

Chapter 4.17

Soft-Touch Haptics Modeling of Dynamic Surfaces

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ABSTRACT

Virtual Reality applications strive to simulate real or imaginary scenes with which users can interact and perceive the effects of their actions in real time. Adding haptic information such as vibration, tactile array, and force feedback enhances the sense of presence in virtual environments. Haptics interfaces present new challenges in the situation where it is crucial for the operators to touch, grasp and manipulate rigid/soft objects in the immersive virtual worlds. Soft-touch haptics modeling is the core component in feeling and manipulating dynamic objects within the virtual environments. For adding the haptic sensations with interactive soft objects, the authors first present multiple

force-reflecting dynamics in Loop subdivision surfaces, and further the haptic freeform deformation of soft objects through mass-spring Bezier volume lattice. The haptic constraint modeling based on metaballs is experimented to intuitively control the interactive force distribution within the dynamically constructed constraint, making the soft-touch simulation of objects simple to manipulate with enhanced realism.

INTRODUCTION

Haptics studies the modality of touch and associated sensory feedback. In contrast to the other sensory channels such as visual and auditory, haptic interaction is the only technique that can provide touch-enabled dynamic & interactive 3D display to

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users. It is an active research field to improve the immersive reality of virtual environments (Chen & Sun, 2006), especially in simulations where it is crucial for the operators to touch, grasp and manipulate the virtual soft objects realistically as in the physical world. Soft-touch haptics modeling is the core component in feeling and manipulating dynamic objects within the virtual environments. Augmenting soft-touch realism in deformable objects provides new touch characteristic in addition with graphical display, and covers a wide range of applications (Aamissepp & Nilsson, 2003) such as geometric modeling, computer animation, and on-line game development.

We present soft-touch haptics modeling and rendering mainly in three themes: multiple force-reflecting dynamics in Loop subdivision surfaces; soft-touch physical freeform deformations; force constraints in interactive design. Loop subdivision is designed to generalize the recurrence relations for the three-directional quartic box splines to triangular meshes of arbitrary topology (Loop, 1987). Because triangular meshes arise in many applications, Loop subdivision becomes one of the most popular subdivision schemes. Subdivision surfaces are motivated to uniformly model any complex surfaces of arbitrary topology. Dynamic subdivision surfaces allow the shape editing of limit surfaces by applying forces interactively on the control meshes, and thus enable the creation of intuitive interface for geometric modeling such as modeling with clay dough. We incorporate the 6-DOF haptic interface in the dynamic modeling of Loop surfaces, where the dynamic parameters are computed easily without subdividing the control mesh recursively. During the haptic interactions, the contact point is traced and reflected to the rendering of updated graphics and haptics. Based on the multi-resolution surfacing representation, our approach permits the users to touch the virtual objects at the varying detailed surfacing levels, and manipulate the dynamics by applying the intuitive forces through the real-time haptic interface.

With the development of haptics techniques, implementing a realistic physics engine within games is possible. Lander simulated bouncy and trouncy response of particles under Newton's dynamics (Lander, 1999) and also mimicked crush effect of large massive objects via matrix deformation (Lander, 2000) in game development. However, the system didn't reflect the realistic force feedback to the players besides deformation in game engine. The demand for realistic haptic feedbacks at high refresh rate leads to additional computation complexity. Integrating non-physical methods with haptic feedbacks is not natural, and cannot provide realistic physical simulation of deformable objects. In our study, we propose the dynamic simulation of mass-spring systems and flexible control of free-form deformation technique in interactive haptics modeling. Through distributing physical properties including mass, spring and damping coefficients of the object to the bounded Bezier volume lattice, the deformations of the object in response to the haptic avatar follow the physical laws and acquire high working rate. Our haptic-freeform model provides touch-enabled simple interface and efficient performance in the flexible deforming controls, then letting the objects move in a dynamic, cartoon-like touching style.

How to add force constraints in interactive design is a challenge task that needs further investigation. Constrained deformation based on metaballs is a flexible technique for designing closed surfaces, and provides simple solutions for creating blends, ramifications and advanced human character design, but short of dynamic interaction of touch sensation. Our work is to apply soft-touch interaction during the process of such constrained deformations. The deformation based on metaball constraint yields a local result which satisfies the desired displacement precisely on the constraint skeleton C , and does not affect the points outside the effective radius R of the metaball M . We study how to apply soft-touch sensation in such deformation using metaball constraints,

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