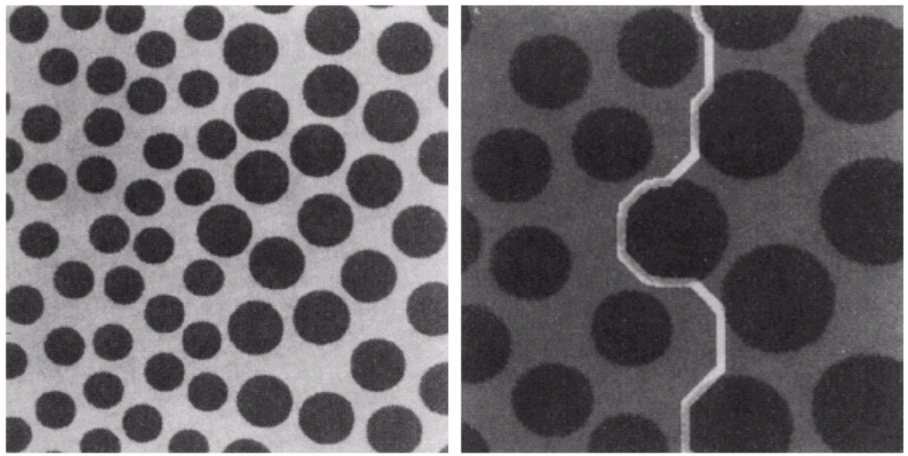
FIGURE 9.34 Result of performing a top-hat transformation on the image of Fig. 9.29(a). (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Operaciones Morfológicas

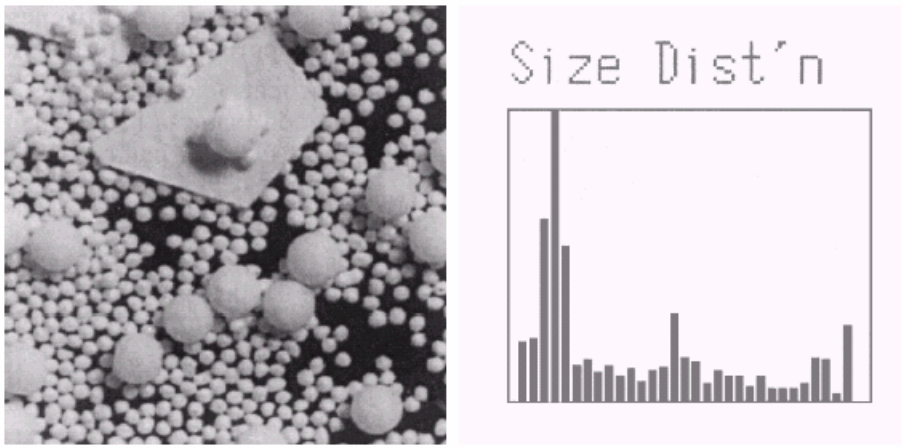


a b

FIGURE 9.35
(a) Original image. (b) Image showing boundary between regions of different texture. (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)



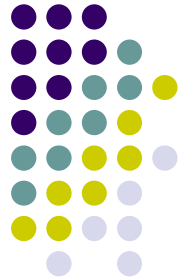
Operaciones Morfológicas



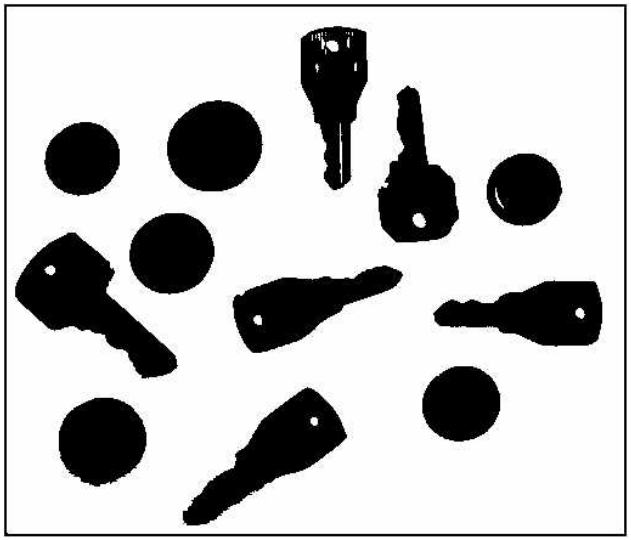
a b

FIGURE 9.36
(a) Original image consisting of overlapping particles; (b) size distribution. (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

Extracción de Regiones y Etiquetado



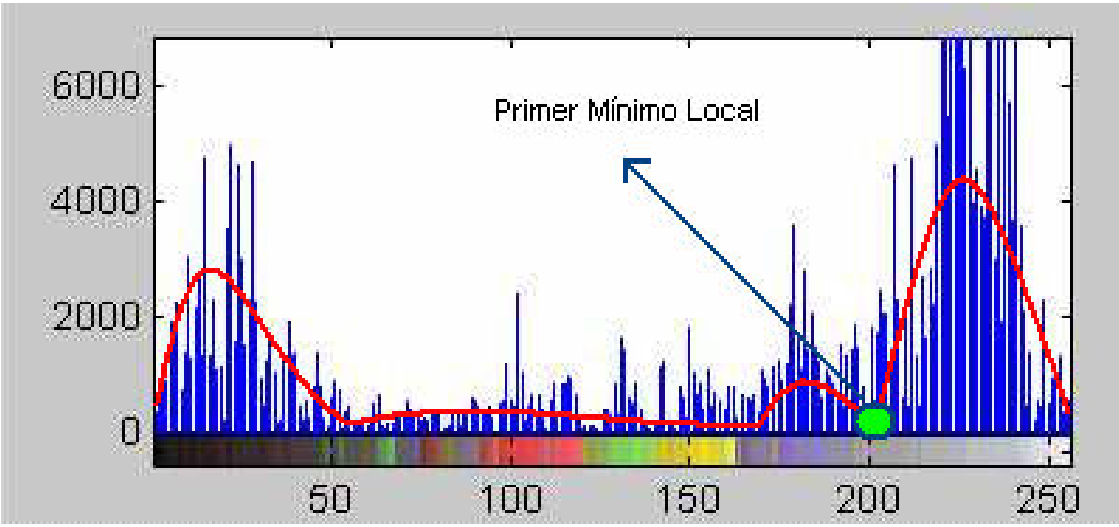
Generalmente la extracción de regiones y su etiquetado se realizan sobre imágenes previamente binarizadas



Selección de umbrales óptimos en el histograma

Extracción de Regiones y Etiquetado

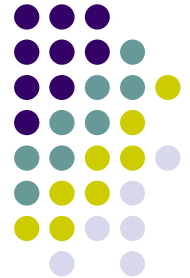
Binarización según histograma



Es posible automatizar la detección del umbral de binarización, "filtrando" el histograma (p. ej. promedio móvil), y detectando el primer mínimo local desde el promedio del fondo de la imagen.

```
[nf nc]=size(A);

HISTOGRAMA=zeros(1,256);
for f=1:nf
  for c=1:nc
    HISTOGRAMA(A(f,c)+1)= HISTOGRAMA(A(f,c)+1)+1;
  end;
end;
```

Extracción de Regiones y Etiquetado

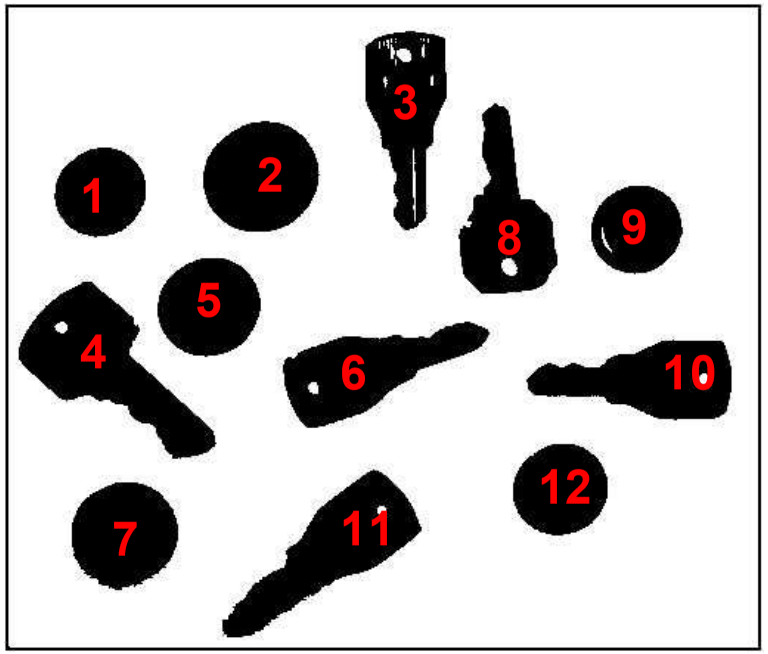


Etiquetado

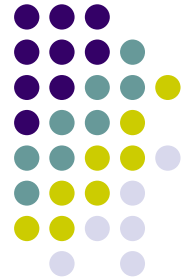
Después de binarizar se puede ejecutar alguno de los algoritmos de etiquetado.

Un Algoritmo muy utilizado es el siguiente:

- **Marcar todos los píxel distintos del fondo con etiquetas diferentes (números)**
- **Iterando desde la esquina superior izq., asignar a cada píxel la menor etiqueta presente en la vecindad (tipo 6)**
- **Repetir proceso pero iterando desde la esquina inferior der.**

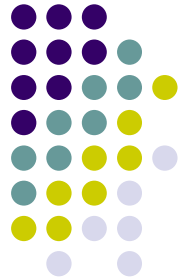


Extracción de Regiones y Etiquetado

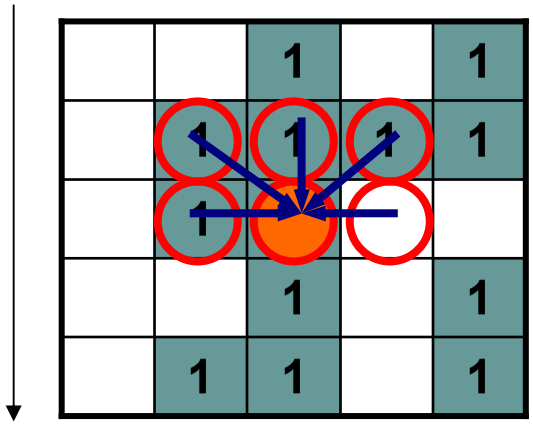


```
E=zeros(nf,nc);
for f=1:nf
   for c=2:nc
      if Ab(f,c)==1
         E(f,c)=ETIQUETA;
         ETIQUETA=ETIQUETA+1;
      else
         E(f,c)=0;
      end;
   end;
end;

//luego propagar las etiquetas menores vecinas....
```

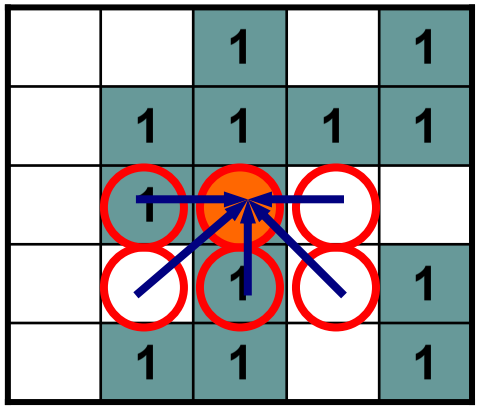
Extracción de Regiones y Etiquetado



Se entiende por vecindad tipo 6:

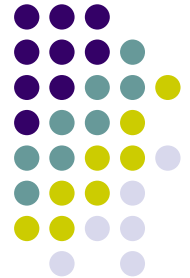


Cuando se realiza iteración desde arriba hacia abajo



Cuando se realiza iteración desde abajo hacia arriba

Extracción de Regiones y Etiquetado



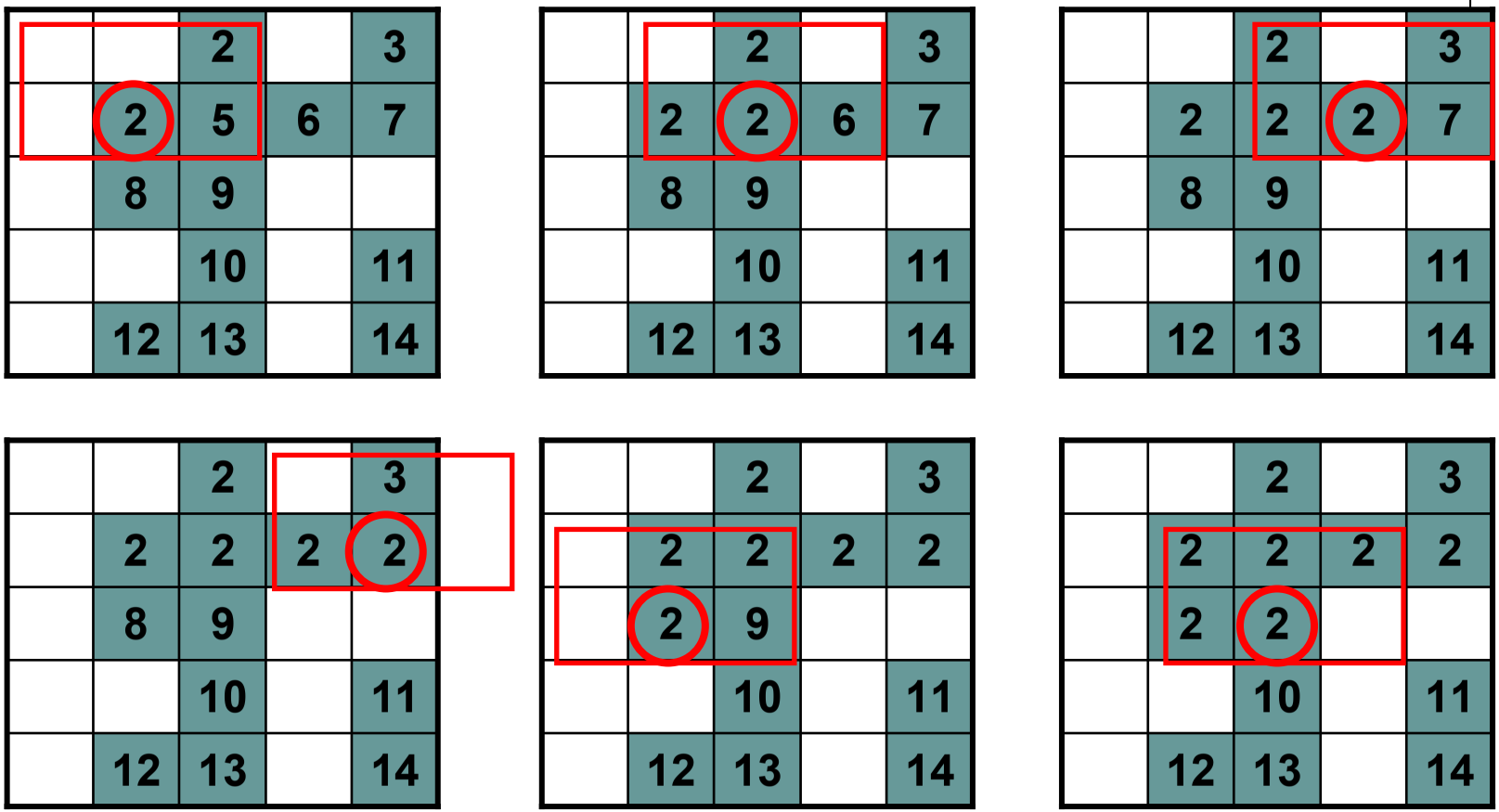
Etiquetado inicial. Supone que todos los píxel son “regiones” u objetos independientes

		1		1
	1	1	1	1
	1	1		
		1		1
	1	1		1

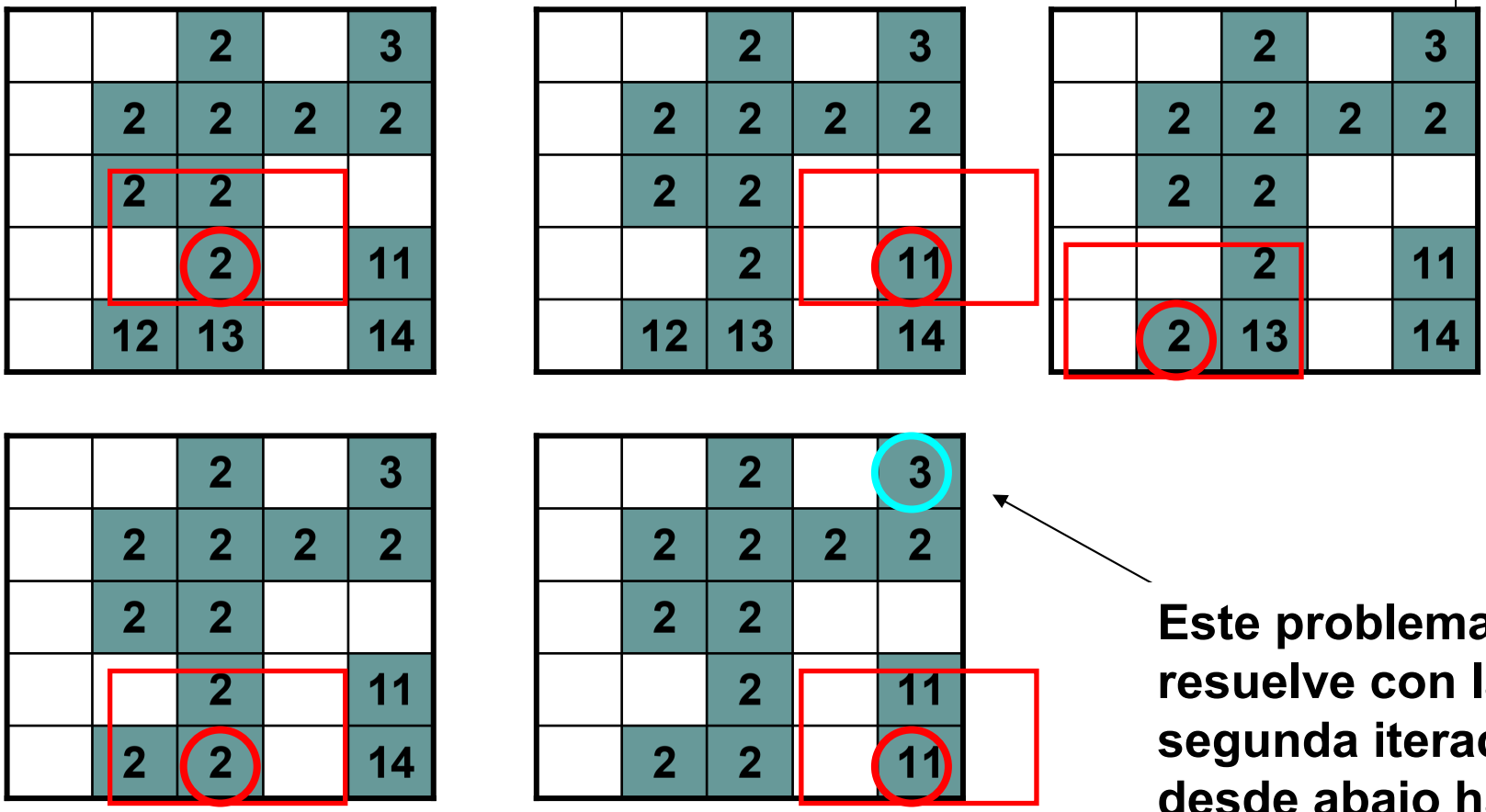
→

		2		3
	4	5	6	7
	8	9		
		10		11
	12	13		14

Extracción de Regiones y Etiquetado

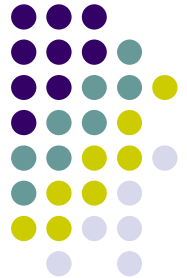


Extracción de Regiones y Etiquetado

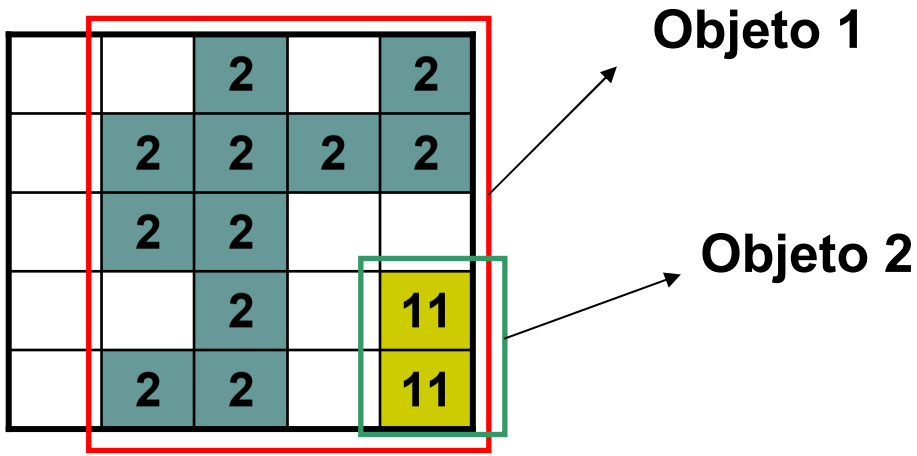


Este problema se resuelve con la segunda iteración desde abajo hacia arriba

Extracción de Regiones y Etiquetado

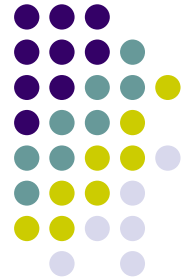


El proceso de etiquetado abre la posibilidad de trabajar directamente con regiones o sub-imágenes, lo que optimiza notablemente el análisis.

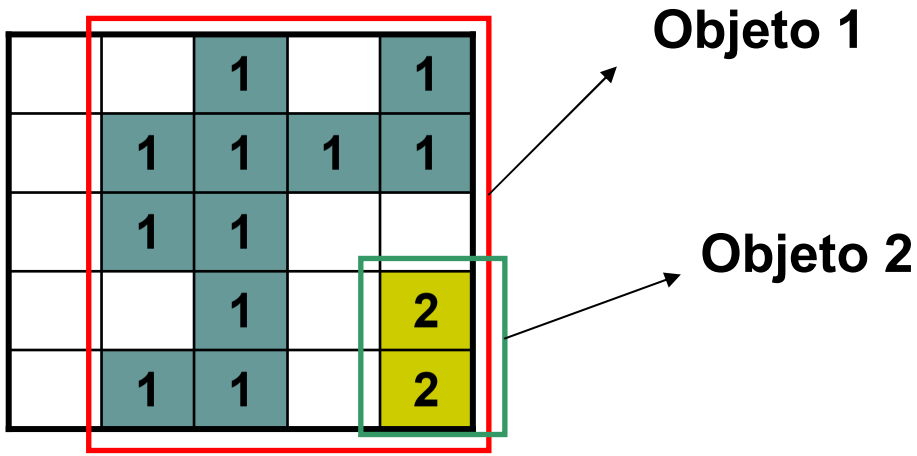


Es importante generar una estructura de datos apropiada para referenciar los "objetos".

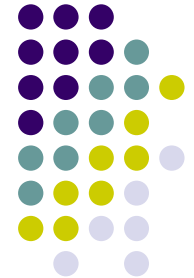
Extracción de Regiones y Etiquetado



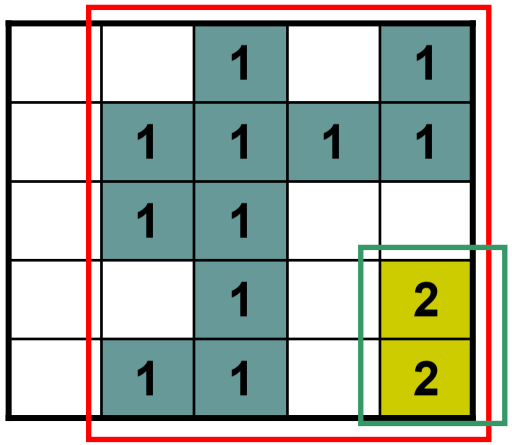
Un paso opcional es renombrar las etiquetas de los objetos encontrados.



Extracción de Regiones y Etiquetado



Es importante generar una estructura de datos apropiada para referenciar los “objetos”.



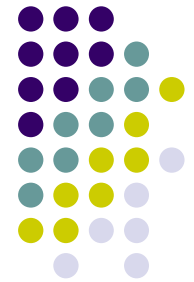
Objeto 1

```
x1: integer;
y1: integer;
x2: integer;
y2: integer;
xp: integer;
yp: integer;
Ancho: integer;
Alto: integer;
Area: integer;
...
Centro...
Razon...
Etc...
```

Objeto 2

```
x1: integer;
y1: integer;
x2: integer;
y2: integer;
xp: integer;
yp: integer;
Ancho: integer;
Alto: integer;
Area: integer;
...
Centro...
Razon...
Etc...
```

Extracción de Regiones y Etiquetado



Muchas de los análisis básico se realizan sobre la estructura de datos. Estas restricciones se denominan "filtros"

```
Type TRegion=record
        x:integer;
        area:integer:
        ...
        end;

var
 D:array of TRegion;
 i,c: integer;

Begin
   c:=0;
   for i:=1 to N do begin
     if (D[i].Area>5) and (D[i].Razon>0.8) then c:=c+1;
   end;
end;
```

Ejemplo donde se cuentan los "objetos" con área mayor a 5 píxel y razón de diámetros mayor a 0.8