holes and automatic or user assisted hole-triangulation, elimination on request of complex vertices and faces, elimination on request of small components, etc
- a mesh simplification library, which performs out-of-core simplification adopting the quadric error metric approach (see Figures 1 and 2)
- a detail preserving library, which resamples bump- or rgb-texture to encode the high frequency detail lost during simplification (see Figure 2)
- a visualization module and GUI components

Our system supports management and simplification of up to O (10^9) triangles meshes. The time overhead due to the external memory management is affordable.

The only other approach which supports out-of-core simplification of huge meshes is the out-of-core clustering solution recently proposed by Lindstrom at Siggraph 2000. This solution is very easy to implement but, unfortunately, it has the drawbacks of the clustering approach: the simplified mesh quality is much lower than the quality of simplified meshes produced with the edge collapse approach, simplification is not adaptive to surface shape and many topological degenerated situations are introduced. We have compared the results produced by OOC Clustering and our OEMM edge collapse simplifier on the same dataset (the David mesh of the Digital Michelangelo Project) and the improvement of shape accuracy supported by our solution was significant.

This project has been developed with the financial support of the Progetto Finalizzato 'Beni Culturali' of the Italian National Research Council and the Project 'RIS+' of the Tuscany Regional Government. Scanned data are courtesy of the Digital Michelangelo Project, Stanford University (USA).

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A Graphical System for Internal Density Modelling by Coons Bodies

by Silvester Czanner and Roman Durikovic

The rise of solid modelling as a principal medium for mechanical product description can be traced to the requirement of informational completeness of geometric representations. Unfortunately, traditional geometry-based systems do not contain the important information neededfor some engineering designs. Many unambiguous solid representation techniques like primitive instancing, cell decomposition, constructive solid geometry have one limitation, they cannot offer ways of representing internal behavior.

In the mechanical industry it is very important to know not only the description of the surface, but also about the interior and the density of the object. Therefore, there was a need for a system which makes it possible to model the interior density of the 3D parameter solids.

A Project between the Software Department of the University of Aizu and the Department of Computer Graphics and Image processing of the Comenius University exists to support and develop a new methodology for representing an internal structure of density of 3D objects. The main goal of the project is to develop a graphical system for modelling and visualizing the interior structures and density of 3D objects. It allows a developer to make modifications into internal structure of 3D object in a natural and intuitive way.

The system can also modify and composite 3D objects (basic elements) to an arbitrary 3D shape. The elements used are so called parametric solids. We are using three types of parametric solids, namely Coons body 0, 1 and 2. The bodies are defined as an extension into four-dimensional space of well-known Coons patches in B-splines form.

Each of the three Coons bodies have different abilities to control the interior structure. The simplest and most limited is Coons body 0 where only the shape of quadrilateral can be changed. Coons body 1 allows the user to control the interior by modification the control points along the edge curves of a parametric solid. The most general is the Coons body 2, having the ability to modify shape and interior by all control points within the boundary surfaces of a parametric solid.

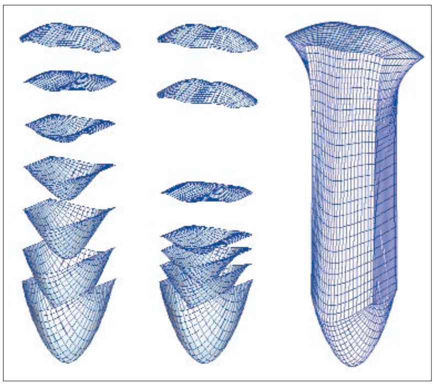

Figure 1: Nail as Coons body 2 with two different interior density distributions applied as initial conditions for two FEM simulations of internal tension.

To understand the interior structure of 3D objects several visualization methods are used. The easiest way to visualize a parametric solid is to display it as a set of isoparametric surfaces. Another option is to visualize a shaded object together with projected parametric curves corresponding to constants u, v and w. The most difficult option is to show the interior changes in time as metamorphoses between two Coons bodies.

The most useful elements are Coons bodies 2. Since, any of them is a B-spline

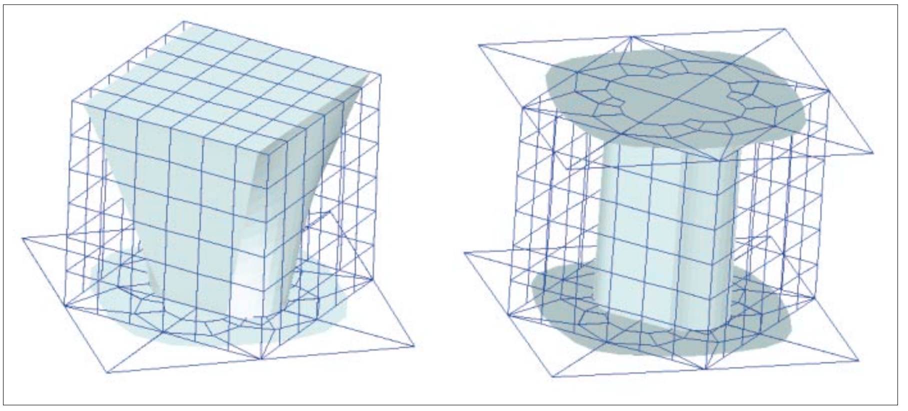

Figure 2: Modelling a spool as Coons body 2 starting from a cube.

Figure 3: Shape represented with five Coons bodies 2..

volume, the shape continuity is simply controlled in a similar way as it is for B-splines. The system can create more complicated shapes such as a composition of several Coons body elements.

Implementation is done under the Linux Red Hat 6.2 operating system and the objects are stored in a scientific format SILO.

The authors see the advantage of this graphical system in the ability to define the boundary and internal initial conditions prior to numerical simulations. Parametric solids can be effectively applied on finite elements with irregular or trimmed boundaries to avoid difficult problems in model design for Fine Elements Methods.

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Multiresolution Modelling of Surface and Volume Data

by Leila De Floriani, Paola Magillo and Enrico Puppo

Multiresolution models have become very popular during the last few years to manage the increasing complexity of surface and volume data visualization. This topic is the subject of several research projects carried out by the geometric modelling and computer graphics group at the Department of Computer and Information Sciences of the University of Genova. Major applications concern terrain modelling in the context of Geographical Information Systems, 3D object modelling, and volume visualization.

The resolution of a geometric model is related to the number of primitives used to represent the details of a shape. Resolution has an impact both on the accuracy of the representation (thus, on the similarity of the model to the real object) and on the size of the data structures (thus, on computational efficiency).

Modern tools both for acquisition of geometry from real world, and for computer-aided design, can provide models at very high resolution. These models are very accurate but often too large to be effectively used in rendering, especially at an interactive rate. Multiresolution refers to the possibility of representing a spatial object at different resolutions, trying to balance the opposing issues of having sufficient accuracy and small size.

The key idea is that usually high resolution is not needed everywhere; the level of resolution can be variable in space and time. For instance, a three-dimensional scene can be rendered using a resolution which is higher near the viewpoint, since many details are required only close to the observer; in an interactive visualization program with a moving viewpoint, the resolution should be adapted dynamically.

Variable resolution is crucial, eg, for real-time visualization in virtual reality (aircrafts, ships, buildings...), scientific data visualization (three-dimensional fields such as temperature, pressure...), geographic information systems (terrain), medicine (volume data from TAC, SPECT...).

Since the production of a model at a specified (variable) resolution is computationally expensive, a multiresolution model is built off-line as a comprehensive structure which organises several pre-computed resolutions and supports a fast on-line combination of different resolutions into a single model, according to user parameters.

The DISI research group has developed the Multi-Tesselation (MT) model, a general multiresolution model for spatial data that does not depend on:

- the dimension of the data (it can model surfaces in space, solid objects, volume data, scalar fields in any dimension...)
- the process used to generate the resolutions that contribute to the model