



Practical Labor of Image Processing Challenges

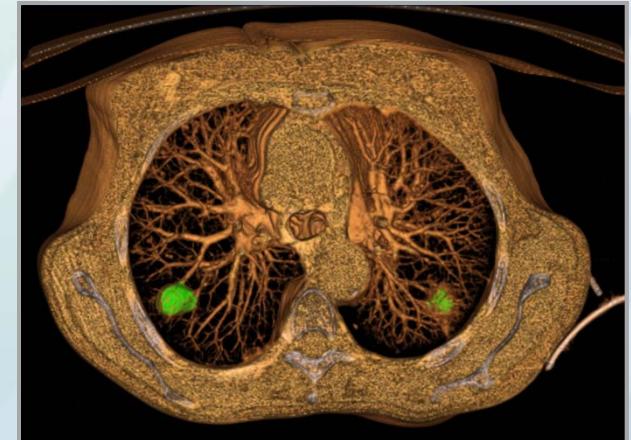
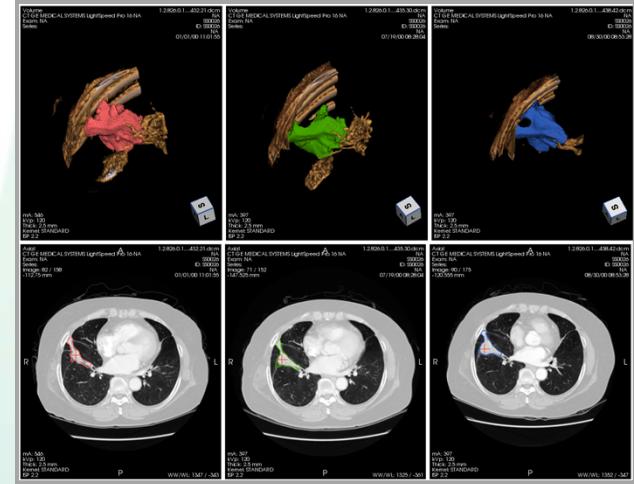
Lung Cancer Workshop
May 2-3, 2011
Wesley D. Turner

Lesion Sizing Toolkit

A free and open source software toolkit for quantitative lesion segmentation in biomedical images

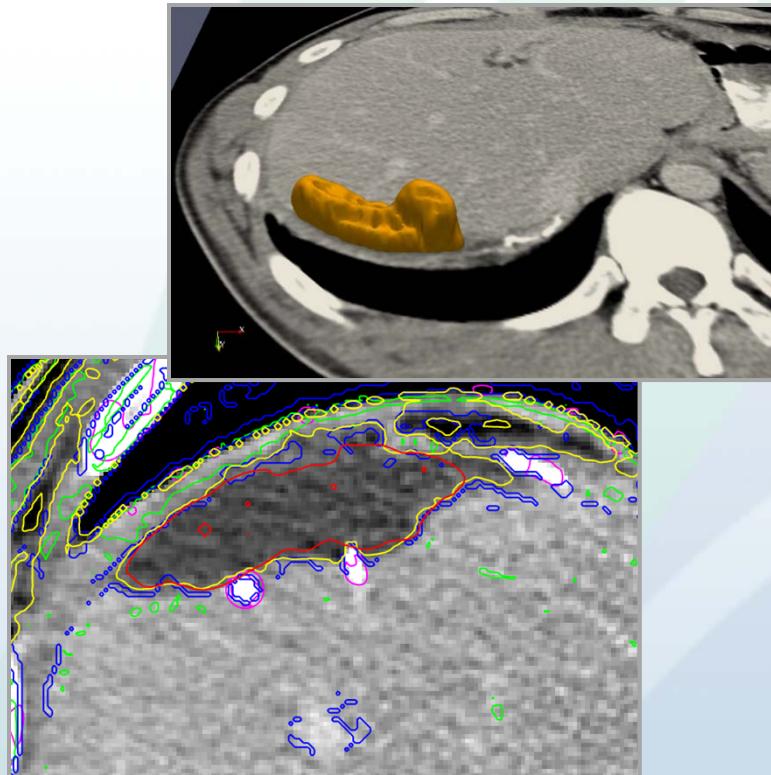
The toolkit provides:

- A modular architecture for lesion sizing in any modality
- A reference algorithm for CT lung cancer lesion sizing
- Example CT lung lesion sizing application



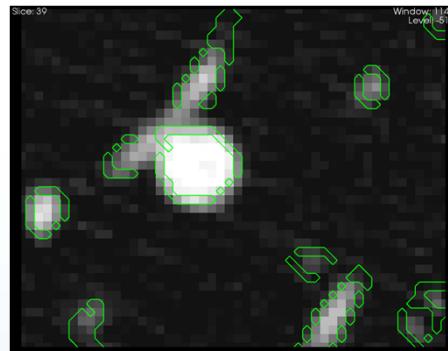
Lesion Sizing Toolkit

- Developed in collaboration with:
 - Air Force Research Laboratory
 - Optical Society of America
 - National Library of Medicine
 - Dr. David Yankelevitz, Mount Sinai
- Now:
 - LSTK received NLM funds as an ITK A2D2
 - Release as an ITK Module imminent
 - Algorithm improvements will follow

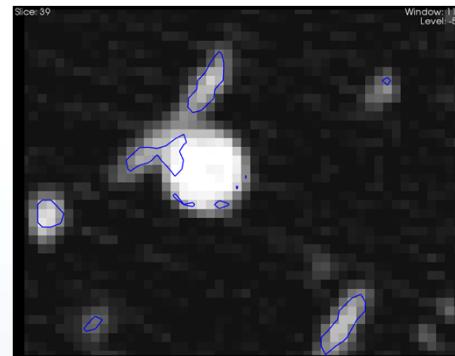


A CT Lung Lesion Sizing Reference Algorithm

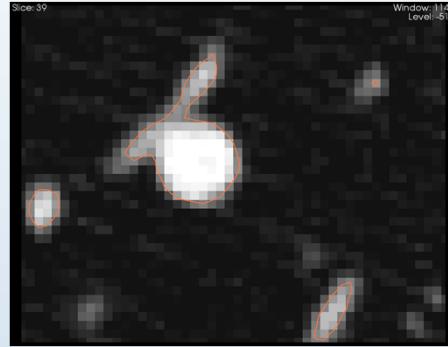
3D Canny Edge



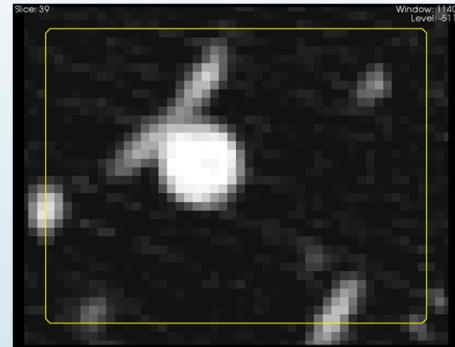
Sato Vesselness



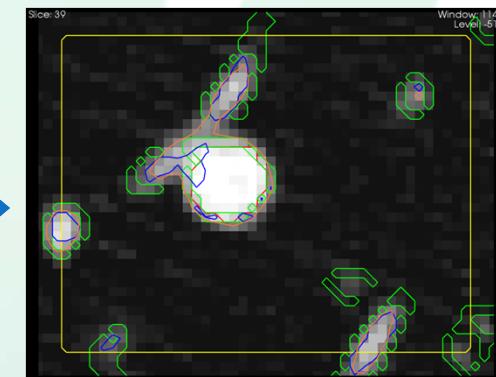
Threshold Sigmoid



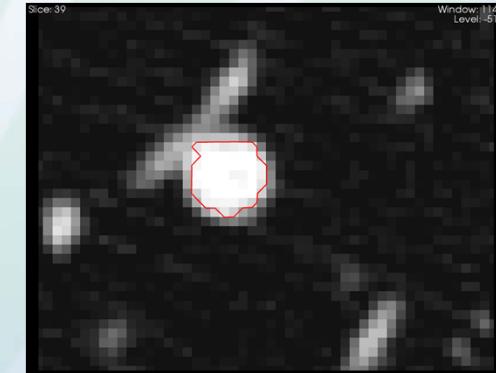
Lung Wall Detector



Aggregated Features



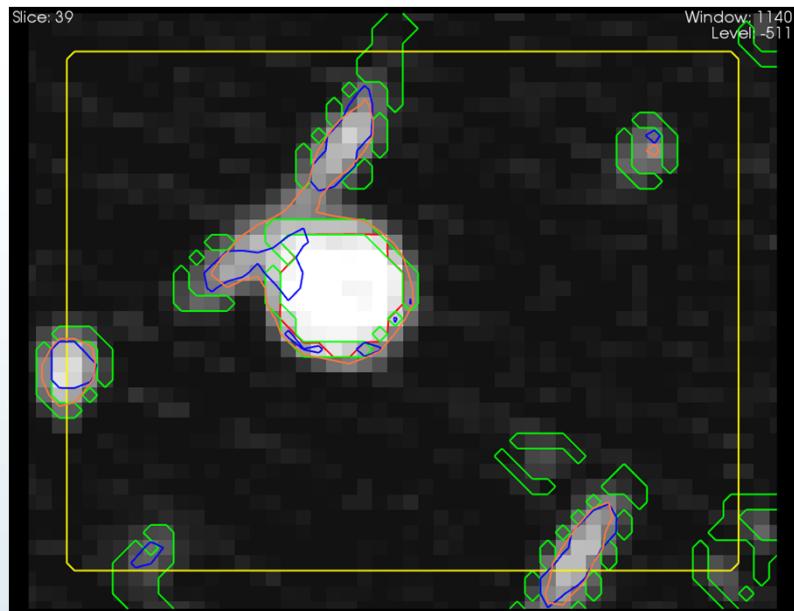
Level-Set Region Growing



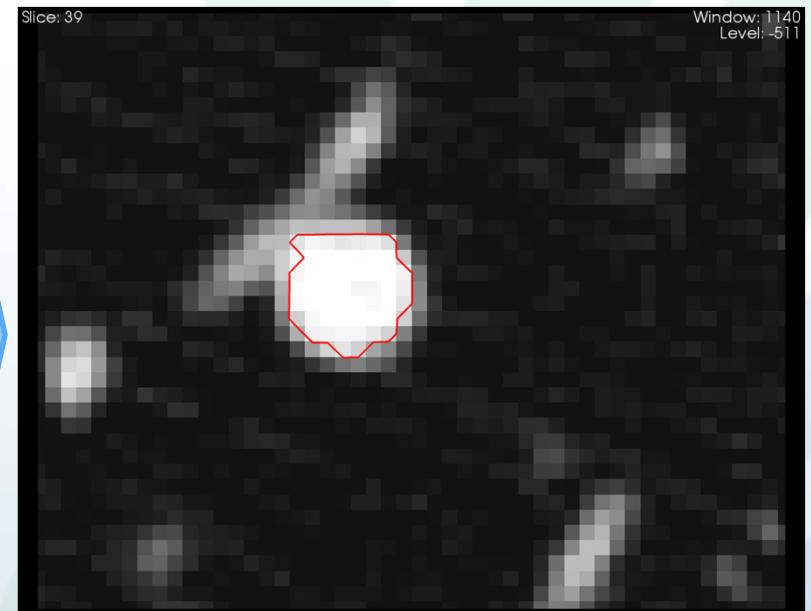
The four region growing “stopping” features are computed in the region of interest and then combined into a single feature using the Feature Aggregator. The Segmentation Manager then applies a level-set region growing algorithm starting from a seed point and expanding until feature boundaries prohibit boundary advancement. Applying all methods on an ROI ensures that the algorithm behaves similarly regardless of lesion location.

A CT Lung Lesion Sizing Reference Algorithm

Aggregated Features



Level-Set Region Growing

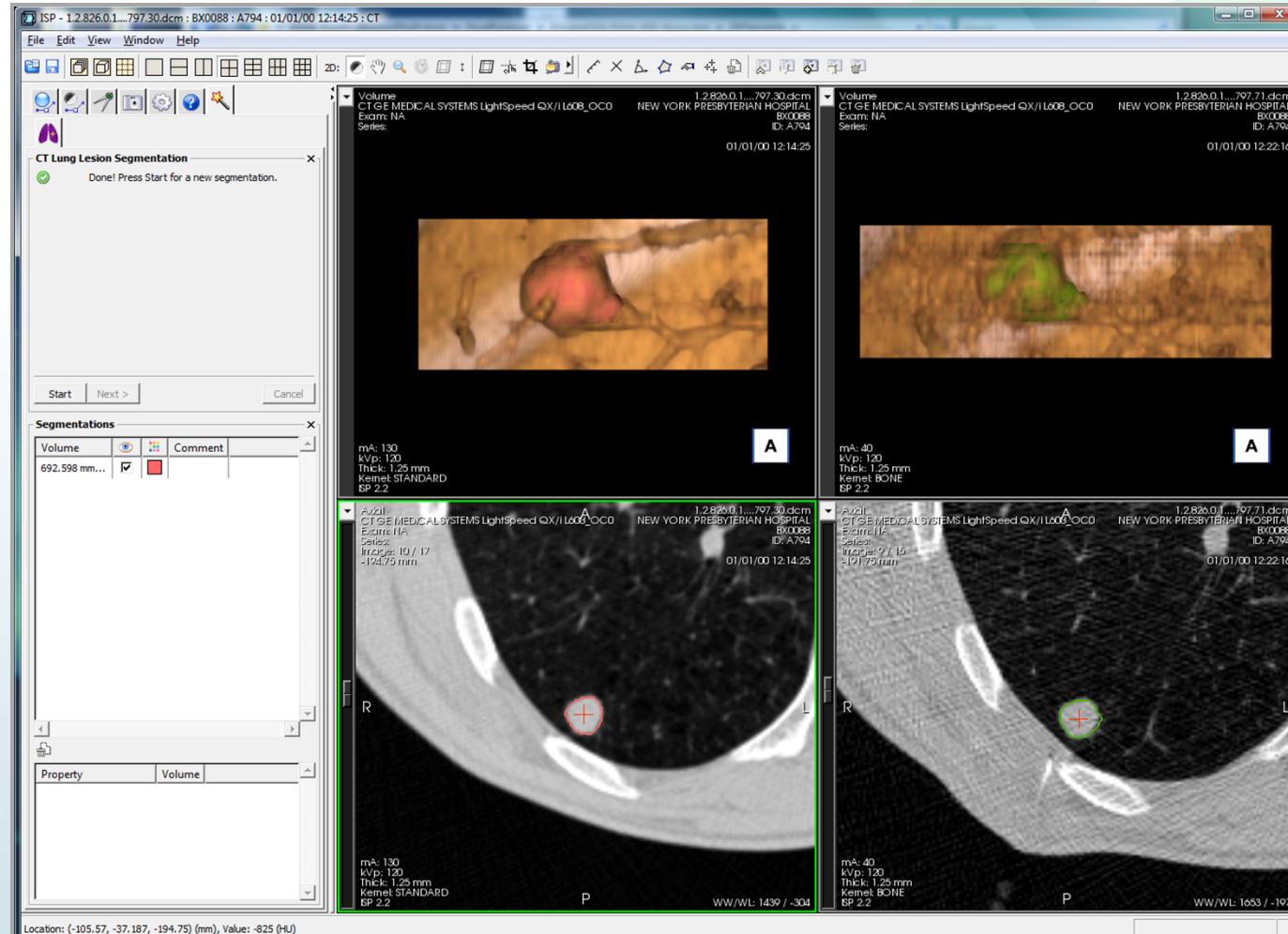


The final boundary resulted in a measured volume that was 4% less than the manufactured lesion volume. In the future we plan to work with the lesion sizing community to add sub-voxel precision on the lesion boundary location. In addition, providing the 3D Canny edge detector with information on acquisition PSF and noise will allow the algorithm to adapt to variations in image acquisition.

Segmentation Results

THE GOOD

CT Lung Lesion Sizing Example 1



$$\Delta V = -3\%$$

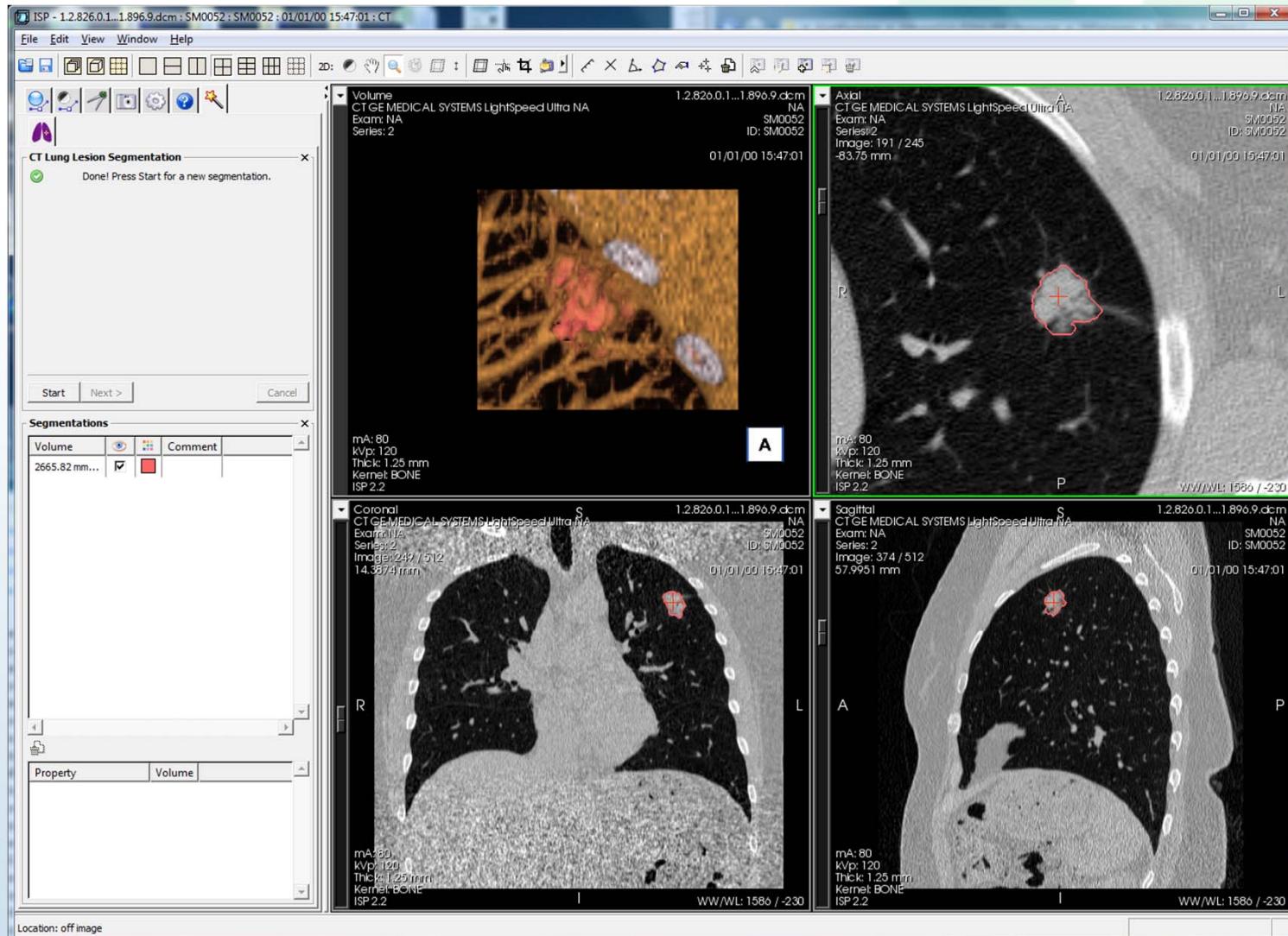
$$T_1 = 693 \text{ mm}^3$$

$$T_2 = 671 \text{ mm}^3$$

Data Courtesy of the Public Lung Database to Address Drug Response



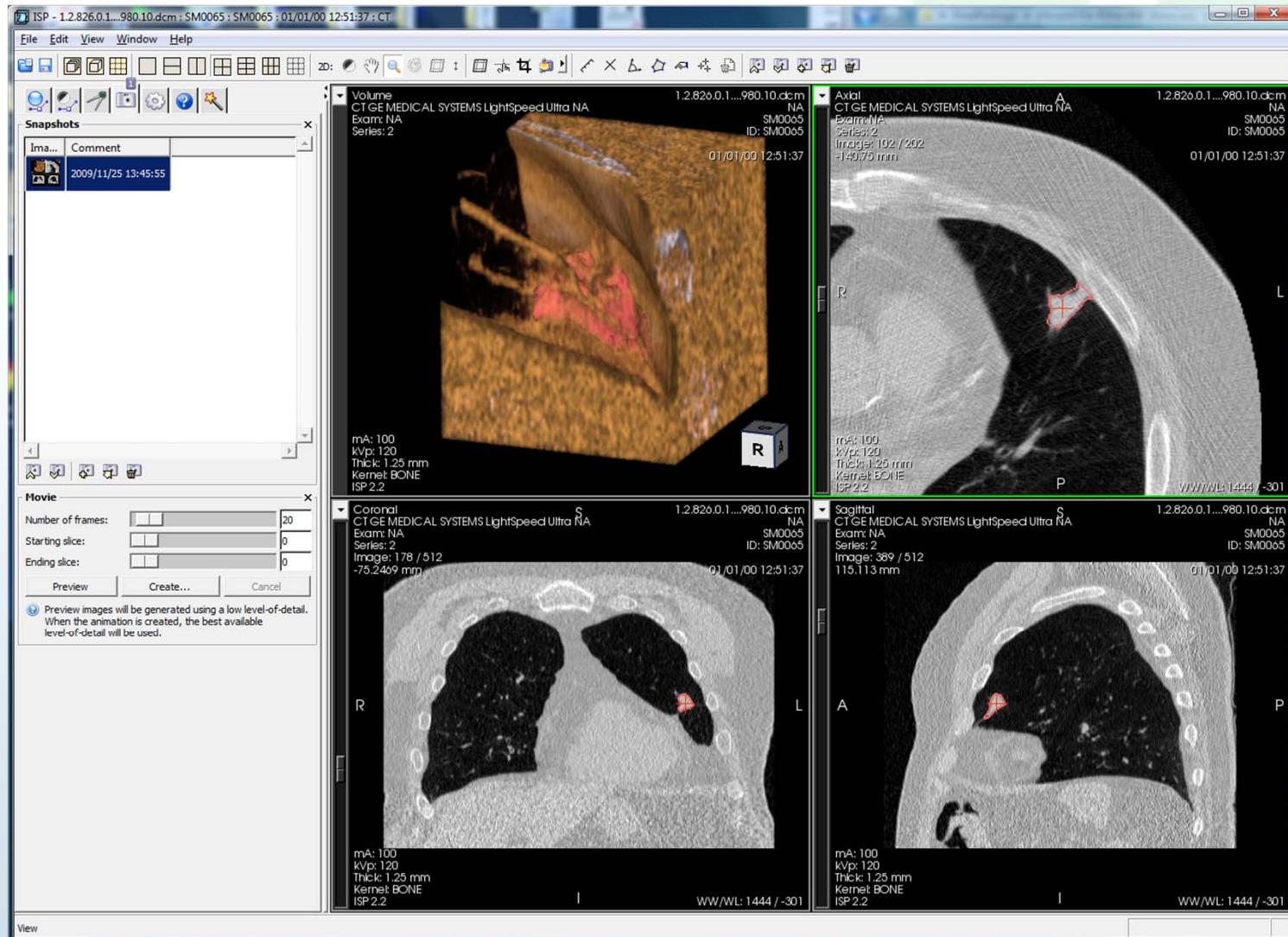
CT Lung Lesion Sizing Example 2



Data Courtesy of the Public Lung Database to Address Drug Response

 **Kitware**

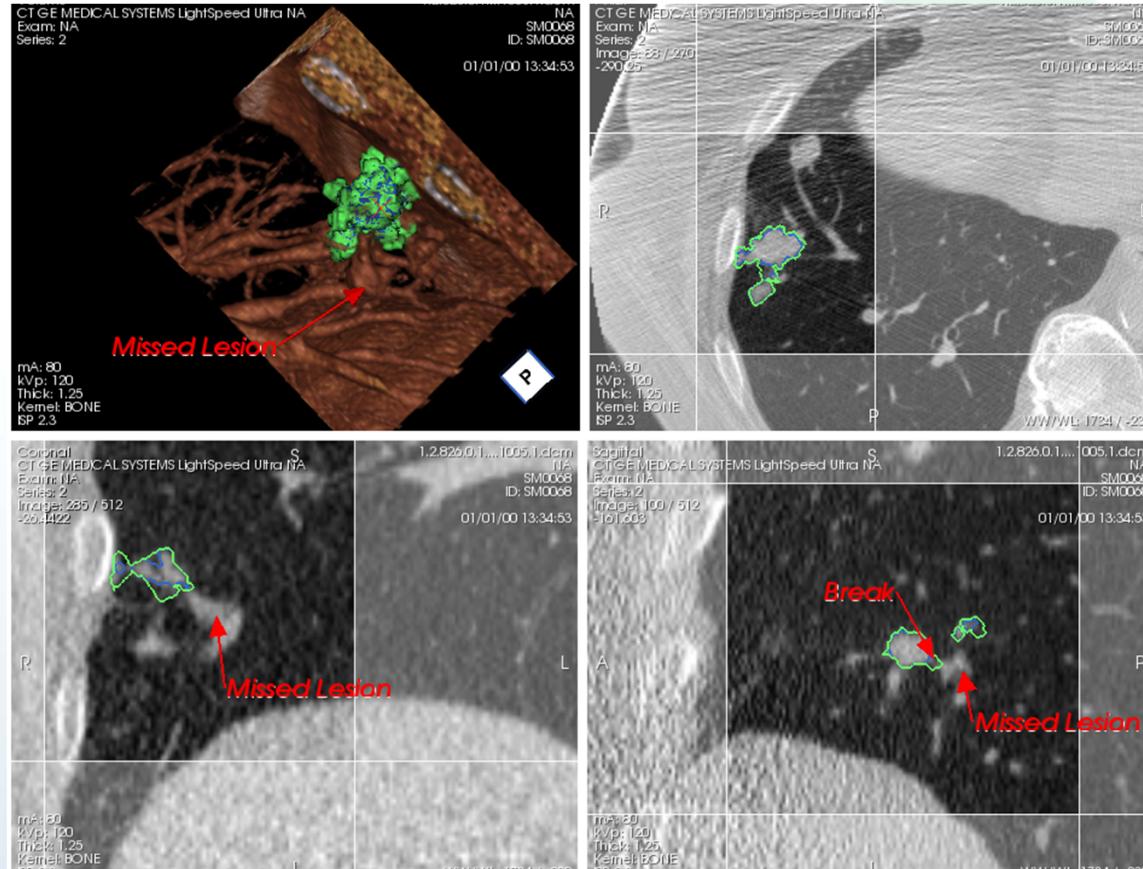
CT Lung Lesion Sizing Example 3



Data Courtesy of the Public Lung Database to Address Drug Response

Segmentation Results

THE NOT SO GOOD

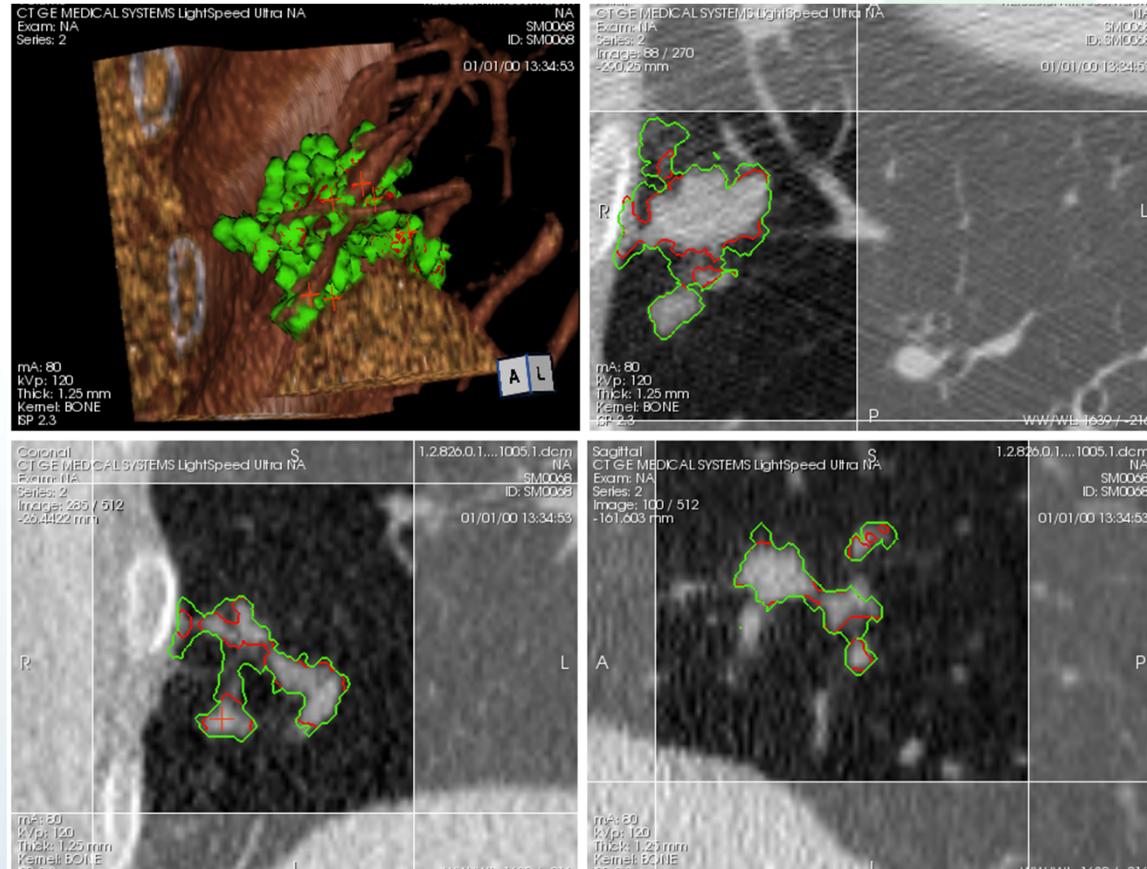


Complex Lesion Shapes

CT Lung Lesion Sizing

Study ID: SM0068 Date: 01/Jan/2000

Data Courtesy of the VIA database.



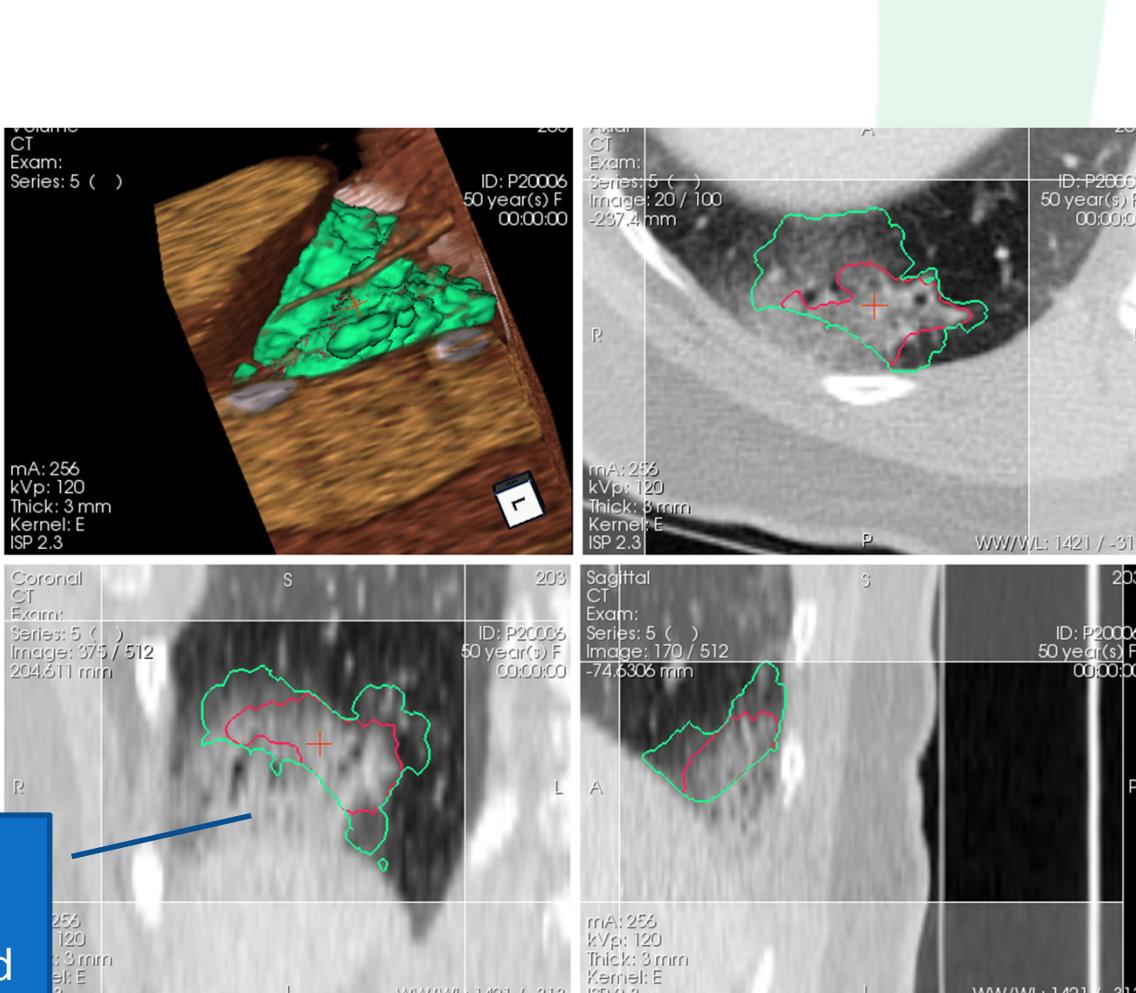
Additional Seed Points Help ...

CT Lung Lesion Sizing

Study ID: SM0068 Date: 01/Jan/2000

Data Courtesy of the VIA database.

Thick Slice
and
Complicated
Location



Complicated lung regions

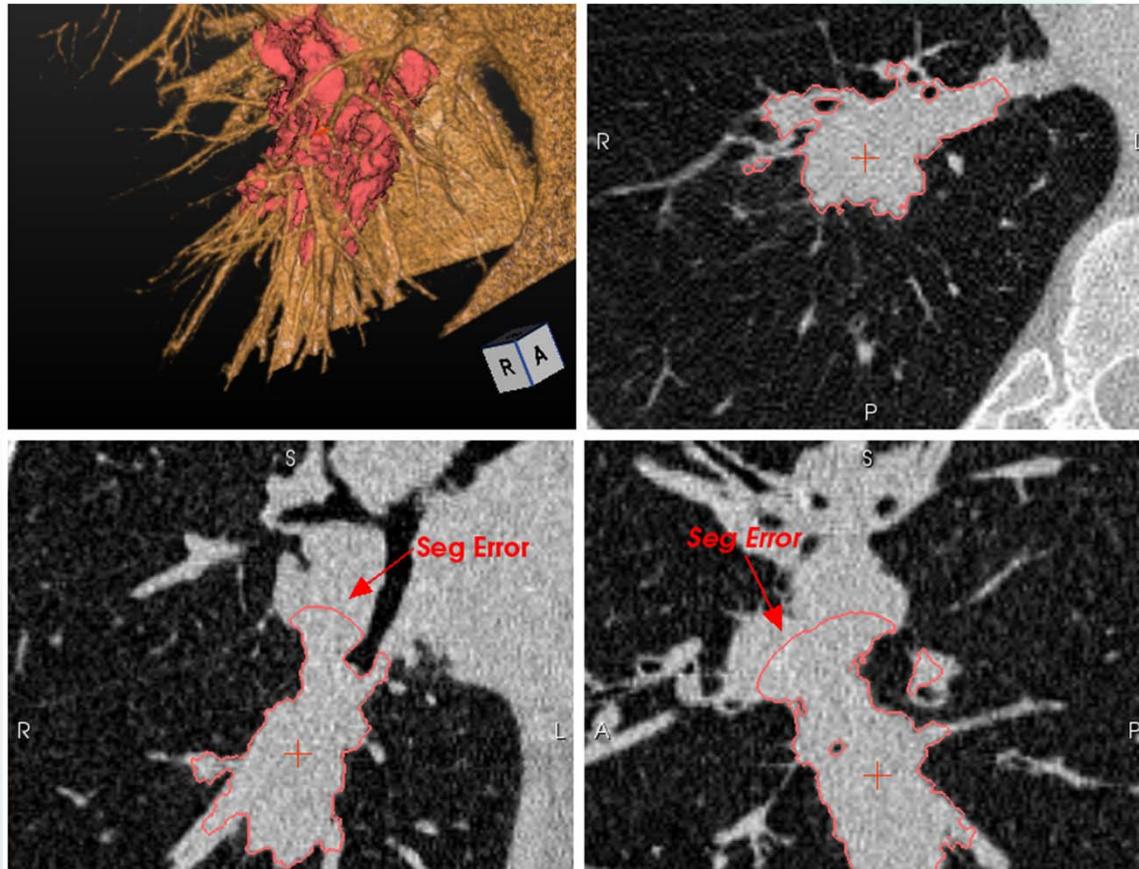
CT Lung Lesion Sizing
Study ID: P20002, Study 3

Data made available by the Lung Cancer Alliance's (LCA) Give-A-Scan Project.

 **Kitware**

Segmentation Results

THE NAVARRA DATA

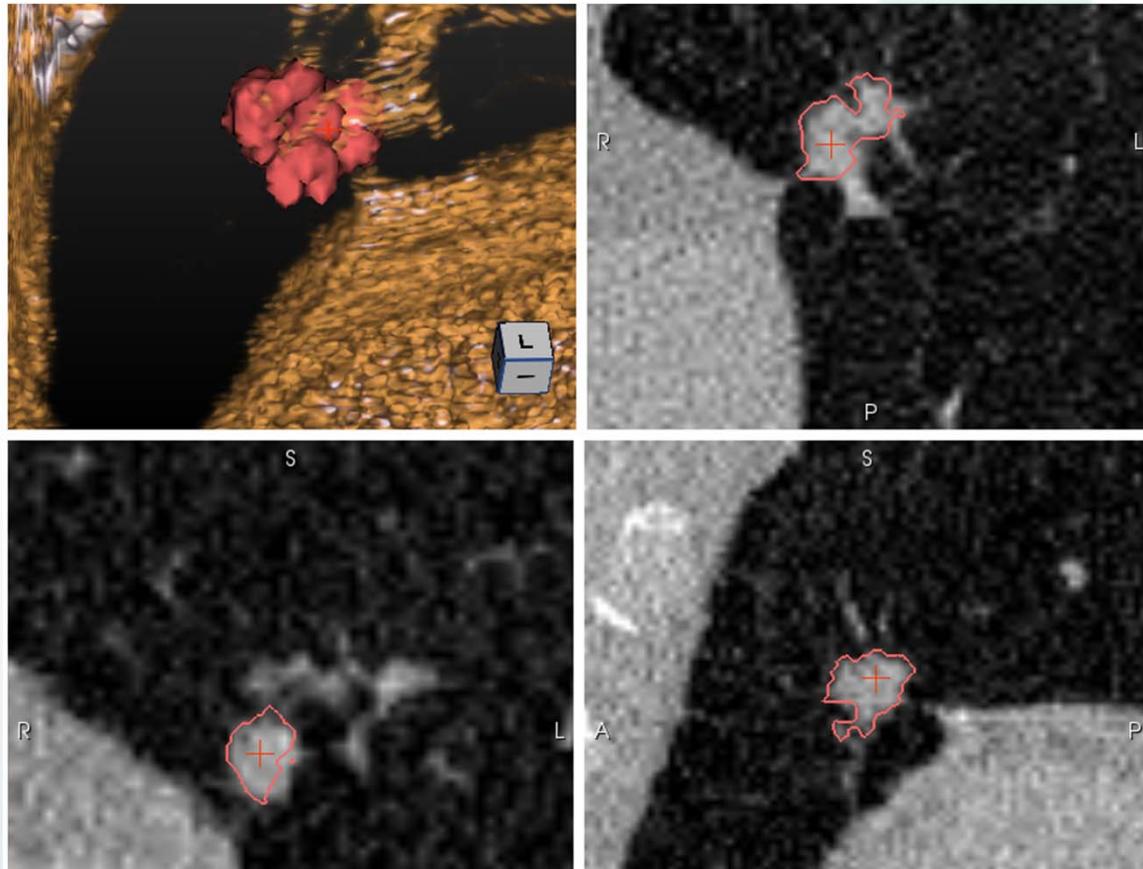


Small Cell Lung Cancer

Complicated shapes near the heart

Data made available courtesy of Dr. Zulueta University of Navarra

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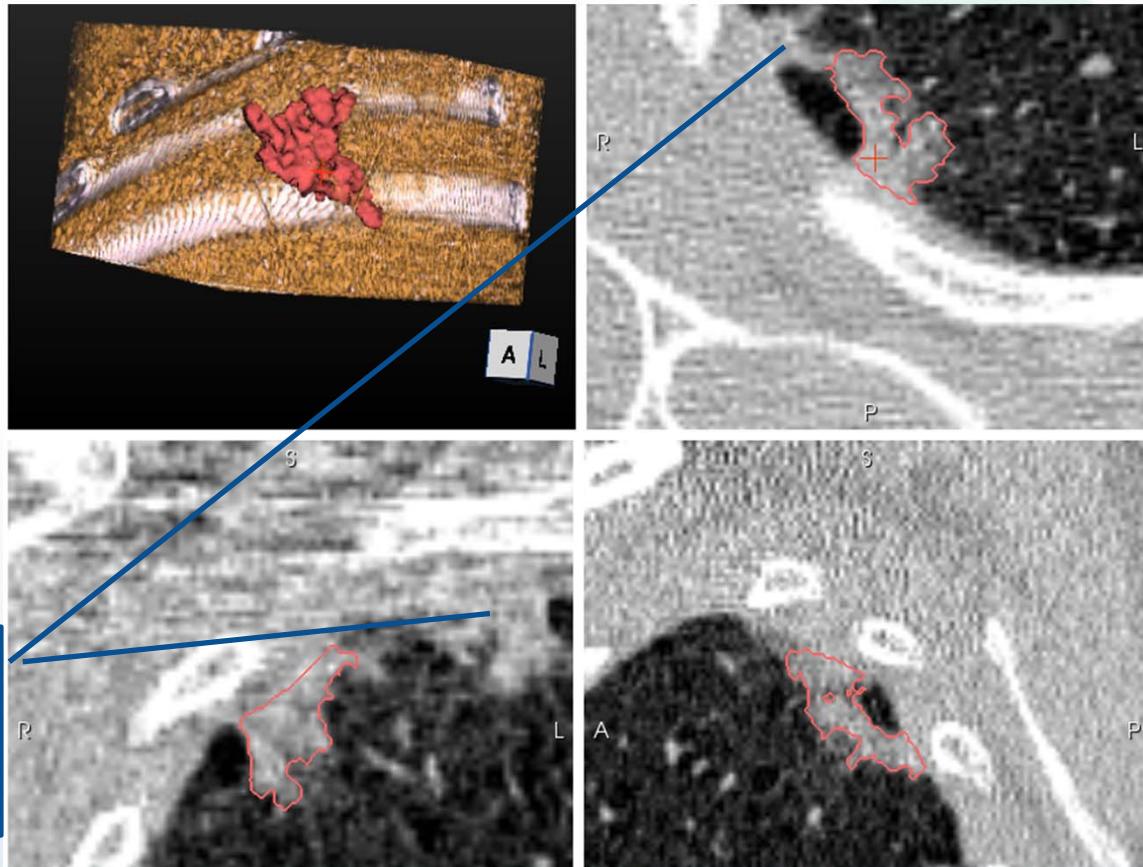
Squamous Cell Carcinoma

Tubular components can be confounded with vessels

Data made available courtesy of Dr. Zulueta University of Navarra

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Multiple, non-spherical and disjoint regions



Large Cell

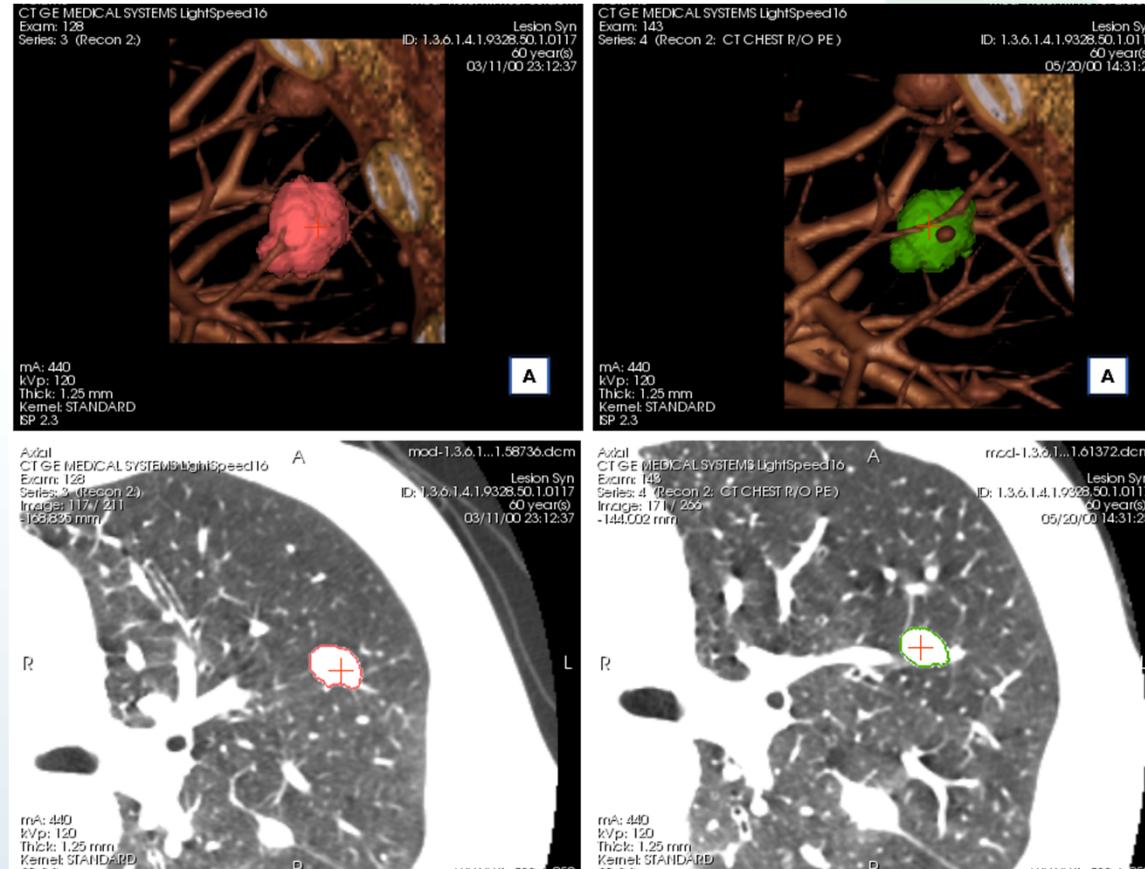
Complex cancer shape

Data made available courtesy of Dr. Zulueta University of Navarra

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Segmentation Results

THE NIST BIOCHANGE CHALLENGE



Synthetic Lesion

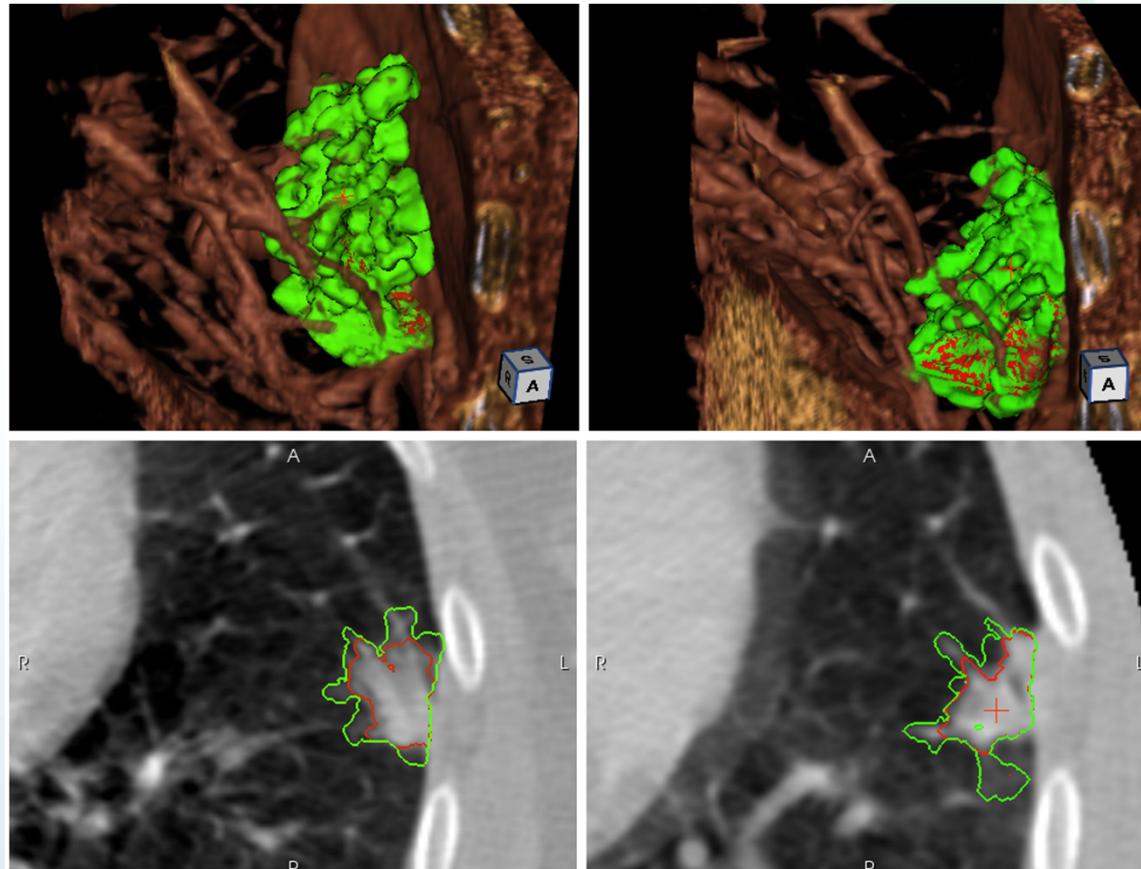
CT Lung Lesion Sizing

Patient A: Time Point 1 vs. Time Point 2

2623 mm³ vs 1548 mm³

Data Courtesy NIST Biochange Challenge.

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Real Lesion

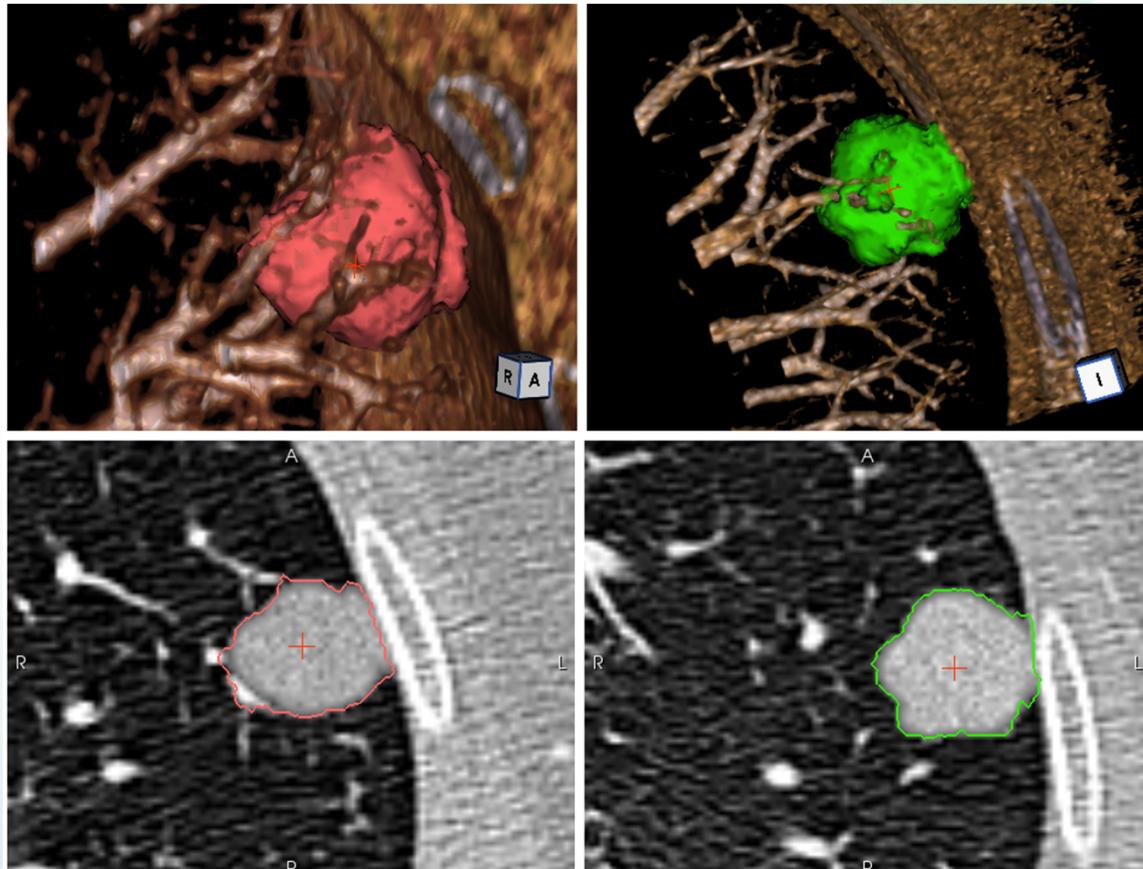
CT Lung Lesion Sizing

Patient B: Time Point 1 vs. Time Point 2

2652 mm^3 vs 2565 mm^3 Solid Boundary

6057 mm^3 vs 4652 mm^3 Part Solid Boundary

Data Courtesy NIST Biochange Challenge.



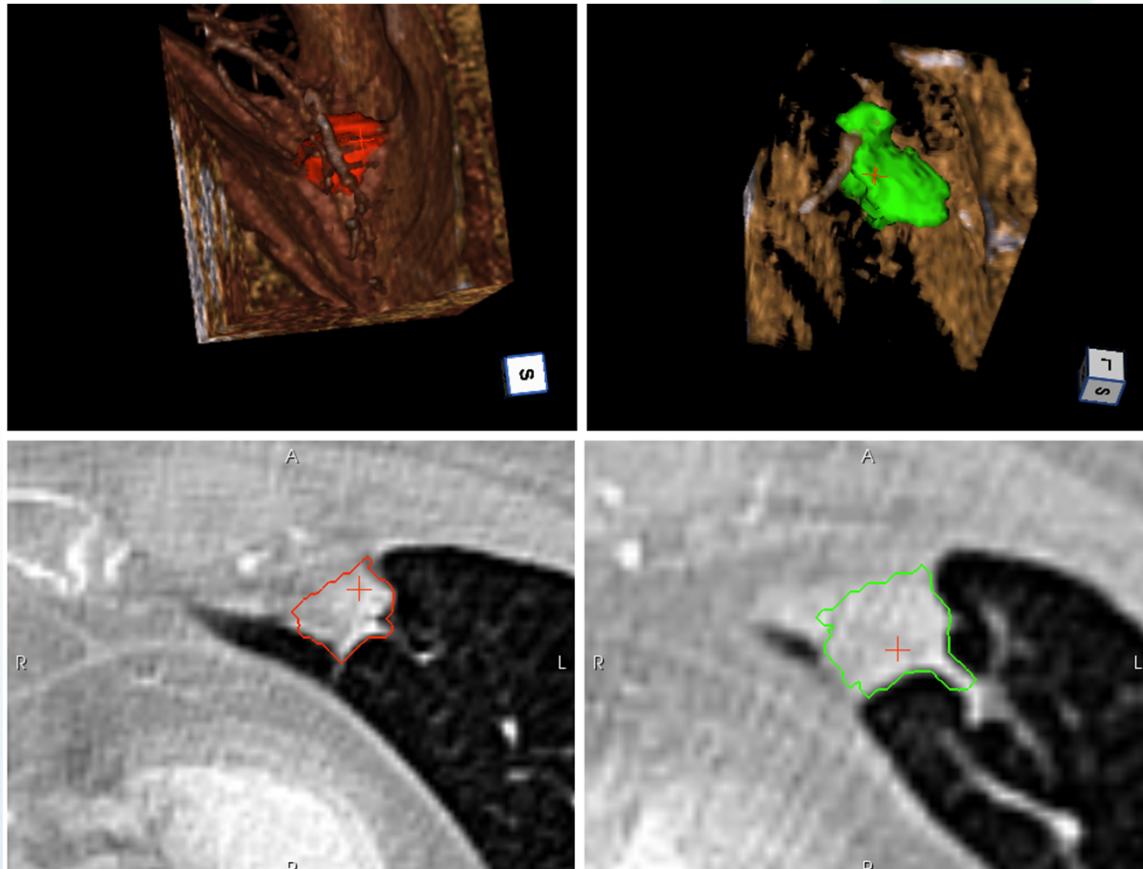
Synthetic Lesion

CT Lung Lesion Sizing

Patient C: Time Point 1 vs. Time Point 2

2652 mm^3 vs 2565 mm^3 Solid Boundary

Data Courtesy NIST Biochange Challenge.



Real Lesion

CT Lung Lesion Sizing

Patient D: Time Point 1 vs. Time Point 2

488 mm³ vs 475 mm³ Solid Boundary

Data Courtesy NIST Biochange Challenge.

 **Kitware**