Segmentation and Annotation of Medical Images with MIPAV

Justin Senseney
SenseneyJ@mail.nih.gov
dcb.cit.nih.gov/~senseneyj

Biomedical Image Processing Research Services Section
Center for Information Technology
mipav.cit.nih.gov
MIPAV Team

Employees
Ruida Cheng
William Gandler
Matthew McAuliffe
Evan McCreedy
Justin Senseney

Fellows
Sara Shen

Contractors
Alexandra Bokinsky, Geometric Tools Inc. (Visualization)
Olga Vovk, SRA International Inc. (Technical Writing)

Alumni
Paul Hemler, Agatha Munzon, Nishith Pandya,
Beth Tyrie, Hailong Wang
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
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
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
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

Opening

Source object

Erosion

Dilation

Result: Erosion + Dilation = Opening

Structuring Element

2D 3x3 structuring element

3D 3x3x3 structuring element
Mathematical Morphology

Closing

Source object

Dilation

Erosion

Result: Dilation + Erosion = Closing

Structuring Element
Mathematical Morphology

Noise Removal

Input

Original boundary

Result

Erode

Dilate

Dilate

Erode

Opening

Closing
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
Advanced Paint
Region Grow
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.

Catchment basins
- Watershed “lines”
- Gradient magnitude
Watershed Segmentation: Interactive

- 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
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!