Dynamic management of segmented structures in 3D Slicer

Csaba Pinter, Andras Lasso, and Gabor Fichtinger

Laboratory for Percutaneous Surgery, School of Computing, Queen’s University, Kingston, ON, Canada
Segmentation

- Also known as contouring
- Delineates structures of interest
  - Manual contouring: Slice by slice
  - Automatic / semi-automatic
- Omnipresent in medical imaging
  - Surgical/radiation therapy planning
  - Intra-surgery navigation
  - Volume/shape analysis
  - 3D printing (interventions)
  - Education
Various representations

• Each optimal for
  • *either* storage (A)
  • *or* analysis (C)
  • *or* visualization (B,D)

• Imposed needs
  • Conversion
  • Simultaneous
    – Visualization
    – Transformation

Typical representations:
A: Contours, B: Surface, C: Image, D: Ribbons
Difficulty #1: Operation

• Operation
  – User needs to be aware of the need for conversion, and also
  – How to perform it

Analysis?
• Volume
• Surface area
• Dose volume histogram
• Dice coefficient
• ...

Analysis ✓
Difficulty #2: Identity

• Operation

• Identity
  – Need to keep track of where the structures came from and what they represent
Difficulty #3: Validity

• Operation

• Identity

• Validity
  – No invalid data should be accessible at any time
Difficulty #4: Coherence

• Operation

• Identity

• Validity

• Coherence
  – Forming a unified whole

Brain (contour)

Tumor (contour)

Brain (image)

Patient
Segmentation “object”

- 1 segmentation contains N segments (structures)
  - Coherence ✓
- Each segment contains multiple representations
  - Identity ✓
- Provides automatic conversions
  - Operation ✓
Master representation

• “Promoted” representation
• Conversions use it as source
• When changed, the other representations are cleared — And re-converted as needed
• When saving to disk, this representation is written
• Solves Validity ✓
Automatic conversion

• Driven by a dynamic graph
  – Nodes are the representations
  – Edges are the converters
    • Can be dynamically added
    • Can define representations
  – Cost metrics for edges
• Automatic conversion follows cheapest path
  – Happens when an absent representation is requested
Implementation

• Software library SegmentationCore
  – Contains all the listed features
  – Uses only the VTK library
  – Can be integrated in many applications

• Segmentations module in SlicerRT
  – Advanced conversion options
  – Simultaneous real-time transformation
  – Advanced visualization in 2D and 3D
  – Extension of the 3D Slicer platform
Architecture: 36 classes (C++)

- Module and widget
- Displayable managers
- Converter roles
- Subject hierarchy plugins
Example use case: MRI/US fusion
Example use case: Finding most similar RT plan in the cloud

- Initialize daily adaptive RT plan from most similar one
  - By geometrical similarity based on segmentation comparison
- Highly parallel computations
- Very large amount of data
- Self-driven scripts in cloud

Andrea et al., IUPESM World Congress 2015
Future work

• Fractional image representation
  – More efficient storage of structures
  – Enables using stochastic methods

• Integration into 3D Slicer core

• Ontologies support
  – Hierarchical organization of structures
  – Standard ontologies used in clinics
Thank you for your attention!
Segmentations user interface

- Managing segments and their properties
- Advanced display options
- Explicit handling of representations
- Convenient import/export
Difficulties with conversion

• **Operation**: User needs to know that conversion is needed, and how to perform the conversion

• **Identity**: Relationships between converted objects need to be preserved to be able to determine their origin and identity

• **Validity**: When a representation changes, the others need to follow, otherwise invalid data is accessible

• **Coherence**: Structures belonging together must be converted together to contain the same data types