Representation and Description
• **Representation** and Description
  
  – Representing regions in 2 ways:
    
    • Based on their external characteristics (its boundary):
      – Shape characteristics
    
    • Based on their internal characteristics (its region):
      – Regional properties: color, texture, and ...
    
    • Both
• Freeman Chain Code:
  – Code the 4 or 8 connectivity
Example:
- Resampling
- 4 and 8 chain codes
• Shape Number

  - Smallest integers of first difference circular chain code.
Chain code: 0 0 0 3 0 0 3 2 2 2 2 2 1 2 1 1
Difference: 3 0 0 0 3 1 0 3 3 0 1 3 0 0 3 1 3 0
Shape no.: 0 0 0 3 1 0 3 3 0 1 3 0 0 3 1 3 0 3
- **Polygon Approximation:**
  - **Splitting:**
    - Segments to two parts based on a criteria (e.g. maximum internal distance)
    - Check each segment for splitting based on another criteria (e.g. linearity error)
    - ....
Signatures:

- A 1-D functional representation of a boundary
  - Distance vs. Angle (in the polar representation):
    - Invariant to translation
    - Non-Invariant to rotation (may be achieved by start point selection)
      » Farthest point from centroid
      » The point on eigen axis
      » Use chain code solution for the start point

- Line tangent angle
- Histogram of tangent angle
Example:
• Boundary Segments:

• Skeletonization / Thinning:
  – Medial Axis Transform (MAT)
    • Point p is belong to medial (Region R and Border B):
      – Has more than one closest neighbor in B
  – Chapter 9 and Page 813
Fourier Descriptors:

\[ s(k) = x(k) + j y(k) \]

\[ a(u) = \sum_{k=0}^{K-1} s(k) \exp\left(-j 2\pi \frac{uk}{K}\right) \]

\[ s(k) = \frac{1}{K} \sum_{u=0}^{K-1} a(u) \exp\left(+j 2\pi \frac{uk}{K}\right) \]

\[ \hat{s}(k) = \frac{1}{P} \sum_{u=0}^{P-1} a(u) \exp\left(+j 2\pi \frac{uk}{K}\right) \]
- **Regional Descriptor:**
  - The simple one:
    - Area (Number of pixels)
    - Perimeter (Length of boundary)
    - Compactness (Perimeter$^2$/Area)
    - Circularity: Ratio of the area to the area of a circle with same perimeter
    - Mean, median, max, min, ratio pixels above/below ... from intensity data.
• **Texture:**
  
  - No formal definition
• Statistical Approaches
  – 1\textsuperscript{st} order grey level statistics
    • From normalised histogram
      – One pixel gray level repeat n times
  – 2\textsuperscript{nd} order grey level statistics
    • From GLCM (Grey Level Co-occurrence Matrix)
      – Repetation of two pixels in a pre-defined neighbourhood
    • Needs:
      – A Positioning Operator, \textbf{P}.
      – GLCM(i,j): # of times that points with gray level $Z_i$ occure relative to points with gray level $Z_j$
• Texture feature from 1\textsuperscript{st} order statistics:

\[ \mu_n(z) = \sum_{i=0}^{L-1} (z_i - m)^n P(z_i), \quad m = \sum_{i=0}^{L-1} z_i P(z_i) \]

\[ R(z) = 1 - \frac{1}{1 + \sigma_z^2} : \text{Gray Level Contrast (Normalized)} \]

\[ \mu_3(z) : \text{Skewness} \]

\[ \mu_4(z) : \text{Kurtosis, Flatness} \]

\[ U(z) = \sum_{i=0}^{L-1} p^2(z_i) : \text{Uniformity} \]

\[ e(z) = -\sum_{i=0}^{L-1} p(z_i) \log(p(z_i)) : \text{Entropy} \]
Gray Level Co-Occurrence Matrix (GLCM):