regions & segmentation

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regions and edges
image array - rectangular tessellation

\[ \alpha[0,0] \]

\( \text{column } j \)

\( \text{m columns} \)

\( \text{row } i \)

\( \text{n rows} \)

4-neighbours

8-neighbours
grey level histogram

number of pixels \( h(z) \)

grey level \( z \)
some definitions

- 4-path
- 8-path
- region
- boundary
segmentation

segmentation is the process of partitioning an image $F[i,j]$ into regions $P_1, \ldots, P_k$, such that:

- $\bigcup_{i=1}^{k} P_i = \text{entire image}$
- $P_i \cap P_j = \emptyset$, $\forall i, j = 1, 2, \ldots, k$, and $i \neq j$
- pixels in each partition satisfy a logical predicate
- pixels in adjacent regions do not satisfy the predicate
segmentation techniques

- discontinuity
  edges

- similarity
  thresholding
  regions
global thresholding

\[ T = T (i, j, P[i,j], F[i,j]) \]
global thresholding - example
local thresholding

\[ T = T(i, j, P[i,j], F[i,j]) \]

divide into subimages
determine threshold for each subimage
process each subimage separately
**dynamic thresholding**

\[ T = T \left( i, j, P[i,j], F[i,j] \right) \]
region-based segmentation

- region growing
- region merging
- region splitting

adjacency

connectivity

homogeneity

grey level  shape
color       size
texture     model
**region growing**

- how do we select:
  - seed points
  - similarity criteria
  - stopping rule

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less than 3

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less than 8
region splitting
region merging

- segment into many small regions
- merge two adjacent regions if similar
- merge all adjacent regions that are similar
- if no two regions can be merged, stop
a hybrid algorithm for the segmentation of 2D-3D images

1. Κ. Χάρης
   Ένας Υβριδικός Αλγόριθμος για την Τμηματοποίηση Δισδιάστατων και Τρισδιάστατων Εικόνων
   Μεταπτυχιακό Δίπλωμα Εξειδίκευσης
   Τμήμα Επιστήμης Υπολογιστών, Πανεπιστήμιο Κρήτης, 1994

2. K. Haris, G. Tziritas, and S. Orphanoudakis
   Smoothing of 2D and 3D Images Using Local Classification

3. S. Orphanoudakis, G. Tziritas, and K. Haris
   A Hybrid Algorithm for the Segmentation of 2D-3D Images
segmentation algorithm overview

input 2D or 3D image → edge-preserving smoothing → gradient approximation → watershed detection → hierarchical region merging → segmented image
**smoothing: method**

\[ N(i,j) \]

- 5x5

If \( N(i,j) \) is homogeneous if

*sample variance \( \leq \) C x noise variance*

If \( N(i,j) \) is heterogeneous

estimate the parameters of the two distributions

\[ \mu_1, \mu_2, \mu_3 \]
**smoothing: method**

- for each pixel, consider its neighbourhood
  - assume that the neighbourhood is either homogeneous or two different regions exist
- assign the pixel to one of a maximum of two different distribution populations present within the neighbourhood
- set the new value of the pixel equal to the arithmetic mean of the population to which the pixel has been assigned
smoothing: example

input image

smoothed image
gradient approximation

- compute intensity gradient of smoothed image
- apply thresholding on the gradient magnitude image

\[
G_T(i,j) = \begin{cases} 
G_T(i,j), & \text{if } G_S(i,j) > T \\
0, & \text{otherwise}
\end{cases}
\]

\(G_S\) : smoothed gradient image
\(T\) : threshold value
watershed detection

- points of low gradient value “sink” first
- tessellation of the input gradient image into catchment basins
- unique label to each catchment basin
watershed detection

raw

smoothed

gradient

raw

watersheds

superimposed
watersheds: effect of gradient thresholding

oversegmented image after watershed detection

T: gradient threshold value

input image
region merging - RAG

region adjacency graph (RAG)

6-partition of an image

for each step merge the two most similar regions
**region merging - RAG**

similarity measure

merge the pair of regions \((R_i, R_k)\)

that minimize the square error

of the mean intensity in

the resulting region

i.e, minimize:

\[
\frac{N_i N_k}{N_i + N_k} (\mu_i - \mu_k)^2
\]

\(N: \) number of pixels in a region

\(\mu: \) mean intensity of a region
examples

input

smoothed

segmentation (25)

overlay

3556 regions

1536 regions

500 regions

50 regions

Eleni Kaldoudi, ICS-FORTH
examples

[Images of medical scans]
summary

segmentation

- thresholding
  - dynamic, local, global

- region based
  - region growing, splitting, merging

- edge detection
  - .......... to be continued
more details in :


