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Literature Review

Art694x12 History of Computer

Graphics

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## Literature Review: **Freeform Curves and Surfaces**

### **Introduction:**

Free-form curves and surfaces were developed to describe curved 3-D objects without using polyhedral representations which are bulky and intractable. To get a precise curve with polygons might require thousands of faces, whereas a curved surface requires much less calculations.

The development of Free-form curves and surfaces for computer graphics begins late 60s with, P. de Casteljau (Citroen) and P. Bezier (Renault), engineers in the french auto industry. Bezier created the UNISURF CAD system for designing cars which utilized his curve theories. P. de Casteljau's research was earlier than Bezier, but was never published so Bezier get most of the credit. These men were pioneers in Computer Aided Geometric Design (CAGD) for the auto industry, which replaced the use of hand drawn french-curve templates in design of auto bodies. Bezier curves were based on Bernstein Polynomials which had been developed by the mathematician Bernstein much earlier. Another kind of basic curve predating the Bezier was the Hermite Curve developed by the mathematician C. Hermite.

Also in the same era as Bezier, Schoenberg, a mathematician at the University of Wisconsin was working on Mathematical Splines, which would influence the work of S. Coons at MIT in Splines, Bicubic Surface Patches, Rational Polynomials around 1968. A surface patch is freeform curved surface defined by two or more curves. A. Forrest at MIT and Riesenfeld at Syracuse in 1973 based their research into Parametric B-Splines on Coon's work. The main difference between B-Splines and Bezier curves is the former allows for local control of key control points and the later has more of a global control system. B-Splines are also faster to calculate for a computer than cubic polynomial based curves like the Hermite and Bezier. Riesenfeld's pioneering development of B-Splines later influenced the E. Catmull's research at Utah.

### **Research at the University of Utah:**

The major breakthroughs in in CAGD were the theory of Bezier surfaces and Coons patches which were later combined with B-spline methods.

E. Catmull, a computer scientist at Utah, developed the first algorithm for the

**Literature Review: —————○** display of curved surfaces in 1974. In the same year a CAGD Conference at the University of Utah included discussion of B-Splines by R. Barnhill.

**Freeform Curves and Surfaces**

### **B-Splines and Beta-Splines:**

Some notable research done on B-splines was done by M. Cox in 1971, C. de Boor in 1972, W. Boehm in 1980, G. Farin in 1982, and T. DeRose in 1988. I. Faux and M. Pratt wrote about B-Splines from a CAD / CAM viewpoint in 1979 applying computer graphics to manufacturing like Bezier.

The Beta-Spline, which a generalization of the uniform cubic B-Spline, was essentially developed by B. Barsky. at the University of California, Berkeley in 1981. Barsky was on of the curve researchers group called "the Killer Bs" which included R. Bartel and J. Beatty from the University of Waterloo, in Ontario.

Many variations of B-Splines have been developed since the 1970s and 80s including NURBS (nonuniform rational B-splines) as described by W. Tiller in 1983, Subdivision Curves, and Trimmed Surfaces as described by R. Farouki and J. Hines in 1985.

### **Important Terms:**

*B-Spline* - A piecewise polynomial function. A spline curve is expressed in terms of B-splines. It is easier to piece curves together using B-splines rather than Bezier curves because they use a set of blending functions that have local support only - the location of the curve depends on only a few control points. Contributors to B-spline development: Ahuja, Catmull and Rom, Clark, Coons, Cox, deBoor, Forest - 1970s.

*Beta-splines* - a generalization of the uniform cubic B-Spline, developed by B. Barsky. at the University of California, Berkeley in 1981.

*Bezier Curves* - polynomial curves expressed in terms of Bernstein polynomials. Part of the UNISURF system developed by P. Bezier. Based on a family of functions called Bernstein polynomials.

*Polynomial Curves* - includes Bezier Curves and .NURBs

*NURBs* - Nonuniform rational B-spline curves

*Computer Aided Geometric Design (CAGD)* - pioneered by P. de Casteljaou (Citroen) and P. Bezier (Renault), auto designers in the 1960s.

*control points* - a common way of controlling the shape of a curves in a predicable way

**Literature Review:** ———○ *piecewise* - a function describing only a small piece of a curve

**Freeform Curves and Surfaces**

*rational polynomials* - defined by the algebraic ratio of two polynomial functions. Developed by Rowin, Roberts, Coons, and Forrest in the 1960s.

*Surface Patches* - the locus of all points of a moving or deforming curve. A surface is often broken down into patches. First developed by Coons.

*others* - quadric surfaces, natural splines, Coons surfaces, etc.

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