CS6491-2020-PROJECT 2: Colliding balls and virus spread

1 Project description

A set of small disjoint disks $D_1 \dots D_n$ remain inside a large circular ring R. All disks have the same radius r. Initially, their centers C_i are the vertices of a regular triangulation, where all triangles are equilateral. At start, each disk C_i is given an initial velocity vector V_i. Initially, all V_i have same magnitude, m, but random orientation.

Your goal is to simulate the precise motion of the disks over time, assuming that, between collisions, each disk travels with constant velocity and that collisions between two disks and between a disk and ring R are perfectly elastic.

To do so, you must perform the simulation in collision-free steps as follows.

You keep track of the time w remaining until the next rendered frame.

At the beginning of each step, you compute the time t to first collision.

If $t<w$, you complete the step:

- move each C_i to $C_i + t\, V_i$
- update $w = w - t$
- compute the new velocities for the two disks that collide at the end of this step

Otherwise, you finish the animation, display the next frame, and then complete the step:

- move each C_i to $C_i + w\, V_i$
- update $t = t - w$
- display the frame
- reset $w = 1./30$ (inter-frame lapse)
- move each C_i to $C_i + t\, V_i$
- update $w = w - t$
- compute the new velocities for the two disks that collide at the end of this step

To compute the time t to first collision, in Phase A, use the naïve approach of computing the exact future collision-time (if any) for all pairs of disks and also each disk with the ring. The value of t is the smallest of these (“first collision”). Hence, this naïve approach has quadratic time-complexity.

In Phase C, investigate a more efficient approach to first-collision tracking: Start with a Delaunay triangle mesh of the initial **sites** (centers C_i) and of a few static points outside of the ring. During animation, maintain the Delaunay triangulation by detecting invalid triangles and invalid edges, and by rearranging the connectivity locally (for example by flipping some of the edges). The idea here is to explore conditions under which the first-collision may be detected by predicting when and where the mesh will become invalid and by using this information to reduce the number of dick/disk collision predictions. I suggest that you attack this phase by: (1) creating the initial triangle mesh and representing it using the Corner Table, (2) maintaining it when the sites move slowly and are allowed to pass through each other without collision detection/handling, (3) combining both (1) and (2).

In Phase B, investigate using this collision model as a tool to better understand virus transmission and the benefits of social distancing and contact tracing. Assume that one, randomly chosen ball represents an infected person. At each collision, when one of the two balls is infected, there is a probability p_i of infecting the other. Propose a parametric model of the contagion, including statistics of when an infected person becomes contagious, how long the person stays contagious, the probability of the person having symptoms. Then, experiment with contact tracing strategies (starting with people who show symptoms and tracking back whom they bumped into recently and who these bumped into afterwards...) and with the efficacy of safety measures (assuming that some given fraction of people identified by contact tracing as potentially contagious take adequate precautions. Use these parameterized statistical behaviors to show what happens for different sets of parameters. What does it take to stop the spread? How long does it take to infect everyone?... As parameters, also include the number of disks, the radius r, and the magnitude m of the initial velocities.

2 Schedule and deliverables

Teams of one, two, or three. One week per phase. Submit all 3 phases together. Due on Tuesdays October 6 before class.

In your slides and code, clearly indicate (cover page of slides and on canvas of your sketch) who are the members of your team.

Submit slides (with, for each phase: problem statement, math/algorithms, images, GIFs, discussion of results, citation of sources) and the zipped folder of your sketch (without images that you used for the GIFs). Make sure that your sketch acknowledges the authors (pictures and names on the canvas).