TRD #1: Image and Geometry Processing

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Overview

• Technical updates
• Software updates
• DBP progress
• Future directions
Image Processing

- Some new modules
- Seg3D
Update: Preprocessing for Shape Analysis

• Shapes to smooth distance transforms
  o ITK methods/executables
  o Stand alone (for time being)
Topology Preserving Antialiasing

Segmentation

Blurred/smoothed

MCF + Topology

Han et al., 2003
Subvoxel Distances to Meshes

• Higherarchical, efficient, super-resolution distance computations
  o Indexing: volumes to faces
Seg3D

• End user application for 3D image processing
Seg3D Update

• Added screen capture
• Image registration tool suite from the NCR Toolset to Seg3D as filters (ongoing)
• Software infrastructure
  o Python interfaces to all functionality for batch processing
  o Upgraded to ITK 4
• Documentation:
  o Incorporated Doxygen documentation generating system
  o Added a new manual documenting the tools and filters and a python script tutorial document
Seg3D Update

• Bug fixes: 12
• User problems/questions addressed: 28
• User mailing list: 102
• Literature citations 2013: 25
Leveraging Seg3D

- Tomographic reconstruction (Aribex)
- Oil and gas exploration (ExxonMobil)
  - Graph cut segmentation
  - Machine-learning based feature detection
Seg3D Future

• Continue to adapt to application needs
• Better integration of new modules
• Out of core editing / large volumes
  o Hierarchical data storage and access
  o Level of detail
Multimaterial Meshing

• Goals:
  o Fast
  o Robust and easy to use
  o Quality (element and geometry)
  o Adaptive / efficient
  o Open-source
Meshing Activities

• Papers
  o IMR 2012
  o IEEE TVCG
  o IMR 2013
  o IMR 2014 (in preparation)

• Adaptivity and unstructured meshes

• Software release
  o Cleaver, December 2012
  o API, command line
  o Simple GUI soon
Adaptivity

• Original algorithm: grading away from surface
• Goal: more flexible adaptivity
  o Driven by “user” demand
• Surfaces has elements proportional to “need”
  o Curvature
  o Distance to other surfaces
Sizing Field

- Distance to medial axis
- New, robust set of tools for feature size (Shankar Sastry)

1. PDE from boundary for distance transform
   - C1 discontinuities -> medial axis
2. PDE from MA to boundary gives feature size
3. Gradient-limited field (PDE) from surface to volume
Adaptivity Example
Adaptivity Example
Adaptivity Example
Unstructured vs Structured Background Lattices

- Easy to generate
- Predictable angles
- Diatic/limited adaptivity
- Anisotropic artifacts

- Harder to generate
- Angles variable
- Flexible adaptivity
- Isotropic as needed
Forming Adaptive Background Grids

• Point distributions
  o Adaptive, regular

• Particle systems
  o Potential fields and controlling spacing

• Solution
  o Charge distributions with an adaptive background charge
  o Knutsson and Westin, MICCAI 2013
Background Potential and Particle Density

• Target density -> potential field -> particle distributions
Unstructured Background Lattice
Cleaver Software

• Cleaver released open source
  o API, command line, user interface
• Cleaver 2 developed, debugged, ready for release
  o Diadic adaptivity and refinement
  o Release date under discussion
Cleaver + Slicer

- ITK/CLI Slicer module developed and tested
  - Output meshes to file
- GitHub release of Cleaver API
- I/O module to support VTK meshes
- Full demo TBA
Overview

Bender is a free, open source software for repositioning voxelized anatomical models. It applies the rigging, skinning and posing technique to volumes by providing an additional step to resample the volume:

- **Rigging**: Specify the skeleton ("rig" or also "armature") that represents the linear sections and joints of the body, by which the body will be re-positioned.
- **Skinning**: Associate the volume voxels associated with each section of the skeleton.
- **Posing**: Animate the rigging by bending and rotating the joints to define the target repositioning of the body.
- **Resampling**: Resample the bones, soft tissues, and skin of the voxelized model onto the repositioned rigging to create a new voxelized model.
Cleaver Future

• Better adaptivity
  o Control
  o Anisotropy
• Quality
  o Methods and theory
• Speed and data size
  o Parallel/distributed implementations
• Other element types
  o Hybrid meshes, hexes
  o DOE research proposal w/Kirby and MIT
ShapeWorks Update

• Rebuilding, hardening code for geodesic distances/features

• Applications to orthopedics/cardiology
  o R01 submission with CARMA/Cates
ShapeWorks Update

- Unified CLI and GUI for workflow
  - Redesigned for clinical use
- Upgrade to ITK4
- Improved testing
ShapeWorks Future

• Robustness and speed
  o "Black box" for users
    – More complex shapes, situations
    – Initialization
    – Better/easier preprocessing
  o Speed affects parameter tuning/use

• Other applications
  o Application domains (e.g. zoology)