Description

- Extracting features from an object for recognition
- ❶ Boundary Descriptors
- ❷ Regional Descriptors

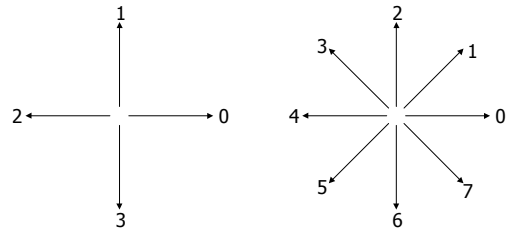
❶ Boundary Descriptors

- Chain Codes
- Signatures
- Polygonal approximations
- Shape Numbers
- Fourier Descriptors

Chain codes

- Represents a boundary as a set of straight line segments of specified length and direction
- Usually a rectangular grid using 4- or 8-connectivity
- Length established by grid resolution
- Direction by code

4-directional code 8-directional code



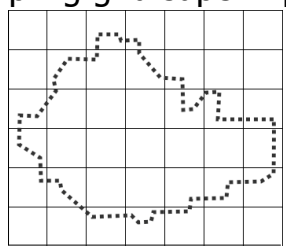
Why grid?

- If coded by pixel
- resulting chain code is too long
- small noises change code, unrelated to boundary

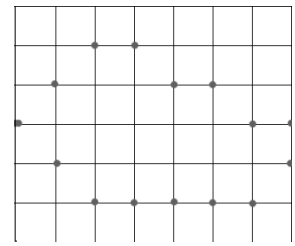
Grid procedure:

- Select a grid spacing
- As the boundary is traversed, a boundary point is assigned to each node of the large grid, depending on the proximity of the original boundary to that node
- Code the path using the direction code

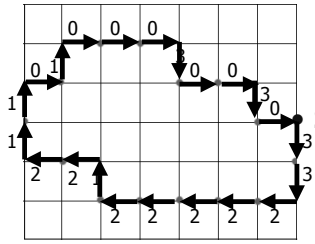
Digital Boundary with resampling grid superimposed



Result of resampling

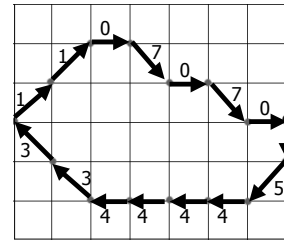


4-directional chain code



33222221221101
00030030

8-directional chain code

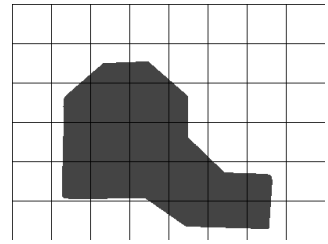


654444331107070

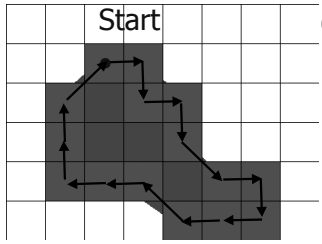
Crack code?

- Taking directions along boundary, considered as a **crack code** in some references, since crack between object and background is used
- Chain code treated as along pixels by them
- A contour pixel is an object pixel that has a background (non-object) pixel as one or more of its 4-connected neighbors

Freeman's chain code



Freeman's chain code



060670644344221

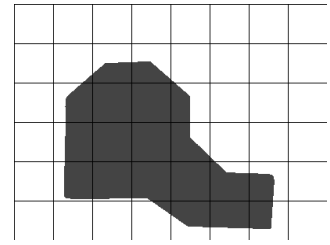
How to make the code for a contour **unique**?

- Treat it as a circular sequence of direction numbers and redefine the starting point so that the resulting sequence forms an integer of minimum magnitude
- 332222122110100030030
- becomes
- 000300303322222122110 1

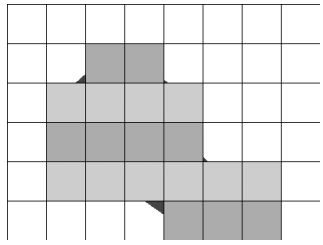
Run code

- based on coding the consecutive pixels along a row
- give the starting position of the run and the ending position of the run
- Various alternatives possible for coding

Run code illustration



Run code illustration



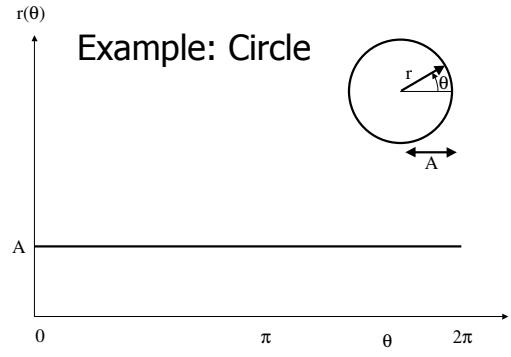
Signatures

- A one dimensional representation of a boundary
- Distance vs Angle
- Tangent, Reference line angle vs boundary position
- Slope density function

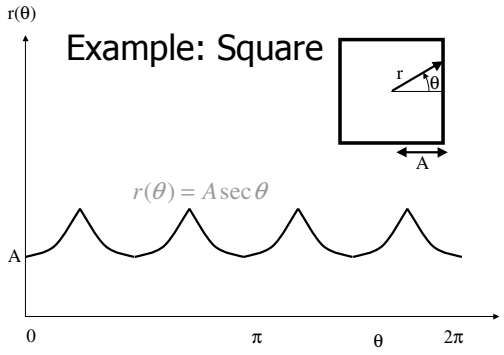
Distance vs Angle

- Plot the distance from the centroid to the boundary as a function of angle
- To make it independent of size, normalize the r(θ) curve to, say, unit maximum value

Example: Circle



Example: Square



How to differentiate signatures?

- Easier, since signatures are one dimensional
- Compute its moments

Polygonal Approximations

- A boundary approximated by polygon
- Arbitrary accuracy possible, but
- Aim: Capture the essence of the shape with fewest possible segments
- Nontrivial, time consuming

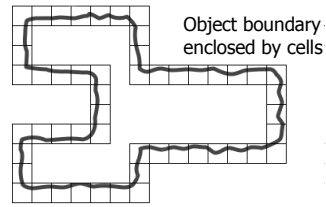
Polygonal Approximations...

- Minimum Perimeter Polygons
- Merging techniques
- Splitting

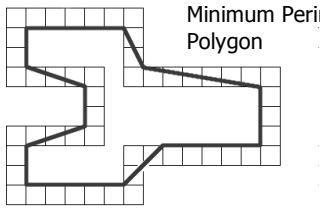
Minimum Perimeter polygons

- Enclose a boundary by a set of concatenated cells
- Imagine the boundary as a rubberband contained within the walls
- Allow the rubberband to shrink, producing a polygon of minimum perimeter

Example



Example



Merging

- Merge points along a boundary until the error exceeds a preset threshold

Splitting

- Subdivide a segment until a given criteria is satisfied
- Example criteria: Maximum perpendicular distance from a boundary segment to the line joining its two endpoints not exceed a preset threshold

Shape Numbers

- First difference of smallest magnitude
- Count the number of directions (counterclockwise) that separate two adjacent elements of the code
- The first element of the difference is computed by using the transition between the last and first components of the chain

Example

- First difference of the 4-directional chain code 10103322 is
- 3133030

Fourier descriptors

- Uses the discrete one dimensional Fourier transform to describe a two-dimensional boundary

$$F(u) = \frac{1}{N}\sum_{x=0}^{N-1} f(x)e^{-j2\pi ux/N}$$

Regional Descriptors

- Simple Descriptors
- Texture
- Skeleton of a region
- Moment Invariants

Simple Descriptors

- Area
- Eccentricity
- Perimeter
- Compactness
- Euler number

Texture

- Provides quantitative measures of properties such as smoothness, coarseness, and regularity

❶ Statistical
  - Yields characterizations: Smooth, coarse, etc

❷ Structural
  - Deals with arrangement of primitives: Regularly spaced lines, etc

Statistical

- Moments of the intensity histogram
- Let z denote discrete image intensity
- $p(z_i)$, $i=1,2,\ldots L$ be the corresponding histogram, where L is the number of levels

Moments

- The nth moment of z about the mean is defined as

$$\mu_n(z) = \sum_{i=1}^{L} (z_i - m_i)^n \, p(z_i)$$

- where m is the mean value of z

$$m = \sum_{i=1}^{L} z_i \, p(z_i)$$

Moments...

- $\mu_0 = 1$
- $\mu_1 = 0$
- μ_2 = variance, denoted by $\sigma^2(z)$
- μ_3 is a measure of skewness
- μ_4 is a measure of its relative flatness
- μ_5 , μ_6 provide further quantitative discrimination of texture content

4	9	2
3	5	7
8	1	6

4	3	2
3	4	3
2	1	3

A relative smoothness

$$R = 1 - \frac{1}{1 + \sigma^2(z)}$$

- For areas of constant intensity, R=0
- For large values of σ^2, R approaches 1

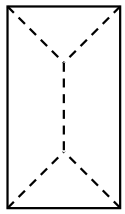
Skeleton of a region

- Reduces a region to a graph
- By thinning, or skeletonizing

Medial Axis Transformation

- The MAT of a region with border B
- For each point p in R, we find its closest neighbour B.
- If p has more than one such neighbour, then it is said to belong to the medial axis of R
- Closest can use different distances

Medial axes



Methods

- Direct implementation of above is computationally prohibitive
- Several algorithms proposed