Stochastic Closest Features Tracking

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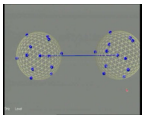
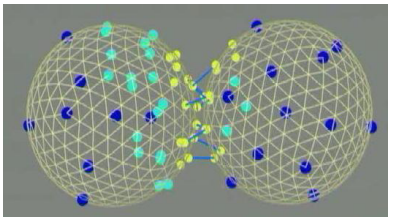
- Based on [Lin-Canny92] (only for convex objects)
  - Steepest descent for single pair of features
  - Accelerated by generalized Voronoi diagram
  - Temporal coherence
- Extension to non-convex, deformable objects:
  - Non-convex → multiple pairs of (locally) closest features
  - Deformable → feature pairs come and go
- Idea
  - Stochastically create pairs of features
  - Converge them to locally closest features



Tracking Closest Pairs: Video



Details

- Algorithm:

```
Do animation step
Add random pairs to list of "active feature pairs"
    For each feature-pair:
        Update features by local search
        Remove "unwanted" pairs
        If collision:
            apply response to local collision area
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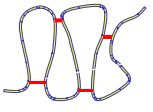
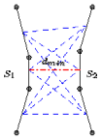


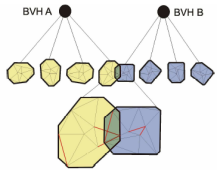
Can also handle self-collisions

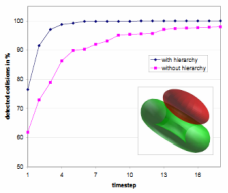
- Updating of feature pair:
  - No Voronoi diagram
  - Compute pairwise distance of all neighbor pairs
- Removal of feature pairs:
  - Distance too large (not likely closest feature)
  - Both features of two pairs too close (redundant)
- Creation of feature pairs:
  - Importance-driven (e.g., velocity-based)
  - Supported naturally by multires model



Acceleration by BV Hierarchy

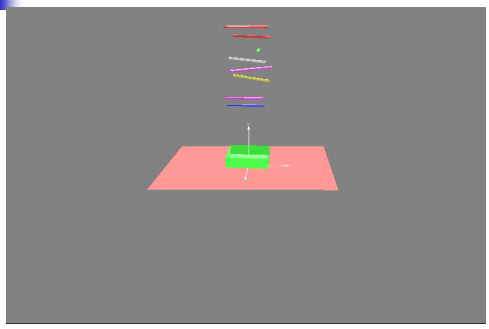
- Use incomplete BVH to find "interesting" regions
- Stochastically sample those regions



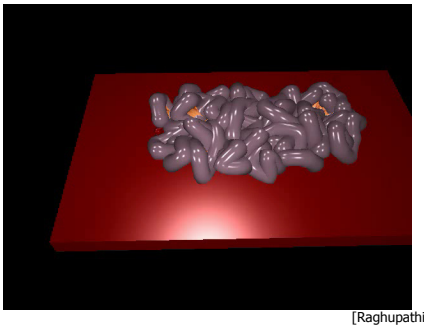


Courtesy: [Kimmerle04]

Thin Objects

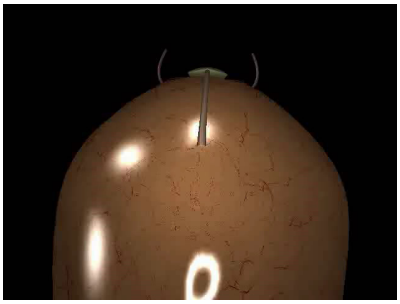


Application: Virtual Intestinal Surgery



[Raghupathi04]

Application (2)



[Raghupathi04]

Conclusions on Stochastic Approach

- Cannot be proven error-free
- Good for plausible & fast simulations
- Interesting alternative/complement to BVHs in specific cases
- Naturally yield time-critical collision detection
- Future work:
  - Precise error bounds

References

- Jan Klein and Gabriel Zachmann, "ADB-Trees: Controlling the Error of Time-Critical Collision Detection", *Proc. VMV '03*
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- Stephane Guy and Gilles Debunne, "Monte Carlo Collision Detection", *INRIA Technical Report RR-5136*, 2004
- Laks Raghupathi et al. "Real-time Collisions and Self-Collisions for Virtual Intestinal Surgery", *Surgical Simulation and Soft Tissue Modeling*, pp.38-46, Springer, 2003
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