Contents

- Brief introduction to Image segmentation
- Types of Image segmentation
- Region growing and Shrinking (split /merge ) method
- Applications of Image segmentation
- Results
Introduction

The shape of an object can be described in terms of:

- Its boundary – requires image edge detection
- The region it occupies – requires image segmentation in homogeneous regions. Image regions generally have homogeneous characteristics (e.g. intensity, texture)
The goal of Image Segmentation is to find regions that represent objects or meaningful parts of objects. Major problems of image segmentation are result of noise in the image.

An image domain X must be segmented in N different regions $R(1),...,R(N)$.

The segmentation rule is a logical predicate of the form $P(R)$. 
Image segmentation partitions the set \( X \) into the subsets \( R(i), \ i=1,\ldots,N \) having the following properties:

\[
X = \bigcup_{i=1}^{N} R(i)
\]

\[
R(i) \cap R(j) = 0 \text{ for } i \neq j
\]

\[
P(R(i)) = \text{TRUE} \text{ for } i = 1,2,\ldots,N
\]

\[
P(R(i) \cup R(j)) = \text{FALSE} \text{ for } i \neq j
\]
The segmentation result is a logical predicate of the form $P(R, x, t)$

- $x$ is a feature vector associated with an image pixel
- $t$ is a set of parameters (usually thresholds) A simple segmentation rule has the form:

$$P(R) : I(r, c) < T$$
In the case of color images the feature vector \( x \) can be three RGB image components \( \{IR(r,c), IG(r,c), IB(r,c)\} \).

A simple segmentation rule may have the form:

\[
P(R,x,t) : (IR(r,c) < T(R)) \land (IG(r,c) < T(G)) \land (IB(r,c) < T(B))
\]
A region is called connected if: .......
A pixel \((x,y)\) is said to be adjacent to the pixel \((a,b)\) if it belongs to its immediate neighborhood.
The 4-neighbourhood of a pixel \((x,y)\)
The 8-neighbourhood of \((x,y)\)
Types

- By Histogram Thresholding
- By Region Growing and Shrinking
- By Clustering in the color space
Region Growing

- A simple approach to image segmentation is to start from some pixels (seeds) representing distinct image regions and to grow them, until they cover the entire image.
- For region growing we need a rule describing a growth mechanism and a rule checking the homogeneity of the regions after each growth step.
Region Growing – cont.d

- The growth mechanism – at each stage $k$ and for each region $R_i(k)$, $i = 1, \ldots, N$, we check if there are unclassified pixels in the 8-neighbourhood of each pixel of the region border.

- Before assigning such a pixel $x$ to a region $R_i(k)$, we check if the region homogeneity: $P(R_i(k) \cup \{x\}) = TRUE$, is valid.
Region Growing – cont.d

- The arithmetic mean $m$ and standard deviation $sd$ of a class $R_i$ having $n$ pixels:

$$M = \frac{1}{n} \sum_{(r,c) \in R(i)} I(r,c)$$

$$sd = \sqrt{\frac{1}{n} \sum_{(r,c) \in R(i)} (I(r,c) - M)^2}$$

Can be used to decide if the merging of the two regions $R_1, R_2$ is allowed, if

$$|M_1 - M_2| < (k)sd(i), i = 1, 2$$

are merged
Region Growing – cont.d

- Homogeneity test: if the pixel intensity is close to the region mean value
  \[ |I(r,c) - M(i)| \leq T(i) \]

- Threshold \( T_i \) varies depending on the region \( R_n \) and the intensity of the pixel \( I(r,c) \). It can be chosen this way:
  \[ T(i) = \{ 1 - \frac{\text{s.d}(i)}{M(i)} \} T \]
Split / Merge

- The opposite approach to region growing is region shrinking (splitting).
- It is a top-down approach and it starts with the assumption that the entire image is homogeneous.
- If this is not true, the image is split into four sub images.
- This splitting procedure is repeated recursively until we split the image into homogeneous regions.
Split / Merge

- If the original image is square $N \times N$, having dimensions that are powers of $2 (N = 2^n)$:
- All regions produced but the splitting algorithm are squares having dimensions $M \times M$, where $M$ is a power of 2 as well ($M=2^m, M \leq n$).
- Since the procedure is recursive, it produces an image representation that can be described by a tree whose nodes have four sons each.
- Such a tree is called a Quadtree.
Split / Merge

Quadtree

R0

R1

R2

R0

R1

R3

R00 R01 R02 R04

R1
Split / Merge

- Splitting techniques disadvantage, they create regions that may be adjacent and homogeneous, but not merged.
- Split and Merge method – It is an iterative algorithm that includes both splitting and merging at each iteration:
Split / Merge

- If a region $R$ is inhomogeneous ($P(R) = \text{False}$) then it is split into four sub regions.
- If two adjacent regions $R_i, R_j$ are homogeneous ($P(R_i \cup R_j) = \text{TRUE}$), they are merged.
- The algorithm stops when no further splitting or merging is possible.
Split / Merge

- The split and merge algorithm produces more compact regions than the pure splitting algorithm.
Results – Region grow
Results – Region growing