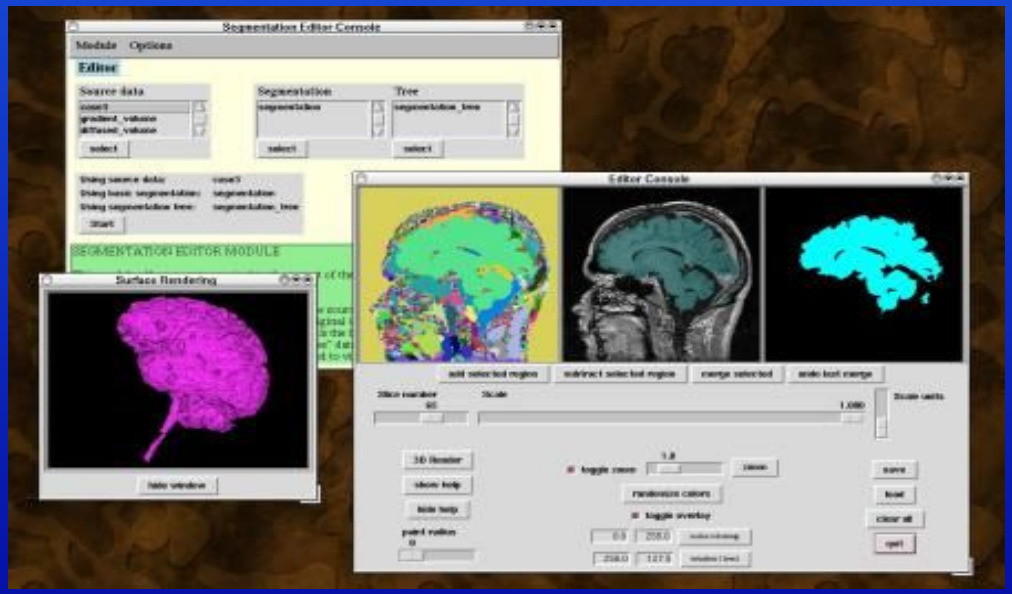
Demo 1
User-assisted Watershed Segmentation



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

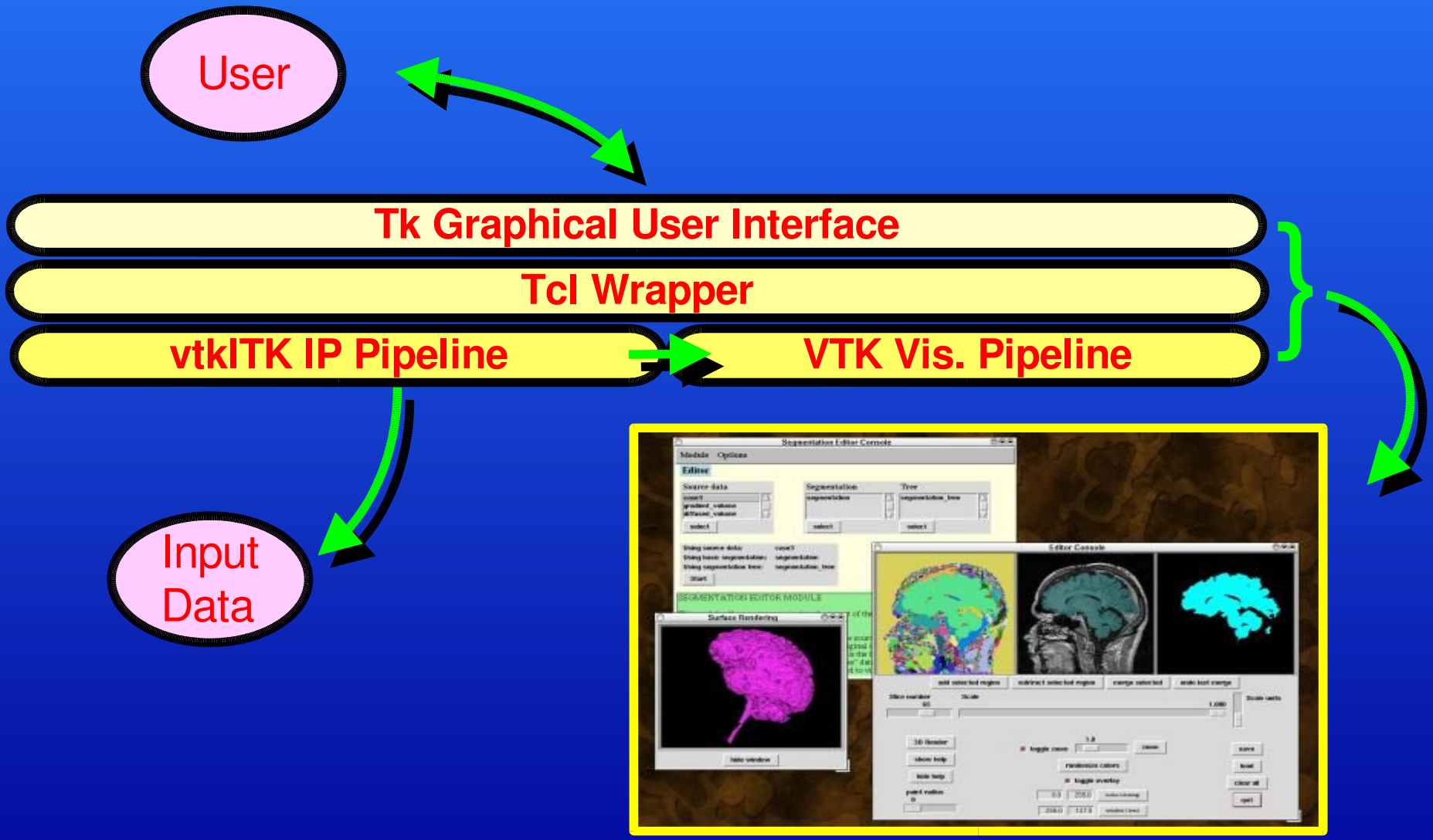
Demo 1: User-assisted Watersheds

How the application is constructed

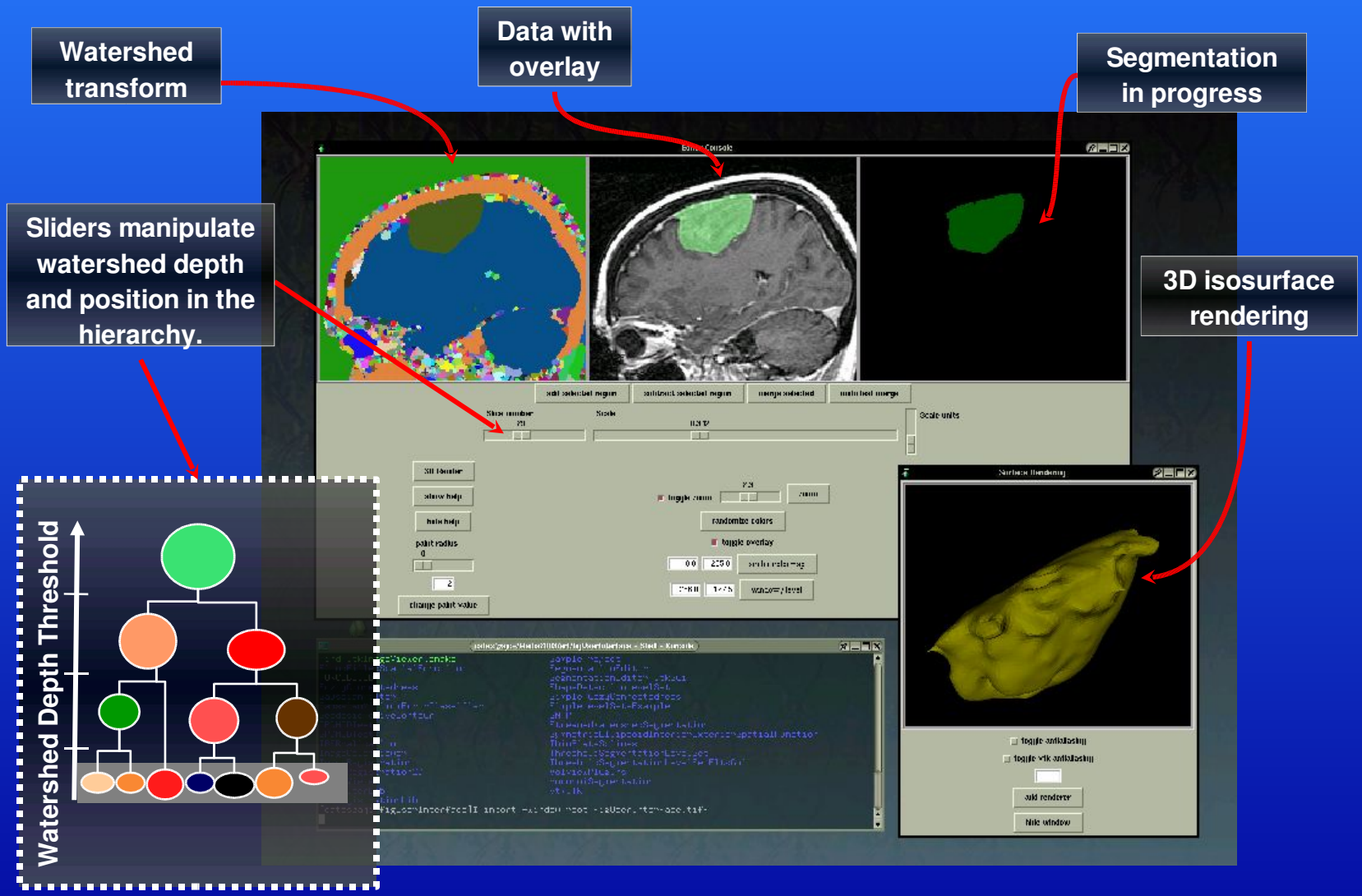
- ITK image processing (watersheds)
- VTK visualization
- Tcl/Tk scripted user interface

Watersheds GUI Design

InsightApplications/SegmentationEditor



Watersheds Interface Overview



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

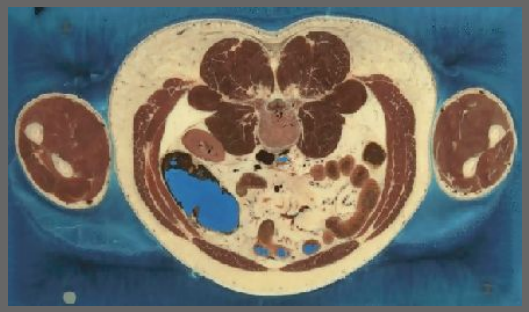
Gradient descent defines ***segmented regions***

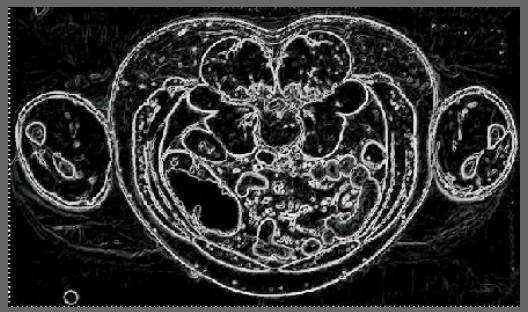
- Set of all pixels whose paths of steepest descent terminate in same local minimum
- Bounded by image features

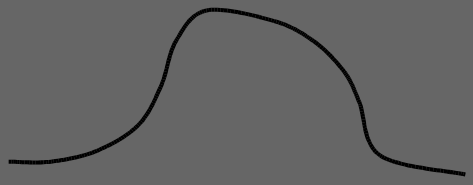
Global – operates on entire image at once

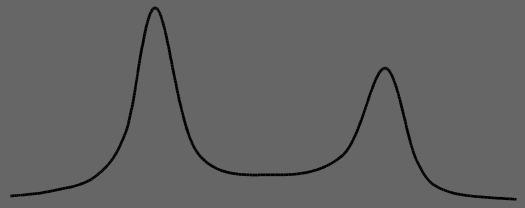
No parameters except preprocessing

The Watershed Transform Illustrated









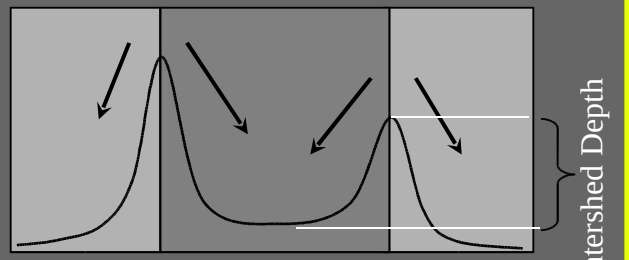


Image (filtered)

Feature Extraction
" Edge Map"

Watershed Transform

The Oversegmentation Problem

Watershed transform produces too many regions

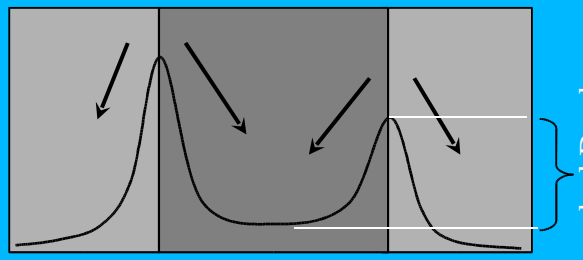
- One per local minimum
- Especially in noisy or highly detailed data

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.**

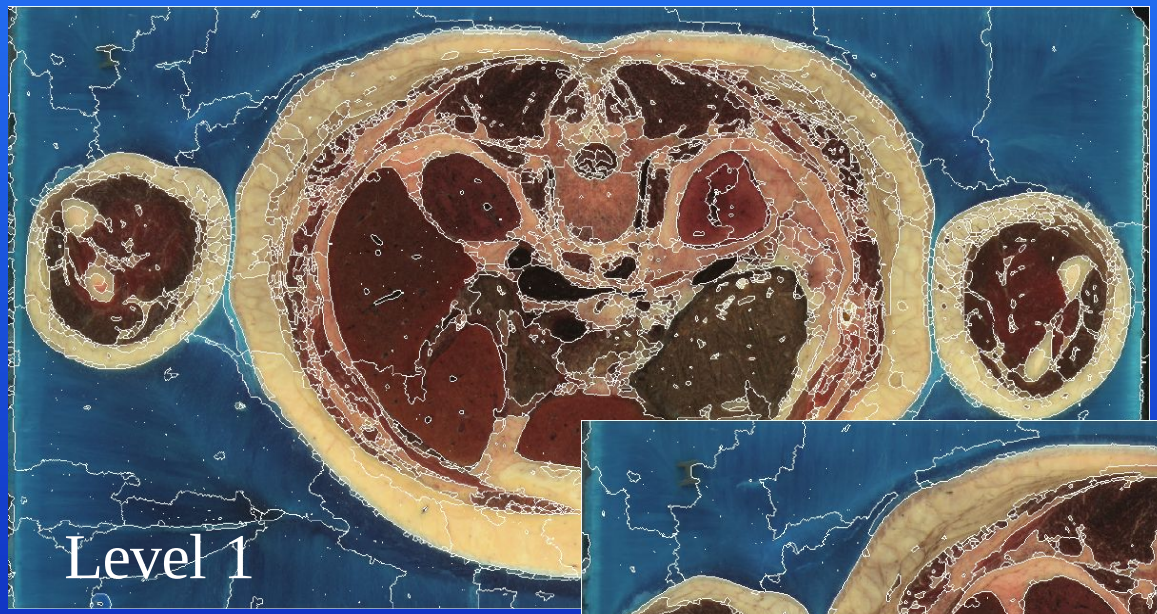
Watersheds Hierarchy

Enforce minimum watershed depths at successively higher levels.



Watershed Transform

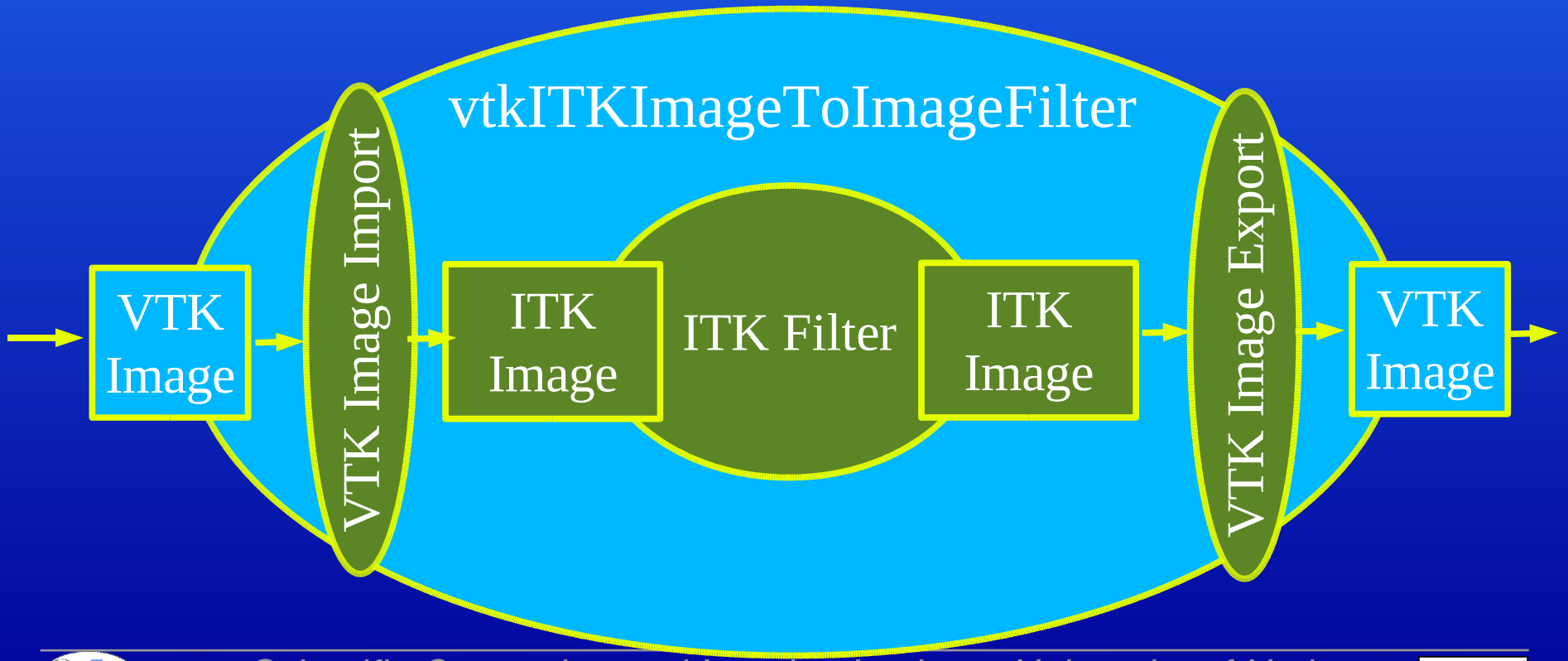
Reducing Oversegmentation with Hierarchies



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

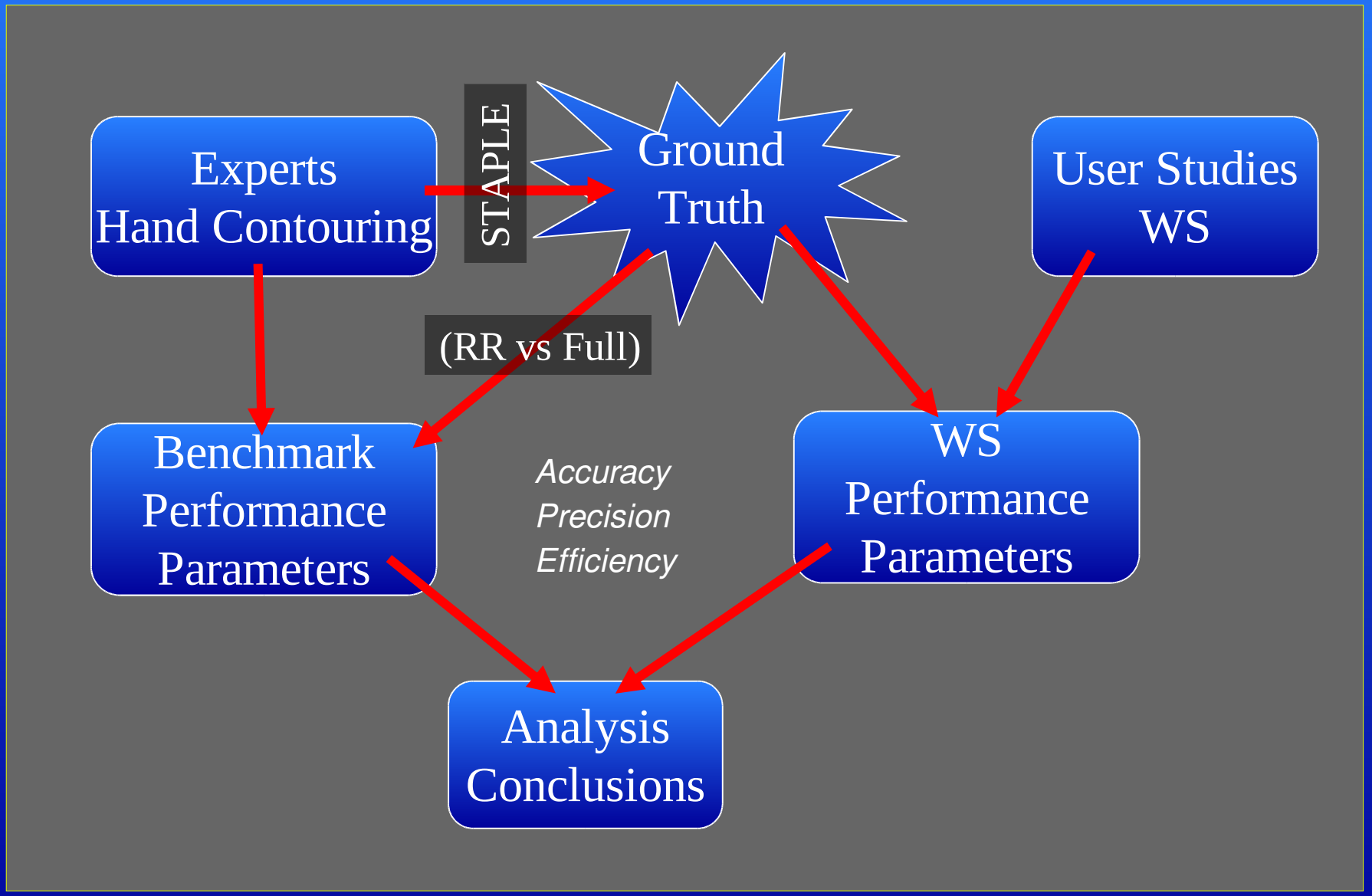
- Can a general purpose segmentation algorithm compete?
- (Are our validation tools up to the task?)

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

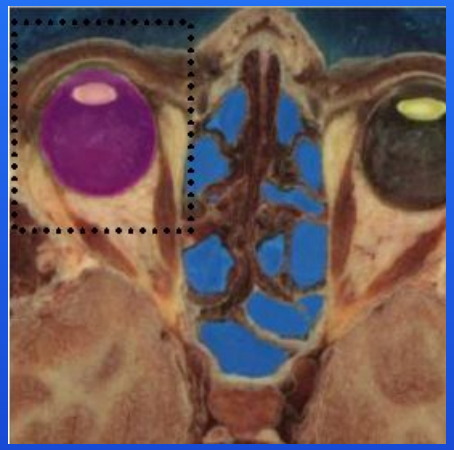
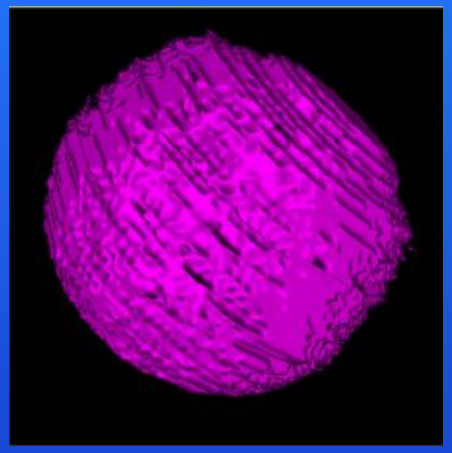
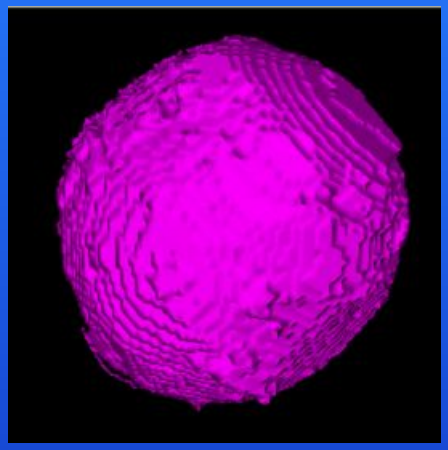
User Study Overview

	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)

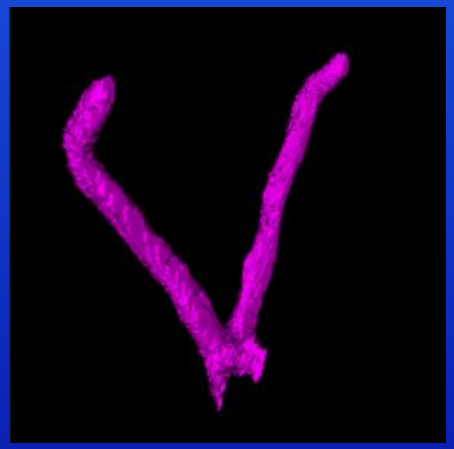
Validation Strategy



Validation Results

Eyeball

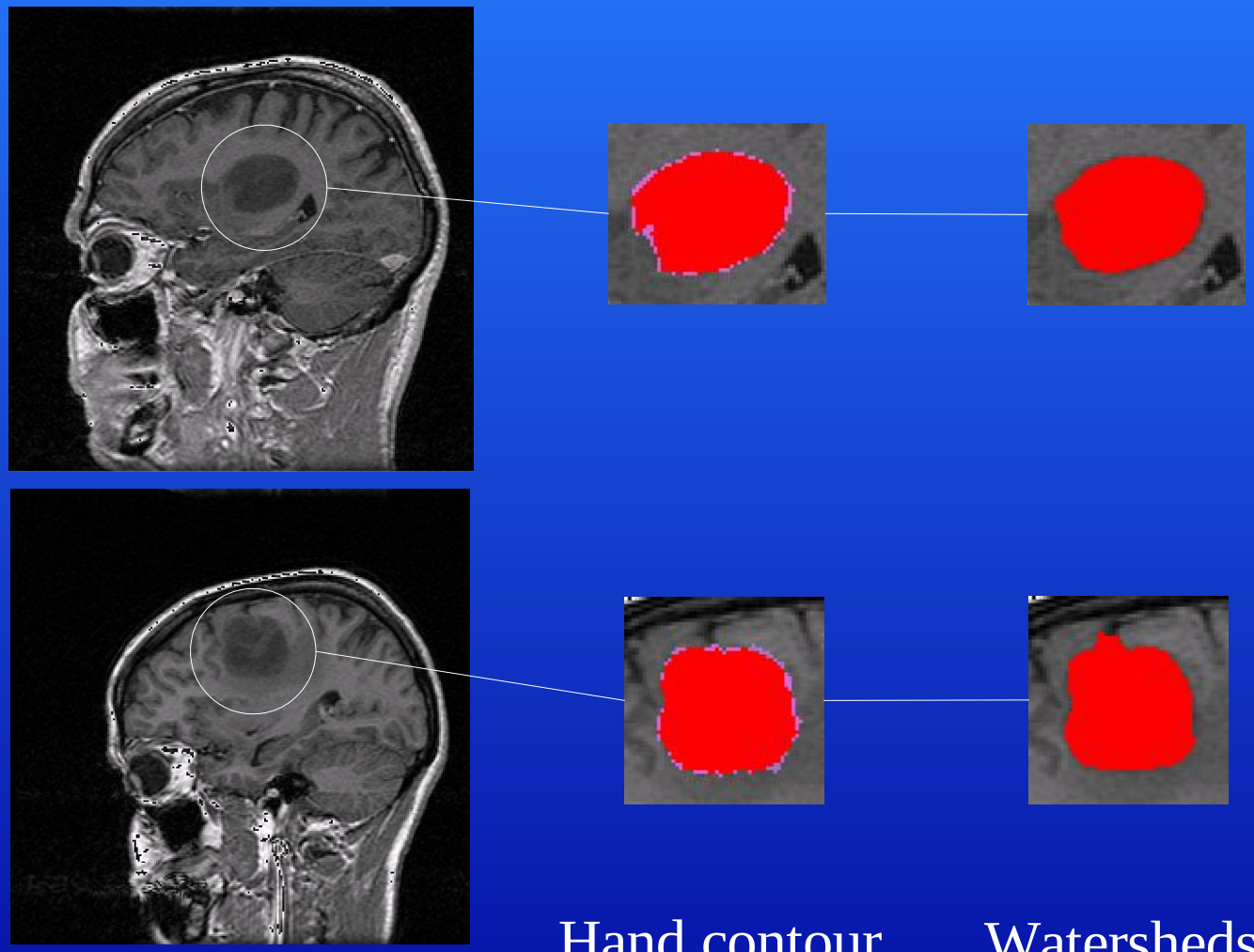

Optic nerves

Data

Hand contour

Watersheds

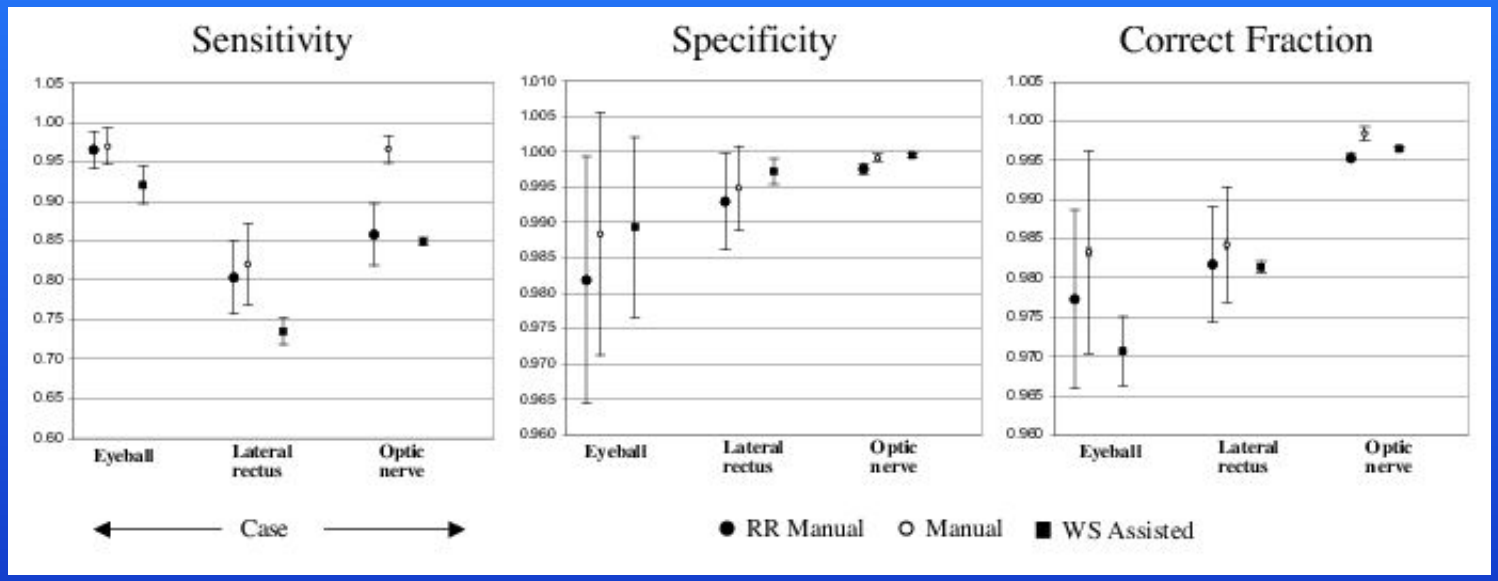
Validation Results



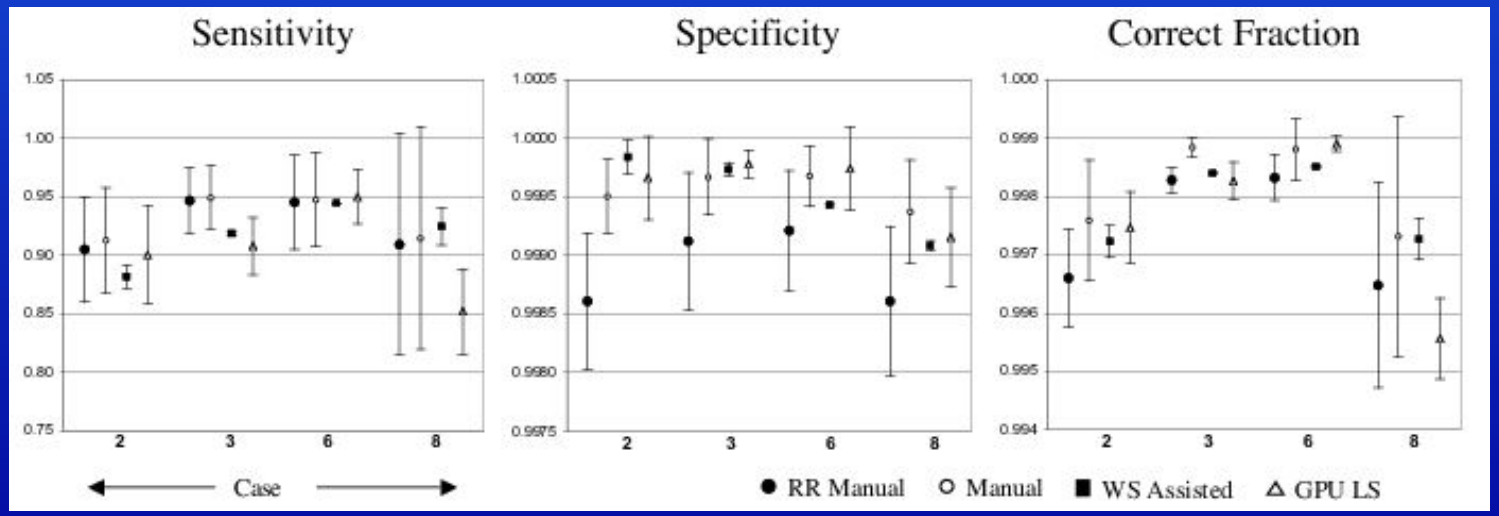
Hand contour Watersheds

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