3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

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Following this tutorial, you will be able to load and visualize DICOM volumes with 3D Slicer, and to interact in 3D with structural images and models of the anatomy.
Overview

Part I: Introduction to the 3DSlicer software

Part II: 3D Data Loading and visualization of DICOM images
- Volume Rendering of thoraco-abdominal CT data
- Surface Rendering of MR head data

Part III: 3D interactive exploration of the anatomy
- Exploration of the Segments of the liver
- Exploration of the Segments of the lung
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Introduction to the 3DSlicer software
3DSlicer 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 version 4.2 is a multi-platform software running on Windows, Linux, and Mac OSX

- Slicer is distributed under a BSD license with no restriction on use
- Slicer is a tool for research, and is not FDA approved

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.
An interdisciplinary platform

An open-source environment for software developers

An end-user application for clinical investigators and scientists

A software platform that is both easy to use for clinical researchers and easy to extend for programmers
3DSlicer History

• 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the Computer Science and Artificial Intelligence (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 the clinical and scientific community
NA-MIC, NAC, NCIGT

PI: Ron Kikinis, M.D.

PIs: Ferenc Jolesz, M.D., Clare Tempany, M.D.
Slicer: Behind the scenes

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

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Slicer Training events

- Hands-on training workshops at national and international venues
- More than 2,000 clinicians, clinical researchers and scientists trained since 2005
Slicer Training events

Major international conferences

− **SfN** 2009, 2011
− **SPIE** 2012, 2013
− **CAOS** 2010
− **CARS** 2010, 2012, 2013
RSNA Activities

Hands-on refresher courses

- 3D Visualization of DICOM images for Radiology Applications
- Quantitative Imaging for Clinical Research and Practice

Quantitative Imaging Reading Room Exhibit

- 3DSlicer: An Open Source Platform for Segmentation, Registration, Quantitative Imaging, and 3D Visualization of Multi-Modal Image Data. #3007
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To start Slicer, select Start → Programs → Slicer4-2.0 (win64)
Navigating the Application GUI

The Graphic User Interface (GUI) of Slicer4 integrates four components:

- the Menu Toolbar
- the Module GUI Panel
- the 3D Viewer
- the Slice Viewer
Click on **Welcome to Slicer** to display the list of modules of Slicer in the Modules menu.
Welcome to Slicer4

Slicer4.2 contains more than 100 modules for image segmentation, registration and 3D visualization of medical imaging data.
Part 1:

Loading a DICOM Volume
Loading a DICOM volume

Click on **Load DICOM Data** in the panel of the Welcome to Slicer module.
Select DICOM local database

The GUI of the DICOM browser window appears
Select DICOM local database

The path to the current local DICOM database of Slicer is set to C:/Pujol2012/QuantitativeImaging_Sunday_Nov25_2012/dicom-database
Select DICOM local database

Click on this path name and change the local database directory to C:/Pujol2012/3DVisualization_Tuesday_Nov27_2012/dicom-database
Click on Choose to set this directory as the local DICOM database of Slicer
Loading a DICOM volume

Click on **Import**, browse to the location of the directory
C:/Pujol2012/3DVisualization_TuesdayNov27_2012/
Select the directory **dataset1_CT-Thorax-Abdomen**
Click on **Import** to load the dataset into Slicer
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_CT**
Loading a DICOM volume

Click to expand the DICOM Browser window.

Slicer displays the snapshots of the DICOM images of the **CT_Thorax_Abdomen_CT** dataset
Loading a DICOM volume

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

(note: this may take a few minutes)
Loading a DICOM volume

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

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

Slicer has a series of window/level presets available

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

Note: a shortcut to this functionality is available through the icon next to the number ‘1’ in the blue banner.
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.
3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering
Volume Rendering

Select the module **Volume Rendering** in the modules menu
Select the volume 6:CT_Thorax_Abdomen
Click on **Preset** in the **Display** tab to display the list of available presets for the transfer function. Select the Preset **CT-Cardiac3**
Select the Rendering **VTK CPU Ray Casting**, and click on the eye icon in the **Volume** tab to display the Volume rendered volume in the 3D viewer.
Volume Rendering

Slicer displays the 3D rendered volume of the CT_Thorax_Abdomen dataset.
Move the **Shift** slider toward the right, to shift the transfer function and display the aorta.
The volume rendered image of the aorta and rib cage appears in the 3D viewer.
Click on the eye icon in the red viewer to turn off the visibility of the anatomical slices in the 3D viewer
Volume Rendering

Use the mouse in the 3D window to rotate the volume rendered image
Volume Rendering

Click on the eye icon in the volume rendering panel to remove the volume rendered image from the 3D viewer.
Click on **Display ROI** to display a region of interest that we will use for cropping the dataset, and check the option **Enabled**.
Volume Rendering

The region of interest appears in the 3DViewer
Position the ROI around the left and right kidneys using the ROI controls in the 2D anatomical views and in the 3D viewer.
Volume Rendering

Click on the eye icon to display the volume rendered image of the kidney.
Volume Rendering

Slicer displays the volume rendered image of the left kidney
Extend the ROI to the right kidney
Volume Rendering

Slicer displays the cropped volume rendered images showing the left and right kidney.
Volume Rendering

Click on File ➔ Exit to quit Slicer
3D visualization of surface models of the brain
This tutorial is a short introduction to the advanced 3D visualization capabilities in Slicer.

The Slicer4 Minute dataset is composed of an MR scan of the brain and 3D surface reconstructions of anatomical structures.

The data are part of the SPL-PNL Brain Atlas developed by Talos, Jakab, Kikinis et al. The atlas is available at:

http://www.spl.harvard.edu/publications/item/view/2037
When the scene is finished loading, Slicer displays:

- a **3D model of the head** in the **3D Viewer**, and
- anatomical **MR slices of the brain** in the **2D Slice Viewers**.
Slicer4 Minute Tutorial: Exploring Slicer’s functionality

To access the Models module, browse through the list of modules...

...or click on the models icon in the toolbar.
Slicer4 Minute Tutorial: **Switching to the Models Module**

Slicer displays the GUI of the Models module.
Slicer4 Minute Tutorial: Basic 3D Interaction

Position the mouse in the 3D Viewer.

Hold down the left mouse button and drag to rotate the model.
Click on the **Slice Visibility** icon to display the Axial Slice in the 3D Viewer.
Slicer4 Minute Tutorial: 3D Visualization

Slicer adds a view of the **Axial slice** in the 3D View.
Click on the layout menu in the toolbar, and select the Conventional layout.
Select the **Skin.vtk**
Change the opacity of the model from **1.0** to **0.0**.
The model of the skull bone and eyeballs become visible through the model of the skin in the 3D viewer.

(skin model opacity = 0.5)
The model of the skin becomes invisible in the 3D viewer.

(skin model opacity = 0.0)
(skull model opacity = 1.0)
Click on the **Slice Visibility icon** in the **Green Slice Viewer** to display the Coronal Slice in the 3D Viewer.
Slicer4 Minute Tutorial: 3D Visualization

The Axial and Coronal Slices are displayed in the 3D Viewer.
Select the 3D model `skull_bone.vtk` in the Model Hierarchy and turn on the Clipping option.
Browse through the **coronal slices** to expose the 3D model of the **white matter**, and the left and right **optic nerves**.
Now make the skull invisible.
Scroll the **Coronal Slices** to display the hemispheric white matter model in the context of the image data in the 3D Viewer.
Select the hemispheric white matter model called `hemispheric_white_matter.vtk`

Turn off its visibility.
Slicer displays the **optic nerve**, **optic chiasm** and **optic tracts** overlaid on the **MR images** of the brain.
Windows/Linux users: Position the mouse in the 3D Viewer, hold down the right mouse button and move the mouse down to zoom in.

Mac users: Position the mouse in the 3D Viewer, hold down the apple button and the mouse button and move the mouse down to zoom in (or use two fingers on the touchpad).
Slicer displays a closer view of 3D anatomical structures overlaid on 2D MR slices.
Close the existing scene and all its data

Select **File->Close Scene**

This removes any dataset previously loaded into Slicer.

Select **File-> Exit** to exit the software
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Part II:

Interactive 3D Visualization of the segments of the liver
Anatomy of the liver

- Right posterior section
- Right anterior section
- Left medial section
- Left lateral section

- Right hepatic vein
- Middle hepatic vein
- Left hepatic vein
- Umbilical vein (remnant)
- Inferior vena cava
- Hepatic artery
- Portal vein
- Gall bladder
- Bile duct
- Hepatic duct
- Cystic duct
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
- IVC
- Right portal vein
- Right hepatic vein
Re-start Slicer, and click on the **Load Data** icon
Loading the Liver Scene

Browse to the directory

C:\Pujol2012\3Dvisualization_Tuesday_Nov27_2012

Select the directory dataset3_CTR-Liver

Select the file LiverSegments_Scene.mrml

Click on OK to load the scene into Slicer
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 V
- Segment VII
- Segment VIII
- Segment IVb
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
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
3D Exploration of Liver Segments

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?
3D Exploration of Liver Segments

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
Select **File → Exit** to close the Liver Scene and exit Slicer.
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 select **Load Data** in the **Welcome to Slicer** module.
Loading the Lung Scene

Click on Choose Files and browse to the directory
C:\Pujol2012\3DVisualization_Tuesday_Nov27_2012

Select the subdirectory dataset4_CT-Chest
Select the file LungSegment_Scene.mrml
Click on Open
Click on OK to load the scene in Slicer
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
Acknowledgments

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

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

Marianna Jakab, Surgical Planning Laboratory, Brigham and Women’s Hospital
3DSlicer website
The NIH/NCI Cancer Imaging Archive (TCIA): A Comprehensive Source of DICOM Imaging Data for Research

C. Carl Jaffe MD, John B. Freymann BS, Justin Kirby, Fred William Prior, PhD, Lawrence R. Tarbox PhD

Wed. Nov. 28, 10:30 am – 12:00 pm SCD 401
Upcoming Slicer courses

SPIE 2013, Orlando, Florida
Cars 2013, Heidelberg, Germany
Upcoming Slicer courses

ECR 2013
Novel technology that shapes Radiology: EIBIR presents IMAGINE

The IMAGINE sessions give research institutes, university groups and companies a chance to present their novel technological developments in medical image analysis and image-guided interventions to the radiology community.

Be part of it! Submit your abstract to be in with a chance to present it to the right audience.

The core of the IMAGINE sessions are interactive sessions in which the presenters demonstrate their work and visitors get hands-on experience with developed techniques and tools.

The session topics will describe novel techniques in one of the following areas:

- Quantitative Image Analysis
- Computer-aided Diagnosis
- Image-guided Interventions
- Image Processing
www.slicer.org
www.na-mic.org

Questions and comments: spujol@bwh.harvard.edu