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Open Kernel System for Modeling Non-manifold Models Based on Partial Elements

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ABSTRACT

Conventional solid or surface modeling systems cannot represent both complete solid model and abstract model in a unified framework. Recently, research on non-manifold modeling system has been accomplished to solve this problem.

This paper describes the open kernel system for modeling non-manifold models which has been developed during last three years. It summarizes the data structure for non-manifold models, system modularization, and the typical characteristics of each module in the system.

A data structure based on partial-topological elements is proposed to represent the relationship among topological elements. It is efficient in the usage of memory and has topological completeness compared with other published data structures. It can handle many non-manifold situations such as isolate vertices, dangling edges, dangling faces, a mixed dimensional model, and a cellular model.

The kernel system is modularized hierarchically. Among the kernel modules, there are geometry modules, topology modules, high level modeling modules, and API modules.

The geometry modules involve two sub-modules hierarchically; curve and surface sub-modules. If a surface modeling system is to be constructed, there is no need to handle topological elements, and it can

be constructed with the geometry module alone. If a 2D drafting system is considered, only the curve sub-module is extracted to make a compact 2D drafting system. To represent the geometry of the curves and the surfaces, NURBS are used. However, the curves and the surfaces have the information about their types; straight line, arc, plane, cylindrical surface, etc., an efficient algorithm for each type can be applied.

The topology modules include the modules for the classification of topological elements, the search of their relationship, and the Euler operators which realize the modeling process mathematically.

The high level modeling modules include several sub-modules for the following tasks; primitive generation, sweeping, sheet model generation, wire model generation, Boolean, rounding, local modification, transformation, interface, and undo/redo. The local modification sub-module covers tweaking operation and modifying operation of the curves and surfaces in a similar way to surface modelers. The sub-modules are independent each other with one exception, i.e., the rounding sub-module is dependent on the sweeping sub-module in that the blending surface for the rounding operation is generated by sweeping operator. The high level modeling module has two typical characteristics. The first, modules have characteristics as a non-manifold modeling kernel. Especially sweeping, Boolean, rounding, and local modification have non-manifold characteristics. Non-solid model such as a sheet model and a wire model are treated equally to a solid model as a natural result of non-manifold modeling system. Thus, modeling operations such as sweeping, Boolean, rounding, and local modification can be applied to solid models or non-solid models. The second, the system treats the n-sided patch as one surface. N-sided patch problem occurs in rounding and local modification operations. In that case, a surface for that patch is derived in the form of NURBS by using the method of interpolating the boundary curves and their cross derivatives.

API modules enable us the usage of the kernel modules mentioned above. Through API modules, the various modeling operations can be used.

The UIF modules are also implemented to package the modeling kernels into an interactive modeling system. The UIF modules are developed using OpenGL and X window in SGI INDIGO2. Since OpenGL and X window have a good interchangeability, our system can be ported in a variety of hardware systems. Actually the current system is ported to a PC running Windows NT by replacing the X libraries with WIN32 libraries.

Keywords: CAD, modeling, non-manifold, open, kernel, NURBS, hierarchy, modularization