Multiresolution Free Form Object Modeling with Point Sampled Geometry

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Abstract In this paper an efficient framework for the creation of 3D digital content with point sampled geometry is proposed. A new hierarchy of shape representations with three levels is adopted in this framework. Based on this new hierarchical shape representation, the proposed framework offers concise integration of various volumetric- and surface-based modeling techniques, such as Boolean operation, offset, blending, free-form deformation, parameterization and texture mapping, and thus simplifies the complete modeling process. Previously to achieve the same goal, several separated algorithms had to be used independently with inconsistent volumetric and surface representations of the free-form object. Both graphics and industrial applications are presented to demonstrate the effectiveness and efficiency of the proposed framework.

Keywords object hierarchy and geometric transformation, feature representation, three-dimensional graphics and realism, system and information processing

1 Introduction

Three dimensional (3-D) geometric models have been widely used for many years for engineering simulation and visualization. Nowadays with the decreases in the cost of commodity computers and the increases of Internet bandwidth, complex free-form models are made accessible to a much larger audience; the potential of using these models is expanded beyond now the well established game market to new applications ranging from virtual museums to e-commerce.

Traditionally parametric surfaces such as tensor product B-spline patches are the most adopted form for free-form shape modeling[1] and the generalization of non-uniform rational B-splines (NURBS) is considered as the de facto CAD standard. Recently with the advances in 3-D digital photography and scanning technology, complex free-form models become ubiquitous through the processing of large sets of point samples.

In this paper we study multiresolution free form models represented by sets of points which we referred to as *point sampled geometry*[2]. Since point sets are discrete in nature while physical objects to be described must have connected volume bounded by continuous surfaces, to build an efficient framework to process point-sampled geometry, we have to answer the following questions.

1) Which mathematic form the point sampled geometry should be represented in? For example, a parametric surface, or an implicit surface, or else that is continuous and approximates/interpolates the set of points.

2) Given a specified mathematic form, how to render/visualize the point-sampled geometry efficiently? For example, any rendering scheme that supports real-time shape editing (or modification).

3) Does that chosen mathematic form support various shape editing operations? If it does, can those operations be efficiently implemented?

In this paper we propose a general framework for multiresolution free-form modeling in point sampled geometry with the answer to the above three questions. This paper, which is condensed from the first author's dissertation[2], is organized as follows. The related work is presented in Section 2. A new hierarchy of shape representations that is adopted in the proposed framework is presented in Section 3. The necessary transformation procedure among the proposed shape hierarchy with an associated geometric modeling/editing toolbox is presented in Sections 4 and 5. In Section 6 we present both industrial and graphical applications

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