

Volume Data Segmentation by Hierarchical Watersheds

Miloš Šrámek

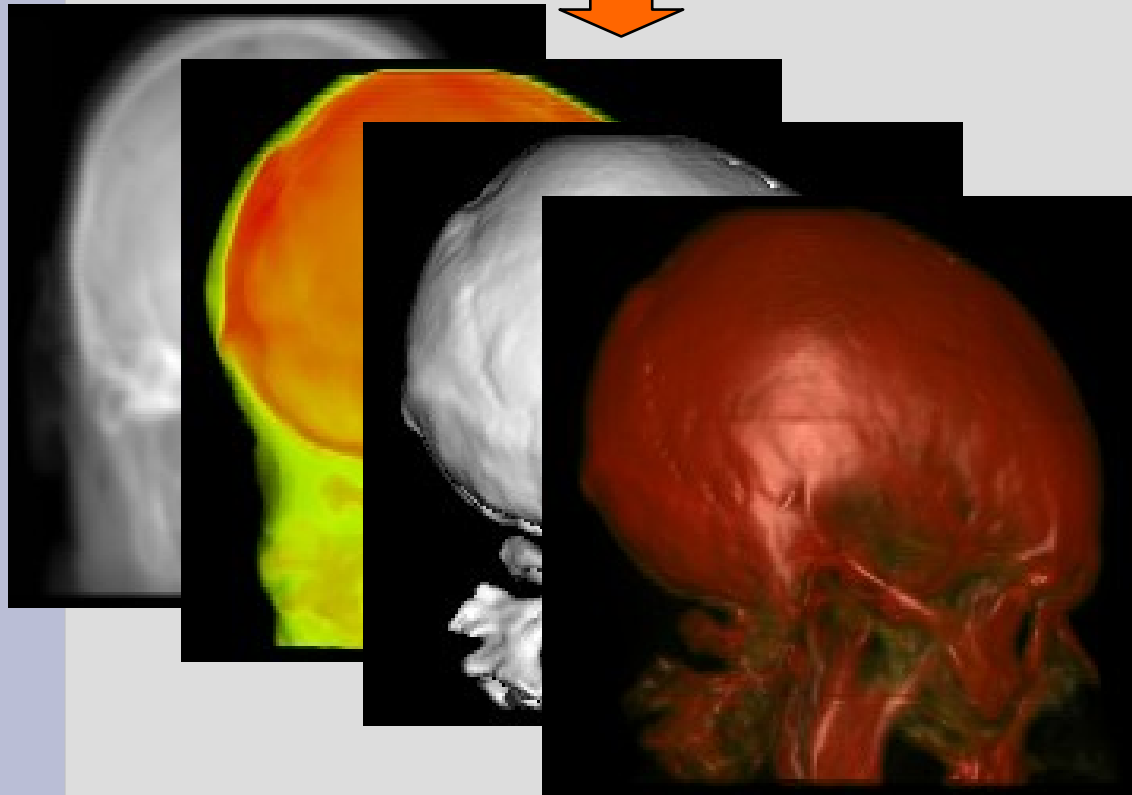
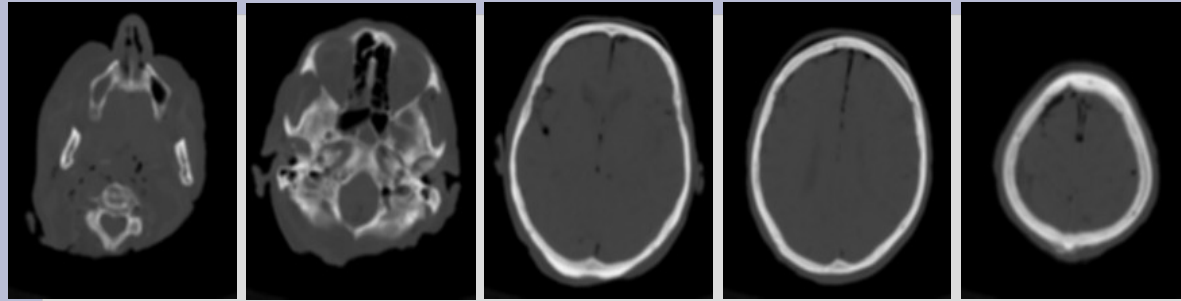
Overview

- Volume imaging
- Interactive Volume Segmentation
- Watershed Hierarchies

Volume Imaging

- Spatially uniform property definition
 - Requires spectral data classification
 - Color and transparency by transfer functions
 - Leads to classic *volume rendering*
- Per object property definition
 - Requires spatial identification of objects by segmentation
 - Arbitrary properties of objects in rendering
 - Surface rendering (model-based, direct)
 - Volume rendering with per-object transfer functions

Volume rendering



Volumetric Data

CT, MRI, USG, PET, SPECT



Processing

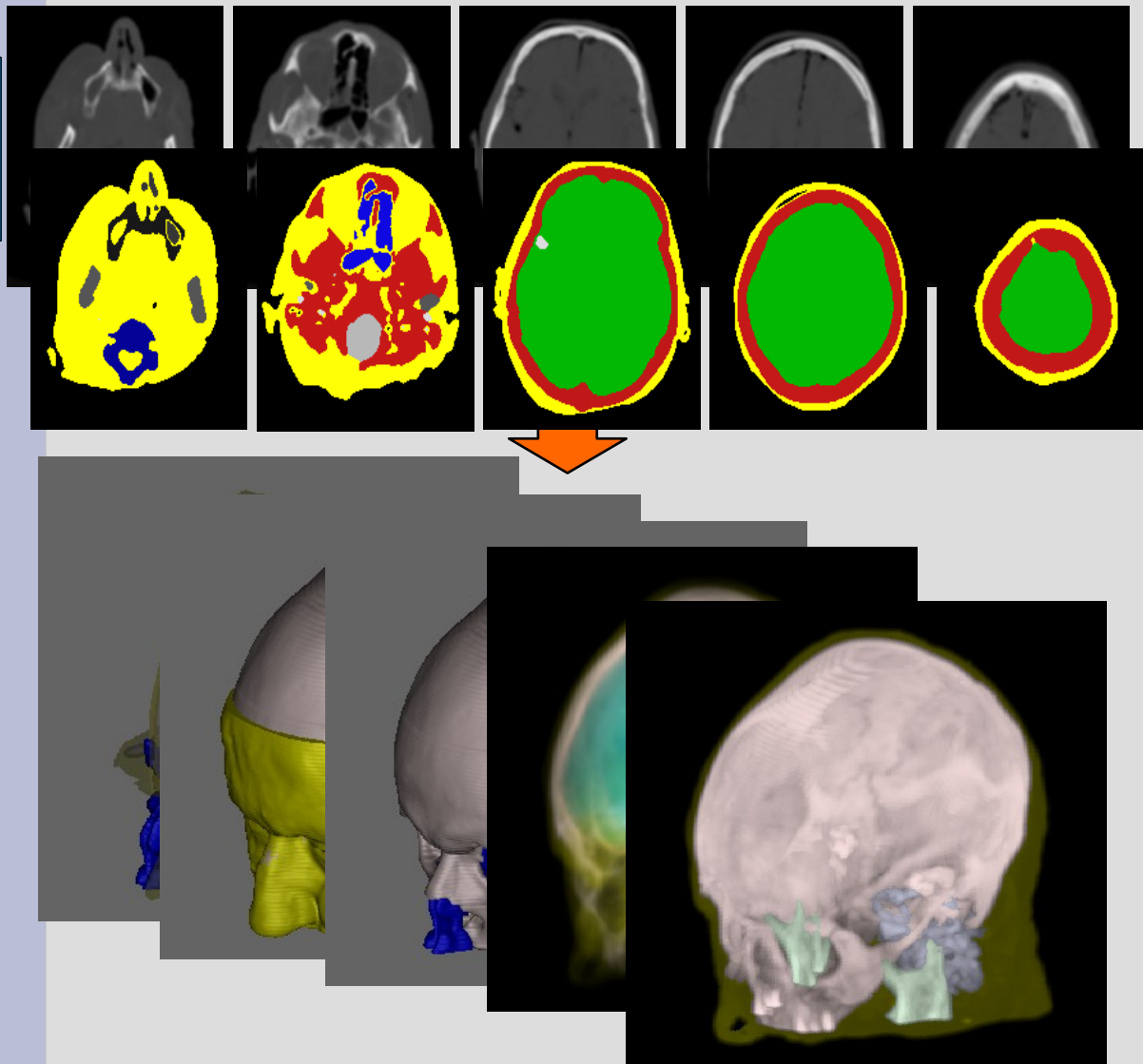
2D & 3D Techniques



Volume Rendering

Transfer Functions

Object-based Rendering



3D Measurement

CT, MRI, US'OG, PET, SPECT



Processing

2D & 3D Techniques



Segmentation

2D & 3D Techniques



Rendering

Surface & Volume Techniques

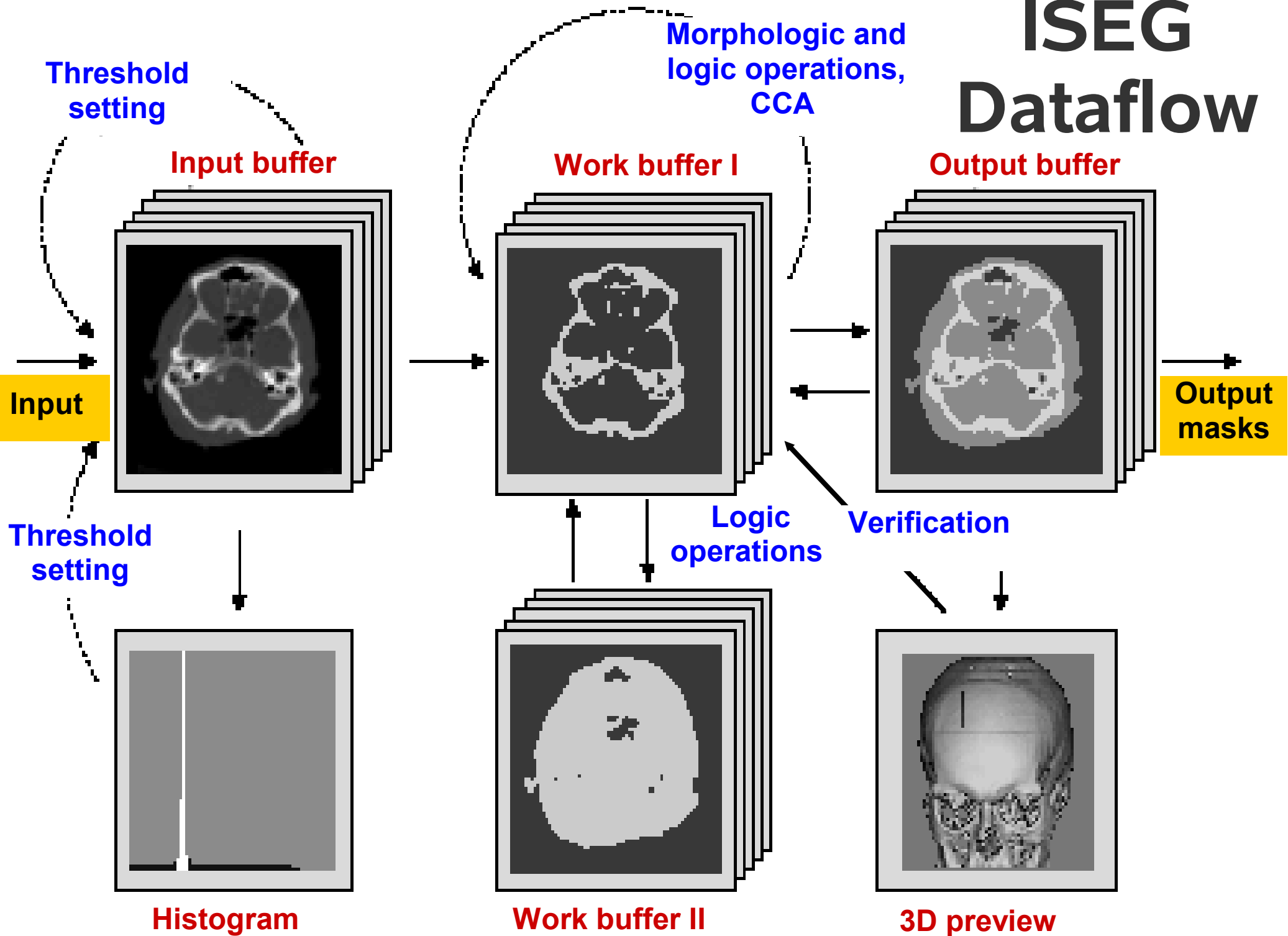
Automatic vs. Interactive Segmentation

- Automatic segmentation
 - Requires hard-wired sequence of operations and rules to accomplish the task
 - Tedious development and single-purpose applications
- Interactive segmentation
 - Implementation of tools, no knowledge representation necessary
 - General purpose
 - Powerful tools required for efficiency

Interactive Segmentation by the ISEG tool

- A technique based on user guided application of simple segmentation operations:
 - Thresholding
 - Morphology
 - Connectivity analysis
- Advantages:
 - Interactivity and feedback

ISEG Dataflow



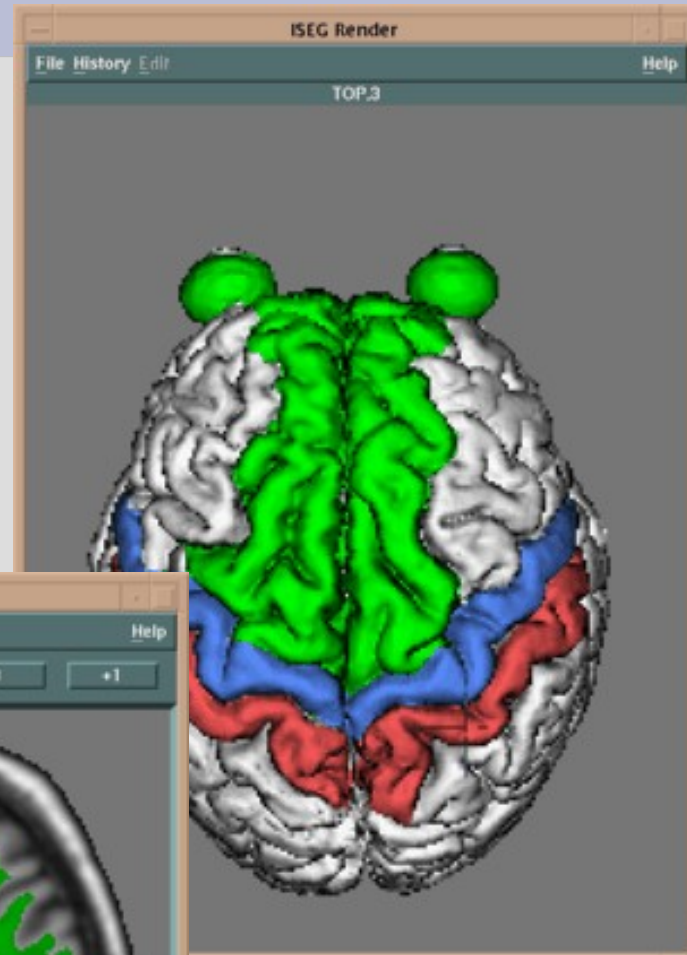
Iseg Implementation



Main window



Histogram



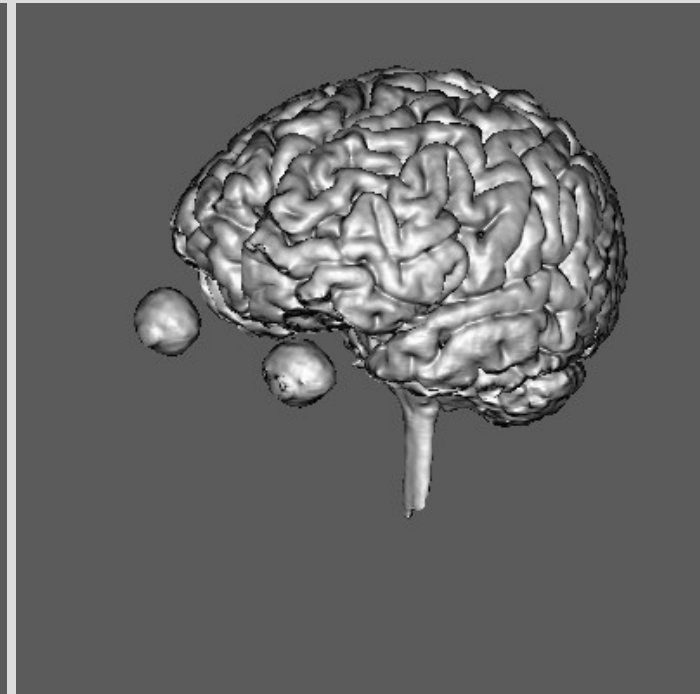
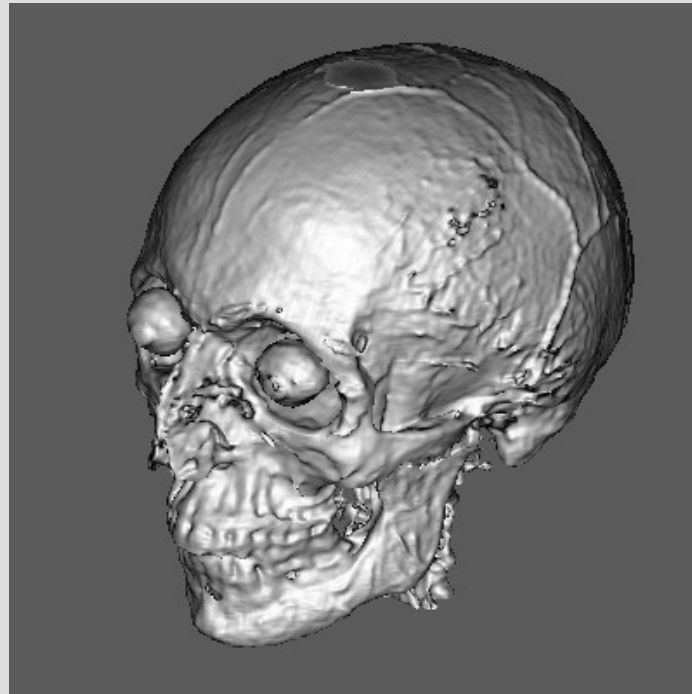
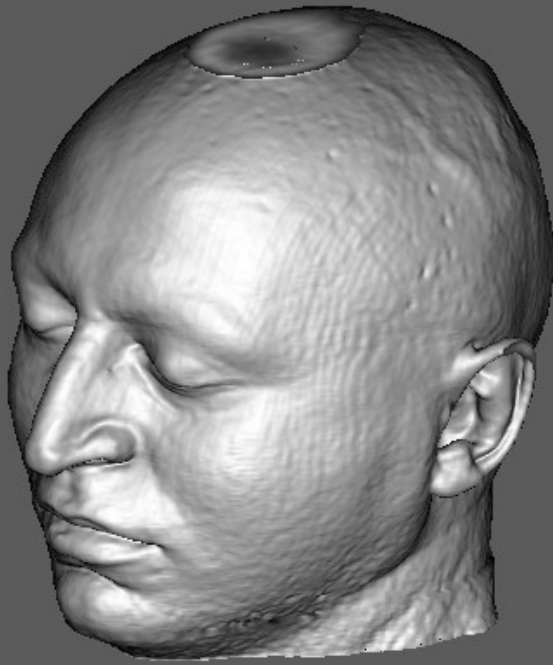
Preview



Edit

Iseg Results

MRI head data segmented in 15 tissues and objects



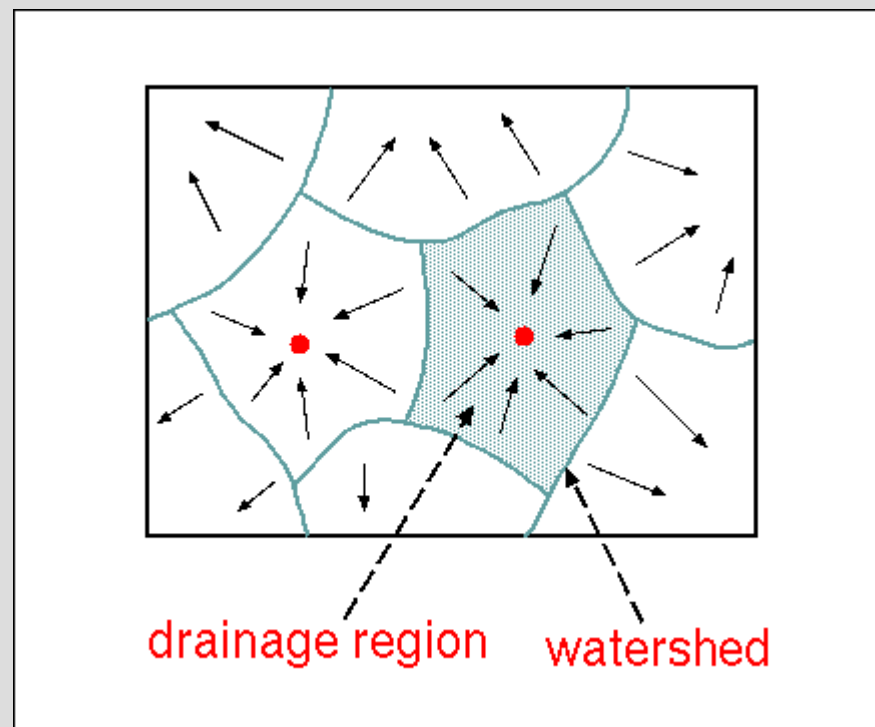
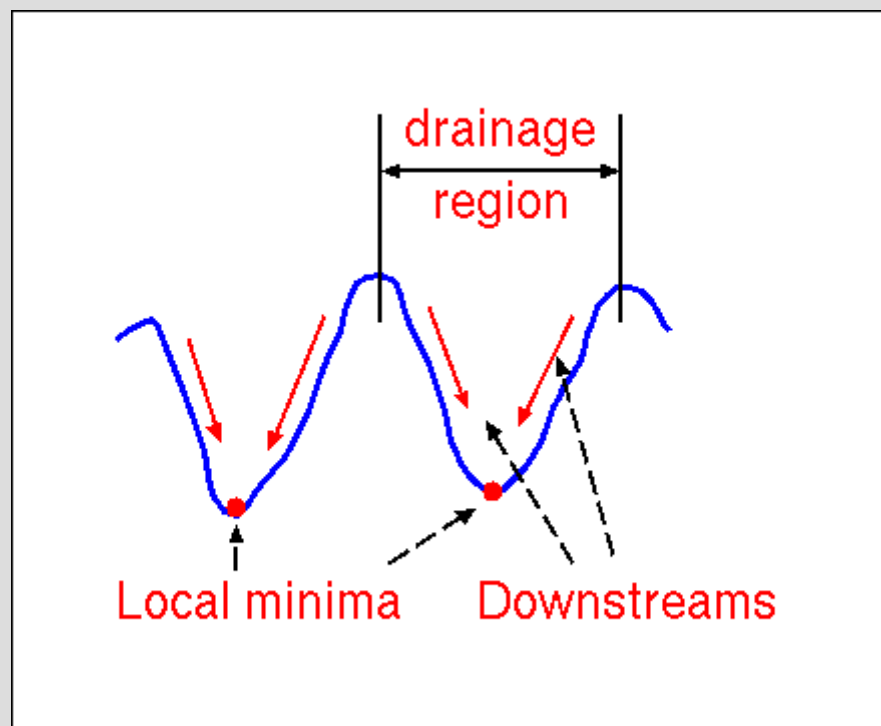
Watershed-based Segmentation

- Watershed: a ridge that separates two adjacent river systems

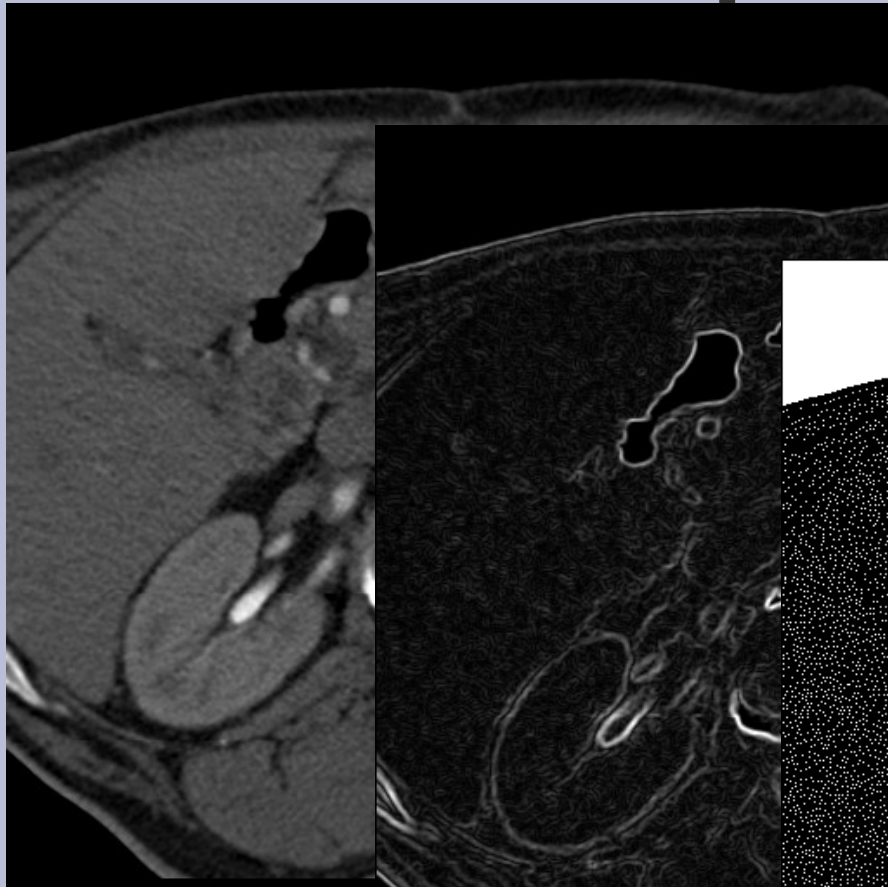


Watershed Segmentation

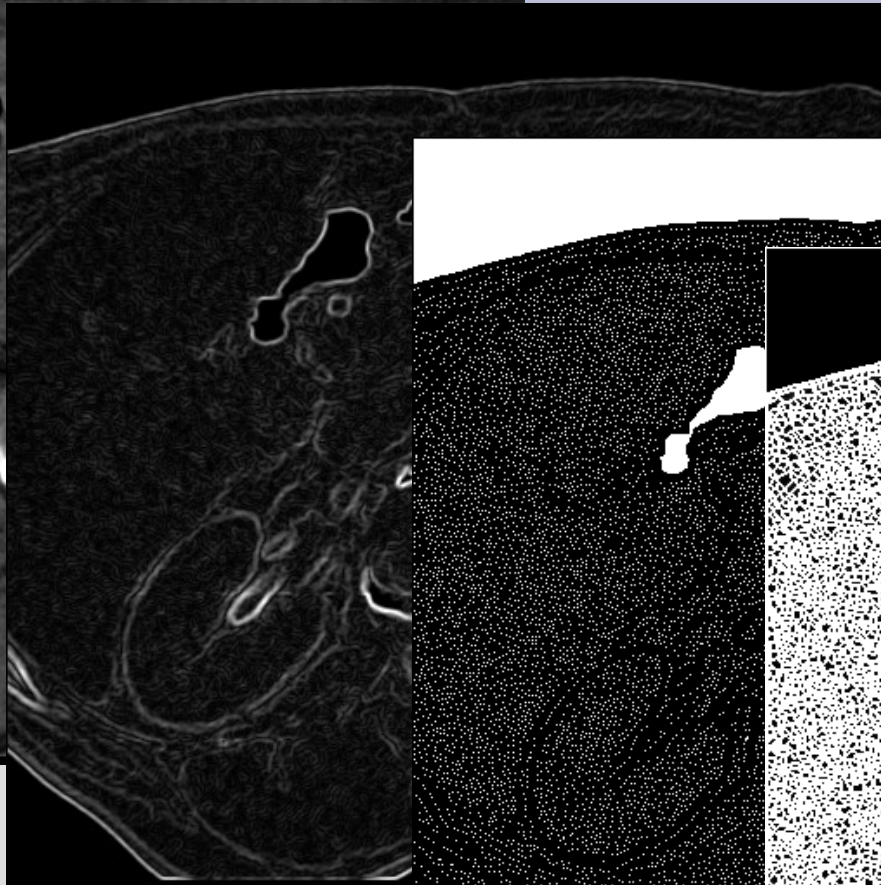
- Waterflow simulation on gradient images:
 - Catchment basins & watershed lines



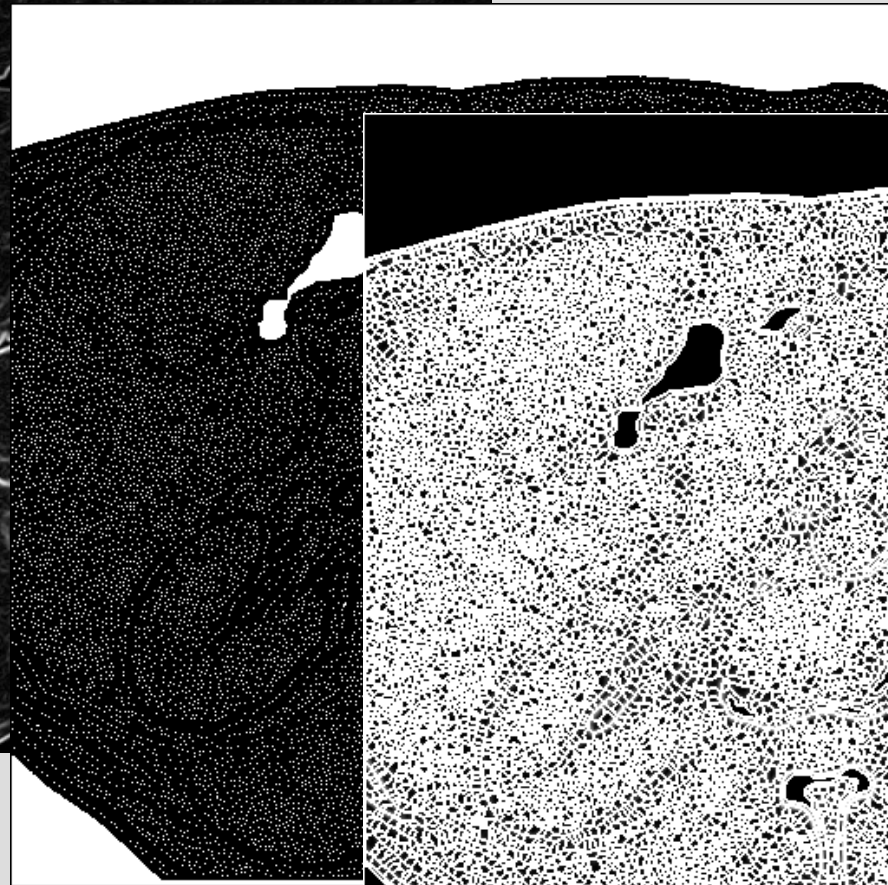
Basic Watershed Implementation



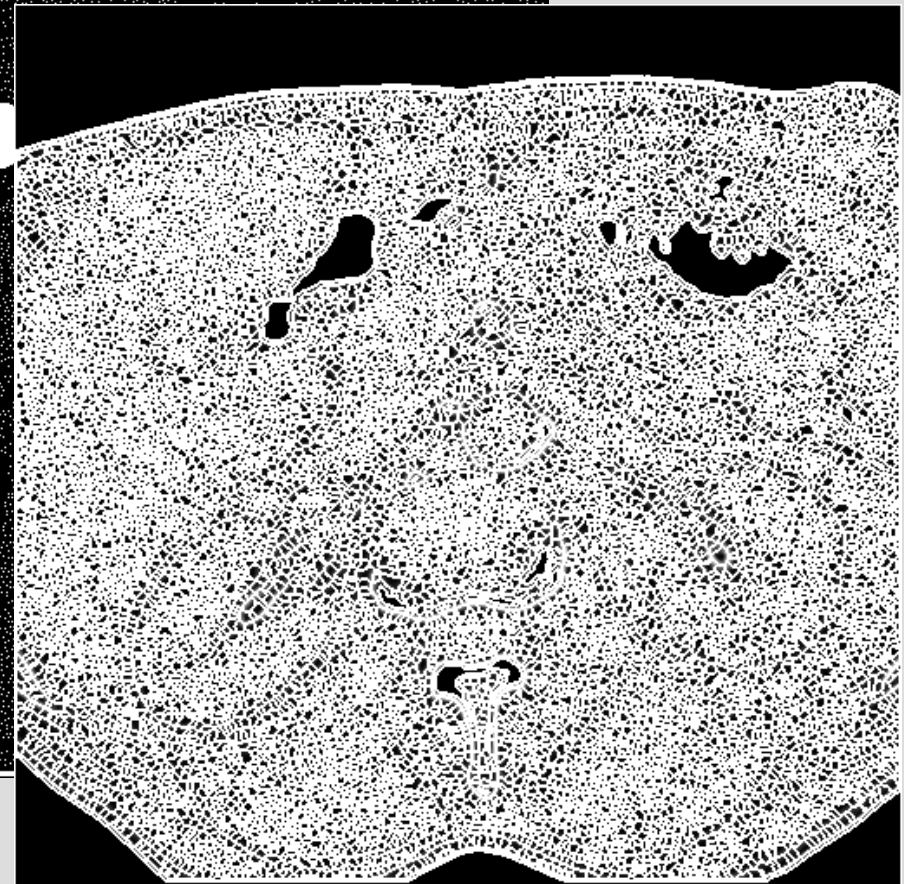
Original



Sobel edges

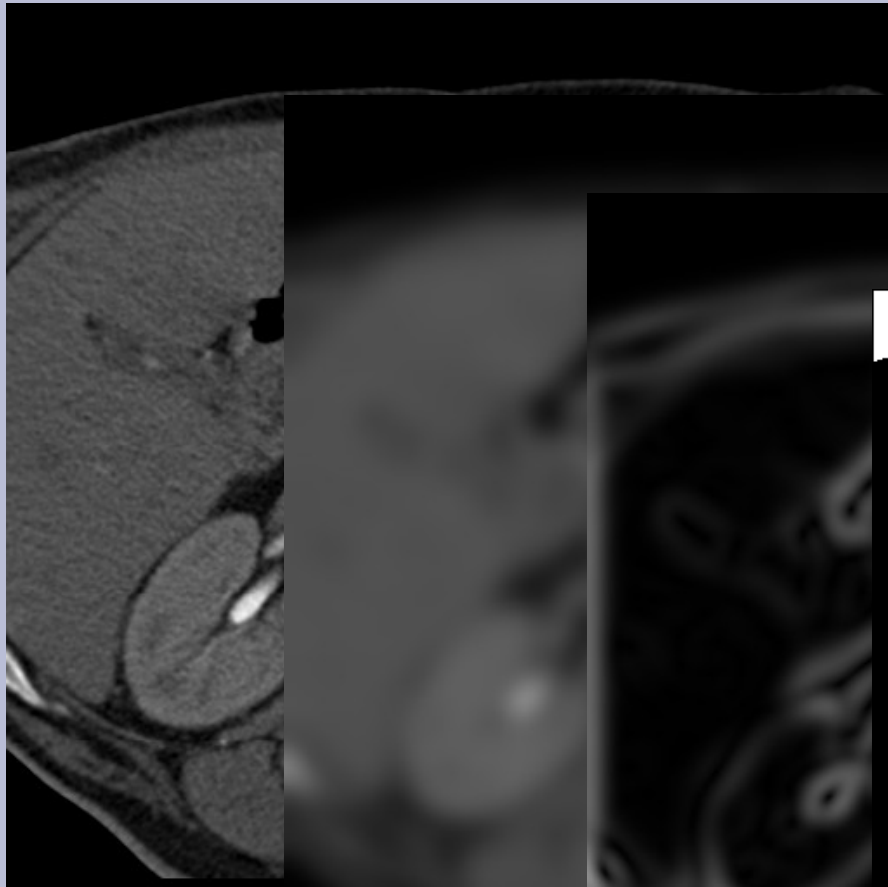


Local minima

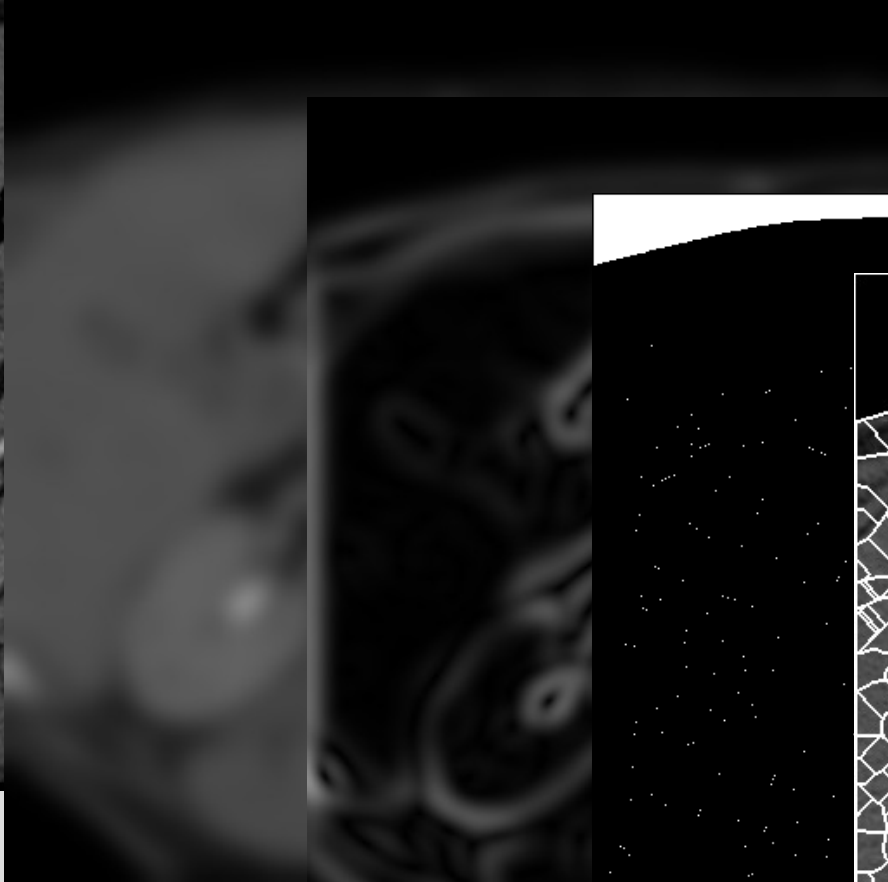


Region boundaries – watersheds

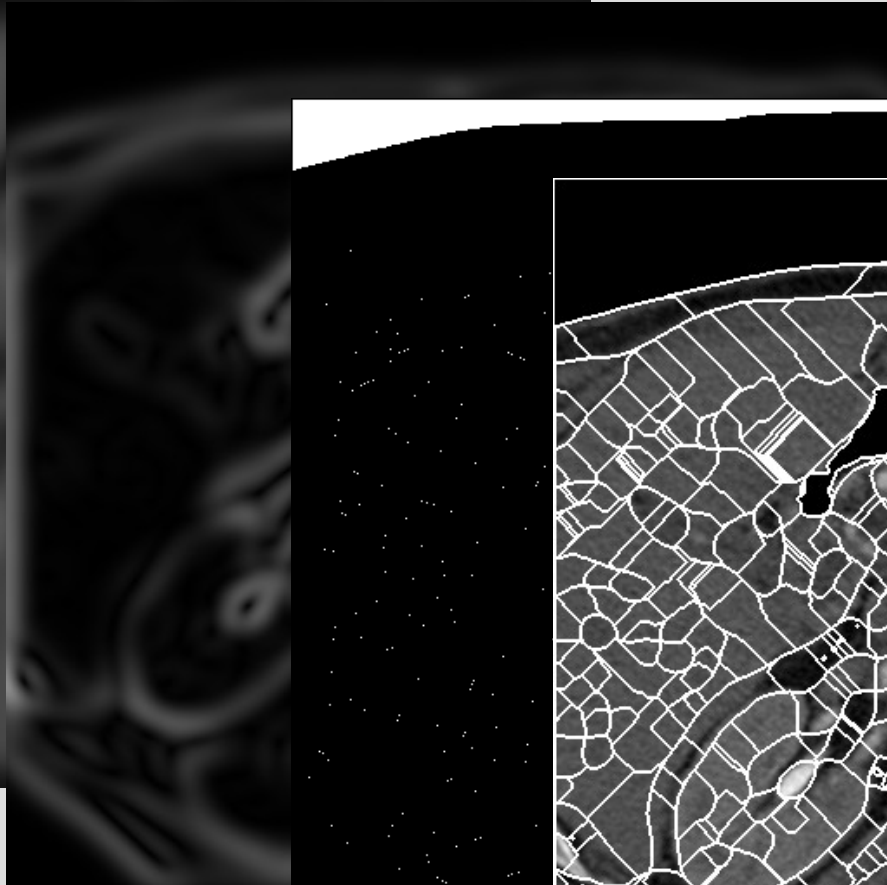
Large Regions by Gaussian Smoothing



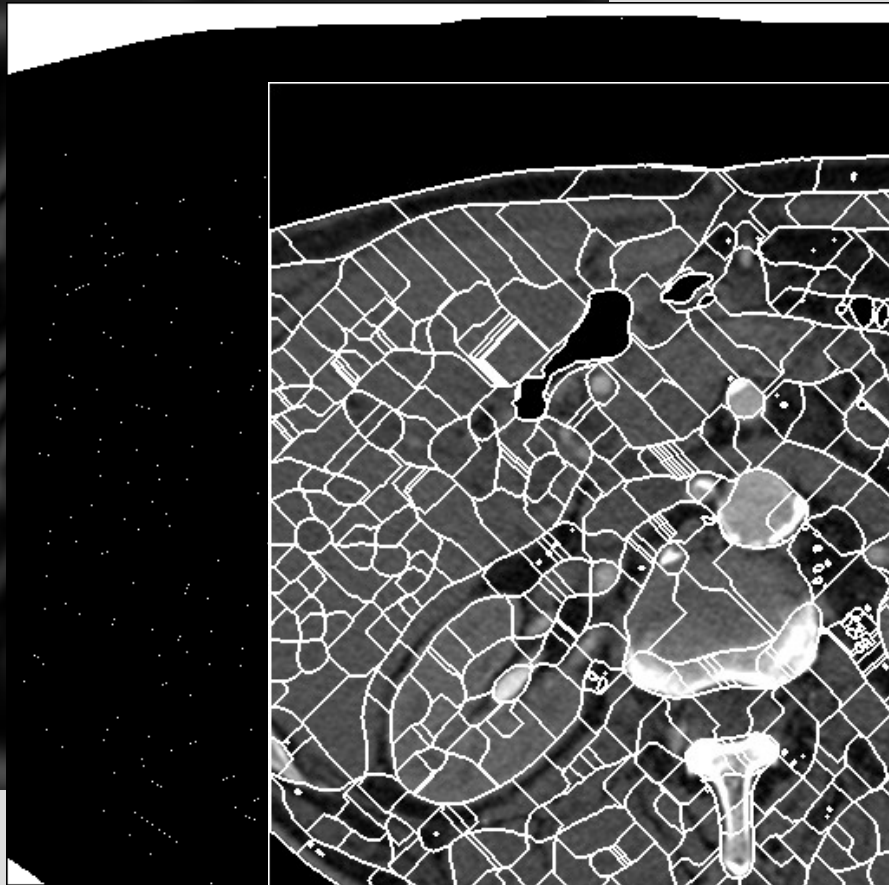
Original



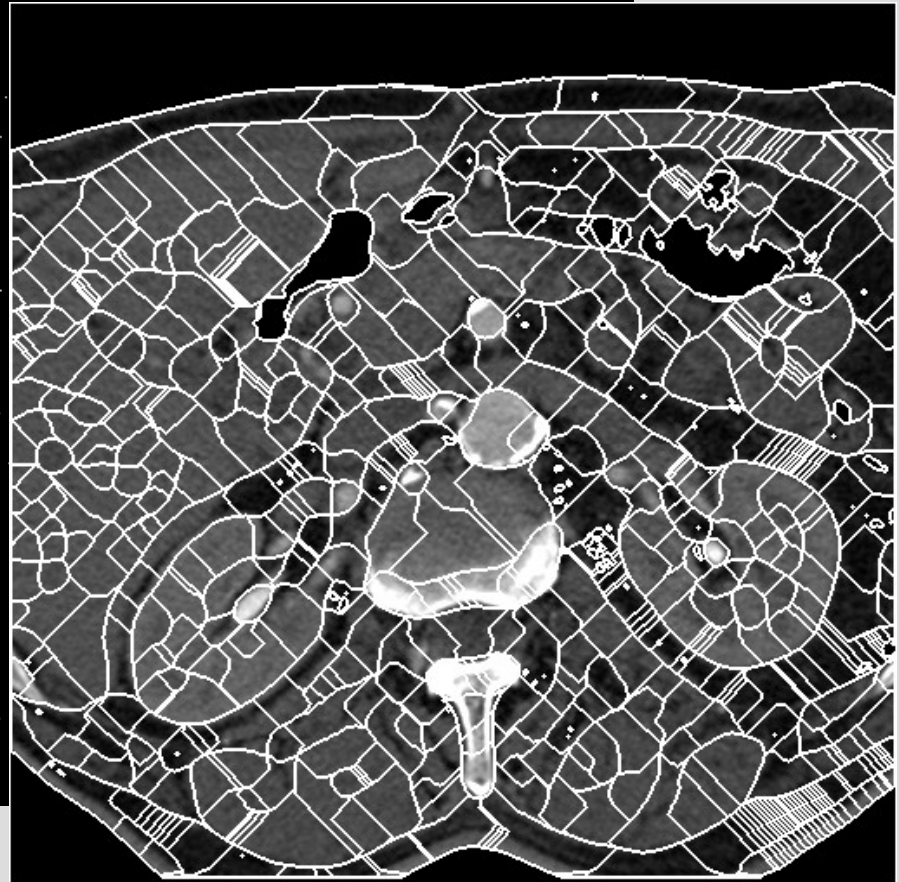
Gaussian blurring, $\sigma=8.0$



Edge detection

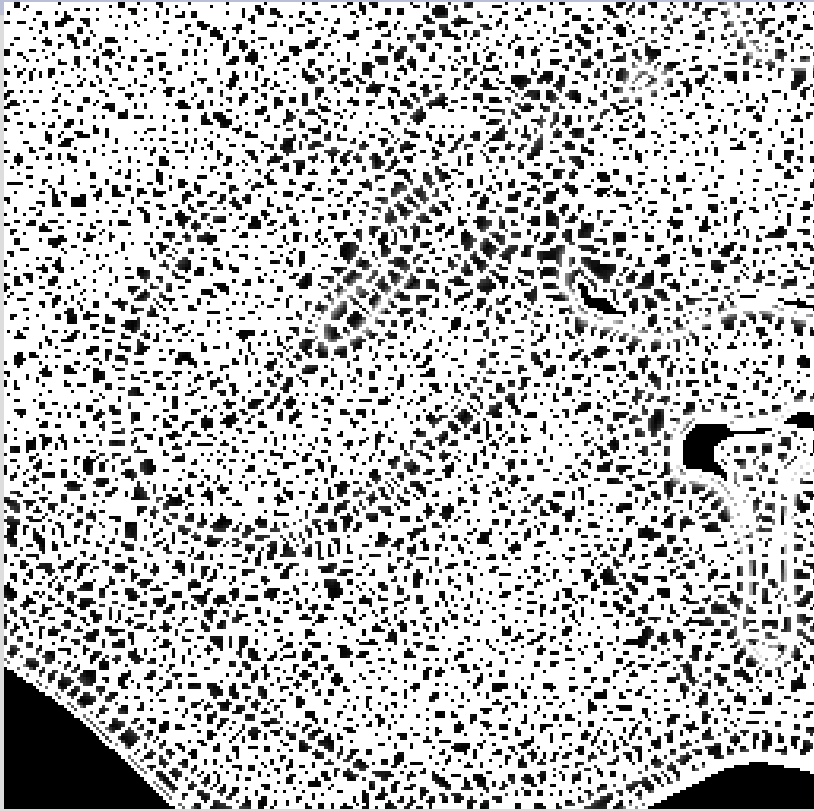


Local minima

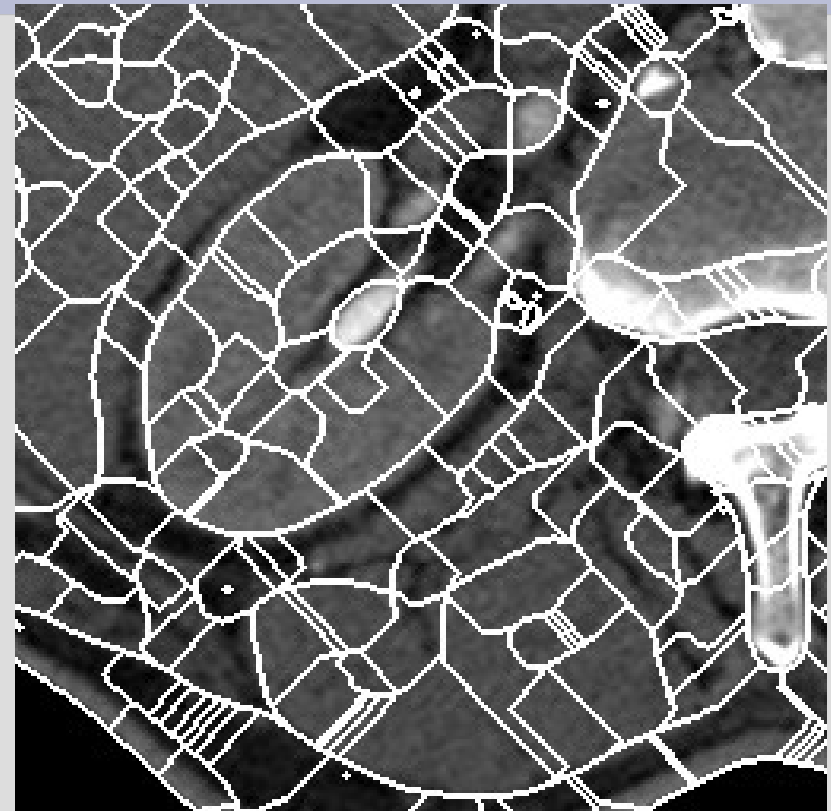


Region boundaries – watersheds

Watershed Drawbacks



No smoothing: numerous
small regions



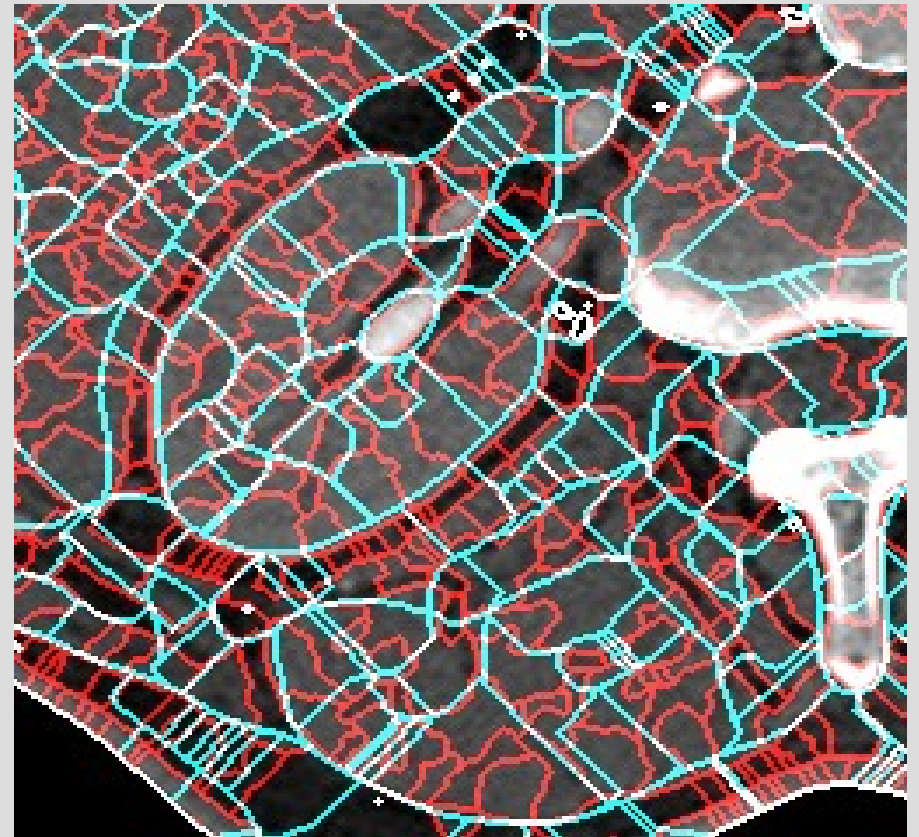
Smoothing: fewer regions
but imprecise contours

The Hierarchical Watershed Transform (HWT)

- **Aimed to override the problems:**
 - Build large regions with precise contours
- **The algorithm:**
 - 1) Build a sequence 1..n of watershed segmentations with an increasing Gaussian σ_i
 - 2) Starting from level 1, *label* each region at level i with a label of the region at level $i+1$ with the highest number of overlapping pixels and *replace* the volume at the level $i+1$ by this result

HWT Contours

- Scale-space approach
- Transfer precise contour information from fine scale levels to coarse ones by region overlapping



HWT Applications

- Multiresolution region hierarchy for image analysis
- Further processing by
 - Similarity-based region merging
 - Interactive hierarchy analysis using a HW accelerated tool



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Thank You!

