3D Slicer Tutorial

January 2017
What is 3D Slicer?

Slicer is an open-source software for segmentation, registration and visualization of medical imaging data.

The platform is developed through a multi-institution effort of several NIH funded large-scale consortia.

Slicer is for medical research only, and is not FDA approved.
3D Slicer contains over 100 modules for segmentation, registration and 3D visualization of medical imaging data.
Supported Platforms

Slicer is multi-platform software developed and maintained on Mac OS X, Linux 64&32, and Windows 64.

Slicer requires a minimum of 2GB of RAM and a dedicated graphic accelerator with 64 MB of on-board graphic memory.
The Welcome module is the default start-up module.
Each module of Slicer includes a series of tabs, which give access to different functionalities.

Click on the arrow symbol to display the content of each tab.
The Main Window tab contains information on the basic organization of Slicer’s user interface.
The Documentation & Tutorial tab contains links to the Slicer4 training compendium and documentation.
Documentation/4.5

Where to start?
- Training pages
- Information on how to use Slicer 4.5
- FAQ
- Set of common questions/answers
- Users mailing list / Sign-up / Browse archives

How to
- Report a problem / Create a feature request

Slicer Application
- Main Application GUI
- Settings
- Extensions Manager
- Mouse Buttons, "Hot-keys" and Keyboard Shortcuts
- Recommended Computer Configurations
- Loading or Saving data and listing of supported data formats.
- Slicer LookUp Tables
- Setting up and using stereoscopic viewing
- QRTesting - Easy way to record and play macros

Modules and Extensions
- Modules by category
- Modules by name
- Modules by contributing organization
- Modules by contributing individual
- Modules by type
- Modules by extension
- Extensions by category
- Extensions by name
- Extensions by contributing organization
- Extensions by contributing individual

List of extensions known to be broken

Developers Corner
- Information for Software Developers
- Source code, contribute patch, develop modules
- Developers mailing list / Browse archives
- Intended for discussion of programming related questions

Miscellaneous
- Documentation guidelines
- Slicer user documentation principle and guidelines
- Visual blog
- Set of screenshots showing Slicer in action.
- Release Notes
- Platform specific issues and considerations
- Announcements & Acknowledgments
- Registration Library
- Real-life example cases of using the Slicer registration tools, incl. datasets and step-by-step instructions to follow and try yourself.

Documentación en Español
- Introducción a 3D Slicer en Español
- Breve descripción de proyecto y un breve viaje por sus principales herramientas y funcionalidades.
- Reconstrucciones volumétricas con 3D Slicer
- Guía de uso para la herramienta de creación de reconstrucciones volumétricas de 3D Slicer.
- Crear modelos/contornos de órganos con 3D Slicer
- Guía rápida introducción para la creación de contornos de órganos para generar vistas volumétricas.
- Endoscopias virtuales con 3D Slicer

Silicér Ammune Tutorial
The Welcome module panel contains shortcuts for loading different types of data. A series of sample data are also available.

Click on Download Sample Data to access the Sample Data Module.
The Sample Data module contains links to 12 different sample datasets that can be downloaded into Slicer.
Click on the link icon to link all three 2D viewers, and on the eye icon next to it to display the slices in the 3D viewer.
Click on the tab Mouse & Keyboard to learn the different mouse actions to rotate the images and zoom in and out.
Loading data and 3D visualization
Loading Data
Slicer automatically opens the ‘Add data into the scene’ window.

Browse to the location of the MR dataset `MR-head.nrrd` on your disk.

Drag and drop it into Slicer.

Click on **OK** to load the dataset into Slicer.
The axial, sagittal and coronal views appear in the 2D viewers.
Click on the **Slicer layout icon**
Click on the **Red slice only** option.
Position your mouse over the **pin icon** to display the slice viewer toolbar.
Once the slice viewer toolbar is displayed, click on the “>>”
This menu will appear once the ">>" button is pressed
Click on the **Lightbox** menu and chose the option "**6x6 view**"
Slicer displays 36 consecutive images of the dicom volume. Use the red slice slider to browse through the data.
Click on the Slicer layout icon and select Conventional.
Position your arrow again on the **pin icon** of the red viewer, select the **Lightbox** menu and change it back to **“1x1 view”**.
Position your arrow again on the **pin icon** of the red viewer and click on the links icon to link all three viewers.
Once the icons are linked, click on the **eye icon** to display all 3 anatomical slices in the 3D viewer.
All three anatomical slices are shown in the 3D viewer.
3D Visualization
Drag and drop the file ‘3DHeadScene.mrml’ into Slicer
A 3D surface model of the head, and 2D anatomical slices appear in the Slicer Viewer.
Select the **Modules** menu and select **Models**
The list of 3D scenes appear in the Models panel.
Position the cursor over the **pin icon** to reveal the slice menu and click on the **eye icon** to reveal the axial slice.
Notice the axial slice through the 3D model of the head

Once the axial slice is displayed in the 3D viewer, click on **Skin** in the list of 3D scenes.
Scroll down the **Models** tabs and locate the "**Color**" tab. Lower the **Opacity** to a transparent level, around .30.
Notice the skin has become almost fully transparent.
Scroll back up to the 3D scenes menu and select **skull_bone**
Turn off its visibility by unchecking the **Visibility** option and notice the bone disappearing from the 3D view of the head.
Position your mouse over the **pin icon** in the coronal slice view and select the **eye icon** to reveal the coronal slice in the 3D view.
The coronal slice is shown in the 3D viewer.
Scroll up and select the 3D scene **hemispheric_white_matter**, then check off the option for **Clip** under the **Visibility** tab.
Scroll down and find the tab **Clipping**, and check off the options for **Green Slice Clipping** and **Negative Space**.
The optic chiasm appears in the 3D viewer.
Scroll up and uncheck the option for **Clip** and lower the **Opacity** of **hemispheric_white_matter**.
Image Registration Slicer3d tutorial
Image Registration

• Spatial transform that maps points from one image to corresponding points in another image

Fig credit: http://depts.washington.edu/bicg/documents/MII_registration10.pdf
Applications

- **Diagnosis**
  - Combining information from multiple imaging modalities

- **Studying disease progression**
  - Monitoring changes in size, shape, position or image intensity over time

- **Image guided surgery or radiotherapy**
  - Relating pre-operative images and surgical plans to the physical reality of the patient

- **Patient comparison or atlas construction**
  - Relating one individual’s anatomy to a standardized atlas

Deformation Models

Method used to find the transformation

- **Rigid & affine**
  - Landmark based
  - Edge based
  - Voxel intensity based
  - Information theory based

- **Non-rigid**
  - Registration using basis functions
  - Registration using splines
  - Physics based
    - Elastic, Fluid, Optical flow, etc.
Parameters

1. **Input Images:**
   a. **Percentage of Samples:** Fraction of voxels of reference image that will be used
   b. **B-Spline grid size:** subdivisions along each axis

2. **Output Settings:**
   a. **Linear Transform:** Set if not B-spline
   b. **BSpline Transform:** Set if BSpline

3. **Transform Initialization Settings:**
   Based on the assumed similarity of structures - moments, center of head (top through neck), etc.

4. **Registration Phases:**
   a. **Rigid, Rigid+Scale, Rigid+Scale+Skew:** Combination of Rotation, Translation, Scale and Skew
   b. **Affine:** Rotation, Translation, Scale, Skew and Shear
   c. **B spline**
   d. **SyN:** Symmetric Normalization, is a diffeomorphic registration method
1. **Image Mask and Pre-Processing**
   a. **Masking input fixed:** Define the area not important for registration
   b. **Masking image moving:** Same but for target image
   c. **ROI AUTO:** Computed automatically for each image option if ROI AUTO is selected
   d. **Histogram Match:** To improve similarity between images
   e. **Median Filter Size:** To reduce noise
   f. **Remove intensity outliers value at one tail:** Eliminate very high or low intensity voxels

2. **Advanced Output Settings**
   a. **Fixed/Moving Image Volume 2:** Used for multimodal image registration
   b. **Background Fill value:** Value for areas with no correspondence
   c. **Interpolation Mode:** Type of interpolation to be used
Rigid and Affine

- Rotations
- Translations
- Skew
- Scaling
- Shear

Fig credit: http://slideplayer.com/slide/6242051/
Non-Rigid

• Registration using basis functions
• Registration using splines
• Physics based:
  • Elastic, Fluid, Optical Flow, etc
• Why?

• Patients move (*alignment of temporal series*)
• Patients change (*pre- / post-treatment images*)
• Patients differ (*creation of atlases*)

Fixed Image: MNI Template
Moving Image: T1 image
Set Percentage of Samples 0.2
Grid-size : 3x3x3
Select Bspline Transform

Select Bspline
### Alternative/Specialized Registration Modules

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fiducial Registration</strong></td>
<td>Aligns images based on pairs of manually selected fiducial points (rigid and affine). Two sets of fiducials (fiducial lists) are required, forming matching pairs to be aligned. This module is in the <strong>Registration/Specialized/Fiducial Registration</strong> menu.</td>
</tr>
<tr>
<td><strong>ACPC Transform</strong></td>
<td>Used to orient brain images along predefined anatomical landmarks: (manually defined) fiducials for the inter-hemispherical midline, anterior- and posterior commissure are used to align an image such that these landmarks become vertical and horizontal, respectively. This module is in the <strong>Registration/Specialized/ACPC Transform</strong> menu.</td>
</tr>
<tr>
<td><strong>BRAINS DemonWarp</strong></td>
<td>Performs automated image warping based on an optic flow mechanism. Deformations are significantly more “fluid” (i.e., have more DOF and are less constrained) than for the nonrigid BSpline method provided in the general (BRAINS) registration above. This module is in the <strong>Registration/Specialized/Demon Registration (BRAINS)</strong> menu.</td>
</tr>
<tr>
<td><strong>Rigid+Affine</strong></td>
<td>Performs rigid, affine, and nonrigid registration, based on image intensity similarities. Same basic functionality as BRAINSfit, with a few differences: choice of similarity function, 1 mask image required only for masking (BRAINSfit requires 2 masks), and initialization via landmarks. This module is in the <strong>All Modules</strong> menu.</td>
</tr>
<tr>
<td><strong>Robust Multiresolution Affine Registration</strong></td>
<td>Performs robust automated affine image registration employing a multi-resolution scheme. This was designed for robustness rather than speed. It can be particularly useful when direct approaches fail, e.g., due to lack of overlap or a lot of “distracting” image content. This module is in the <strong>All Modules</strong> menu.</td>
</tr>
</tbody>
</table>
Select landmarks for fixed image
Tutorial for Segmentation in 3D Slicer
Image Segmentation

- Image segmentation is the process of partitioning a digital image into multiple segments
Image Segmentation

- Image segmentation is the process of partitioning a digital image into multiple segments
Application:

- Segment tissues and body organs
- Heart segmentation and analysis of cardiac images
- Surgical planning
- Simulation of surgeries
- Tumor detection and segmentation
- Brain development study
- Functional mapping
- Blood cells automated classification
- Mass detection in mammograms
Image Segmentation methods:

1. Thresholding
2. Region Growing
3. Graph Cut
4. Atlas-based method
5. ....
Simple Region Growing
Region Growing method:

(a) Start of Growing a Region

(b) Growing Process After a Few Iterations
Module Description

- A simple region growing segmentation algorithm based on intensity statistics.
- To create a list of fiducials (Seeds) for this algorithm, click on the tool bar icon of an arrow pointing to a starburst fiducial to enter the 'place a new object mode' and then use the fiducials module.

Slicer Toolbar
Use Cases:

- This module can be used to obtain a volumetric segmentation of a region of interest
  - Example volumetric segmentation of a tumor given a set of fiducial points selected on the tumor
  - This module is useful for obtaining a 2-class segmentation
  - The fiducials are placed on parts of the image that correspond to the target (foreground)
  - The segmentation can be refined by modifying the number of iterations, the multiplier, and the neighborhood radius options available on the user interface panel
  - Additionally, the user may also place additional fiducials on the image

User input in the form of fiducials

Segmentation result: Multiplier=2.5, Neighborhood radius=1, Number of Iterations=5
Panels and their use

- **Smoothing iterations**: Number of smoothing iterations
- **Timestep**: Timestep for curvature flow

**Segmentation Parameters**

- **Number of iterations**: Number of iterations of region growing
- **Multiplier**: Number of standard deviations to include in intensity model
- **Neighborhood Radius**: The radius of the neighborhood over which to calculate intensity model
- **Output Label Value**: The integer value (0-255) to use for the segmentation results.
- **Seeds**: Seed point(s) for region growing

**IO**
Fast GrowCut module
Graph Cut:

• Seek division of image into foreground and background.
• Turn image into graph, each pixel connected to neighbors and special source (foreground) and sink (background nodes).
• A cut of the graph divides it into foreground and background
Module Description:

- This module is a fast version of the GrowCut method.
- It is a powerful algorithm that uses example segmentation to create a full segmentation of the volume.
- Multiple label colors can be used to define regions that represent parts of anatomical structures.
- The algorithm will seek out the best labeling for an adjacent pixel to match your example.
Overview:

1. Install Fast GrowCut Effect extension
2. Load Sample Data
3. Start Fast GrowCut
4. Turn On All Slice Views in the 3D Viewer
5. Draw Seed Regions
6. Corrections
1. Install Fast GrowCut Effect Extension

1. Open the Extension Manager from the toolbar
2. Find the Fast Grow Cut Effect module and click install
3. Once installed, restart Slicer
2. Load Sample Data

1. Select ‘Download Sample Data’ from the Welcome panel

2. Select MRBrainTumor1

3. Select the Editor module from the drop down menu

4. Click ‘OK’ on the Color Table pop-up window
3. Start Fast GrowCut
4. Turn On All 3 Slicer Views in the 3D Viewer
5. Draw Seed Regions

Use the Paint Effect to draw seed regions. Use Label 1 for the foreground and Label 2 as the background. It is important that no part of the scribble you make within the mass (Label 1) includes the outside region and vice versa. The algorithm is sensitive to seeding and will not be forgiving of an outlier.

When finished, press 'G' to run Fast GrowCut.
6. Corrections

• If you are not satisfied, press ‘S’ to toggle between seed image and the segmentation result
• Edit on the seed image to reduce over/under segmentations
• When you are finished editing on the seed image, press ‘G’ to run Fast GrowCut again
• The steps on this slide may be repeated until you are satisfied with your segmentation
LA Scar Segmenter
Module Description

- This module performs the segmentation of the left atrial scarring tissue from MR images.
- Assume that the endocardium of the left atrium is provided. The module starts with searching for the left atrial wall.
- Then, the scarring tissue is extracted by looking for brighter voxels inside the wall.
- This module is specifically designed for the segmentation of the left atrial scars from MR images.
1. Load source image
2. Load endocardium label image

- Pulmonary veins need to be excluded from this label image
3. Select Segmentation->Left Atrial Segmentation module

4. Choose the source and label image. Create/select an output image.

5. Press the Apply button
Panels and their use