Physics Based Models for Viscoplastic Bodies applied to Free Form Modelling with Virtual Clay

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WORKSHOP   VIA 2004

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☒ Presentation   Session ☒ Physical models in virtual reality application

☐ Demo

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The paper has two main objectives : first, to demonstrate methods for modelling viscoplastic bodies in real time, and second, to present an application in VR for modelling free forms with virtual clay. Two physics based models are presented in this paper. The first one results from the dynamic equations in case of viscoplastic materials and the second one constitutes a simplified solution of first one, powerful in real time, and leading to a realistic behaviour of the materials.

Researches on Computer Graphics, Virtual Reality systems and CAD systems share at least one goal: providing methods for creating realistic pictures of natural phenomena. The attention of scientific community has been more and more drawn to problems involving models of soft bodies: elastic material, liquids and gaseous phenomena (like smoke). Because computing hardware is now at a stage where the computation of a simulation can be done in real time, numerical techniques have been proposed for many of the above problems. But if a great deal of research has been made on elastic material, liquids and gaz, relatively little has been produced in the area of viscoplastic models.

After a brief survey of the main models used for the simulation of soft bodies, we analyse the reasons why they are not suitable for viscoplastic case. Then, the paper goes through the equations of the physics involved in the simulation of viscoplastic bodies. The main characteristic of the viscoplastic materials is the way they flow. The dynamics of such materials can be precisely described by the Navier Stokes equation :

$$\rho\frac{\partial v}{\partial t}+\rho\left(\rho.grad\right)v=\rho f-gradp+\eta\Delta v \qquad (1)$$

where ρ is the density of the material, v is the velocity field, p is the pressure, η is the viscosity and f represents the external forces applied to the material. A second equation is also used ensuring the incompressibility of the material :

$$div(v) = 0 \qquad (2)$$

From these equations, we discuss the hypothesis that can be adopted for the simulation of the flowing of viscoplastic fluid. A numerical solution based on an explicit integration scheme is proposed to compute the solution given the initial conditions and the external pressure. In order to compute numerical values of the velocity field, a workspace discretized into voxels is used.

A second model is presented that constitutes a simplified solution of the first one when the viscosity of the material can be neglected. A numerical solution based on the use of cellular automata with different repartition rules is suggested. Results of simulation are presented in Figure 1.

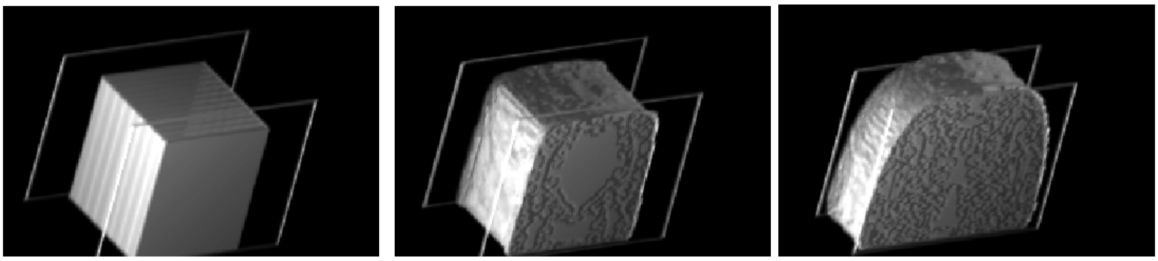

Figure 1 : Cube pressed by two big plates (repartition rule 3)

Finally, the paper presents an application for free form modelling with virtual clay. The objective of this application is to integrate into CAD systems or Virtual Environment the gesture of a specialist when he works viscoplastic materials. The displacements of the tool interacting with the material are measured through a human-machine interface and are interpreted through an interaction model to generate the pressure field applied to the physics based model of the material. The effects of the tool are reported in real time on the numerical model.