Real-Time Cloth Simulation

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Introduction

For the many aspects related to the field of cloth simulation, solutions from fast cloth integration methods to complex collision handling have been developed. However, collision handling is often identified as the bottleneck for real-time simulations. In this thesis, we base our work on fast collision detection methods. We propose a new approach for handling cloth self-collisions and collisions between cloth and deformable volumes.

Collision Handling

Based on *Layered Depth Images* - LDIs, we make use of a recent *collision detection* algorithm [1] which performs a volumetric discretization of any volume into an entity of parallel sticks, the LDI. This generation can be performed at every time step of a simulation and we have a reliable tool for detecting collisions in real-time for deformable bodies.

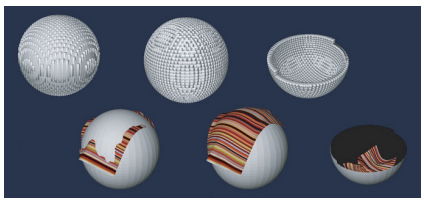

Figure 1: The modifications we brought to the LDI tool result in great overall stability of our system and allow, moreover, to perform collision detection on both sides of any open mesh.

Figure 1, left-hand side, illustrates an LDI instance generated over a sphere and how a cloth piece falls onto it. It is not possible to use the LDI in its original state and we added modifications to the LDI-library. These are mainly an inflation of the LDI structure and a method that returns the triangle through witch a cloth-point has penetrated the body and allows us to compute an accurate and reliable *collision response*. Furthermore, we obtained great system stability by using three instances of an LDI along the X, Y and Z axes, Fig. 1, center. We could reduce the time needed for this three-instances generation by reducing a factor of 3 through an approach that later allowed us to perform collision detection on both sides of a surface and thus to work with open meshes, Fig. 1, right-hand side and Fig. 2).

Figure 2: The two-side collision detection allows to work with open meshes. Here the cloth falls and then slides onto a plate.

Self-collisions

We then consider *self-collision* of the cloth. Again we make use of the LDIs and developed an algorithm involving collision detection and collision avoidance. Moreover, a further process ensures a minimum distance between close triangles so that the number of colliding triangles is reduced at every time step. The results obtained with our self-collision algorithm are illustrated in Fig. 3.

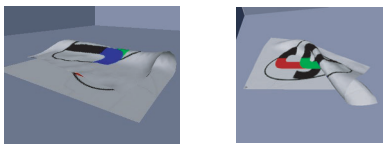

Figure 3: Two cases of self-collision handling by our algorithm performing collision detection and avoidance along with a minimal distance process to keep colliding triangles separated.

Experiments

We performed several experiments, in which we could measure the time needed by the different processes involved in the simulation loop. The measurements showed that we achieve a frame-rate of about 30 fps on a Pentium IV 2.8 GHz, that the generation time of the LDIs is constant over the entire simulation, and that the computations for the collision handling are of the same magnitude as the cloth integration or the visualization processes. In a further experiment, we included a walking avatar into our system. Fig. 4 illustrates how a simple cloth starts falling onto it and then follows its movements. We did not design more complicated clothes as we had neither the necessary tools and nor a mechanism for fixing parts of the clothes to the avatar.

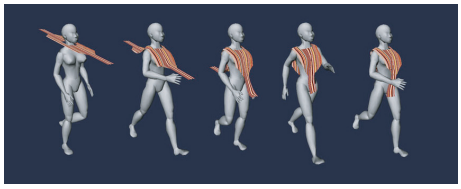

Figure 4: Simulation with a walking avatar with a simple cloth falling onto it.

References

[1] Bruno Heidelberger, Matthias Teschner, and Markus Gross. Volumetric Collision Detection for Deformable Objects. Technical Report 395, Computer Science Department, ETH Zurich, Switzerland, April, 2003.