

Representación y Descripción

De la imagen a la lista....

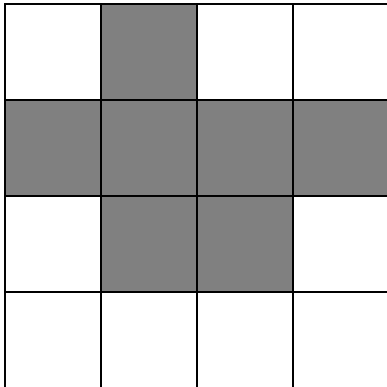
- Se pretende compactar de alguna forma guardando la información “necesaria y suficiente” para cumplir con determinados objetivos.

Run length codes

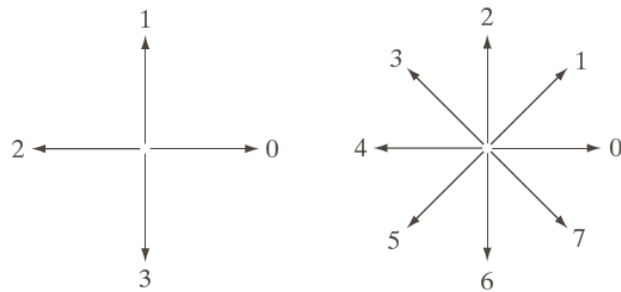
- Una imagen binaria es representada como una sucesión de 1's y 0's.
- Dirección del primer 1 y largo del tramo de pixels de este valor.
- El valor se obtiene en una pasada.
- Los pixels del borde no están ordenados.

Ejemplo Run Length

- $(0,1)$ 1, $(1,0)$ 4, $(2,1)$ 2.

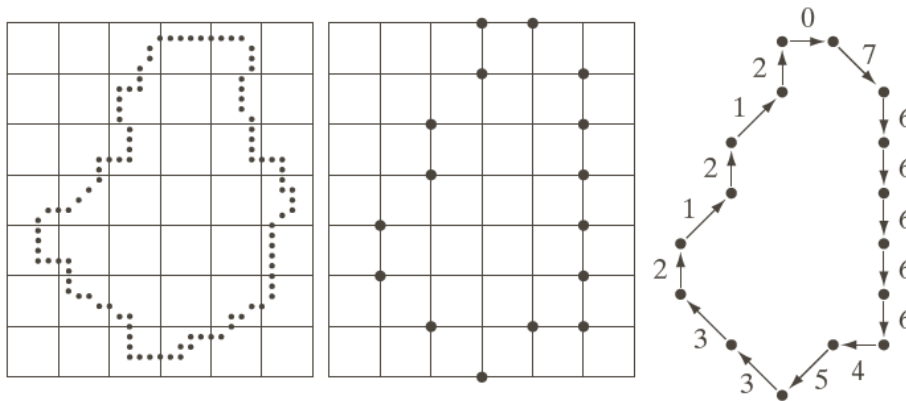


Chain code



a b

FIGURE 11.3
Direction numbers for (a) 4-directional chain code, and (b) 8-directional chain code.



a b c

FIGURE 11.4
(a) Digital boundary with resampling grid superimposed. (b) Result of resampling. (c) 8-directional chain-coded boundary.

Etiquetado

- Dada una imagen binaria se trata de obtener una lista de listas de pixeles conexos (regiones).
- Pixeles caracterizados por su posición en la imagen original y eventualmente otros atributos (nivel de gris por ejemplo).

Etiquetado. Algoritmo (1).

- La imagen binaria. El fondo vale 0 y los objetos valen 1.
- Se crea una imagen de salida, inicializada a 0. Se pasa por la imagen una máscara:

| | |
|---|---|
| A | B |
| C | M |

M es el pixel corriente en la imagen de entrada. **Msalida**, **A**, **B** y **C** apuntan a la imagen de salida.

Etiquetado. Algoritmo (2).

If (M != 0)

 If (A > 0) Msalida = A;

 Else If (B > 0 && C == 0) Msalida = B;

 Else If (B == 0 && C > 0) Msalida = C;

 Else If (B > 0 && C > 0)

 Msalida = C;

 equivalencia (C,B);

 Else Msalida = Nlabel++;

Else

 If (B > 0 && C > 0 && B != C)

 equivalencia(B,C);

Etiquetado. Algoritmo (3)

Recorrer la tabla de equivalencias para homogeneizar las zonas conexas.

Escribir una lista de listas conexas (regiones).

(a)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

0 Background

1 Foreground

(b) only background neighbors

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

new label (2)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(c) exactly one neighbor label

⋮

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

neighbor label is propagated

⋮

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(d) two different neighbor labels

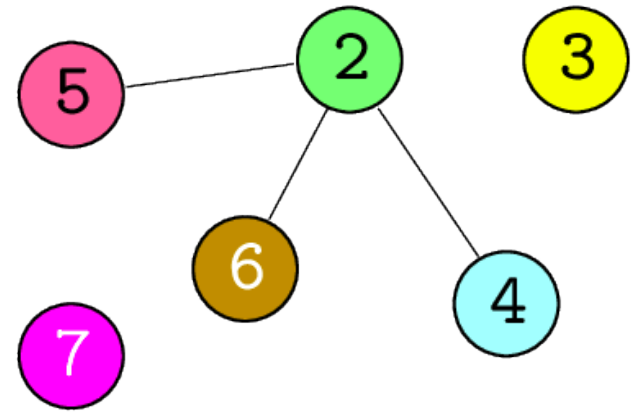
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 3 | 3 | 0 | 4 | 0 |
| 0 | 5 | 5 | 5 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

one of the labels (**2**) is propagated

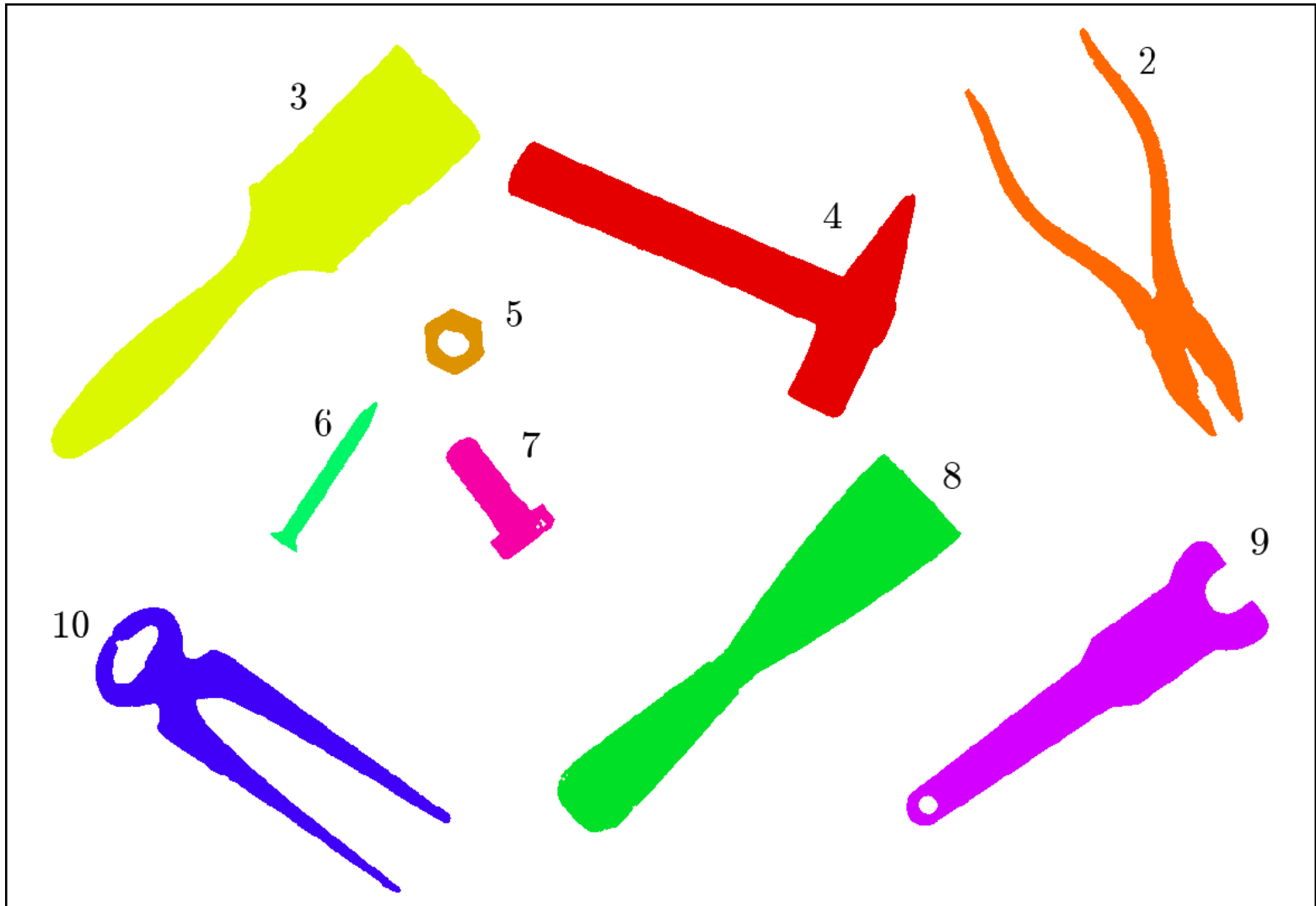
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 3 | 3 | 0 | 4 | 0 |
| 0 | 5 | 5 | 5 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 3 | 3 | 0 | 4 | 0 |
| 0 | 5 | 5 | 5 | 2 | 2 | 2 | 0 | 0 | 3 | 0 | 0 | 4 | 0 |
| 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| 0 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 |
| 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 |
| 0 | 7 | 7 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(a)

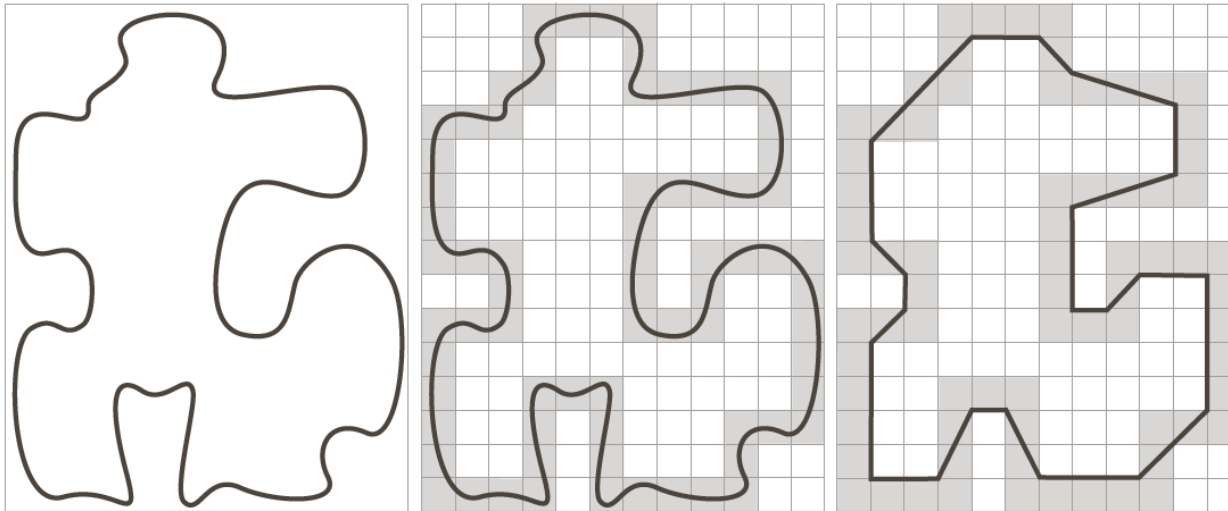


(b)



Digital Image Processing, An algorithmic introduction using Java. Burger and Burge

Aproximación poligonal



a b c

FIGURE 11.6 (a) An object boundary (black curve). (b) Boundary enclosed by cells (in gray). (c) Minimum-perimeter polygon obtained by allowing the boundary to shrink. The vertices of the polygon are created by the corners of the inner and outer walls of the gray region.

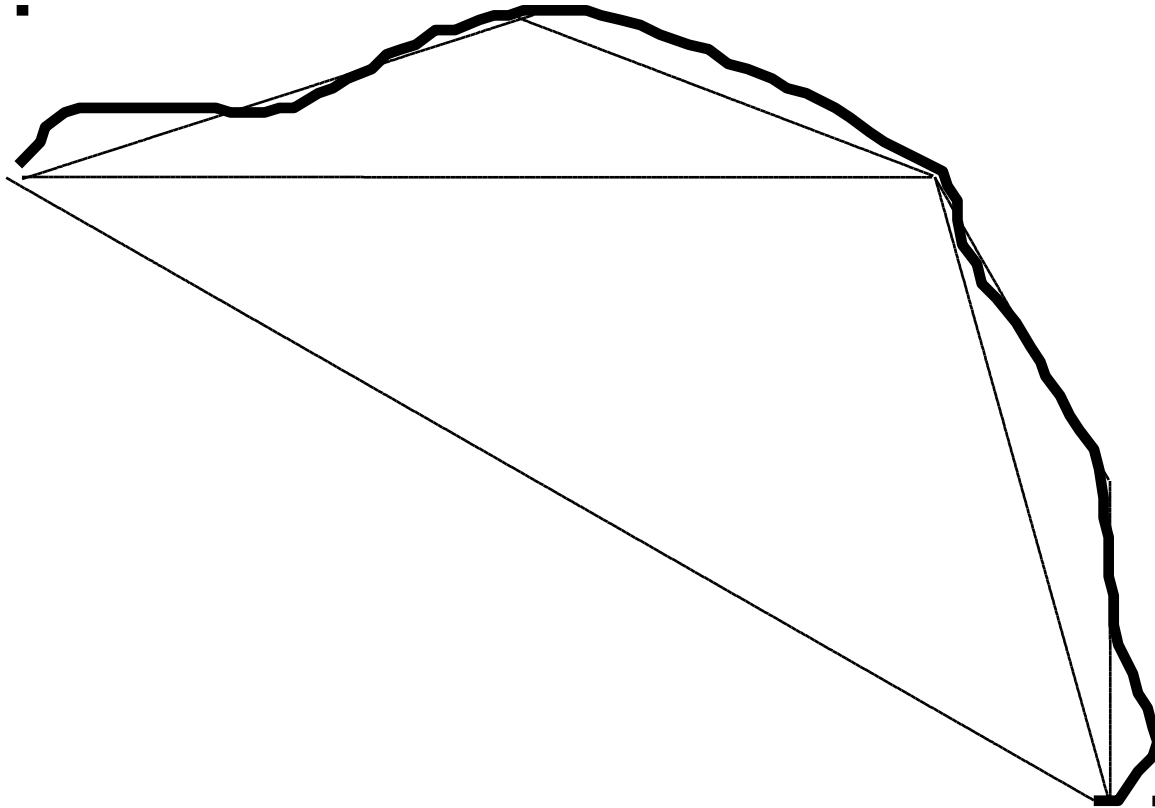
Aproximación poligonal de contornos.

- Determinar los puntos de corte en una curva (un borde por ejemplo).
 - Sklansky u otro algoritmo...
- Afinar buscando máxima curvatura localmente.
- Aproximar los trozos por rectas aplicando mínimos cuadrados.

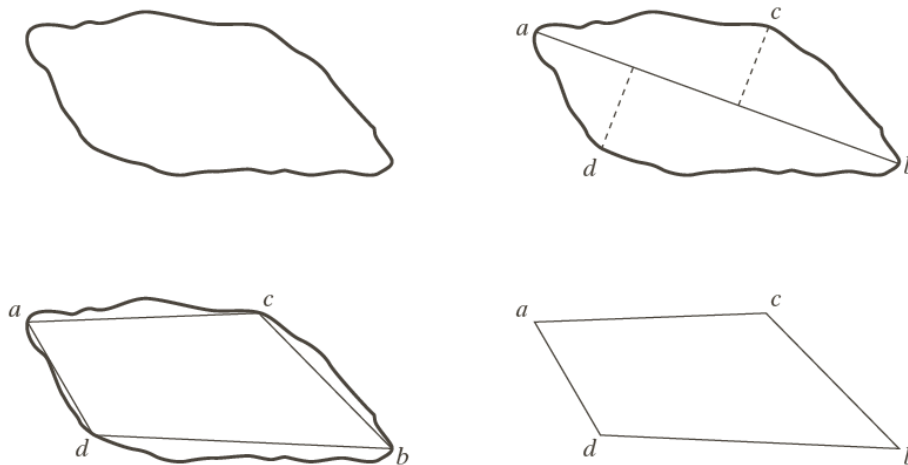
Búsqueda de puntos de máxima curvatura ...

- Dividir iterativamente el contorno en dos partes en el punto de la curva que es el más lejano al arco.
- El parámetro **d** es la distancia entre el punto más lejano al arco y el arco mismo.
- El algoritmo se para cuando **d** es más pequeño que un error dado.

Sklansky



Aproximación poligonal

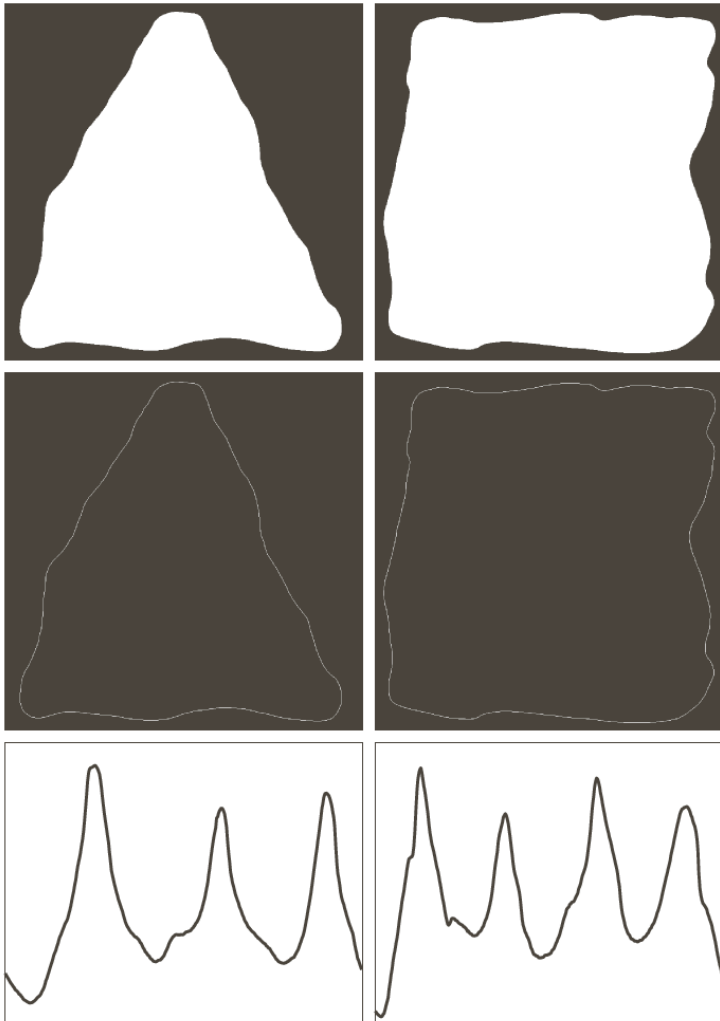


| | |
|---|---|
| a | b |
| c | d |

FIGURE 11.9

(a) Original boundary.
(b) Boundary divided into segments based on extreme points. (c) Joining of vertices.
(d) Resulting polygon.

Firmas y segmentos de bordes...



a b
c d
e f

FIGURE 11.11 Two binary regions, their external boundaries, and their corresponding $r(\theta)$ signatures. The horizontal axes in (e) and (f) correspond to angles from 0° to 360° , in increments of 1° .

Clasificación

Caracterizar los objetos

- Medidas que sirvan como descriptores.
- Cuáles?
 - Representativos.
 - Discriminantes.
 - Generales.
 - Invariantes?.

Descriptores

- Longitud del contorno: número de pixels del contorno.
 - Distancia $\sqrt{2}$ o 1 según sea diagonal o no.
- Diámetro del contorno: Distancia máxima entre 2 puntos del contorno.
- Eje Mayor: línea que conecta los 2 puntos extremos del diámetro.

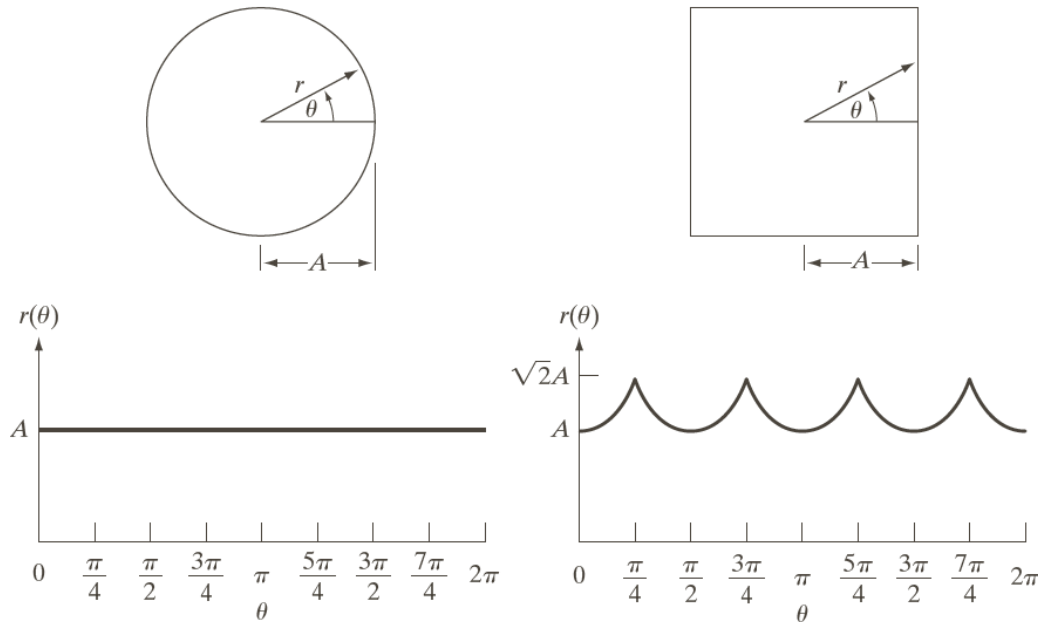
Curvatura

- Derivada de la pendiente del contorno.
- Noción de convexidad y concavidad
- Cambio de signo de la curvatura.
- Reparametrización por longitud de arco.

Firmas

- Función unidimensional de un contorno que es más fácil de tratar.
- Por ejemplo: distancia del borde al centro.

Firmas



a b

FIGURE 11.10

Distance-versus-angle signatures.

In (a) $r(\theta)$ is constant. In (b), the signature consists of repetitions of the pattern

$r(\theta) = A \sec \theta$ for $0 \leq \theta \leq \pi/4$ and $r(\theta) = A \csc \theta$ for $\pi/4 < \theta \leq \pi/2$.

Descriptores de Fourier

- Se representan en el plano complejo los pares (x,y) de puntos del contorno recorridos en sentido contrario a las manecillas del reloj como: $s(k)=x(k)+ jy(k)$

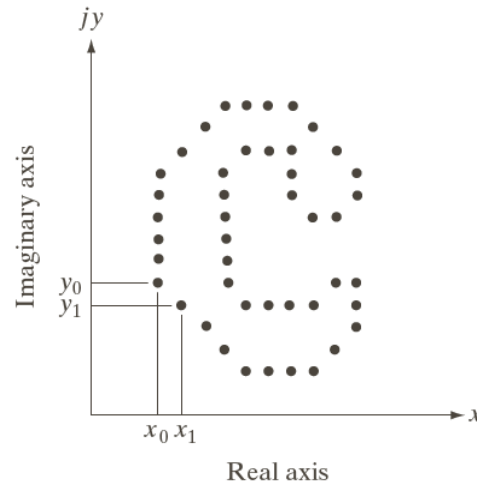


FIGURE 11.19

A digital boundary and its representation as a complex sequence. The points (x_0, y_0) and (x_1, y_1) shown are (arbitrarily) the first two points in the sequence.

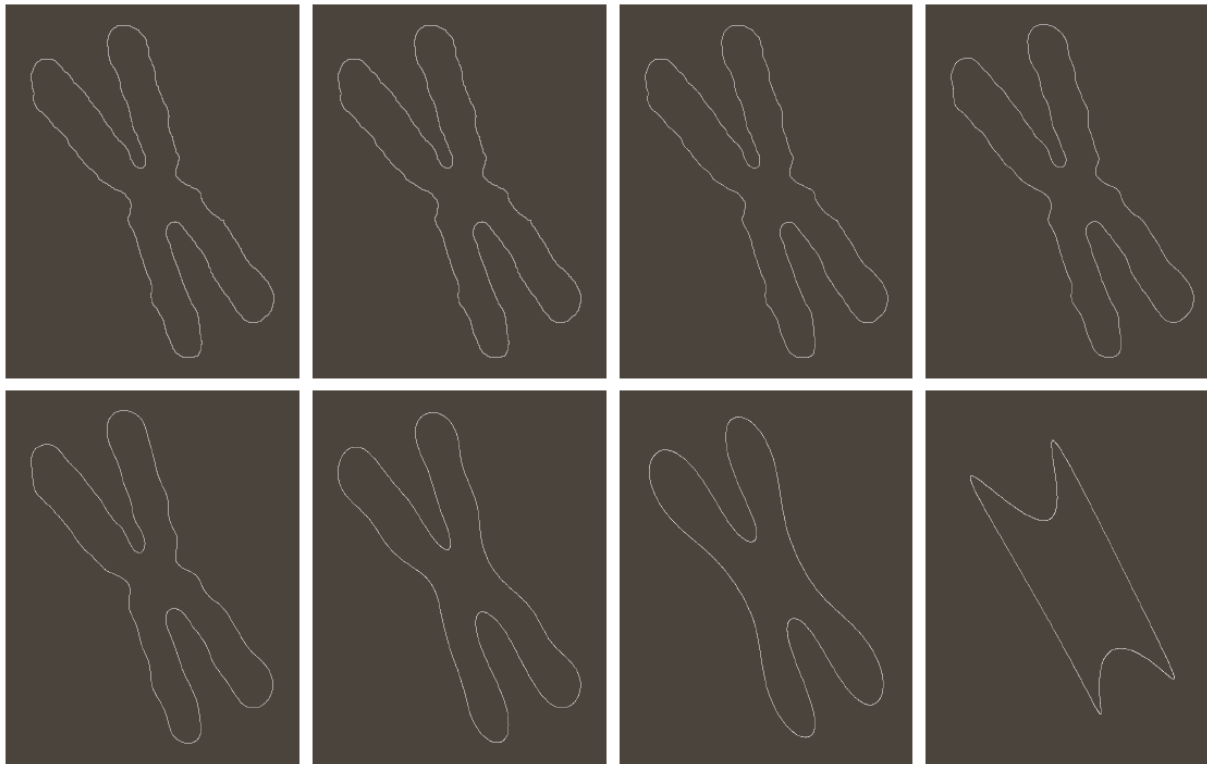
Descriptores de Fourier

- Son los coeficientes complejos $a(u)$ de la DFT de la serie $s(k)$.

$$a(u) = \frac{1}{N} \sum_{k=0}^{N-1} s(k) e^{-j2\pi uk/N} \quad u = 0, 1, 2, \dots, N - 1$$

$$s(k) = \sum_{u=0}^{N-1} a(u) e^{j2k\pi u/N} \quad k = 0, 1, 2, \dots, N - 1$$

Descriptores de Fourier



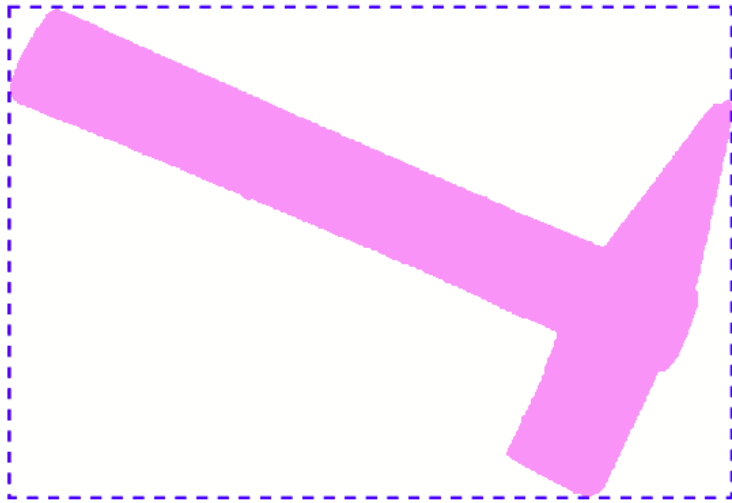
| | | | |
|---|---|---|---|
| a | b | c | d |
| e | f | g | h |

FIGURE 11.20 (a) Boundary of human chromosome (2868 points). (b)–(h) Boundaries reconstructed using 1434, 286, 144, 72, 36, 18, and 8 Fourier descriptors, respectively. These numbers are approximately 50%, 10%, 5%, 2.5%, 1.25%, 0.63%, and 0.28% of 2868, respectively.

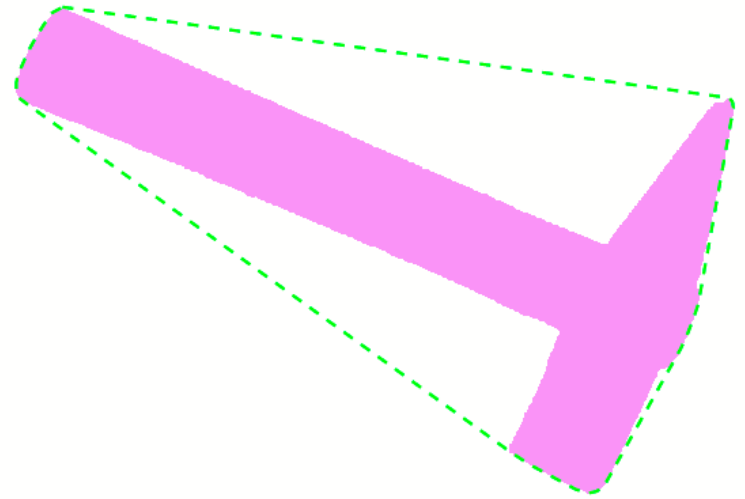
Descriptores de región

- Medidas:
 - Área.
 - Perímetro.
 - Momentos.
- Factores de forma: relaciones entre varias medidas simples.
- Descripciones simbólicas.

Paralelogramo circunscrito y cerco convexo (convex hull)



(a)



(b)

Perímetro y área

- Area: número de píxeles del objeto.

- **Perímetro:**

$$\text{Perimeter}(\mathcal{R}) = \sum_{i=0}^{M-1} \text{length}(c'_i)$$

$$\text{with } \text{length}(c) = \begin{cases} 1 & \text{for } c = 0, 2, 4, 6 \\ \sqrt{2} & \text{for } c = 1, 3, 5, 7 \end{cases}$$

Cerco convexo

- Conjunto arbitrario convexo más pequeño que contiene al objeto.
- En general se limita a un número fijo de lados.

Momentos

- Para una imagen $f(x,y)$.

$$m_{pq} = \sum_{i=0}^M \sum_{j=0}^N i^p j^q f(i, j)$$

$$m_{00} = \sum_{i=0}^M \sum_{j=0}^N f(i, j)$$

- Centroides: m_{01} y m_{10}

- Valores medios: $\bar{x} = \frac{m_{10}}{m_{00}}$ y $\bar{y} = \frac{m_{01}}{m_{00}}$

Momentos centrales

- Referidos a los valores medios:

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

$$\mu_{00} = m_{00}$$

$$\mu_{10} = m_{10} - \frac{m_{10}}{m_{00}} m_0 = \mu_{01} = 0$$

$$\mu_{20} = m_{20} - \bar{x} m_{10}$$

$$\mu_{02} = m_{02} - \bar{y} m_{01}$$

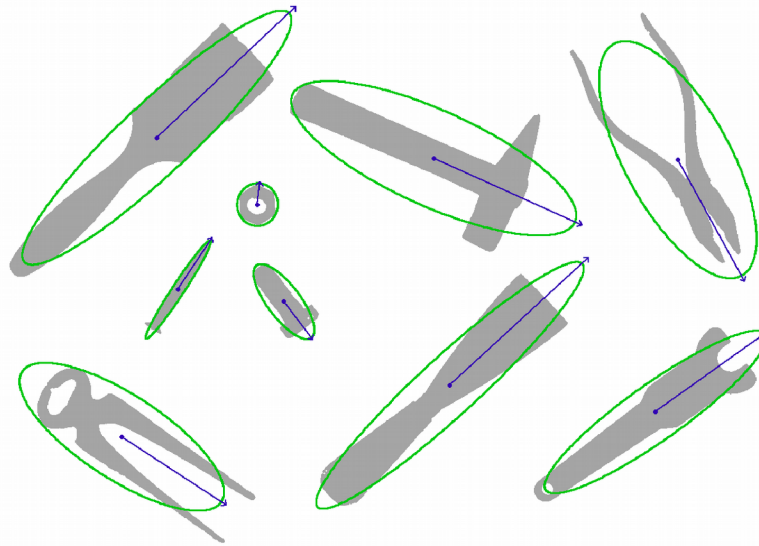
Orientación y eccentricidad

- Orientación:

$$\Theta_R = 0.5 \tan^{-1} \frac{2\mu_{11}(R)}{\mu_{20}(R) - \mu_{02}(R)}$$

- Excentricidad:

$$ECC = \frac{\mu_{20} + \mu_{02} + \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}}{\mu_{20} + \mu_{02} - \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}}$$



Momentos centrales normalizados

- Se normalizan respecto al momento central de orden 00.

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}}$$

$$\gamma = \frac{p+q}{2} + 1$$

Momentos invariantes

- Utilizando los momentos centrales normalizados se pueden derivar 7 momentos invariantes ante transformaciones de escala, rotación y traslación.

Momentos invariantes

$$\varphi_1 = \eta_{20} + \eta_{02}$$

$$\varphi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$

$$\varphi_3 = (\eta_{30} + 3\eta_{12})^2 + (3\eta_{21} - \eta_{12})^2$$

$$\varphi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{12})^2$$

$$\varphi_5 = \dots$$

Momentos invariantes

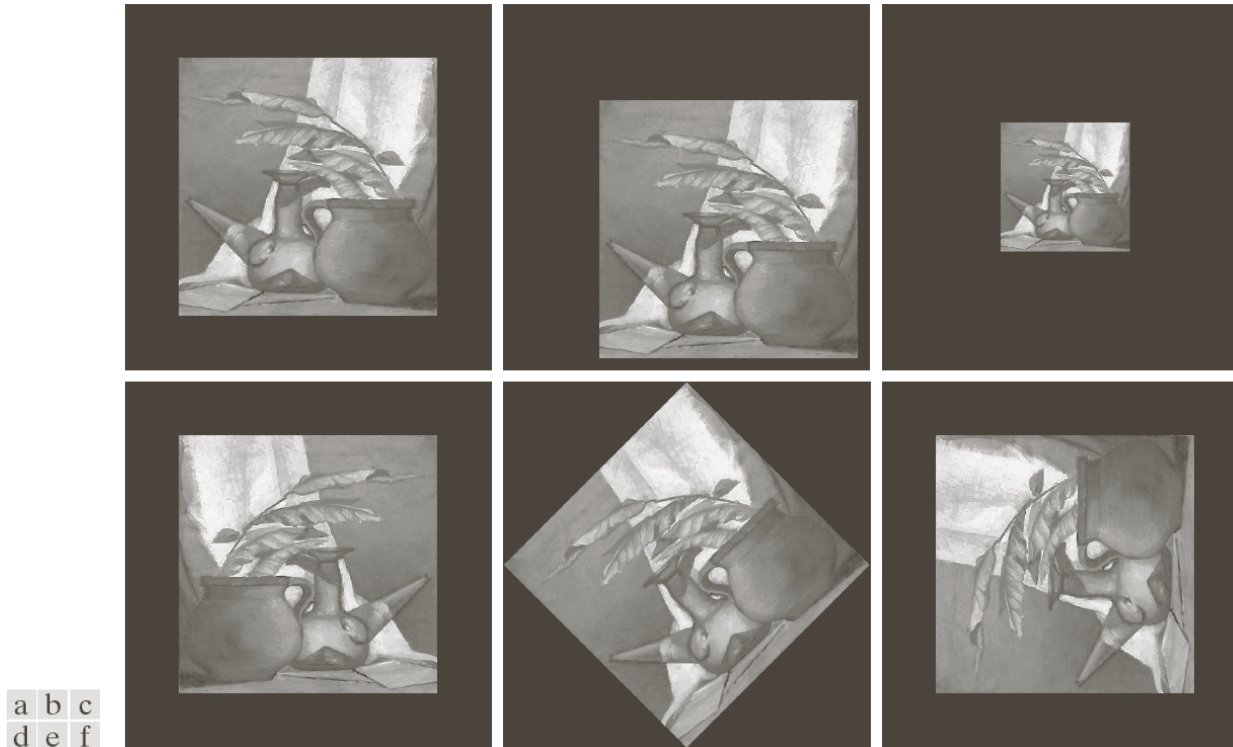


FIGURE 11.37 (a) Original image. (b)–(f) Images translated, scaled by one-half, mirrored, rotated by 45° and rotated by 90° , respectively.

Momentos invariantes

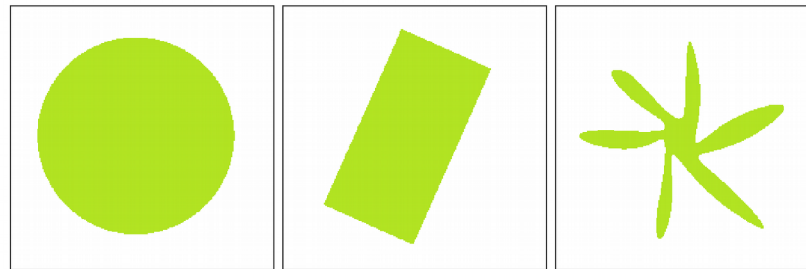
| Moment Invariant | Original Image | Translated | Half Size | Mirrored | Rotated 45° | Rotated 90° |
|------------------|----------------|------------|-----------|----------|-------------|-------------|
| ϕ_1 | 2.8662 | 2.8662 | 2.8664 | 2.8662 | 2.8661 | 2.8662 |
| ϕ_2 | 7.1265 | 7.1265 | 7.1257 | 7.1265 | 7.1266 | 7.1265 |
| ϕ_3 | 10.4109 | 10.4109 | 10.4047 | 10.4109 | 10.4115 | 10.4109 |
| ϕ_4 | 10.3742 | 10.3742 | 10.3719 | 10.3742 | 10.3742 | 10.3742 |
| ϕ_5 | 21.3674 | 21.3674 | 21.3924 | 21.3674 | 21.3663 | 21.3674 |
| ϕ_6 | 13.9417 | 13.9417 | 13.9383 | 13.9417 | 13.9417 | 13.9417 |
| ϕ_7 | -20.7809 | -20.7809 | -20.7724 | 20.7809 | -20.7813 | -20.7809 |

TABLE 11.5
Moment invariants for the images in Fig. 11.37.

Circularidad

- Relación entre el área (A) y el perímetro (P) del objeto (longitud de su contorno) en relación con un círculo:

$$C(R) = 4\pi \frac{A(R)}{P^2(R)}$$



1.001

0.672

0.086

Factores de forma

- Relación entre el área (A) y el perímetro (P) del objeto (longitud de su contorno):

$$D = \frac{A}{P^2}$$

Ejemplo

| Forma | Area | Perímetro | D |
|------------|---------------------|-----------------------------------|------------------------------|
| Círculo | $\pi \frac{d^2}{4}$ | πd | $\frac{1}{4\pi}$ |
| Elipse | πab | $2\pi \sqrt{\frac{a^2 + b^2}{2}}$ | $\frac{ab}{2\pi(a^2 + b^2)}$ |
| Cuadrado | t^2 | $4t$ | $\frac{1}{16}$ |
| Rectángulo | kt^2 | $2(k + 1)t$ | $\frac{k}{4(k + 1)^2}$ |