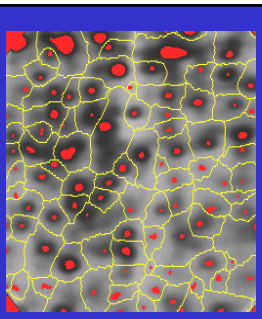
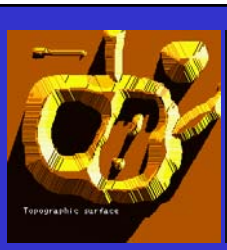

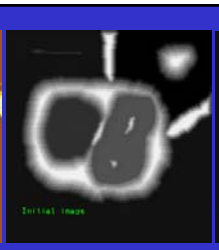

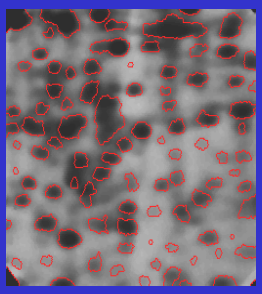

Watershed Transformation

Backfrieder und Mülleder

Backfrieder-Hagenberg

Contents

- Definition & Usage
- Mathematical Background
- Algorithms, Examples
- Problems & Solutions
- Conclusion & Outlook

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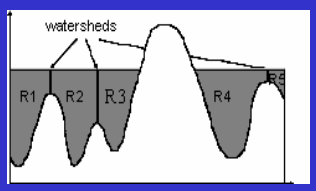
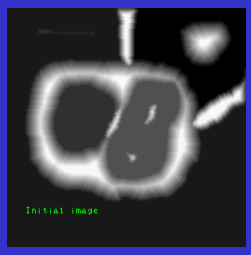
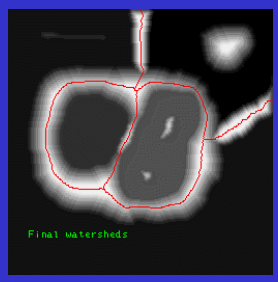
Definition & Usage

- Tool for morphological image segmentation.
- ***Process***: Grey tone image ➔ topographic surface ➔ flooding ➔ catchment basins ➔watershed lines







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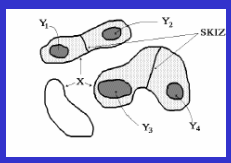
Mathematical Background

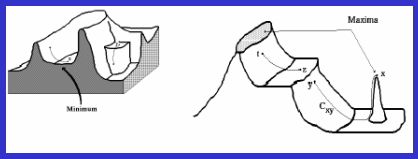
- ***gradient***
  detects the amplitude edges at which gray-levels change suddenly

- ***distance function***
  the distance of every point to the complementary set

- ***geodesic zone of influence***
  set of points closer to Yi than Yj
  SKIZ = boundaries between



- ***minima and maxima***



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Algorithms, Examples

Algorithmic definition by immerson (Vincent and Soille)

Recursion with the grey level increasing from hmin to hmax, in which the basins associated with the minima of the grey-value image are successively expanded.

The following figure shows a simple Example of how the algorithm works. This example is based on 4-connectivity:

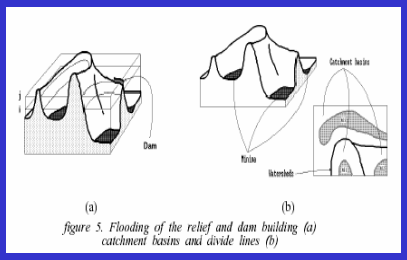
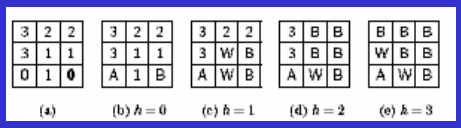


figure 5. Flooding of the relief and dam building (a) catchment basins and divide lines (b)

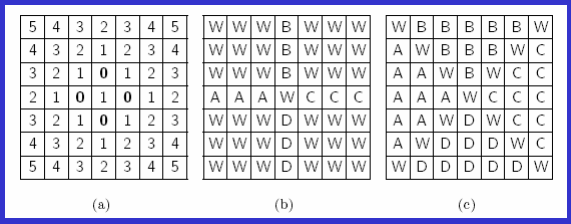


Algorithms, Examples

Algorithmic definition by topographical distance

CB(mi) is the set of points in the upstream of a single minimum mi. The watershed consists of the points p which are in the upstream of at least two minima, i.e., there are at least two paths of steepest descent starting from p which lead to minima. Any pixel in the upstream of a watershed pixel (➔ thick watersheds).

lower complete: each node which is not in a minimum has a neighbouring node of lower value



Algorithms, Examples

Topographical distance by *Hill Climbing*

```
1:    Input: lower complete digital grey scale image (V,E, im).
2:    Output: labelled image lab on V .*)
3:    #define wshed 0 (* label of the watershed pixels *)
4:
5:    LabelInit (*initialize image lab with distinct labels for minima *)
6:    (* and special label mask for all other pixels *)
7:    (* interior pixels of minima excluded *)
8:     while not empty(S) do
9:              select point p from S with minimal grey value;
10:             remove p from S;
11:             for all steepest upper neighbours of p
12:                     if lab[q] == mask then
13:                             lab[q] = lab[p];
14:                     else if ((lab[q]  != wshed) and (lab[q] != lab[p]) then
15:                             lab[q] = wshed;
16:                     end if
17:             end for
18:   end while
```

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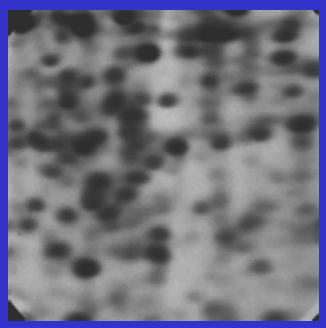
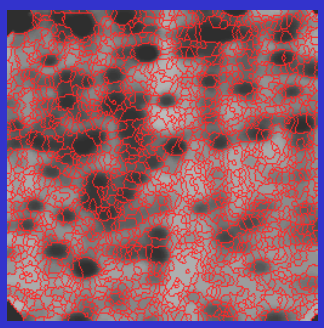
Problems

- ***Oversegmentation***

The original watershed method produces severe oversegmentation.

many local minima ➔ small basins ➔ a lot of watersheds





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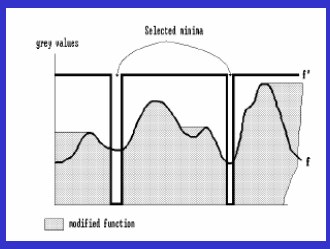
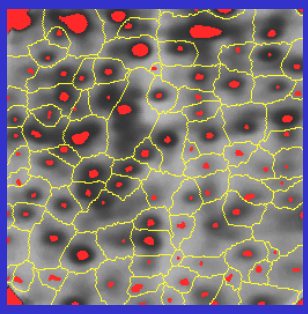
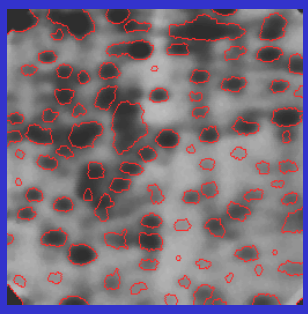
Solutions

- ***Marker controlled watershed***
  Mark patterns to be segmented ➔ make minima of the marker set M ➔ As many catchment basins as there are markers







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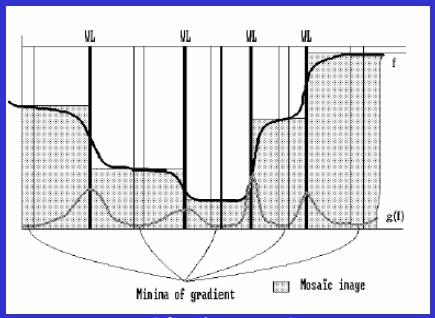
Solutions

- **The mosaic image:** ***Hierarchical segmentation***

  watershed of gradient ➔ label every catchment basin with grey value of initial image corresponding to the minima of the gradient ➔ simplified image ➔ fusion criteria ➔ repeat process



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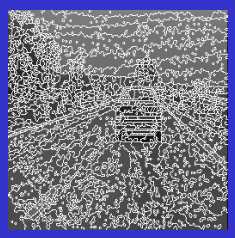
Solutions



Initial image (left) and initial watershed of the gradient (right).

Mosaic image (left) and first level of hierarchy (right).

Conclusion & Outlook

- Provides closed contours.
- Good match of contours even if over-segmented.
- Can be applied in many situations.
- Preprocessing (markers) neccessary.

- WT applied to colour prints
- Local WT, extracting regions of interest (ROI)

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References

- http://cmm.ensmp.fr/~beucher/publi/pfefferkorn.pdf
- http://oldwww.rug.nl/hpc/people/arnold/articles/fundamenta.pdf
- http://www.gris.uni-tuebingen.de/publics/paper/Stoev-2000-RafSi.pdf
- http://cmm.ensmp.fr/~beucher/wtshed.html

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