Fall over or Sliding down?

Yu Guo*
Shenzhen Institutes of Advanced Technology

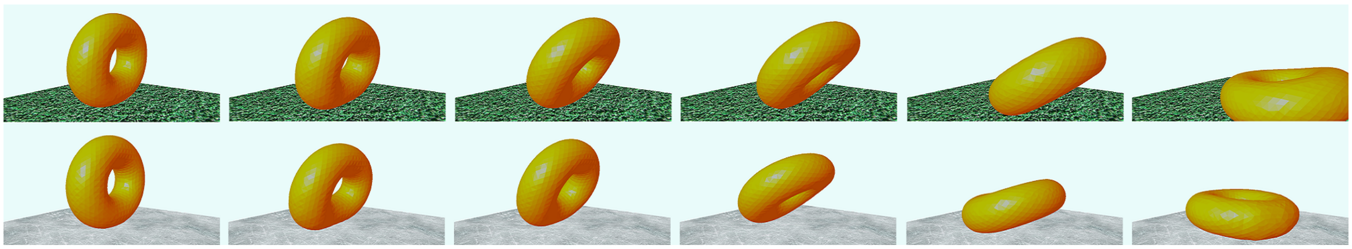

Figure 1: *Above: Fall over with static friction; Below: Sliding down with non-friction.*

1 Introduction

In animations and virtual reality, contact models have been widely used in many areas like rigid body collision and soft body deformation. Contact happens on a locally optimal configuration which forms Vertex/Face (VF) and Vertex/Vertex (VV) contacts. Several optimal methods have been developed to this, such as Continuous Collision Detection (CCD) and Linear Complementarity Problem (LCP) with Gauss-Seidel iterative solver [Kaufman et al. 2008].

Frictions and contact corrections affect each other at the in-contact moment. For accurately simulating the interplay between them, a robust and effective algorithm with iteration and optimization was needed. The complexity of the algorithm becomes the main bottleneck for the frictional contact model. In recent solid contact simulation, node based deformation method such as FEM [Irving et al. 2007] has been mostly used. We present a contact model depending on constraints coupled with frictions which is called portable frictional contact model. Although it does not reach the optimal result, the flexibility and convenience of our method make it an easier use in contact simulation.

2 Our Approach

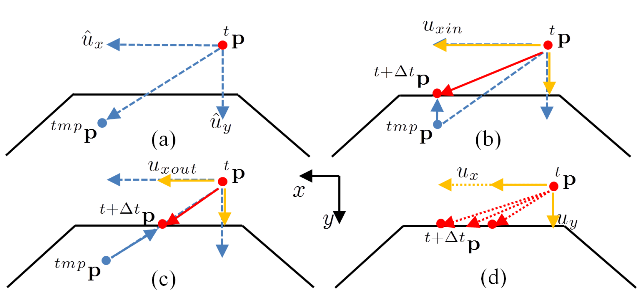

Figure 2: *(a) Displacement without contact. Contact with (b) non-friction; (c) static friction; (d) kinetic friction.*

In FEM simulation, a discrete system is described by a set of points contacting. We calculate displacement for each point i in isotropic time step Δt. Here (Fig.2) we use a 2D sketch to demonstrate the spatial situation. Blue vectors in (a) reflect that point i should have moved from ${}^{t}\mathbf{p}$ to ${}^{tmp}\mathbf{p}$ if it is no constraint. (b) represents non-friction case. Displacement (yellow vector) in y-direction is shortened by the constraint of local contact surface but in x-direction the displacement doesn't change. ${}^{t+\Delta t}\mathbf{p}$ is the final position of point i which is called in-projection. (c) represents static friction case in which out-projection is illustrated by the red vector. Displacement in x-direction keeps the original ratio to the displacement in y-direction. (d) shows the kinetic friction situation between (b) and (c). We obtain

$$ {}^{t+\Delta t}\mathbf{p} = {}^{t}\,\mathbf{p} + [u_x, u_y]^T \tag{1}$$

u_x stands for kinetic friction between static friction to non-friction, u_y is a constant value unless contact doesn't happen. Where

$$ (u_y/\hat{u}_y)\hat{u}_x = u_{xout} \leqslant u_x \leqslant u_{xin} = \hat{u}_x \tag{2}$$

3 Result

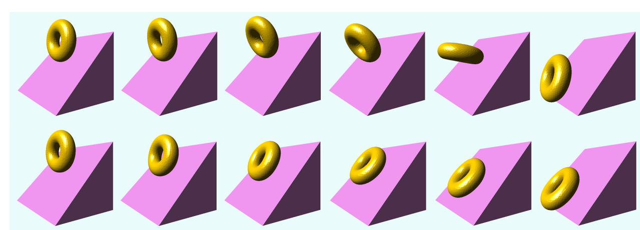

Figure 3: *Above: Fall over with static friction; Below: Sliding down with non-friction.*

Fig.1 and 3 exhibit results of our method. We use soft torus in Fig.1 to illustrate how the contact process looks like. The above figure shows that during the static friction effect the torus fall down in front of it and the below figure shows that without friction the torus only slip on its feet. In Fig.3, we change the torus to rigid material and use a 45° inclined plane to replace the horizontal plane. The above figure accurately describes the torus bounces, turns and flips with static friction. But the torus with non-friction slides down a sloped surface. Briefly speaking, simplest model brings good performance.

References

IRVING, G., SCHROEDER, C., AND FEDKIW, R. 2007. Volume conserving finite element simulations of deformable models. *ACM Trans. Graph. 26*, 3 (July).

KAUFMAN, D. M., SUEDA, S., JAMES, D. L., AND PAI, D. K. 2008. Staggered projections for frictional contact in multibody systems. *ACM Trans. Graph. 27*, 5 (Dec.), 164:1–164:11.

*e-mail:tflsguoyu@gmail.com

SIGGRAPH Asia 2012, Singapore, November 28 – December 1, 2012.
ISBN 978-1-4503-1757-3/12/0011