3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

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Overview

**Part 1:** DICOM data loading in 3DSlicer

**Part 2:** 3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering

**Part 3:** 3D Interactive exploration of MR head data using Surface Rendering

**Part 4:** 3D interactive exploration of the segments of the liver using Surface Rendering

**Part 5:** 3D interactive exploration of the segments of the lung
Following this tutorial, you will be able to load and visualize volumes within Slicer4.2, and to interact in 3D with structural images and models of the anatomy.
Slicer is a freely available open-source platform for segmentation, registration and 3D visualization of medical imaging data.

3DSlicer is a multi-institutional effort supported by the National Institute of Health.
3DSlicer

- An end-user application for image analysis
- An open-source environment for software development
- A software platform that is both 
  easy to use for clinical researchers and easy to extend for programmers
3DSlicer version 4.2 is a multi-platform software running on Windows, Linux, and Mac OSX.

Disclaimer
It is the responsibility of the user of 3DSlicer to comply with both the terms of the license and with the applicable laws, regulations and rules. Slicer is a tool for research, and is not FDA approved.
3DSlicer History

- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)

Image Courtesy of the CSAIL, MIT
3DSlicer History

- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)
- 2012: Multi-institution effort to share the latest advances in image analysis with clinicians and scientists
NA-MIC and NAC

The National Alliance for Medical Image Computing (NA-MIC) is a multi-institutional, interdisciplinary team of computer scientists, software engineers, and medical investigators who develop computational tools for the analysis and visualization of medical image data. The purpose of the Center is to provide the infrastructure and environment for the development of computational algorithms and open-source technologies, and then oversee the training and dissemination of these tools to the medical research community.

Supported by the National Institutes of Health, Roadmap Initiative.

Information about collaborating with NA-MIC is available on our wiki.

The Neuroimage Analysis Center (NAC) develops image processing and analysis techniques for basic and clinical neurosciences. The NAC research approach emphasizes both specific core technologies and collaborative application projects. The activities of the NAC are centered at the Harvard Medical School and the Surgical Planning Laboratory at the Brigham and Women's Hospital in Boston, with collaborations throughout the United States and the rest of the world.

The NAC is a major research center supported by the National Center for Research Resources (NCRR), a component of the National Institutes of Health.
Slicer: Behind the scenes

Slicer is built every night on Windows, Mac and Linux platforms.
Slicer Training

• Hands-on training workshops at national and international venues

• >2,000 clinicians, clinical researchers and scientists trained since 2005
Welcome to Slicer4

To start Slicer, select Start → All Programs → Slicer4-2
Welcome to Slicer 4.2

Click on **Welcome to Slicer** to display the 92 modules of Slicer in the Modules menu.
Welcome to Slicer4

Slicer4.2 contains more than 90 modules for image segmentation, registration and 3D visualization of medical imaging data.
Part 1:

Loading a DICOM Volume
Most radiological imaging equipment produce images in DICOM file format (‘.dcm files’)

The DICOM 3.0 File Format
Loading a DICOM volume

Click on **Load DICOM Data** in the panel of the Welcome to Slicer module.
Loading a DICOM volume

The DICOM Details window appears
Click on **Local Database**, and select the directory 
C:\Documents and Settings\Administrator\Desktop\3DSlicerData\DICOM-database
Loading a DICOM volume

Click on Import, browse to the location of the 3DSlicerData directory
Loading a DICOM volume

Select the subdirectory **CT-Thorax-Abdomen**, and click on **Import** to load the directory in the DICOM browser.
Loading a DICOM volume

The patient1 DICOM dataset appears in the DICOM browser. Click on ‘patient1’ to display the file hierarchy, select the DICOM volume **CT_Thorax_Abdomen**
Loading a DICOM volume

Click to expand the DICOM Browser window.

Slicer displays the snapshots of the DICOM images of the CT_Thorax_Abdomen dataset
Loading a DICOM volume

Click on **Load Selection to Slicer** to load the DICOM volume into Slicer
Loading a DICOM volume

Slicer displays the axial, coronal and sagittal slices of the DICOM dataset.
Loading a DICOM volume

Click on the Window Level Preset **CT-abdomen**, or adjust manually the Window and Level using the Manual W/L slider.
Loading a DICOM volume

Select the module **Volume Rendering** in the Modules Menu
Loading a DICOM volume

Position the mouse cursor over the red banner in the Red Viewer to display the slice menu. Click on the **Link 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.
Loading a DICOM volume

The three anatomical slices appear in the 3D viewer. Use the right-mouse button in the 3D Viewer to zoom in and out.
Loading a DICOM volume

Use the left-mouse button in the 3D Viewer to rotate the 3D volume
Loading a DICOM volume

Position the mouse over the blue banner in the 3D viewer window to display the 3DView controller, and click on the top left icon to center the 3D view on the scene.
Loading a DICOM volume

Click on the Slicer layout menu icon, and select the Conventional Widescreen layout.
Loading a DICOM volume

Use the red slice, yellow slice and green slice sliders to slice through the volume in all three anatomical directions.
Part 2:

3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering
Loading a DICOM volume

Select the module **Volume Rendering** in the modules menu.
Loading a DICOM volume

Select the Preset **CT-Cardiac3** in the **Display** tab
Loading a DICOM volume

Select the Rendering **NCI GPU Ray Casting**, and click on the eye icon in the **Volume** tab to display the Volume rendered volume in the 3D viewer.
Slicer displays the 3D rendered volume of the CT_Thorax_Abdomen dataset
Use the **Shift** slider to shift the transfer function and display the aorta.
GPU Volume Rendering
GPU Volume Rendering

Use the right-mouse button to zoom in. Click on **Display ROI** to display a region of interest that we will use for cropping the dataset.
Position the ROI around the left and right kidneys using the ROI controls both in the 3D viewer and in the 2D views
Click on **Enable** to display the cropped volume rendered image.
Slicer displays the cropped volume rendered images showing the left and right kidney.
GPU Volume Rendering

Click on File → Exit to quit Slicer
Part 2:

3D visualization of surface models of the brain
3D Slicer Scene

- A Slicer scene is a MRML file which contains a list of elements loaded into Slicer (volumes, models, fiducials…)

- The tutorial scene contains an MR scan of the brain and 3D surface models of anatomical structures.
3D models of the brain

- The tutorial data are part of the SPL-PNL Brain Atlas developed by Thalos et al.

- **RSNA 2011 Presentation:**
  
  *Publicly available RaxLex-linked Anatomy Atlases for Image Analysis Informatics and Education.* Michael Halle, Samira Farough, Marianna Jakab, Ron Kikinis
  
  Thurs. Dec. 1\textsuperscript{st}, 11:10-11:20 am
  
  Room S402AB
Loading a Scene

Re-start Slicer, and elect File $\rightarrow$ Load Data in the Welcome to Slicer module
Browse to the directory **MR-Head**, located on the Desktop: C:\Documents and Settings\Administrator\Desktop\3DSlicerData
Select the file **slicer4minute.mrml**, and click on **Open**
Loading a Scene

Click on OK to load the 3D scene in Slicer
Loading the Slicer Scene

A 3D surface model of the head, and 2D anatomical slices appear in the Viewer.
Loading the Slicer Scene

Select the module **Models** from the Modules menu.
Models module

The list of 3D models appear in the Models panel.
3D Visualization

Position the mouse cursor over the red banner in the axial view. Click on the eye icon to display the slice in the 3D viewer.
3D Visualization

Slice through the 3D model of the head using the axial slider.

Select the model ‘Skin.vtk’ in the list of models, and expand the tab ‘Material Properties’ under ‘Display’.
3D Visualization

Lower the opacity of the skin model using the Opacity slider
Select the skull_bone.vtk model, and turn off its visibility.
3D Visualization

The 3D surface of the white matter appears in the 3D viewer.
Click on the eye icon in the green viewer to display the coronal slice in the 3D viewer.
Select the 3D model `hemispheric_white_matter.vtk`, and select the option **Clip** in the **Display tab**.
Select the tab Clipping, and set the Green Slice Clipping to Negative Space.
The optic chiasm appears in the 3D viewer
3D Visualization

Select File ➔ Exit to close the Brain Scene, and exit Slicer
Part 4:
Interactive 3D Visualization of the segments of the liver
Anatomy of the liver
Liver dataset

The liver dataset is a contrast-enhanced CT abdominal scan of a healthy 36 year-old male.
3D segments of the liver

- Segment II
- Segment III
- Segment IVa
- Segment IVb
- Segment VI
- Segment V
- Segment VII
3D segments of the liver

- Segment II
- Segment I
- Segment VII
- Segment III
- Segment IVb
- IVC
- Segment VI
- Segment V
Liver vasculature

- Middle hepatic vein
- Left portal vein
- Left hepatic vein
- Caudate vein
- Main portal vein
- Right hepatic vein
- Right portal vein
- IVC
Loading the Liver Data Scene

Re-start Slicer, and elect
File → Load Data in the
Welcome to Slicer module
Loading the Liver Scene

Load the file **Scene-Liver.mrml** located in:

C:\Documents and Settings\Administrator\Desktop\3DSlicerData\LiverData
Liver Segments Scene

The elements of the scene appear in the Viewer
3D models of the liver

Segment II
Segment III
Segment IVa
Segment IVb
Segment VI
Segment VII
Segment VIII
Segment V
Segment IVb
3D models of the liver

- Segment II
- Segment I
- Segment VII
- Segment III
- Segment IVb
- IVC
- Segment VI
- Segment V
3D models of the liver

- Middle hepatic vein
- Left portal vein
- Left hepatic vein
- Caudate vein
- Main portal vein
- IVC
- Right portal vein
- Right hepatic vein

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Example:
What organ abuts the left-most margin of segment II in this patient?
3D Exploration of Liver Segments

Select the module **Models**

Click on the Liver Structures Models Hierarchy
Select the model **Liver_Segment II**
Turn on/off its visibility to locate it in the 3D viewer.
3D Exploration of Liver Segments

Position the mouse in the 3D Viewer, hold down the left mouse button and drag to orient the 3D model to a superior view.
Question 1:
What organ abuts the left-most margin of segment II in Patient 1?
Question 1:
What organ abuts the left-most margin of segment II in this patient?

Answer 1: Stomach
Question 2: Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland?
Question 2: Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland?

Answer 2: Segment VII
Question 3:
Which vessel separates Segment IVb and Segment V?
Middle Hepatic Vein

Question 3: Which vessel separates Segment IVb and Segment V?

Answer 3: The middle hepatic vein
Closing the Liver Scene

Select File → Exit to close the Liver Scene and exit Slicer.
Part 4:

Interactive 3D Visualization of the segments of the lungs
Segments of the lung

Segmentation and 3D surface reconstruction of the lung and pulmonary vessels

Acknowledgment:
Segmentation of the lung surface and vasculature: Raul San Jose Estepar, Ph.D., George Washko, M.D., Ed Silverman, M.D. and James Ross, MSc. Brigham and Women’s Hospital (K25 HL104085) and COPDGene (01 HL089897 and U01 HL089856)
Segments of the lung

3D parcellation of arteries and veins from original model of pulmonary vessels
(Kitt Shaffer, M.D., Ph.D. - Sonia Pujol, Ph.D.)

- Right Upper Lobe (RUL)
  - RUL Pulmonary Vein
  - RUL Anterior Segment
  - RUL Apical Segment
  - RUL Posterior Segment
- Right Middle Lobe (RML)
  - RML Pulmonary Vein 1 & 2
  - RML Lateral Segment
  - RML Medial Segment
- Right Lower Lobe (RLL)
  - RLL Pulmonary Vein 1,2,3
  - RLL Anterior Basal Segment
  - RLL Medial Basal Segment
  - RLL Lateral Basal Segment
  - RLL Posterior Basal Segment
Loading the Chest Data Scene

Re-start Slicer, and elect
File ➔ Load Data in the
Welcome to Slicer module
Loading the Lung Scene

Load the file **LungSegment_Scene.mrml** located in:
C:\Documents and Settings\Administrator\Desktop\3DSlicer\LungData
Position the mouse cursor in the top left corner of the 3D viewer, and select the top left icon to center the 3D view on the scene.
Loading the Lung Scene

Select the module **Models** from the modules Menu.
Slicer displays the list of 15 surface models of pulmonary structures.
Lung Segments – Question 1

Q1: Why is there a gap in the vessels at the arrows?
Question 2: Which segment’s vascular supply is shown at the arrow?
Question 2: Which segment’s vascular supply is shown at the arrow?

Answer 2: Right Upper Lobe Apical Segment
Question 3: Which segment’s vascular supply is shown at the arrow?
Question 3: Which segment’s vascular supply is shown at the arrow?

Answer 3: Right Lower Lobe Pulmonary Vein 1
Question 4: Classify the segments of the lower lobe by size
Lung Segments – Question 4

Smallest: Medial Basal
Lung Segments – Question 4

Largest: Anterior / Posterior Basal
3D Visualization of DICOM images

- Interactive user-interface to load and manipulate greyscale volumes, labelmaps and 3D models.
- User-defined 3D view of the anatomy
- 3D Open-source platform for Linux, Mac and Windows
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