Towards Time-Critical Collision Detection for Deformable Objects Based on Reduced Models

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Goals and motivations

Interruptible collision detection processes have only been used in rigid bodies simulations **[1]**.

We propose an algorithm to carry out collision detection for deformable objects using a time-critical mechanism.

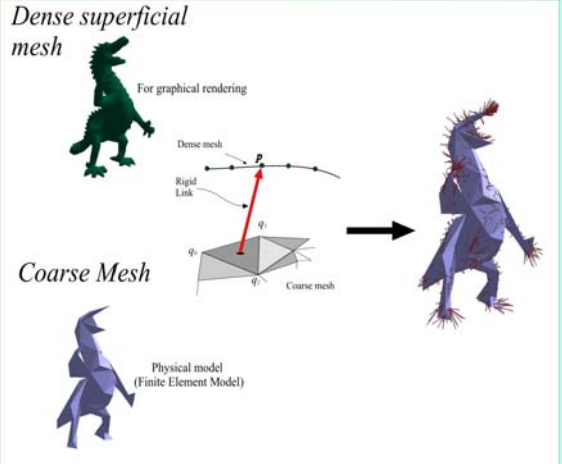
Main contributions:

1) Handling thin long triangles.
2) Optimizing interruptible tree traversal.

Deformable model

We simulate deformations using two meshes: a dense superficial mesh, for graphical rendering and a coarse mesh for physical simulations. The coarse mesh is a *reduced representation* of the original model and it is based on an Explicit Finite Element approach **[2]**.

When the coarse mesh deforms, it pulls or pushes the dense mesh through *rigid links* which are computed in an off-line process.



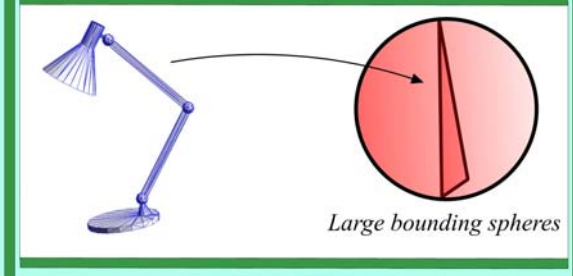
Collision detection handling

We use *sphere-tree hierarchies* to detect collisions between deformable objects. The coarse mesh is used to update the hierarchies during object deformations.

James and Pai were the first to use reduced models to update tree hierarchies **[3]**.

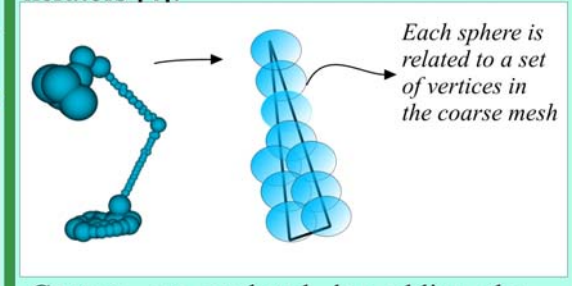
The problem:

Objects with thin triangles.



Our solution:

Use adaptive medial axis sphere-tree generators **[4]**.



Centers are updated by adding the average displacements of the corresponding coarse vertices to the original center. Sphere radii, r, are updated using a heuristic:

$$r_{new} = \lambda\, r_{original}$$

λ depends on the maximum *distance rate change* between the sphere center and its corresponding coarse vertices

Optimized interruptible traversal:

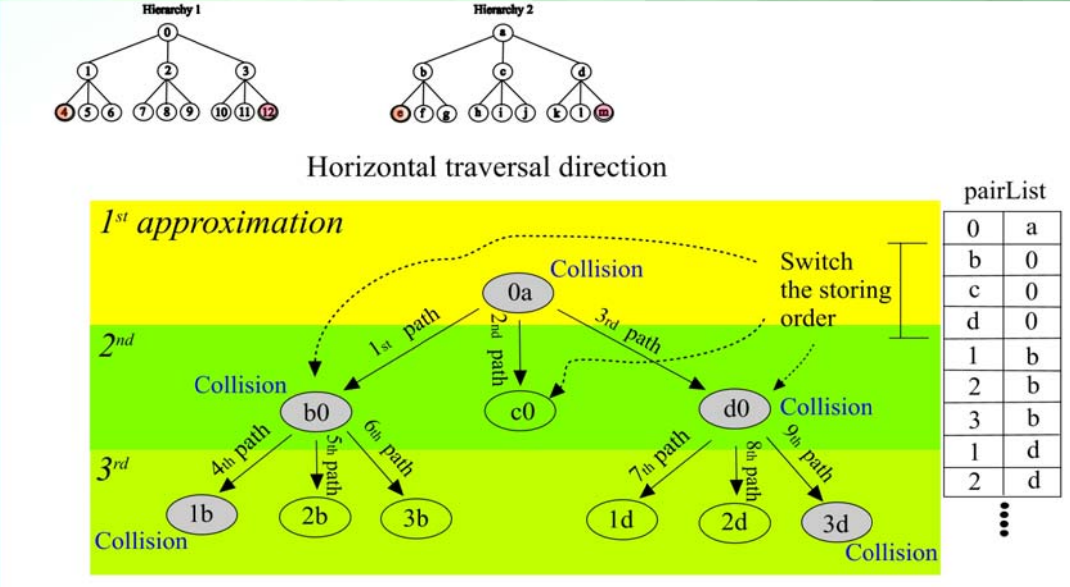
Traversing the hierarchy using a *breadth-first search.*

Key aspects:

a) Pair entity: It stores the colliding pair of spheres. The order in which we store the spheres changes during the search. This allows stepped and optimized traversals.

b) Two FIFO (first input - first output list): PAIRLIST stores spheres to be tested during collisions. COLLISIONLIST stores colliding pairs of leaf spheres.

c) At each sphere collision test critical times are checked: if the process must be interrupted then forces are computed using sphere pairs in both lists, otherwise only leaf spheres are used.



[1] J. Dingliana and C. O'Sullivan. Graceful degradation of collision handling in physically based animations. *Computer Graphics Forum,* 19(3):229-248, August 2000.

[2] J. O'Brien and J. Hodgins, Graphical modeling and animation of brittle fracture. In Proceedings of *ACM SIGGRAPH 1999*, pages 137-146. ACM Press/Addison-Wesley Publishing Co. August 1999.

[3] D. James and D. Pai. BD-Tree: Output-sensitive collision detection for reduced deformable models. *ACM Transactions on Graphics (ACM SIGGRAPH 2004)*, 23(3), August 2004.

[4] G. Bradshaw and C. O'Sullivan. Adaptive medial-axis approximation for sphere-tree construction. *ACM Transactions on Graphics,* 23(1):1-26, 2004.

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