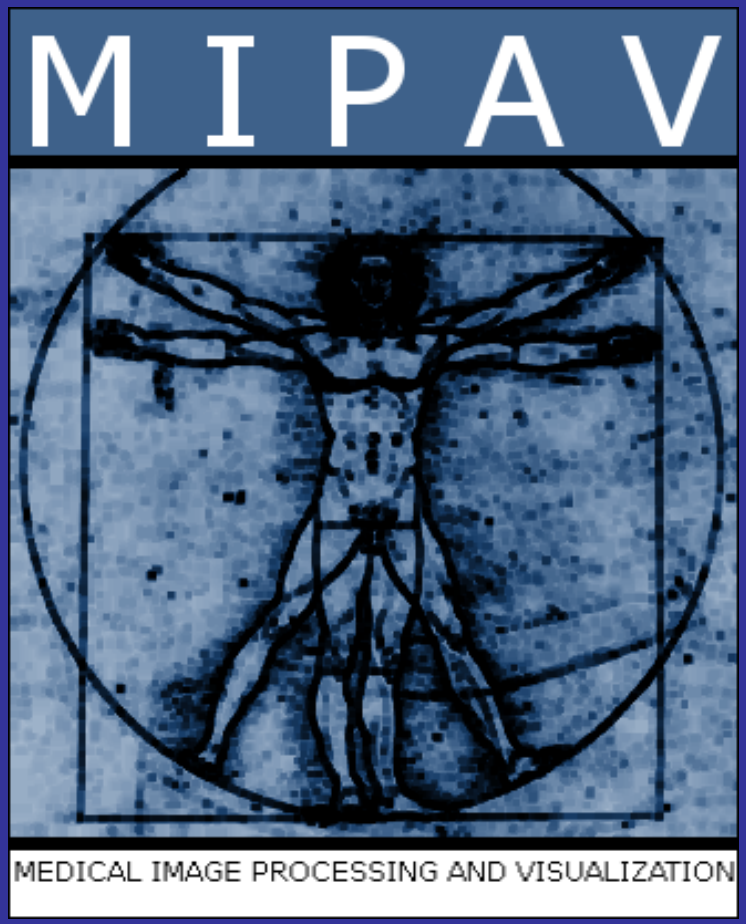

http://mipav.cit.nih.gov

Segmentation and Annotation of Medical Images with MIPAV

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CIT

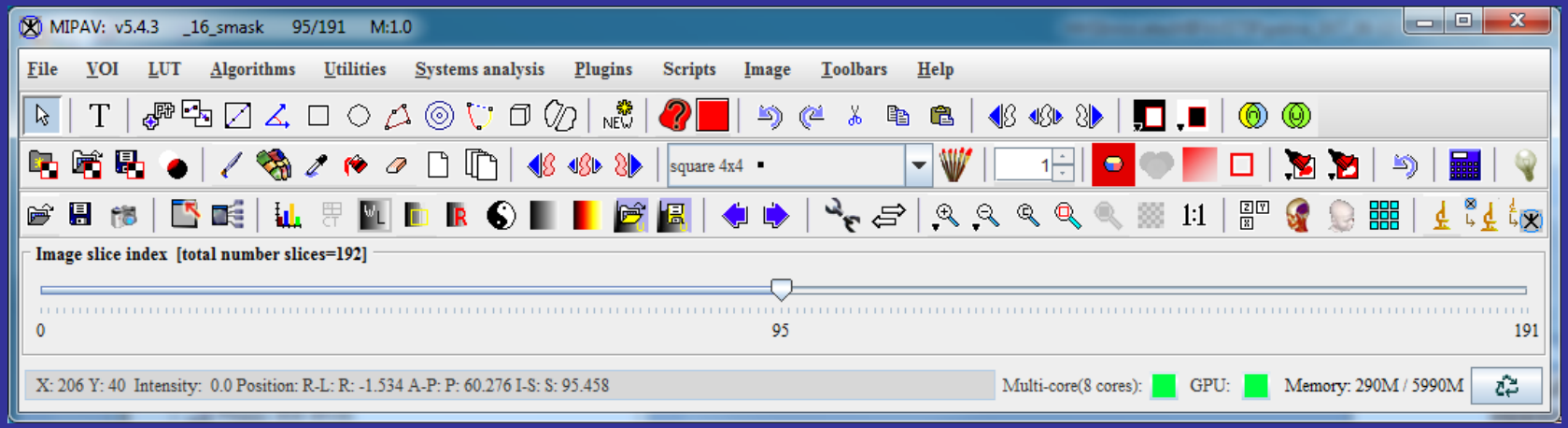
Agenda

- Review
- VOI
  - Creation
  - Manipulation
- Masks
  - Creation
  - Conversion
  - Morphological operators (2D and 3D)
- Paint
  - Creation
  - Fill
  - Segmentation
    - Fuzzy C-means
    - Level set
    - Thresholding
    - Watershed
- Histogram
  - Equalization and matching

CIT

Review

- MIPAV as collaboration tool
  - Opens all image formats
  - Scriptable
  - Quantitative and qualitative



VOI

Volume of interest

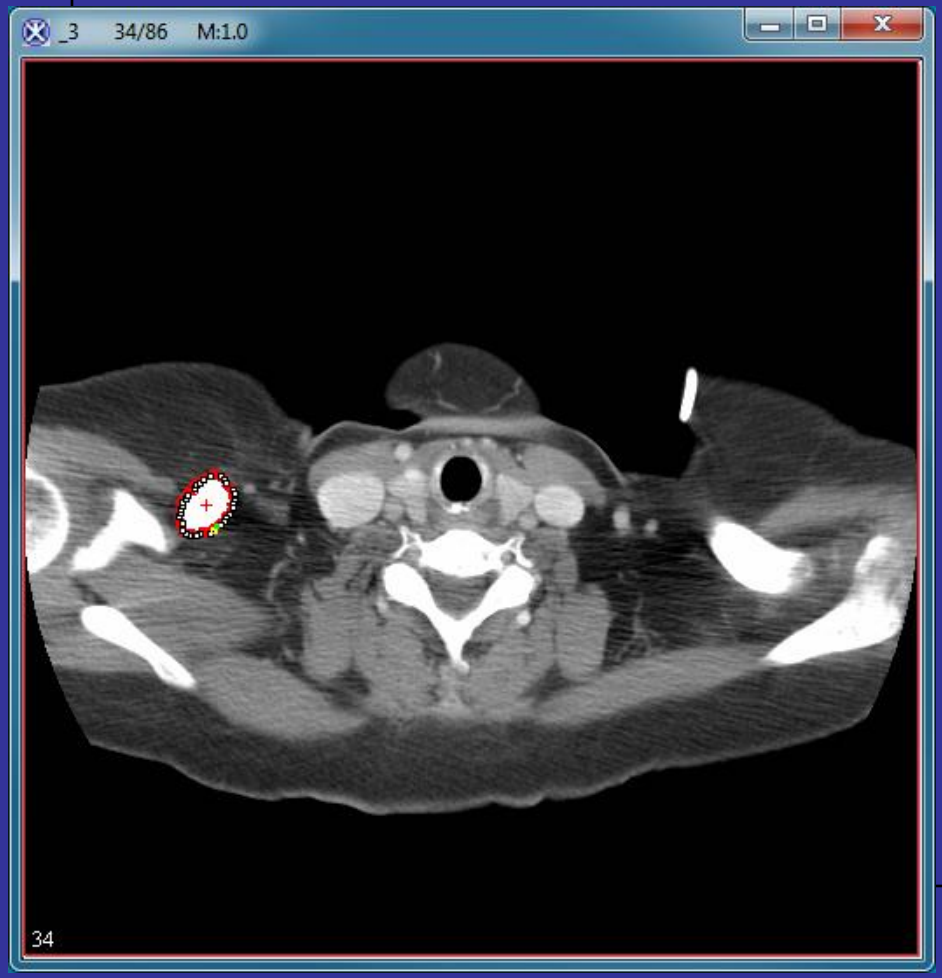
Agenda

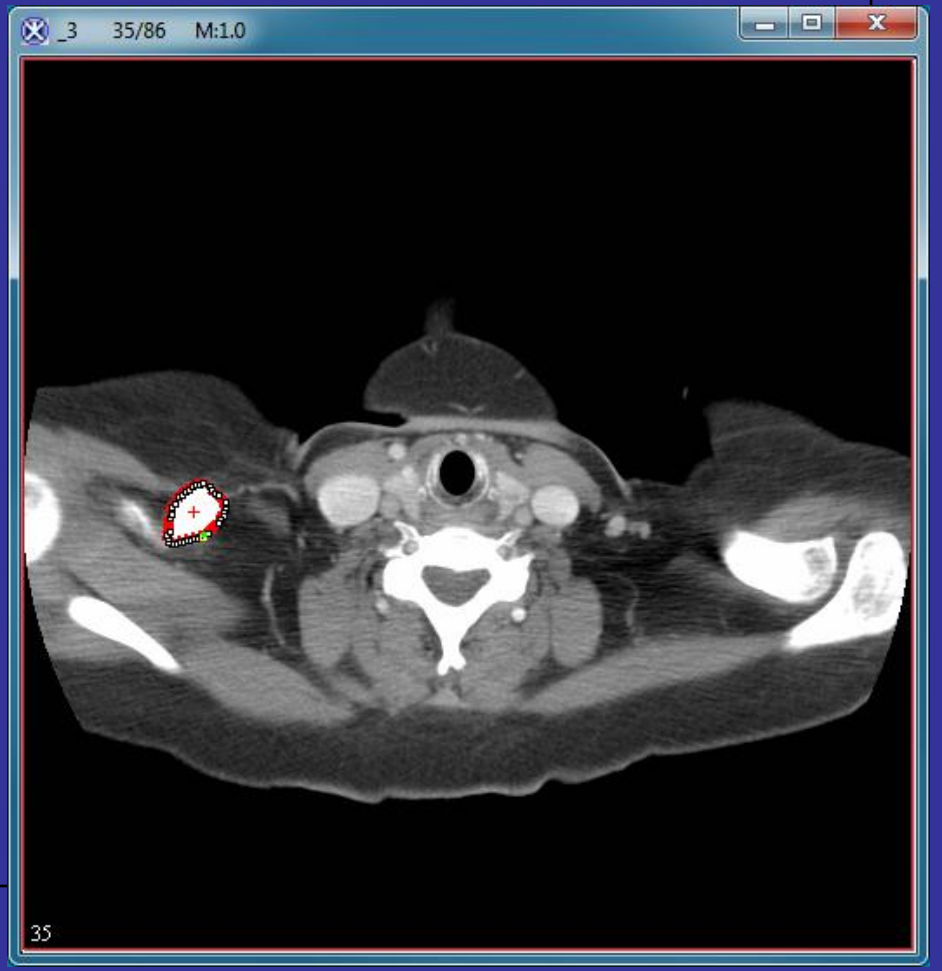
- VOI (Volume of interest)
  - Definition
  - Creation
    - Annotations
    - Points
    - Lines
    - Curves
    - Cube
  - Manipulation
    - Split
    - Undo/Redo
    - Cut/Copy/Paste
    - Propagation

CIT

VOI

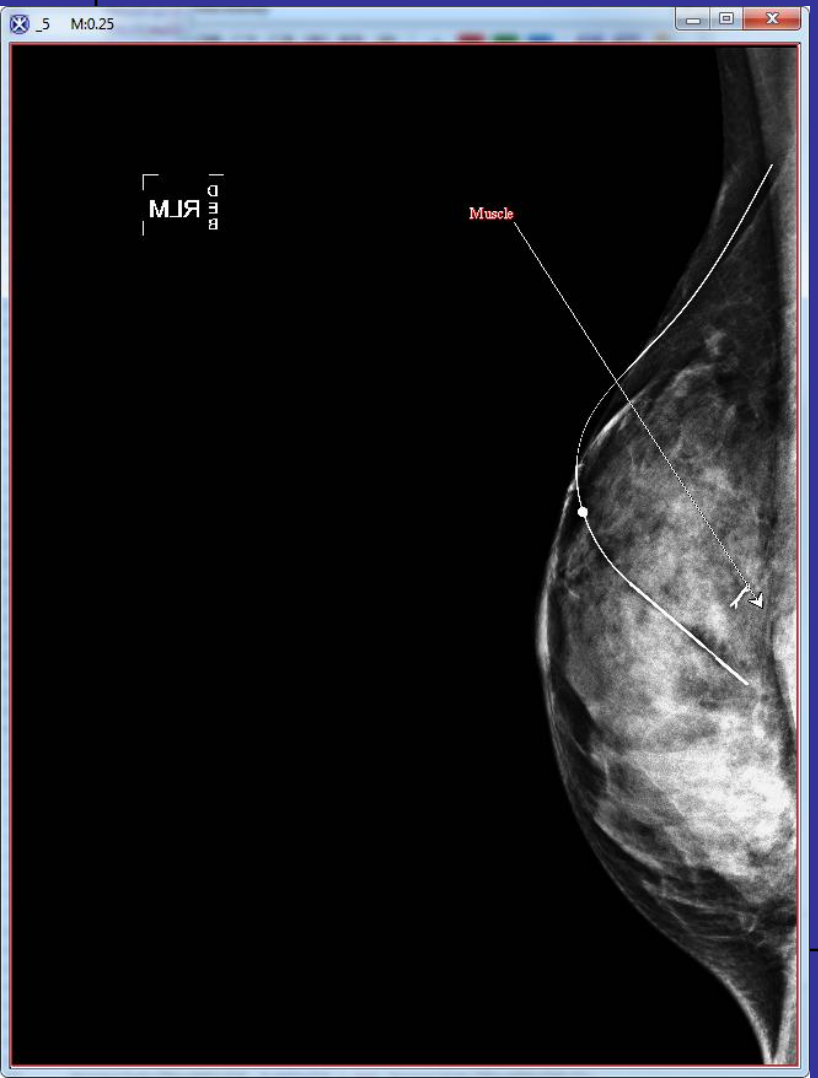
– Volume of interest – one or more contours on an image

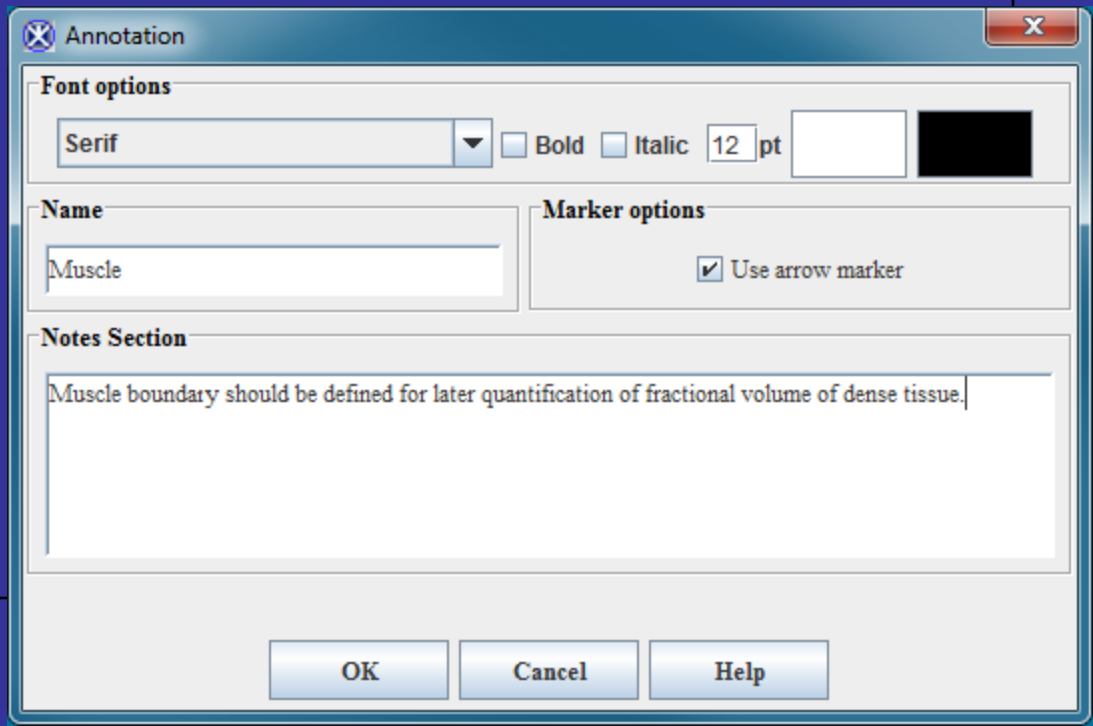




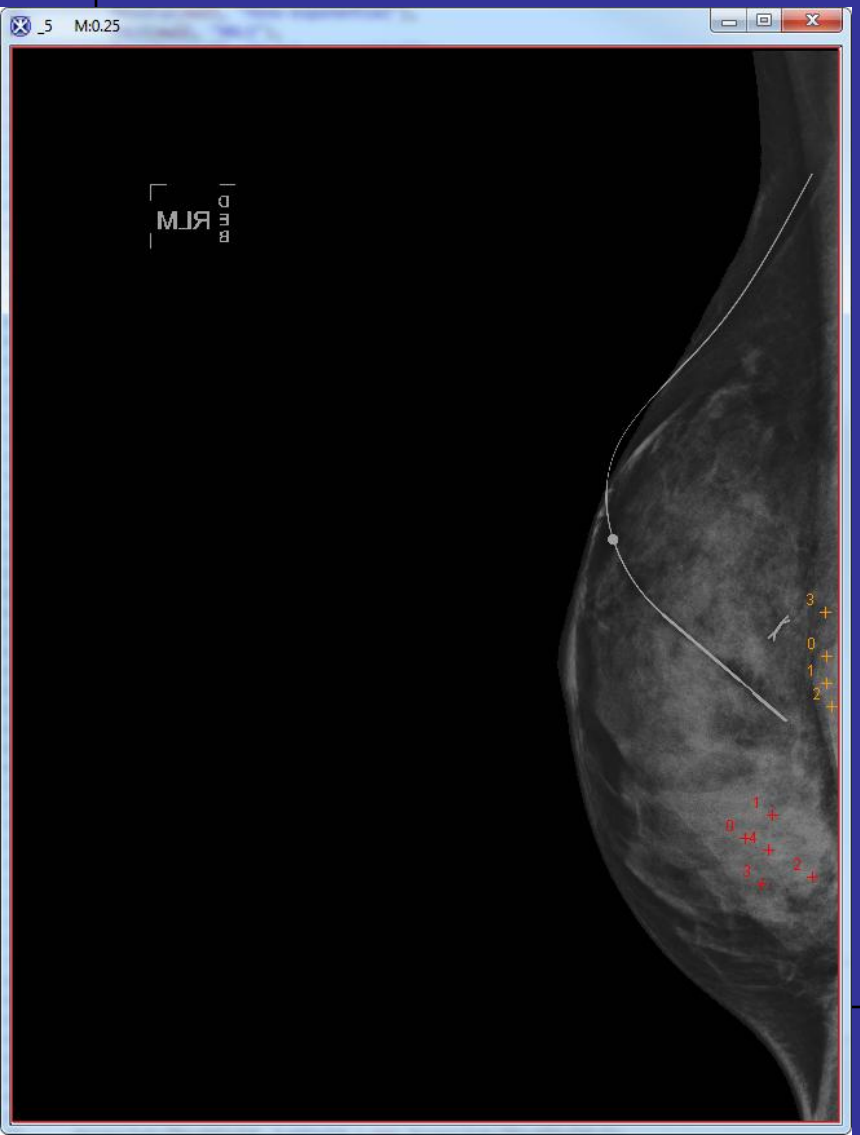
Annotation

- Save names and notes
- Place in text location, move arrow

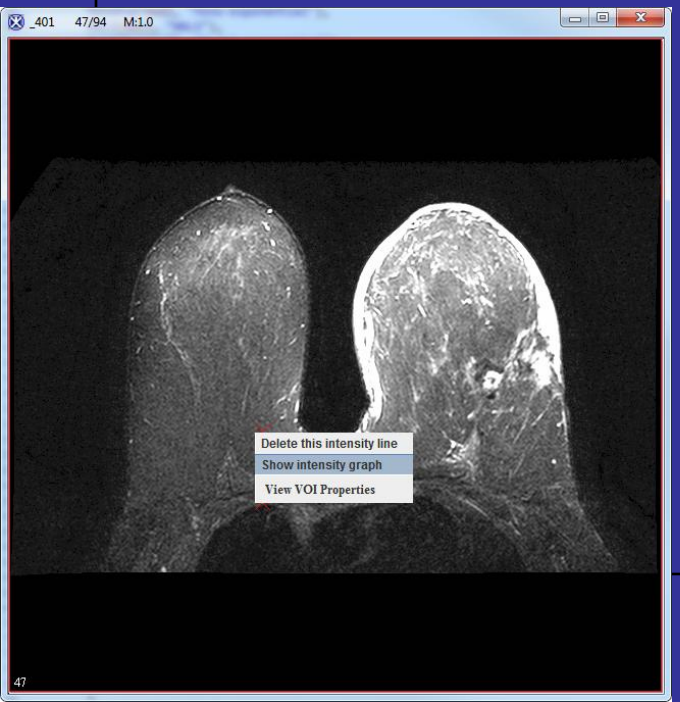




Point

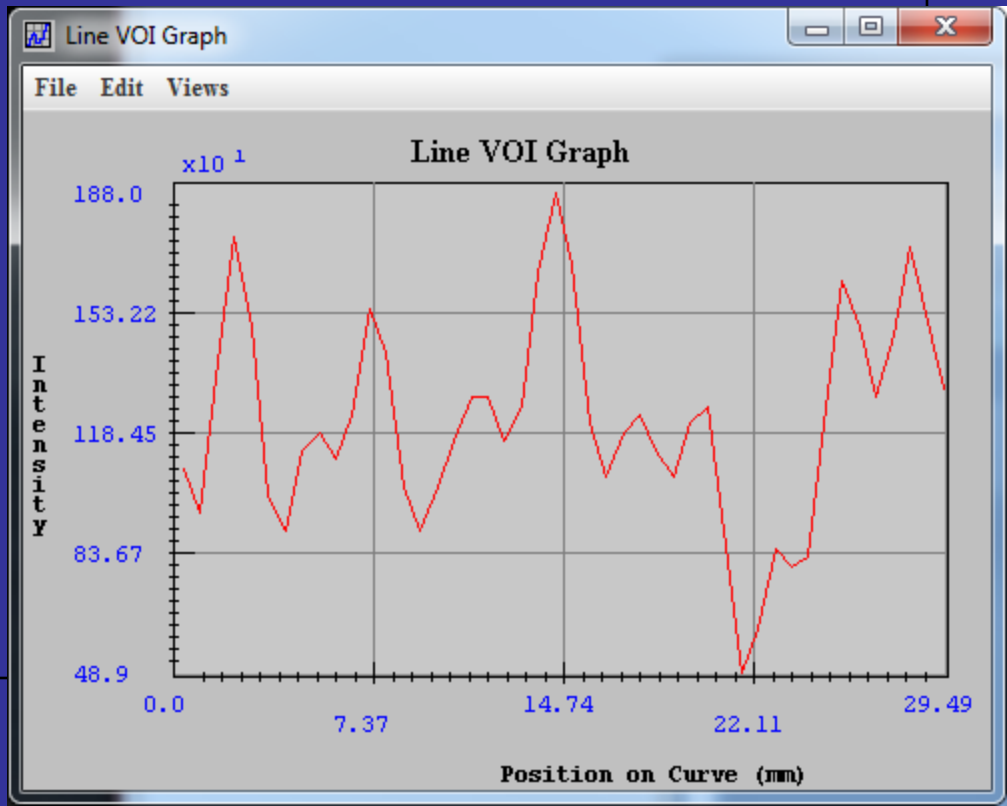


- Shift for multiple points
- Delete removes, renumbers to keep consecutive
- Can move

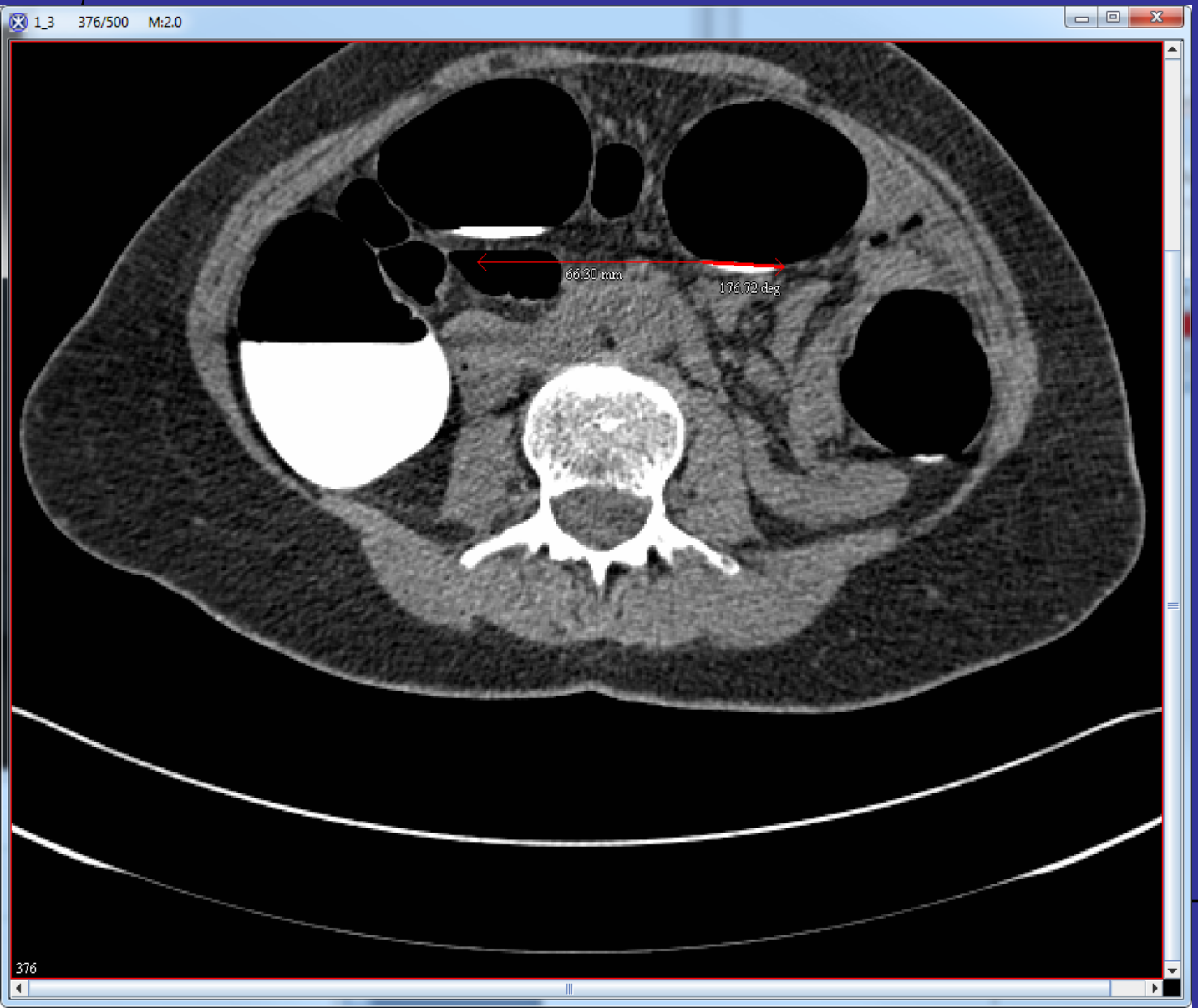


Line

- Right click to show options
- Intensity plot from green point



Protractor



- Initial point is intersection of two lines
- Draw outwards
- Re-click to orient angle

Square

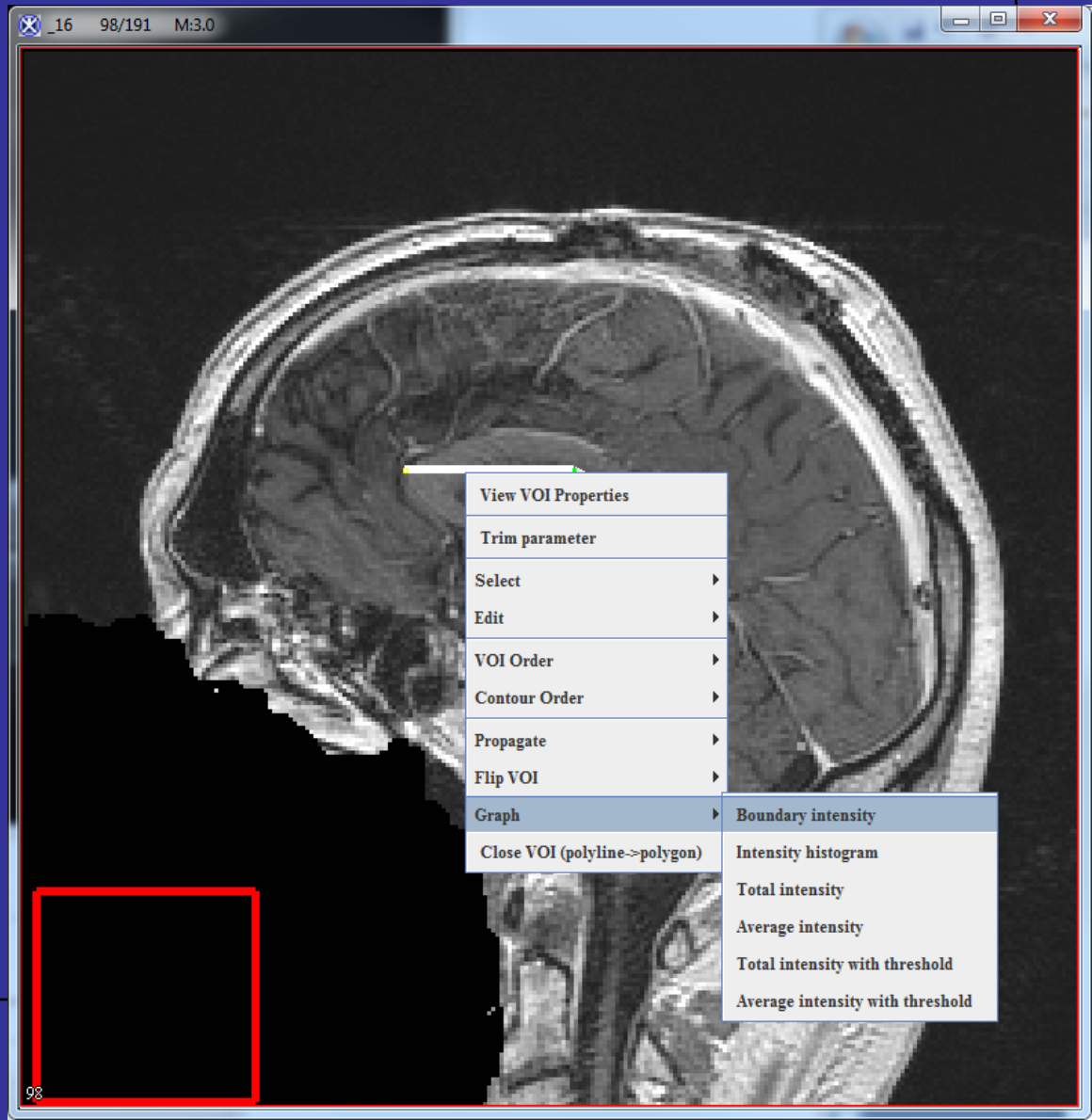
- Start with any corner, drag in any direction
- To modify, click a point, becomes “active” VOI.

Circle

- Start at circle center
- Drag entire shape

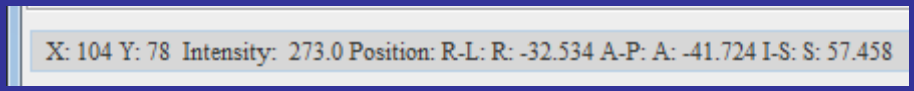
Polyline/polygon

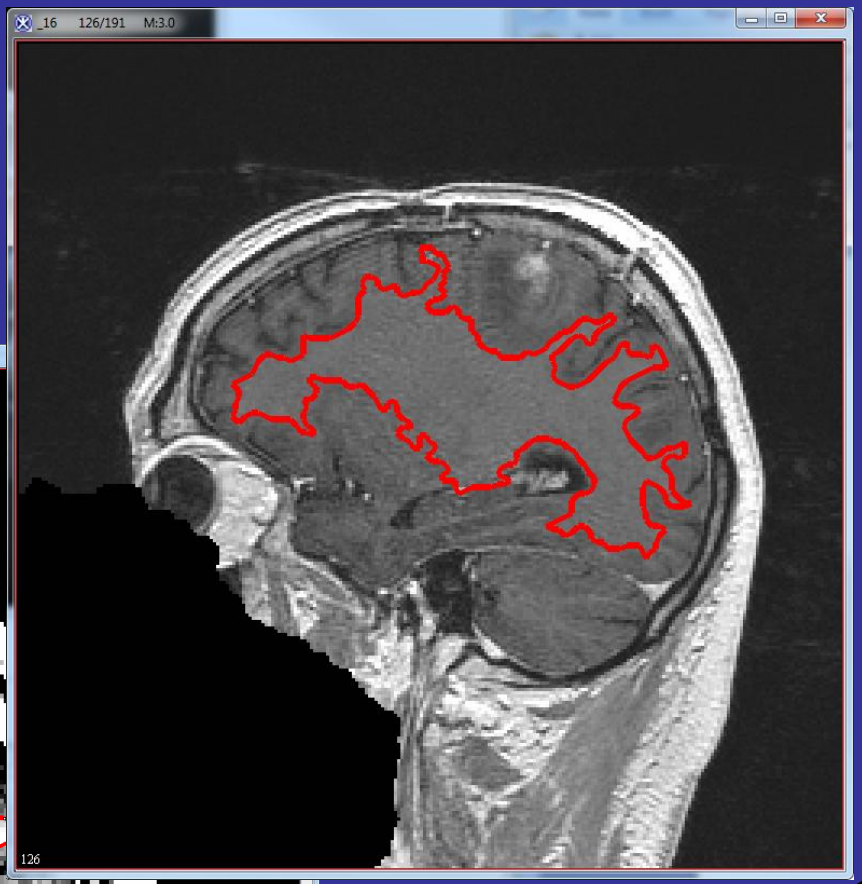
- Shape can be open

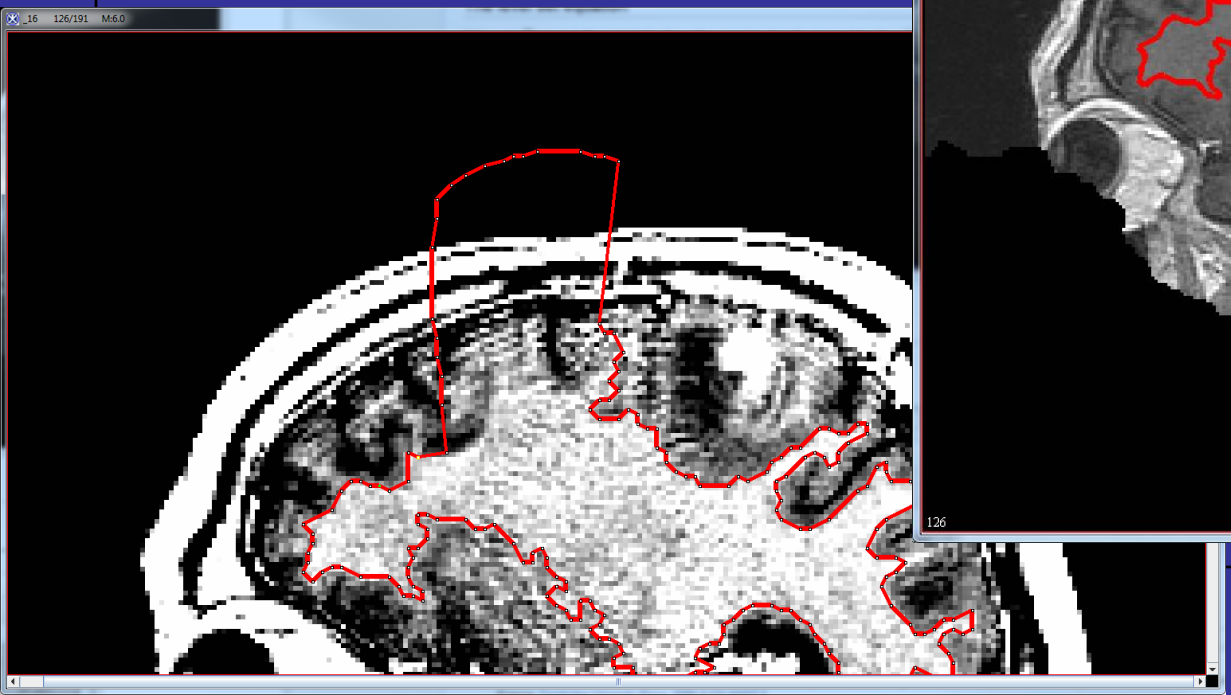


Levelset

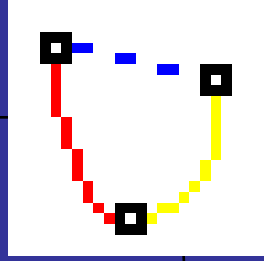
- Looks for closest intensity value
- Topographic map
- Once active, alt+hold down mouse to modify boundary.



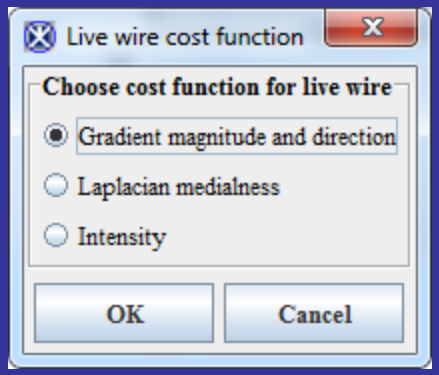




Livewire

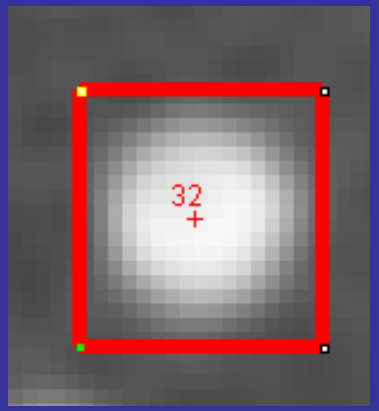


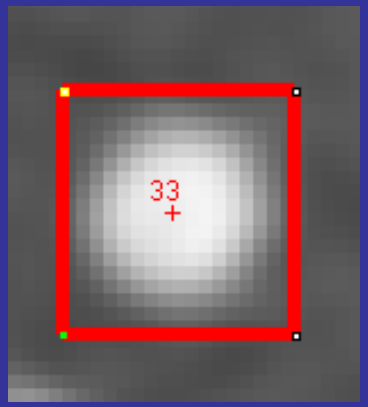
- Larger changes in magnitude with smaller distance.
- Minimum cost

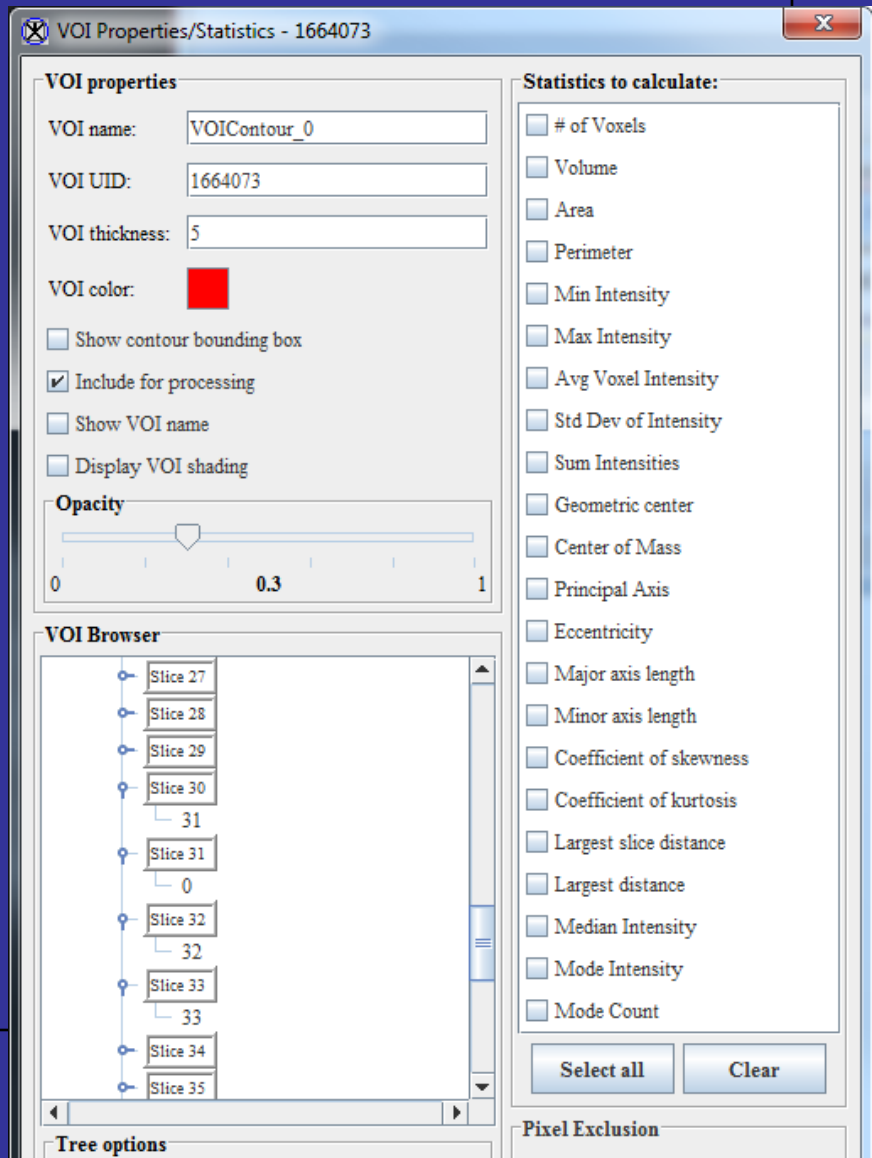


Cube

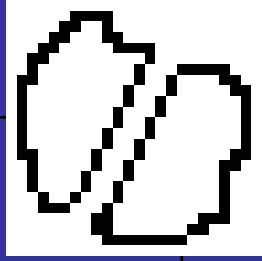
- "0" is always the initial curve
- Numbering does not indicate slice



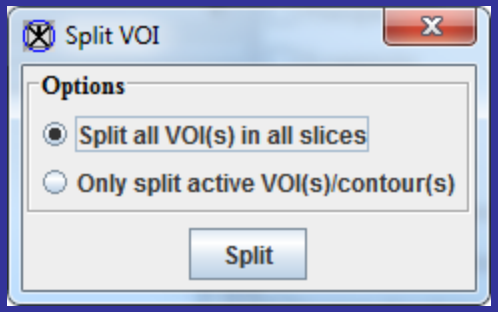


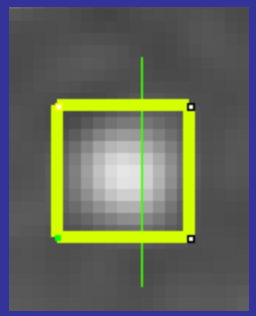


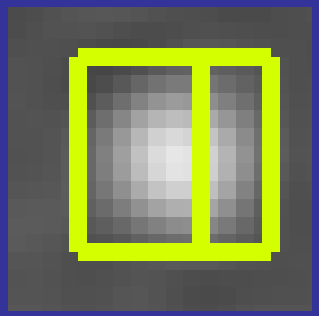
Split

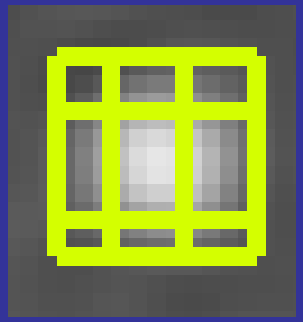


- Splits into same VOI, different contour
- Each contour is closed
- Multiple VOIs split
- Multiple contours split

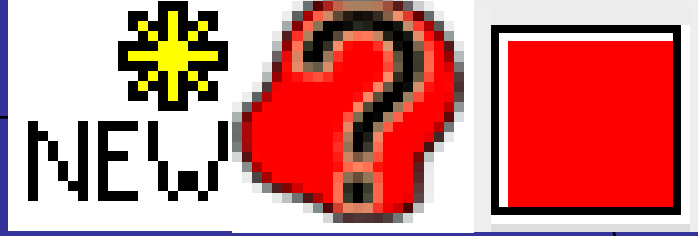




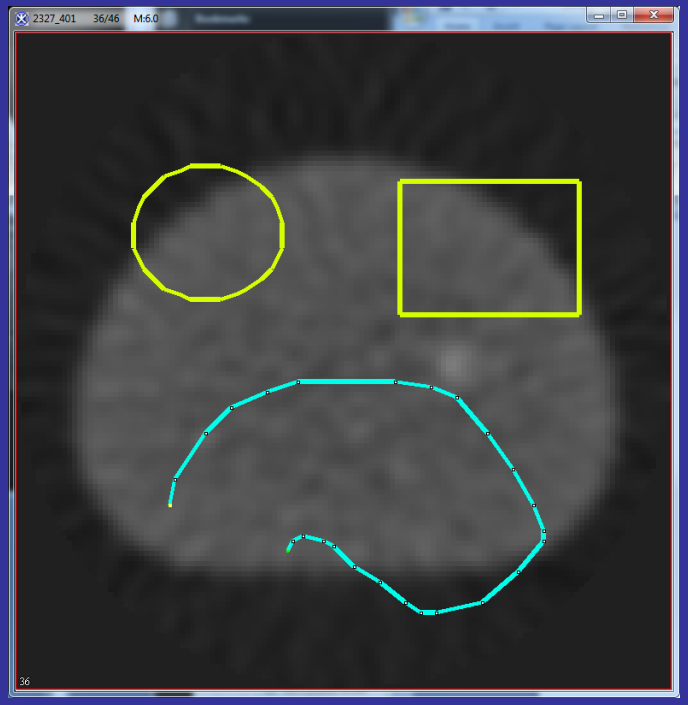


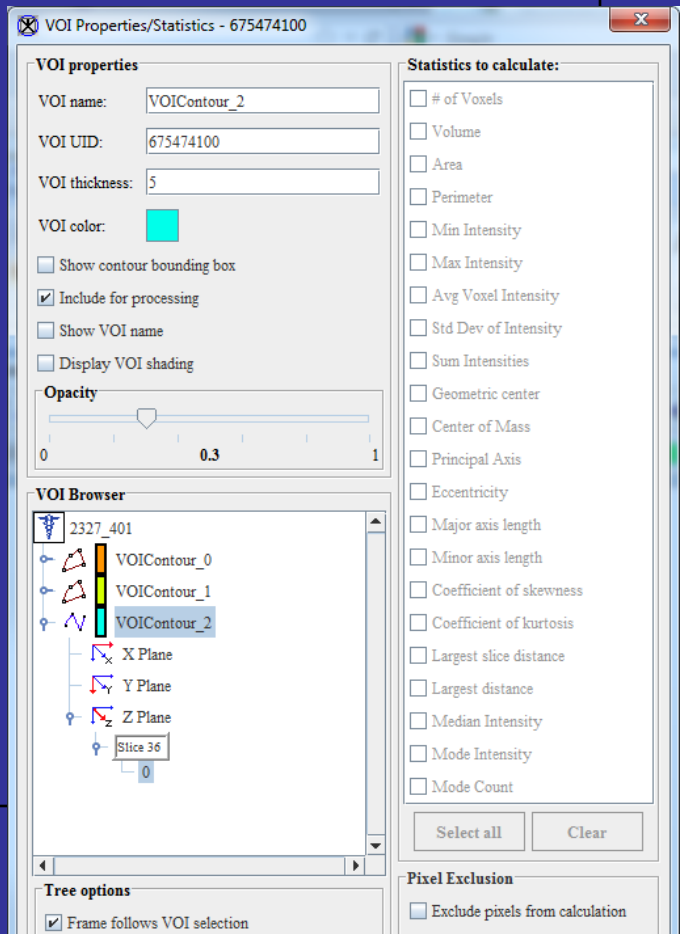


New VOI



- Open/closed VOIs cannot be combined
- Statistics





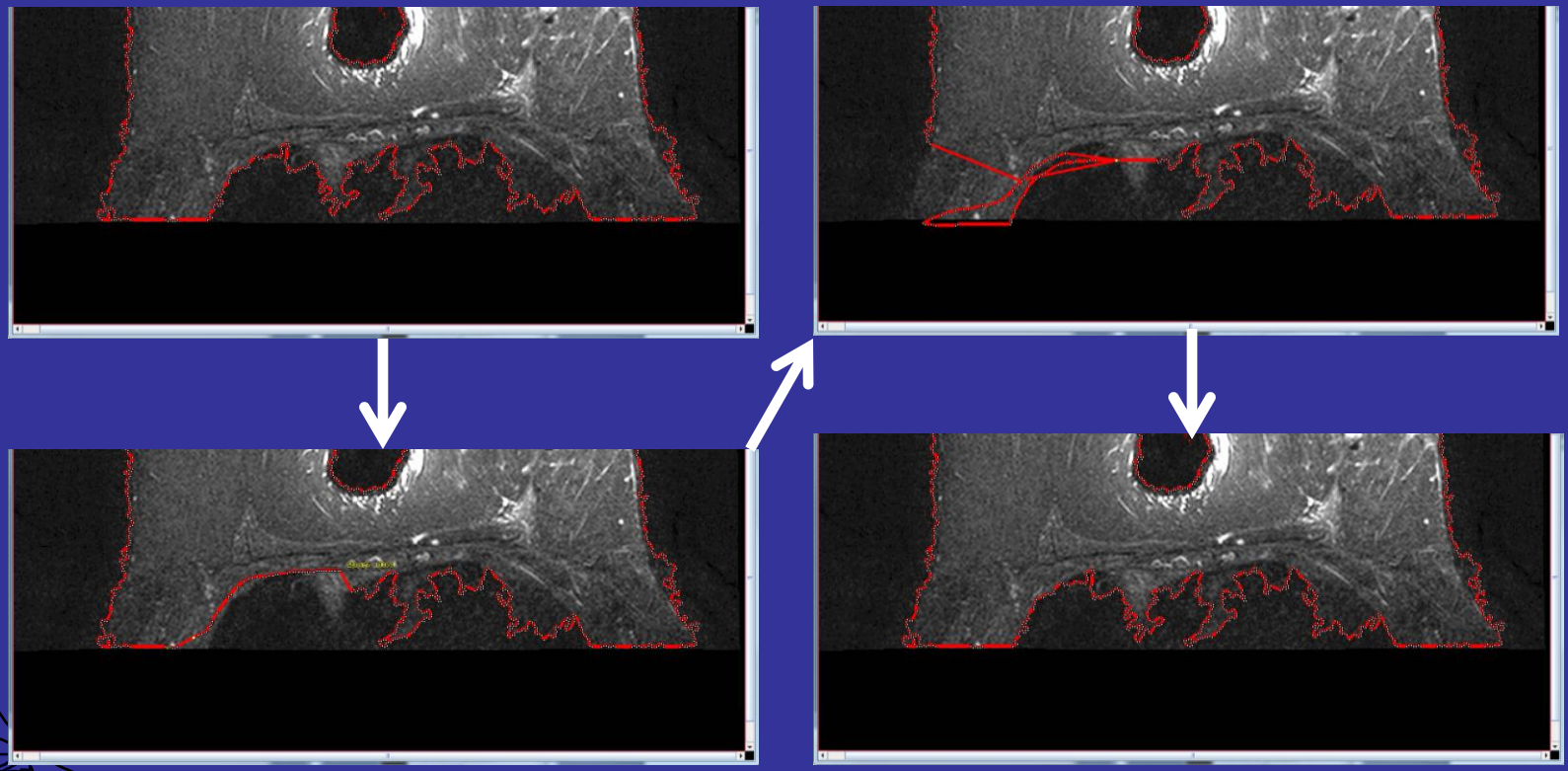
Quiz

- Manual VOI change using ALT+hold down mouse. Which direction is required?
- A. clockwise
- B. counter-clockwise

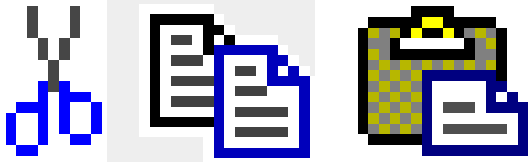
Answer: Both, but choose one each time

Undo/Redo

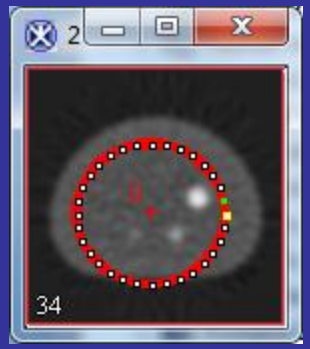
- Applies to VOI operations only
- Keyboard shortcut: Ctrl+Z (Undo), Ctrl+Y (Redo)

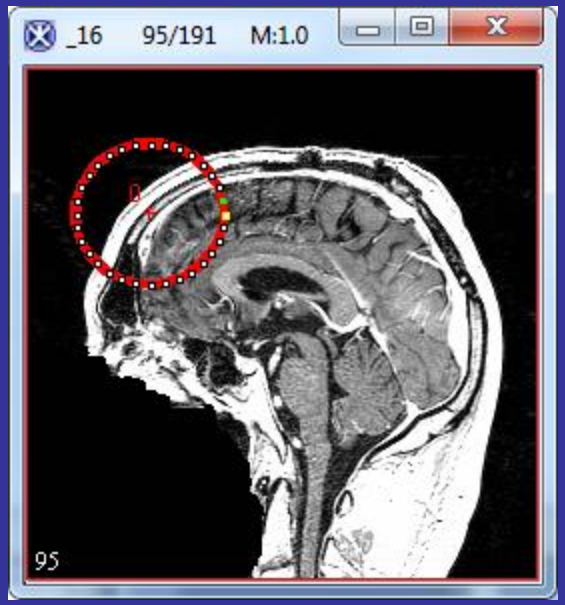


Cut/Copy/Paste



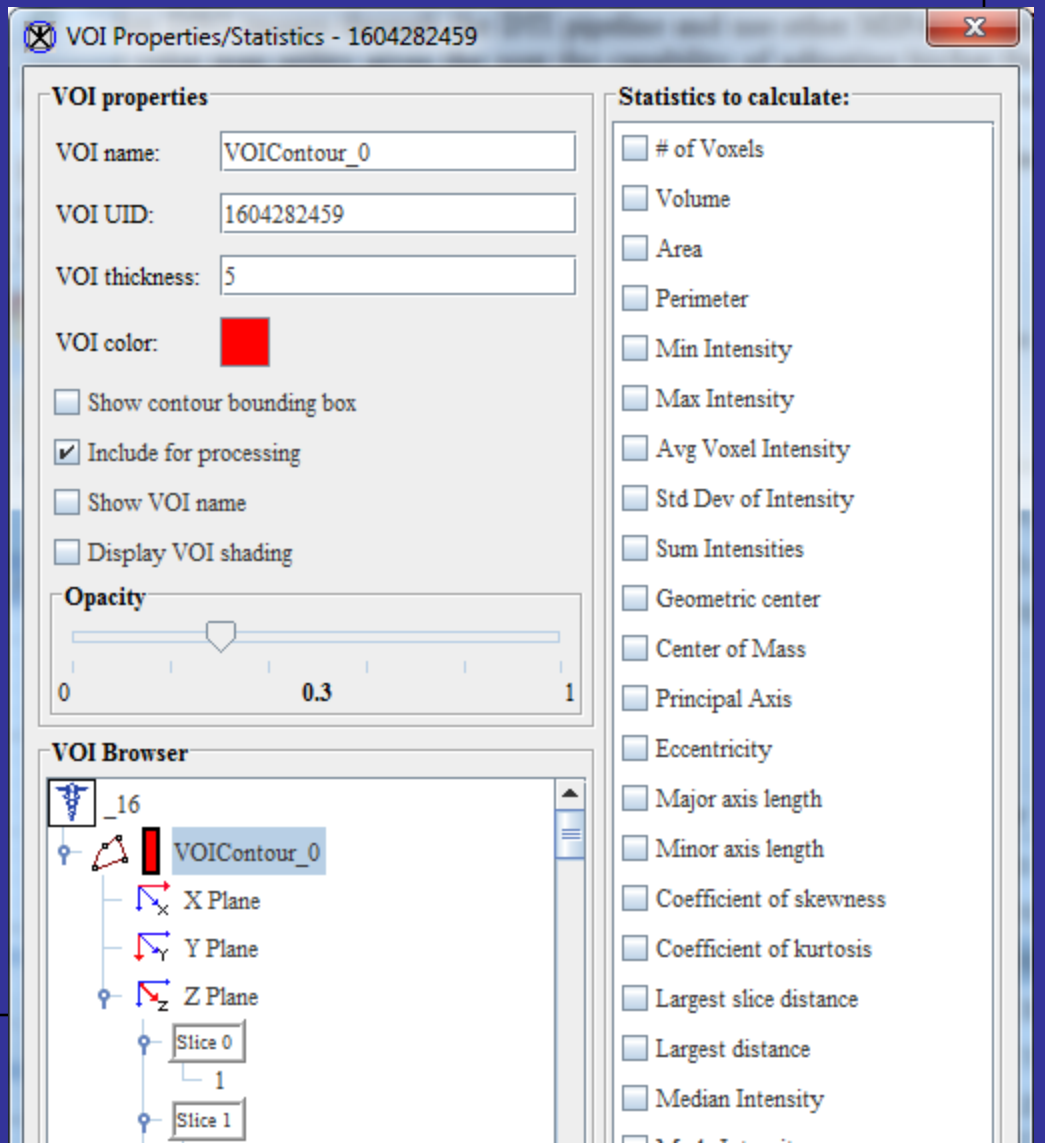
- Cut – delete, store to paste
- Copy – store to paste
- Paste – Place active VOI in current slice of active image





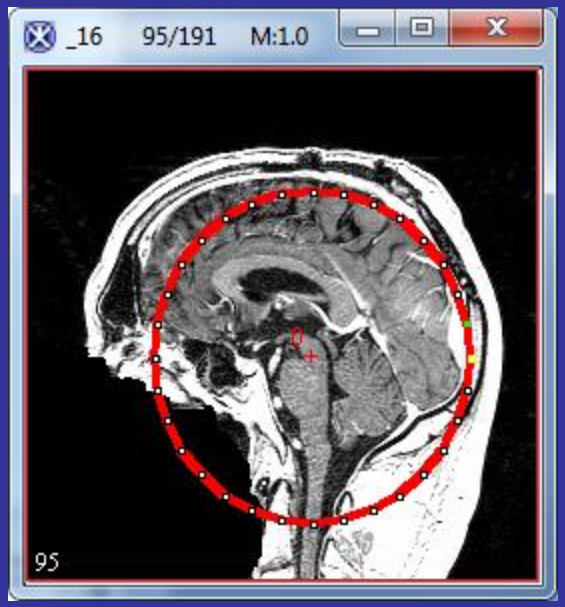
Propagate

- Down one slice
- Up one slice
- To all slices



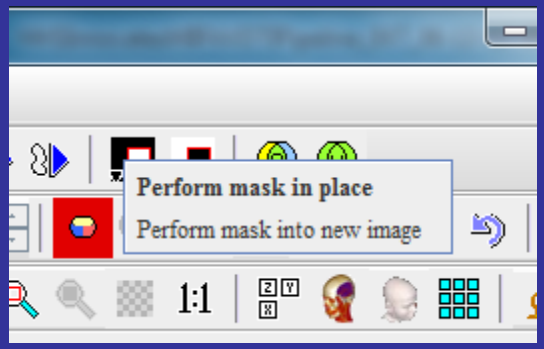
And

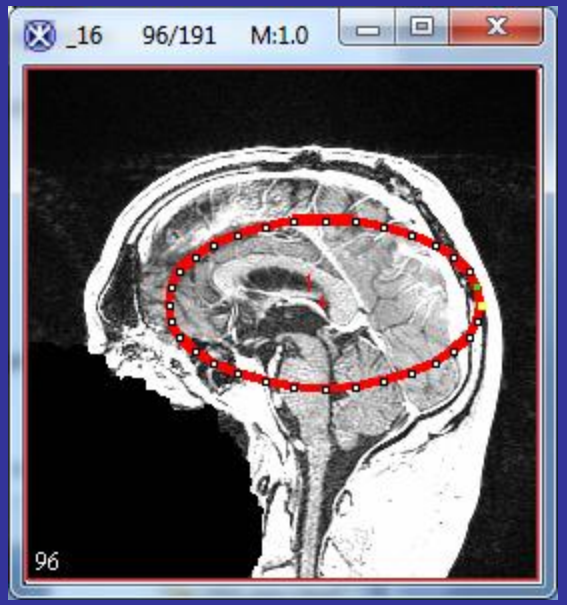
- Default is in place

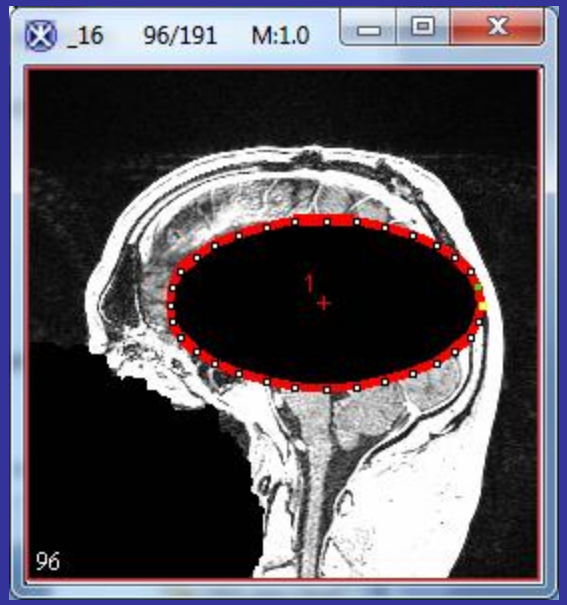


Fill

- Fills with zeros

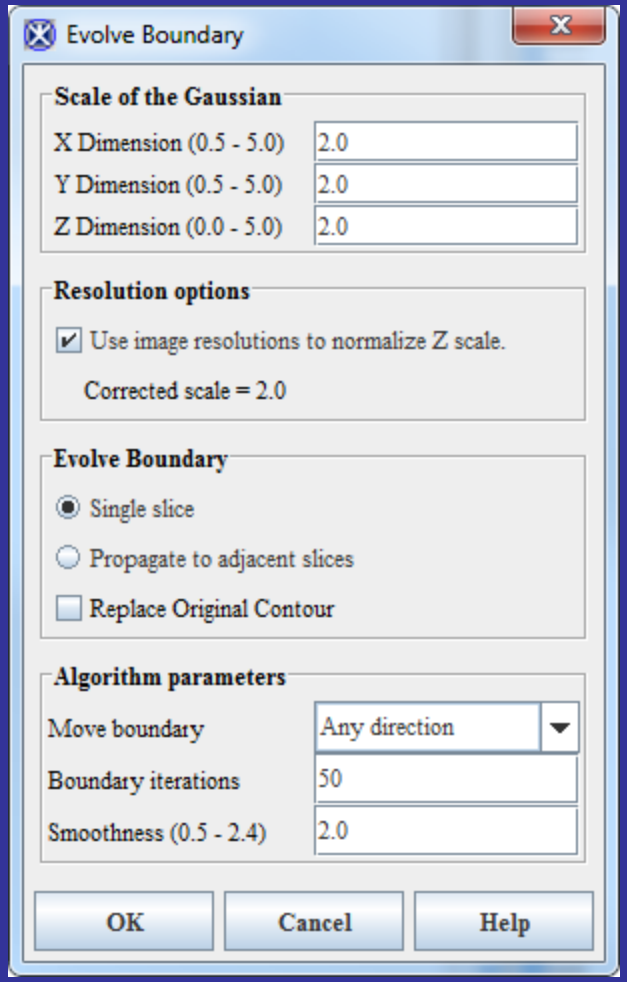






Evolve Boundary

- Active contour
- Combine with propagation to adjacent slices
- Small Gaussian sensitive to noise



Interpolate

- Define contours on non-contiguous slices
- Contours part of same VOI
- Must be selected

Slice 86

Slice 89

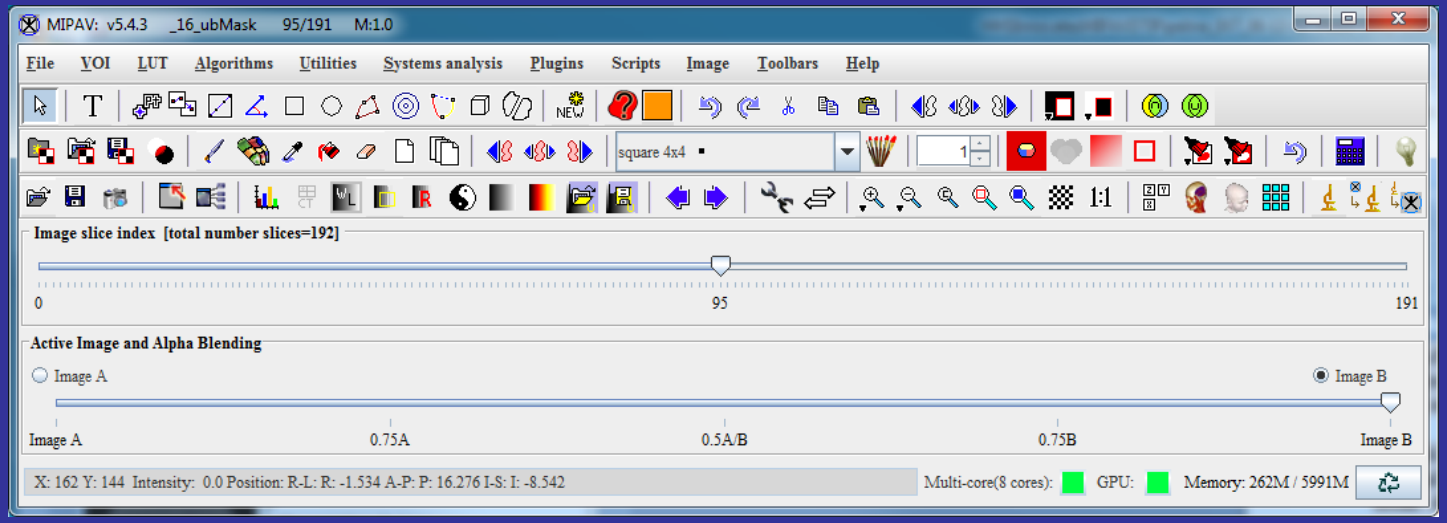
Slice 95

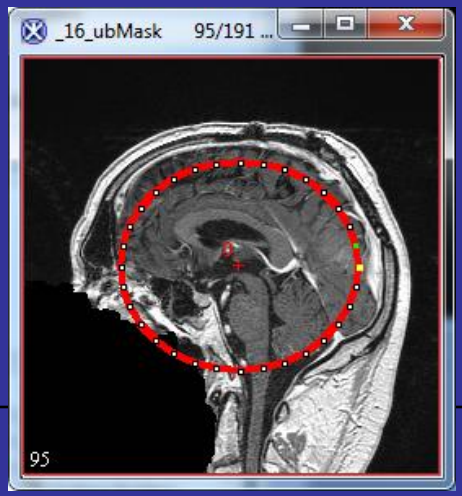
Break

Mask

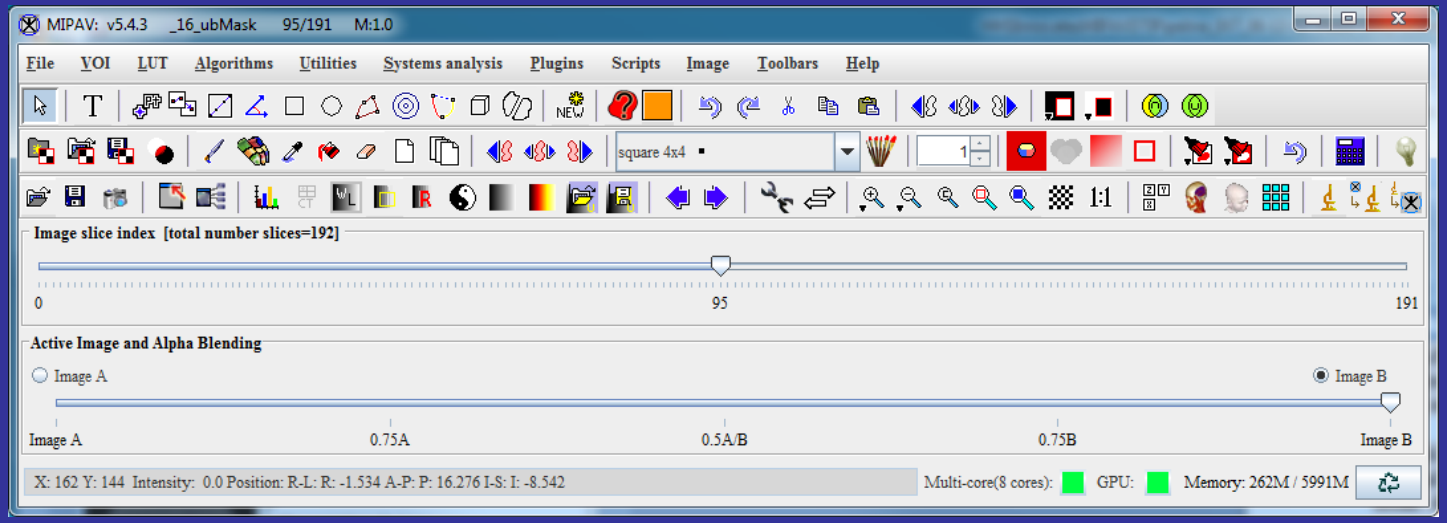
Defined on pixels

Create new mask



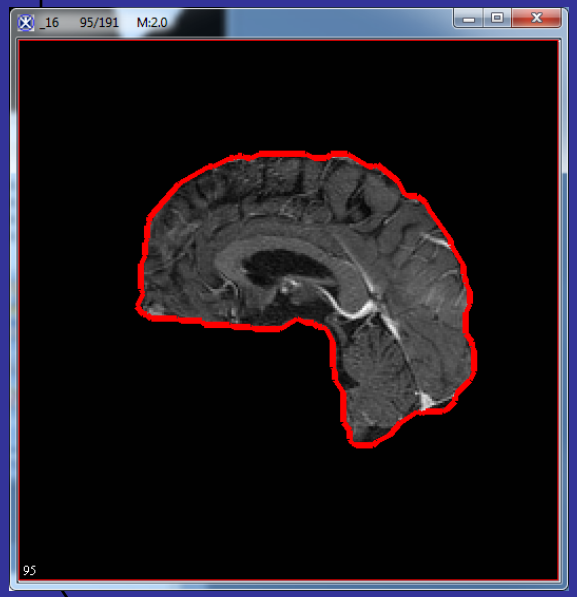


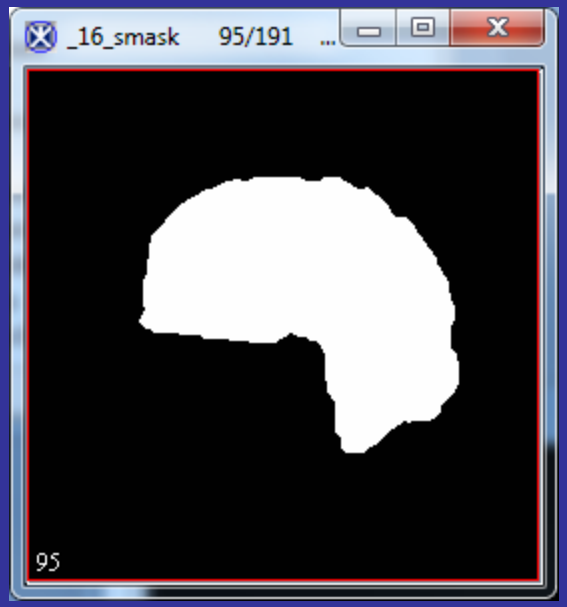
Open/Save mask

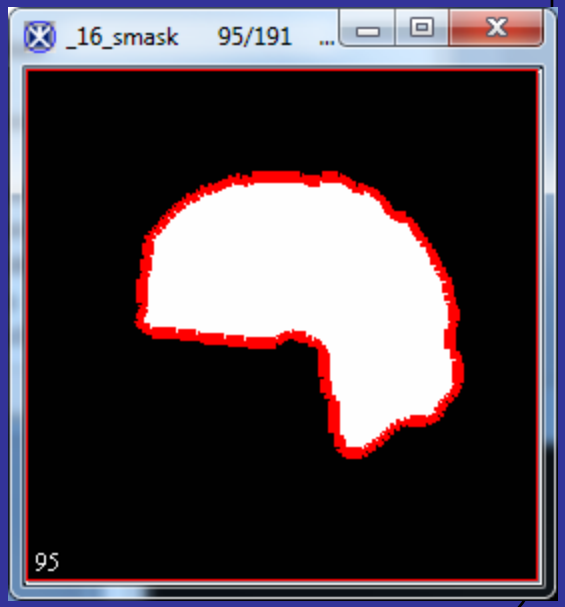


Conversion

VOI menu options

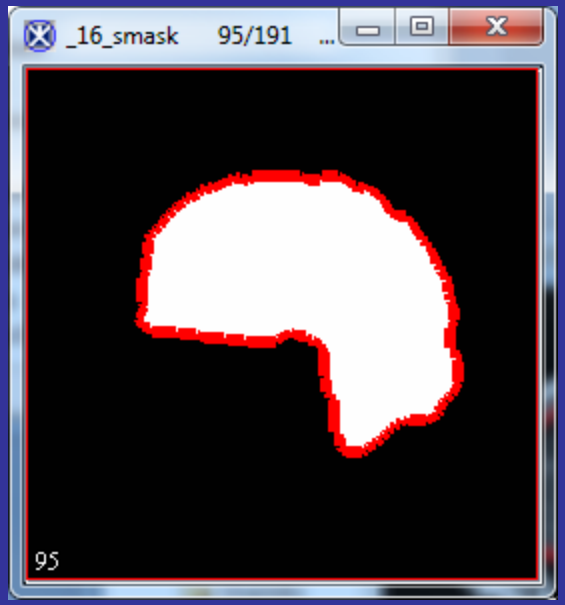


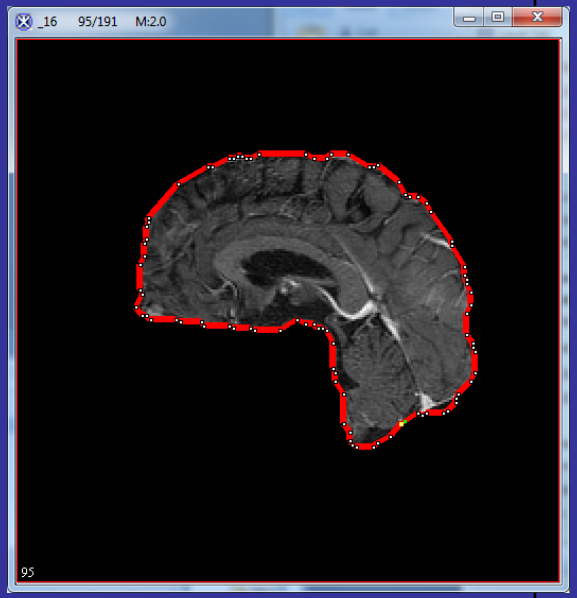




AND Mask operation

Performs actual conversion





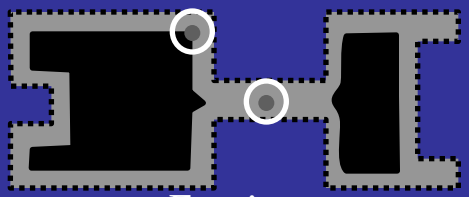
Morphology

Mathematical Morphology

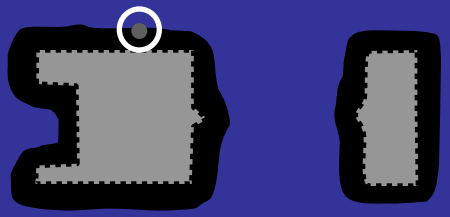
- Erosion
- Dilation
- Opening
- Closing
- Distance maps

Mathematical Morphology

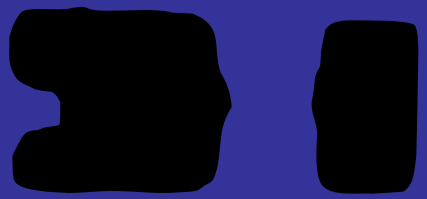
Source object



Erosion



Dilation



Result: Erosion + Dilation = Opening

Opening

Structuring Element

0	1	0
1	1	1
0	1	0

2D 3x3 structuring element

0	0	0
0	1	0
0	0	0

0	1	0
1	1	1
0	1	0

0	0	0
0	1	0
0	0	0

3D 3x3x3 structuring element

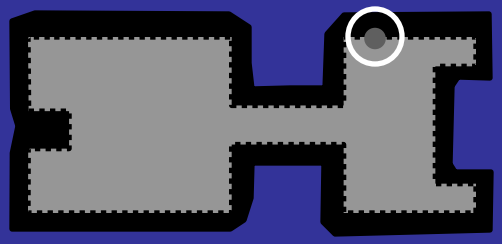
CIT

Mathematical Morphology

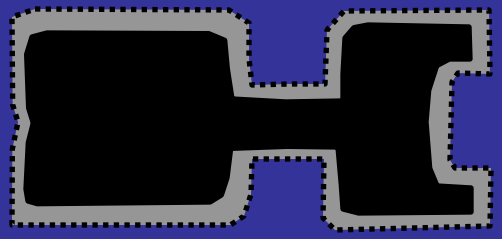
Closing

Source object

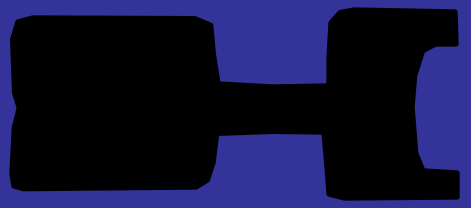
Structuring Element



Dilation



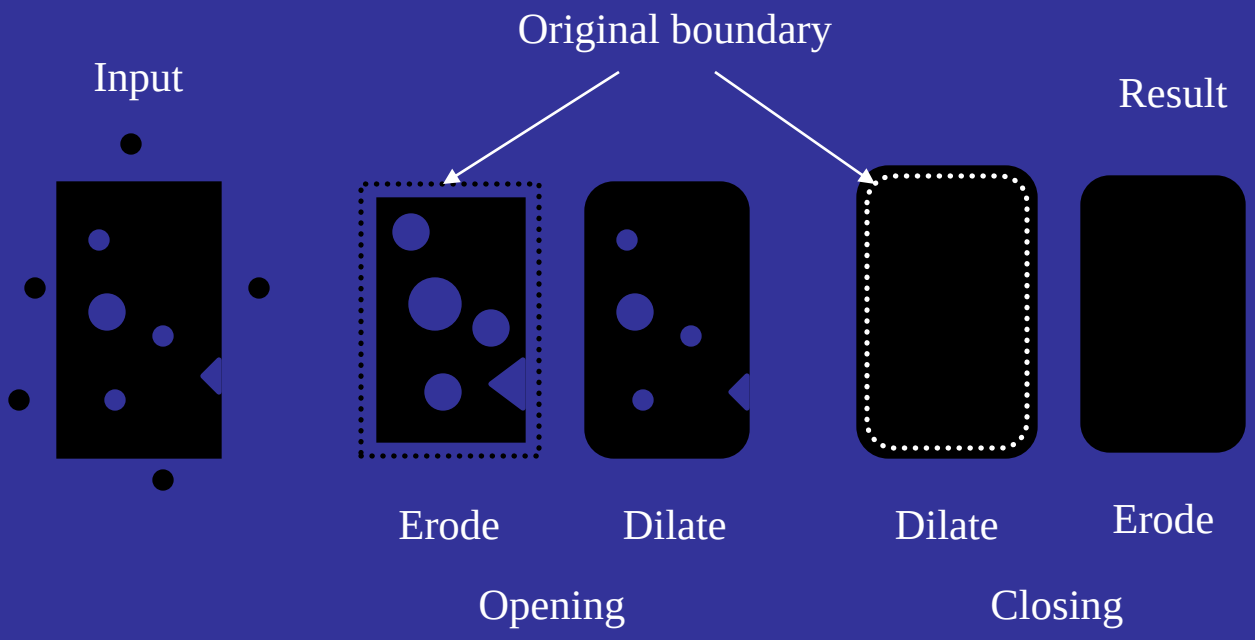
Erosion



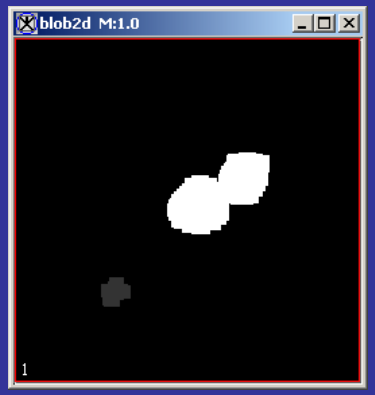
Result: Dilation + Erosion = Closing

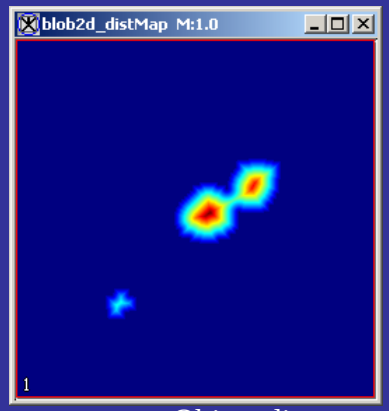
Mathematical Morphology

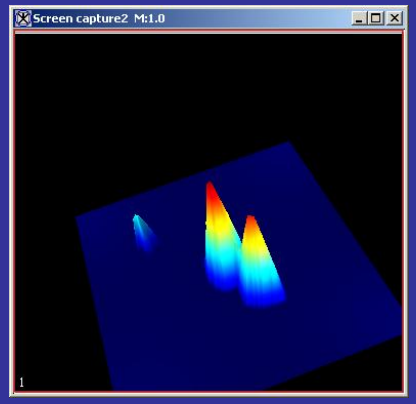
Noise Removal



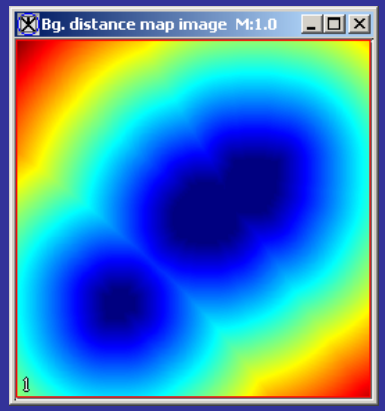
Distance transform

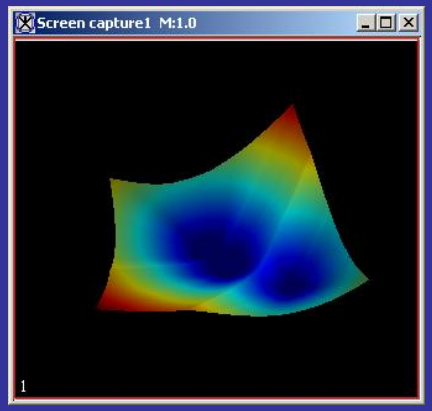






Object distance - minimum Euclidian distance
from any edge to a point interior to the object



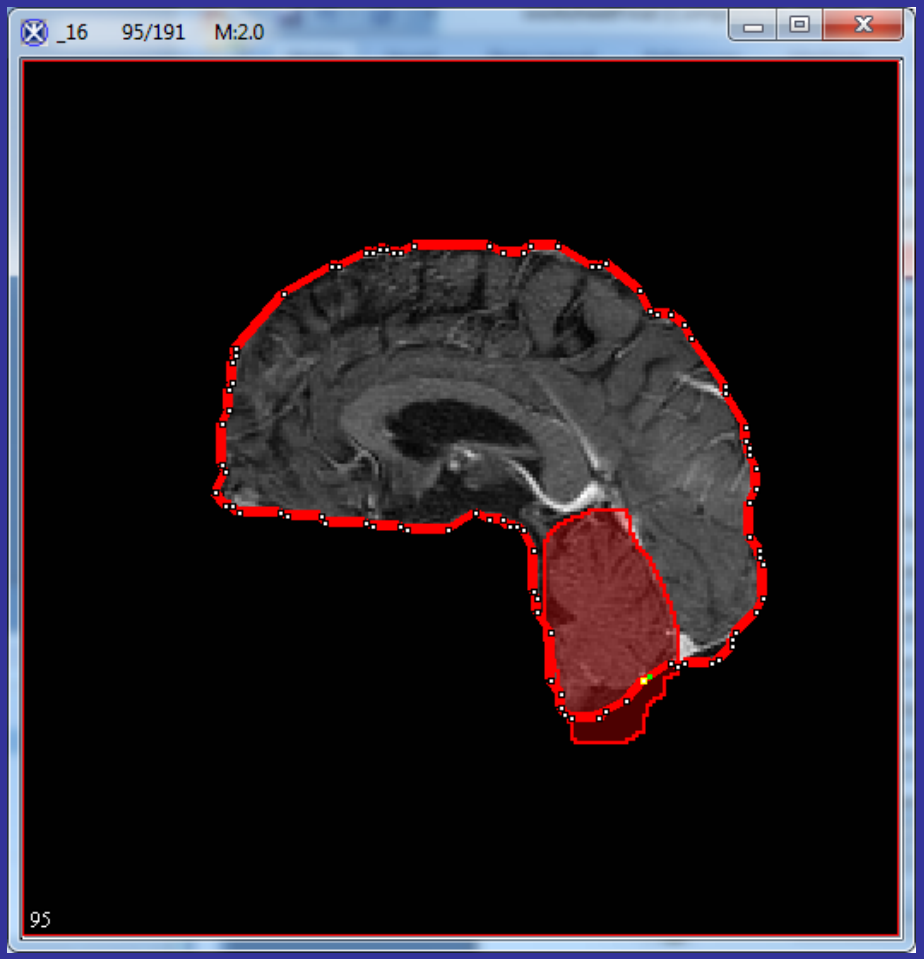


Background distance - minimum Euclidian distance
from any edge to a point exterior to the object (i.e. background)

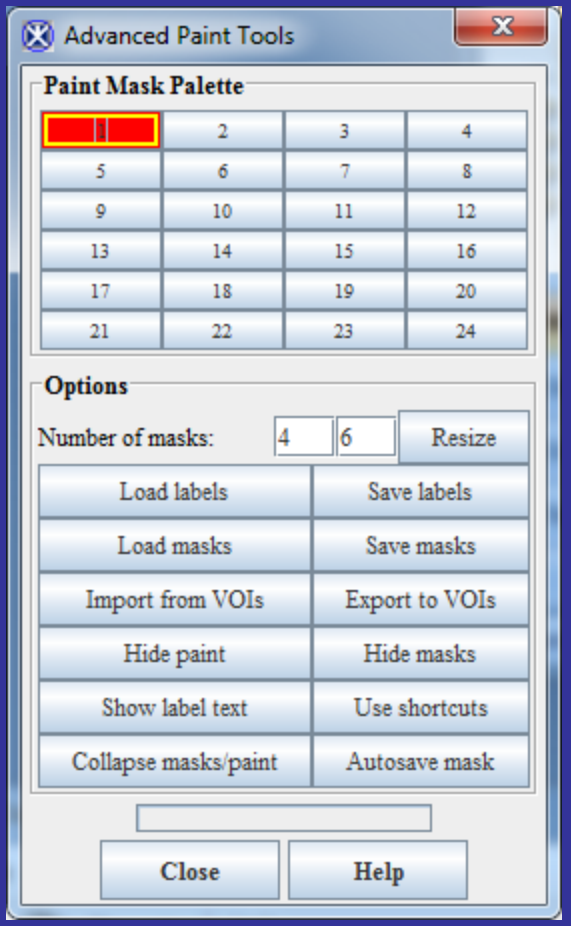
Paint

Defined on masks

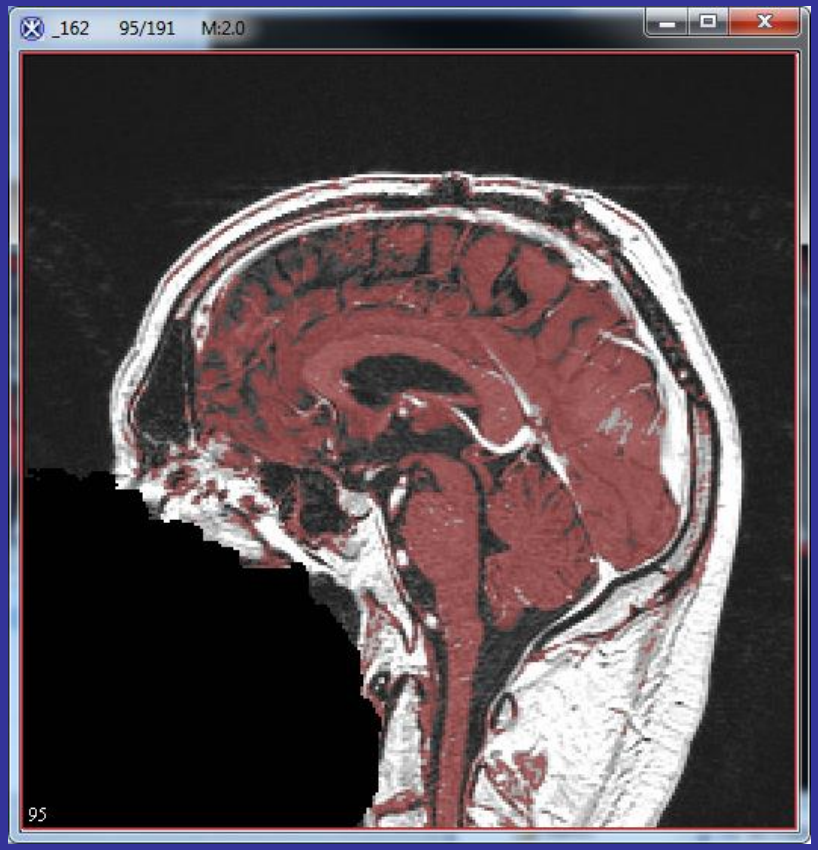
Brush

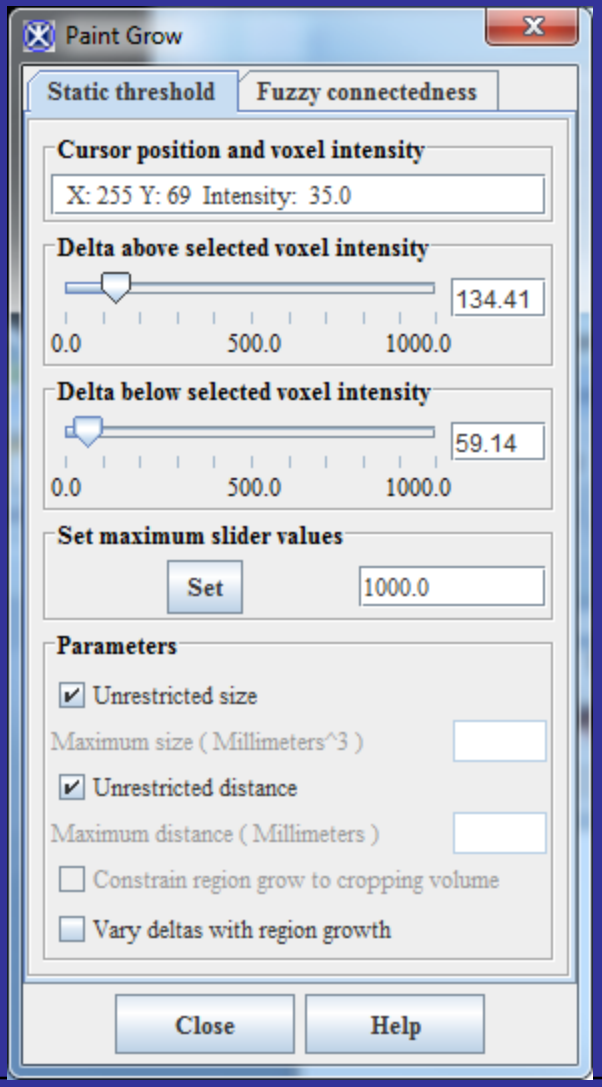


Advanced Paint

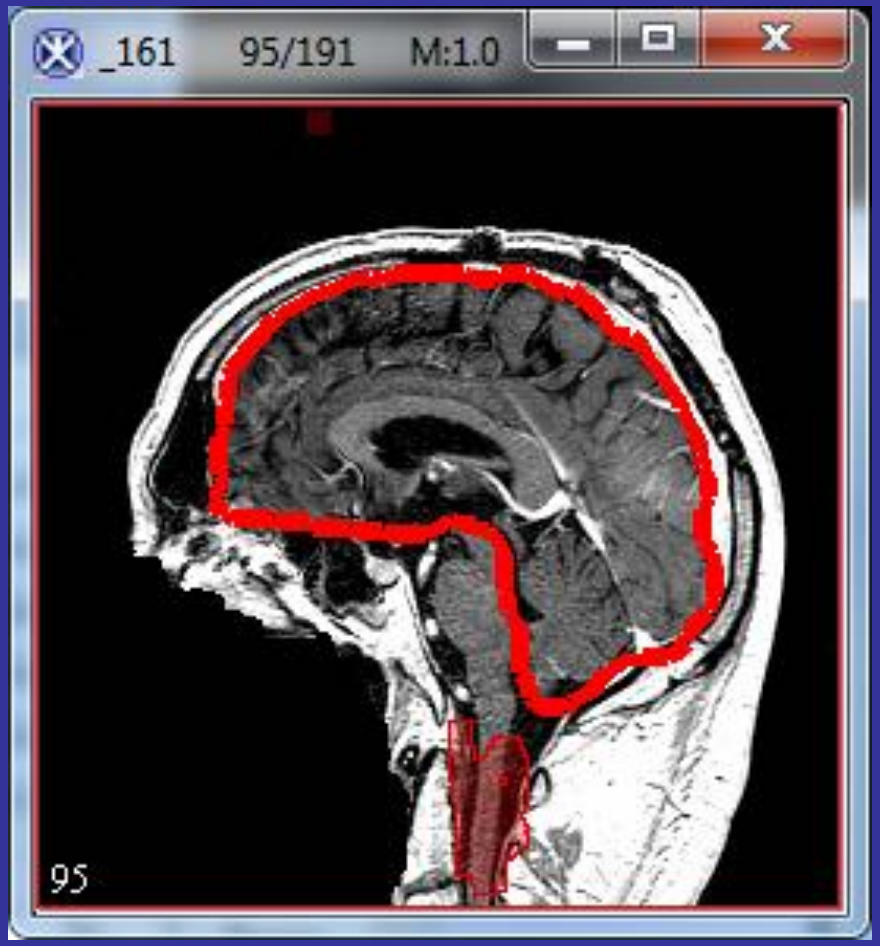


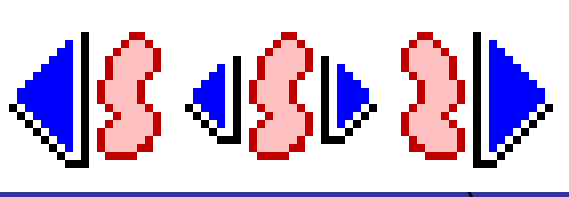
Region Grow


_162 95/191 M:2.0
95


Paint Grow
Static threshold
Fuzzy connectedness
Cursor position and voxel intensity
X: 255 Y: 69 Intensity: 35.0
Delta above selected voxel intensity
134.41
0.0
500.0
1000.0
Delta below selected voxel intensity
59.14
0.0
500.0
1000.0
Set maximum slider values
Set
1000.0
Parameters
Unrestricted size
Maximum size (Millimeters^3)
Unrestricted distance
Maximum distance (Millimeters)
Constrain region grow to cropping volume
Vary deltas with region growth
Close
Help

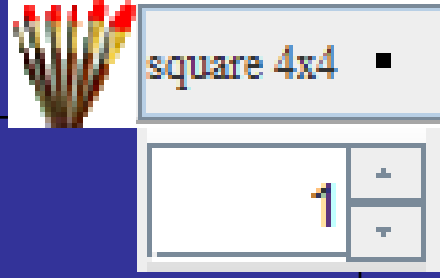
Erasers





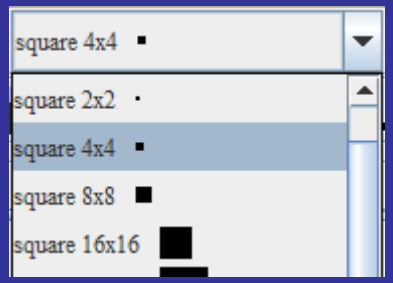
Propagation

- Same as VOI options
- No active contour solution

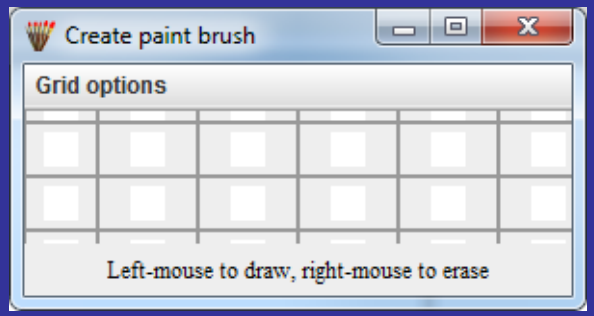


Paint brush options

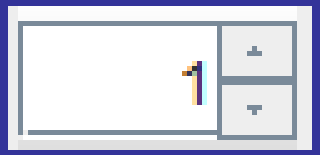
- Brush size



- Brush pattern



- Brush intensity

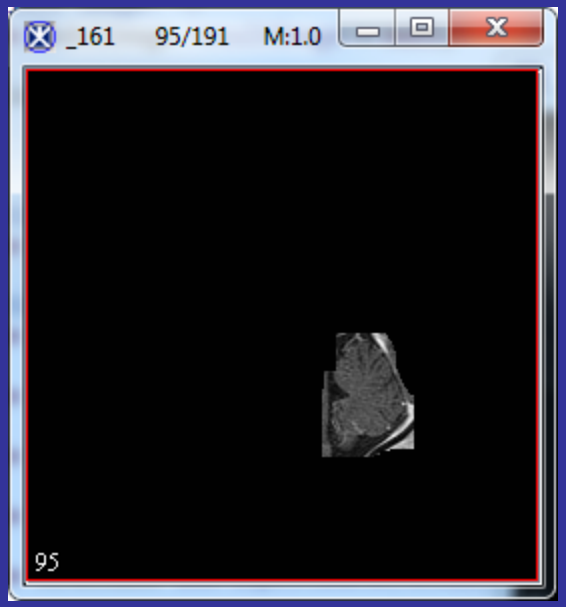


Paint display options

- Select color
- Change opacity
- Show border

Mask options

- Just like VOI mask options, another conversion tool

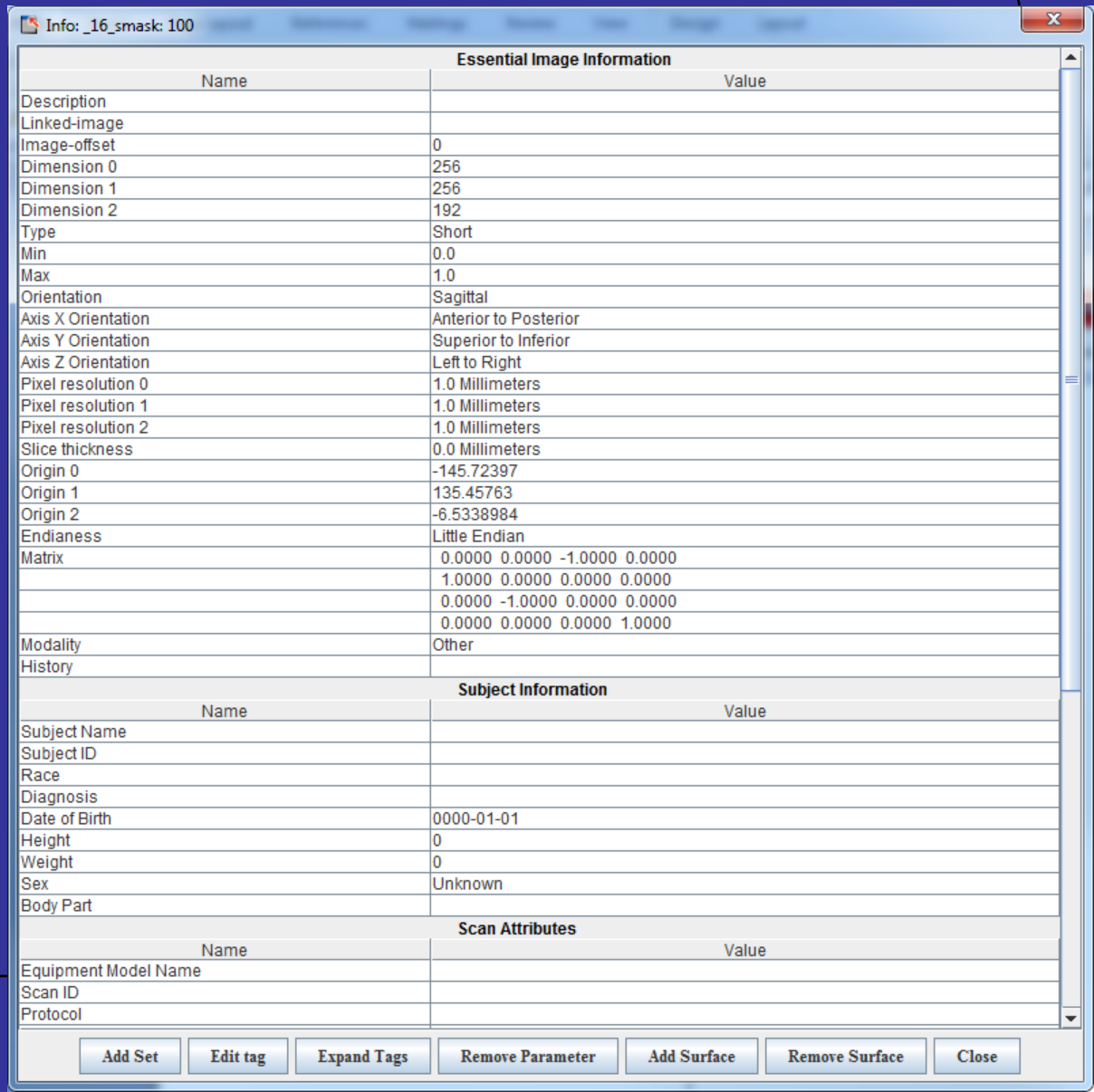


Undo paint

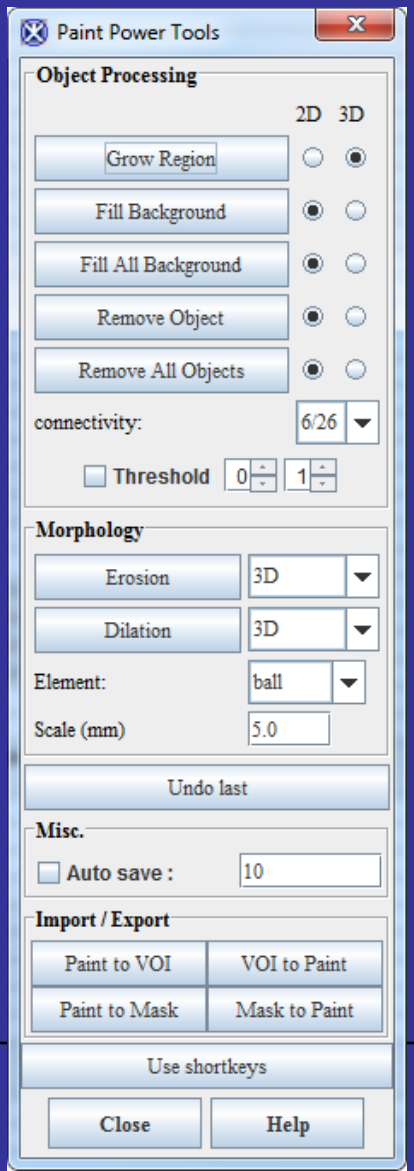
- Only applies to paint
- Does not change masks

Calculate volume

- Units of image
- Resolution of image



Power paint tools

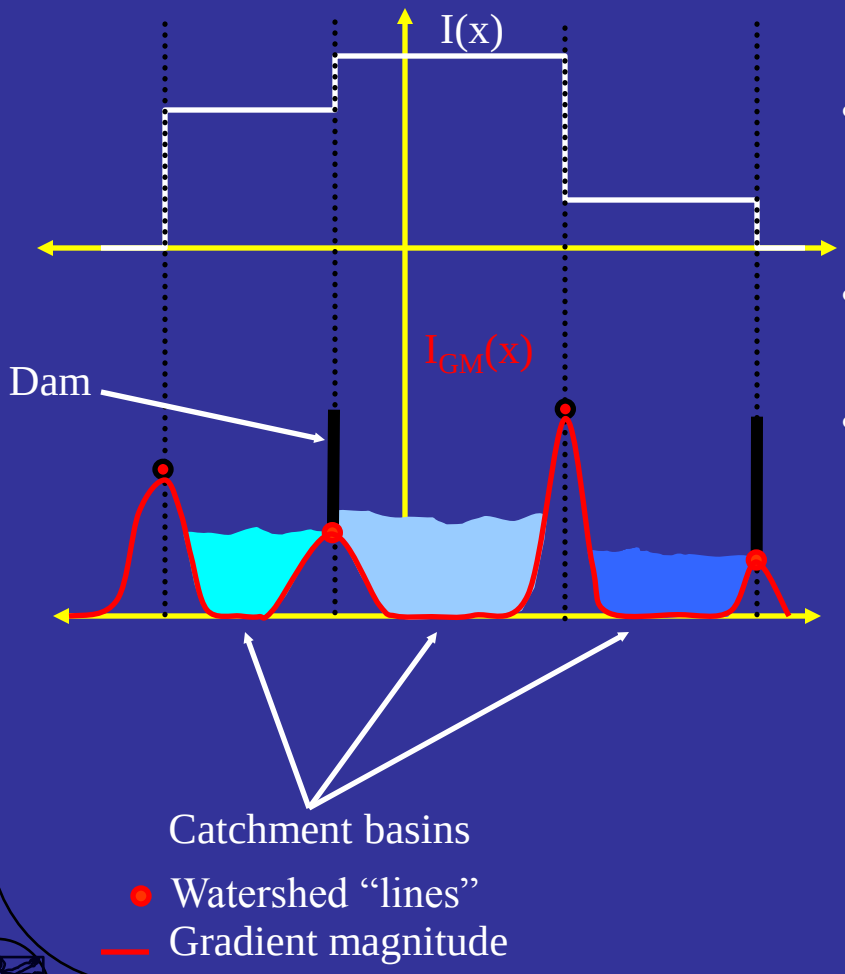


Segmentation

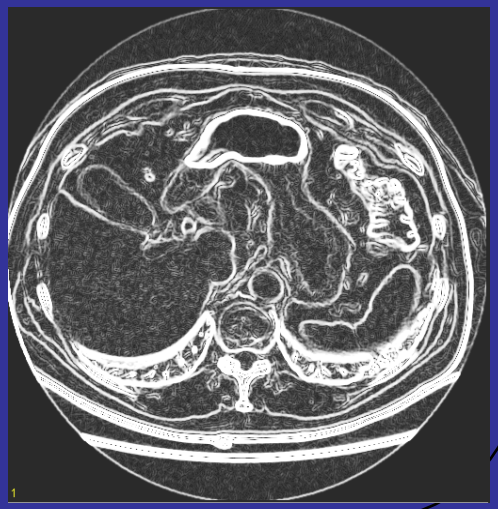
Watershed Segmentation

- Watersheds are a classic field of topography.
- Example of a watershed: *Great Divide* of the U.S.
  - A drop of water falling one side flows down until it reaches the Atlantic ocean, whereas a drop falling on the other end flows until it reaches the Pacific ocean.
- The above two watersheds or catchment basins are separated by what is termed the watershed line.
  - Catchment basins: minima of the watershed
  - Watershed line: maxima of the watershed

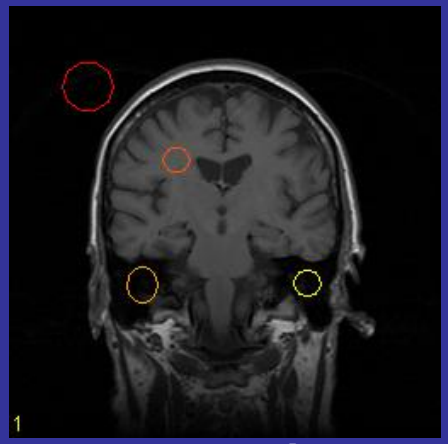
Watershed Segmentation



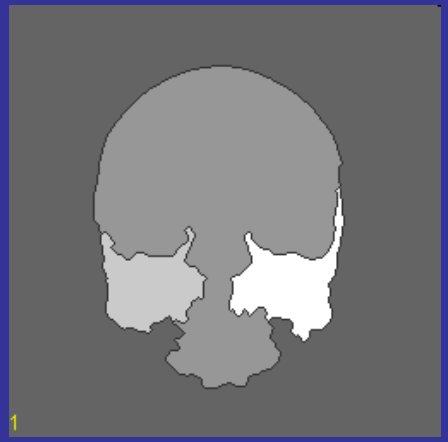
- Find the lowest point in each basin and begin "flooding".
- When two basins meet a watershed point (1D) is identified and a dam is formed.
- Continue flooding until all basins and watershed points are formed.
- Note: this method can produce over segmentations.



Watershed Segmentation: Interactive



MRI image with ROIs



Segmented basins

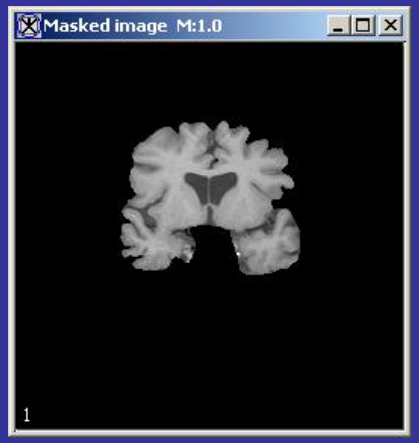
- Find the lowest point in each basin identified by a Region of Interest (ROI) and force the gradient magnitude to zero at all ROIs. Begin "flooding" in those regions.
- When two basins meet a watershed line (2D) is identified and a dam is formed.
- Continue flooding until all ROI basins until all regions are flooded.

Voxel Classification

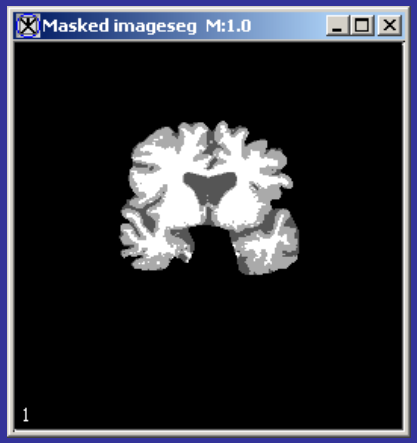
- Groups of voxels are not physically connected then the segmentation technique is termed voxel classification and voxels sets are referred to as **classes**

- Cluster methods do not inherently incorporate spatial information and therefore can be sensitive to factors like intensity inhomogeneities.

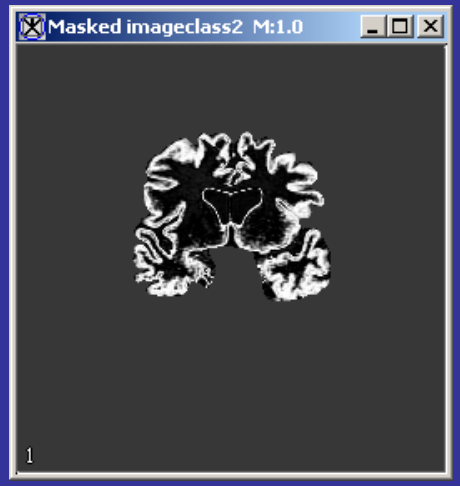
Fuzzy C-means



T1 – MRI

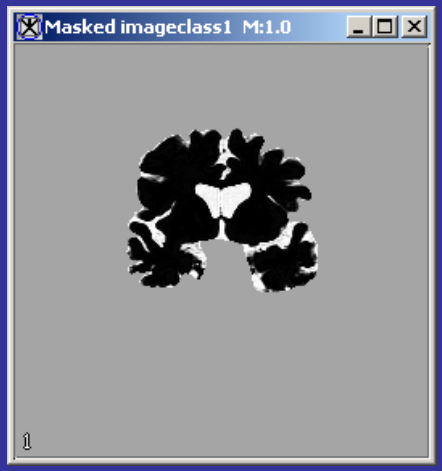


Hard segmentation – G,W,CSF



Fuzzy Gray

Fuzzy White

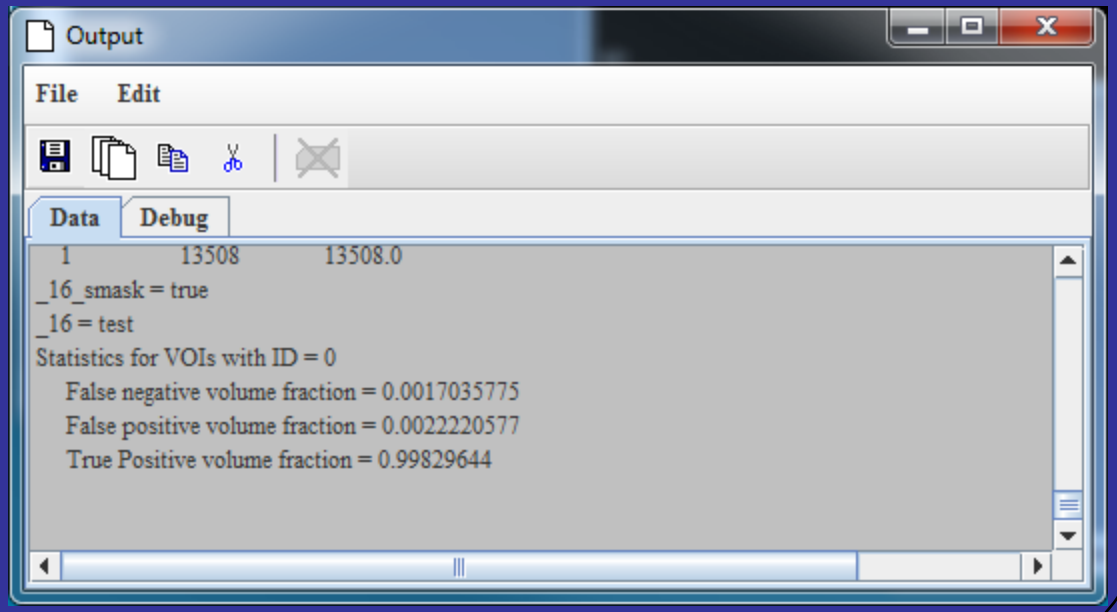


Fuzzy CSF

CIT

Segmentation Evaluation

- Compared to ground truth VOI
- Requires converting masks to VOIs



Acknowledgments

- Images from NCI's Cancer Imaging Archive: http://cancerimagingarchive.net/

- Examples from NIH collaborators.

Thank you!