The Efficient and Robust Sticky Viscoelastic Material Simulation

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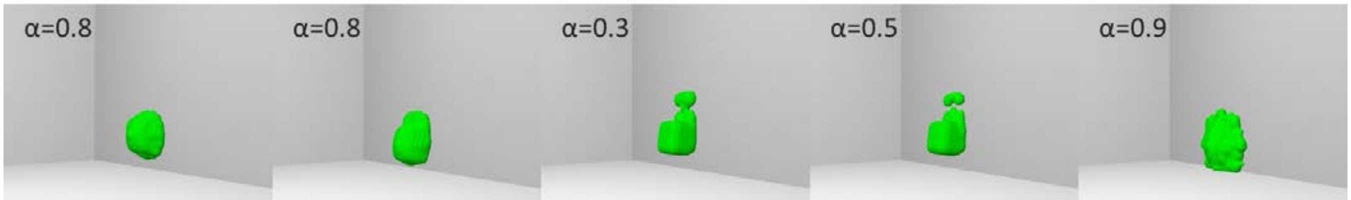

(a)[Takamatsu et al. 2011] (b) Our method (c) Results of changing the parameters ($\alpha = 0.3, 0.5, 0.9$)

Figure 1: *As a result of colliding between viscoelastic material and the wall*

1. Introduction

We present a method to simulate a sticky viscoelastic material that, considers the effects of collision against other objects. In computer graphics, viscoelastic simulation is widely used in films and games. Games with real-time properties require high efficiency and robustness of such simulations. Takamatsu et al. presented a fast and practical method for animating particle-based viscoelastic fluids. They compute the behavior of plausible viscoelastic fluids by combining two well-established approaches, Lattice Shape Matching (LSM) and Smoothed Particle Hydrodynamics (SPH). Their method allows for viscoelastic material simulation that requires a significant amount of computational cost but is implemented easily. However, their method does not consider the expression of stickiness. Therefore, we propose a new method that can represent stickiness by adding friction to the velocity between the viscoelastic material and other objects.

2. Simulation of sticky viscoelastic material

We adopt Takamatsu's method to simulate internal deformation of a viscoelastic material. Their method updates particle velocity using a linear interpolation with the parameter α $(0 \leq \alpha \leq 1)$. The particle coordinates are updated according to the following equation.

$$\boldsymbol{v}_i^{t+\Delta t} = \alpha \boldsymbol{v}_i^{SPH} + (1-\alpha)\boldsymbol{v}_i^{LSM}. \quad (2.1)$$

The proposed method adds a stickiness term, based on the method proposed by Clavet et al., to the velocity in order to consider sticky collision against an object as shown in Figure 2.

$$I^{stick} = -\Delta t k^{stick} \frac{1}{d_{stick}} \left(d_i^2 - \frac{d_{stick}^2}{4} \right) \frac{p_{n_1} + p_{n_2}}{|p_{n_1} + p_{n_2}|}. \quad (2.1)$$

Here, k^{stick} is a viscosity coefficient, d_i is the Euclidian distance between particles and the object, and d^{stick} is a threshold value. Preferably, the value of d^{stick} is 0.1. $\boldsymbol{p}_{n_1}$ and $\boldsymbol{p}_{n_2}$ are vectors perpendicular to the normal. The I^{stick} term is added to Eq. (2.1); thus, coordinates are updated as follows:

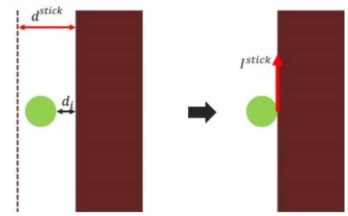

Figure 2: *Conceptual diagram of the sticky effect*

$$\boldsymbol{v}_i^{t+\Delta t} = \alpha \boldsymbol{v}_i^{SPH} + (1-\alpha)\boldsymbol{v}_i^{LSM} + I^{stick}. \quad (2.3)$$

$$\boldsymbol{x}_i^{t+\Delta t} = \boldsymbol{x}_i^{t} + \Delta t \boldsymbol{v}_i^{t+\Delta t} \quad (2.4)$$

3. Results

We performed an experiment in which we simulated a sticky viscoelastic material colliding with a wall. The number of vertices was 3375. All experiments are performed using a 3.40GHz Intel® Core™ i7-3700 CPU. As shown in Figure.1, it is possible to represent the stickiness between a viscoelastic material and wall. The proposed method performed the simulation with a total computation time that was the same as Takamatsu's method. The representation of the viscoelastic material required 103.1 (ms), whereas the representation of stickiness required only 2.5 (ms).

4. Conclusions

We have confirmed the utility of the proposed method. In the future, we wish to consider three things. First, we would like to represent plasticity and division of the viscoelastic material. In the proposed method, if the alpha value is large, division is possible; however it always recombines under the influence of Shape Matching. Second, we should consider volume preservation. If we can implement volume preservation, the shape is not bankrupt. In addition, it is important for the proposed method to improve computation efficiency for neighboring particle search and to take advantage of GPU implementation.

References

Kenji Takamatsu, Takashi Kanai, "A Fast and Practical Method for Animating Particle-Based Viscoelastic Fluids", *CASA 2011*

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