Simulation of Deformable Biological Structures with a Tethered Particle System Model

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A new model is proposed for the simulation of deformable biological structures such as proteins, membranes, tissues, and organs. The idea involves the use of discrete-event simulation to track the motion of large numbers of colliding particles. If two approaching particles reach an inner limiting distance, they collide, rebound outwards, and may become "tethered". When two separating tethered particles reach an outer limiting distance, then provided they remain tethered, they retract inwards. By constraining the distances between pairs of particles in this manner, a variety of deformable structures may be represented. A model of a presynaptic terminal of a nerve cell is presented as an example.

We expect the proposed tethered particle system to offer a considerably simpler alternative to existing deformable structure modeling techniques such as the finite element method (FEM). Many have noted that impulse-based simulations similar to ours are hopelessly inefficient at resolving simultaneous or nearly-simultaneous collisions of three or more particles. We therefore introduce a condition whereby multiple small colliding particles may act, temporarily, as a single body. With this approximation we hope to rectify the inefficiency of impulse-based methods without sacrificing simplicity or validity.