Inner Sphere Trees for Proximity and Penetration Queries

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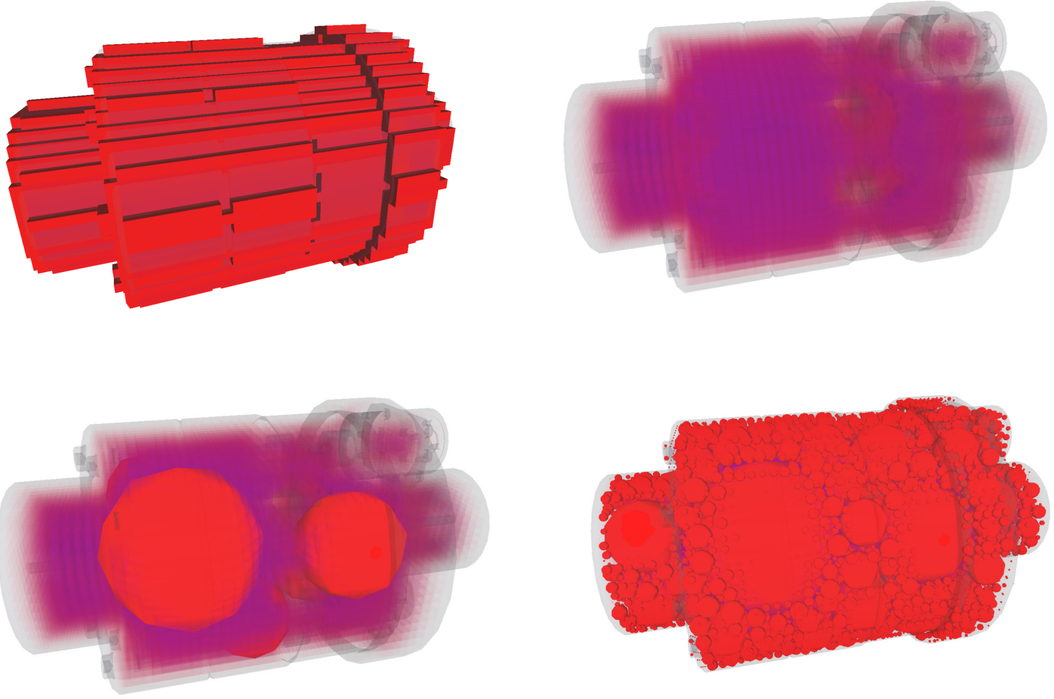
Goals

- High refresh rates (1 KHz)
- Stable and continuous forces
- Memory consumption like BVH based approaches

Our Approach

- Bound objects densely from the inside
- with a set of non-overlapping spheres
- Construct an “inner bounding volume hierarchy”



The Sphere Packing

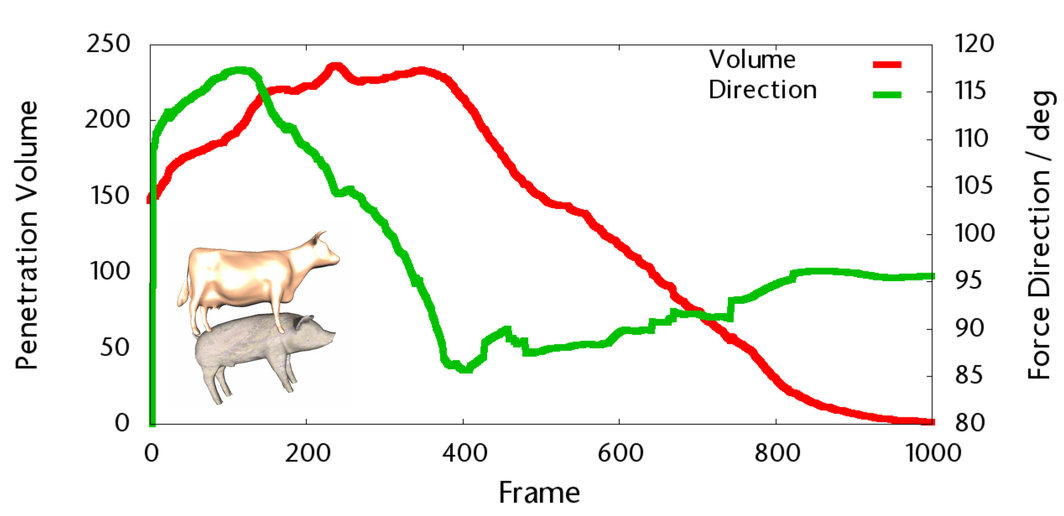
- Heuristic based on discrete distance fields
- Greedily create spheres sorted by distance to the surface
- Update distance field iteratively

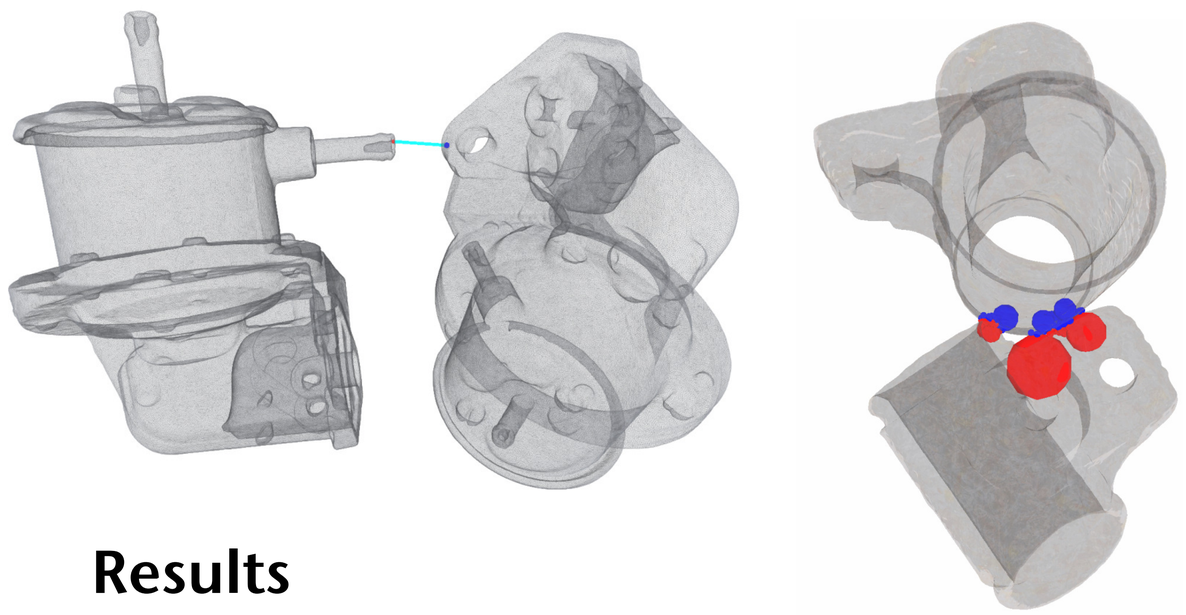
Hierarchy Creation

- Extended version of Batch Neural Gas
- Minimize the mean squared euclidian distance of points
- Magnification control to include the extent of spheres

IST Traversal

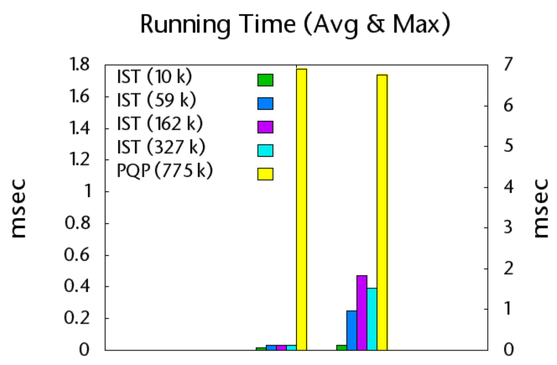
- Uniform algorithm with support for
- Proximity queries and
- Penetration volume computation
  - related to water displacement
  - corresponds to physically motivated force

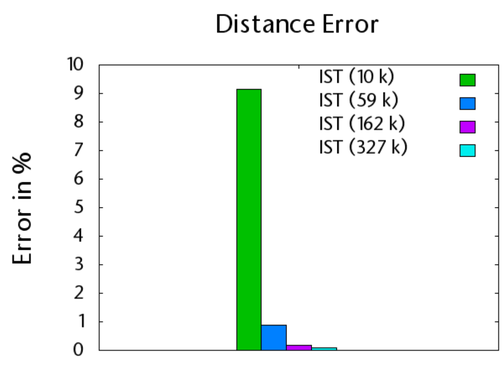


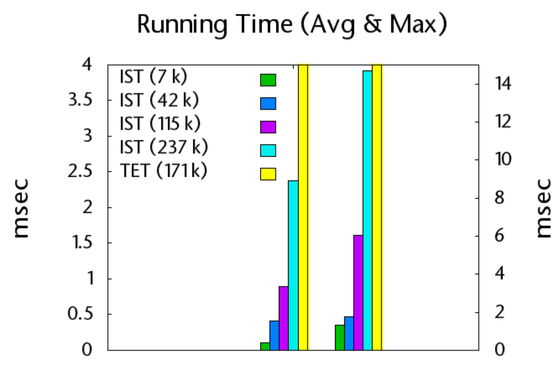


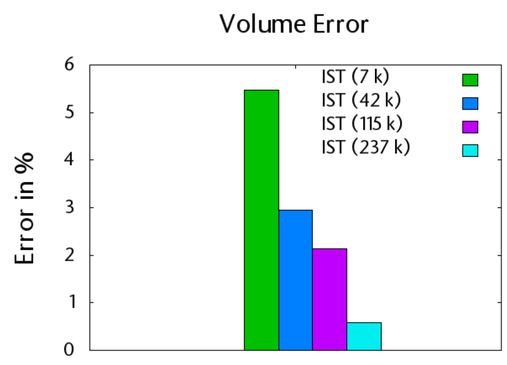
Results

- Both traversals perform at haptic rates
- High accuracy with error < 1%
- Independent of object complexity
- Continuous forces









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