Watershed Segmentation

Using Meyer's Flooding Algorithm (Priority Flooding)

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Contents

The Watershed Transform

Let f have minima $\{m_k\}_{k \in I}$, for some index set I. The catchment basin $CB_i(m_i)$ of a minimum m_i is defined as the set of points $x \in D$ which are topographically closer to m_i than to any other regional minimum m_j:

$$CB(m_i) = \{x \in D | \forall j \in I \backslash \{i\} : f(m_i) + T_f(x, m_i) < f(m_j) + T_f(x, m_j)\}$$

The watershed of f is the set of points which do not belong to any catchment basin:

$$Wshed(f) = D \cap (\bigcup_{i \in I} CB(m_i))^c$$

Let W be some label. $W \in I$. The **watershed transform** of f is a mapping $\lambda : D -> I \cup \{W\}$, such that $\lambda(p) = i$ if $p \in CB(m_i)$, and $\lambda(p) = W$ if $p \in Wshed(f)$ [3]

Animation

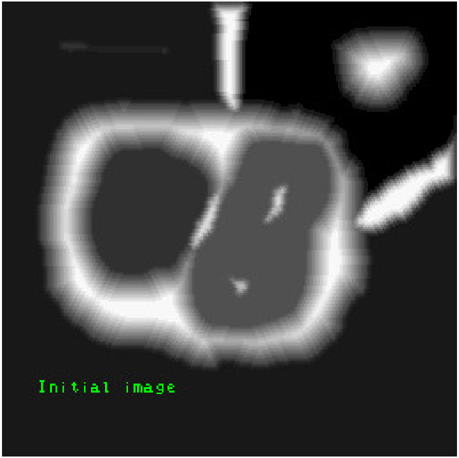

Figure: Flooding Algorithm Visualized [1]

Priority Flooding with Ordered Queue Algorithm

The algorithm is the following [2]:

1. We find the local minima in the image. Each of them is assigned with a unique marker
2. We simulate a flooding process that uses a priority queue. Each element of the image needs to be marked additionally, depending on whether it was already placed into this queue or not (an additional marker)
    1. We mark elements, that already have a unique marker, with an additional marker
    2. We add elements that have marked neighbors into the queue. We also mark them with an additional marker
    3. We remove the first element from the queue. If all its marked neighbors were marked with the same marker, we mark the element itself by this marker. If the selected element was a neighbor of elements with different markers, we mark it with a special marker, meaning that it is an element of the watershed
    4. Neighbors of this element that have not been marked with an additional marker yet are placed into the priority queue. Then, we proceed to Step iii

References

Serge Beucher. *IMAGE SEGMENTATION AND MATHEMATICAL MORPHOLOGY*. 2010. URL: https://www.cmm.mines-paristech.fr/~beucher/wtshed.html.

F Meyer and S Beucher. "The Morphological Approach to Segmentation: The Watershed Transformation". In: *Mathematical Morphology in Image Processing*. 1st ed. Vol. 34. Marcel Dekker Inc., 1993, pp. 452–464.

Jos Roerdink and A. Meijster. "The Watershed Transform: Definitions, Algorithms and Parallelization Strategies". In: *Fundam Inf* 41 (Oct. 2003). DOI: 10.3233/FI-2000-411207.