ACM/CS 114
Parallel algorithms for scientific applications

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Winter 2010

A more careful look at contact detection

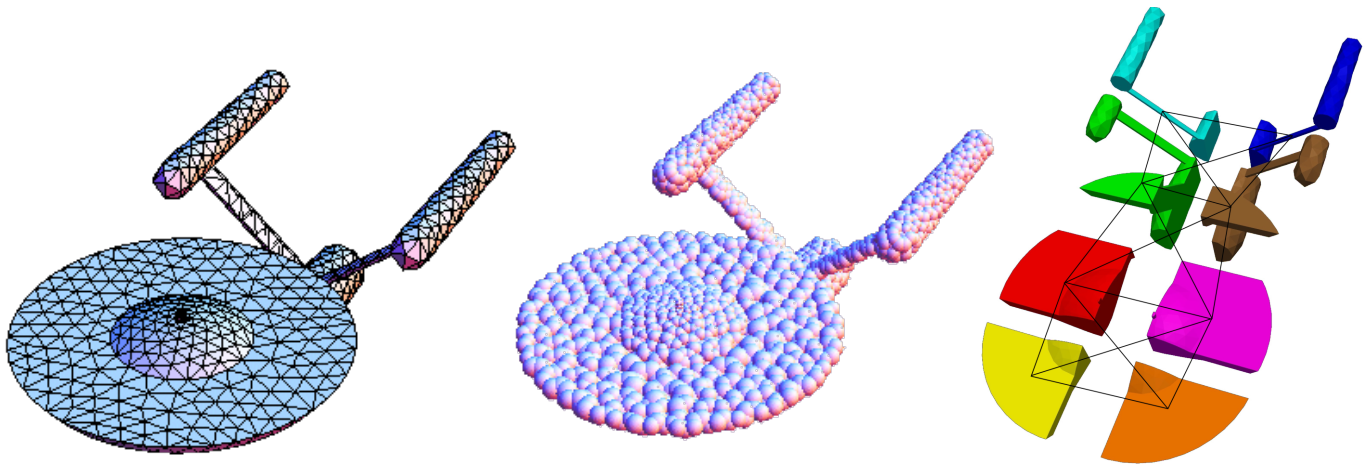
- consider a collection of tetrahedral meshes that model bodies in relative motion with triangular meshes as boundaries
- during the simulation, the bodies may come in contact
  - with each other or themselves
  - *contact events* consist of intersections among nodes, edges or faces
  - unless the mechanics is informed of the contact events, the objects will inter-penetrate
  - contact *detection* involves isolating the pairs of topological entities from each boundary that have intersected, whereas contact *resolution* refers to the calculation of appropriate restoring forces on the bodies
- the typical simulation update step proceeds along the following lines
  1. define the contact surfaces at time t
  2. predict the location of the nodes at a later time $t + \Delta t$ by integrating the equations of motion
  3. search for potential contact events among nodes, edges and faces to identify the contact candidates
  4. perform a detailed search to isolate the entities that come in actual contact
  5. correct the future location of the nodes by applying forces that tend to remove the overlap

Contact search

- the contact candidate identification in Step 3 and Step 4 above have the potential to dominate the calculation
  - given a candidate pair, the intersection logic involves very expensive geometrical calculations
  - naïve algorithms are $\mathcal{O}(n^2)$ in the number of topological entities on the boundary, prohibitively expensive even for moderate size calculations
- hence, a more sensible strategy is to break the contact search up into two separate steps
  - find a relatively fast algorithm to narrow down the candidates to a small number
  - perform the detailed calculations on the reduced set
- the search in Step 3 requires a specialized data structure that can encode the locations of the mesh nodes to support fast queries
  - build a bounding box that contains the initial and final position of a given surface element, perhaps in some reduced form
  - enlarge this box to account for the motion of the nodes

Volume based contact detection

- volume based approaches replace the elements on the boundary with equivalent spheres
- a variety of geometrical criteria can be used:
  - equivalent volume
  - diameter determined by the longest edge
- contact detection can take place very efficiently using ORQ algorithms
- simple spring models resolve the contact forces
  - based on simple potentials that take into account the sphere inter-penetration



Who knows?