EUROGRAPHICS 2009 / P. Dutré and M. Stamminger
(Guest Editors)

Volume 28 (2009), Number 2

A method for global elastic-plastic deformation for haptic interaction.

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Abstract

As realtime simulation of elastic-plastic defomation demands large amounts of calculation , it is limited to small-scale models. We propose a simulation method of global elastic-plastic defomation. In our method ,elastic-plastic defomation is simulated by rheologic model using LCP solver for stable simulation. In addition we present skin mesh using SSD and adapt rheologic model for joints.

Categories and Subject Descriptors (according to ACM CCS):

1. Introduction

3D animation is composed by a continuous Keyframe of the character. It is necessary to transform 3D model to produce the Keyframe. To transform 3D model, the key frame is made by moving the position of the control axis. However, it is difficult to operate the control axis of three dimensions with the mouse of two dimension device. Then, the method of easily operating the control axis in three dimensions is needed. The method of making the Keyframe by the motion capture using the doll is proposed in the research of the past. This method can easily make the Keyframe. However, it is a problem that the doll corresponding to the character is necessary. Therefore, the method by which it is possible to correspond to the character with various frames and Keyframe can be made easily is necessary. In our research, to make the Keyframe easily, the Keyframe is made by the virtual reality space by a physical simulation and the force feedback interface. Moreover,to do the operation similar to the doll in the virtual reality space, the transformation of ball-jointed doll is simulated. The deformation characteristic of the ball-jointed doll is an elastic deformation when the load is small, and the elastic-plastic deformation when the load is large. The operation similar to an actual doll in the virtual reality space becomes possible by simulating this deformation characteristic.

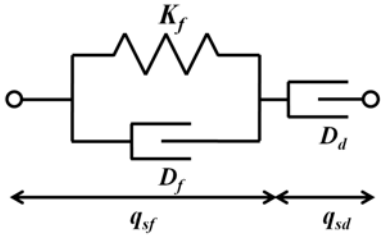

Figure 1: *Three-element model.*

2. Computation of elastic-plastic defomation

The deformation characteristic of the ball-jointed doll is simulated. Therefore, the transformation simulation that we are the elastic deformation when the load is small, and is the inelastic deformation when the load is large is made. The elastic deformation is simulated with Voigtmodel that connects the spring and the damper in parallel. On the other hand, the elastic-plastic deformation is simulated by three element model. (Figure.1) The deformation characteristic of the doll is simulated by switching from Voigt model to three element model by the size of the torque of the joint. Hasegawa proposes the method for simulating the Voigt model with stability. This thesis explains method that the three element models' transformations are simulated . Three element model is composed of Voigt model $q_{sf}$and damper q_{sd}. Moreover, the speed is described w, and power is described λ.

Figure 2: *Proposed character posture input system.*

Expression (1) consists of the relation between power and displacement.

$$\begin{cases} \lambda_s = -K_f q_{sf} - D_f w_{sf} = -D_d w_{sd} \\ q_s = q_{sf} + q_{sd} \end{cases} \tag{1}$$

Expression (1) is discretized by the Implicit Euler method.

$$w_s[t+1] = -C\lambda_s[t+1] - Dq_{sf}[t] \tag{2}$$
$$C = \frac{D_d + D_f + K_f h}{D_d(K_f h + D_f)}$$
$$D = \frac{K_f}{K_f h + D_f}$$

Expression (2) unites to the restraint conditional expression and the motion equation. In addition, the coalition type is solved with LCP(Linear Complementaly Problem). Thus, the elastic-plastic deformation can be simulated with stability.

3. Result

We built the transformation simulation of the globe joint doll into 3D model. In addition, 3D model is transformed by using the haptic interface.(Figure. 2) When force is presented, resistance by the transformation is felt as a reaction force by me. Moreover, the amount of the transformation was able to be adjusted according to the amount of power. Therefore, it was felt that it became easy for us to move the control axis of the character.