This is the first of two theme issues on computer-aided geometric design (CAGD). The second will appear in January 1993. In a nutshell, CAGD deals with the mathematical representation of geometrical objects to facilitate computer-assisted representation, analysis, and display. This concept emerged in the early 1970s and has grown into a vital and active area of study and research. Today, it enjoys the support typically accorded any scientific discipline: workshops, seminars, textbooks, and journals.

The Society for Industrial and Applied Mathematics (SIAM) sponsors a conference series with meetings about every two years, the most recent being in Tempe, Arizona, in November 1991. While I did not plan this special issue as a chronicle of that meeting, the two are closely linked through the participants and contributors and the themes and topics.

Throughout this project, one of my main goals was to provide readers of IEEE CG&A with the best possible CAGD articles. To this end, the announcements and solicitations for papers mentioned an extensive reviewing process. Even though authors generally know that heavy refereeing means extra effort in the form of revisions and compromises, this did not seem to deter them. The sheer number of high quality papers received made the selection process quite difficult, even with two issues allowed the topic.
My second major goal was to provide readers with an overview of CAGD. The general approach used for compiling a collection of papers for a special issue does not always guarantee broad coverage. Fortunately, in this case the papers cover a large percentage of the topics that make up CAGD.

Much of CAGD work concerns the core theme of computer-aided design, analysis, and production of 3D objects. The paradigm of constructive solid geometry associated with the area of solid modeling has proven to be powerful. Aristides Requicha and Jarek Rossignac take a broad view of solid modeling, surveying this area with an emphasis on recent (over the past 10 years) advances.

Usually, implicit methods are associated with solid modeling. The defining equations are kept simple so as to facilitate geometric processing operations such as intersections or offsets. Simple equations diminish the possibility of free-form shapes, yet design with higher order implicit equations does not seem to have a bright future. This dilemma adds support to the use of parametric surface patches such as nonuniform rational B-splines (NURBS). Gerald Farin gives a tutorial and survey on NURBS. We hear a lot about NURBS these days, and it is generally accepted that this class of parametric patches is rapidly becoming a de facto industry standard. Actually, NURBS have been around since the early days of computer graphics. They are a direct result of applying B-splines in the context of homogeneous coordinates. A thorough study of this subject should include these earlier works.

A different and less well-known approach to free-form surface representation is surveyed by Michael Lounsbery, Stephen Mann, and Tony DeRose. These methods consist of an assembly of triangular patches, and they can handle very general topologies. While the mathematical developments are rather elegant, empirical results with these methods indicate the need for further research.

The outer surface of an automobile body is a prime example of a free-form surface. Before a mathematical surface can be accepted as a design, it is extremely important to analyze its quality. This requires tools beyond conventional graphics rendering. Hans Hagen and his associates survey surface interrogation methods in their article.

While parametric surfaces are, in general, necessary for the representation of free-form surfaces, in some cases you can use the more simple functional representation. For example, if the surface is to be "stamped," then you must be able to represent it by a function. James Cavendish and Samuel Marin describe a system based upon a functional representation specially suited to multifeatured surfaces such as those found in automobile inner panels.

The use of a Bernstein basis for representing polynomials has proven useful in CAGD. In addition to the geometric interpretation of the coefficients (control points), this representation provides stability and other parameters important in numerical calculations. When a parametric polynomial is represented in Bernstein form, it is called a Bezier curve or surface. Thomas Sederberg and Rida Farouki introduce the idea of interval-valued control points and illustrate the usefulness of their new interval Bezier curves.

Triangulations, tessellations, and, more recently, medial axis transforms are all concepts that have proven to be invaluable in the mathematical representation of geometric objects. David Lavender and his colleagues extend the notion of a Voronoi diagram to solid models and discuss algorithms for computing it.

Stay tuned for more. The articles in the January 1993 issue will match the high quality presented here. You will see additional material on the implicit/algebraic versus parametric approach to object modeling, plus articles covering other CAGD topics. These topics will include geometric processing, triangulations and tessellations, cyclides, blossoming, and scattered data interpolation.

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