Creating Animations of Fluids and Cloth with Moving Characters

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1. Introduction

This sketch describes a computer simulation technique for creating animations including fluids and cloth with moving characters. There are no efficient computer simulation based tools to create such animations. We propose a particle based simulation scheme to treat fluids, cloth and characters in a single domain. Our method achieves computer simulation based animation in which fluids, cloth and characters interact with one another, at a cost practical.

Physically-based modeling has been an important research topic in computer graphics and virtual reality. Recently, simulations of fire, gas, sand, fluids, solid and cloth have been gaining attention, as they add distinctive realism to animated scenes. One of the major problems of this approach is difficulty in establishing a unified approach for representing geometry in physical environments. Many applications treat interactions of different materials in a non-unified manner.

In the fields of computer graphics, computer simulation technique for fluid flow which is based on the Eulerian formulation is a focus of research actively. Hence, special attention must be given to the changing shape of the fluid domain in the case of fluid-solid interaction. The problem becomes harder to solve interactions between fluids and clothes are considered. Since cloth is very thin, even small interpenetrations can lead to cloth extending beyond to the wrong side. In order for the fluid-cloth interaction to be captured correctly, it is necessary to treat the fluid at the same resolution as the cloth. This suggests that an adaptive mesh method that concentrates grid points in the interface region will be efficient. But this is not efficient enough for use in the field of computer graphics. Generally a cloth object is constituted of a polygonal mesh containing many hundreds of polygons for smooth movement.

2. Cloth Simulation and Fluid Simulation

Clothes are modeled as a combination of mass-distributed particles and elastic forces that work between the particles. This is similar in the case of fluids particle based fluid flow solvers are used. We use Smoothed Particle Hydrodynamics (SPH), a powerful particle method, for solving complex fluid dynamical problems. Using SPH we can easily numerically simulate the impact problem for arbitrary shaped bodies, including gravity and a finite volume of fluid. We use the explicit integration method that allows a good treatment of the complex contact conditions among different materials and enables the soft movement of cloth. But with explicit integration methods, the time step must be very small for the system not to diverge. In order to reduce computational cost, we need some specialized technique for accelerating collision detection. Because we are especially interested in the fluids-cloth interaction, and we use a loosely connected particle system for animating viscous fluids and a strictly connected particle system for animating cloth, this problem can be solved using the thickened triangle volume (TTV) method, as described in the next section.

3. Thickened Triangle Volume Method

We propose the thickened triangle volume (TTV) method to handle collisions. Using the TTV method, we can treat collisions between fluid-solids, cloth-solids, cloth-cloth and fluids-cloth in a uniform manner. The idea is that we focus on face (triangle)-point collision detection and reaction, taking advantage of the fact that the time step chosen is sufficiently small. Of course, face-point collision handling is not enough for perfect avoidance of penetrations. But when the triangles are fine enough compared with the threshold (ε) of collision detection, this approach works well. Another feature of the TTV method is that it does not use history information at all. TTV is the volume with the shape which thickened the original triangle to its normal direction and widened it to horizontal direction a little (Figure 1). For collisions between solids and other objects such as cloth and fluid, we use one-sided triangle volume (Figure 2), because solid has inside and outside. But when it comes to self-collisions of the cloth or collisions between cloth and fluids, we use double-sided triangle volume (Figure 3), because cloth does not have inside and outside. When collision is detected, a particle inside the TTV is moved onto the boundary of the TTV.

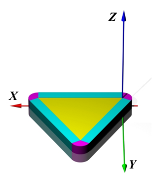


Figure 1:TTV

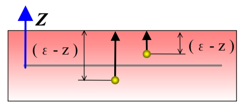


Figure 2: one-sided volume(for solid)

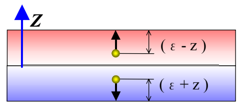
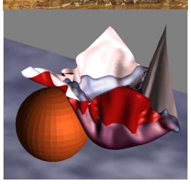
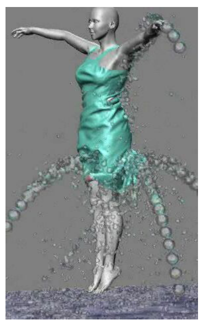


Figure 3: double-sided volume(for thin object)

4. Examples





5. References

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