Physically Based Simulation For Soft Objects

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Summary

First of all, I would like to borrow some words from Demetri Terzopoulos in [TPB+89] :

"Physically-based techniques facilitate the creation of models capable of automatically synthesizing complex shapes and realistic motions that were, until recently, attainable only by skilled animators, if at all. Physically-based modeling adds new levels of representation to graphics objects. In addition to geometry – forces, torques, velocities, accelerations, kinetic and potential energies, heat, and other physical quantities are used to control the creation and evolution of models. Simulated physical laws govern model behavior, and animators can guide their models using physically-based control systems. Physically-based models are responsive to one another and to the simulated physical worlds that they inhabit."

After hearing these words, the value of investigating the field of physically based simulation is obvious. Many novel methods have been proposed regrading this topic but there are still some blank left to be painted. There are algorithms for simulating deformable objects under outer forces such as blowing by wind or tearing force. There also are algorithms for fluid simulating such as the motion of pouring water in to a cup. However, there rarely are research on the interaction between fluid and soft deformable surfaces.

I would like to write a program to simulate the motion of a balloon filled with water under the gravity and its collision with different objects with various properties such as another balloon filled with water, the ground, rigid objects, etc. If this can be done, then it is not a hard job to simulate the fat of a characters moving along with the characters' movement in animation production. Animators will no longer editing the same movement for characters with different body size. It the same idea as skeleton animation but there is no need for manually assigning the weights of skeleton for each vertices which is a tedious job and the penetration is unavoidable during the calculation.

In order to complete such system, I am planning to combine the particle system which is widely used in fluid simulation with existing simulation method of deformable objects. Once this method works on simulating the shape of soft objects like balloons filled with water, I will complete the dynamic part using the rigid body collision and contact as references. Finally, if both parts are working well, I will try to implement a system to simulate the soft tissue of characters' body moving along with their legs and bodies.

List of goals

- Finish the modeling part. Write a program to simulate the falling of a balloon fills with fluid by the due date of the first update report. If this method is not plausible, try to find other representation for soft objects modeling.
- Partly finish the dynamic part. Add simulation for the soft objects hitting the ground and bouncing up by the due date of the second update report.
- Complete the simulation system. The simulated objects should appear normally in the interaction with other soft objects or rigid objects at the due date of this project.
- If the final goal is completed in advance or after the course ends, try to implement a system simulating the soft tissue moving accordingly with the movement of bones and make it parameterized so the stiffness of the tissue is controllable by users.

References

[TPB+89] D. Terzopoulos, J. Pltt, A. Barr, D. Zeltzer, A. Witkin, and J. Blinn. Physically-based modeling: Past, present, and future. In *ACM SIGGRAPH 89 Panel Proceedings*, SIGGRAPH '89, page 191–209, New York, NY, USA, 1989. Association for Computing Machinery.