Lecture 6 – Representation & Description (表示与描述)

This lecture will cover:

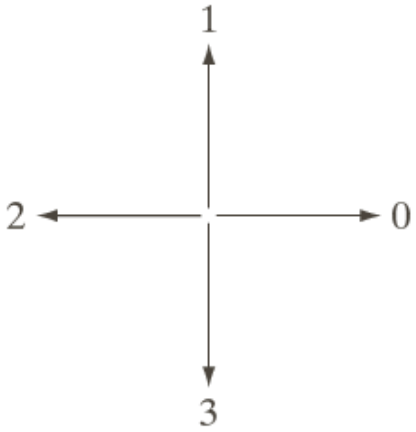
– Representation（表示）
- Chain codes （链码）
- Polygons（多边形）
- Signatures（标记图）
- Boundary segments（边界线段）
- Skeletons（骨架）

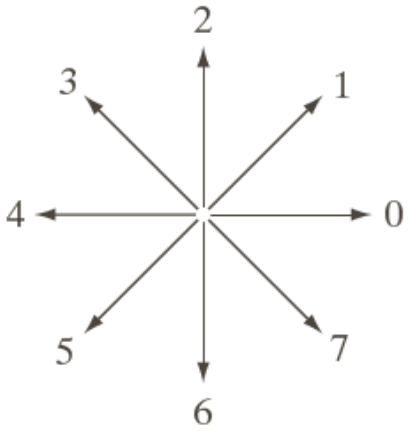
– Boundary Descriptors（边界描绘子）
- Simple Descriptors（简单描绘子）
- Shape Numbers（形状数）
- Fourier Descriptors（傅里叶描绘子）
- Statistical Moments（统计矩）

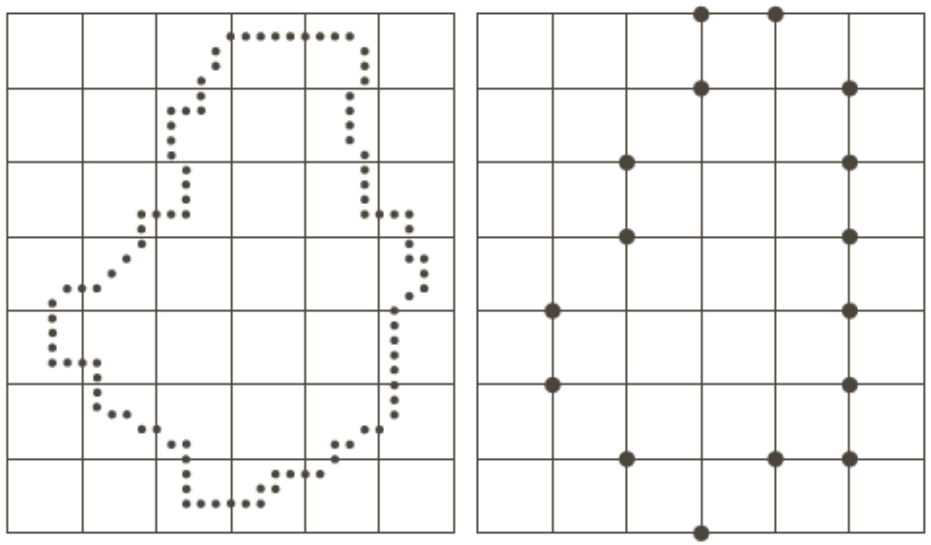
– Regional Descriptors（区域描绘子）
- Simple Descriptors（简单描绘子）
- Topological Descriptors（拓扑描绘子）
- Moment Invariants（不变矩）

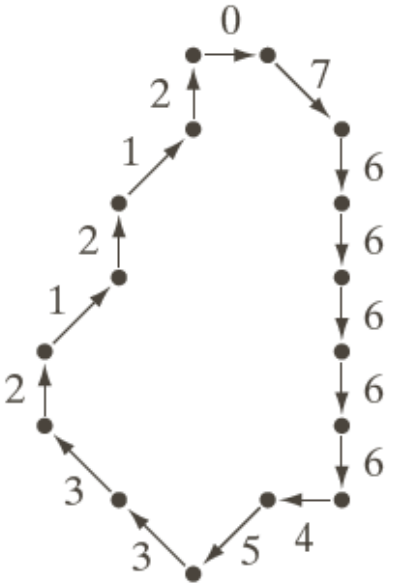
Chain codes （链码）

- **Freeman Chain code**



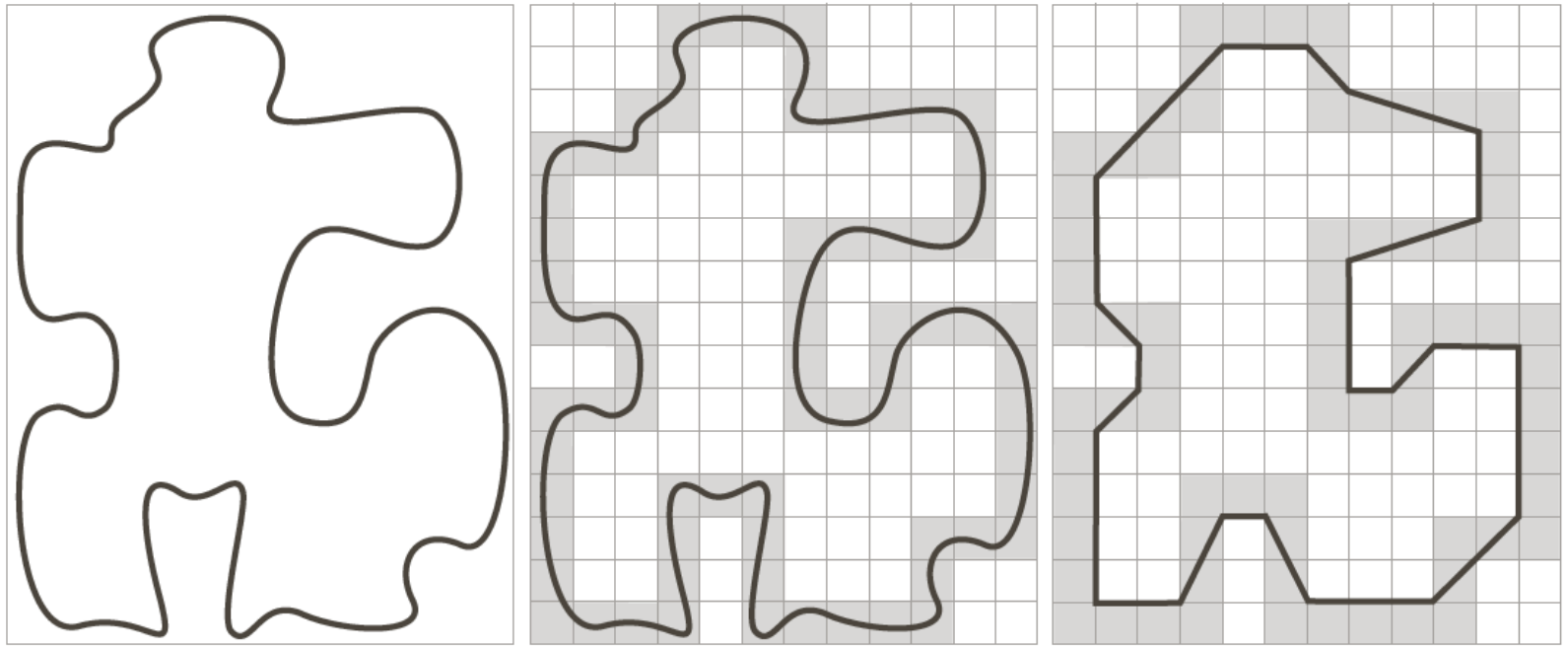






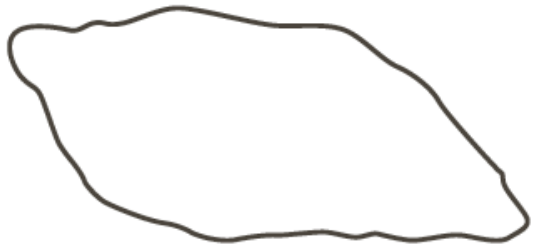
Polygons（多边形）

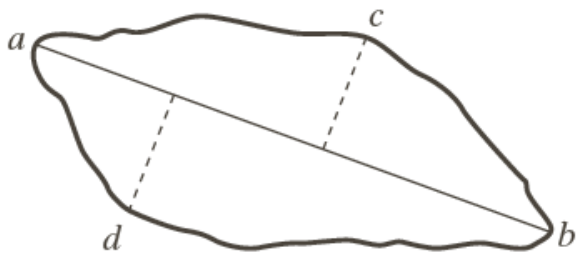
- **Minimum-perimeter polygon (MPP，最小周长多边形)**

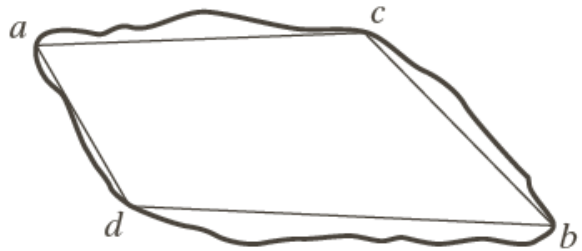


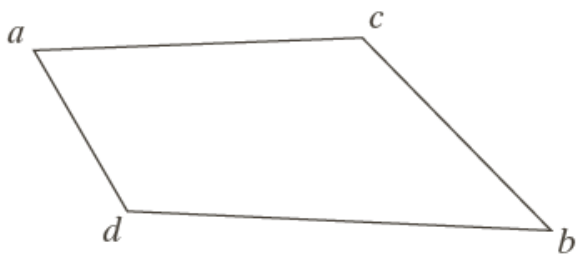
Other Polygonal Approximation

- **Merging Techniques（聚合技术）**
- **Splitting Techniques（分裂技术）**

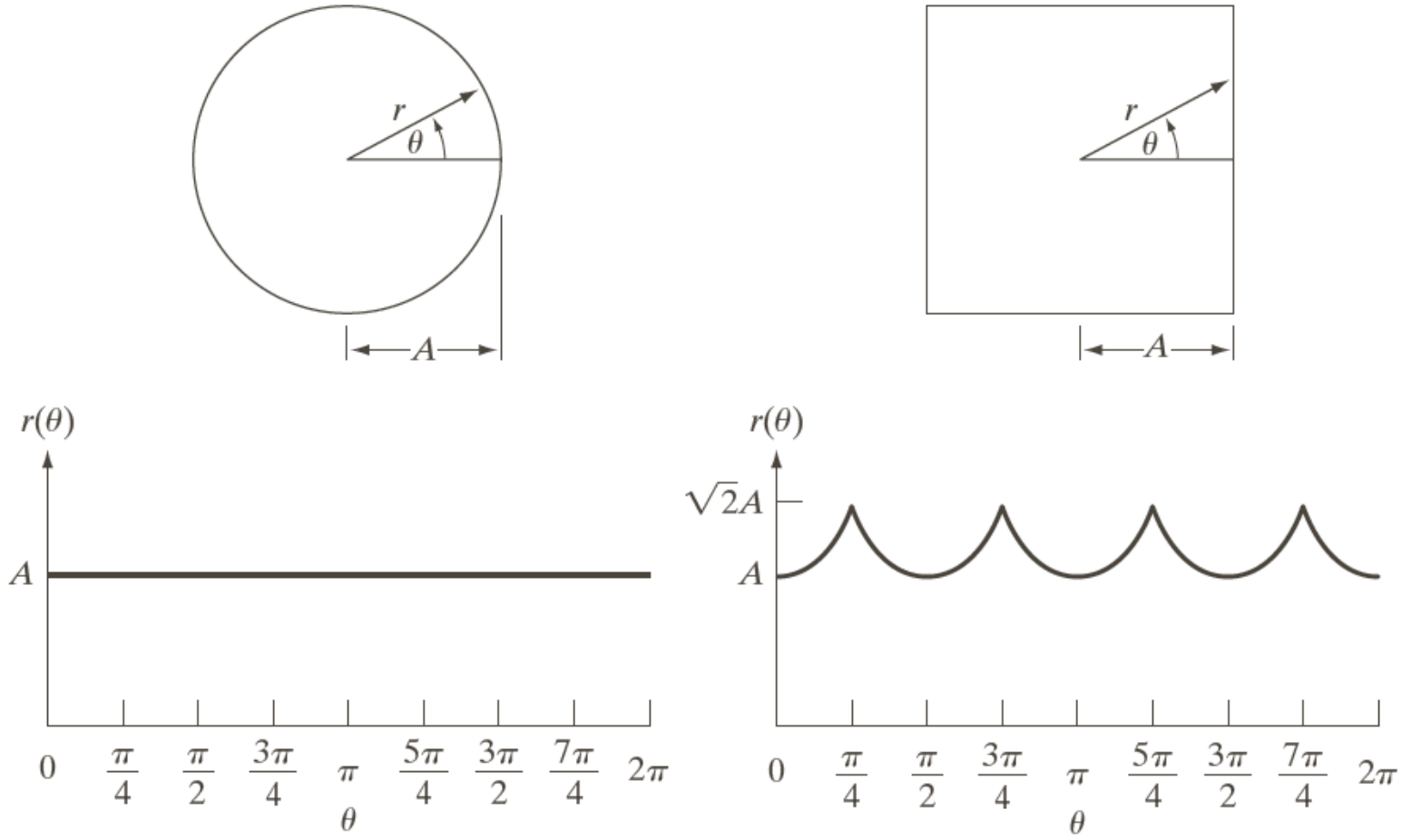




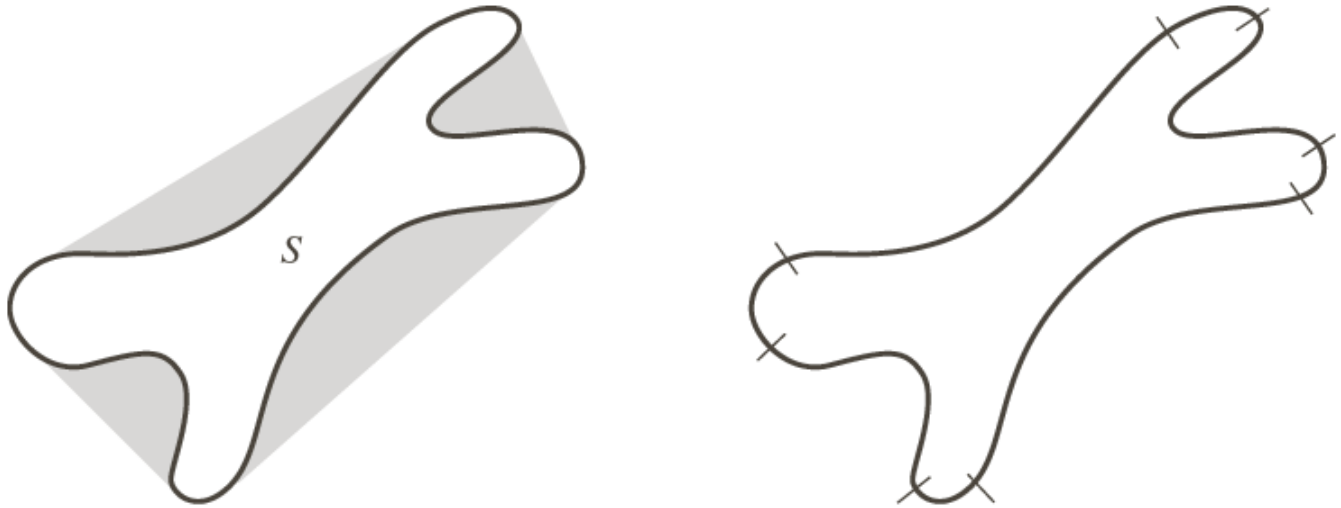




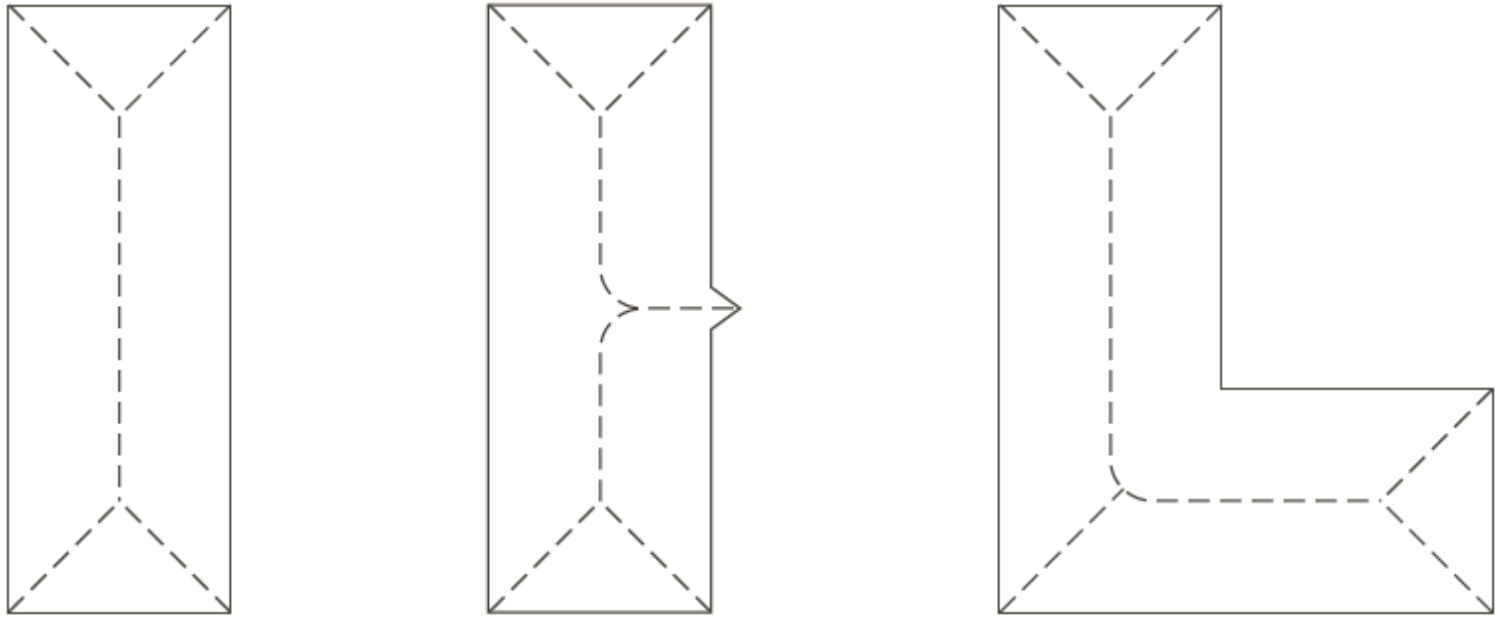
Signatures（标记图）



Boundary segments（边界线段）

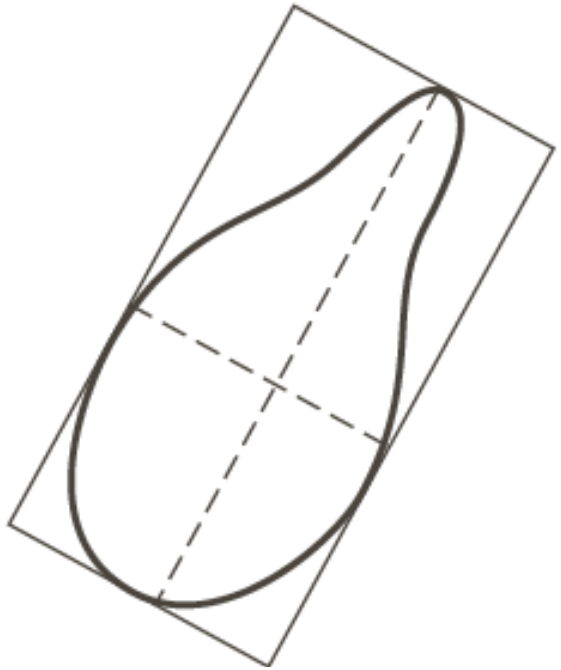


Skeletons（骨架）

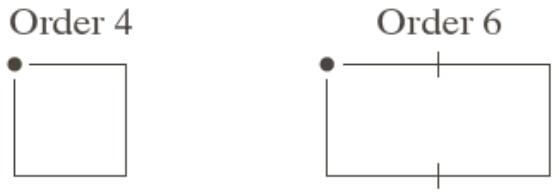


Simple Boundary Descriptors（简单边界描绘子）

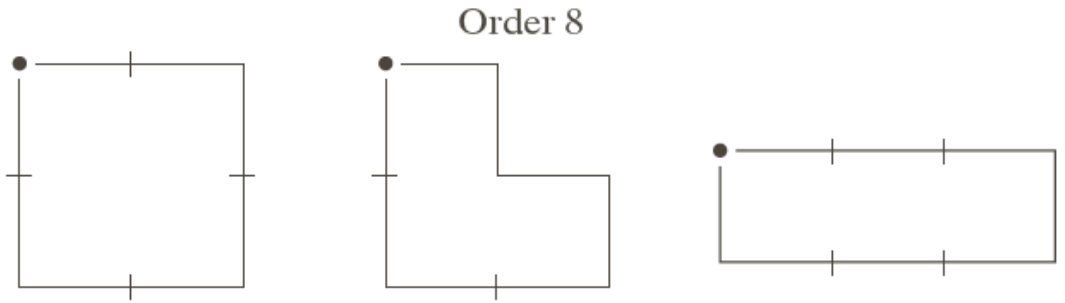
- Length（长度）
- Diameter（直径）: $\mathrm{Diam}(B) = \max_{i,j}[D(p_i, p_j)]$
- Major Axis（长轴）
- Minor Axis（短轴）
- Basic rectangle（基本矩形）
- Eccentricity（偏心率）
- Curvature（曲率）



Shape Numbers（形状数）



Chain code:	0 3 2 1	0 0 3 2 2 1
Difference:	3 3 3 3	3 0 3 3 0 3
Shape no.:	3 3 3 3	0 3 3 0 3 3



Chain code:	0 0 3 3 2 2 1 1	0 3 0 3 2 2 1 1	0 0 0 3 2 2 2 1
Difference:	3 0 3 0 3 0 3 0	3 3 1 3 3 0 3 0	3 0 0 3 3 0 0 3
Shape no.:	0 3 0 3 0 3 0 3	0 3 0 3 3 1 3 3	0 0 3 3 0 0 3 3

Fourier Descriptors（傅里叶描绘子）

- **The sequence of coordinates**

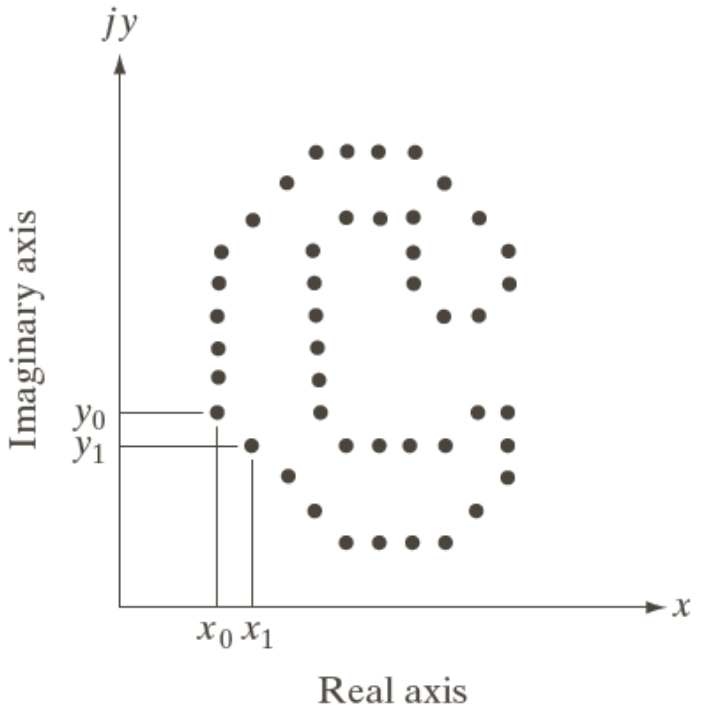
$$s(k) = x(k) + jy(k)$$

- **The Fourier Descriptor**

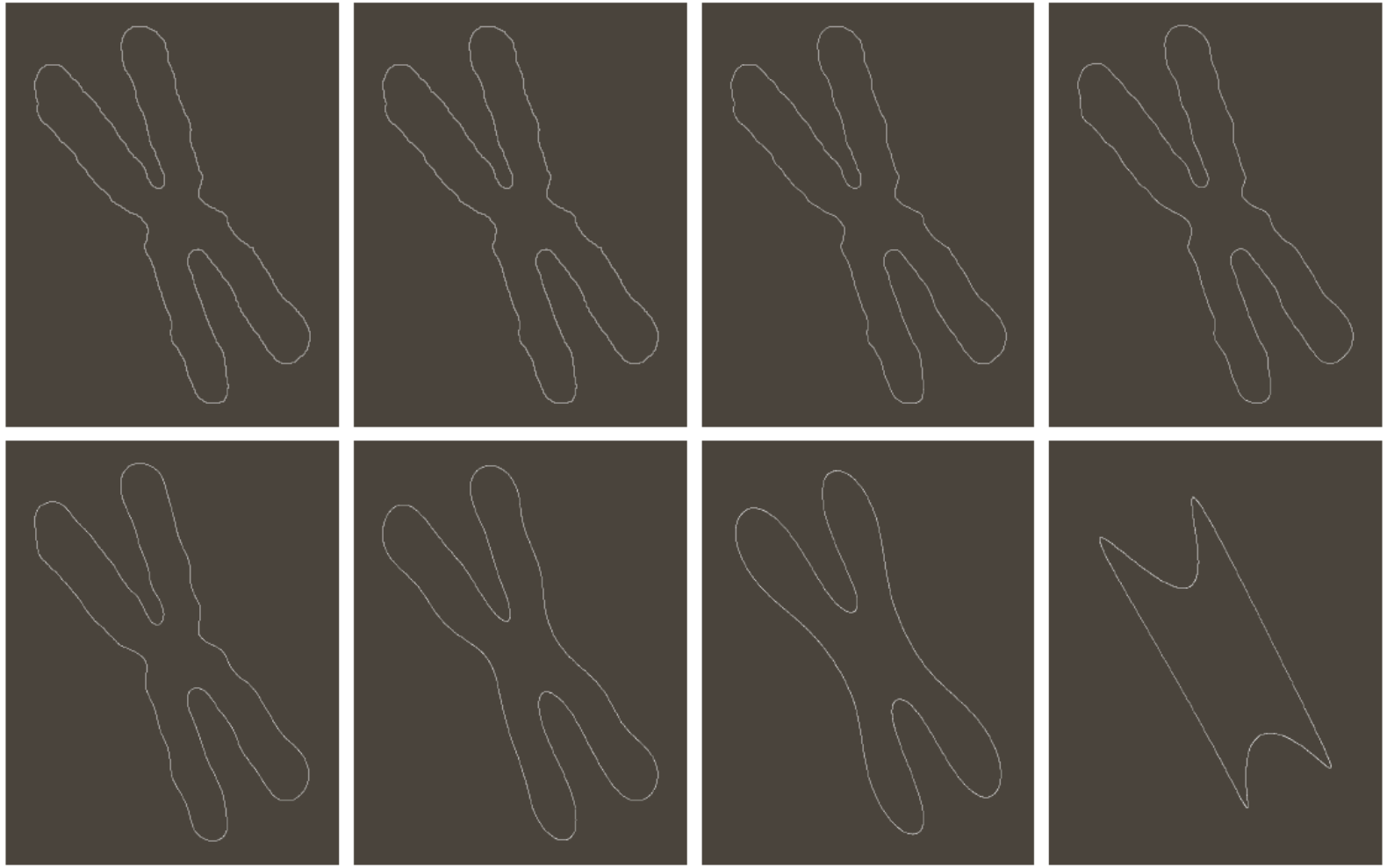
$$a(u) = \sum_{k=0}^{K-1} s(k) e^{-j2\pi uk/K}$$

- **The IDFT**

$$s(k) = \frac{1}{K} \sum_{u=0}^{K-1} a(u) e^{j2\pi uk/K}$$



Fourier Descriptors（傅里叶描绘子）

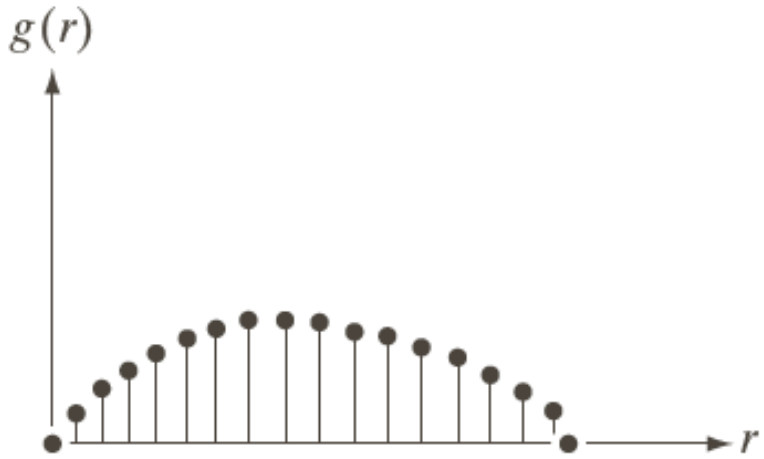


Some Basic Properties

Transformation	Boundary	Fourier Descriptor
Identity	$s(k)$	$a(u)$
Rotation	$s_r(k) = s(k)e^{j\theta}$	$a_r(u) = a(u)e^{j\theta}$
Translation	$s_t(k) = s(k) + \Delta_{xy}$	$a_t(u) = a(u) + \Delta_{xy}\delta(u)$
Scaling	$s_s(k) = \alpha s(k)$	$a_s(u) = \alpha a(u)$
Starting point	$s_p(k) = s(k - k_0)$	$a_p(u) = a(u)e^{-j2\pi k_0 u/K}$

Statistical Moments（统计矩）

- Mean: $m = \sum_{i=0}^{K-1} r_i g(r_i)$
- The nth moment of r about its mean: $\mu_n(r) = \sum_{i=0}^{K-1} (r_i - m)^n g(r_i)$

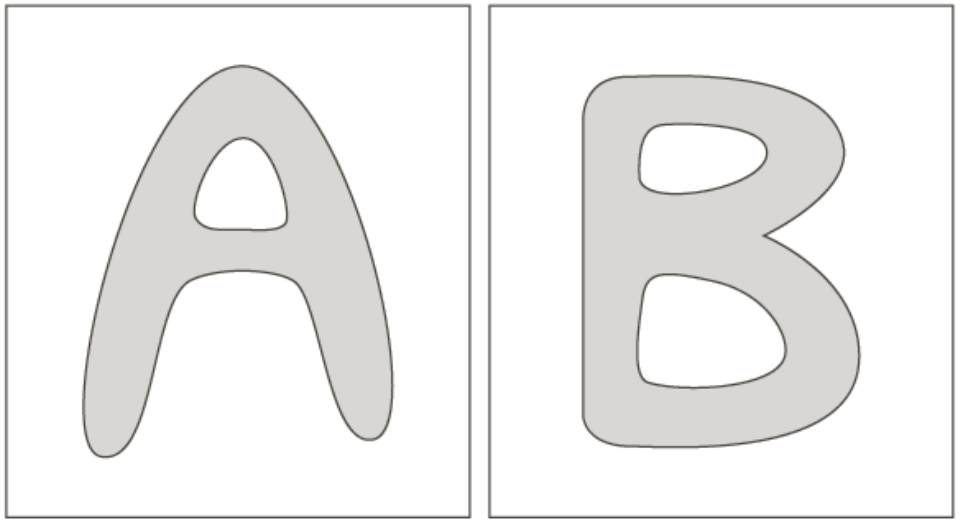


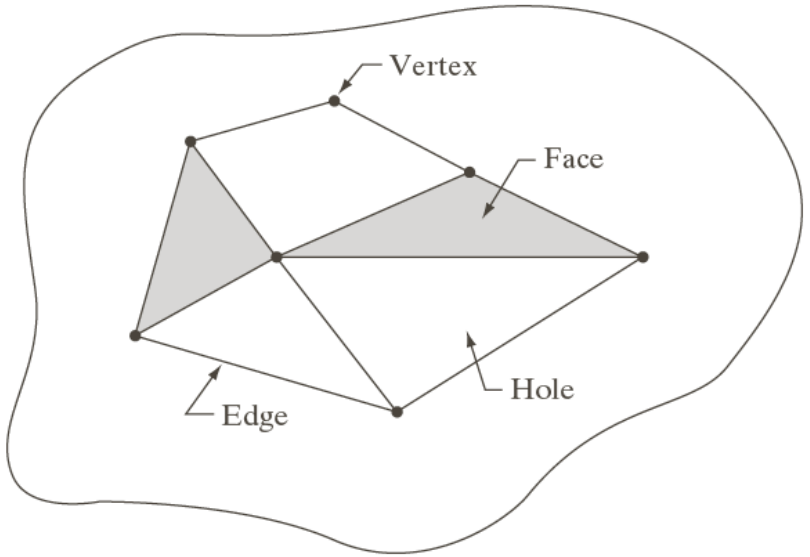
Simple Regional Descriptors（简单区域描绘子）

- Area（面积）
- Perimeter（周长）
- Compactness（致密性）: P^2/A
- Circularity ratio（圆度率）: $R_c = 4\pi A/P^2$
- Intensity related descriptors:
  - ✓ Mean and Median
  - ✓ Minimum and Maximum
  - ✓ The number of pixels with values above and below the mean

Topological Descriptors（拓扑描绘子）

- Euler Number (欧拉数): $E = C - H$
- Euler Formula (欧拉公式): $E = C - H = V - Q + F$





Moment Invariants（不变矩）

- Central moment of order $(p+q)$:

$$\mu_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (x - \bar{x})^p (y - \bar{y})^q f(x, y)$$

- The normalized central moment :

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

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

Moment Invariants（不变矩）

$$\Phi_1 = \eta_{02} + \eta_{20}$$

$$\Phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$

$$\Phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$

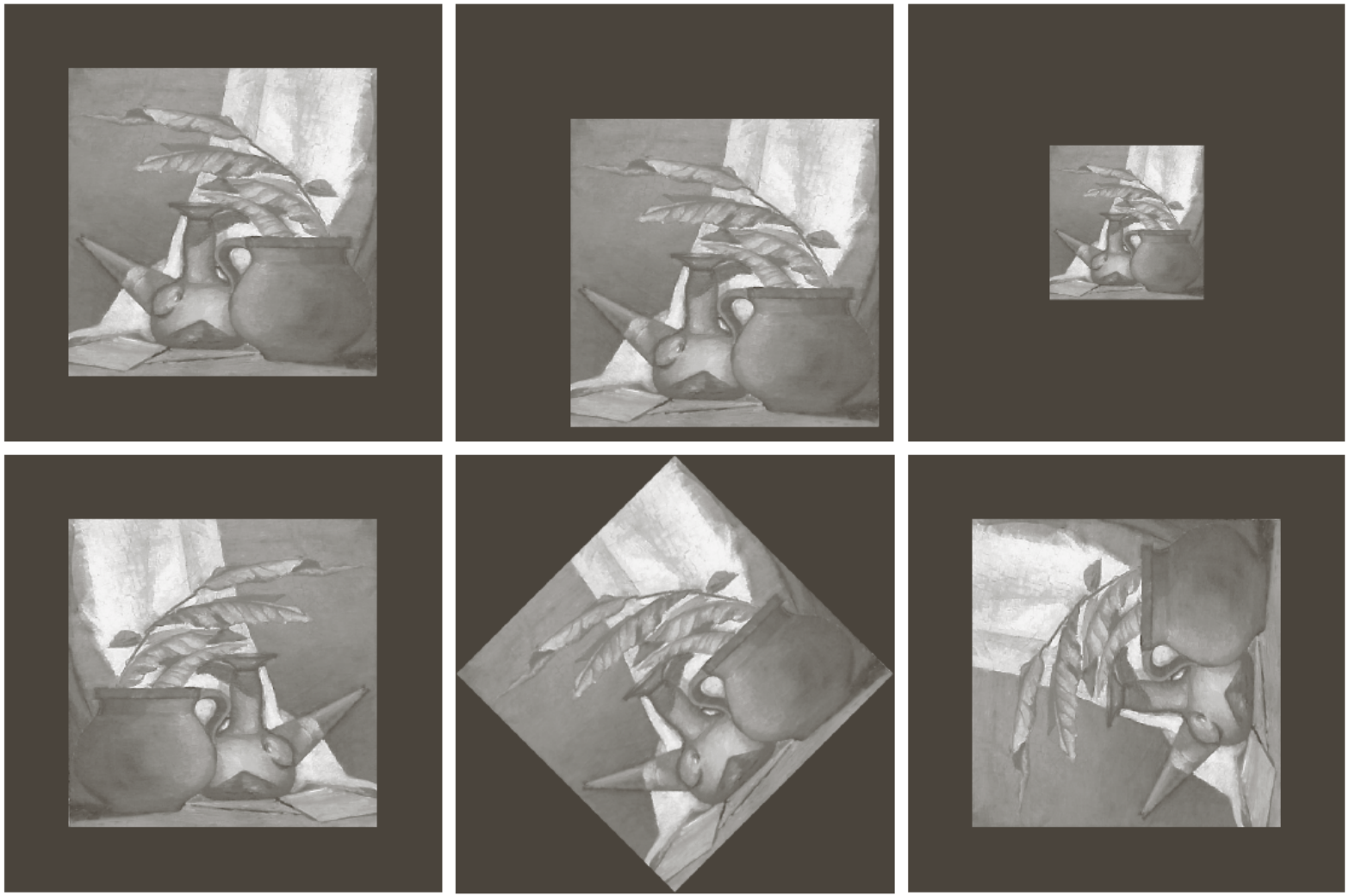
$$\Phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$

$$\Phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

$$\Phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})\,(\eta_{21} + \eta_{03})$$

$$\Phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{12} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

Moment Invariants（不变矩）



Moment Invariants（不变矩）

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