Preface

This issue is devoted to aspects of computer-aided design (CAD). The objectives of CAD are to provide means for the design and analysis of products and their manufacturing environments to ensure high-quality, economical, error-free designs, created with high productivity and short lead times. These objectives are tied to the concept of using interactive systems to synthesize designs and, through exhaustive analysis, to ensure that they are error free. Effective user interfaces, together with speed of feedback of such systems, are intended to allow rapid design, analysis, and, at least, iterative optimization. Further benefits can come from organization that allows previously serial steps to be executed in parallel; in particular, by providing a design database that allows product and manufacturing design to proceed together.

The paper on solid modeling for production design describes one of the first uses of a high-function solid modeling system for design and analysis of a complex product in a production environment. The product, large CPU mainframes, can be characterized as being assemblies of large numbers of relatively simple parts. The system achieves acceptable performance through approximate and simple object surface representation. The technology and, more importantly, the process of moving a research activity into production use are described.

Two papers describe techniques for direct handling of higher-order surfaces and their intersections. Many modeling systems support the natural quadric surfaces of the sphere, cone, cylinder, and plane. However, engineering applications also require the torus. Adequate analytical tools for the representation of intersections of natural quadrics with tori are not known. The paper on piecewise-circular curves presents a new form of smooth interpolation, based on the use of circular arcs. The technique was created to provide approximate means of treating intersections with tori. The paper on trimmed-surface algorithms develops rigorous mathematical techniques for describing and using boundaries of objects that are trimmed from surfaces by intersections with other surfaces.

In performing geometric calculations in a digital computer, one is brought immediately to the problem of representing and manipulating real numbers with the data types available. The paper on simple unit vectors explores a basic problem in three-dimensional computer geometry in terms of what can be done exactly and what must be approximated.

The modeling systems used in CAD often must represent transformations that take place in an object, either as part of the designer's conceptual process or as a result of manufacturing operations. The paper on shaping geometric objects by cumulative translational sweeps describes a new parametric algorithm for modifying the boundary of an object. By suitable choice of parameters, the algorithm can be used to represent a range of physical phenomena, including expansion, shrinkage, and others arising in semiconductor manufacture.

The two papers on a Voronoi decomposition algorithm and its implementation contain several interesting lessons. In the field known as computational geometry, a very theoretical approach is generally taken. Algorithms are proposed and analyzed for their worst-case performance. Since geometric singularities occur with vanishing probability, they are not included. The algorithms are generally complex and difficult to implement. The two-dimensional algorithm dealt with in the two papers is general in the sense that it handles all multiply-connected polygonal domains, and yet is simple enough to allow straightforward implementation. Although it does not have the best known worst-case computational complexity, its ease of implementation and coverage of all cases make it of interest. The implementation paper describes a novel use of Voronoi decomposition in the characterization and performance analysis of multilayer two-dimensional VLSI wiring geometry. It is interesting to note that the algorithm was created as applied research in its own right, and that its application to analysis of VLSI layouts came from a chance conversation at a conference.

In the general area of design and analysis of systems that depend on several physical phenomena, the bond graph has emerged as a tool for representing the flow of energy, e.g., mechanical, electrical, and magnetic. The automation of the analysis of nonlinear systems based on bond graphs requires the automatic generation of the analytic representation of the system and the automated production of numerical solutions. The paper on R-fields in bond graphs addresses a problem in the automated production of numerical solutions and describes a means for significantly reducing computation time.

Many of the techniques discussed and presented in this issue are often computationally intensive. The paper on simulated annealing describes studies of how to exploit a parallel machine architecture to speed up execution of an important wiring and chip placement system.

Finally, the papers in this issue generally relate to existing systems and individual technologies. What does the future hold? CAD systems are generally very large, and are expensive to construct and maintain. Important areas for future work are to provide appropriate system architectures and languages, and to address the problem of making the systems more economical in terms of human resources.

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