3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

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Overview

Part 1: Introduction to data loading and 3D visualization of brain images

Part 2: 3D interactive exploration of the segments of the liver

Part 3: 3D interactive exploration of the segments of the lung
3D Visualization of the Anatomy

Following this tutorial, you will be able to load and visualize volumes within Slicer4, 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.

3D Slicer 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 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)
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- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)

- 2011: Multi-institution effort to share the latest advances in image analysis with clinicians and scientists
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 oversees 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.
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

• >1,700 clinicians, clinical researchers and scientists trained since 2005
3DSlicer version 4.0
Welcome to Slicer4

To start Slicer, select Start → All Programs → Slicer4-4.0.gamma-2011-11-23
Welcome to Slicer4

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

Slicer4 contains more than 90 modules for image segmentation, registration and 3D visualization of medical imaging data.
PART 1: LOADING A DICOM VOLUME
The DICOM 3.0 File Format

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

Image001.dcm
Image002.dcm
Image003.dcm
....
Select File ➔ Add Volume in the main menu
Loading a DICOM volume

Browse to the location of the **dicom** directory, located in
C:\Documents and Settings\Administrator\Desktop\3D
Double-click on the directory 1.3.12.2.1107.5.2.32.35162.3.2006111717401884850201701.0.0.0 to access the dicom images
Select the first file in the list of DICOM images and click on Open.
Loading a DICOM volume

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

Left-click on the Slicer layout icon
Select Red slice only from the layout menu
Loading a DICOM volume

Position the mouse button at the top left corner of the window to display the slice menu
Loading a DICOM volume

Click on the Lightbox view icon in the slice menu, and select the 6x6 view option.
Loading a DICOM volume

Slicer display 36 consecutive images of the dicom volume. Use the red slice slider to browse through the dicom data.
Loading a DICOM volume

Left click on the red window icon, and select the Conventional layout
Loading a DICOM volume

Select the lightbox viewer in the red slice menu, and come back to 1x1 view.
Loading a DICOM volume

Click on the links icon to link all three viewers, and on the eye icon to display the slices in the 3D Viewer.
Loading a DICOM volume

The three anatomical slices appear in the 3DViewer
Loading a DICOM volume

Use the left-mouse button to rotate the camera, and the right-mouse button to zoom in and out.
Close the scene

Select **File → Close Scene** to close the Slicer Scene
Exit Slicer

Select **Slicer → Quit** to exit the software
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

Select File → Load Scene from the main menu
Loading a Scene

Browse to the directory **3D**, located on the Desktop:

C:\Documents and Settings\Administrator\Desktop\3D
Loading a Scene

Select the directory **3DHeadData**, and open the file **slicer4minute.mrml**
Loading a Scene

Open the file `slicer4minute.mrml`
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.
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.
3D Visualization

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.
3D Visualization

The optic chiasm appears in the 3D viewer.
3D Visualization

Select **File → Exit** to close the Brain Scene, and exit Slicer
Part 3:
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
- Segment IVb
- Segment III
- Segment II
- Segment VII
- Segment VI
- Segment V
Liver vasculature

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

Select **File → Load Scene** from the main menu

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

C:\Documents and Settings\Administrator\Desktop\3D\LiverData
The elements of the scene appear in the Viewer.
3D models of the liver

- Segment VII
- Segment VI
- Segment V
- Segment IVb
- Segment IVa
- Segment III
- Segment II
- Segment VIII

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

Question 3: Which vessel separates Segment IVb and Segment V?
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, Boston, MA
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 Lung Scene

Select **File ➔ Load Scene** from the main menu

Load the file **LungSegment_Scene.mrml** located in:

C:\Documents and Settings\Administrator\Desktop\3D\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.
Select the module **Models** from the modules Menu.
Lung Segments

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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www.slicer.org
www.na-mic.org

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