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# **Dose accumulation for adaptive radiation therapy**

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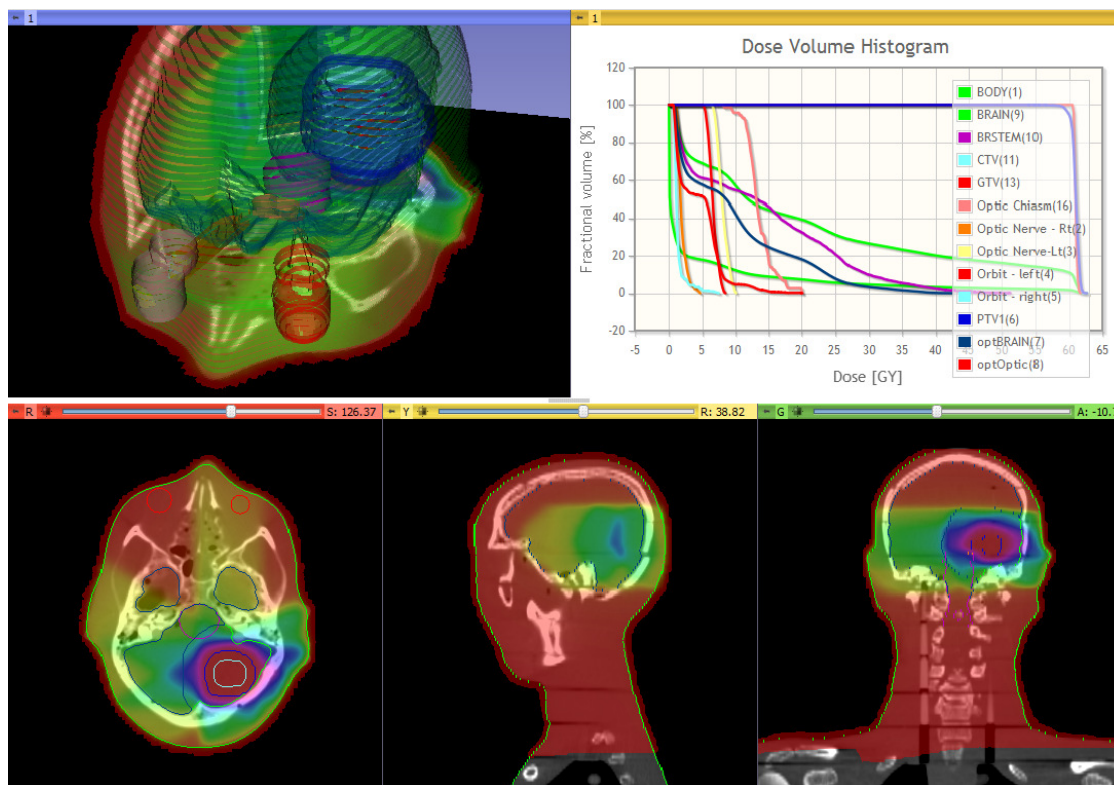
NA-MIC Tutorial Contest: Summer 2012

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# Learning Objective

This tutorial demonstrates how to perform dose accumulation for adaptive radiation therapy





# Pre-requisite

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This tutorial assumes that you have completed the following tutorial:

Data Loading and 3D Visualization

Sonia Pujol

[http://www.slicer.org/slicerWiki/index.php/Documentation/4.1/Training#Slicer4\\_Data\\_Loading\\_and\\_3D\\_Visualization](http://www.slicer.org/slicerWiki/index.php/Documentation/4.1/Training#Slicer4_Data_Loading_and_3D_Visualization)



# Material

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This tutorial requires the installation of the Slicer 4.1 with RT extension 0.3 release and the tutorial dataset. They are available at the following locations:

**Slicer4.1 RT extension 0.3** download page:

<https://www.assembla.com/spaces/slicerrt/wiki/Download>

**Tutorial dataset:**

<https://www.assembla.com/spaces/slicerrt/documents/bMuuwgYTKur4yP-acwqjQWU/download/bMuuwgYTKur4yP-acwqjQWU>

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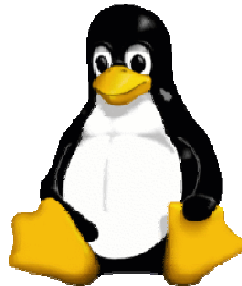


# Platforms

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Currently only tested  
on Windows Platform



Work in progress ...



# Overview

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- Part 1: Loading and visualization
- Part 2: Rigid registration
- Part 3: B-spline deformable registration
- Part 4: Dose accumulation
- Part 5: DVH comparison



# Overview

- Part 1: Loading and visualization
- Part 2: Rigid registration
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- Part 5: DVH comparison



# Loading DICOM-RT data

1. Start 3D Slicer

2. Click "Load DICOM Data"





# Loading DICOM-RT data

1. Click "Import"

2. Select DICOM directory "Original" from the tutorial data

The screenshot shows the 3D Slicer 4.1.0 interface. The 'DICOM Details' window is open, showing an 'Import' button highlighted with a red box. A blue arrow points from this button to the 'Original' directory in the 'Import DICOM files from directory...' dialog. The dialog shows a file list with 'Original' selected and highlighted with a red box. Other files in the list include 'ENT DSA Screen Shot.jpg', 'ENT Screen Shot.jpg', and 'readme.txt'. The 'Directory' field in the dialog is set to 'Original'. The 'Files of type' dropdown is set to 'Directories'. The 'Import' button is visible at the bottom right of the dialog.



# Loading DICOM-RT data

1. Select "CT: ENT IMRT"

2. Inspect RT objects to be loaded

3. Click "Load Selection to Slicer"

The screenshot shows the 3D Slicer 4.1.0 interface. The DICOM Details dialog box is open, displaying a table of DICOM objects. The table has columns for Name, Age, Scan, Date, Subject ID, Number, Institution, and Referrer. The selected row is 'CT: ENT IMRT' with a Number of 1. Below the table is a list of RT objects with checkboxes. The checked items are '3: RTSTRUCT: ENT', '4: RTPLAN: BRAI1', '5: RTDOSE', and '2: ENT IMRT'. At the bottom of the dialog box, the 'Load Selection to Slicer' button is highlighted. The background shows the 3D Slicer main window with the DICOM browser on the left and the 3D view on the right.

| Name         | Age | Scan | Date       | Subject ID | Number | Institution | Referrer |
|--------------|-----|------|------------|------------|--------|-------------|----------|
| RTSTRUCT     |     |      | 2011-09-22 |            | 0      |             |          |
| RTPLAN       |     |      | 2011-09-22 |            | 0      |             |          |
| RTIMAGE      |     |      | 2011-09-22 |            | 0      |             |          |
| RTDOSE       |     |      | 2011-09-22 |            | 0      |             |          |
| CT: ENT IMRT |     |      | 2011-09-20 |            | 1      |             |          |

| RT Object  | Reader        | Warnings   |
|--|---------------|--|
| <input checked="" type="checkbox"/> 3: RTSTRUCT: ENT           | RT            |  |
| <input checked="" type="checkbox"/> 4: RTPLAN: BRAI1           | RT            |  |
| <input checked="" type="checkbox"/> 5: RTDOSE                  | RT            |  |
| <input checked="" type="checkbox"/> 2: ENT IMRT                | Generic DICOM |  |
| <input type="checkbox"/> 2: ENT IMRT for ContentTime of 085845 | Generic DICOM | Images are not equally spaced (a difference of 20 in spacings was detected). Slicer will load this series as |
| <input type="checkbox"/> 2: ENT IMRT for ContentTime of 085844 | Generic DICOM | Images are not equally spaced (a difference of 15 in spacings was detected). Slicer will load this series as |
| <input type="checkbox"/> 2: ENT IMRT for ContentTime of 085846 | Generic DICOM | Images are not equally spaced (a difference of 17.5 spacings was detected). Slicer will load this series as  |
| <input type="checkbox"/> 2: ENT IMRT for ContentTime of 085833 | Generic DICOM | Images are not equally spaced (a difference of 15 in spacings was detected). Slicer will load this series as |
| <input type="checkbox"/> 2: ENT IMRT for ContentTime of 085843 | Generic DICOM | Images are not equally spaced (a difference of 15 in spacings was detected). Slicer will load this series as |



# Loading DICOM-RT data

1. Select "Data" module

2. Select "CT: ENT IMRT", Right click "Rename"  
Change name to "Day1\_CT",  
Select "5: RTDOSE", Right click "Rename",  
Change name to "Day1\_dose"

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6/11/2012



# Visualization of DICOM-RT data

1. Select "Volume" module

2. Select "Day1\_CT" first, "Day1\_dose" next

3. Change color map and window/level

4. Select "Day1\_CT" as background "Day1\_dose" as foreground, Change "Day1\_dose" opacity to 0.5



# Visualization of DICOM-RT data

3D Slicer 4.1.0

File Edit View Help

Modules: **Data**

1. Select "Data" module

2. Right click "3:RTSTRUCT: ENT - all structures" then click "Edit property ..."

3:RTSTRUCT: ENT - all structures

- BRAIN
- BRSTEM
- CTV
- Dose 5200[cGy]
- GTV
- Lens - left
- Lens - right
- Optic Chiasm
- Optic Nerve - Rt
- Optic Nerve-Lt
- Orbit - left
- Orbit - right
- PTV1
- optBRAIN
- optOptic

Scene Model: Transform

Filter:

MRML Node Inspector

Load & Add Scenes Or Individual Datasets

Data Probe

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6/14/2012



# Visualization of DICOM-RT data

1. Select "Body" to edit property

2. Click on the opacity number, Use slider to change opacity

3. Visualize Inner ROIs

3D Slicer 4.1.0

File Edit View Help

Modules: Models

3DSlicer

Help & Acknowledgement

Scene

- Body
- BRAIN
- BRGTEM
- CTV
- Dose 5200[Gy]
- GTV
- Lens - left
- Lens - right
- Optic Chiasm
- Optic Nerve - Rt
- Optic Nerve-Lt
- Orbit - left
- Orbit - right

0.30

R P A

R: 1.22 G A: 4.30

S: 136.37 Y

L F B

Data Probe

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# Loading Day2 data

1. Select "Add volume" from "File" menu

2. Select "Day2\_CT.nrrd" to load

3. Click "Open"



# Visualizing deformation

1. Select "Volume" module

2. Select "Day1\_CT" first  
"Day2\_CT" next

3. Change color map  
and window/level

4. Select "Day1\_CT" as background  
"Day2\_CT" as foreground, change its opacity to 0.5





# Loading Mask volume

The screenshot shows the 3D Slicer 4.1.0 interface. The 'File' menu is highlighted in the top-left corner. A blue callout box with a yellow border points to the 'File' menu with the text: "1. Select 'Add volume' from 'File' menu". An 'Open' dialog box is open in the center, showing a file list. A blue callout box with a yellow border points to the 'MaskVolume.nrrd' file in the list with the text: "2. Select 'MaskVolume.nrrd' to load". Another blue callout box with a yellow border points to the 'Open' button in the dialog box with the text: "3. Click 'Open'". The 3D view on the right shows a green and red mask volume overlaid on a CT scan of a human head. The Windows taskbar at the bottom shows the time as 4:03 PM on 6/11/2012.



# Loading Mask Volume

3D Slicer 4.1.0

File Edit View Help

Modules: Data

3DSlicer

Help & Acknowledgement

Display & Modify Scene

Nodes

- Scene
  - View
  - Default Scene Camera
  - Day1\_CT
  - Day1\_dose
  - BODY
  - 3: RTSTRUCT: ENT - all structures
  - BRAIN
  - BRSTEM
  - CTV
  - Dose 5200[Gy]
  - GTV
  - Lens - left
  - Lens - right
  - Optic Chiasm
  - Optic Nerve - Rt
  - Optic Nerve-Lt
  - Orbit - left
  - Orbit - right
  - PTV1
  - optBRAIN
  - optOptic
  - Day2\_CT
  - Day2\_CT\_rigid
  - MaskVolume

Scene Model: Transform

Filter:

MRML Node Inspector

Load & Add Scenes Or Individual Datasets

Data Probe

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4:04 PM  
6/11/2012

1. Right click "MaskVolume" and select "Edit property ..."



# Visualizing Mask Volume

1. Check "LabelMap" option

2. Select "MaskVolume" as LabelMap layer, Change opacity to 0.5



# Overview

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- Part1: Loading and visualization
- **Part2: Rigid registration**
- Part3: B-spline deformable registration
- Part4: Dose accumulation
- Part5: DVH comparison



# Rigid registration

1. Select "General Registration (BRAINS)" module

2. Set Fixed and Moving images To "Day1\_CT" and "Day2\_CT"

3. Set Linear Transform to "Day2\_rigid\_xfm" and Output Image to "Day2\_CT\_rigid"

4. Select "Rigid(6 DOF)" option

5. Select "MaskVolume" as Masks

6. Click "Apply"



# Resample dose map

1. Select "Resample" module

2. Set Image To Warp to "Day2\_dose"  
Reference Image "Day1\_dose"

3. Set Output Image to  
"Day2\_dose\_rigid"

4. Set Warp by Transform  
to "Day2\_rigid\_xfm"

5. Click "Apply"



# Overview

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- Part1: Loading and visualization
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# Deformable Registration

1. Select "General Registration (BRAINS)" module

2. Set Fixed and Moving Images to "Day1\_CT" and "Day2\_CT"

3. Set BSpline Transform to "Day2\_bspline\_xfm" and Output Image to "Day2\_CT\_bspline"

4. Select "Rigid" and "BSpline" option

5. Select "MaskVolume" as Masks

6. Click "Apply"





# Resample dose (BSpline)

1. Select "Resample" module

2. Set Image To Warp to "Day2\_dose"  
Reference Image to "Day1\_dose"

3. Set Output Image  
"Day2\_dose\_rigid"

4. Set Warp by Transform  
to "Day2\_rigid\_xfm"

5. Click "Apply"



# Overview

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- Part1: Loading and visualization
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# Dose Accumulation

3D Slicer 4.1.0

File Edit View Help

Modules: Volumes

All Modules

- Annotations
- DICOM
- Data
- Editor
- Models
- OpenIGTLinkIF
- Scene Views
- Transforms
- View Controllers
- Volume Rendering
- Volumes
- Welcome to Slicer

Radiotherapy

- Dose Accumulation**
- Dose Volume Histogram

Wizards

- Informatics
- Registration
- Segmentation
- Quantification
- Diffusion
- IGT
- Filtering
- Surface Models
- Converters
- Endoscopy
- Utilities
- Developer Tools
- Legacy
- Testing
- Work in Progress

Active Volume | Day2\_dose\_bspline

Volume Information

Image Dimensions: 176

Image Spacing: 2.5

Image Origin: 219.97169495

Scan Order: Axial IS

Number of Scalars: 1

Scalar Type: float

Scalar Range: Min: -99.88254547

File Name:

LabelMap:

Window/Level Presets:

Display

Lookup Table: Green

Interpolate:

Window Level editor presets:

W: 62 Auto W/L L: 31

Threshold: Off

0.00 62.23

► Histogram

Data Probe

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6/13/2012



# Dose accumulation (rigid)

1. Check off "Show dose volume only"

| Volume  | Weight |
|---|--------|
| <input type="checkbox"/> Day1_CT                    | 1.00   |
| <input checked="" type="checkbox"/> Day1_dose       | 0.5    |
| <input type="checkbox"/> Day2_CT                    | 1.00   |
| <input type="checkbox"/> Day2_dose                  | 1.00   |
| <input type="checkbox"/> MaskVolume                 | 1.00   |
| <input checked="" type="checkbox"/> Day2_dose_rigid | 0.5    |
| <input type="checkbox"/> Day2_dose_bspline          | 1.00   |
| <input type="checkbox"/> accumulated_dose_rigid     | 1.00   |

2. Check "Day1\_dose". Check "Day2\_dose\_rigid" and change both weights to "0.5"

3. Set Output Volume to "accumulated\_dose\_rigid"

4. Click "Apply"



# Dose accumulation (BSpline)

1. Check off "Show dose volume only"

2. Check "Day1\_dose" and "Day2\_dose\_bspline" and change both weights to "0.5"

| Volume  | Weight |
|---|--------|
| <input type="checkbox"/> Day1_CT                      | 1.00   |
| <input checked="" type="checkbox"/> Day1_dose         | 0.50   |
| <input type="checkbox"/> Day2_CT                      | 1.00   |
| <input type="checkbox"/> Day2_dose                    | 1.00   |
| <input type="checkbox"/> MaskVolume                   | 1.00   |
| <input type="checkbox"/> Day2_dose_rigid              | 1.00   |
| <input checked="" type="checkbox"/> Day2_dose_bspline | 0.5    |
| <input type="checkbox"/> accumulated_dose_rigid       | 1.00   |
| <input type="checkbox"/> accumulated_dose_bspline     | 1.00   |

3. Set Output Volume to "accumulated\_dose\_bspline"

4. Click "Apply"



# Overview

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# DVH comparison

**Select  
“Dose Volume Histogram”  
Module under “Radiotherapy”**

| Volume  | Weight |
|---|--------|
| Day1_CT   | 1.00   |
| <input checked="" type="checkbox"/> Day1_dose       | 0.50   |
| Day2_CT   | 1.00   |
| Day2_dose   | 1.00   |
| MaskVolume  | 1.00   |
| <input checked="" type="checkbox"/> Day2_dose_rigid | 1.00   |
| Day2_dose_bspline                                   | 1.00   |
| accumulated_dose_rigid                              | 1.00   |
| accumulated_dose_bspline                            | 1.00   |

Accumulated dose volume:

Data Probe

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6/13/2012



# DVH comparison

1. Set Dose Volume to “Day1\_dose”, “accumulated\_dose\_rigid”, “accumulated\_dose\_bspline” respectively, set Structure Set to “PTV1”

Input  
Dose Volume: Day2\_dose\_bspline  
Structure Set: PTV1  
Compute DVH

Output  
Chart: Chart

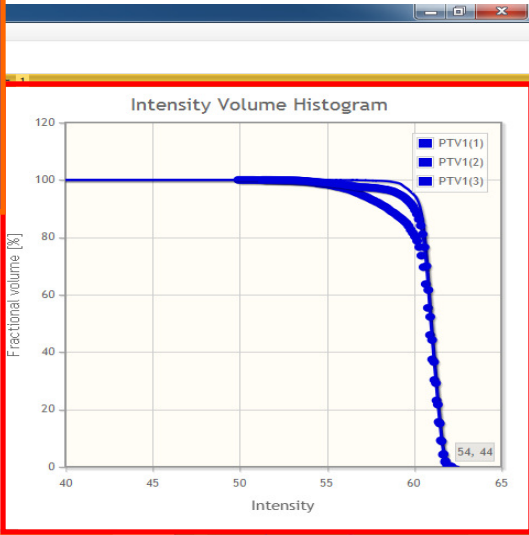
| Structure | Total volume (cc) | Mean dose ((null)) | Min dose ((null)) | Max dose ((null)) | Max do |
|-----------|-------------------|--------------------|-------------------|-------------------|--------|
| 1 PTV1    | 127.016           |                    |                   |                   | 62.612 |
| 2 PTV1    | 127.016           | 60.4116            | 49.9189           | 62.2752           |        |
| 3 PTV1    | 127.016           | 60.7529            | 51.3206           | 62.2347           |        |

Advanced Options  
V Metric for Dose Values: Gy - Show cc - Show %  
D Metric for Volumes: cc - Show Gy  
Export DVH to file... Export DVH metrics to file...

Data Probe

2. Click “Compute DVH”

3. Check boxes to Display DVH curves

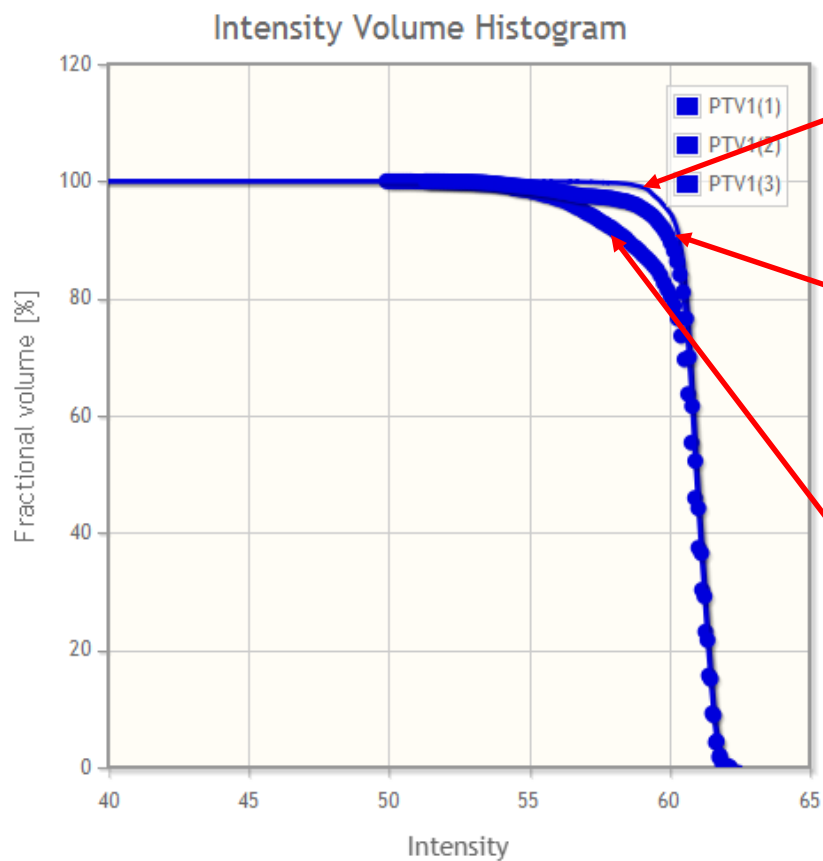


4. DVH curves displayed In Chart Window





# DVH comparison



Prescribed Dose DVH

Accumulated DVH (BSpline)

Accumulated DVH (Rigid)



# Conclusion

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In this tutorial, we have demonstrated:

1. DICOM-RT import
2. RT data visualization
3. Day to day CT/Dose volume registration
4. Dose accumulation
5. DVH computation and comparison



# Acknowledgments

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