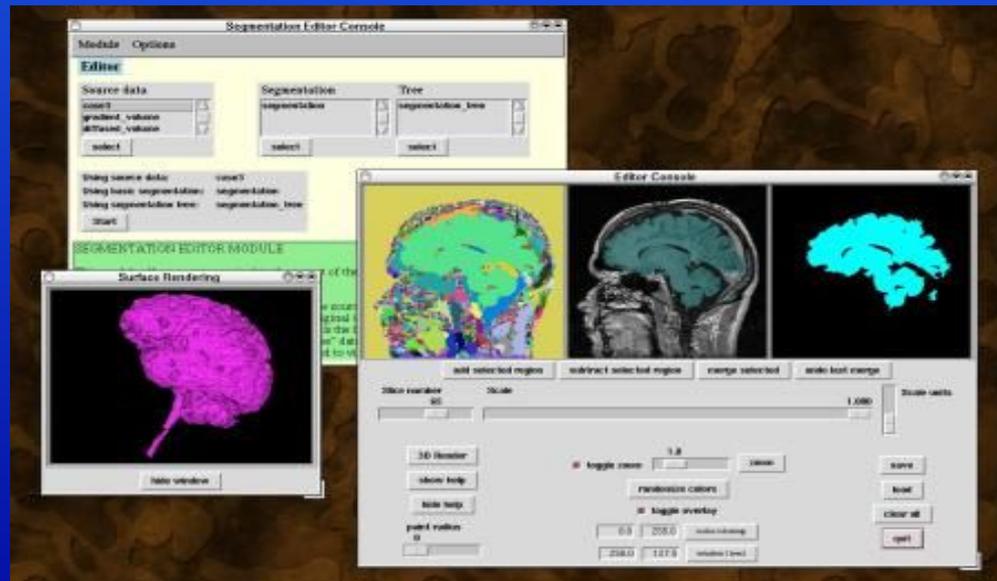


Demo 1

User-assisted Watershed Segmentation



Demo 1: How the segmentation works

A hierarchy of global image segmentations is generated using the watershed transform

The user picks and combines regions from the watershed hierarchy to produce a final segmentation

Demo 1: User-assisted Watersheds

How the application is constructed

- ITK image processing (watersheds)

- VTK visualization

- Tcl/Tk scripted user interface

Watersheds GUI Design

InsightApplications/SegmentationEditor

User

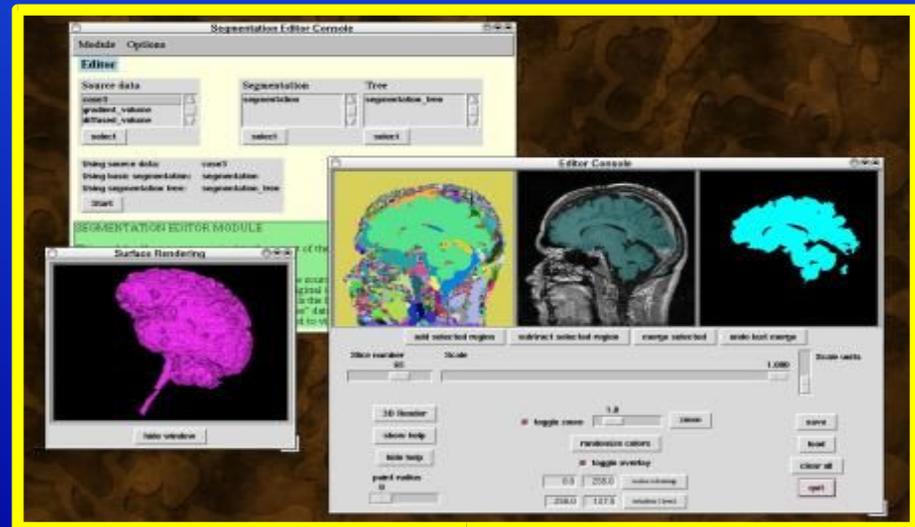
Tk Graphical User Interface

Tcl Wrapper

vtkITK IP Pipeline

VTK Vis. Pipeline

Input Data



Watersheds Interface Overview

The screenshot shows the Watersheds software interface with several key components labeled:

- Watershed transform:** Points to the leftmost window showing a multi-colored watershed segmentation of a brain slice.
- Data with overlay:** Points to the middle window showing the original MRI slice with a green region highlighted.
- Segmentation in progress:** Points to the rightmost window showing a single green region, likely representing a selected watershed.
- Sliders manipulate watershed depth and position in the hierarchy:** Points to the control panel below the main windows, which includes sliders for 'Scale' and 'HSTP', and buttons for 'fill locator', 'show help', 'help help', 'point radius', and 'change point value'.
- 3D isosurface rendering:** Points to the 'Surface Rendering' window at the bottom right, which displays a 3D yellow isosurface of the segmented region.

A dashed box on the left contains a **Watershed Depth Threshold** graph. The y-axis is labeled 'Watershed Depth Threshold' and the x-axis is unlabeled. The graph shows a hierarchical tree structure with nodes of various colors (green, orange, red, blue, black, white) representing different levels of the watershed hierarchy.

Demo 1: User-assisted Watersheds

This demo leads you through a segmentation of a brain tumor in a 3D MRI dataset using the Watershed Segmentation Editor.

How to run the demo program

Click once on the “Demo 1” icon

Follow the instructions in the green windows

Watershed segmentation theory.

The remainder of this document outlines the theory behind the watershed segmentation algorithm and some validation work conducted at the University of Utah. This material is helpful for understanding the demo. It is not necessary for running the demo.

Morphological Watersheds Theory

Large body of research over 20 years

Inspired by hydrology – treat image as landscape and look for its watershed regions

“Watershed Transform” – the algorithm that identifies the watershed regions

Main Variations

- ✓ Top-down: classify pixels by shortest *topological* distance to local minima
- × Bottom-up: simulated immersion algorithms

- L. Vincent, P. Soille, Watersheds in digital spaces: An efficient algorithm based on immersion simulations, PAMI 13 (6) (1991) 583–598.

ITK Watershed Transform

Image treated as a topological relief map –
intensity represents height

Gradient descent defines ***segmented regions***

- Set of all pixels whose paths of steepest descent terminate in same local minimum
- Bounded by image features

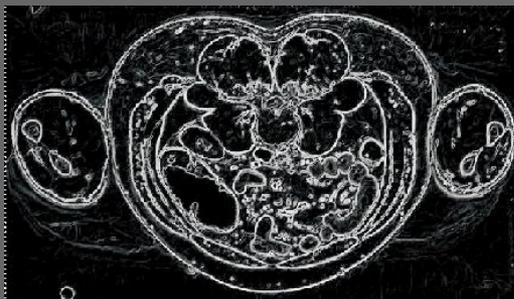
Global – operates on entire image at once

No parameters except preprocessing

The Watershed Transform Illustrated



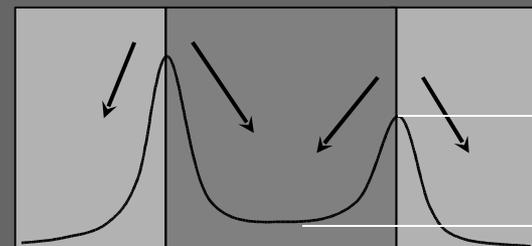
Image (filtered)



Feature Extraction
"Edge Map"



Watershed Transform



Watershed Depth

The Oversegmentation Problem

Watershed transform produces too many regions

- One per local minimum
- Especially in noisy or highly detailed data

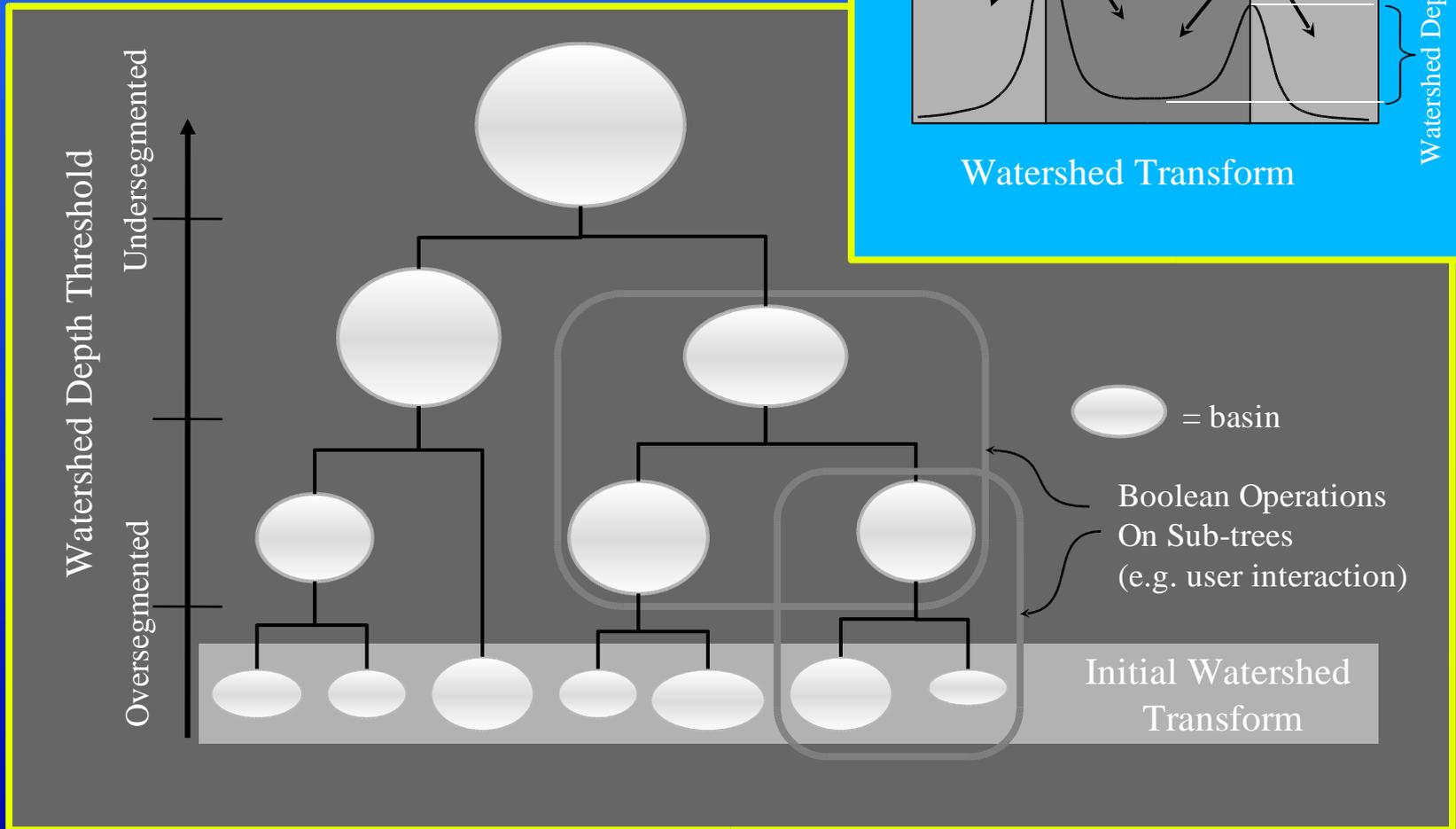
To alleviate oversegmentation

- ✓ Hierarchical approach – merge adjacent regions according to increasing *watershed depth*

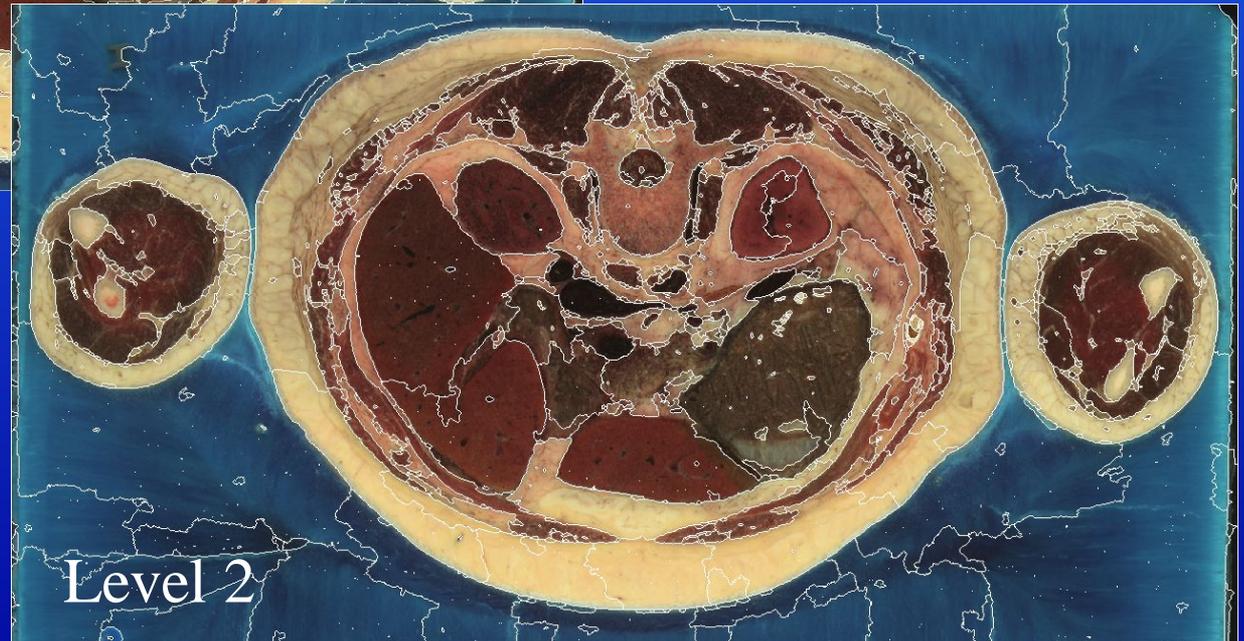
- A. P. Mangan, R. T. Whitaker, Partitioning 3D surface meshes using watershed segmentation, IEEE Transactions on Visualization and Computer Graphics 5 (4) (1999) 308–321.

Watersheds Hierarchy

Enforce minimum watershed depths at successively higher levels.



Reducing Oversegmentation with Hierarchies

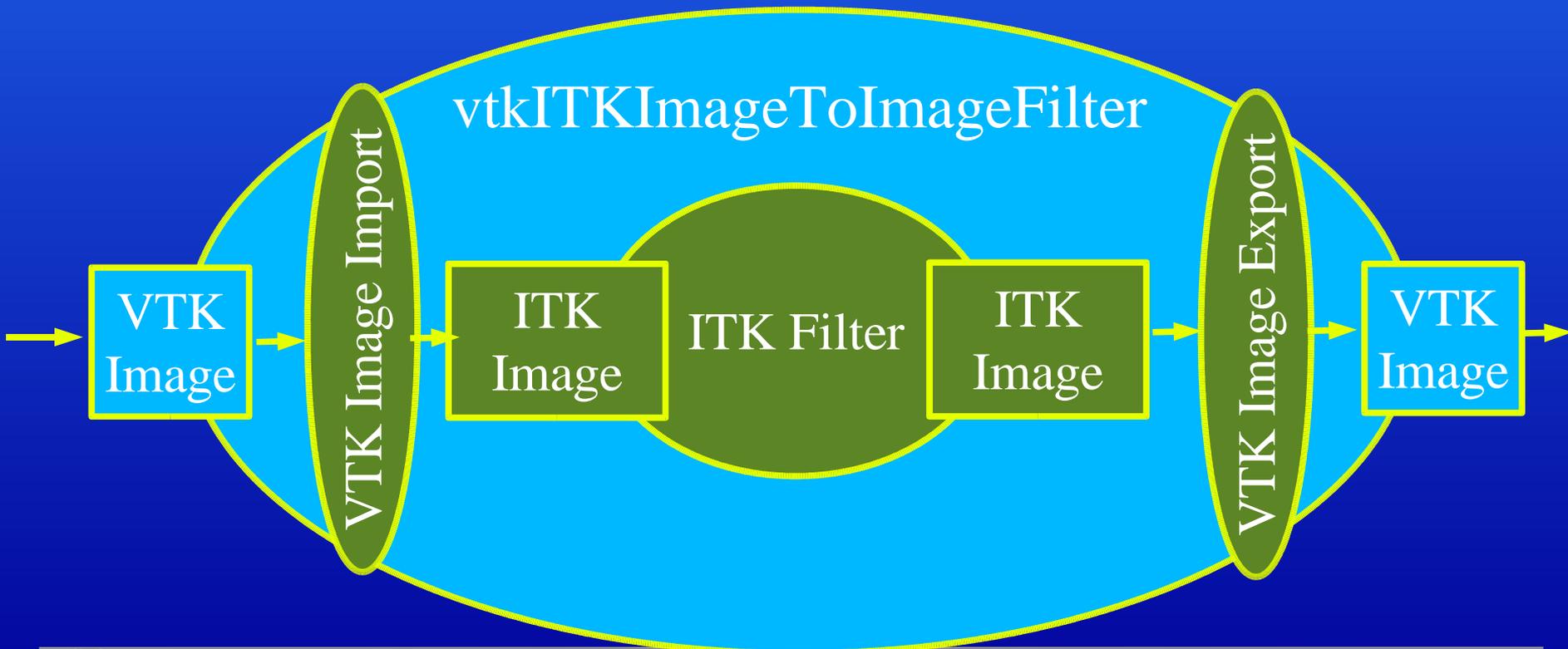


How is ITK integrated with VTK? vtkITK

InsightApplications/vtkITK

Mechanism for converting ITK filters into VTK filters

VTK wrapped for Python, Tcl, Java



Interactive Watersheds Validation: User Study

Comparison of user-assisted hierarchical watersheds with hand-contouring

Hand contouring

- *De facto* standard
- General and reliable(?)

Issues

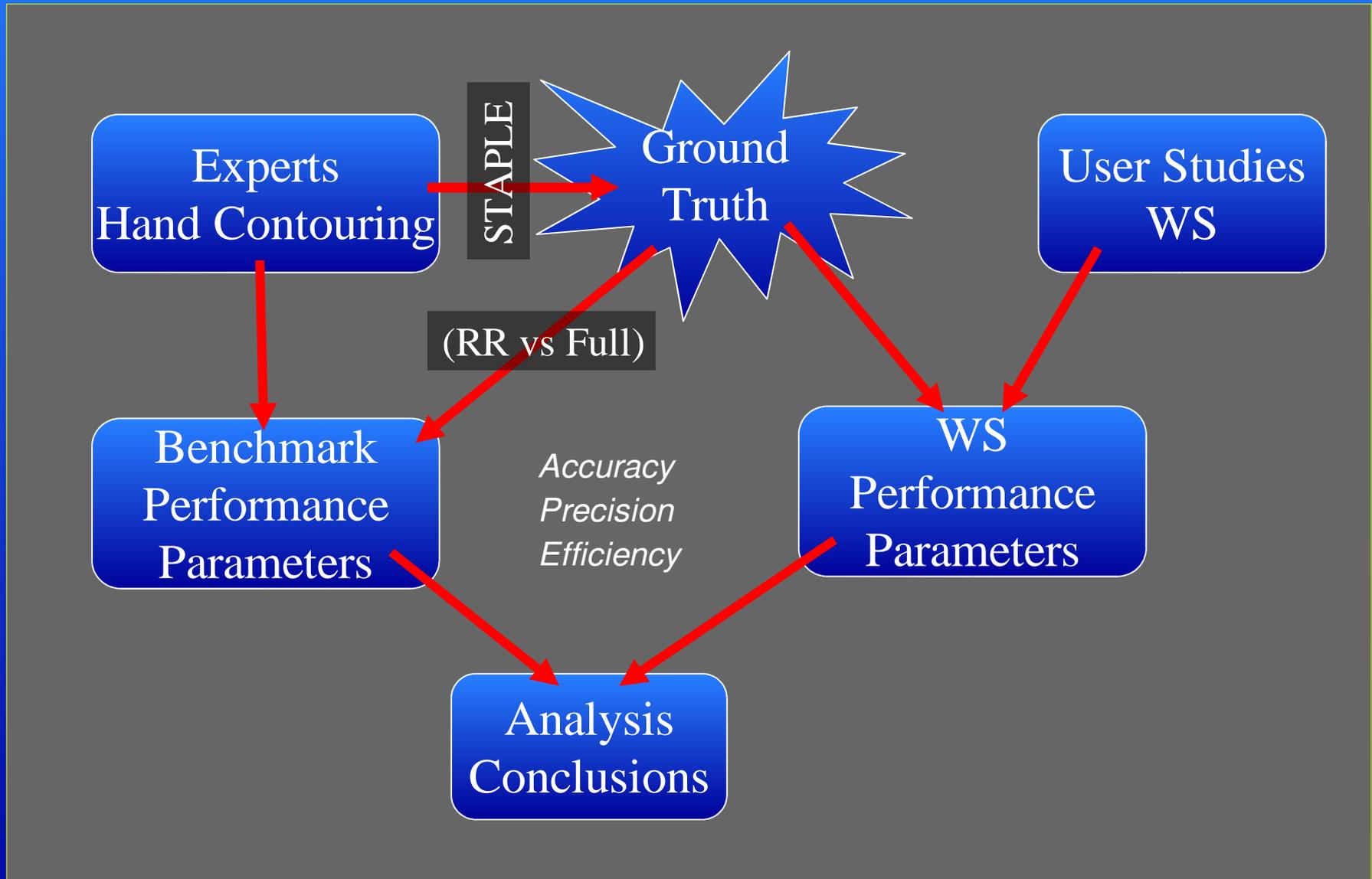
- Can a general purpose segmentation algorithm compete?
- **(Are our validation tools up to the task?)**

Cates, Whitaker, Jones, "Case Study: An Evaluation Of User-Assisted Hierarchical Watershed Segmentation", Medical Image Analysis, Under review.

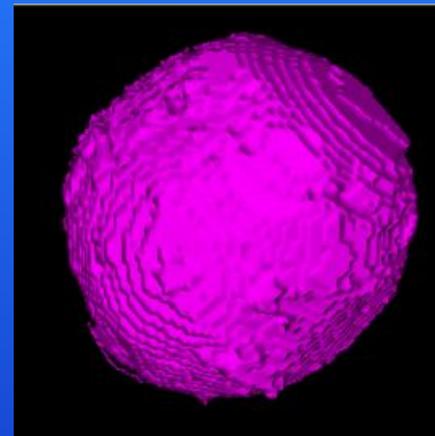
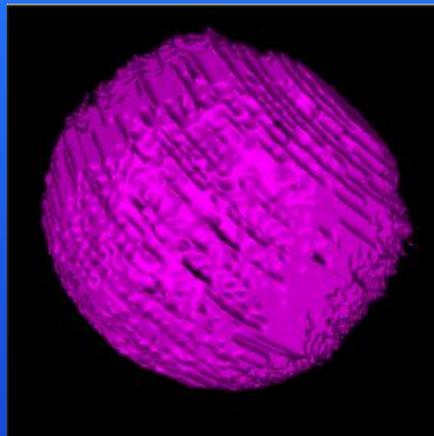
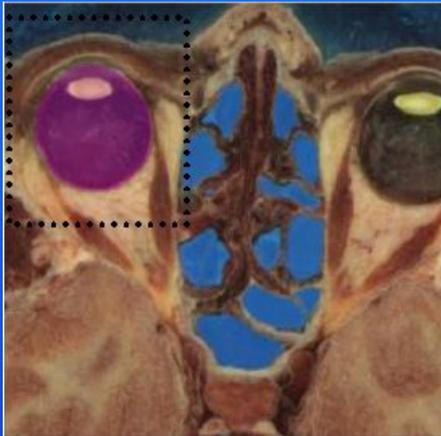
User Study Overview

	Ground Truth Subjects (Slicer)	WS Segmentation Subjects
MRI Brain Tumor (4 cases)	Slice from HBW BT database (4 per case)	Radiologists (3) from Univ of Utah
VHP Cryosection (Eyeball, optic nerve, lateral rectus)	3rd-year med. students at HBW and Utah (EB-4, ON-3, LR-8)	3rd-year med. students at Utah (7)

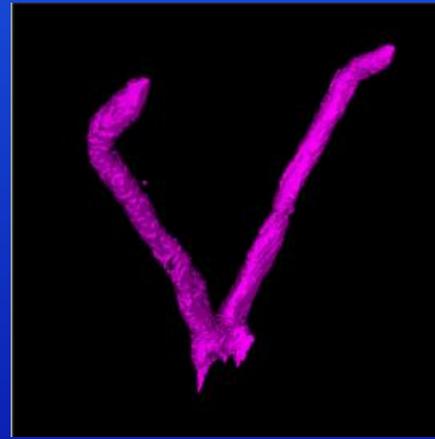
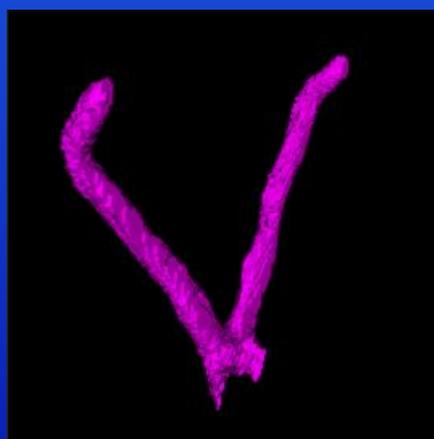
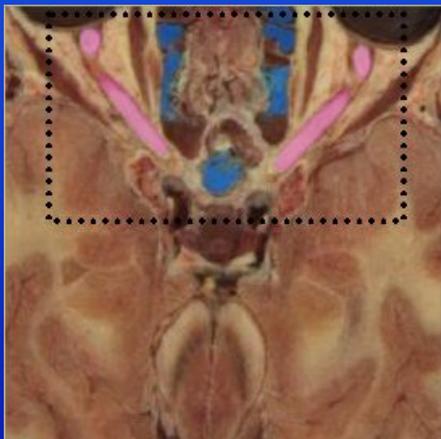
Validation Strategy



Validation Results



Eyeball



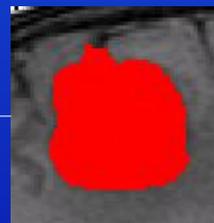
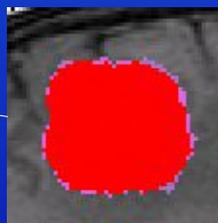
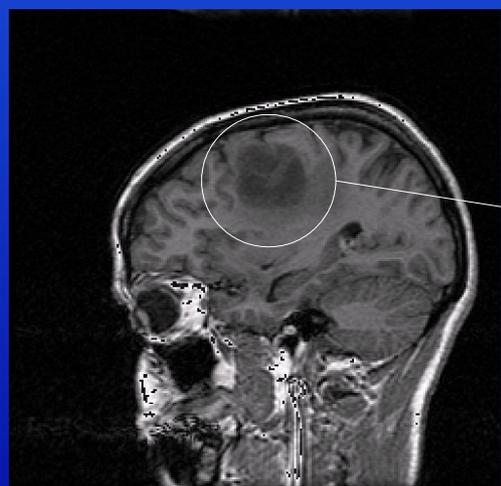
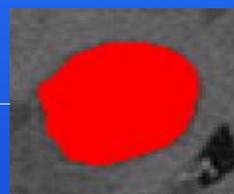
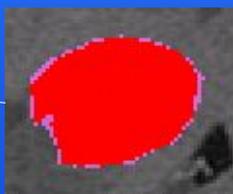
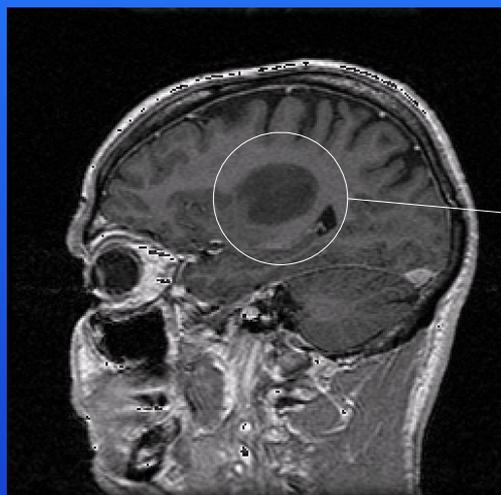
Optic nerves

Data

Hand contour

Watersheds

Validation Results

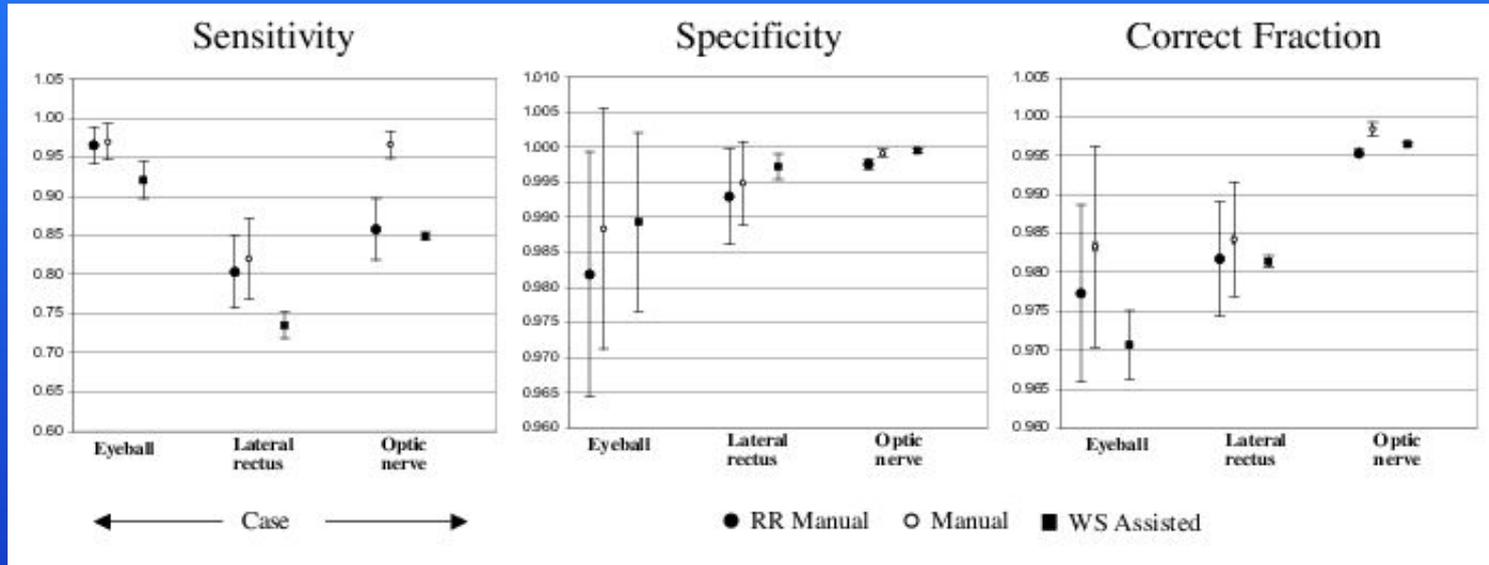


Hand contour

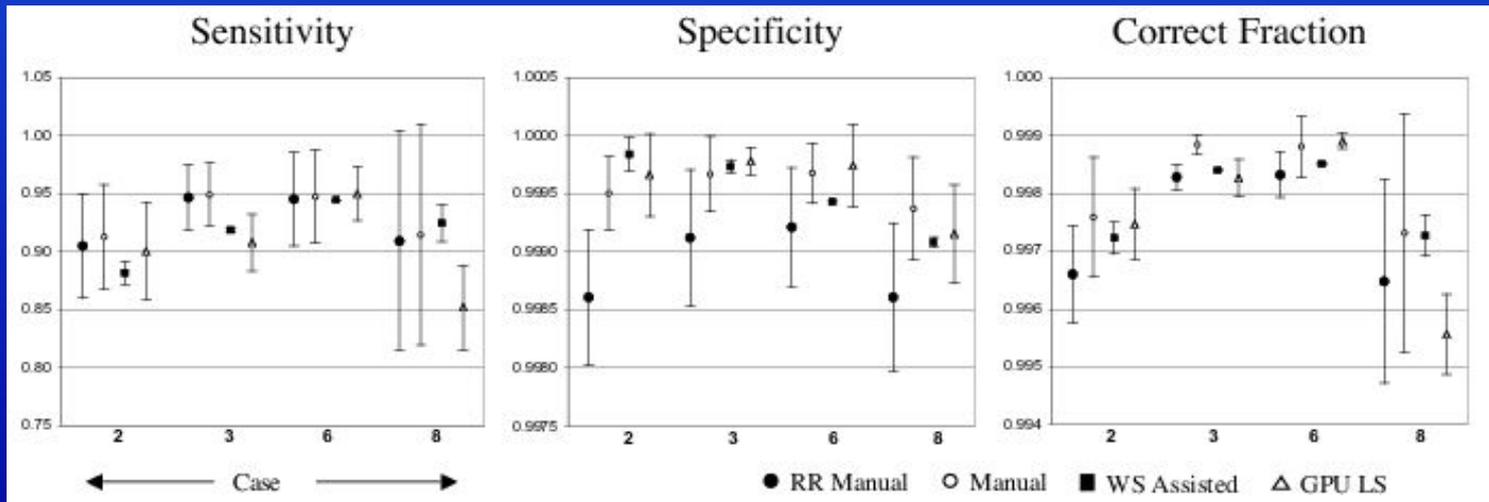
Watersheds

Validation Results

Visible Human cryosections



Brain tumor MRI



Summary of Validation Results

Accuracy

- Sensitivity (TPF) is generally low
- Total correct fraction generally within variation of experts (better for tumor data)
- Generally better than *level-set* approach

Precision

- Significantly better than both hand contouring and level-set

Efficiency

- Versus hand contouring, no comparison (30 min vs. 2-3 hours)
- Versus level-set, more preprocessing and comparable user times

Time/expertise to tune hidden parameters issue

Validation Conclusions

Watershed Segmentation

- WS probably makes more sense vs hand contouring in many applications
- True positive fraction is an issue – could tune for that metric

Validation

- Rich set of systematic tools
- Pixel-based – shape metrics lacking
- Hand contouring for ground truth questionable