

Feature description

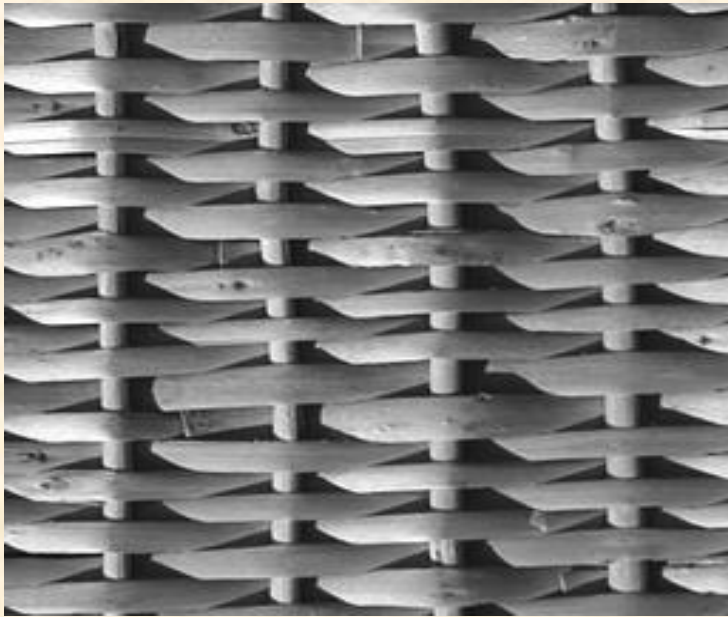
After an image has been segmented the detected region needs to be described (represented) in a form more suitable for further processing.

Representation of an image region can be carried out in two ways:

- by characterising features of its boundary, i.e. edge of a region,
- by characterising features of its interior, i.e. set of pixels constituting the region

Feature description

Region-based description



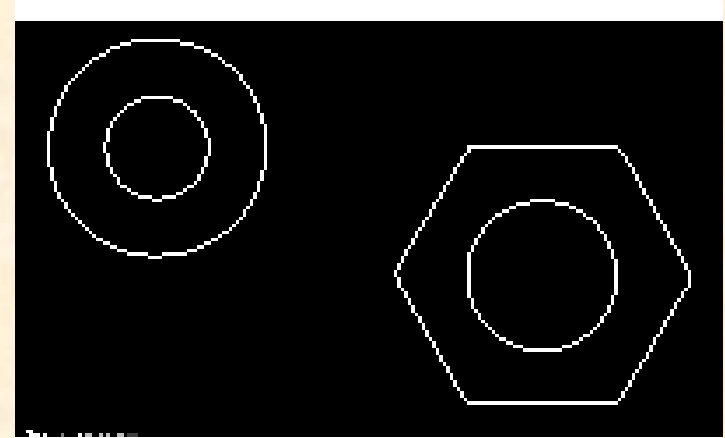
Boundary-based description



Boundary (edge) representation

Boundaries are linked edges that characterise shape of an object. They are required in computation of geometry features such as size and orientation.

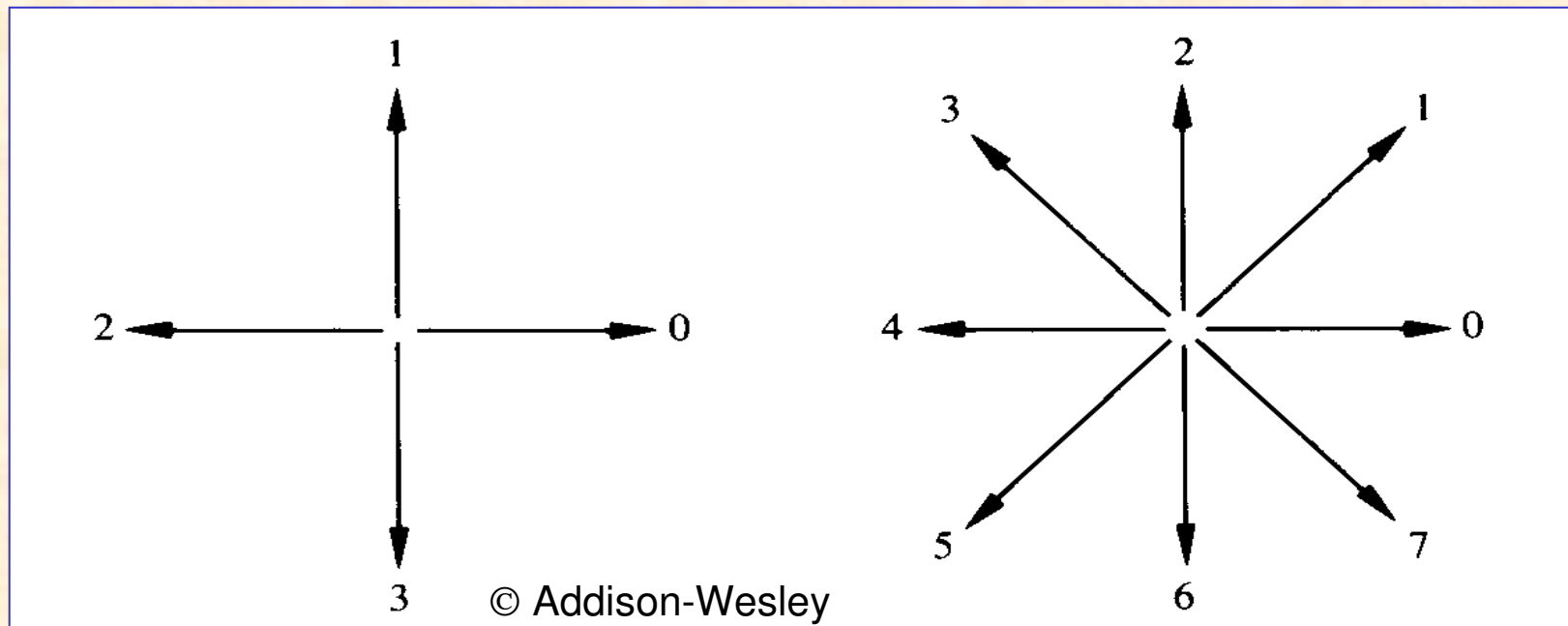
Edge representation methods aim at describing information about their shape in a way that is more suitable for coding and analysis (e.g., by means of transforming information from 2-D data to 1-D data).



Chain codes (Freeman codes)

Chain codes are used to represent a boundary by a connected sequences of straight-line segments of specified length and direction.

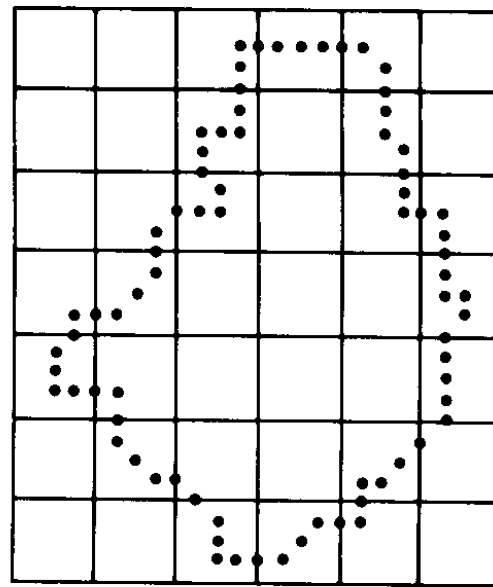
Typically, Freeman codes are based on the **four-** or **eight-connectivity** neighbourhoods.



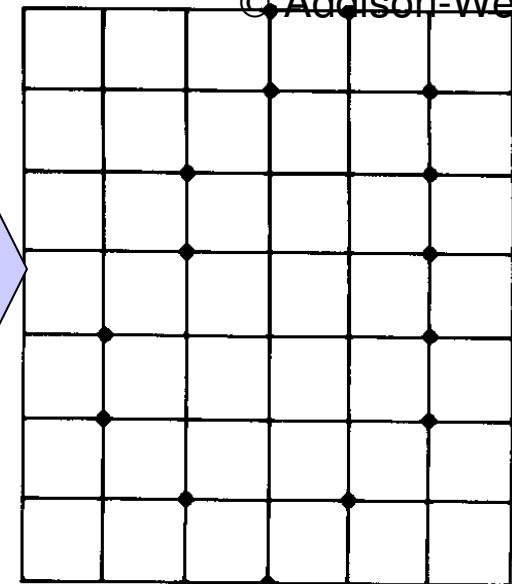
Chain codes

Small disturbances along the boundary due to noise can cause false contour values.

It can be eliminated by selecting larger grid spacing.

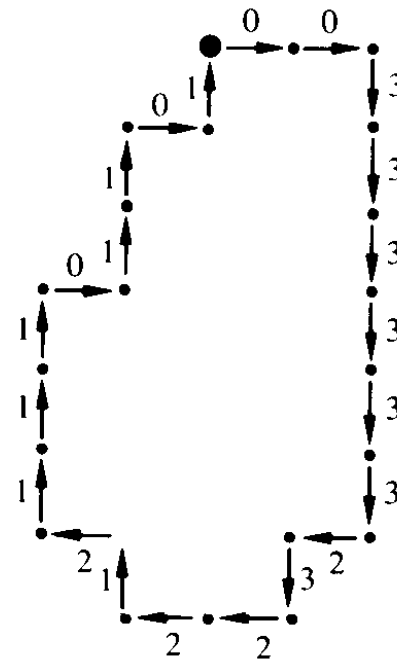


(a)

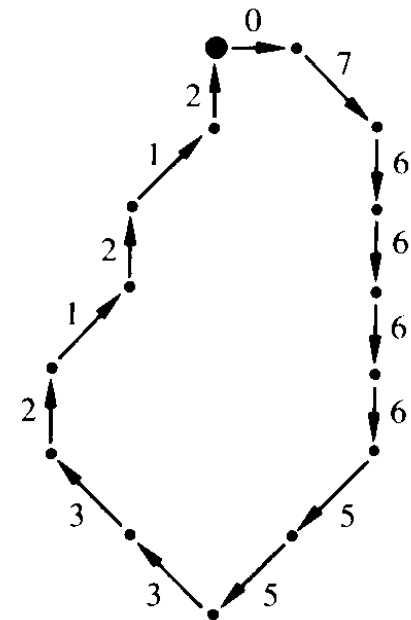


(b)

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(c)

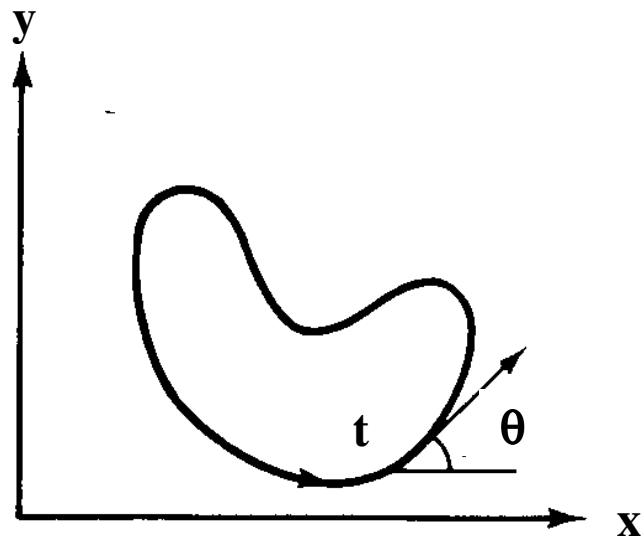


(d)

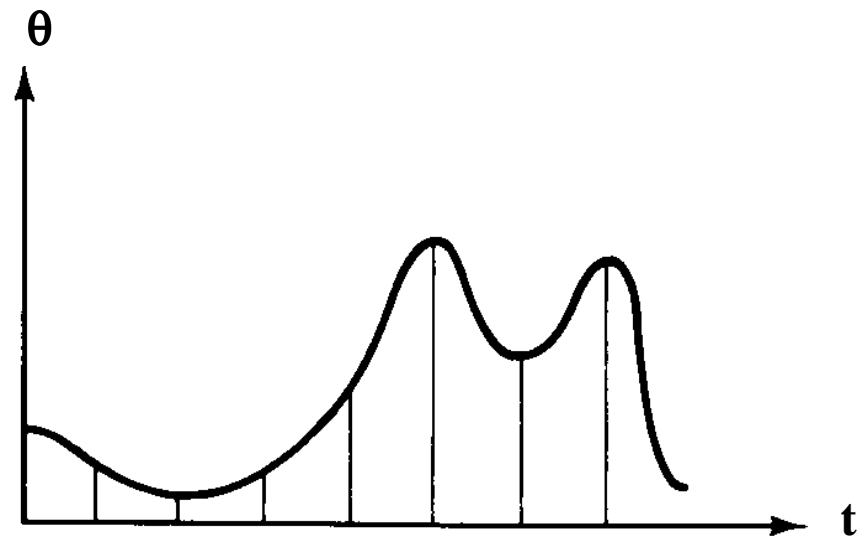
Chain codes (Freeman codes)

Chain codes can be generalised by increasing the number of allowed directions for connecting successive boundary pixels.

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parametric representation of a contour



$\theta(t)$ - angle θ vs. parameter t

Signatures

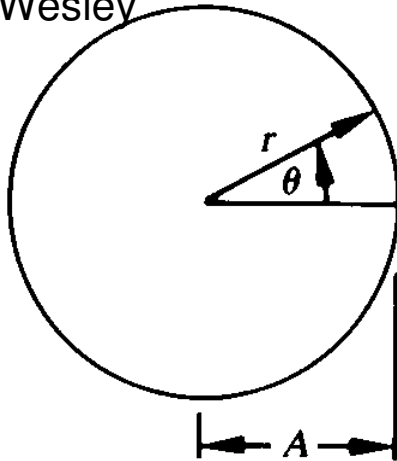
A **signature** is a 1-D functional representation of a boundary. The simplest representation is to plot the distance from the centroid to the boundary as a function of angle.

Making signatures invariant:

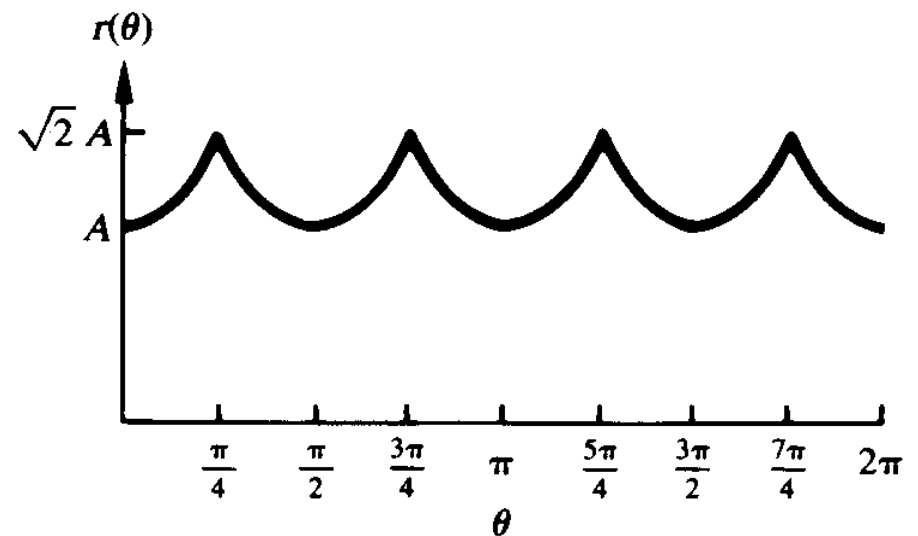
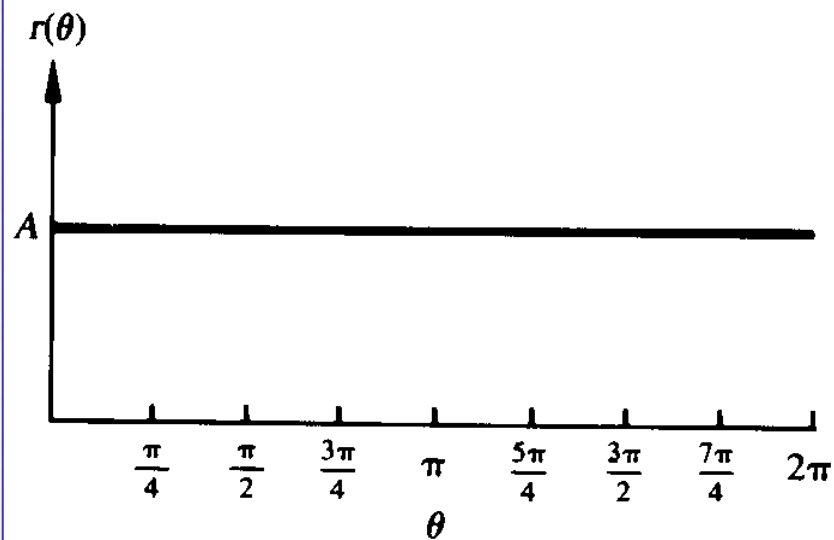
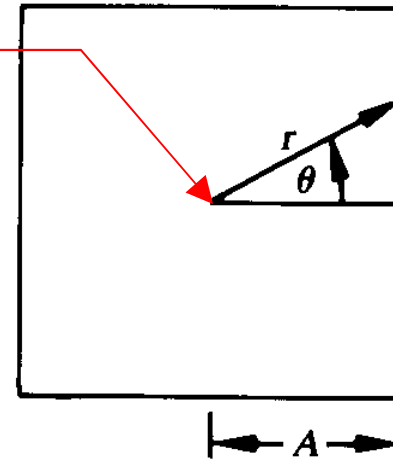
- dependence on rotation can be rejected by choosing the starting point as the point farthest from the centroid;
- normalisation for scaling can be implemented by removing the mean value of the signature function.

Geometrical figures and their signatures

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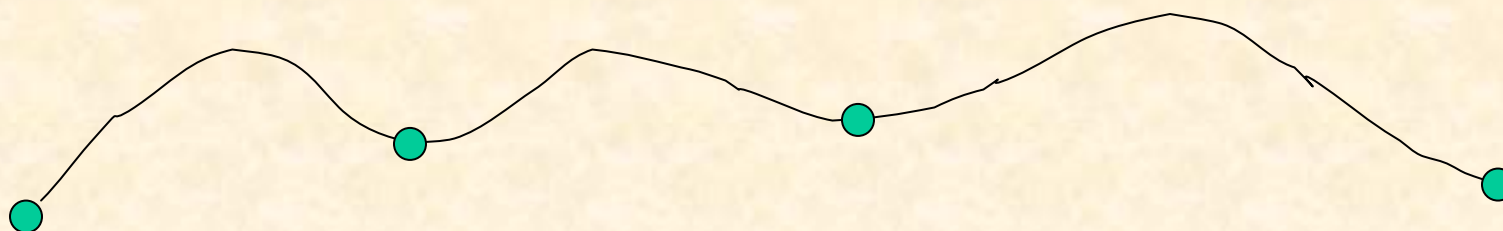


centroid



B-spline Representation

B-splines are piecewise polynomial functions that can provide local approximations of contour shapes using a small number of parameters. B-splines are used in shape synthesis and analysis, computer graphics, and recognition of shapes from boundaries.



B-spline Representation

A general expression for a B-spline function is:

a)
$$p(x) = p_i(x) \quad x_i \leq x \leq x_{i+1} \quad i = 0, 1, \dots, k-1$$

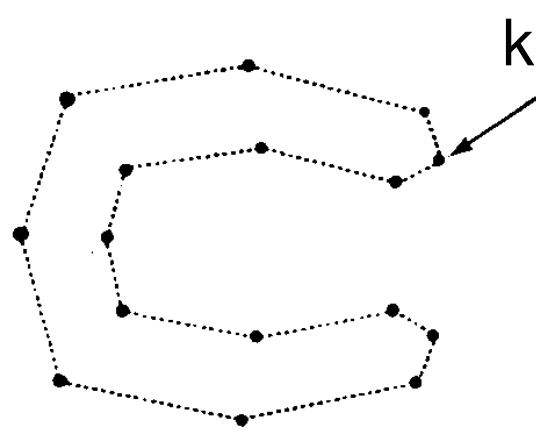
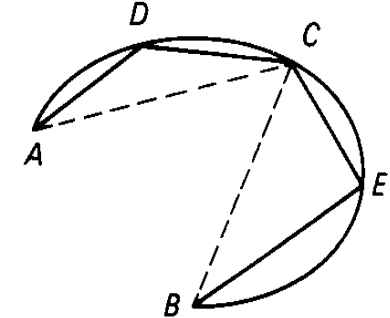
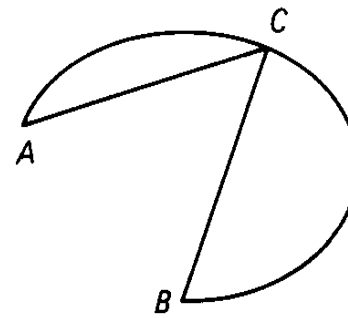
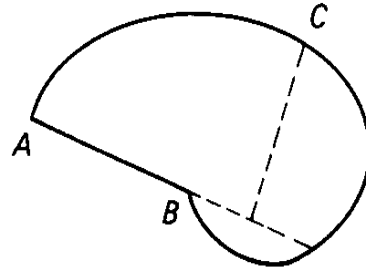
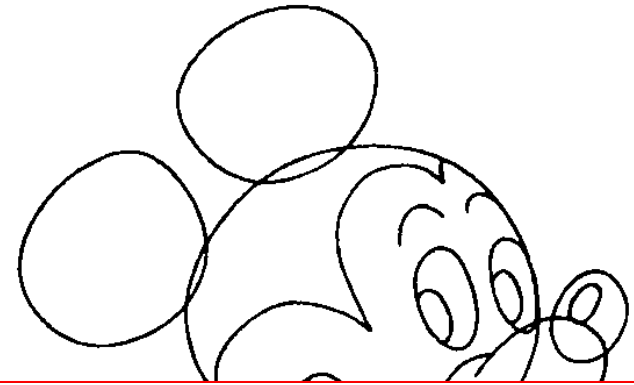
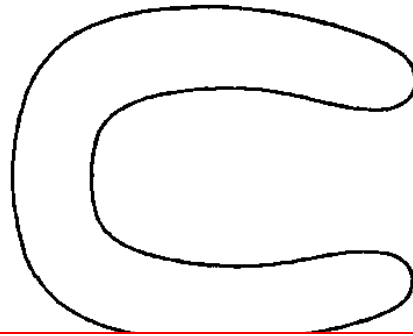
b)
$$p_i^j(x_i) = p_{i+1}^j(x_i) \quad j = 0, 1, \dots, r-1, \quad i = 1, \dots, k-1$$

where x_1, \dots, x_{k-1} are called the breakpoints (or knots),

$p_i(x)$ are polynomials, and $p_i^j(x)$ is its j -th derivative.

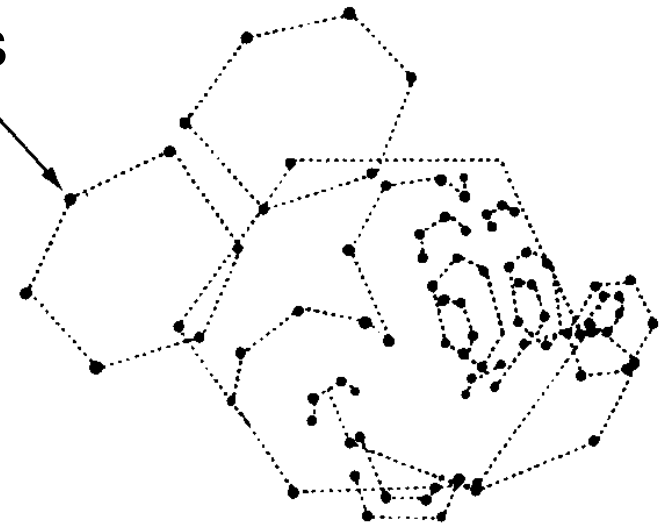
(b) requires that derivatives of the neighbouring B-splines at the knots are equal (in computer graphics applications $r=3$).

B-splines in contour representation



(c)

knots



(d)

Syntactic representation

Primitive
structural
symbols



a



b



c

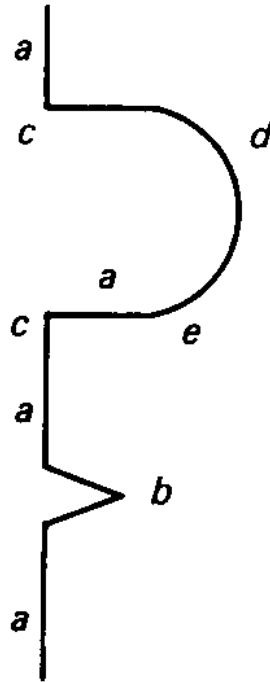


d



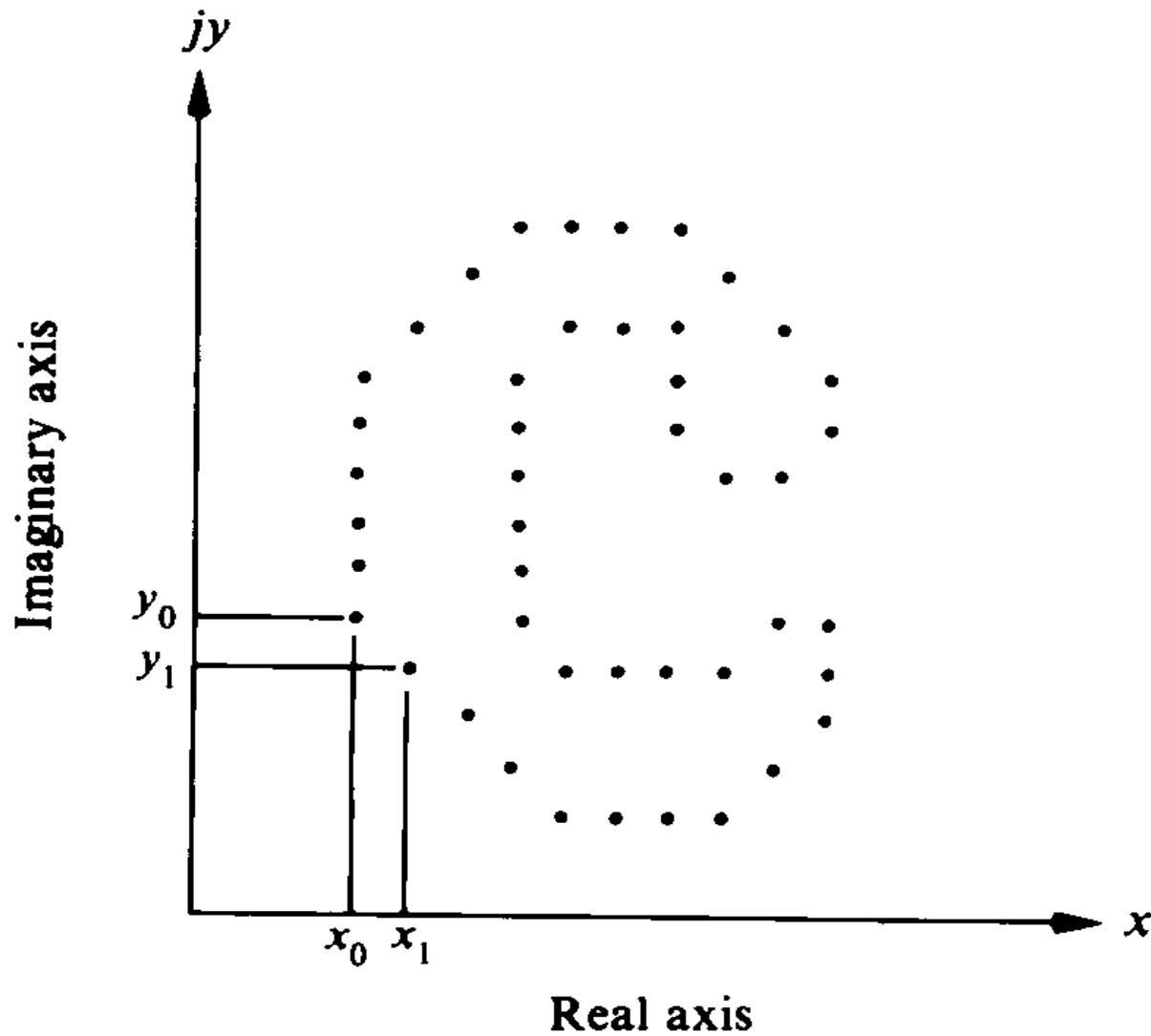
e

Object structure



In syntactic representation the boundary is decomposed into the set of primitive sub-pattern shapes. By adding a syntax, such as connectivity rules, it is possible to obtain a syntactic representation, which is simply a string of symbols, each representing a *primitive*.

Fourier Descriptors



Fourier Descriptors

Once the boundary trace is known, it can be considered as a pair of waveforms $x(t)$, $y(t)$:

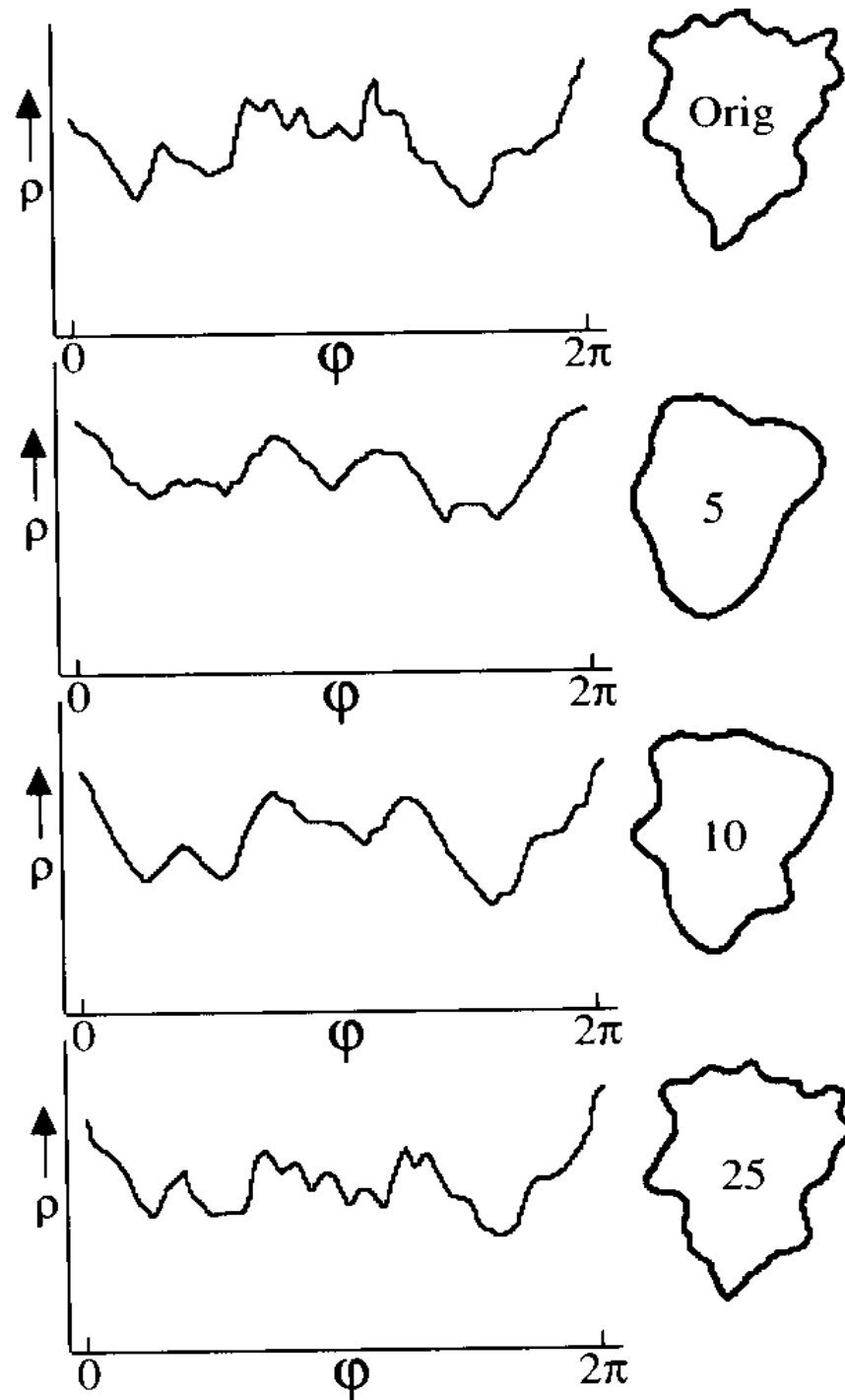
$$s(k) = x(k) + jy(k) \quad k = 0, 1, \dots, N-1$$

Its DFT representation is:

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

The complex coefficients $a(u)$ are called the **Fourier descriptors** of the boundary.

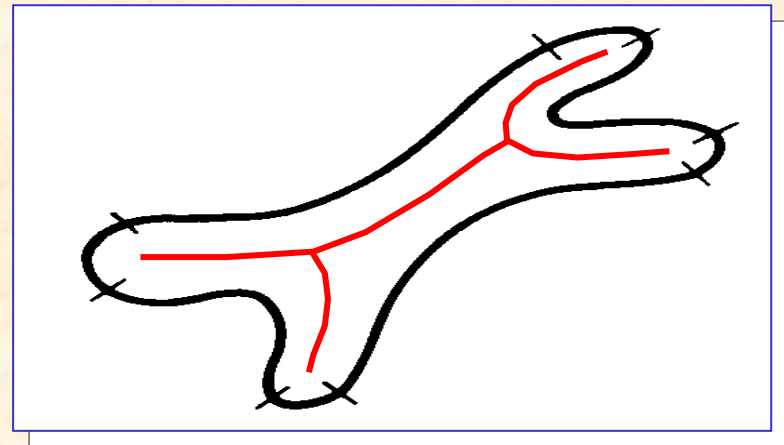
Reconstruction of
region boundary
from first 5, 10 and
25 terms in Fourier
expansion



Skeleton

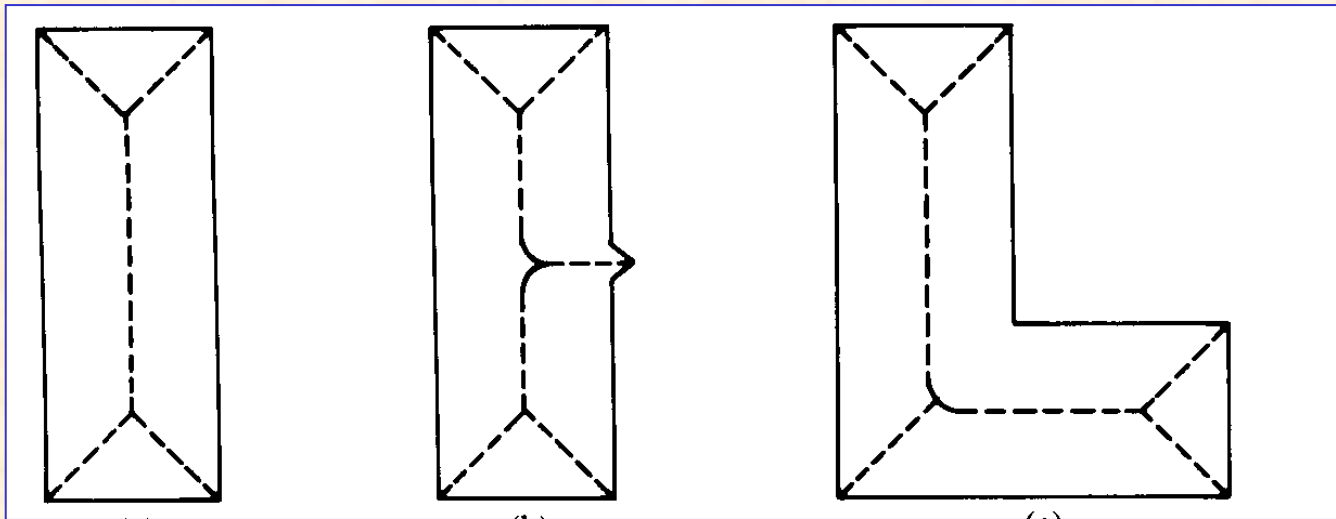
An important way of shape description is reducing the size of the object to its „skeleton”.

The concept of object skeleton is frequently used in image analysis applications, e.g. optical character recognition, edge tracking etc.



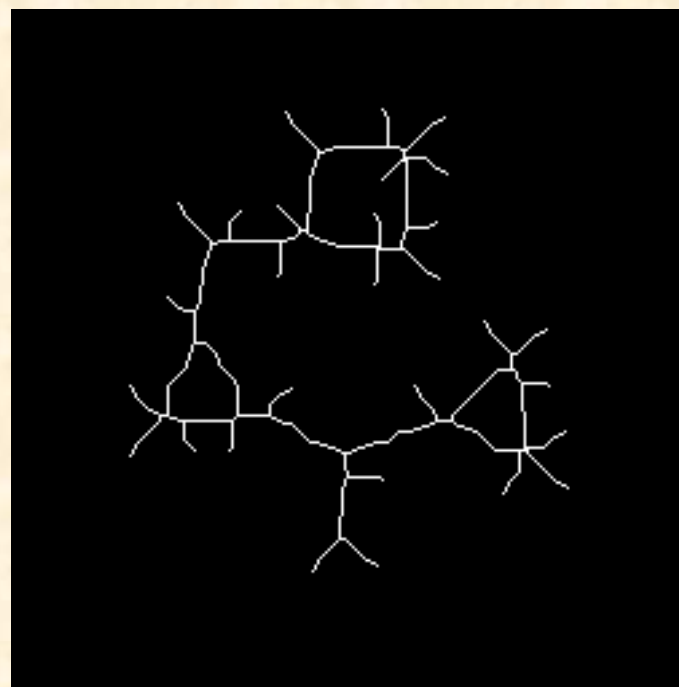
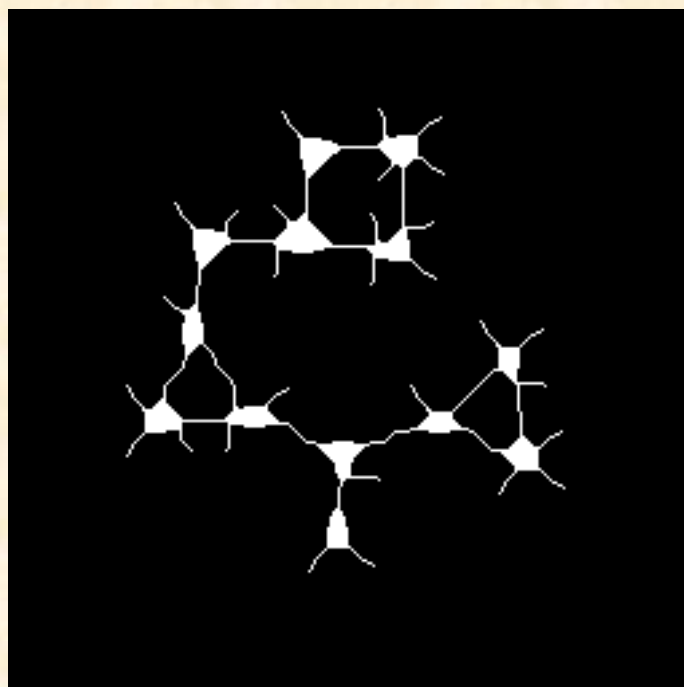
Skeletonization

Skeleton of an object can be obtained by means of ***medial axis transformation***.



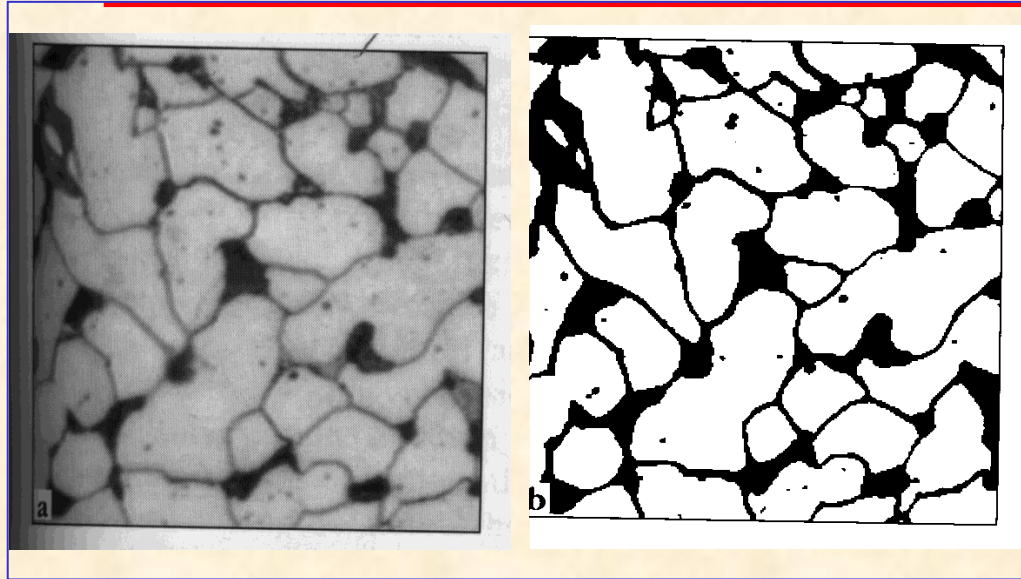
Skeletons of example shapes

Skeletonization – Matlab example



```
%MATLAB  
BW = imread('circles.tif');  
BW1=bwmorph(BW,'skel',Inf); %Inf – multiple erosion  
imshow(BW1);
```

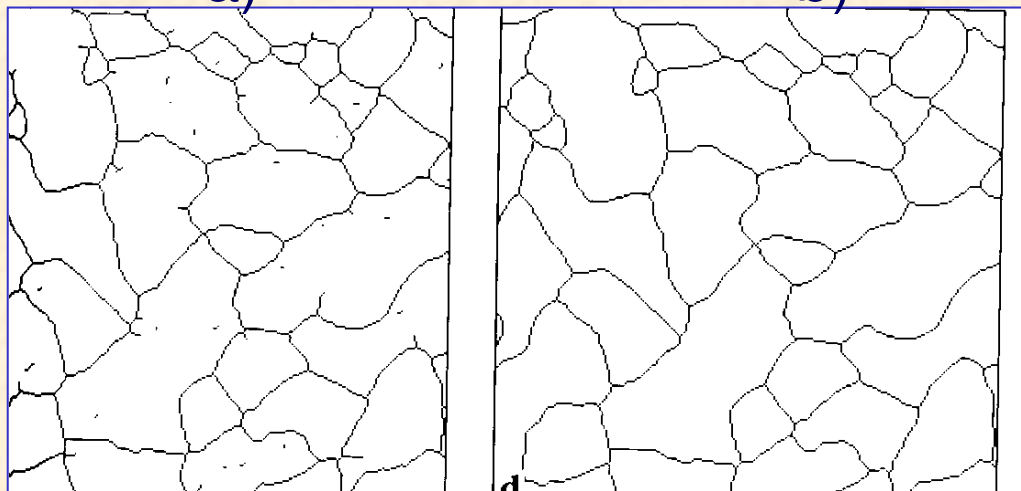
Object skeleton - applications



Microscopic images of steel (with carbon particles):

a) source image

b) thresholded image



c) after skeletonizing

d) after pruning