Improvements in SlicerRT, the radiation therapy research toolkit for 3D Slicer

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Motivation behind SlicerRT

Commercial treatment planning systems (TPS)
- Expensive
- Closed
- Cover only routine clinical procedures
- Not extensible
- Not flexible

Existing research tools
CERR, PLUNC, dicompyler, etc.
- Inconvenient
- Insufficient user and developer support
- Limited feature set
- Open-source?
- Poor documentation
- Large, non-modular code base
- Unstable

SlicerRT
- Free
- Extensible
- Flexible
- Open-source
- Platform-independent
- Well documented
- User-friendly
- Stable

Open-source?
DICOM-RT import/export

- Import integrated into core DICOM import plugin mechanism
- Supported data types:
  - RT structure sets → Contours → Fiducial point
  - RT dose map
  - RT image
  - RT plan isocenter, beams
  - Planning CT, MR, etc.
- Basic DICOM-RT export is implemented

Standard layout after loading phantom dataset
Contour analysis

- Multiple representations (automatic conversion)
  - Ribbon model
  - Rasterized volume
  - Closed surface model
- Contour comparison
  - Dice coefficient
  - Hausdorff distance
- Contour morphology
  - Expand, shrink
  - Combine using logical operators
Dose analysis

- Dose volume histogram (plot visualization + metrics)
- Dose accumulation
- Dose comparison (gamma)
- Isodose contours / surfaces
- External beam planning (photon, proton)
- Registration
  - BSpline registration
  - Landwarp registration
External beam planning

This module provides a basic framework for RT planning and dose calculation for photon and proton beams.

Photon MLC beam created in external beam planning module.
External beam planning - proton

External beam planning module UI

Aperture

Range compensator

Target

Beam dose distribution
Subject hierarchy

New concept for organizing data

- Nice and intuitive way of organizing and handling data
  Bring basic features in a data-centered tree view, such as
  - Show/hide
  - Transform branch

- Extendable through plugins
  Broad API allowing many customizations, such as
  - DICOM export
  - Registration
Subject hierarchy - plugins

- Default
- DICOM
- Volumes
- Registration
- Parse local data
- Contours
- RT objects
- Many more to come ...

ParseLocalData plugin in action
Non-linear transform support

- Transforms are applicable in “real-time” to
  - Volumes (slice views, slice view in 3D)
  - Models (3D view, slice intersection)
  - Markup points, ruler

- Transform types
  - Linear
  - B-spline: arbitrary grid orientation, optional bulk transform
  - Grid (displacement field): arbitrary grid orientation

- Operations
  - Display
  - Invert
  - Combine

- Limitations
  - Volume rendering, processing in CLI modules: not real-time, need to harden transform
  - Composite transform cannot be saved
  - Annotation ROI transform is limited
  - Not possible to define a “reference” volume when hardening a transform
Transform info

Transform to parent:
- Computed by inverting transform from parent.

Transform from parent:
- Displacement field:
  - Grid size: 94 x 64 x 28
  - Grid origin: 119.531, 119.531, -77.7
  - Grid spacing: 3.75, 3.75, 5.5
  - Grid orientation:
    - -1, 0, 0
    - 0, -1, 0
    - 0, 0, 1

Displacement vector RAS: (12.1, -0.1, -2.5)

Edit
- Identity
- Invert

Display

Apply transform

Data Probe
Transform display
Transform display
Gel dosimetry analysis

- “Slicelet” for gel dosimetry analysis workflow
- Wizard-like simplified user interface
SlicerRT extension for 3D Slicer

- Collection of RT-specific modules, includes Plaslimatch
- Distributed as a 3D Slicer extension: can be downloaded, installed, upgraded using the extension manager in Slicer

SlicerRT extension in the 3D Slicer app store (free)
Next steps

Planned for the next 6 months:

• DICOM-RT export
• External beam planning
• Contour mechanism – integration to 3D Slicer core
• Digitally reconstructed radiograph (DRR)
• Rasterization evaluation and improvements
• Scripting examples
• More testing and validation

More information: http://SlicerRT.org
Thank you for your attention!