



NA-MIC

National Alliance for Medical Image Computing

<http://www.na-mic.org>

Segmentation for 3D printing

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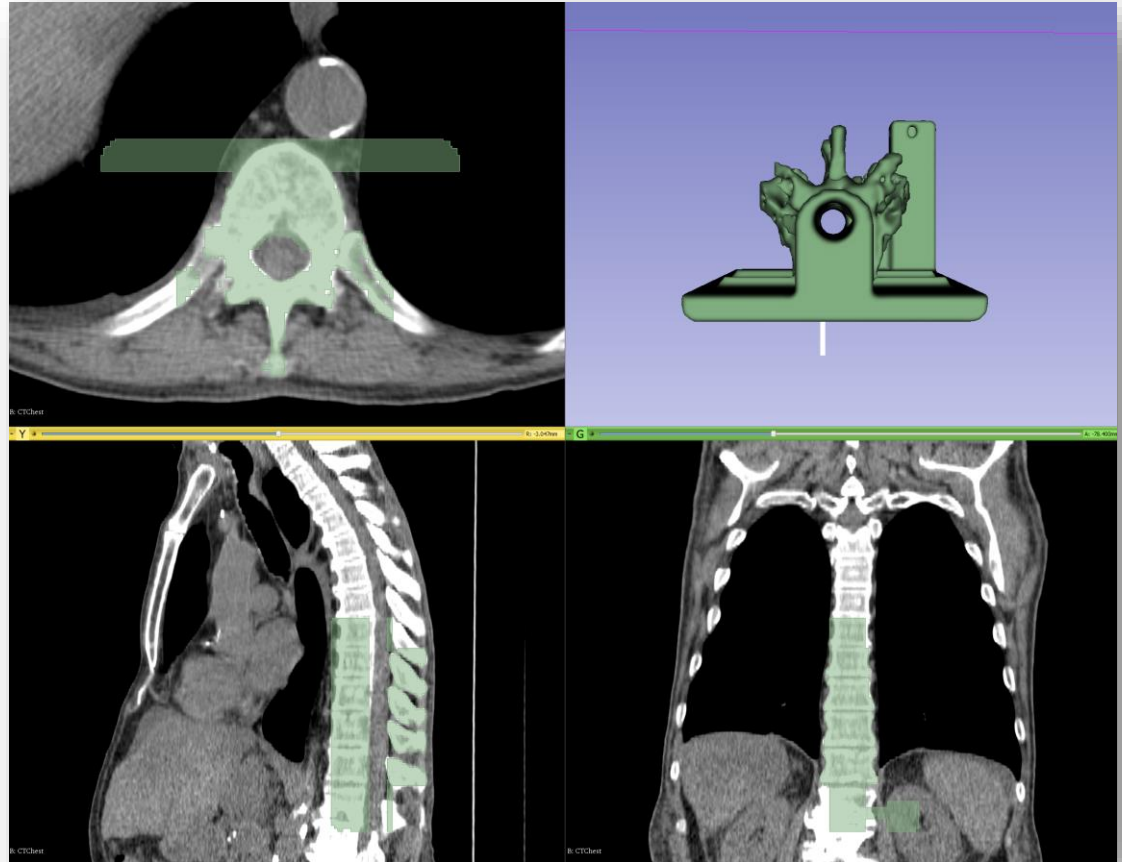
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NA-MIC Tutorial Contest: Winter 2017



Learning Objective

This tutorial demonstrates segmentation in Slicer's new Segment Editor module for the purpose of 3D printing





Clinical utility of the created spine phantom

- Training phantom for needle insertion
- Electromagnetic marker holder
- Filled with gel (~soft-tissue)
- Covered with sheet (~skin)
- Tube with water in the center



[Moult et al. 2013](#)





Material

This tutorial requires the installation of a recent Slicer 4.7 nightly release, which is available at the **Slicer** download page:

<http://download.slicer.org/> (see row of Nightly Build)

Tutorial dataset: Phantom base STL model

<http://www.na-mic.org/Wiki/images/1/1e/BasePiece.stl> (source: [PerkLab](#))

Wiki pages:

<https://www.slicer.org/wiki/Documentation/Nightly/Modules/Segmentations>

<https://www.slicer.org/wiki/Documentation/Nightly/Modules/SegmentEditor>



Platforms

- Developed and maintained on Windows 64bit, Mac OSX, and Linux 64bit & 32bit



- Slicer requires
 - Minimum 2GB RAM
 - 64 bit strongly suggested



Segment Editor module

- Successor of the 'Editor' module
- In addition to Editor it provides
 - real-time 3D surface update
 - editing on oblique slices
 - overlapping segments, and much more
- It is considered stable
 - But development is still underway



Overview

1. Load CT image
2. Segment vertebrae to be 3D printed
3. Add phantom base to segmentation
4. Merge and finalize phantom
5. Save phantom segment to STL file for 3D printing



Part 1: Load CT image

Overview:

- Load sample CT Chest dataset
- Set image contrast for better visibility



1/1: Load CT Chest dataset

3DSlicer

Welcome

Load DICOM Data

Load Data

Install Slicer Extensions

Download Sample Data

Customize Slicer



Download MRHead

Download CT Chest

Download CTACardio

Download DTIBrain

Download MRBrainTumor1

Download MRBrainTumor2



1/2: Sample CT loaded

3D Slicer 4.7.0-2017-01-06

File Edit View Help

Modules: # Sample Data

3D Slicer

- Help & Acknowledgement
- Reload & Test
- BuiltIn
 - Download MRHead
 - Download CTchest
 - Download CTACardio
 - Download DTIBrain
 - Download MRBrainTumor1
 - Download MRBrainTumor2
 - Download BaselineVolume
 - Download DTIVolume
 - Download DWIVolume

Download finished

Requesting load *CTchest* from
C:/Users/Csaba/AppData/Local/Temp/Slicer/RemoteIO/CT-chest.nrrd...

Load finished

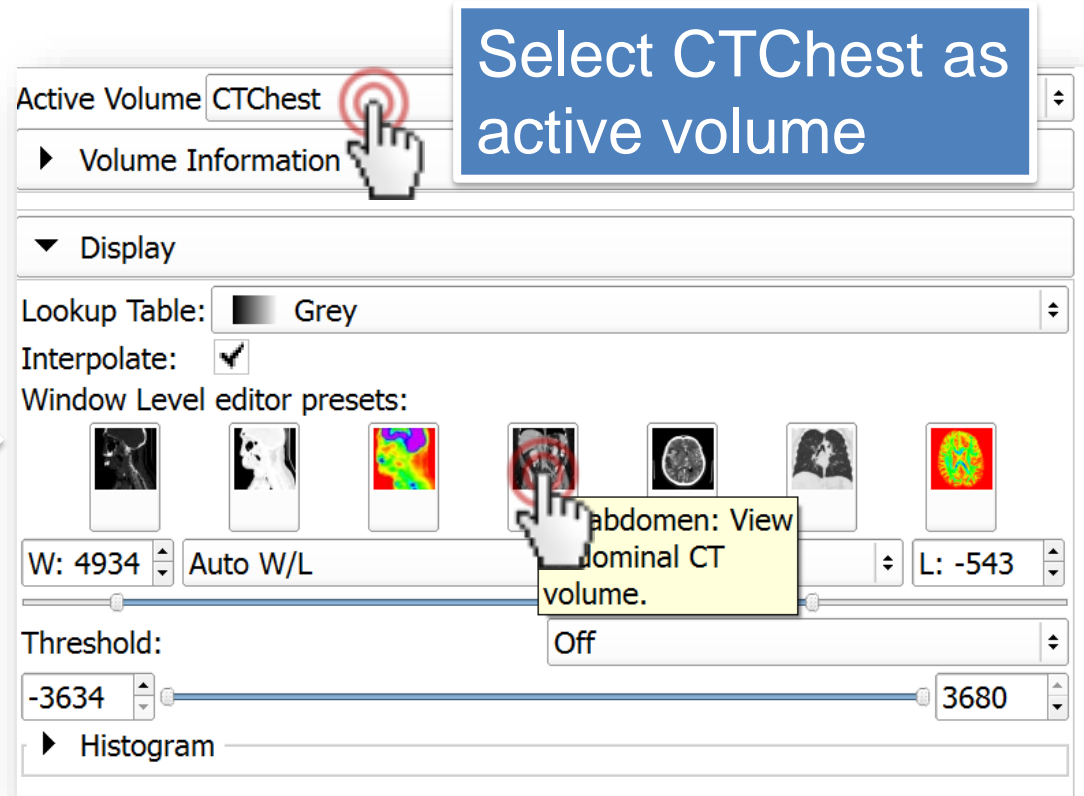
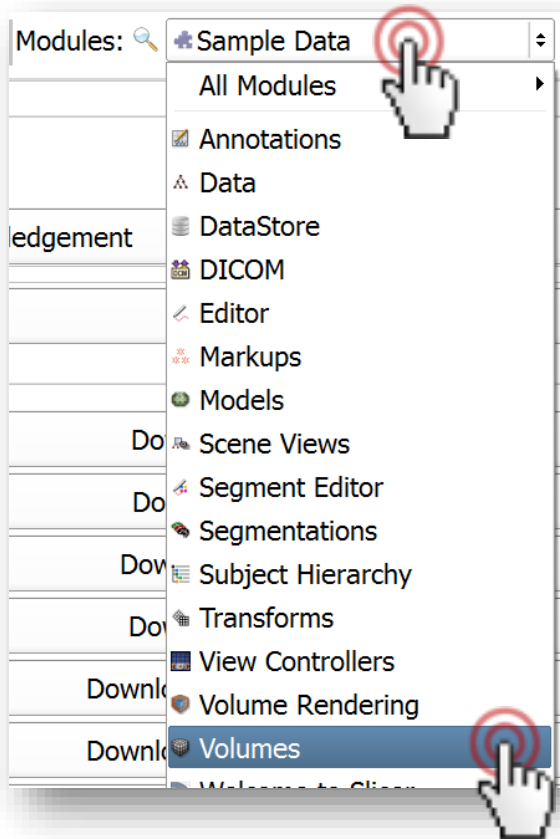
Data Probe

Show Zoomed Slice

L
F
B



1/3: Change contrast





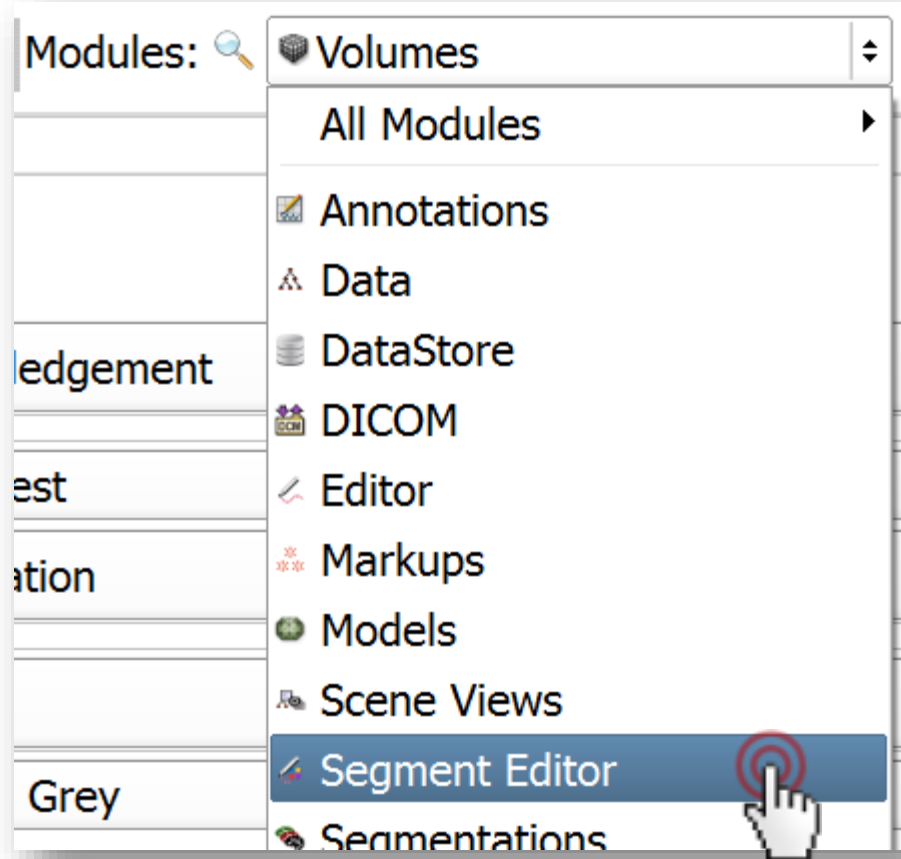
Part 2: Segment vertebrae

Overview:

- Add new segment
- Threshold bone
- Remove speckles with Islands
- Cut out vertebrae with Scissors



2/1: Switch to Segment Editor module





2/2: Add new segment

Segmentation: Segmentation

Master volume: CTchest

+ Add segment - Remove selected Create surface

Empty segmentation

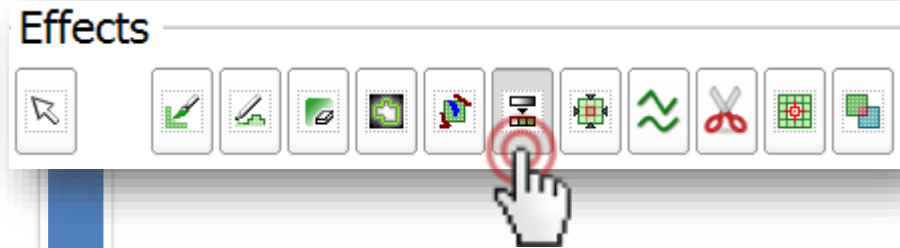
	Color	Name

- Segmentation automatically created
- CT volume automatically selected as master

(Master is the segmented volume that defines the resolution of the segments)





2/3: Threshold to get bone




Threshold

Set segment based on master volume intensity range. All previous contents of the segment is overwritten on Apply.

Threshold Range:

100.00   3071.00

Set 100 Use For Paint

Apply 



2/4: Remove speckle with the Islands effect



Select
Islands effect

Islands

Edit islands (connected components) in a segment.

- Keep largest island
- Remove small islands
- Split islands to segments
- Keep selected island
- Remove selected island
- Add selected island

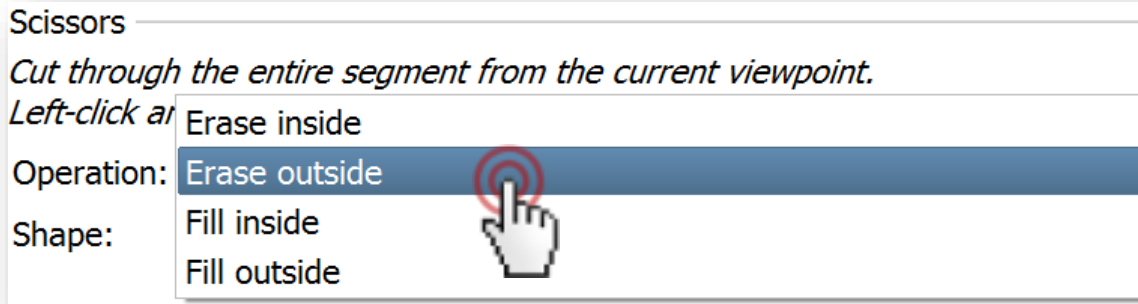
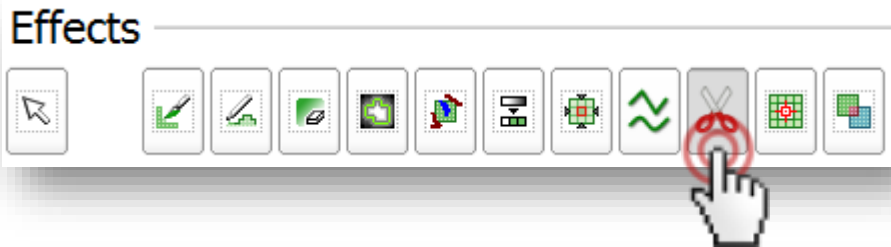


2/5: Remove speckle with the Islands effect





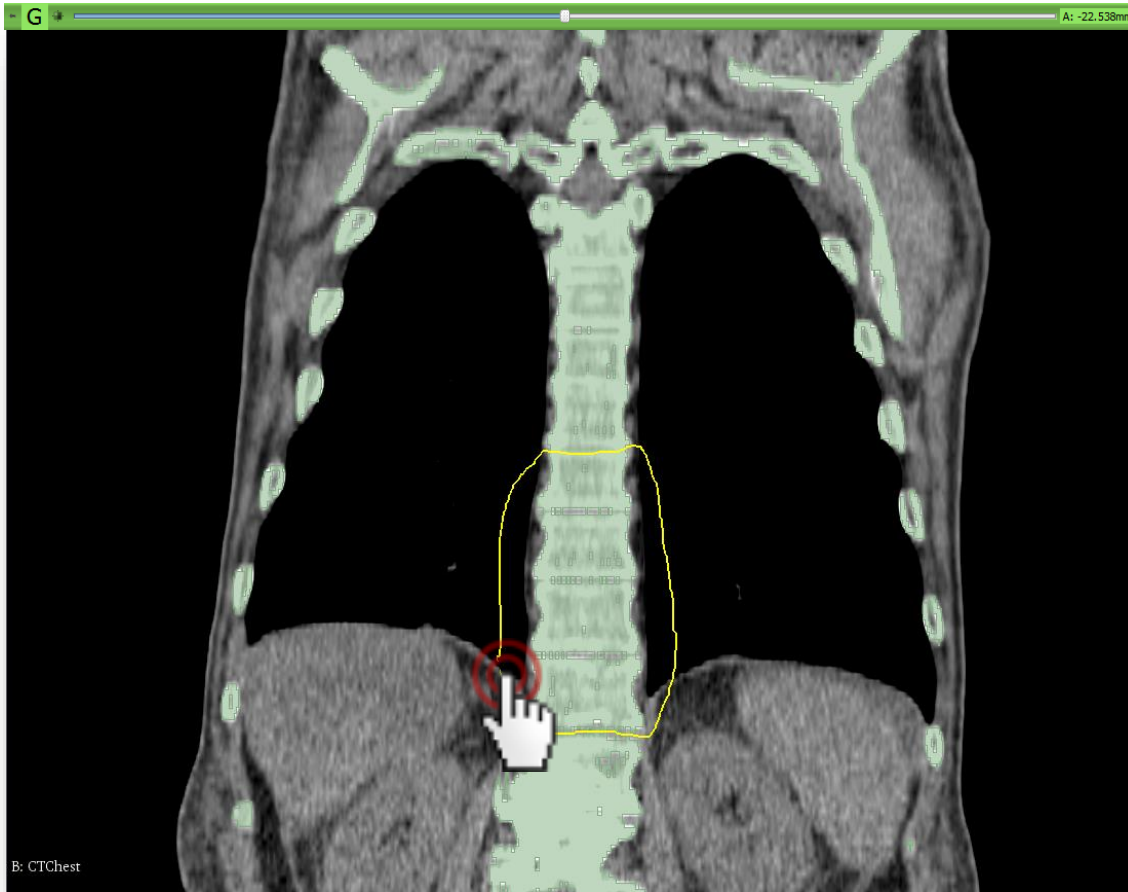
2/6: Cut out vertebrae with the Scissors effect



1. Select Scissors effect
2. Choose 'Erase outside' as operation
3. Choose 'Free-form' shape



2/7: Cut out vertebrae with the Scissors effect



Trace around the desired vertebrae with the scissor on the coronal view (green slice)



2/8: Show segment as surface in 3D view

Segmentation: Segmentation

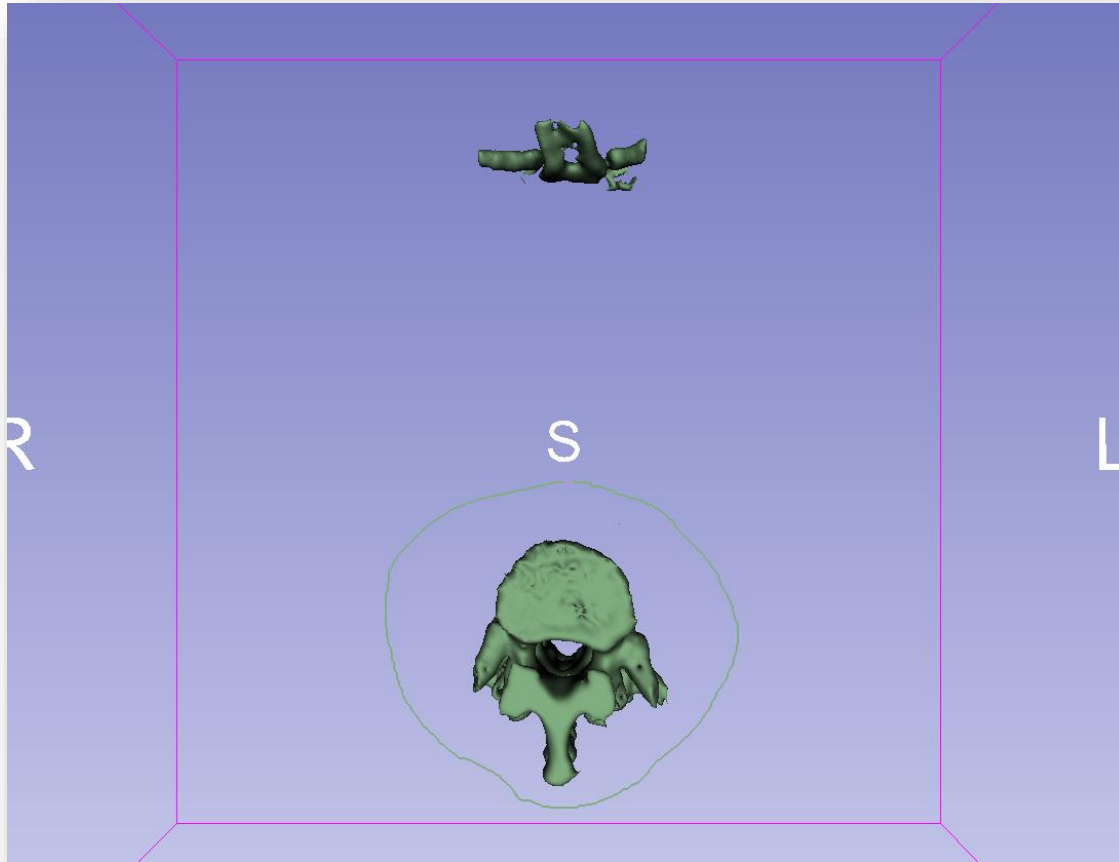
Master volume: CTchest

+ Add segment - Remove selected Create surface

S



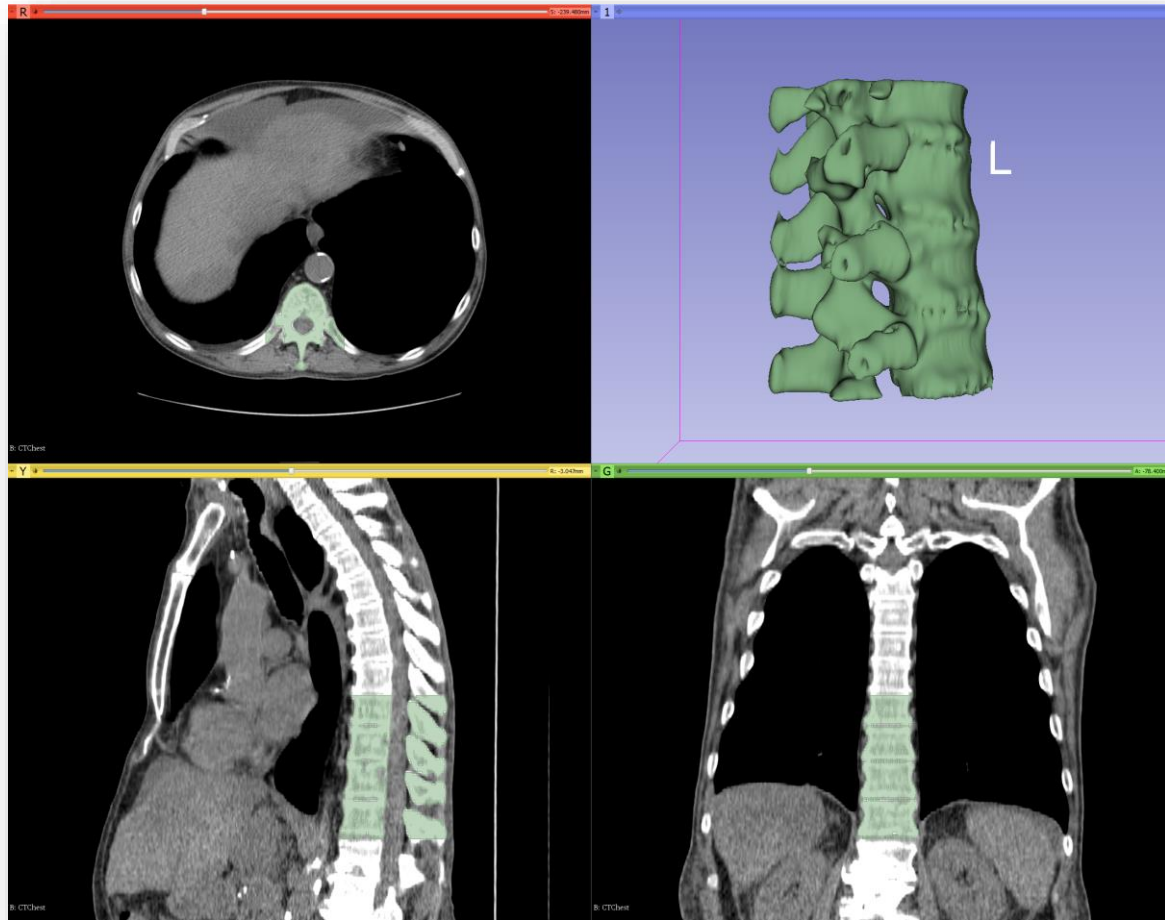
2/9: Remove remaining parts with Scissors



Select the vertebrae in the 3D view to erase the remaining parts (ribs on the anterior side in this case)



2/10: Vertebrae are segmented





Part 3: Add phantom base

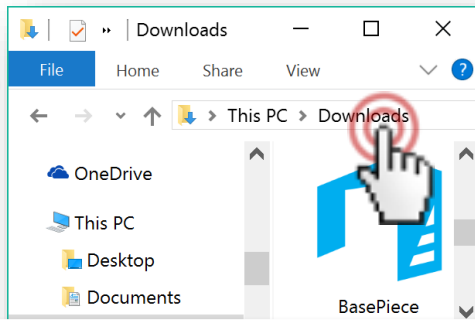
Overview:

- Load phantom base STL file
- Transform model to desired position and orientation
- Import model to segmentation node
- Cut hole through middle of the spine

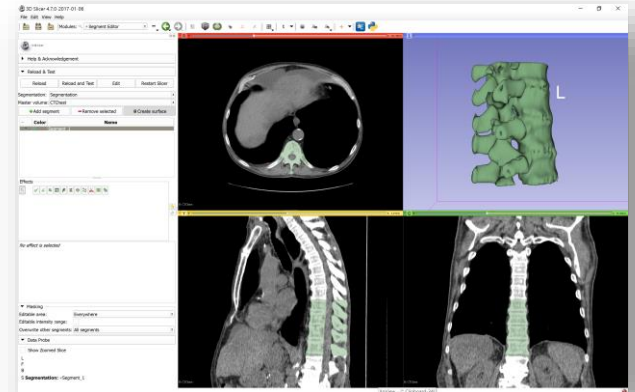


3/1: Load phantom base as model node

Download phantom base STL file from
<http://www.na-mic.org/Wiki/images/1/1e/BasePiece.stl>

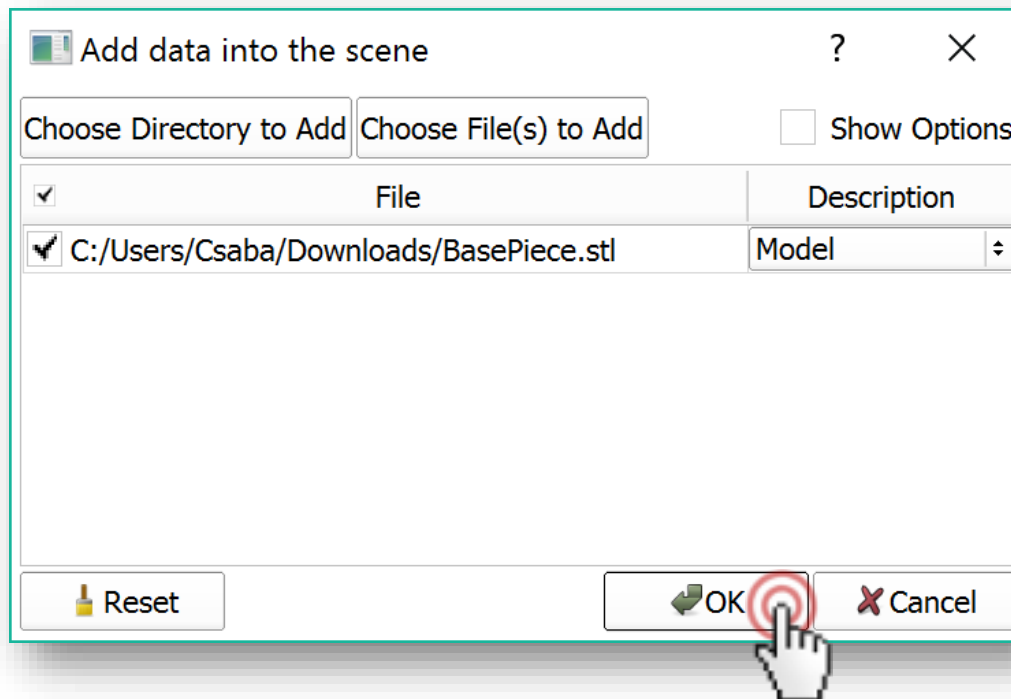


Drag&drop 'BasePiece.stl'
onto the Slicer



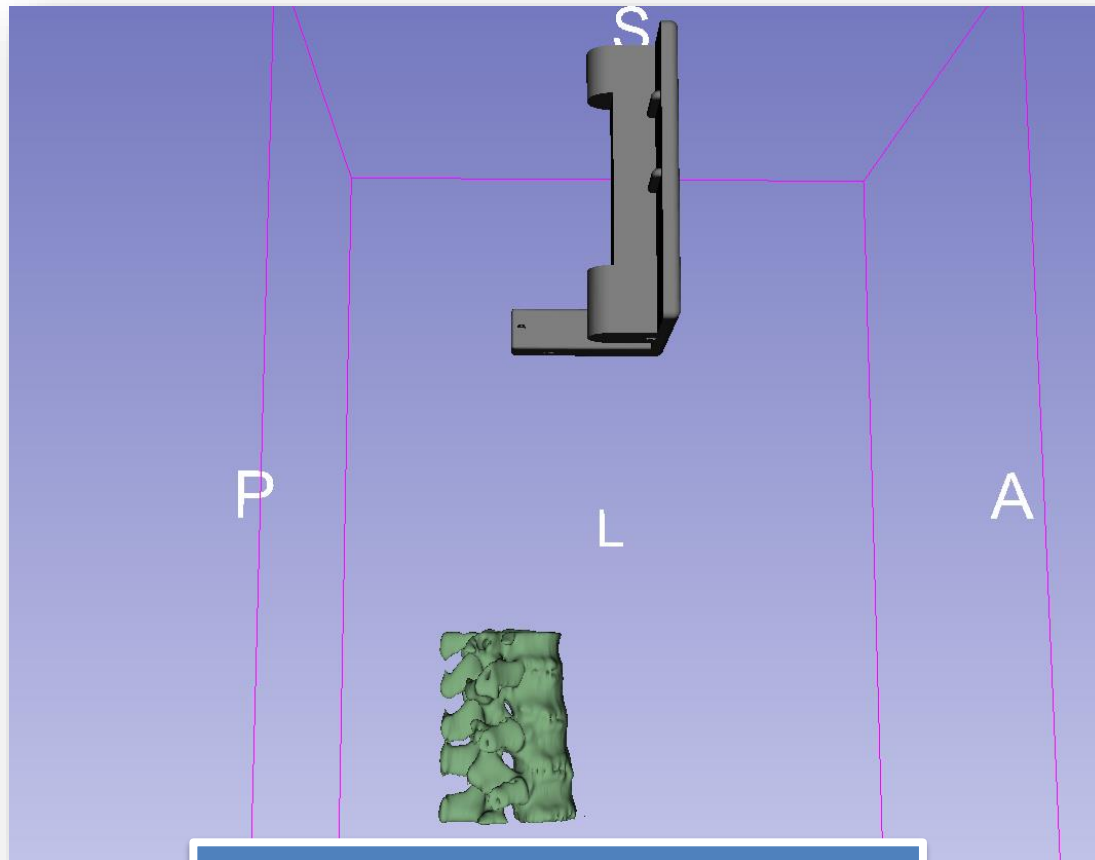


3/2: Load phantom base as model node





3/2: Load phantom base as model node



Phantom base is loaded



3/1: Make base semi-transparent in Models

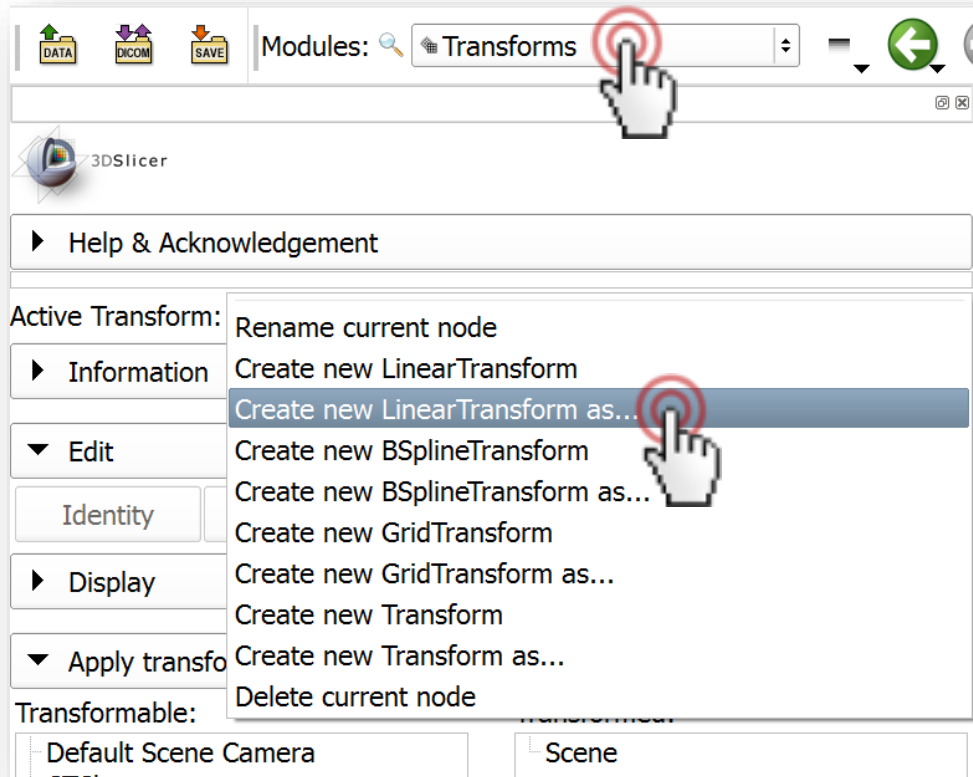
1. Switch to Models module
2. Decrease opacity to 0.8

When both the segmentation and the model are opaque, it is hard to see when they are in a good relative position

The screenshot shows the 3DSlicer interface. At the top, there are icons for 'DATA', 'DICOM', and 'SAVE'. Below these is a 'Modules:' dropdown menu with 'Models' selected. A hand cursor is pointing at the 'Models' button. Below the modules bar is the '3DSlicer' logo and a 'Help & Acknowledgement' button. Further down, there is an 'Include Fibers' checkbox and a 'Scroll to...' search box. At the bottom, the 'Scene' panel is visible, showing 'BasePiece' selected. A hand cursor is pointing at the 'BasePiece' entry. To the right of 'BasePiece' is a slider control for opacity, set to 0.80, with another hand cursor pointing at the value.



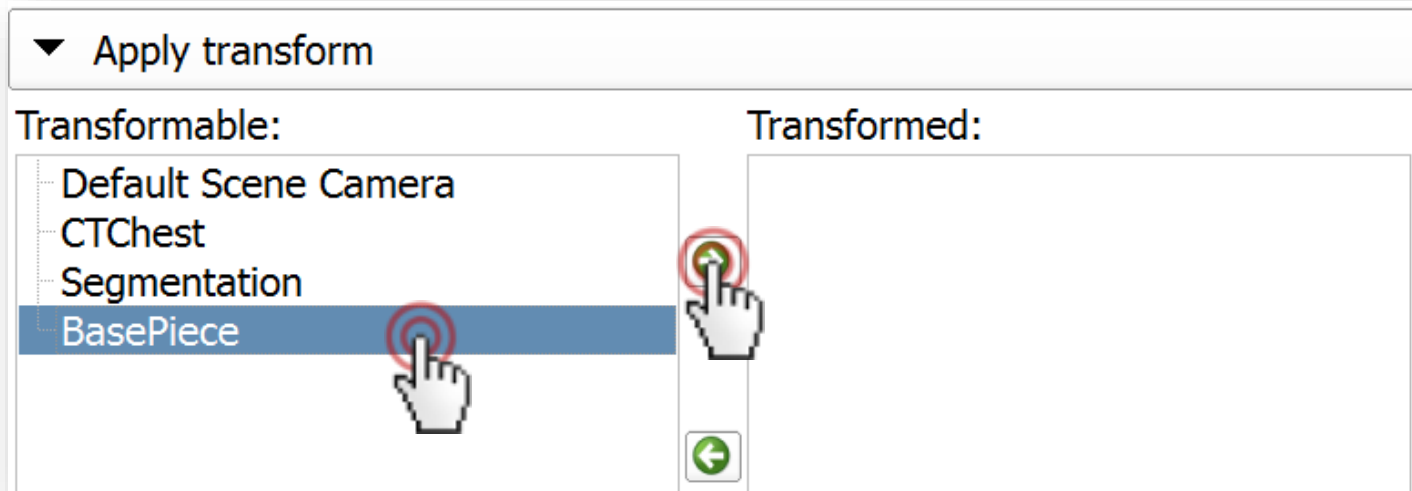
3/2: Create transform



1. Switch to Transforms module
2. Create linear transform
3. Name it 'SpineToBaseTransform'



3/3: Apply transform to base



1. Select base piece
2. Move it under the transform



3/5: Move base into place

Active Transform: SpineToBaseTransform

Information

Edit

Transform Matrix

1.00	0.00	0.00	-60.00
0.00	1.00	0.00	-60.00
0.00	0.00	1.00	-320.00
0.00	0.00	0.00	1.00

Translation

LR: -60.000mm

PA: -60.000mm

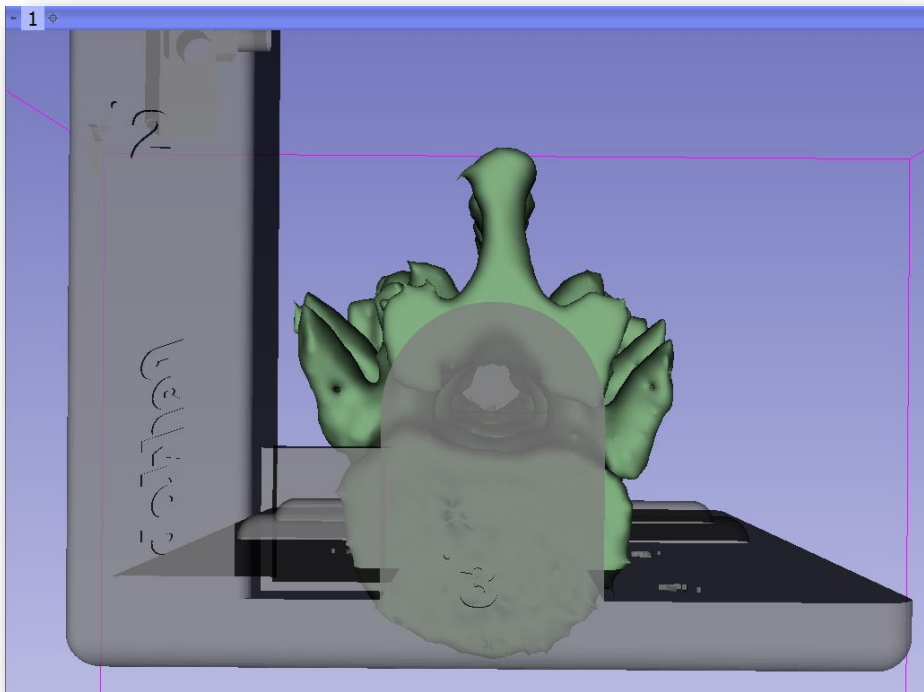
IS: -320.000mm

Min: -400.000mm Max: 200.000mm

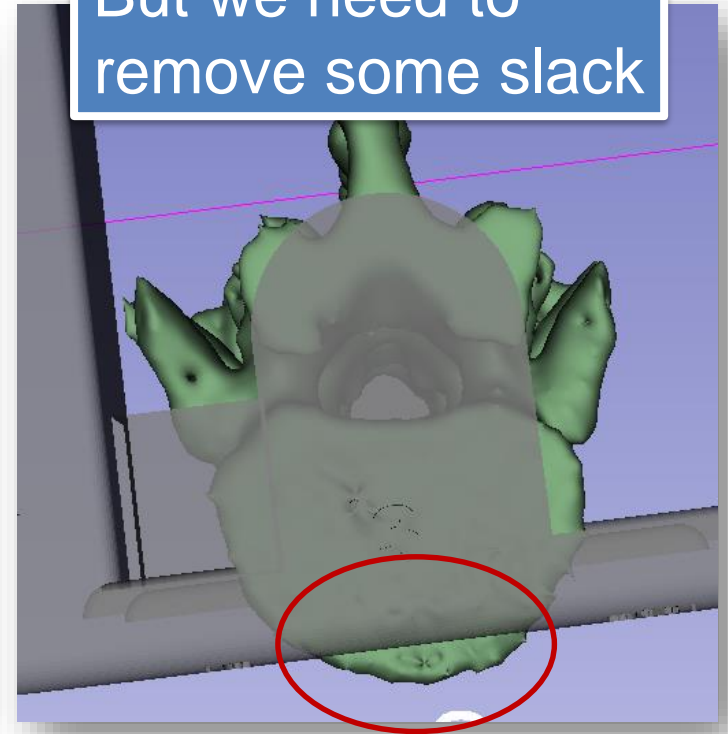
1. Decrease minimum value to -400
2. Move sliders until the base is in the correct position (values in picture are the final ones)



3/6: Base is in the correct position



But we need to remove some slack





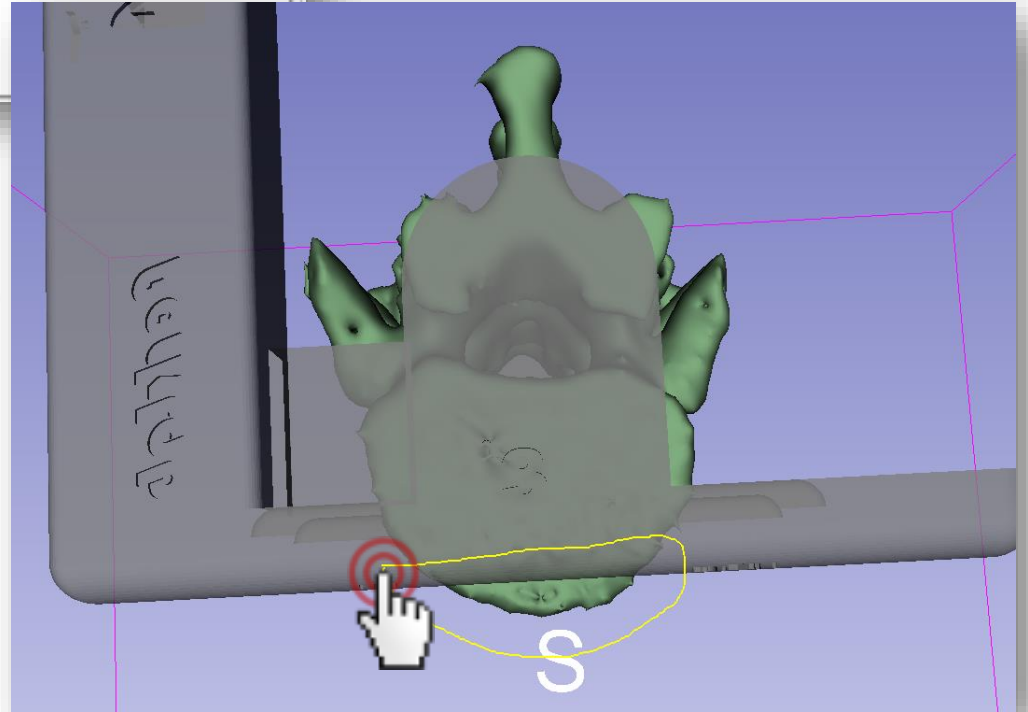
3/7: Use Scissors effect to remove slack

Scissors
Cut through the entire segment from the current viewpoint.
Left-click at

Operation:	Erase inside
Shape:	Erase outside
	Fill inside
	Fill outside



1. Back to Segment Editor
2. Erase slack





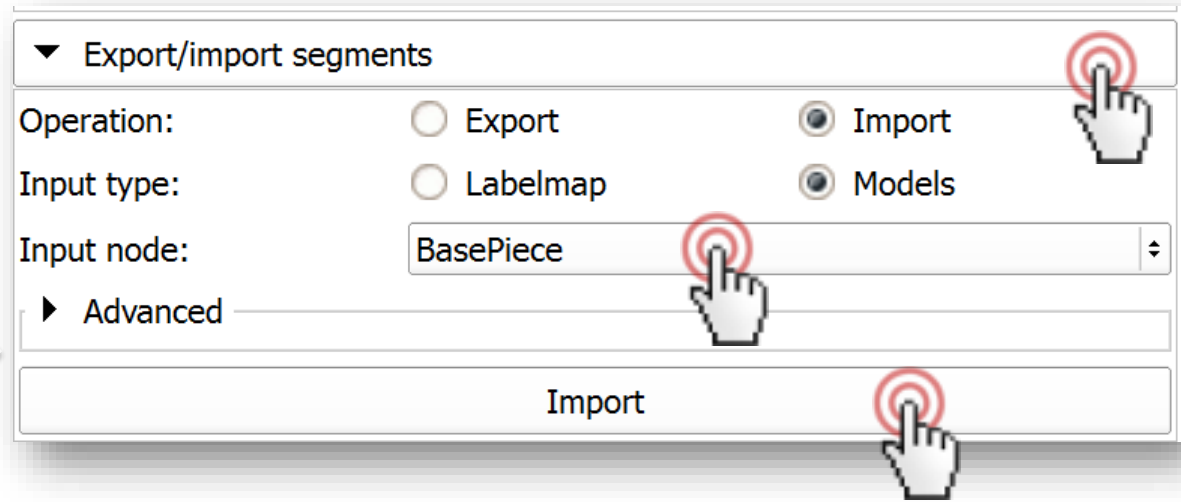
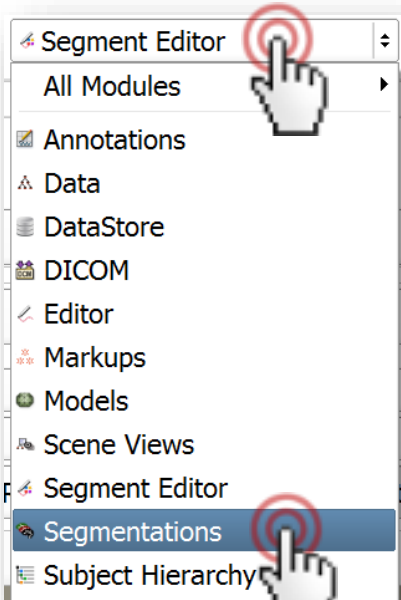
Part 4: Merge and finalize phantom

Overview:

- Create segmentation from base piece
- Copy base piece segment into vertebrae segmentation
- Merge two segments
- Cut hole through phantom



4/1: Import base into segmentation





4/2: Import base into segmentation

Master representation is needed t... X

? Segment is to be added in segmentation 'Segmentation' that contains a representation (Closed surface) different than the master representation in the segmentation (Binary labelmap). The master representation need to be changed so that the segment can be added. This might result in unwanted data loss.

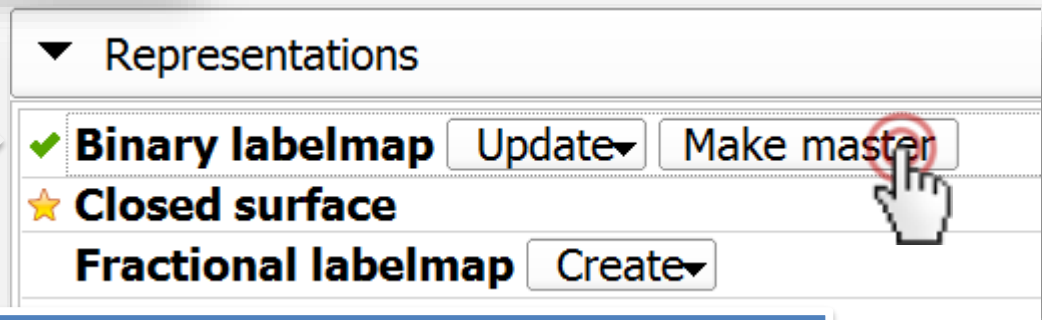
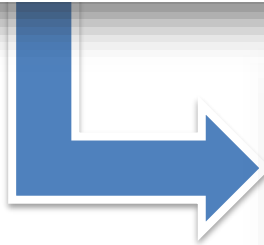
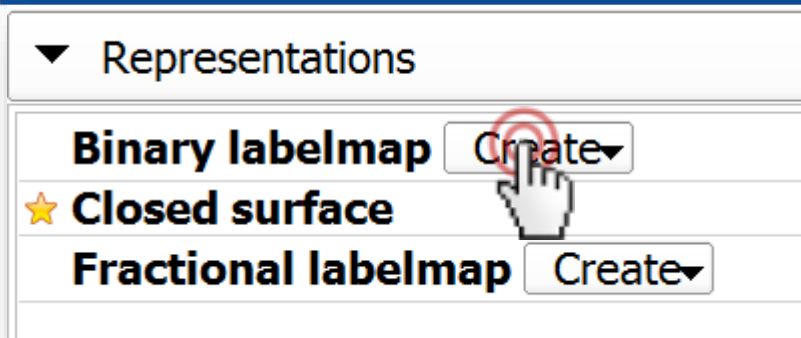
Do you wish to change the master representation to Closed surface?

Yes No

Base piece is a surface, and the vertebrae were created as labelmaps. Convert to surface to allow import



4/3: Convert back to labelmap to allow editing



1. Make binary labelmap master again to allow editing in Segment Editor
2. Click yes in popup



4/4: Merge the two in Segment Editor

Back to Segment Editor

Segmentation: Segmentation
Master volume: CTchest

+ Add segment - Remove selected Create surface

	Color	Name
		Segment 1
		BasePiece

Effects

Logical operators
Apply logical operators on a segment or combine it with other segments.

Operation: Add Apply Bypass masking

Add segment:

	Segment 1
	BasePiece

Numbered callouts 1 through 5 indicate mouse clicks on the 'Segment 1' row, the 'Merge' icon, the 'Add' dropdown, the 'Apply' button, and the 'BasePiece' row respectively.



4/5: Remove base piece segment

Software interface showing a list of segments and control buttons.

Buttons: + Add segment, - Remove selected, Create surface

	Color	Name
		Segment 1
		BasePiece

The 'BasePiece' segment is highlighted in blue, and a hand cursor is pointing at it. Another hand cursor is pointing at the 'Remove selected' button.



4/6: Cut hole through phantom using Scissors

Scissors

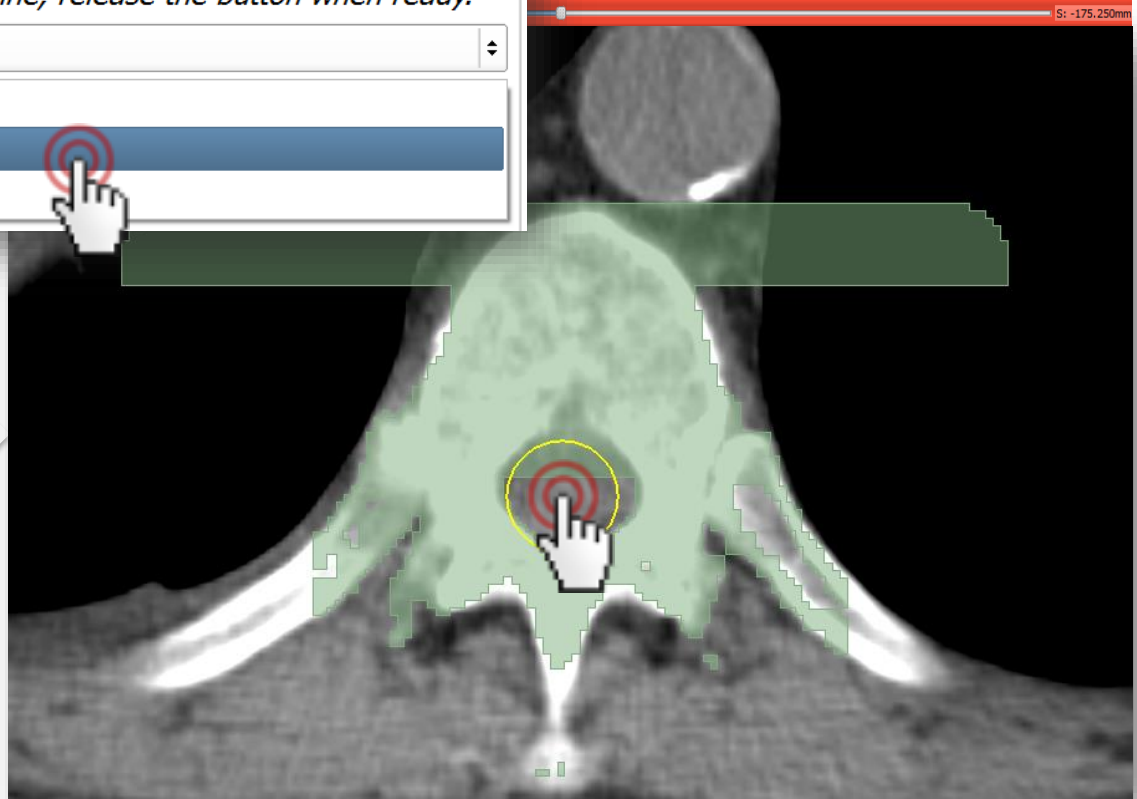
*Cut through the entire segment from the current viewpoint.
Left-click and drag to sweep out an outline, release the button when ready.*

Operation: Erase inside

Shape: Free-form

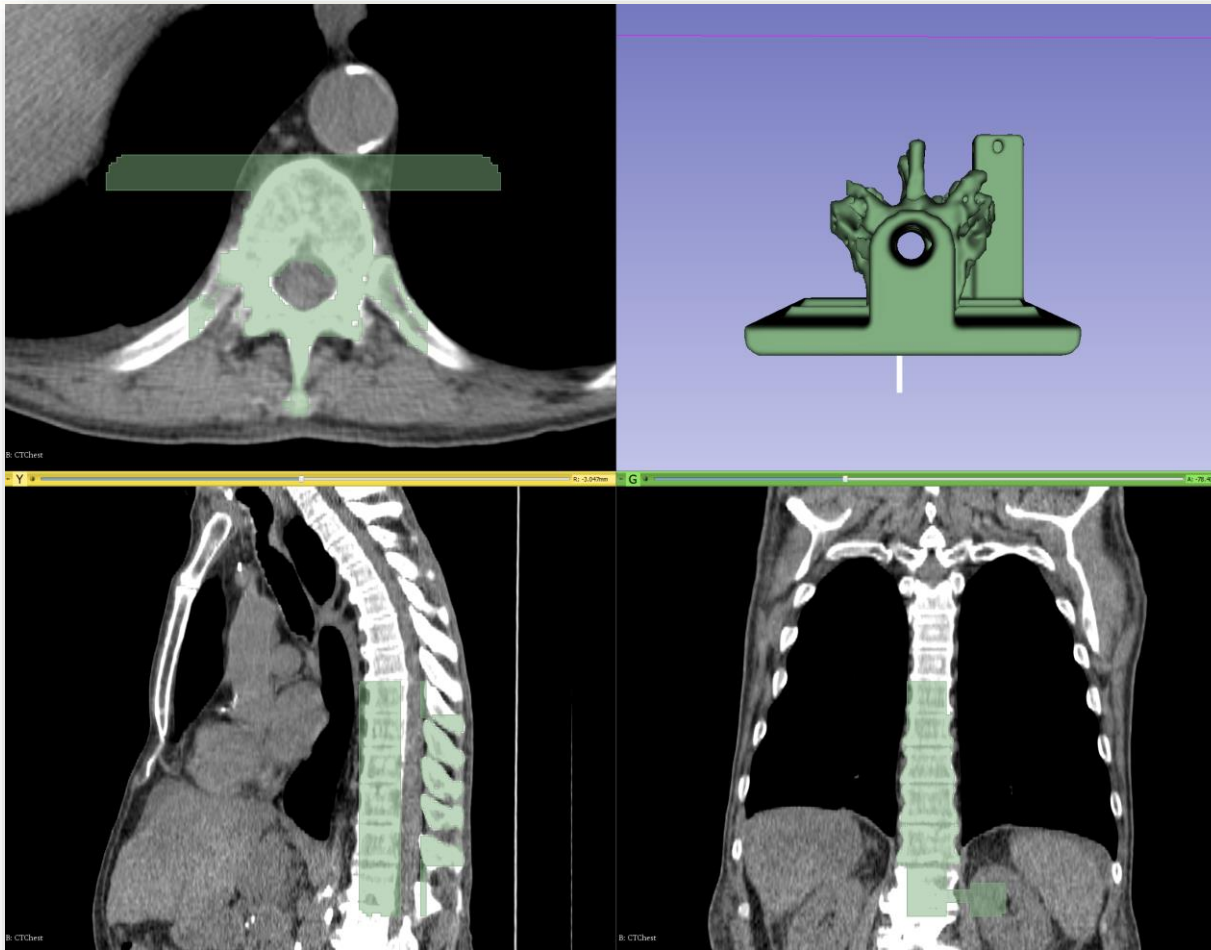
Circle

Rectangle





4/7: Phantom is ready





Part 5: Save phantom to STL

Overview:

- Export phantom segment to model node
- Save model to STL file



5/1: Export phantom segment into model

Switch to Segmentations module

▼ Export/import segments

Operation: Export Import

Output type: Delmap Models

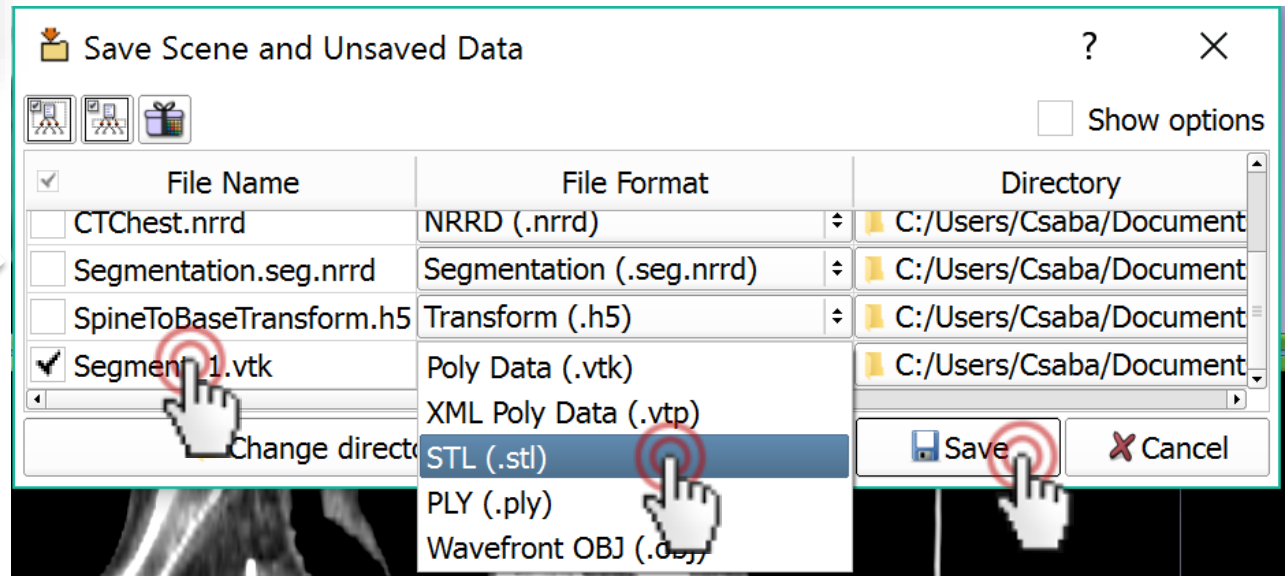
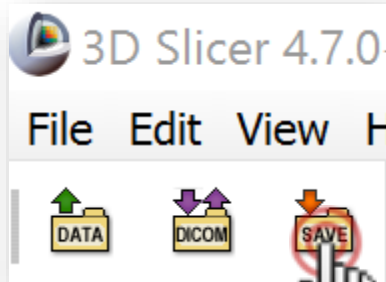
Output node:

▶ Advanced

Export



5/2: Save model into STL





Conclusion

Segmentation and conversion to surface is now easier with the new Segment Editor and Segmentations modules.



Acknowledgments



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Cancer Care Ontario



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