Particle Systems for Sampling and Meshing of Non-Manifold Domains

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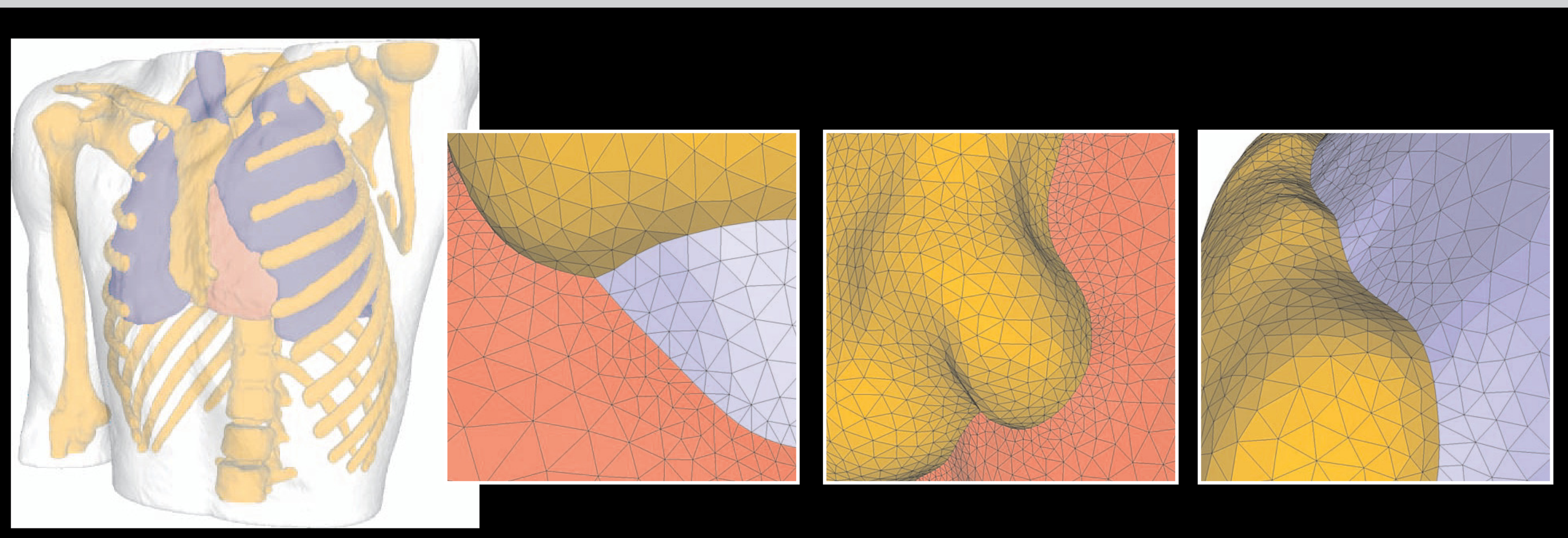
1. Abstract:

Non-manifold and non-smooth geometries occur frequently in many domains, including biomedical image data and CAE.

These shapes have complex features that need to be preserved in output meshes, while meshing using high quality surface and volume elements.

Our approach relies on a particle system for adaptive, isotropic sampling of the surfaces, then uses a Delaunay-based scheme to build surface triangulations and volume tetrahedralizations.

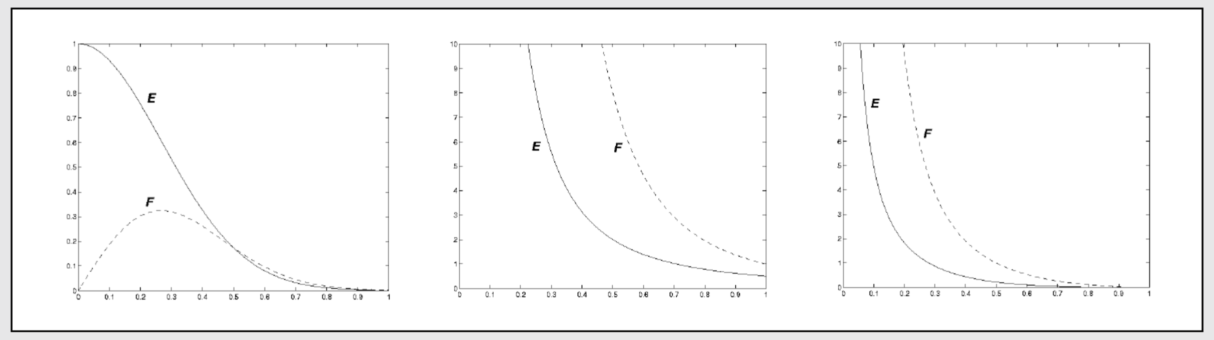
These meshes are suitable for further processing, such as FEM techniques frequent in CAD and biomedical simulations.



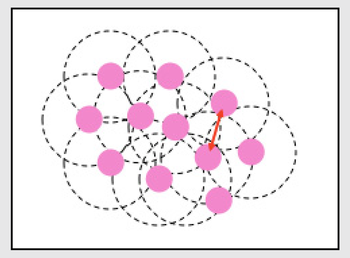
2. Particle Systems:

Particles distribute to minimize potential
- Particle-Particle interactions
- Minimize through incremental updates dynamic)
- Gradient descent

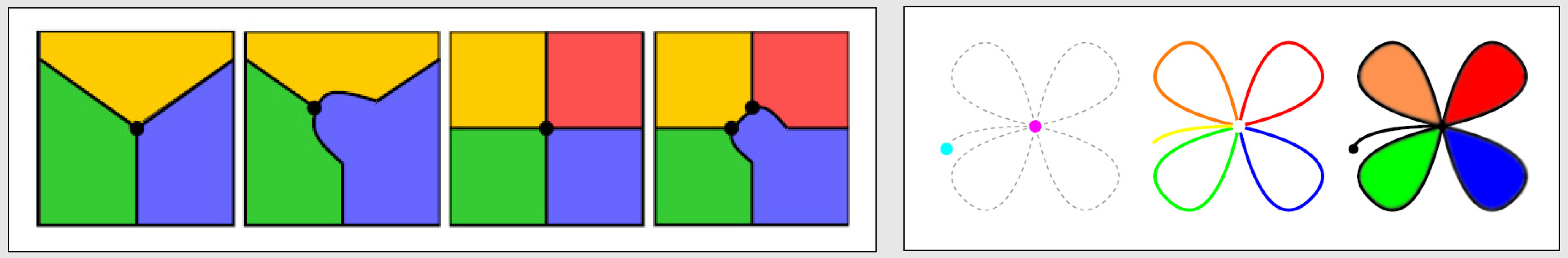
Potential Functions:



Organize sets of particles to achieve desirable geometric configurations (E.g., Density, Distribution)



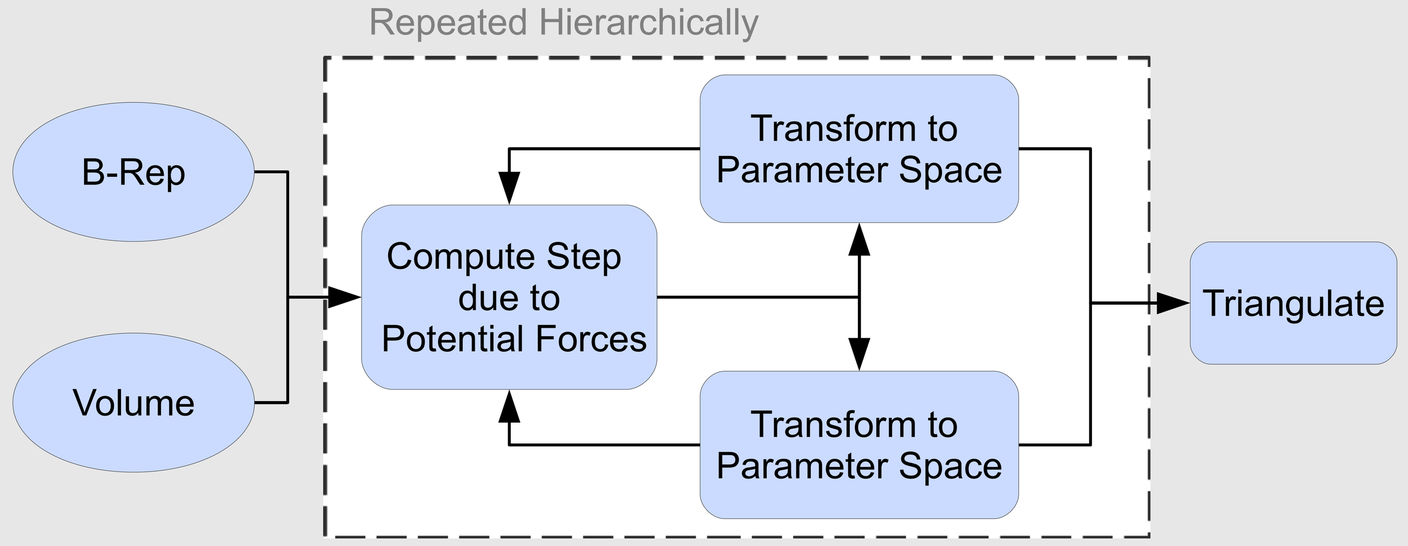
3. Shape Model:

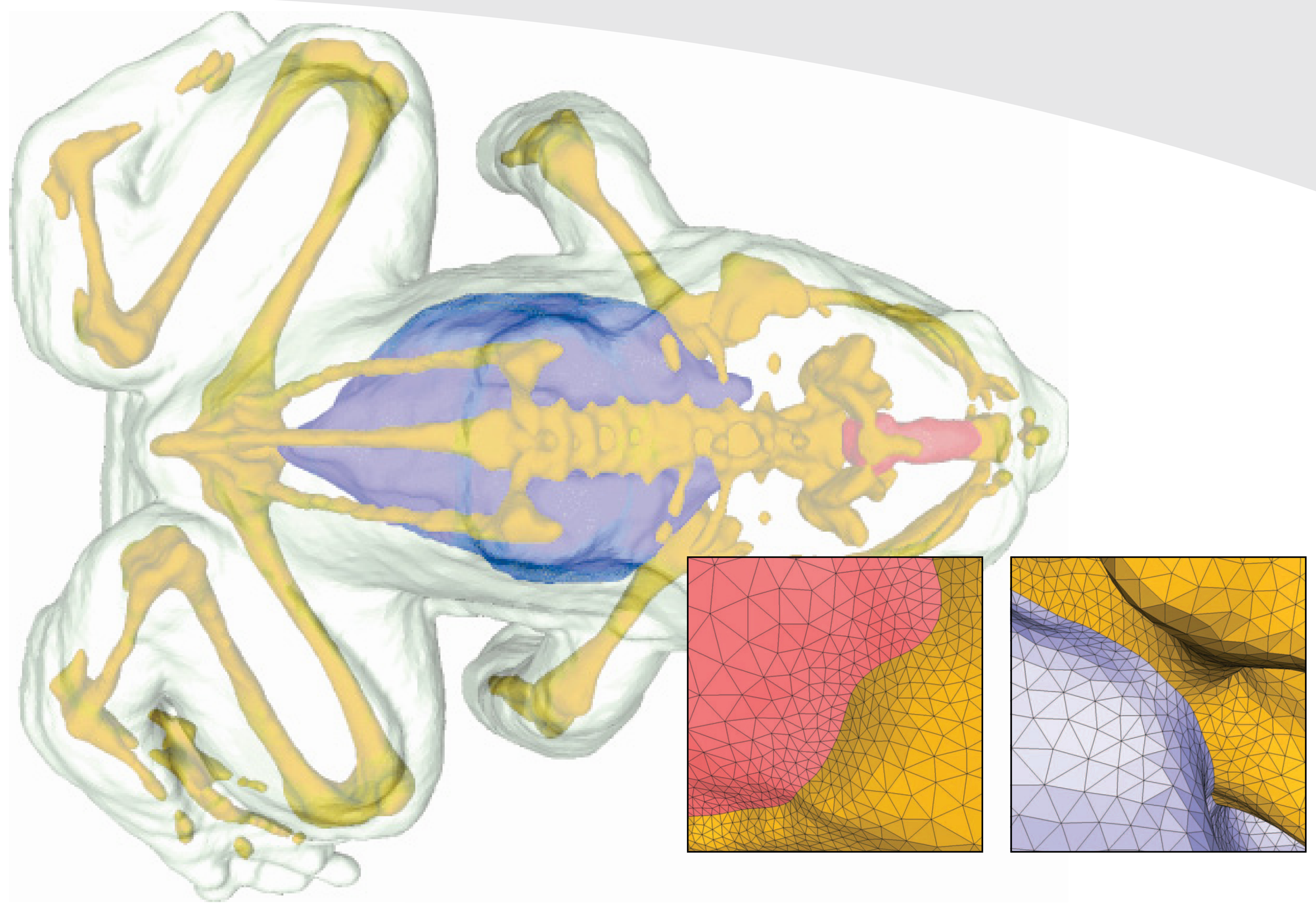


Accurately capturing surface and material interfaces is simplified greatly by using a hierarchical shape model.

We treat all models piecewise-smooth complexes. These complexes are composed of varying dimension k-cells.
2-cells : Surface Patch Interiors, Face (2-D)
1-cells: Surface Patch Boundaries, Edge (1-D)
0-cells: Edge Intersections, Vertex (0-D)

4. Particle Pipeline:

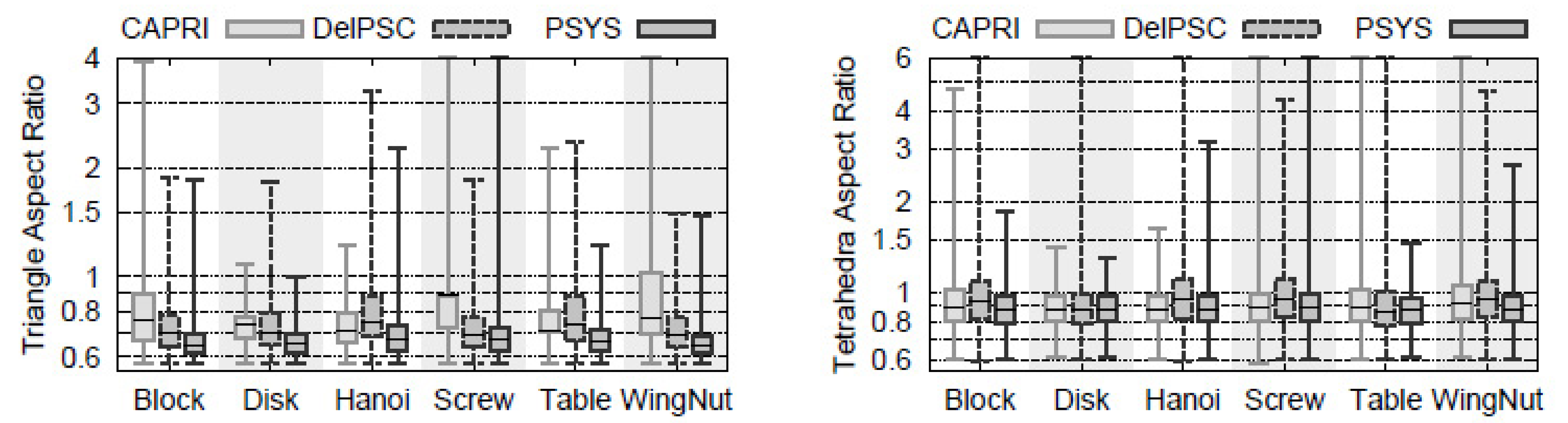




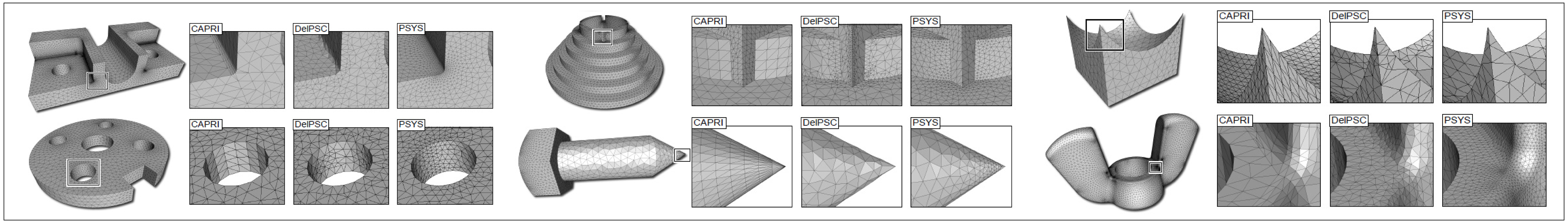
5. Result Summary:

Domains:
- Biomedical image Data
- CAD/CAE B-Rep Models

Benefits:
- High quality elements
- Precise Interface Representation
- Adaptivity
- Automatic Sizing Field Estimation
- Little to no user interaction required



A comparison of mesh quality for our PSYS method, compared to DelPSC and the CAPRI library's default mesher.



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