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Abstract:

Solid modeling systems are always central modules of CAD systems. The degree of robustness of this type of software depends on the principles underlying its design. This work presents a short description of the architecture and the modeling process of a new hybrid solid modeling system called GeneSys. The concept of full perspective modeling is also presented.

Keywords:

Solid modeling system, CAD systems.

GENESYS - A NEW HYBRID SOLID MODELING SYSTEM

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INTRODUCTION

Solid Modeling Systems are always central modules of CAD Systems. The degree of robustness of this type of software depends on the principles underlying its design. This work presents the architecture and the modeling process of a new Hybrid Solid Modeling System (**HSMS**), called **GeneSys** [4][5].

The fundamental idea underlying the design of **GeneSys** is its ability to integrate multiple representations schemes consistently. The approach for such a hybrid modeling system has been strongly advocated by Requicha [8] and Chiyokura [2], as the only way to compensate the limitations of individual representation schemes.

The development of **Genesys** follows the design criteria pointed out by recent research on Intelligent CAD (**ICAD**) [3]. In this approach the following aspects are considered: **Modeling Process, Geometric Consistency, Knowledge Representation,** and **Perception/Cognitive Needs**. Moreover, one of the basic assumptions of **GeneSys** is that solid modeling should be carried out in a full 3D perspective environment.

THE ARCHITECTURE OF A HYBRID SYSTEM

GeneSys is a hybrid system in the sense that it integrates an extended Boundary Representation Scheme (**BRep**) with a modified Constructive Solid Geometry (**CSG**) modeling tree (called history tree). The domain of both representations is restricted to physical realizable manifold solids.

GeneSys adopts an extended **BRep** scheme with the following characteristics:

(a) the ordinary **BRep** hierarchy is extended to include the entities **World-Object-Solid**;
(b) attributes/geometry are separated from the topological data structure;
(c) the adjacency relationships are implemented through a winged-edge data structure (Baumgart [1]).

The ordinary **CSG** tree has been modified in order to be incorporated into **GeneSys**. The nodes of the modified **CSG** tree store not only boolean operators but also high-level modeling operators. These high-level operators are implemented in terms of basic operations (**BOP**'s) which can be geometric or topological operations (Chiyokura [2]). This new **CSG** tree represents not only the history design process of the solid but also its assembly hierarchy.

THE MODELING PROCESS

GeneSys hybrid architecture gives more flexibility to the modeling process and extends the domain of the modeling space that the system can represent. Although sometimes it is natural for users to proceed with global operations like the union of two solids, most of the time the solids are more easily modified through direct transformations (i.e. local operations). **GeneSys** supports both techniques.

The authors have confirmed the strong inclination users have to organize the world in a sound and simple hierarchy. The basic hierarchy of **GeneSys** (i.e. **World-Object-Solid**) satisfies this need.

One of the most important characteristic of **GeneSys** is the possibility to manipulate solids by walking in a dynamic history tree (which produces updated visual versions of 3D entities). In the history tree, the user can undo/redo operations followed by the creation of new branches with no loss of information. This process of modeling is often done by users when they are looking for new versions of a specific solid.

The modeling process is carried out in a two-window environment. One window contains the history tree and the other is used for full 3D perspective modeling.

GEOMETRIC CONSISTENCY

GeneSys tackles the problem of geometric consistency at a higher level through the **Geometric Modeling Interface** (**GMI**) module and the **High-Level Operations** (**HOP**) module. All the modeling techniques are based upon compact and efficient low-level operators, leaving to **GMI/HOP** all the responsibility to achieve geometric consistency. The **GMI** module is capable of interactively guiding the user during the modeling process. This characteristic of the system inhibits the user to incur into basic geometric mistakes, such as the splitting of a triangular face. The **HOP** module treats the geometric processes that are not interactively done by the user, such as boolean operations. **HOP** also provides high-level modeling tools to **GMI**. This approach is much more realistic than any attempt to insert geometric tests in **BOP**'s. Moreover, in this case, the undo/redo basic operations (**BOP**'s) are very efficient.

KNOWLEDGE REPRESENTATION

The question of knowledge representation for Solid Modeling Systems comprises topics of Intelligent User Interface, Pictorial Information and Design Automation. These topics are too complex to be presented in this work. However, the authors believe that the data structure and the history tree of **GeneSys** can be used as a lower level support to the future development of a Knowledge-Based CAD System.

The attributes of the data structure can be used as slots to store parameters for Pictorial Reasoning, Feature Modeling and Product Modeling [7]. The history tree can also help the incorporation of semantics into the system. Furthermore, it can be used for both generation and recognition of 3D entities (in contrast to the usual systems that only generate them, as pointed out by Helm and Marriot [6]).

PERCEPTION AND COGNITIVE NEEDS

The question of satisfying perception and cognitive needs of the user is taken very seriously in the design of **GeneSys**. In the case of Solid Modeling Systems this question is quite clear: users do not adapt themselves to the three-dimensional environment provided by CAD systems. The reasons are twofold:

- The users great difficulty to manipulate 3D solids on a 2D screen;
- The skill that users have developed to manipulate 3D objects through their projections (i.e. technical drafting) along many years;

A solution to this problem is to encourage users to develop new skills based on their cognitive needs for 3D perception, such as modeling in a full perspective environment. Some special features have been developed in order to satisfy these needs, e.g.: **Solid Dynamic Manipulation** and **Solidness Perception**. Also, it has been observed that the modeling process described above (with its two-window environment) satisfies the user's cognitive needs.

CONCLUSIONS

The approach presented in this work leads to a more robust, reliable and efficient Solid Modeling System for Computer Graphics Applications. Also, **GeneSys** has introduced an original approach to the question of cognitive needs and 3D perception in Solid Modeling Systems. The main innovative results are as follows:

- The hybrid characteristic of the system is achieved by integrating two distinct representations in a straightforward and consistent way.

- The architecture of **GeneSys** provides robust, efficient and consistent geometric/topological modeling techniques implemented via the **GMI→HOP→BOP** pipeline.
- The extended **BRep** and history tree seem to be quite appropriate to incorporate knowledge representation.
- The extended **BRep** and history tree integrate the intuitive hierarchy of the assembly planning process and the modeling process.
- The extended **BRep** provides a high modular structure which is ready to incorporate additional features, object oriented methods and more complex geometry information.
- The extended **BRep** seems to be an appropriate structure to incorporate parametric relationships into the system.
- The set of features of **GeneSys** that enhance the user's 3D perception provides the necessary support for full perspective modeling. This approach is the keystone to achieve effectiveness and to induce users to place reliance upon CAD Systems.

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