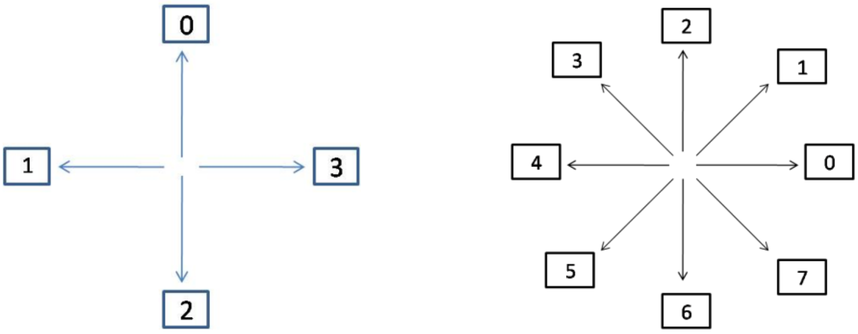
Image Representation

Representation

The segmentation techniques usually consider the pixel along a boundary and pixel contained in the region. And an approach to obtain the descriptor that is compact the data into representation. There are several approaches above.

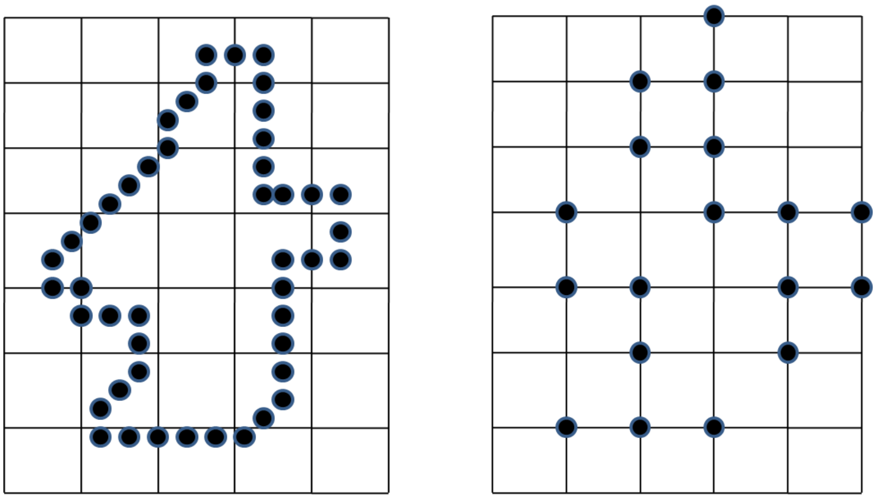
5.1 Chain Code

The chain code is used to represent a boundary by the length and the direction of straight-line segments. Typically, this representation is based on 4- or 8- connectivity of the segments.

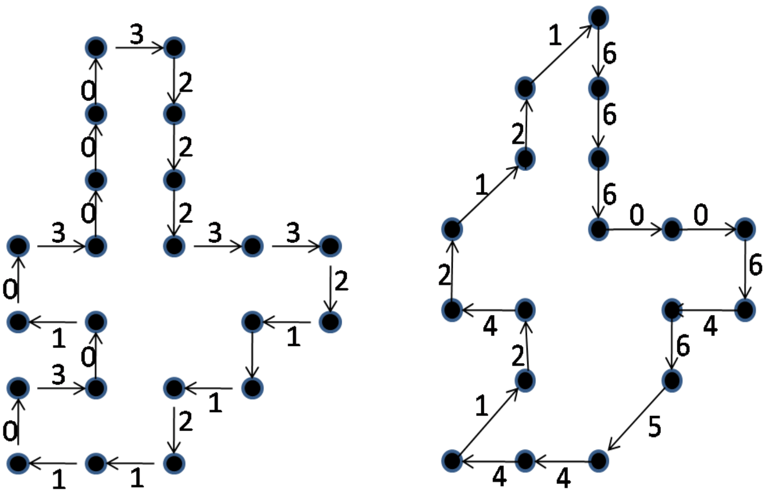


(a) (b)

Fig.5.1.1 (a) 4-directional chain code (b) 8-directional chain code.



(a) (b)



(c) (d)

Fig.5.1.2 (a) Digital boundary with resampling grid srperimposed. (b) Result of resample. (c) 4-directional chain code. (d) 8-directional chain code

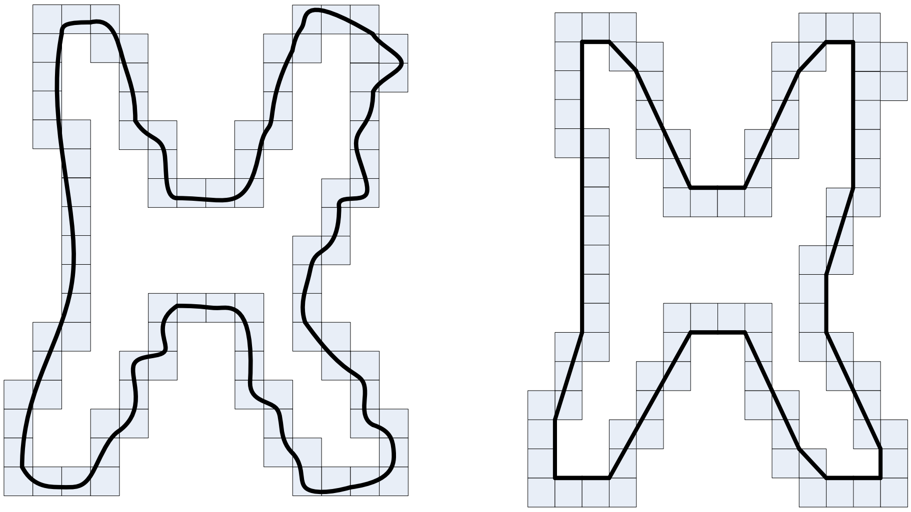
Digital images are uaually processed in a grid format, but it may not match shape of the boundary if the chain of codes is quite long or the boundary is distributed by the noise. An approach frequently used to circumvent the problems just discussed is to resample the boundary by selecting a larger grid spacing. It can be seen that the accuracy and samples is related to grid spacing.

5.2 Polygonal Approximations

The goal of polygonal approximation is to capture the essence of the boundary shape with the fewest possible polygonal segments. Several polygonal approximation techniques of middle complexity and processing requirements are suitable for image processing applications.

5.2.1 Minimum Perimeter Polygons

We visualize this enclosure as two walls corresponding to the outside and inside boundaries of the strip of cells, and think of the object boundary as a rubber band contained within the wall. If the rubber band is allowed to shrink, it takes the shape shown in Fig.5.2.1



(a) (b)

Fig.5.2.1 (a) Object boundary enclosed by cells, and (b) Minimum perimeter polygon.

5.2.2 Merging Techniques

Merging techniques based on average error or other criteria have been applied to the problem of polygonal approximation. The approach is to merge points along a boundary until the least square error line fit of the points merged so far exceeds a preset threshold.

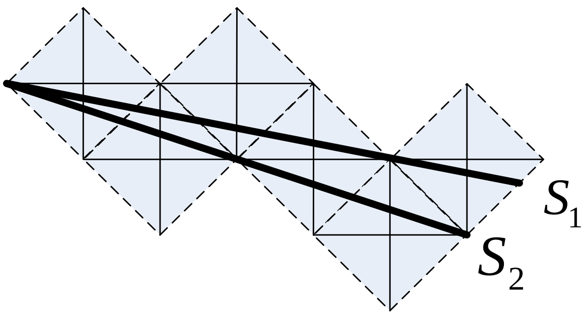


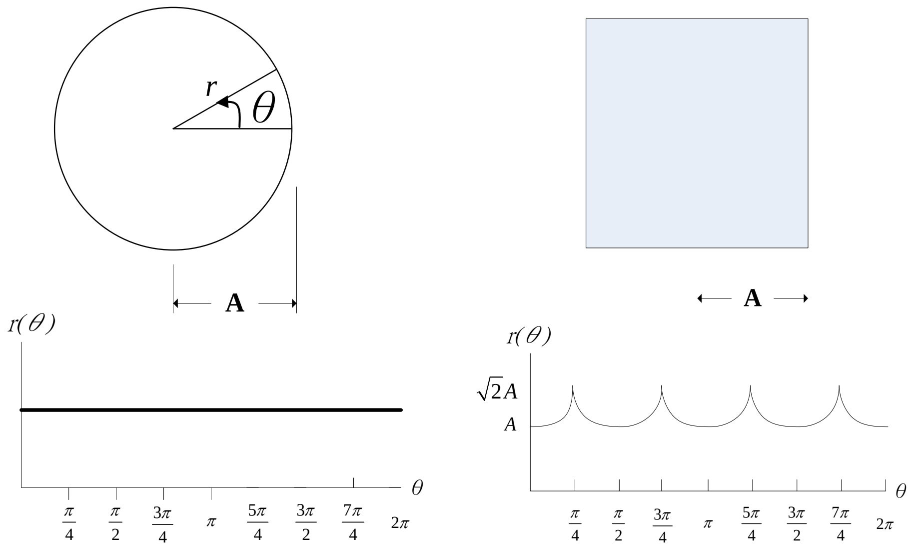
Fig.5.2.2 Merge approach of a set of digital boundary

5.2.3 Splitting Techniques

An approach of the splitting techniques is subdivided a segment successively into two part until a criterion is satisfied. For instance, a requirement might be that the maximum perpendicular distance from a boundary segment to the line joining its two end point not exceed a preset threshold.

5.3 Signature

Signature is a approach that translate 2-D function to 1-D function. One of the simplest is to plot the distance from the center to the boundary as a function of angle, as illustrated in Fig.6.3.



(a) (b)

Fig.5.3 (a), (b): Distance signature of circle and rectangular shapes.

5.4 Boundary Segments

Decomposing a boundary into segments often is useful. Decomposition reduces the boundary's complexity. This approach is useful when the boundary contains one or more concavities. In this case use of the convex hull of the region enclosed by the boundary is a powerful tool for robust decomposition of the boundary.

5.5 Skeletons

Skeletons mean thinning. The skeleton of a region may be defined via the MAT (medial axis transformation) proposed by Blum [1967]. According to the definition, the step 1 flags a contour point p_1 for deletion if the following conditions are satisfied: (a) $2 \le N(p_1) \le 6$

(b) $T(p_1) = 1$

(c) $p_2 \cdot p_4 \cdot p_6 = 0$

(d) $p_4 \cdot p_6 \cdot p_8 = 0$ (5.5-1)

Where $N(p_1)$ is the number of nonzero neighbors of p_1: that is,

$$N(p_1) = p_2 + p_3 + \dots\dots + p_8 + p_9 \qquad (5.5\text{-}2)$$

p_9	p_2	p_3
p_8	p_1	p_4
p_7	p_6	p_5

Fig.6.5 Neighborhood arrangement used by the thinning algorithm

In section 2, conditions (a) and (b) remain the same, but conditions (c) and (d) are changed to

$$(c')\ \ p_2 \square p_4 \square p_8 = 0$$

$$(d')\ \ p_2 \square\ p_6 \square\ p = 0 \qquad (5.5\text{-}3)$$

The iteration of the thinning algorithm consists of (1) applying step 1 to flag border points for deletion; (2) deleting the flagged points; (3) applying step 2 to flag the remaining border points for deletion; and (4) deleting the flagged points.

6. Descriptor

In this section, we discuss boundary descriptors and regional descriptors.

6.1 Boundary Descriptors

There are several approaches to describe the boundary of a region. We illustrate as follows.

6.1.1 Some Simple Descriptors

There are several simple descrioptors. Just like basic rectangular, eccentricity, curvature and so on. Basic rectangular is the rectangular that generate by major axis and minor axis. Eccentricity is the ratio of major axis and minor axis. Curvature is defined as the rate of the boundary that use convex and concave to describe the boundary.

6.1.2 Shape Numbers

The first difference of a chain-coded boundary depends on the starting point. The shape number of such a boundary, based on the 4-directional code is defined as the first difference of smallest magnitude. For a desired shape order, we find the rectangle of order n whose eccentricity best approximates that of the basic rectangle and use this new rectangle to establish the grid size.

6.1.3 Fourier Descriptors

The Fourier descriptors are starting at an arbitrary point (x, y). Each coordinate pair can be treated as a complex number so that

$$s(k) = x(k) + jy(k) \tag{6.1.3-1}$$

This representation has one great advantage that it reduces a 2-D to a 1-D problem. The discrete Fourier transform (DFT) of $s(k)$ is

$$a(u) = \frac{1}{K}\sum_{k=0}^{K-1} s(k)e^{-j2\pi uk/K} \tag{6.1.3-2}$$

for $u = 0,1,2,......,K-1$ .The complex coefficients $a(u)$ are called the Fourier descriptors of the boundary. The inverse Fourier transform of these coefficients restore $s(k)$. That is,

$$s(k) = \sum_{u=0}^{K-1} a(u)e^{j2\pi uk/K} \tag{6.1.3-3}$$

for $k = 0,1,2,....,K-1$. Suppose, however, that instead of all the Fourier coefficients, only the first P coefficient is used. This is equivalent to setting $a(u) = 0$ for $u > P-1$. The result is the following approximation to $s(k)$:

$$\hat{s}(k) = \sum_{u=0}^{P-1} a(u)e^{j2\pi uk/K} \tag{6.1.3-4}$$

The smaller P becomes, the more detail that is lost on the boundary. And the bigger P becomes, it more similar to boundary.

6.1.4 Statistical Moments

The shape of boundary segments can be described quantitatively by using simple statistical moments, such as the mean, variance, and higher-order moments. Let us treat the amplitude of g as a discrete random variable v and form an amplitude histogram $p(v_i)$, $i = 0,1,2,....A-1$, where A is the number of discrete amplitude increments in which we divide the amplitude scale, and p() is the probability of value vi. The equation of nth moment about its mean is

$$u_n(v) = \sum_{i=0}^{A-1} (v_i - m)^n p(v_i) \tag{6.1.4-1}$$

where

$$m = \sum_{i=0}^{A-1} v_i \, p(v_i) \tag{6.1.4-2}$$

An alternative approach is to normalize g(r) to unit area and treat it as a histogram. In other words, $g(r_i)$ is now treated as the probability of value r_i occurring. In this case, r is treated as the random variable and the moments are

$$u_n(r) = \sum_{i=0}^{K-1} (r_i - m)^n \, g(r_i) \tag{6.1.4-3}$$

where

$$m = \sum_{i=0}^{K-1} r_i \, g(r_i) \tag{6.1.4-4}$$

In this notation, K is the number of points on the boundary, and $u_n(r)$ is directly related to the shape of $g(r)$. Basically, what we have accomplished is to reduce the description task to that of describing 1-D functions. The advantage of moments over other techniques is that implementation of moments is carry a physical explain of boundary shape and this approach is insensitive to rotation.