Watershed segmentation

Sonka et. al. section 11.7 p. 590-595

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Introduction

watershed = vattendelare



http://www.unep-wcmc.org/information_services/publications/MountainWatch_Bishkek/presspack/photos.htm

Three types of segmentation:

- *Thresholding* Based on pixel intensities, often using the shape of the histogram for automation.
- Edge-based Search for discontinuities in the image, and try to connect objects or border.
- *Region-based* Group similar pixels: region growing, merge & split.

Thresholding



Model: a nucleus is a connected region with an intensity greater than the image background.

Thresholding drawbacks

- Resulting segmentation is very sensitive to the choice of threshold, and has great influence on the further analysis (e.g. description of shape).
- Thresholding will not separate touching objects.





Edge based segmentation

Search for objects surrounded by an edge rather than objects brighter/darker than the background



Region based segmentation

region splitting and merging (top-down method)

- 1. Set up some criteria for what is a uniform area (ex mean, variance, bimodality of histogram, texture, etc)
- 2. Start with the full image and **split** it in to 4 sub-images.
- 3. Check each sub-image. If not uniform, divide into 4 new sub-images.
- 4. After each iteration, compare touching regions with neighboring regions end **merge** if uniform.

The method is also called "quadtree" division.



Region based segmentation cont.

region growing (bottom-up method)

- 1. Find starting points
- 2. Include neighboring pixels with similar features (grey-level, texture, color).
- 3. Continue until all pixels have been included with one of the starting points. Problems:

Not trivial to find good starting points, difficult to automate Need good criteria for similarity.

Ex. watershed



Region based segementation



Watershed segmentation

- See the image as a topographic surface, with both valleys and mountains.
- Assume that there is a hole in each minima and the surface is immersed into a lake.
- The water will enter through the holes at the minima and flood the surface.
- To avoid the water coming from two different minima to meet, a dam is build whenever there would be a merge of the water.
- Finally, the only thing visible of the surface would be the dams. These dam walls are called the watershed lines.

Watershed cont.

Can be used directly on the image, on an edge enhanced image or on a distance transformed image.

Example of watershed directly on a gray-level image





Binary images



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Distance function

Distance function, $dist_X(p)$, is the shortest distance between pixel p and the background.

Sonka et. al page 584, eq. 11.55

Binary images



Distance transform of BW



Distance transform of BW



Watershed transform of BW



Grey scale images





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Seeded watershed



Model: Every object contains a "seed". E.g., every cell has a cell nucleus which can be detected by thresholding and shape-based watershed segmentation. Using the nuclei as seeds, the cytoplasms are easy to find.

Finding the cell nucleus



Model: A nucleus is a connected region that is 1. brighter than the local background



2. surrounded by a sharp edge



Extension to 3D

Same approach as for 2D, extending all 3x3 operators to 3x3x3.



Maximum intensity projection of 256x256x100 image



Segmentation result: Each cell (in 3D) has its own ID number and measurements can be made on the individual cells.

Time-lapse images

Time-lapse images, or movies, are created by repeated imaging of a changing environment.





Time-lapse sequence of cells growing on a microscope slide

Volume rendering of the motion, or tracks, of three of the cells.