II. Image Description

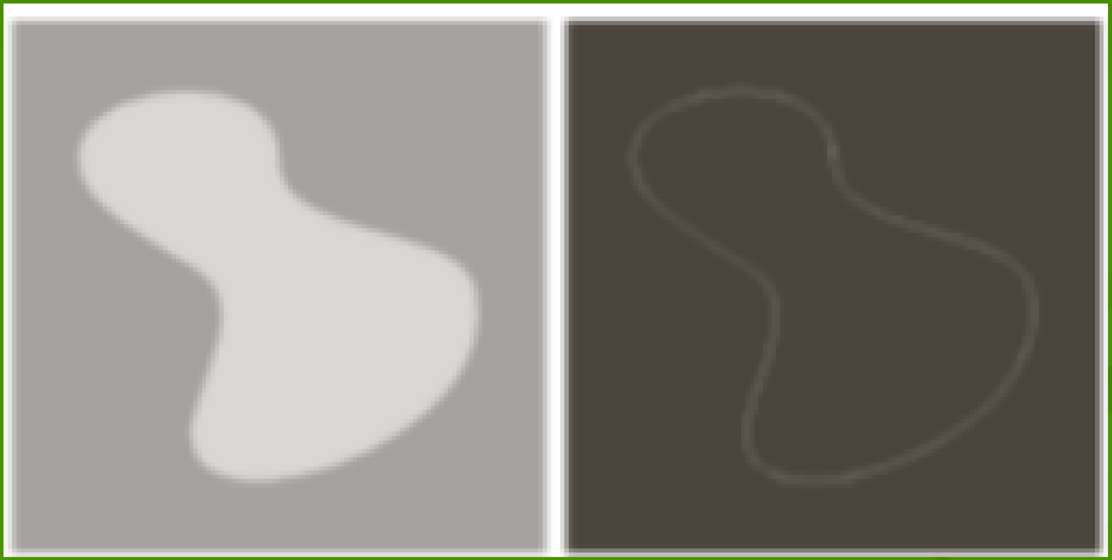
- Types of Image Description

1. Boundary-based description

2. Region-based description

1. Boundary-based Description

1. Length (perimeter)



2. Region-based Description

2. Area

Drawback of the Length & Area

Scale Sensitivity or Scale Dependent

Length1 = 20, Area1 = 300

Length2 = 50, Area2 = 1850

Length3 = 100, Area3 = 7600

3. Compactness

Compactness = Area / (length)2 → dimensionless

Length1 = 20, Area1 = 300
Compactness1 = 0.75

Length2 = 50, Area2 = 1850
Compactness2 = 0.74

Length3 = 100, Area3 = 7600
Compactness3 = 0.76

Topological Descriptors
4. No. of Connected Component (C)

C = 1

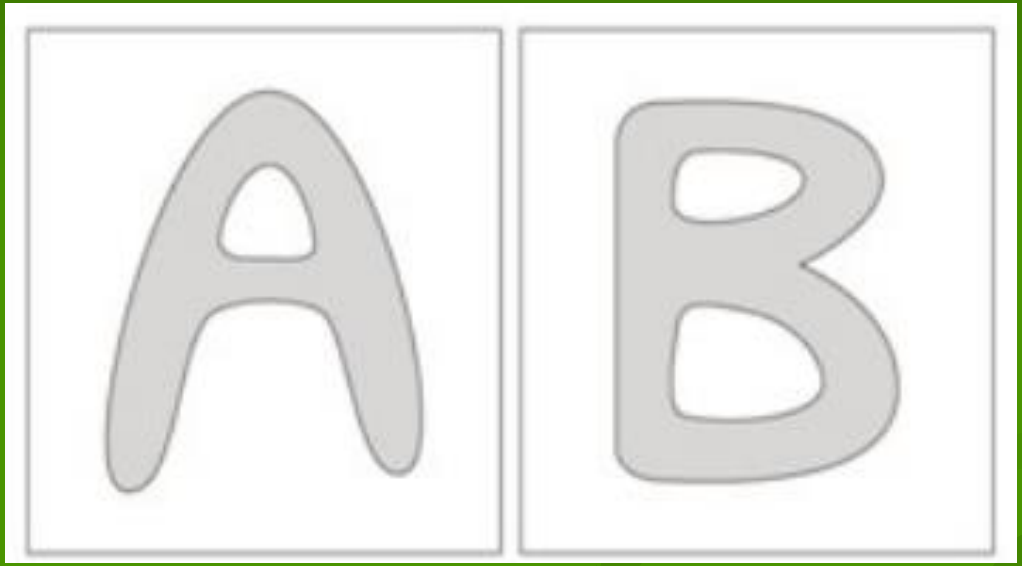
5. No. of Holes (H)

H = 2

6. Euler Number (E)

E = C – H = 1 – 2 = -1

Example



C = 1	C = 1
H = 1	H = 2
E = 0	E = -1

Example

	C	H	E
j	2	0	2
C	1	0	1
ض	2	1	1
ت	3	0	3
ش	4	0	4

7. Moment Invariant

1. Scale Insensitive
2. Rotation Insensitive
3. Translation Insensitive

7. Moment Invariant

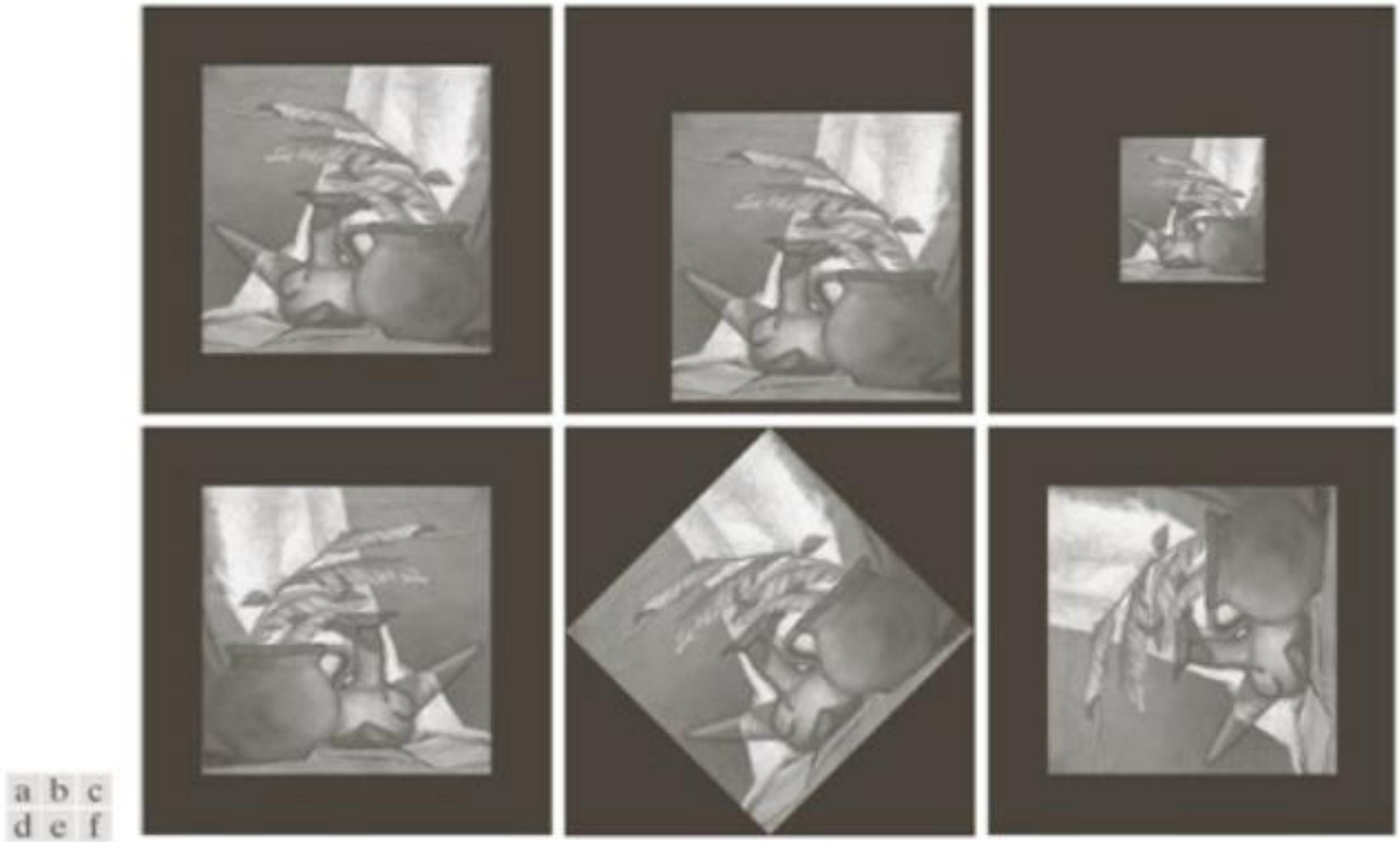


FIGURE 11.37 (a) Original image. (b)–(f) Images translated, scaled by one-half, mirrored, rotated by 45° and rotated by 90°, respectively.

7. Moment Invariant

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

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.

7. Moment Invariant Computations

Two-dimensional (p+q)th order moment are defined as follows:

$$m_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x^p y^q f(x,y)dxdy \qquad (1)$$
$$p,q = 0,1,2,\cdots$$

If the image function f(x,y) is a piecewise continuous bounded function, the moments of all orders exist and the moment sequence $\{m_{pq}\}$ is uniquely determined by f(x,y);

$$\phi_1 = \eta_{20} + \eta_{02}$$
$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$
$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \mu_{03})^2$$
$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \mu_{03})^2$$
$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2]$$
$$+ (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$
$$\phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$
$$+ 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$
$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2]$$
$$- (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[(3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

The seven moment invariants are useful properties of being unchanged under image scaling, translation and rotation.

One should note that the moments in (1) may be not invariant when f(x,y) changes by translating, rotating or scaling. The invariant features can be achieved using central moments, which are defined as follows:

$$\mu_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} (x-\bar{x})^p (y-\bar{y})^q f(x,y)dxdy \qquad (2)$$
$$p,q = 0,1,2,\cdots$$

where

$$\bar{x} = \frac{m_{10}}{m_{00}} \qquad \bar{y} = \frac{m_{01}}{m_{00}}$$

The pixel point ($\bar{x}$, $\bar{y}$) are the centroid of the image f(x,y).

The centroid moments μ_{pq} computed using the centroid of the image f(x,y) is equivalent to the m_{pq} whose center has been shifted to centroid of the image. Therefore, the central moments are invariant to image translations.

Scale invariance can be obtained by normalization. The normalized central moments are defined as follows:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}}, \quad \gamma = (p+q+2)/2, \; p+q = 2,3;\cdots (3)$$