Experiment 9: Image Segmentation using Region based techniques using MATLAB

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Region based segmentation

Classification of region based segmentation:

- Region growing
- Split & merge
- Watershed technique
- K-mean clustering

1. Region growing

- Region growing consist of very fine segmentation merging together similar adjacent regions.
- Region adjacency graphs are used to represent segmentation data. Each node represents a region. An edge exists between two nodes if corresponding regions are adjacent.
- A homogeneity predicate $H(R)$ is a function that takes a region $R$ and returns true or false according to the pixel properties.
- Basic formulation for region-based segmentation is given by a partition \( \{R_1, R_2, ..., R_n \} \) such that:
  - $\forall k$ $R_k$ is connected
  - $\forall k$ $H(R_k)$ is true
  - $R_i \cap R_j = \emptyset$ for all $i=1, 2, 3, ..., n$ (region must be disjoint)
  - $P(R_i) =$true (if all pixels in $R_i$ have the same gray level.
  - $P(R_i \cap R_j) =$false (indicates region $R_i$ & $R_j$ are difficult in the sense of predicate.

- **absolute intensity homogeneity**
  - $\forall p, q \in S \mid I(p) - I(q) \mid \leq s$

- **differential intensity homogeneity**
  - $\forall p, q \in S$ and (p neighbor of q) $| I(p) - I(q) | \leq s$

- First point in region growing is to select a set of seed points. Seed point selection is based on some user criteria (e.g.-pixel in certain grayscale range, pixels evenly spaced on grids).
- Segmentation results in a logical predicate of the form $P(R, X, t)$. $X$ are the feature vector associated with an image pixel and $t$ is a parameter (threshold).
2. Region splitting and merging technique

The opposite approach to region growing is region shrinking. It starts with the assumption that the entire image is homogeneous. If this is not true, the image is split into 4 sub images. The splitting procedure is repeated recursively until we split the image into homogeneous regions. Procedure can be described by a tree whose nodes have 4 sons each, such a tree is called a QUADTREE.

- $S = \text{qtdecomp}(I)$ divides a square image into four equal sized square blocks, and then tests each block to see if it meet some criteria of homogeneity.
- $[\text{vals}, r, c] = \text{qtgetblk}(I, S, \text{dim})$ returns in vals an array containing the dim by dim blocks in the quadtree decomposition of I. S is the sparse-matrix returned by qtdecomp, it contains the quadtree structure's and c are vectors containing the row and column coordinates of the upper left corners of the blocks.

I = [3 3 1 3 2 3 6 6
     3 3 2 3 4 5 6 8
     3 3 1 3 10 15 5 5
     3 3 1 3 20 25 6 6
     20 22 20 22 1 2 3 4
     20 22 22 20 5 6 7 8
     20 22 20 20 9 10 11 12
     22 22 20 20 13 14 15 16];

S = qtdecomp(I, 5);
[val, r, c] = qtgetblk(I, S, 4);
vals
r
c
result: vals(:,:, 1) =
3 3 1 3
3 3 2 3
3 3 1 3
3 3 1 3
vals(:,:,2) =
20 22 20 22
20 22 22 20
20 22 20 20
22 22 20 20
r =
1
5
c =
1
1
3. Segmentation by Watershed

In geography, watershed is the ridge that divides area drained by different river system. A catchment basin is the geographical area draining into river to reservoir. The watershed transform applies the ideas to grayscale image processing in a way that can be used to solve a variety of image-segmentation problem.

Watershed principle for image segmentation:

- Local minima of the gradient of the image may be chosen as marker.
- Marker based watershed transformation make use of specific marker positions which have been either explicitly defined by the user or determined automatically with morphological operators.

Segmentation procedure:

- Compute segmentation function.(This is an image whose dark regions are the objects we are trying to segment)
- Compute foreground markers. (These are connected blobs of pixels within each of the objects)
- Compute background marker.(pixels that are not part of any object)
- Modify the segmentation function so that it only has minima at foreground and background locations.
- Compute watershed transform of modified segmentation function.

Functions used:

- $\text{Imopen}(I,se)$ performs morphological opening on the grayscale or binary image $I$ with the structuring element $se$.
- $\text{Imerode}(I,se)$ erodes the image $I$, argument $se$ is a structuring element returned by strlen function.
- $\text{Imreconstruct } (\text{marker},\text{mask})$ performs morphological reconstruction of the image marker under the image mask.
- $\text{Imclose}(I,se)$ performs morphological close operation on grayscale or binary image returning closed image.
- $\text{bw=imregionalmax}(I)$ finds the regional maxima of $I$. It returns the binary image $bw$ that identifies the location of the region maxima in $I$.
- $\text{bw=imregionalmax}(I,\text{conn})$ computes the regional maxima of $I$ using the specified connectivity. For two dimensional connectivity’s conn can have values 4,8 and for three dimensional it is 6,18 or 26.
- $[D,L]=\text{Bwdist}(bw,\text{method})$ computes the distance transform of binary image $bw$. For each pixel in $bw$, the distance transform assigns a number that is the distance between that pixel and the nearest non-zero pixel $bw$. Method specifies distance matric. By default bwdist function use Euclidean distance matric .L is the label matrix. Bw can be numeric or logical and D,L are double matrices with same size as bw.
<table>
<thead>
<tr>
<th>methods</th>
<th>Descriptions</th>
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<tbody>
<tr>
<td>‘chessboard’</td>
<td>Max distance between ((X_1, Y_1)) and ((X_2, Y_2)) is (\max(</td>
</tr>
<tr>
<td>‘Cityblock’</td>
<td>(D =</td>
</tr>
<tr>
<td>‘Euclidean’</td>
<td>(D = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2})</td>
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<tr>
<td>‘quasi-euclidean’</td>
<td>(</td>
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<td>((\sqrt{2} - 1)</td>
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- \(L = \text{Watershed}(A)\) computes a label matrix identifying the watershed regions of the input \(A\). \(L\) are integer values greater than equal to zero. Elements labeled 0 don’t belong to watershed regions, elements labeled 1 belongs to first watershed region, 2 second and so on. By default watershed use 8 connected neighborhoods for 2-D inputs, 26 for 3D inputs.
- \(\text{Imimposemin}(I, bw)\) modifies the intensity image \(I\) using morphological reconstruction so it only has regional minima whenever \(bw\) is zero.