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.

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 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)
- 2011: 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 to 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

• >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-2011-11-24
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.
Slicer User Interface

Main Menu

GUI panel of the Slicer Welcome Module

Data Probe

Toolbar

3D viewer

2D anatomical viewers
PART 1: LOADING A DICOM VOLUME
The DICOM 3.0 File Format

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

Image001.dcm
Image002.dcm
Image003.dcm
....
Select the DICOM module from the Modules menu
DICOM module

Enter the path to the directory where you would like to install the **Slicer-dicom** database on your machine.
Click on **Import**, and browse to the location of the **dicom** directory, located in **C:\Documents and Settings\Administrator\Desktop\3D**
DICOM module

Select the **dicom** directory, and click on **Import**

Note: Loading the dicom dataset in the database may take a few minutes.
DICOM module

Double-click on the bwh_atlas2 series to access the MPRAGE dataset.

The thumbnails of each image of the volume appear in the DICOM panel.
Double-click on the bwh_atlas2 series to access the MPRAGE dataset.

The thumbnails of each image of the volume appear in the DICOM panel.
DICOM module

Browse through the images using the arrows buttons to inspect the MPRAGE volume.
DICOM module

Click on Load Selected Series to Slicer
DICOM module

Slicer is loading the MPRAGE dataset
The axial, coronal and sagittal slices appear in the 2D viewers.
To change the **Window/Level** of the image, position the mouse cursor in one of the viewers, and hold down the left button:

- Move the mouse cursor up/down to change the image level
- Move the cursor left/right to change the image window
Window/Level

Note: the Window/Level of the images can be adjusted using the W/L slider in the module Volumes.

Go back to the DICOM module.
DICOM module

Select Red slice only from the layout menu
Position the mouse button at the top left corner of the window to display the slice menu.
Position the mouse cursor in the image, hold down the right mouse button, and move the mouse cursor down to zoom in.
DICOM module

Hold down the middle mouse button and move the mouse cursor to explore a different part of the image.
Position the mouse on the top left corner of the image to display the slide menu, and click on the icon to re-center the image and adjust the view to the size of the window.
DICOM module

Click on the Lightbox view icon in the slice menu, and select the 6x6 view option
DICOM module

Slicer display 36 consecutives images of the dicom volume. Use the red slice slider to browse through the dicom data.
DICOM module

Left click on the red window icon, and select the Conventional layout.
DICOM module

Select the lightbox viewer in the red slice menu, and come back to 1x1 view
DICOM module

Select Four-up in the layout menu
Hold down the **Shift** key on your keyboard, and move the mouse cursor in the red viewer.
DICOM module

Slicer displays the sagittal and coronal slices that correspond to the location of the mouse cursor in the axial image.
DICOM module

Select **Conventional** from the layout menu, to return to the conventional layout of Slicer.
DICOM module

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

The three anatomical slices appear in the 3DViewer
Position the mouse cursor in the 3D viewer, and use the left-mouse button to rotate the camera, and the right-mouse button to zoom in and out.
DICOM module

Select the module Data from the module menu
Close the Scene

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

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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
- IVC
- Right portal vein
- Right hepatic vein
Select **File → Load Scene** from the main menu

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

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

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
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.
3D Exploration of Liver Segments

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?
Question 3: Which vessel separates Segment IVb and Segment V?
Answer 3: The middle hepatic vein
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.
Loading the Lung Scene

Select the module **Models** from the modules Menu.
Slicer displays the list of 15 surface models of pulmonary structures.
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
Lung Segments – Question 3

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
Acknowledgments

National Alliance for Medical Image Computing (NA-MIC)
(NIH Grant U54EB005149)

Lung Data: Estepar, Washko, Silverman, Ross - Brigham and Women’s Hospital. K25 HL104085, COPDGene 01 HL089897 and U01 HL089856

Neuroimage Analysis Center (NAC)
(NIH Grant P41 RR013218)
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