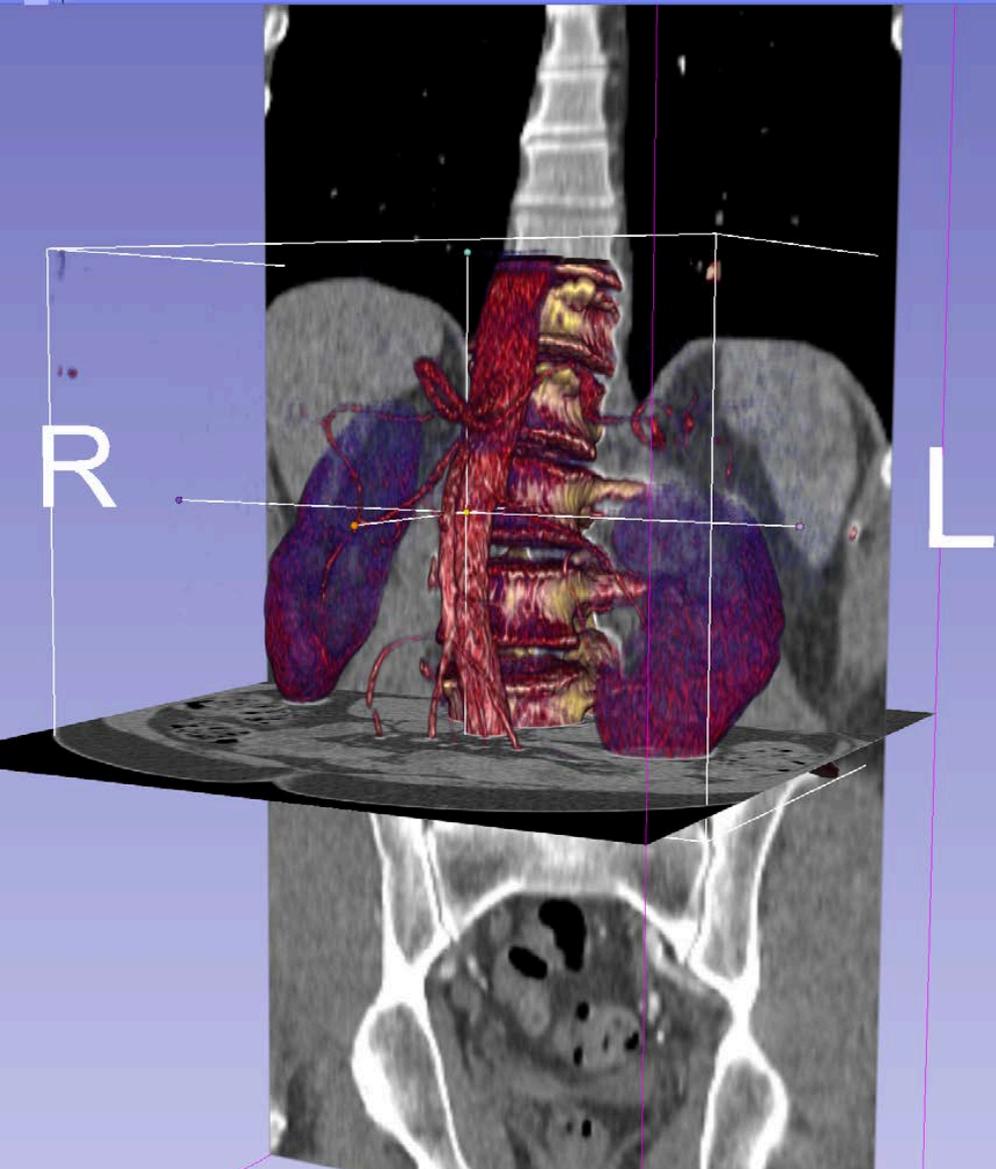


Basics of Data Loading and 3D Visualization in 3D Slicer

Sonia Pujol, Ph.D.

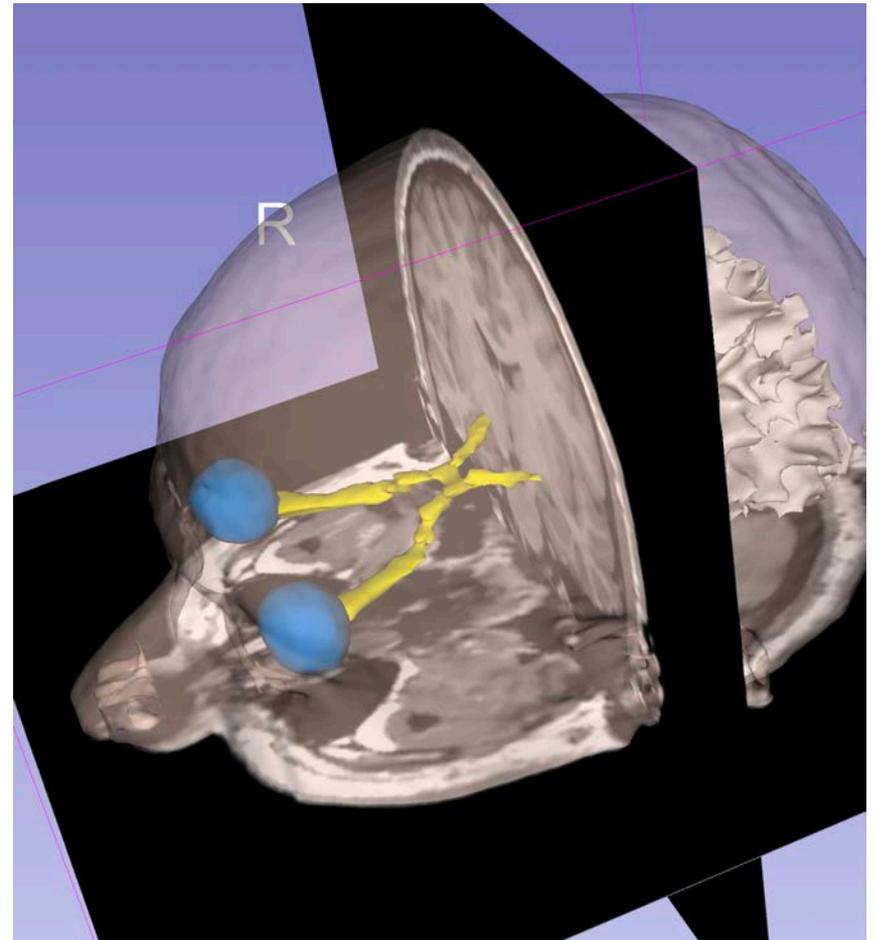
Director of 3D Slicer Training & Education

Assistant Professor of Radiology
Brigham and Women's Hospital
Harvard Medical School



Overall Goal

This tutorial is an introduction to the basics of loading and viewing DICOM images and 3D models in 3D Slicer.

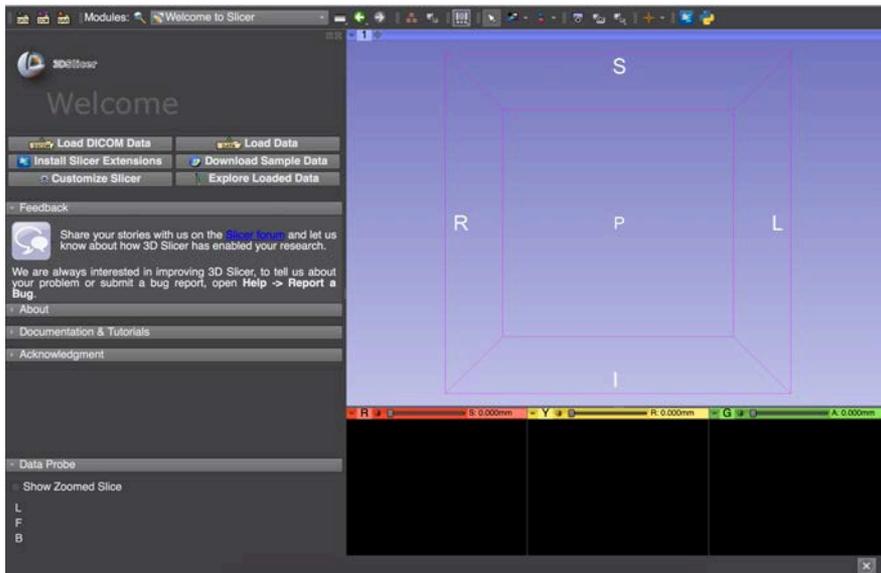


Learning Objectives

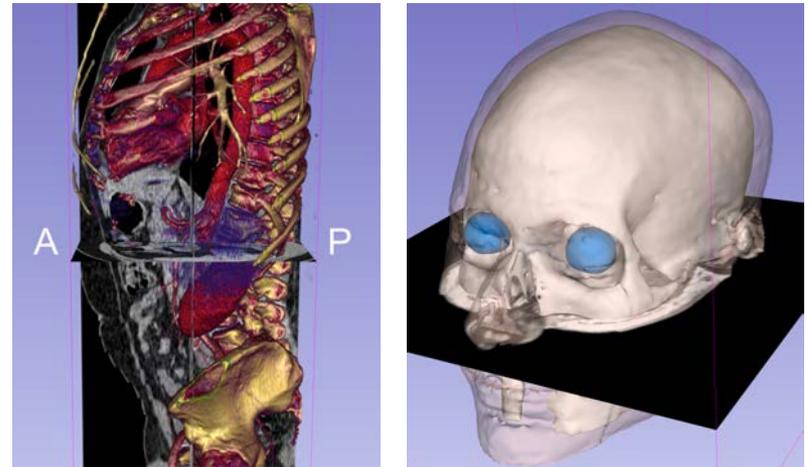
Following this tutorial, you will be able

- to load and visualize DICOM images in Slicer
- to perform volume rendering of CT data
- to load and visualize 3D models reconstructed from MRI data

Tutorial materials



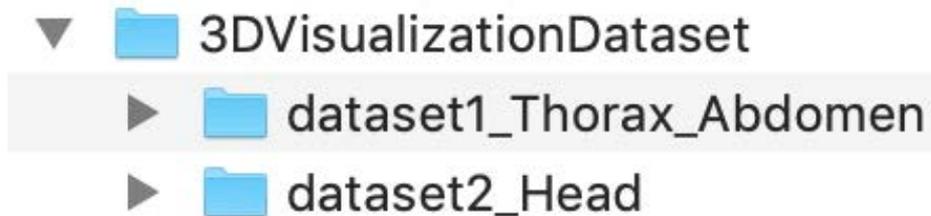
3D Slicer version 4.11.0



3DVisualizationDataset.zip

Tutorial dataset

- The file 3DVisualizationDataset.zip contains two directories:
 - dataset1_Thorax_Abdomen
 - dataset2_Head
- Unzip the file 3DVisualizationDataset.zip on your computer to access the datasets



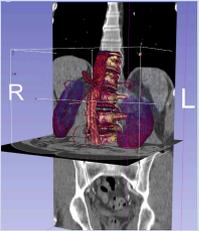
Disclaimer

- 3D Slicer is a free open source software application distributed under a BSD style license.
- The software is not FDA approved or CE-Marked, and is for research use only.

Tutorial Outline



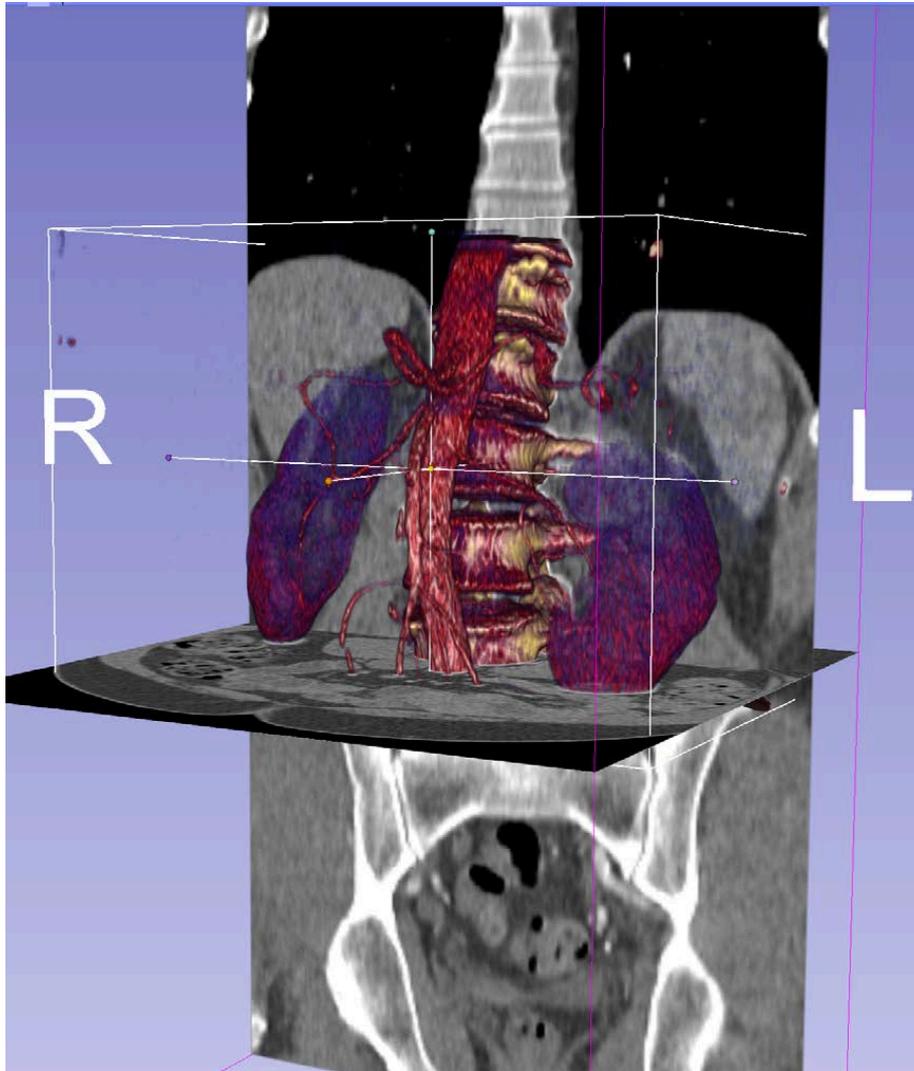
Part 1: Loading and Viewing DICOM data



Part 2: Volume Rendering



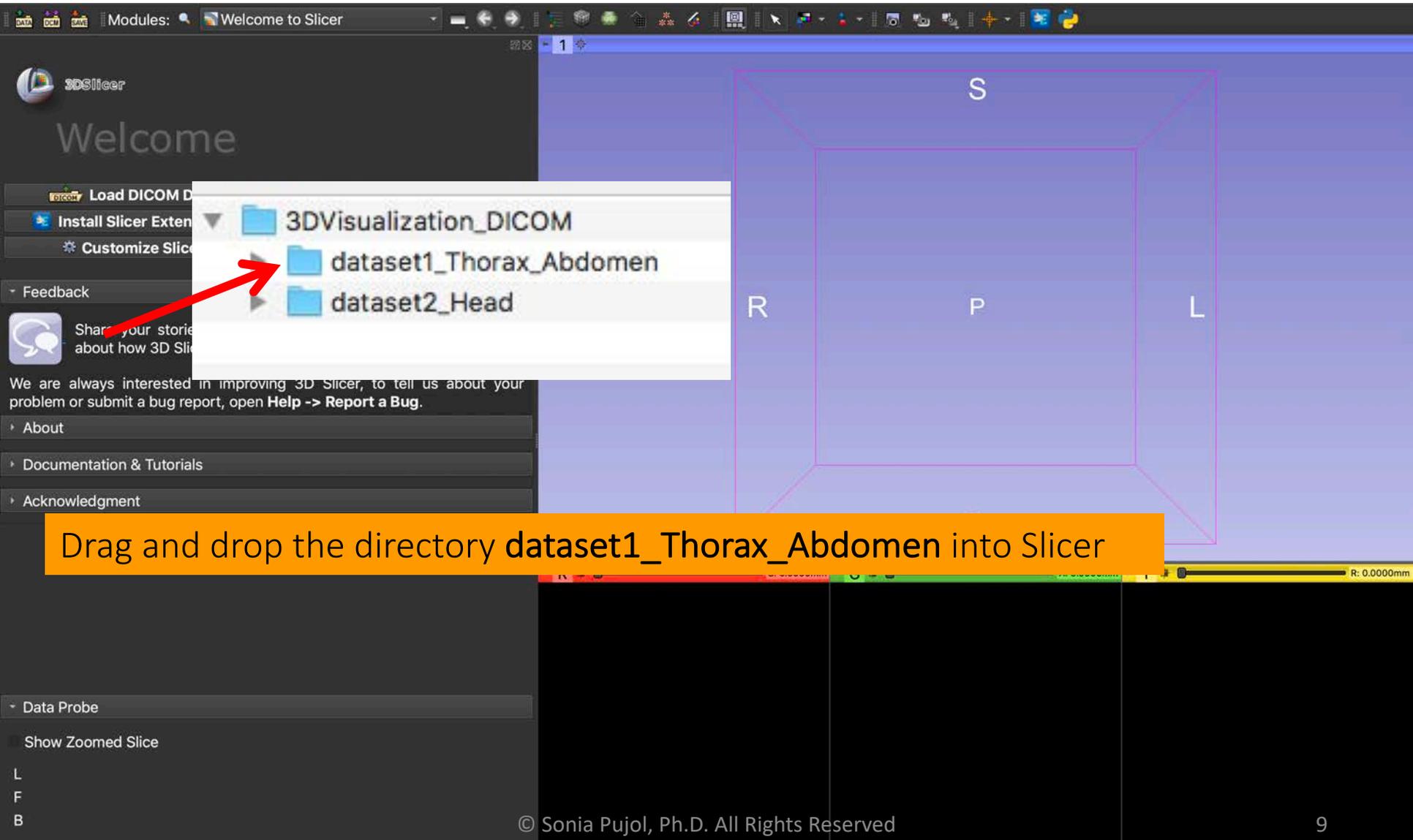
Part 3: Loading and Viewing 3D models



Part 1

DICOM Data Loading

Loading a DICOM volume



The screenshot shows the 3D Slicer software interface. The main window displays a 3D view of a volume with a purple wireframe bounding box. The bounding box is labeled with 'S' at the top, 'R' on the left, 'P' in the center, and 'L' on the right. A file explorer window is open over the interface, showing a directory structure. A red arrow points to the folder 'dataset1_Thorax_Abdomen'. The file explorer shows the following structure:

- 3DVisualization_DICOM
 - dataset1_Thorax_Abdomen
 - dataset2_Head

Below the file explorer, there is a yellow text box with the following text:

Drag and drop the directory `dataset1_Thorax_Abdomen` into Slicer

The interface also shows a 'Welcome to Slicer' message and a 'Data Probe' section at the bottom left.

Loading a DICOM volume

The screenshot displays the 3D Slicer software interface. On the left is a sidebar with a 'Welcome' message and several buttons: 'Load DICOM Data', 'Load Data', 'Install Slicer Extensions', 'Download Sample Data', 'Customize Slicer', and 'Explore Loaded Data'. Below these are sections for 'Feedback' and 'Data Probe'. The main window shows a 3D grid with axes labeled R, P, L, S, and I. A dialog box titled 'Select a reader' is open in the center, asking 'Select a reader to use for your data?' and offering the option 'Load directory into DICOM database'. An orange callout box highlights the 'OK' button with the text 'Click on OK to load the directory in the DICOM database'. At the bottom, there are sliders for 'R: 0.0000mm' and 'G: 0.0000mm'.

Loading a DICOM volume

The screenshot shows the 3DSlicer DICOM module interface. The top toolbar includes icons for file operations and navigation. The main area is divided into three panels: Patients, Studies, and Series. The Patients panel shows a table with columns for Patient name, Patient ID, Birth date, Sex, Studies, Last study, and Date added. The Studies panel shows a table with columns for Study date, Study ID, Study description, Series, and Date added. The Series panel shows a table with columns for Series #, Series description, Modality, Size, Count, and Date added. A 'Load' button is visible at the bottom right of the interface.

Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
patient1	patient1_ID			1	Wed Jun 1 2005	2020...953

Study date	Study ID	Study description	Series	Date added
20050601	6936864	CT Thorax Abdomen	1	2020...953

Series #	Series description	Modality	Size	Count	Date added
6	CT_Thorax_Abdomen	CT	512x512	291	2020...953

Slicer displays the user interface of the DICOM module

The patient1 study contains a CT Thorax Abdomen dataset



Loading a DICOM volume

The screenshot shows the 3DSlicer DICOM database interface. The 'Patients' table is highlighted, with 'patient1' selected. A red arrow points from the 'Load' button at the bottom to the 'patient1' row. The 'Studies' and 'Series' tables are also visible, with the first row in each highlighted. The 'Load' button is circled in red at the bottom center.

Select patient1 and click on Load to load the dataset in Slicer

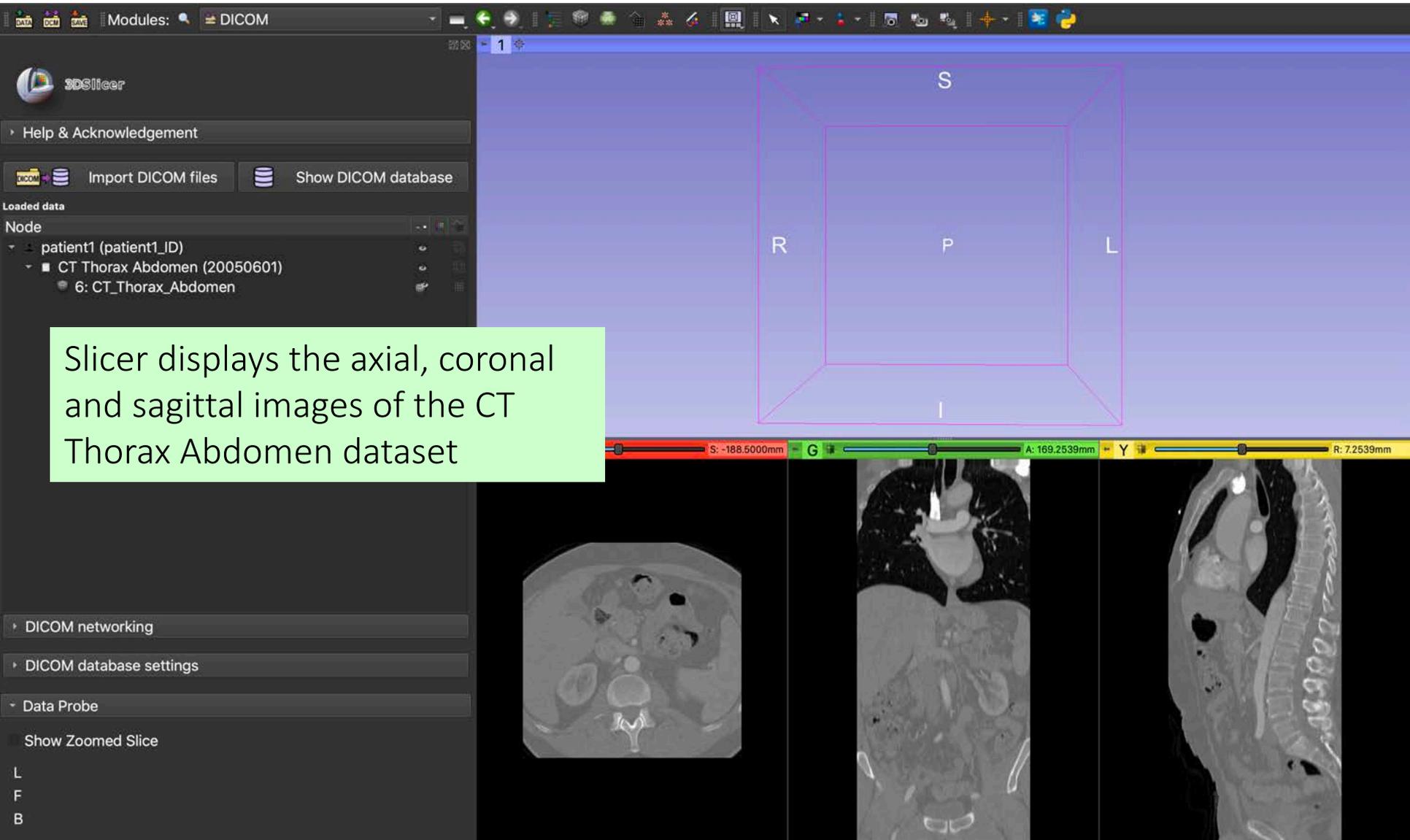
Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
patient1	patient1_ID			1	Wed Jun 1 2005	2020...953

Study ID	Study description	Series	Date added
6936864	CT Thorax Abdomen	1	2020...953

Series #	Series description	Modality	Size	Count	Date added
6	CT_Thorax_Abdomen	CT	512x512	291	2020...953

Load

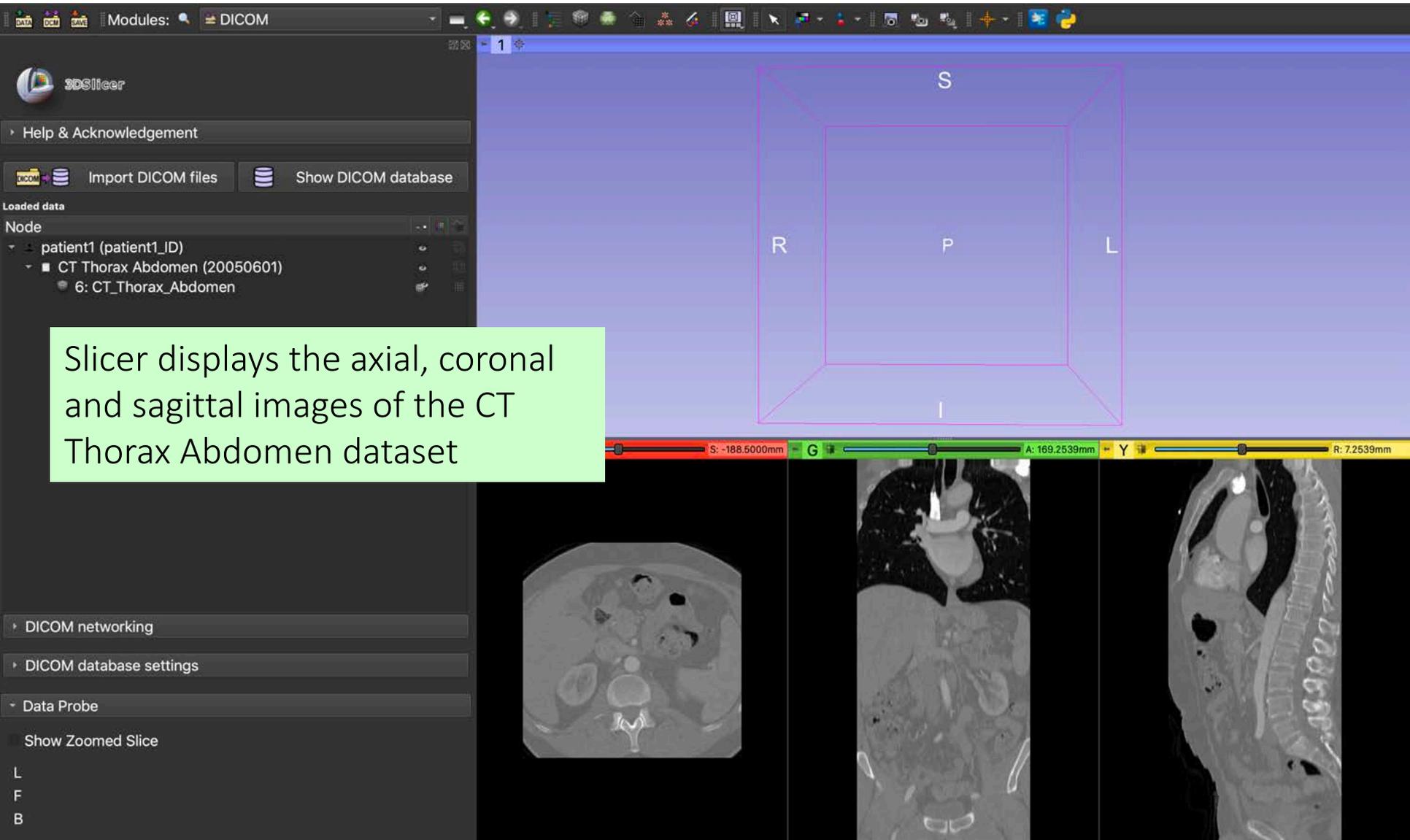
Loading a DICOM volume



Slicer displays the axial, coronal and sagittal images of the CT Thorax Abdomen dataset



Loading a DICOM volume



Loading a DICOM volume

The screenshot displays the 3DSlicer software interface. On the left, the 'Modules' menu is open, with 'DICOM' circled in red. Below it, the 'Volumes' module is highlighted in blue, with a red arrow pointing to it. The main 3D view shows a purple wireframe box representing a volume, with axes labeled 'S' (Superior), 'I' (Inferior), 'R' (Right), 'L' (Left), and 'P' (Posterior). Below the 3D view, three 2D slices are shown: an axial slice on the left, a coronal slice in the middle, and a sagittal slice on the right. The status bar at the bottom indicates coordinates: S: -188.5000mm, A: 169.2539mm, R: 7.2539mm.

Left click on DICOM to display the list of modules of Slicer

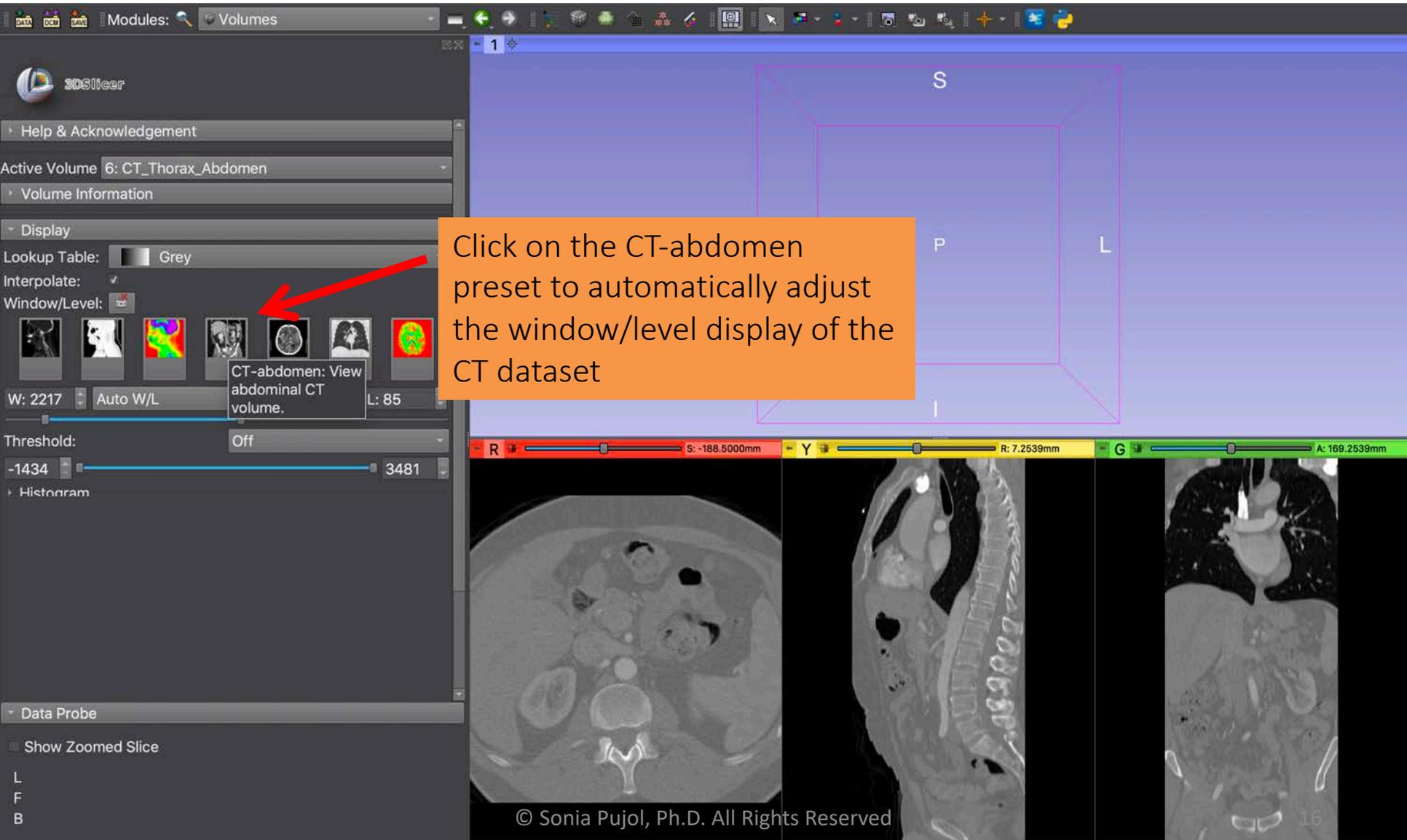
Select the module Volumes

L
F
B

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Loading a DICOM volume



Loading a DICOM volume

Position the mouse cursor over the red banner in the Red Viewer to display the slice menu.

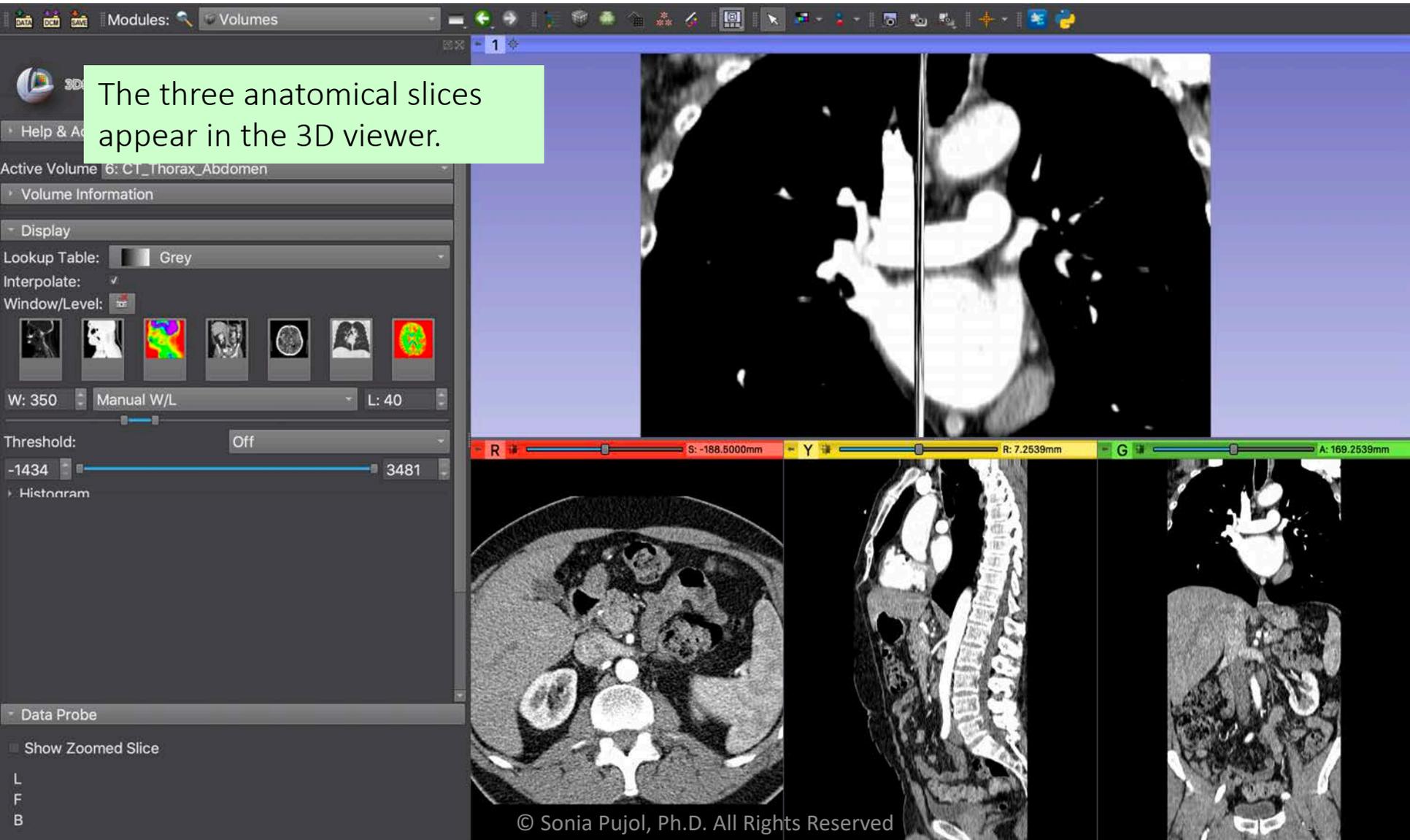
Click on the Links icon to link the slice controls across all Slice Viewers.

Click on the Eye icon to display the three anatomical slices in the 3D Viewer

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Visualizing DICOM images

The three anatomical slices appear in the 3D viewer.



Visualizing DICOM images

The screenshot displays the Slicer software interface with a layout menu open. The menu lists various visualization options, with 'Conventional Widescreen' selected. The interface includes a top toolbar, a left sidebar with 'Display' and 'Data Probe' panels, and a main viewing area with multiple image windows. An orange callout box highlights the menu selection process.

Click on the Slicer layout menu icon, and select the Conventional Widescreen layout

Modules: Volumes

Help & Active Volume Volume I

Display

Lookup Table: Grey

Interpolate:

Window/Level:

W: 350 Manual W/L L: 40

Threshold: Off

-1434 3481

Histogram

Data Probe

Show Zoomed Slice

L
F
B

Conventional
Conventional Widescreen
Conventional Quantitative
Four-Up
Four-Up Table
Four-Up Quantitative
Dual 3D
Triple 3D
3D only
3D Table
One-Up Quantitative
Red slice only
Yellow slice only
Green slice only
Tabbed 3D
Tabbed slice
Compare
Compare Widescreen
Compare Grid
Three over three
Three over three Quantitative
Four over four
Two over two
Side by side
Four by three slice
Four by two slice
Three by three slice

R S: -186 Axial 6: CT_...bdo

7.2539mm G A: 169.2539mm

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Visualizing DICOM images

The screenshot shows the Slicer software interface with a layout menu open. The menu is titled 'Conventional' and lists various display options. The 'Conventional Widescreen' option is highlighted in blue. The interface also shows a 'Display' panel on the left with a 'Lookup Table' set to 'Grey', 'Interpolate' checked, and 'Window/Level' set to 'Manual W/L'. The 'Threshold' is set to 'Off' with a range from -1434 to 3481. The 'Data Probe' panel at the bottom left shows 'Show Zoomed Slice' checked. The main view area displays several DICOM images in different orientations (axial, sagittal, coronal) and a zoomed-in view of a slice. The status bar at the bottom shows 'Axial' and '6: CT_...bdo'.

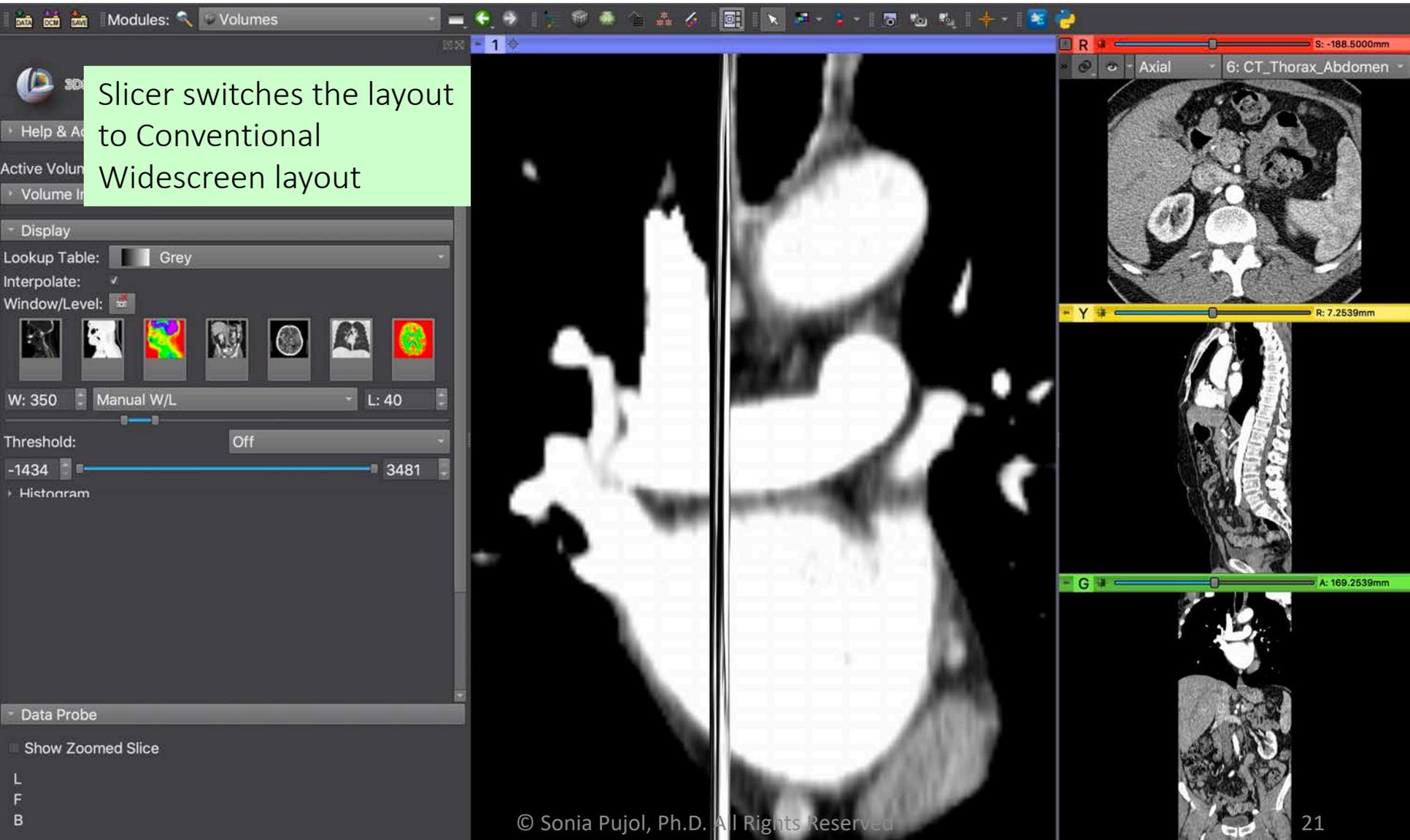
Click on the Slicer layout menu icon, and select the Conventional Widescreen layout

- Conventional
- Conventional Widescreen**
- Conventional Quantitative
- Four-Up
- Four-Up Table
- Four-Up Quantitative
- Dual 3D
- Triple 3D
- 3D only
- 3D Table
- One-Up Quantitative
- Red slice only
- Yellow slice only
- Green slice only
- Tabbed 3D
- Tabbed slice
- Compare
- Compare Widescreen
- Compare Grid
- Three over three
- Three over three Quantitative
- Four over four
- Two over two
- Side by side
- Four by three slice
- Four by two slice
- Three by three slice

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Visualizing DICOM images



Visualizing DICOM images

The screenshot displays a medical imaging software interface. The main window is a 3D viewer showing a coronal view of a CT scan of the thorax and abdomen. A vertical line indicates the current slice position. To the right, a multi-planar reconstruction (MPR) view shows three orthogonal slices: Axial (top), Sagittal (middle), and Coronal (bottom). The software interface includes a top toolbar with various navigation and viewing tools. On the left, a sidebar contains a 'Volumes' panel with 'Active Volume 6: CT_Thorax_Abdomen', 'Volume Information', 'Display' settings (Lookup Table: Grey, Interpolate: checked, Window/Level: Manual W/L, W: 350, L: 40), 'Threshold' settings (Off, -1434 to 3481), and a 'Histogram' section. An orange callout box is overlaid on the 3D viewer, containing the text: 'Use the right mouse button in the 3D Viewer to zoom in and out'. The bottom right corner of the interface shows the page number '22' and a copyright notice: '© Sorin Pujol, PhD. All Rights Reserved'.

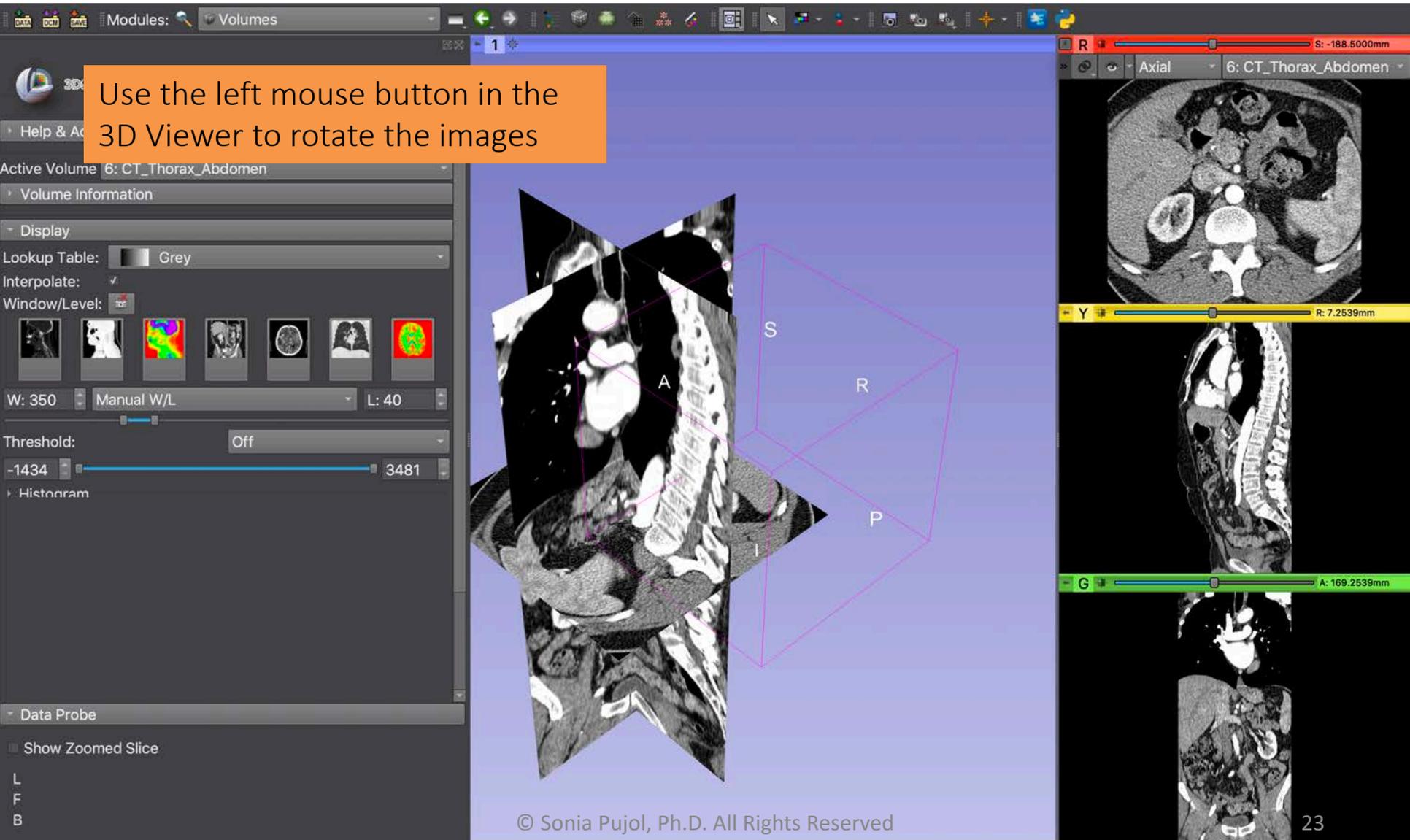
Use the right mouse button in the 3D Viewer to zoom in and out

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Visualizing DICOM images

Use the left mouse button in the 3D Viewer to rotate the images



3D Viewer Controller

The screenshot displays the 3D Slicer software interface. At the top, a blue banner contains a pin icon and a '1' icon. A red arrow points to the pin icon. Below the banner is a 3D view controller with a top row of icons, the second of which is highlighted by a red arrow. The main 3D view shows a CT scan volume with a purple wireframe bounding box and orientation axes labeled S, R, P, and I. To the right, a vertical stack of three CT scan slices is shown, with a red slider at the top (R: -188.5000mm), a yellow slider in the middle (R: 7.2539mm), and a green slider at the bottom (A: 169.2539mm). The interface includes a 'Modules' menu, a 'Volumes' list, and a 'Data Probe' section at the bottom left.

Position the mouse cursor over the pin icon in the blue banner of the 3D viewer window to display the 3DView controller

Click on the second icon on the top row of the 3DView controller to center the 3D view on the scene

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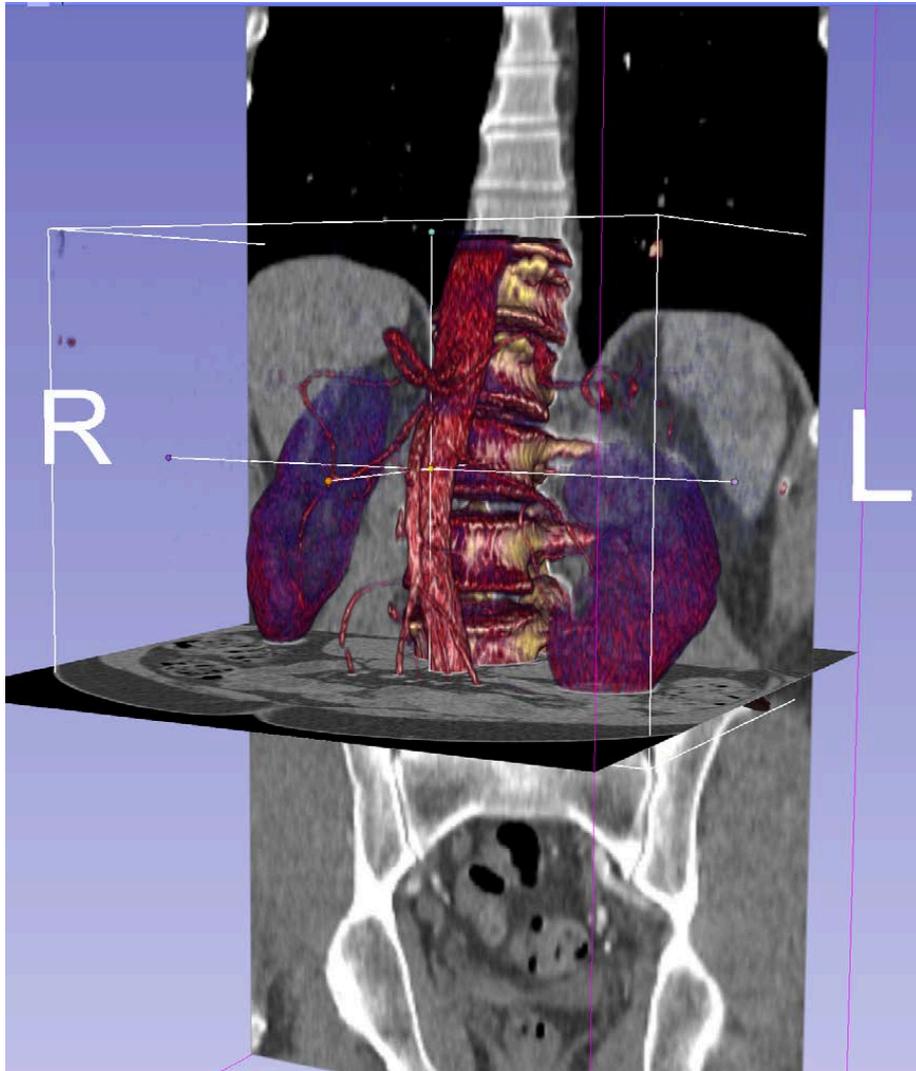
3D Viewer Controller

The screenshot displays the 3D Slicer software interface. On the left, the 'Modules' panel is open, and the 'Volume Rendering' module is selected and highlighted in blue. The main 3D view shows a CT scan of a thorax and abdomen, rendered in a 3D perspective view. The view is framed by a purple wireframe box with labels 'S' (Superior), 'I' (Inferior), 'L' (Left), 'R' (Right), and 'P' (Posterior). On the right side, there are three orthogonal views: an Axial view at the top, a Coronal view in the middle, and a Sagittal view at the bottom. Each view has a corresponding color-coded slider (Red for Axial, Yellow for Coronal, Green for Sagittal) and a position indicator (e.g., 'S: -188.5000mm', 'R: 7.2539mm', 'A: 169.2539mm').

Select the Volume Rendering module in the list of modules

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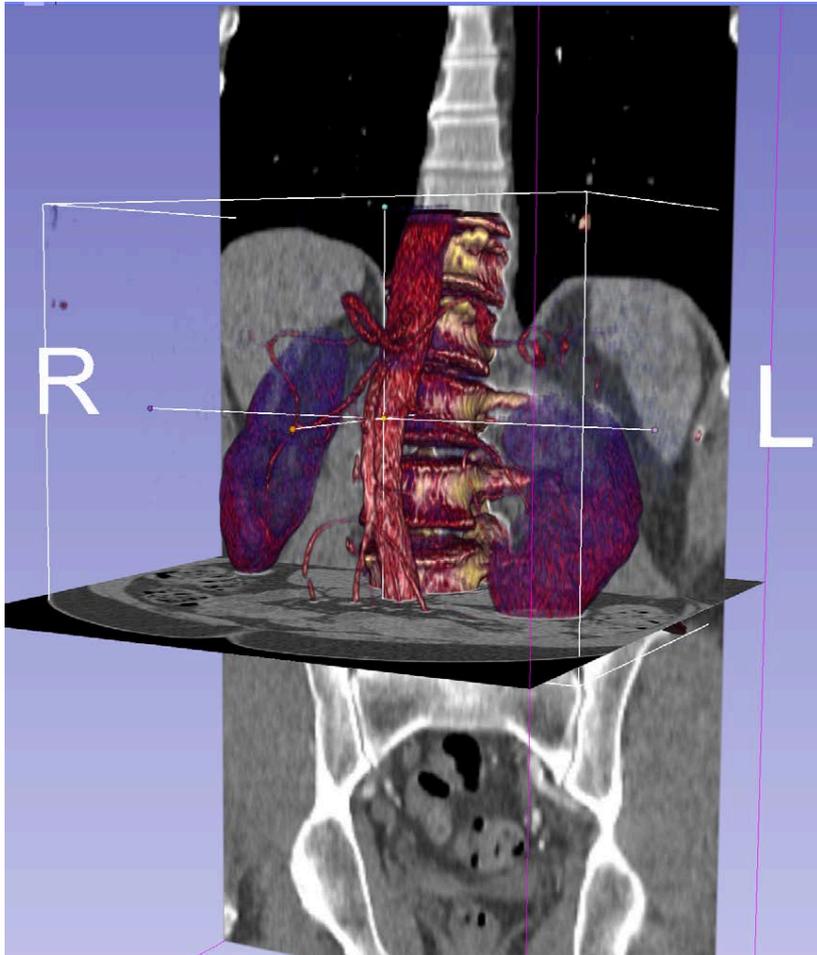
25



Part 2

Volume Rendering

Volume Rendering



- Volume rendering techniques enable 3D visualization of 3D datasets
- The Volume Rendering module in Slicer enables interactive 3D visualization of DICOM images

Volume Rendering

Click on Preset in the Display tab and select the preset CT-Cardiac3

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Volume Rendering

3DSlicer

Modules: Volume Rendering

Home Acknowledgement

Volume: 6: CT_Thorax_Abdomen

Inputs

Display

Preset: CT-Cardiac3

Shift: [Slider]

Crop: Enable Display ROI Fit to Volume

Rendering: VTK GPU Ray Casting

Advanced...

Data Probe

Show Zoomed Slice

L
F
B

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Select VTK GPU Ray Casting Rendering
Click on the eye icon in the Volume tab to display the volume rendered image in the 3D viewer

Volume Rendering

Use the shift slider to change the transfer function and display the aorta

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Volume Rendering

Modules: Volume Rendering

3DSlicer

Help & Acknowledgement

Volume: 6: CT_Thorax_Abdomen

Inputs

Display

Preset: CT-Cardiac3

Shift: [Slider]

Crop: Enable Display ROI Fit to Volume

Rendering: VTK GPU Ray Casting

Advanced...

Data Probe

Show Zoomed Slice

L
F
B

A P

R S: -188.5000mm

Axial 6: CT_Thorax_Abdomen

Y R: 7.2539mm

G A: 169.2539mm

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Click on Display ROI to display a region of interest (ROI) in the 3D viewer and check the option Enable

Volume Rendering

Turn off the visibility of the axial, sagittal and coronal slices in the 2D viewer

Position the ROI around the left kidney using the color handles

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Volume Rendering

Modules: Volume Rendering

3D Slicer

Help & Acknowledgement

Volume: 6: CT_Thorax_Abdomen

Display

Preset: CT-Cardiac3

Shift: [Slider]

Crop: Enable Display ROI Fit to Volume

Rendering: VTK GPU Ray Casting

Advanced...

Data Probe

Show Zoomed Slice

L
F
B

A P

R S: -188.5000mm

Axial 6: CT_Thorax_Abdomen

Y R: 7.7617mm

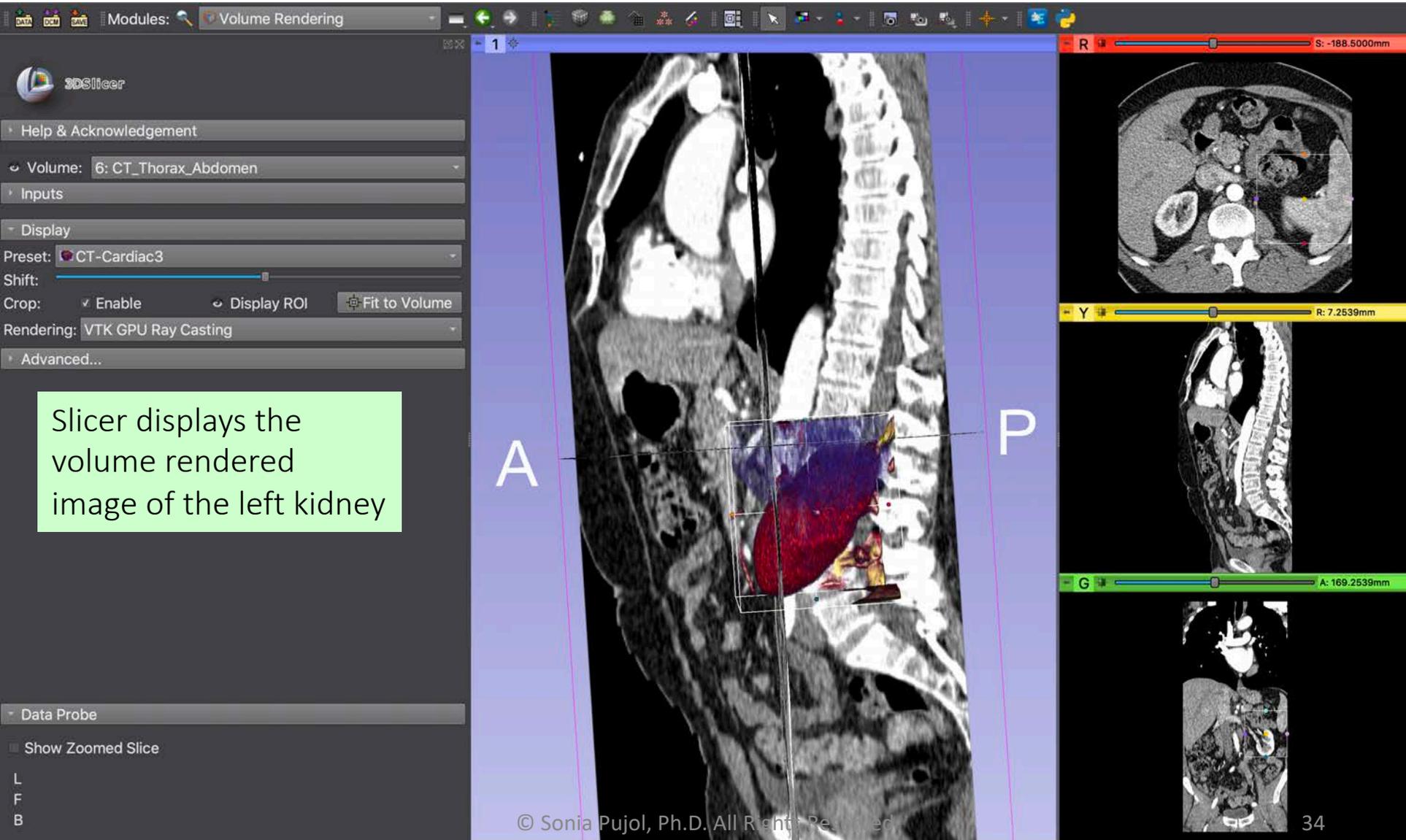
G A: 169.2539mm

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Click on the eye icon to display the volume rendered image

Volume Rendering



Volume Rendering

Extend the ROI to generate a volume rendered image of the right kidney

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Volume Rendering

Slicer 4.11.0

File Edit View Help

- Add Data ⌘O
- Download Sample Data
- DICOM
- Save ⌘S
- Recently Loaded
- Close Scene ⌘W

Help & Acknowledgement

Volume: 6: CT_Thorax_Abdomen

Inputs

Display

Preset: CT-Cardiac3

Shift: [Slider]

Crop: Enable Display ROI Fit to Volume

Rendering: VTK GPU Ray Casting

Advanced...

Data Probe

Show Zoomed Slice

L
F
B

Click on File → Close Scene in the main menu

R

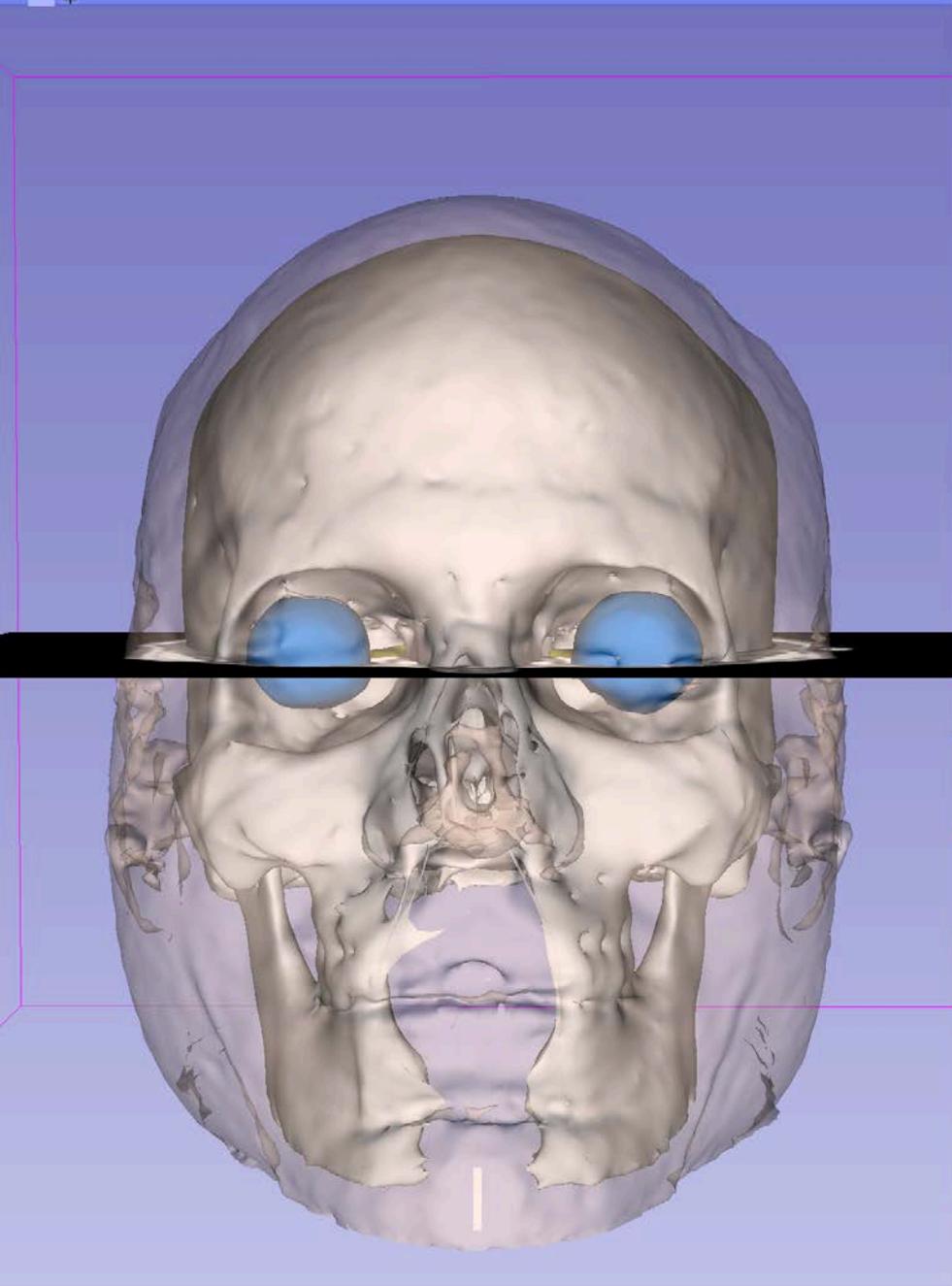
R: -286.5000mm

Y: R: 22.4883mm

G: A: 103.2383mm

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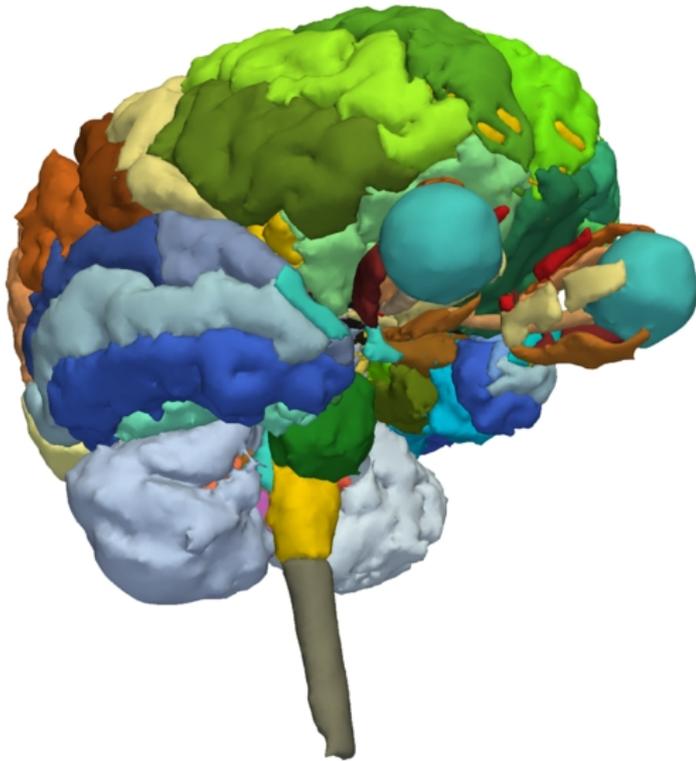
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Part 3

Loading and
viewing 3D models

Tutorial dataset



- The directory **dataset2_Head** contains the Slicer scene called **Head_scene.mrb**
- The scene contains 3D models from the **SPL brain atlas** developed by the department of Radiology at Brigham and Women's Hospital, Harvard Medical School (NIH P41 RR013218, NIH R01 MH05074)

- ▼ 3DVisualizationDataset
 - ▶ dataset1_Thorax_Abdomen
 - ▶ dataset2_Head

Slicer Scene



Slicer stores all loaded data in a repository called a scene



Each data set, such as an image volume, surface model, or point set, is represented as a node in a Slicer scene.



All Slicer modules operate on the data stored in a Slicer scene.

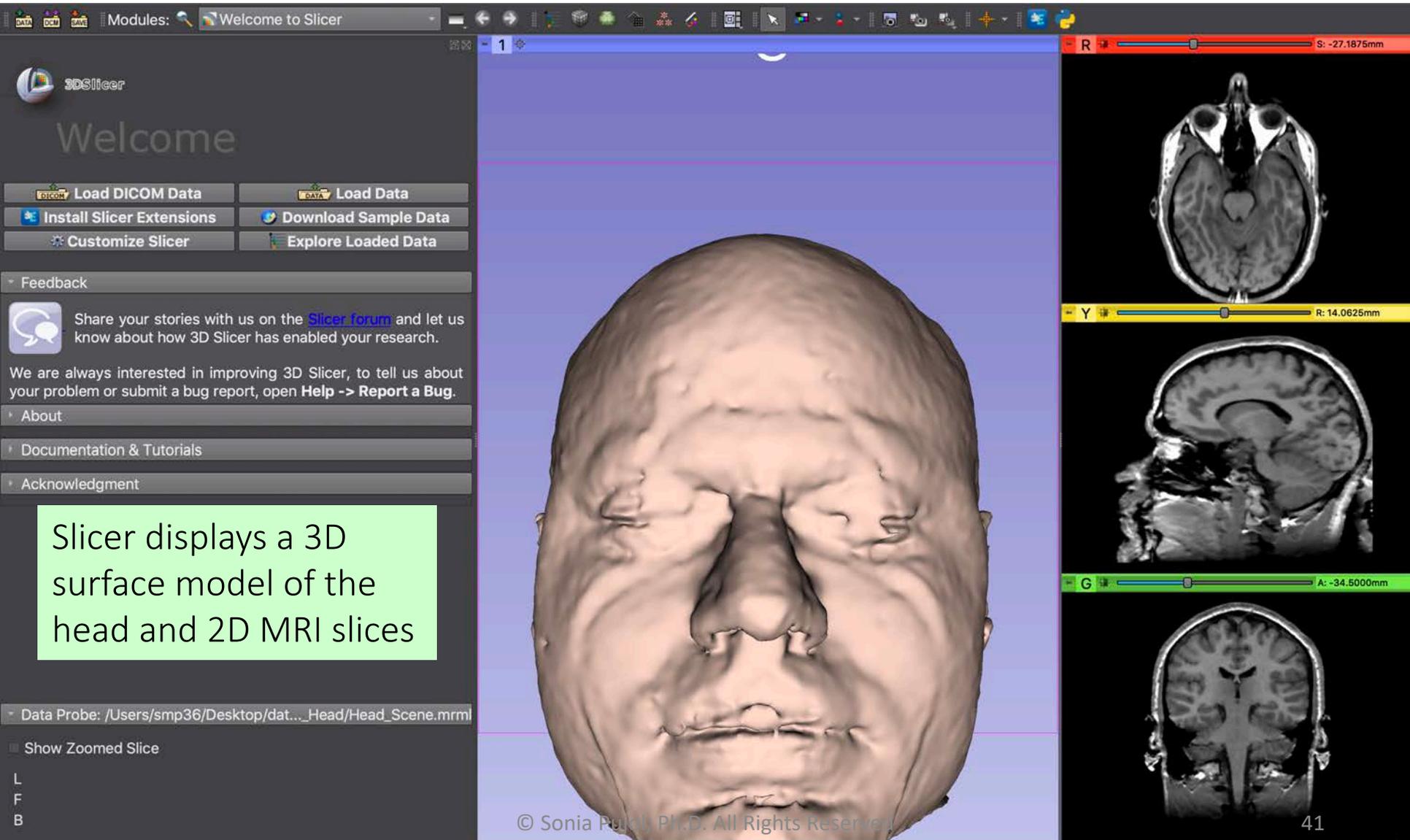
Loading a Scene

The image shows the 3D Slicer software interface. On the left is a sidebar with a 'Welcome' message and buttons for 'Load DICOM Data', 'Load Data', 'Install Slicer Extensions', 'Download Sample Data', 'Customize Slicer', and 'Explore Loaded Data'. The main window is a 3D view with a blue background and a white 'S' in the center. A file explorer window is open over the 3D view, showing a directory structure: 'data' > '3DVisualizationDataset' > 'dataset2_Head' > 'Head_Scene.mrb'. A red arrow points from the file name to the 3D view. On the right side of the interface, there are three horizontal sliders labeled 'R', 'S', and 'G' with values of 0.0000mm.

Drag and drop the file **Head_Scene.mrb** located in the **dataset2_Head** directory into Slicer

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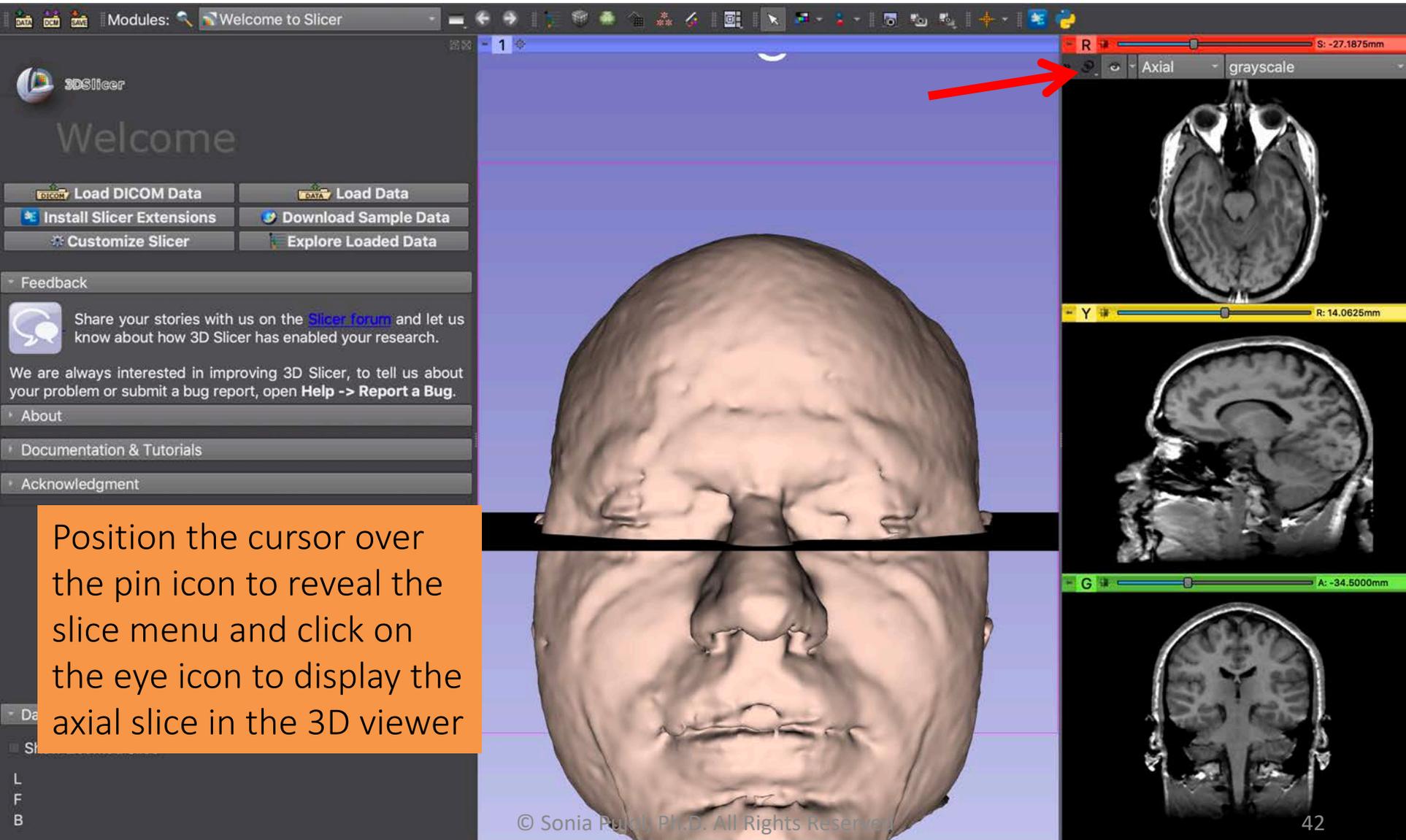
Loading a Scene



Slicer displays a 3D surface model of the head and 2D MRI slices



Viewing 3D models

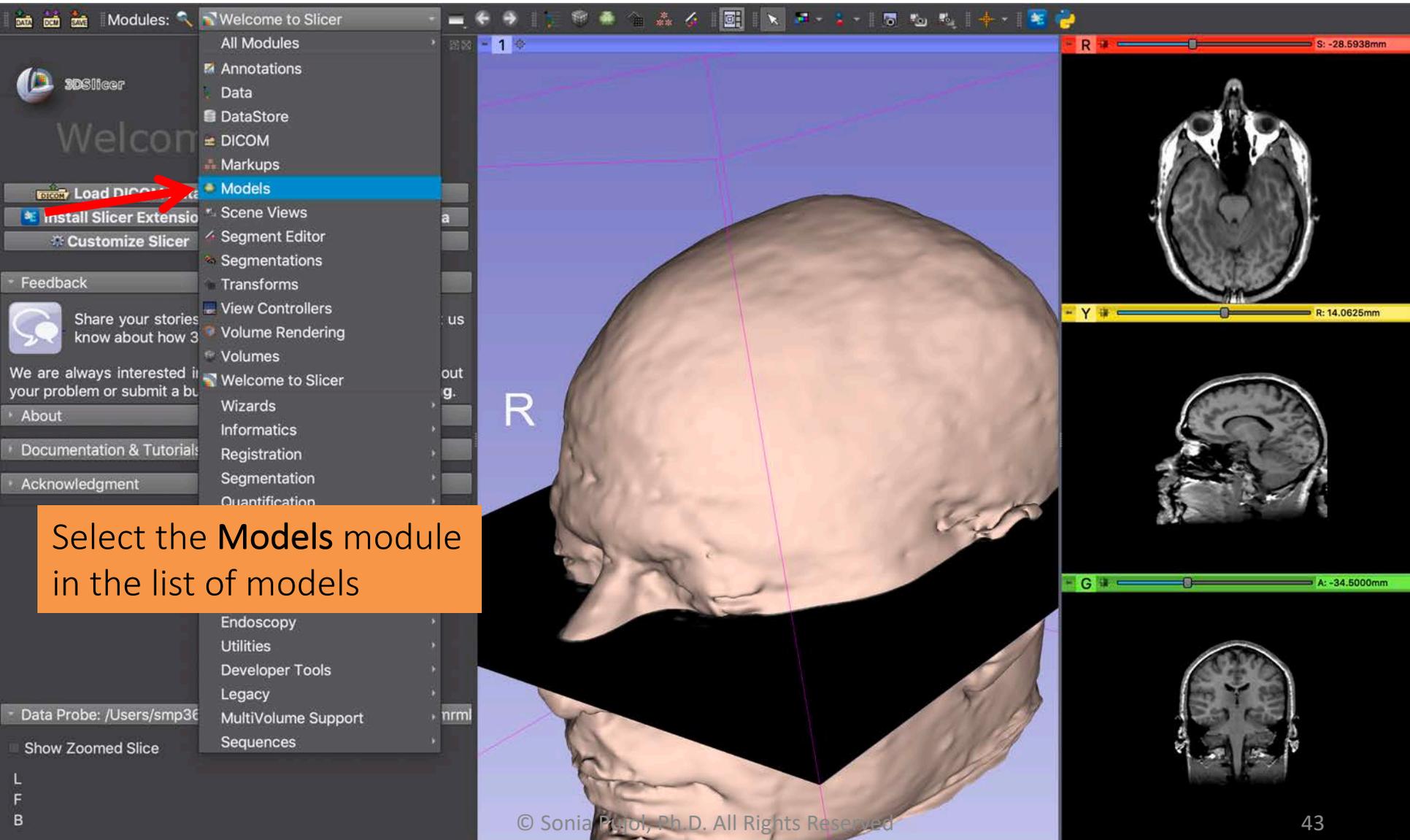


The image shows the 3D Slicer software interface. The main window displays a 3D model of a human head. On the right side, there are three orthogonal MRI slices: Axial, Sagittal, and Coronal. A red arrow points to the slice menu in the top right corner, which is currently set to 'Axial' and 'grayscale'. The interface includes a toolbar at the top, a sidebar on the left with various options like 'Load DICOM Data', 'Install Slicer Extensions', and 'Customize Slicer', and a bottom status bar.

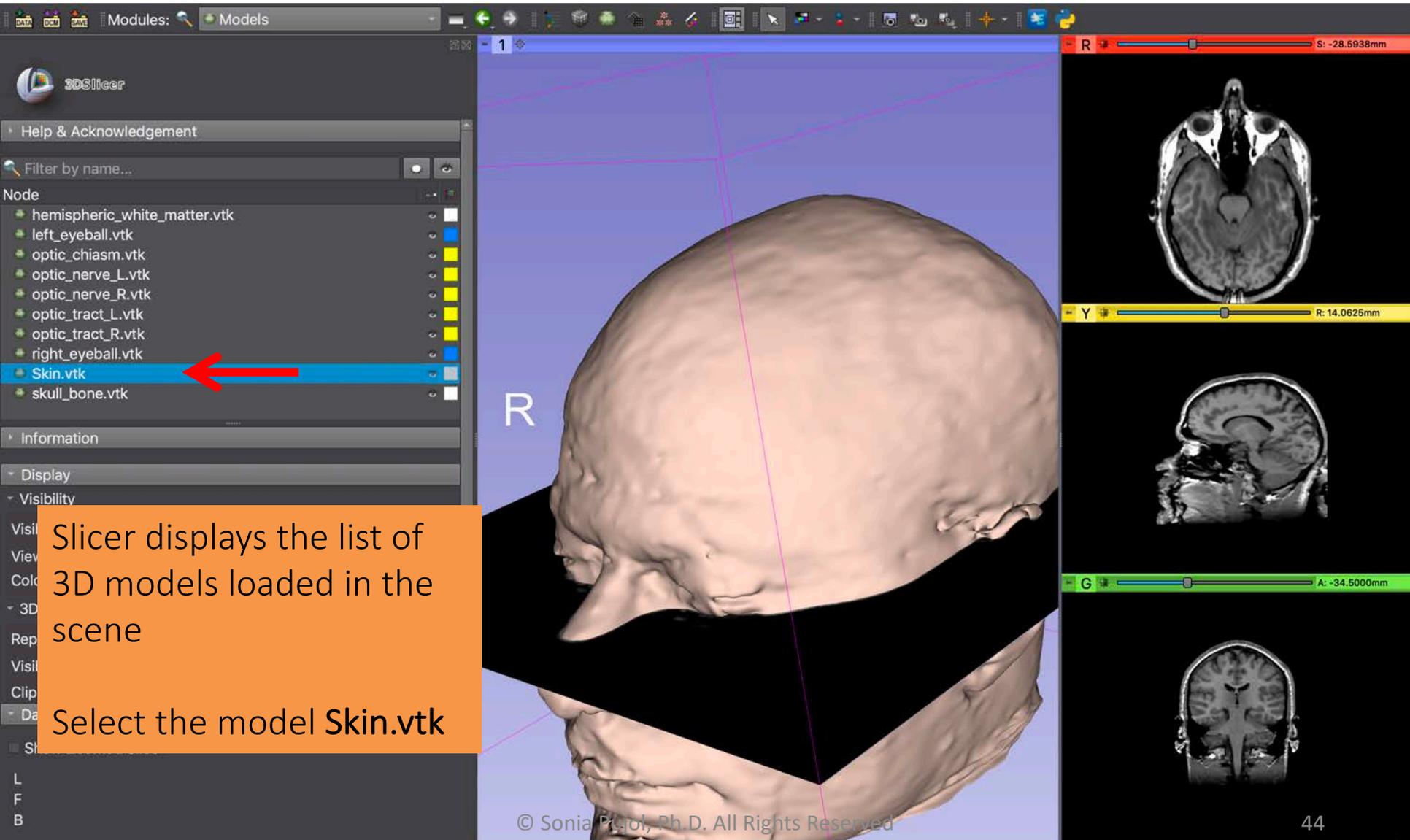
Position the cursor over the pin icon to reveal the slice menu and click on the eye icon to display the axial slice in the 3D viewer

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Viewing 3D models



Viewing 3D models



Slicer displays the list of 3D models loaded in the scene

Select the model **Skin.vtk**

Viewing 3D models

The screenshot displays the 3D Slicer software interface. On the left, the 'Node' list includes 'hemispheric_white_matter.vtk', 'left_eyeball.vtk', 'optic_chiasm.vtk', 'optic_nerve_L.vtk', 'optic_nerve_R.vtk', 'optic_tract_L.vtk', 'optic_tract_R.vtk', 'right_eyeball.vtk', 'Skin.vtk', and 'skull_bone.vtk'. The 'Skin.vtk' node is selected. In the 'Visibility' panel, the 'Opacity' slider is set to 0.50, with a red arrow pointing to it. The '3D Display' panel shows 'Representation: Surface'. The main 3D view shows a skull model with semi-transparent skin and blue eyeballs. The right side of the interface shows two axial MRI slices with coordinate indicators: 'R' (Right) at -51.0938mm, 'Y' (Anterior-Posterior) at 14.0625mm, and 'G' (Superior-Inferior) at -34.5000mm.

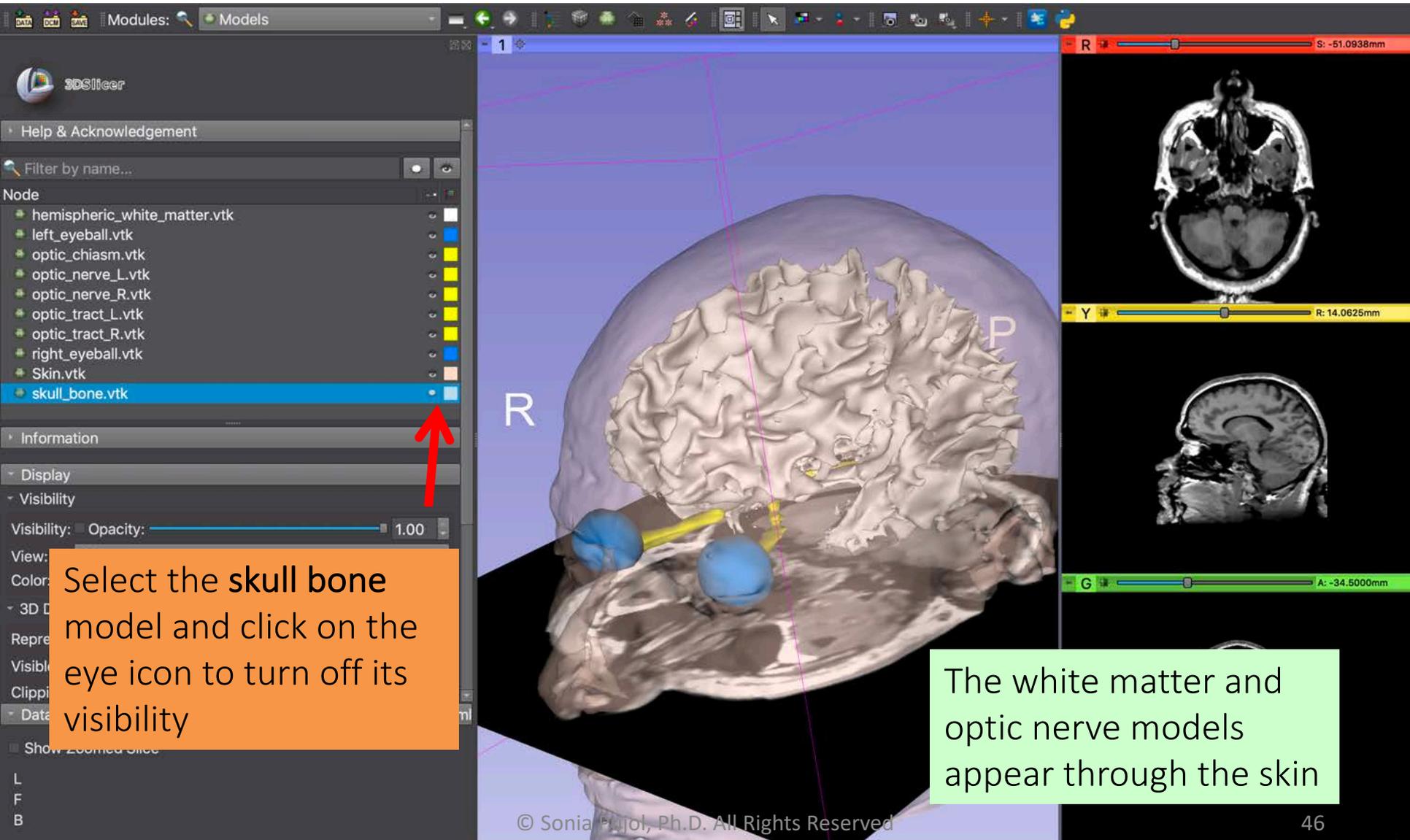
Lower the opacity of the Skin model using the visibility slider

The skull bone and eyeballs models appear through the skin

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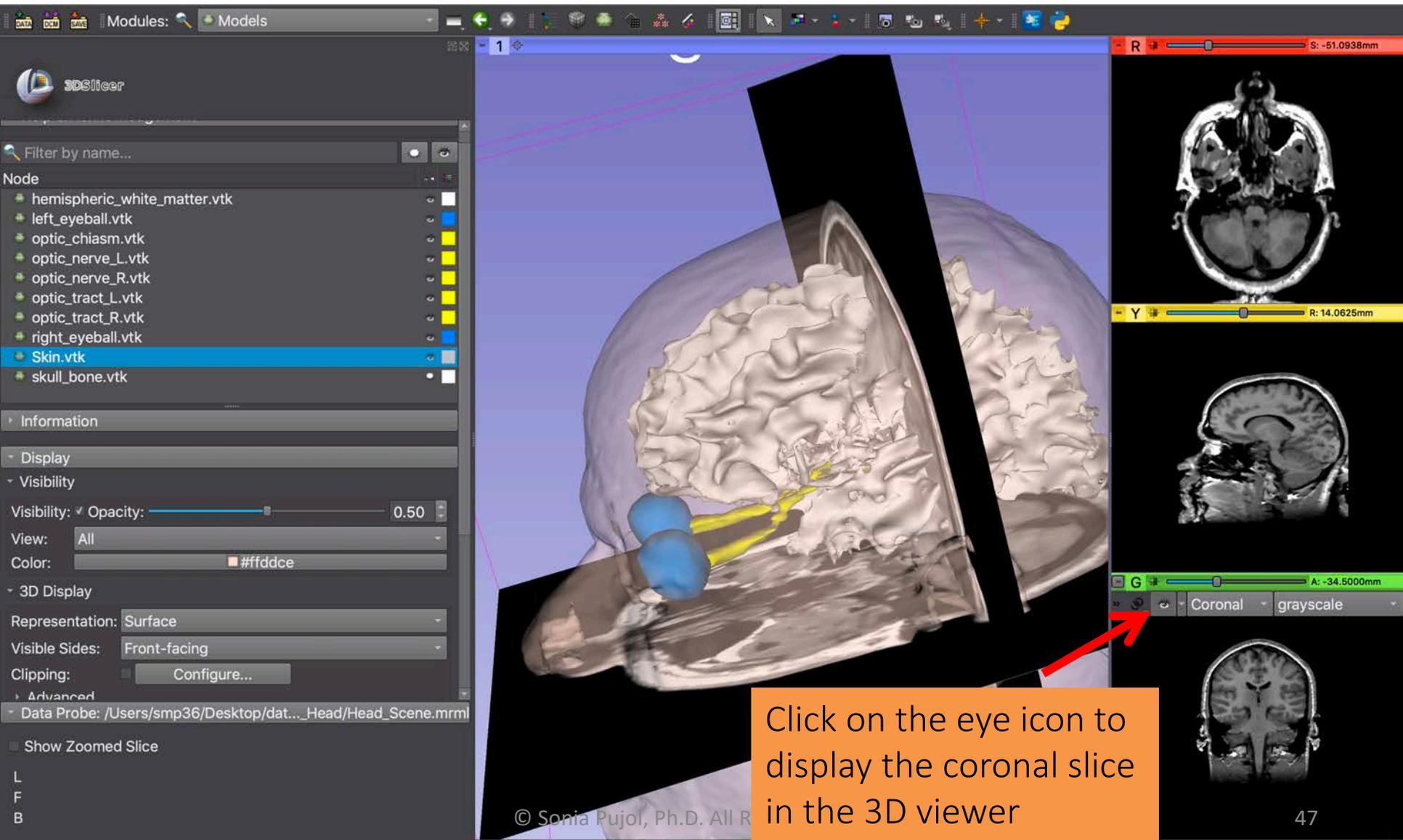
Viewing 3D models



Select the **skull bone** model and click on the eye icon to turn off its visibility

The white matter and optic nerve models appear through the skin

Interacting with 3D models



Interacting with 3D models

The screenshot displays the 3D Slicer software interface. The central 3D view shows a brain model with a semi-transparent white matter volume and a black clipping plane. The left sidebar contains a 'Models' list with 'hemispheric_white_matter.vtk' selected. Below it, the 'Clipping' option is checked. The right sidebar shows three orthogonal MRI slices (axial, sagittal, and coronal) with their respective position sliders.

3D Slicer

Models

- hemispheric_white_matter.vtk
- left_eyeball.vtk
- optic_chiasm.vtk
- optic_nerve_L.vtk
- optic_nerve_R.vtk
- optic_tract_L.vtk
- optic_tract_R.vtk
- right_eyeball.vtk
- Skin.vtk
- skull_bone.vtk

Information

Display

Visibility

Visibility: Opacity: 1.00

View: All

Color: #ffffff

3D Display

Representation: Surface

Visible Sides: All

Clipping: Configure...

Advanced

Slice Display

Visible:

R: S: -51.0938mm

Y: R: 14.0625mm

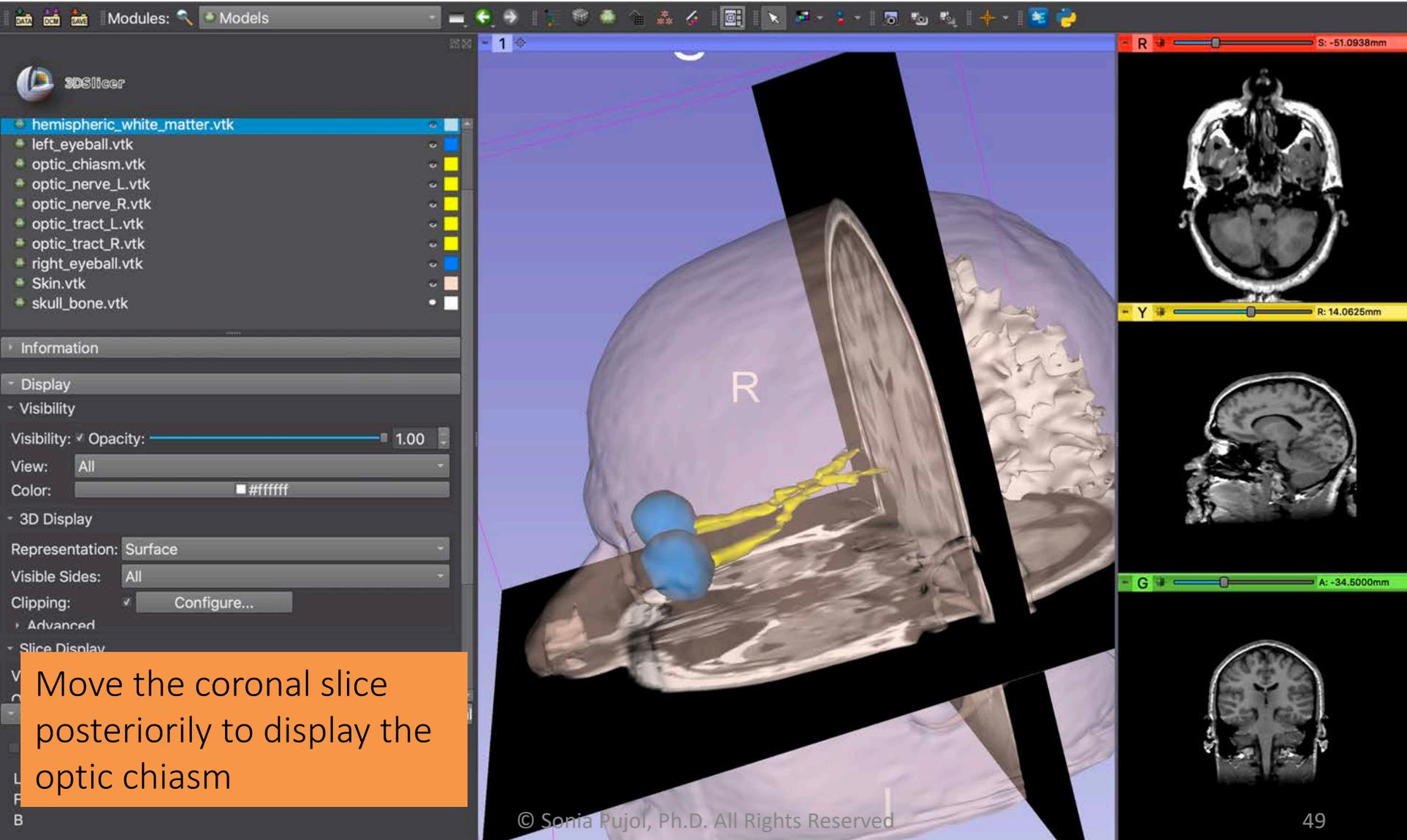
G: A: 9.0000mm

Select the hemispheric white matter model and select the option Clipping

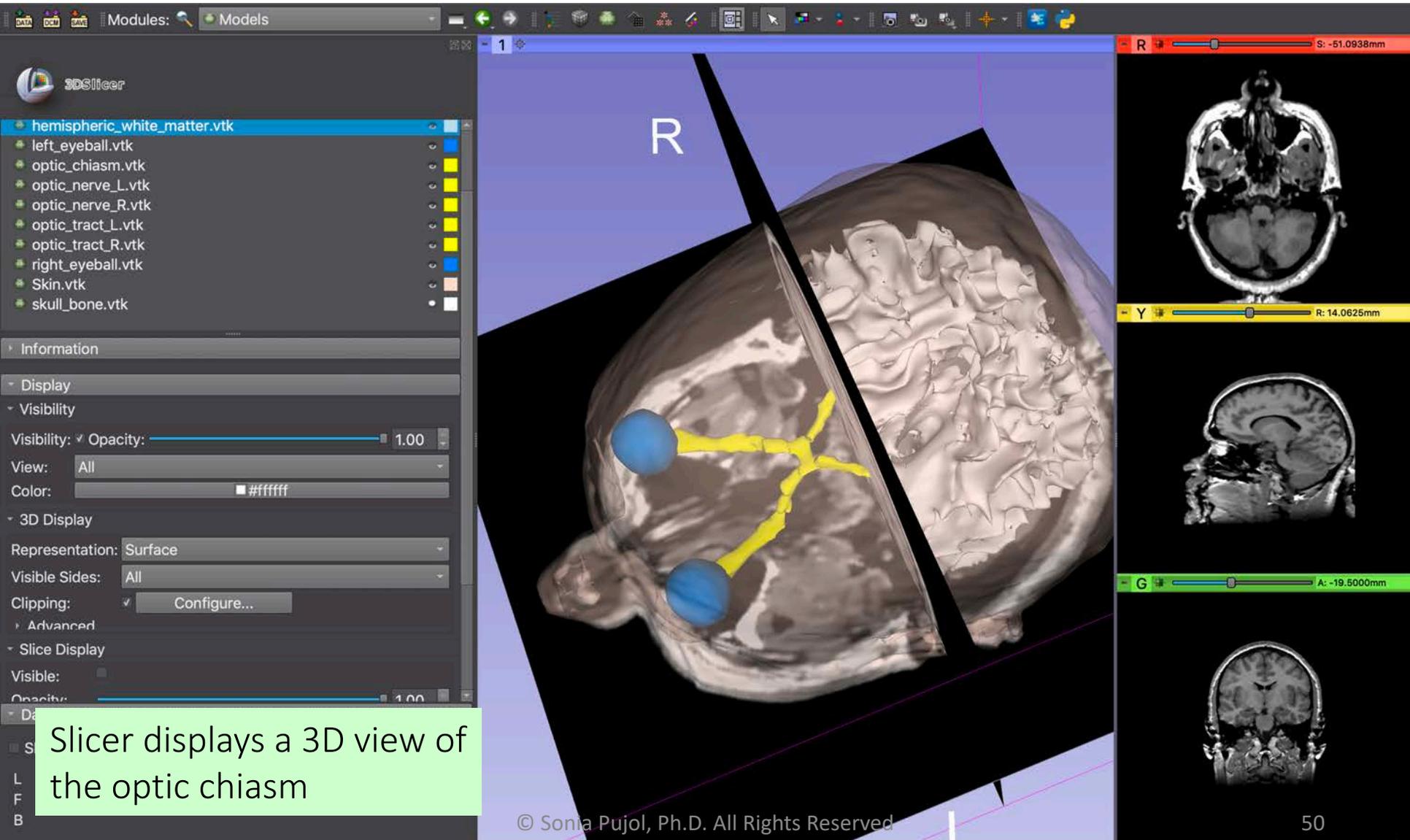
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Interacting with 3D models



Interacting with 3D models

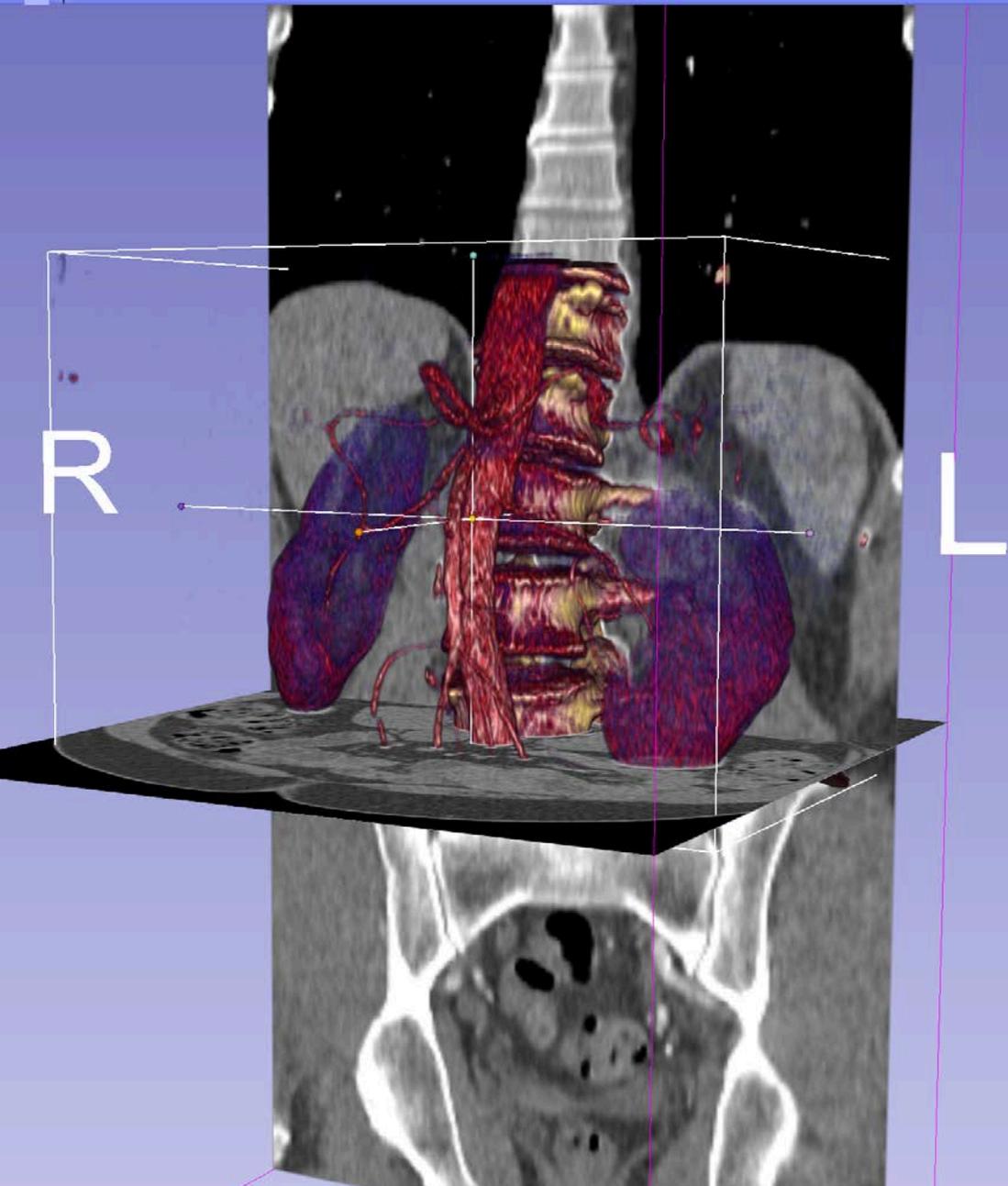


Conclusion

- 3D Slicer provides advanced functionalities for loading and viewing 3D medical imaging data
- The tutorial demonstrates how to use volume rendering and 3D surface modeling for interactive visualization of CT and MRI data

Contact: spujol@bwh.harvard.edu

Acknowledgments



Neuroimage Analysis
Center
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