Research Topics at the CoGVis/MMC Group[*]

1 Introduction

The CoGVis/MMC group at the Faculty of Media at the Bauhaus–University Weimar has a cooperation with the ABS–CBN Foundation, Inc., which operates in the field of educational television for children on the Philippines. For these educational telecasts besides human actors hand–driven puppets are used.

Traditionally these puppets are made out of materials like foam, rubber and latex, but their production process is time consuming and therefore expensive. Due to these economical issues the cooperation aims in a computer aided alternative to the whole production process.

For this reasons our group is developing an artist friendly modeler for three-dimensional objects and a real–time simulation software, which is able to animate the puppets on the fly. The main challenge and the main difference to other modeling and animation tools, is that real world interaction is implemented, so that artists without experience in computer–aided modeling and animation can easily build and animate virtual puppets.

2 Computer Graphics Techniques

For computer–aided modeling and animation different computer graphics techniques are used.

2.1 Mesh Optimization

Real–time simulation of elastic materials requires an adequate representation of the models. On the one hand, our models should have a dense surface for good visual appearance, but on the other, the physically simulated mesh should be as least dense as possible due to performance reasons. To achieve this trade, we are using two different connected meshes: one dense surface mesh for rendering, and a reduced one for the physical simulation.

2.2 Realistic Surface Effects

The main challenge for the visualization of real-life materials is the highly complicated reflection behavior plus self occlusion and self shadowing of the material. For the visualization we use BTF-datasets and have developed an advanced rendering scheme to achieve real time frame rates at high visualization quality on mid cost graphics hardware. Furthermore several schemes for the simulation of grass and fur have been developed and fitted into applicable physical models.

3 Physical Simulation and Animation

An essential aspect when simulating latex puppets is the simulation of elastically deformable materials, which behave in a reasonable way when the puppeteer moves his fingers.

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Figure 1: Simulation of anisotropic reflections

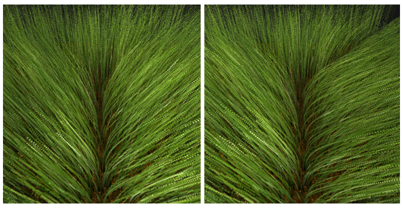

Figure 2: Simulation of grass

3.1 Glove Interaction

The puppeteer interacts with the virtual puppet via a low cost hand glove. In the modeling step, interaction regions (node groups) are defined. During the real–time animation process, the movement of the fingertips is converted into forces and fed to the physics engine as external forces acting on the corresponding nodes.

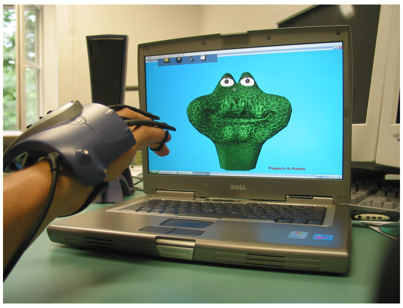

Figure 3: Animation of a puppet with a data glove

3.2 Mass-Spring Solver

The simulation of deformable materials in real–time requires an adequate material model, by which animation can be achieved at a computation complexity allowing real–time application. At the moment, we are using a system of mass points linked by springs as such a model.

Since the movement of masses through space is determined by the Newtonian laws of motion, simulating a system of masses results in a large system of differential equations.

Numerically solving such a system in real–time still remains as a big challenge in Computer Science. We are therefore implementing and analyzing different existing numerical methods as well as following new ideas in this direction.

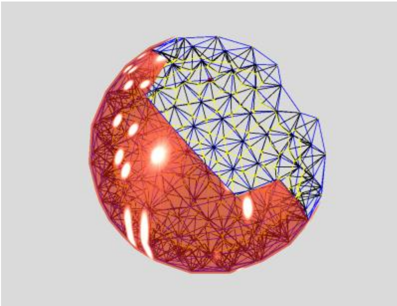

Figure 4: mass-spring system used for animation

3.3 Collisions

Another rudimental component in physically–based animation applications is collision detection and response. Processing, for instance, only two deformable objects by conventional collision detection algorithms, the number of the operations to be performed will be tremendously high. For this reasons, we currently research techniques for collision detection which uses positioning information, and which apply probability models, in order to reduce the number of computations.

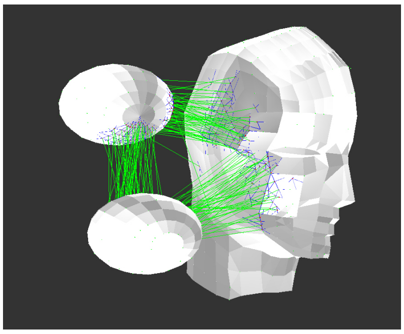

Figure 5: Colision detection of two models

3.4 Skeleton–based Simulation

For simulating stiff objects, such as the extremities of a puppet, a skeleton based physical simulation is used. This means that the skeleton of an object is used to hold an elastic skin. The skeleton itself is generated automatically out of the original object by computing the medial surface.

3.5 Facial Animation

Based on psychological work and an existing facial animation solution, a system is developed which provides facial actions for humanoid characters of various proportions. The use of adapted non–linear deformations based on performance driven motion data provides the animation artist with a fast, flexible and intuitive tool for animation.

Figure 6: Facial animation of an polygon model

4 Interaction Techniques

To simulate real world modeling interactions is the main aim of the modeler, which uses parametric objects like Non–Uniform–Rational–B–Splines (NURBS).

4.1 Trimming

Trimming (cut) an area directly out of a NURBS model is a challenging task, because the input is on the visual 3D cartesian representation of the 2D parametric mathematical model. The trimming itself is done on the mathematical representation, but there is a lack of computing the visual input direct on the math model. To solve this problem we are using an inverse evaluation of the NURBS object.

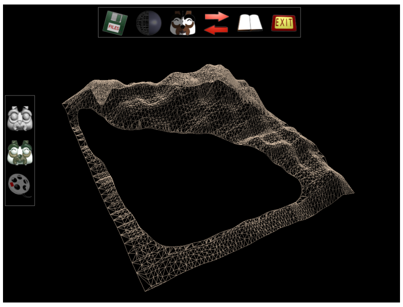

Figure 7: Direct trimming of a parametric surface

4.2 Deformation

The same problem with direct input on NURBS has effect on deformation, but it doesn't need to be done with the same accuracy, because here the control points are effected and not the surface. For this reason we are working with pseudo-inverse B-Spline basis functions.

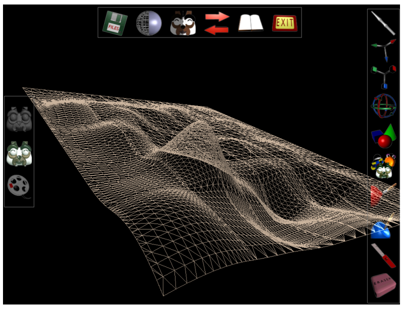

Figure 8: Direct deformation of a parametric surface