

LOGISMOS – Complex Topology and Multiple Object Interactions

Graph-Based Image Segmentation: LOGISMOS

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More than Rectangles and Tubes: Generalization to complex shapes

- **Step 1: Pre-segmentation**
 - Derive topology of objects of interest from image data → approximate segmentation
- **Step 2: Mesh Generation**
 - Specify structure of a base graph defining neighboring relations among voxels on the sought surfaces
- **Step 3: Image Resampling**
 - Resample along a ray intersecting every vertex of the mesh forming graph columns.
- **Step 4: Graph Construction**
 - Weighted directed graph G built using from columns, with neighboring relations, smoothness constraints, and inter-surface separation.
- **Step 5: Graph Search**
 - Searching for *optimal closed set*.

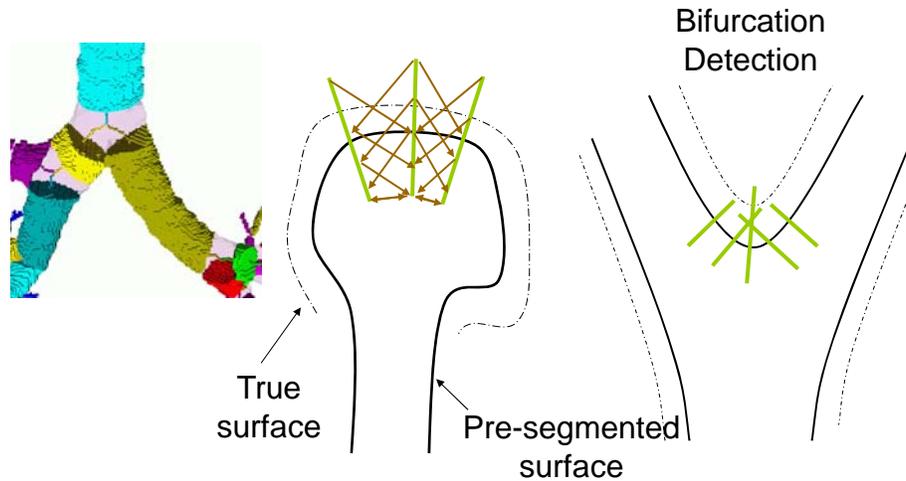
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Problems of Step 3 – Colliding Columns



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Electric Lines of Force (ELF)

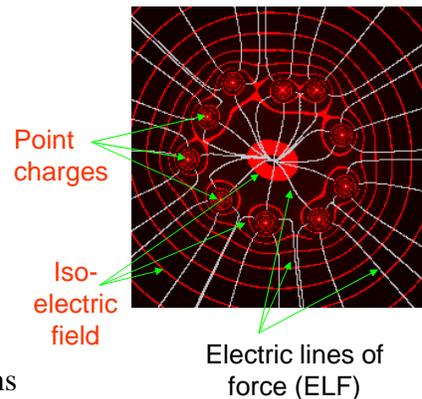
- An electric field theory motivated search direction

$$E_i = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}$$

$$E = \sum_i E_i$$

- Non-intersecting
- Easy to compute
- Expanding to any positions

- Non-ELF medial-surface approach also possible



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3D Airway Double Surface

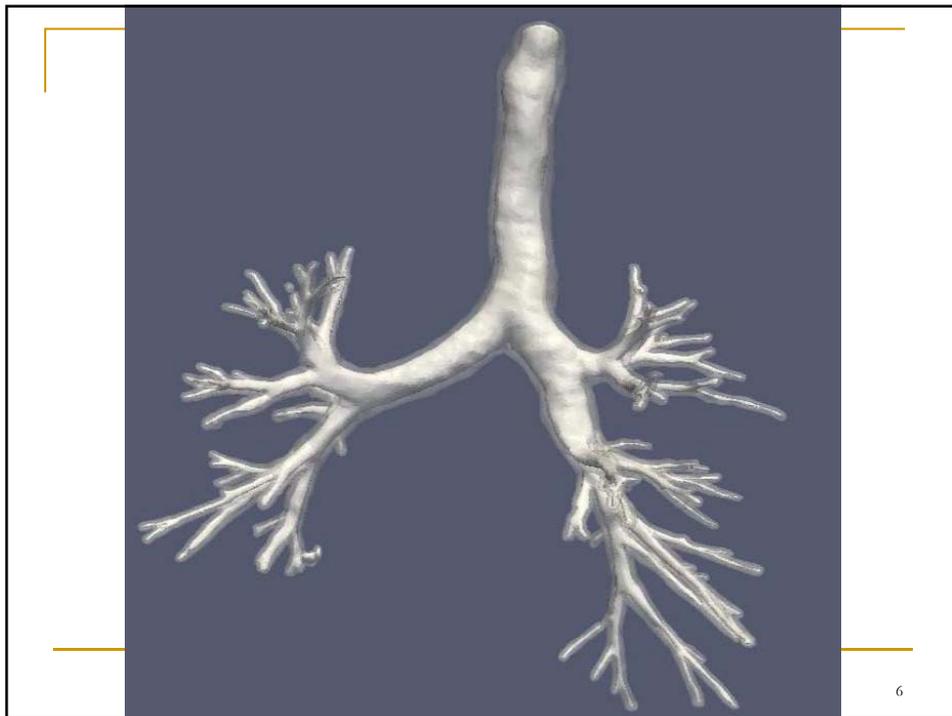


Inner surface

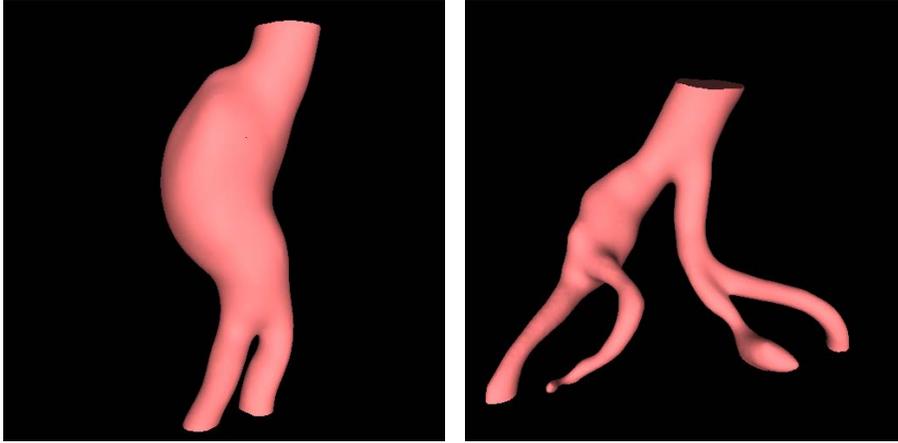


Double surfaces

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Aortic Thrombus from MDCT

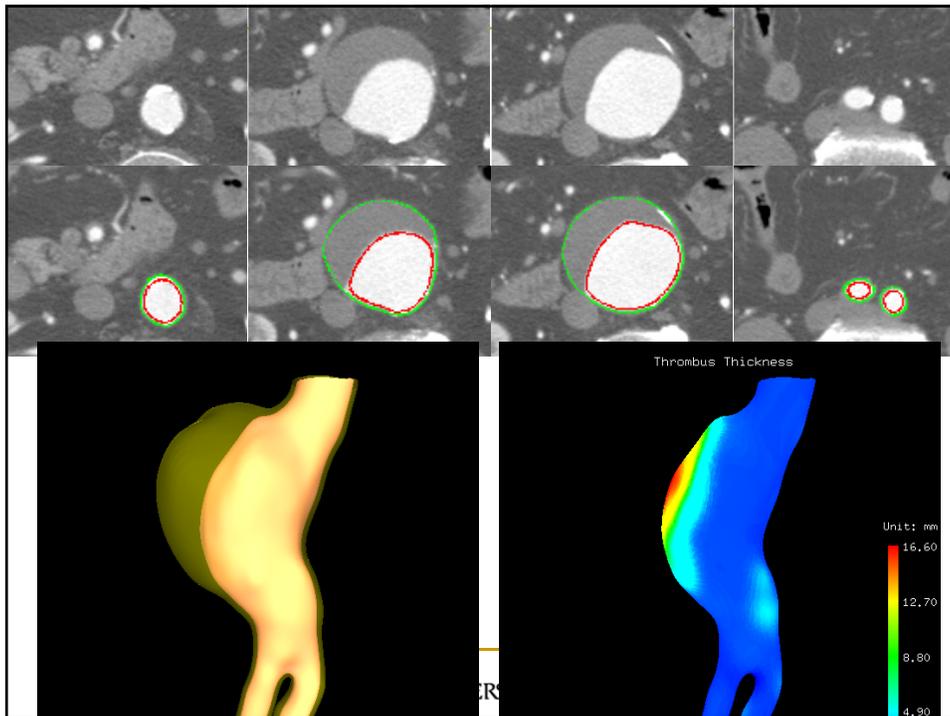


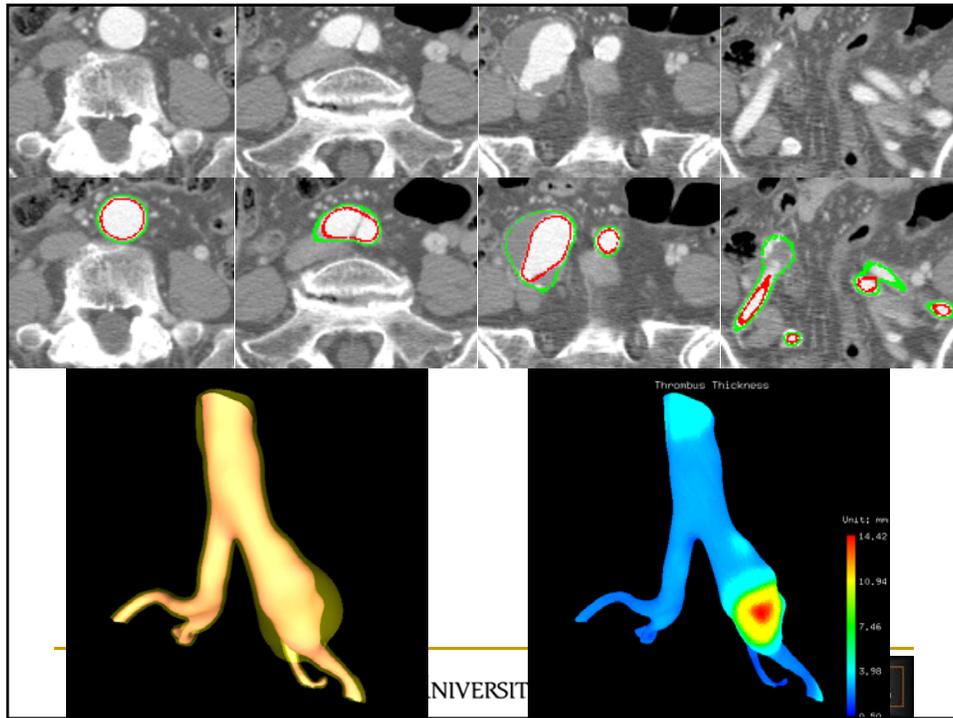
Preliminary aortic/iliac lumen segmentation



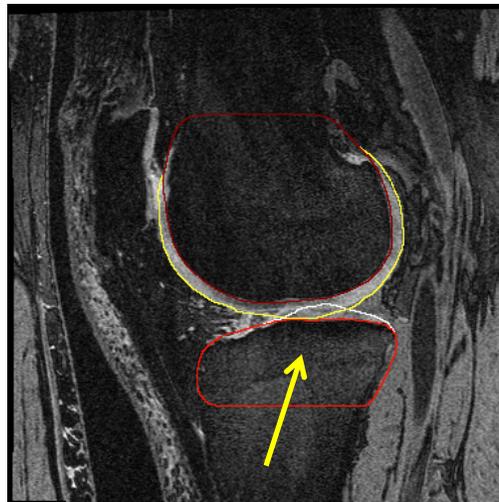
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Cross-Object Interactions



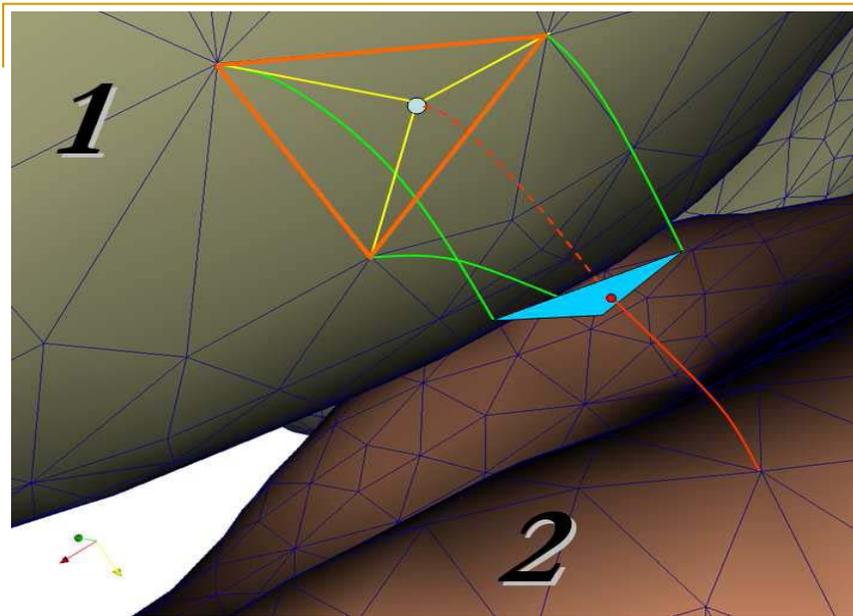
Multi-object 3D segmentation

- Regions of object-to-object interactions
 - reflected in inter-graph arcs
- Steps:
 - Identify regions of pairwise interaction
 - Link interacting surfaces = create inter-graph arcs
 - Build/solve resulting graph
- Example
 - Prostate – Bladder – (Rectum)
 - Knee-joint cartilage segmentation
 - Femur/Tibia/Patella cartilage thickness



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Prostate – Bladder Segmentation

Input Image → **Pre-segmentation** → **Pre-segmented Surfaces**

Final result ← **Graph Optimization** ← **Constructed Graph**

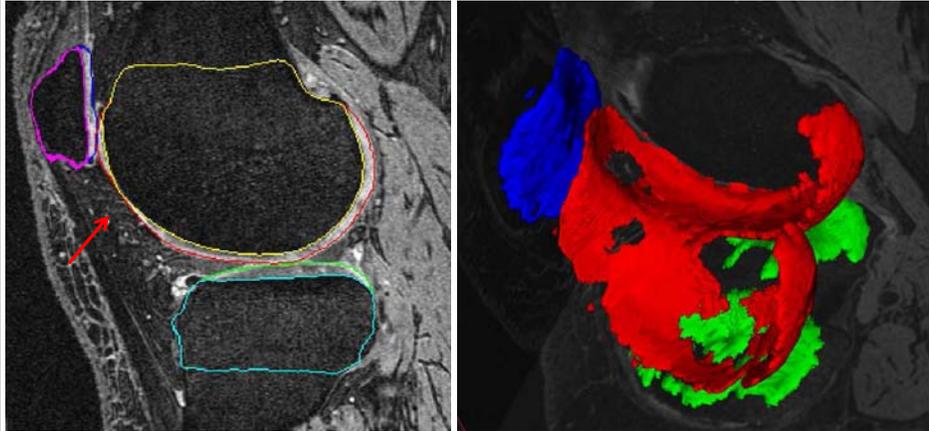
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Healthy Knee

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Severe Osteoarthritis

DEMO



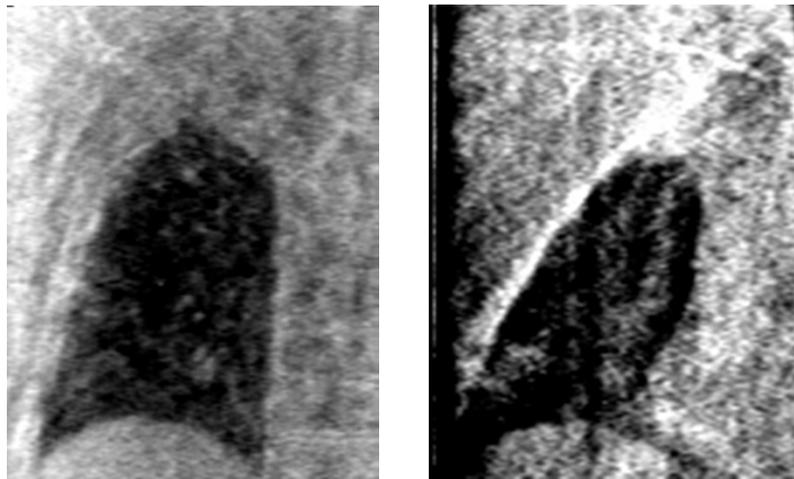
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Simultaneous segmentation of an object and up to two surfaces (MVCBCT)



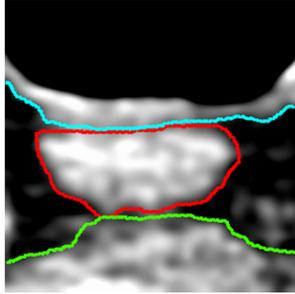
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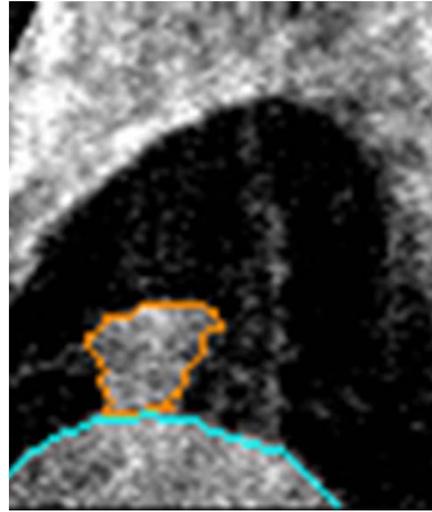
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Mutually interacting
terrain-like surfaces
and regions of
arbitrary topology



A lymph node (red) in X-ray CT data.



A lung tumor (orange) in megavoltage cone-beam CT



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