A RESEARCH PERSPECTIVE ON SOLID MODELING

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EXTENDED ABSTRACT

The solid modeling systems that emerged in the 1970's offer some important advantages over alternative means for describing industrial parts and products for CAD/CAM applications. These advantages accrue largely because solid modeling demands (1) that a clear distinction be made between computer-based representations of solid objects (sometimes called "geometric models") and the algorithms that utilize representational data to do useful things, and (2) that the representations used be "geometrically complete." This paper offers a research perspective on past and current trends in solid modeling.

Three major lines of research were pursued throughout the 1970's. The first dealt with representation schemes for solid objects. A number of schemes were identified, and a theoretical framework evolved in which the various approaches could be analyzed and compared. Boundary representations (in which a solid is described in terms of its bounding "faces" and "edges") and Constructive Solid Geometry (in which a "complex" solid is described as a Boolean composition of "primitive" solids) found the widest acceptance because each is geometrically complete and covers a domain sufficient for most functional mechanical parts. Other known schemes (e.g. translational and rotational sweep, primitive instancing, cell decomposition) are frequently used either as a basis for user input, to represent geometric objects at the lowest levels of boundary and CSG schemes, or as auxiliary approximate representations for computational purposes.

A second line of research focused on the design of "core" algorithms to build, maintain, and convert between geometric representations and to solve mathematical problems such as surface/surface intersection and edge/solid classification.

The third main line of research dealt with the use of solid modeling in few key applications. Examples include the generation of graphic renderings (both shaded color and engineering line drawings), mass property analysis, and the verification of programs for numerically controlled machine tools.

As the decade neared its end, representational principles and computational techniques for relatively simple solid objects, e.g. those bounded by subsets of quadric surfaces, were well in hand. Research began and is continuing in a number of important areas. Highlights include:

-- The use of solid models in more advanced applications. Examples include automatic finite element mesh generation, dynamic interference testing, and various "model driven things" (e.g. robot programming, vision, machining, and process planning).

-- The study of representations and mathematical algorithms for extending current systems to include "blending" or more general sculptured surfaces.

-- The study of techniques aimed at making current systems more efficient either through the use of clever algorithms that seek to exploit "object locality" (or "coherence") or through special hardware.

Solid modeling has moved out of its infancy and is gaining a foothold in industrial CAD/CAM. While enough is known to build useful solid modeling systems today, many challenging technical issues remain and considerable research is needed to fully exploit their potential.

KEYWORDS: Solid Modeling