

SIGGRAPH 93
20th International Conference
on Computer Graphics and
Interactive Techniques

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COURSE NOTES 25

**Modeling, Visualizing and Animating
Implicit Surfaces**

ORGANIZERS

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LECTURERS

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Pacific Data Images
Jim Blinn
California Institute of Technology
John Hart
Washington State University
Geoff Wyvill
University of Otago



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Modeling, Visualizing, and Animating with Implicit Surfaces

Welcome to Modeling, Visualizing, and Animating with Implicit Surfaces

In this course we will survey implicit surfaces, discuss their usefulness, describe their advantages and disadvantages relative to other modeling techniques, and present the latest techniques for their design. Until recently, implicit surfaces have received little attention, partly due to the difficulties of visualizing them interactively. From the moment one realizes that it is easier to draw a circle with $(r \cos \theta, r \sin \theta)$ than it is with $(x^2 + y^2 = r^2)$, one is slowly led away from the world of implicit surfaces.

Welcome back!

Implicit surfaces are different from parametric surfaces. The latter, in use in many commercial modeling systems, are familiar to most of the computer graphics community. Implicit surfaces aren't necessarily less practical, they are simply different. They require different techniques for their creation, modification and visualization and have different properties and applications from their parametric counterparts.

The speakers in this course will discuss their current work in developing techniques to make implicit surfaces practical in modeling and animation. By definition, implicit surfaces embrace an extremely large set of surfaces. Undoubtedly, as they receive increased use in computer graphics, concepts will be developed that unify and distinguish various implicit forms. We hope the variety of approaches, applications and results presented in this course will stimulate interest in this exciting branch of modeling.

Brian Wyvill, *Calgary, Alberta*
Jules Bloomenthal, *Palo Alto, California 1993*

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Speaker Biographies

Chandrajit Bajaj, PhD Chandrajit is a professor of Computer Science at Purdue University and directs the Collaborative Modeling Laboratory. His group has developed a client/server, distributed and collaborative geometric design environment called SHASTRA, which allows multi user interactive modeling and visualization of algebraic surfaces in both implicit and parametric form.

Thad Beier, MSc After graduating from Johns Hopkins University, Thad performed research and animation at the New York Institute of Technology Computer Graphics Lab for five years. He then conducted research and animation for eight years at Pacific Data Images, where he is R&D technical director.

Jim Blinn, PhD Jim is a professor at the California Institute of Technology and prominent contributor to Computer Graphics. His many papers have greatly influenced Computer Graphics and are amongst the most cited works in the field. Jim is a recent recipient of a prestigious MacArthur Foundation grant for his work in educational computer graphics animation.

Jules Bloomenthal, MSc Jules studied Computer Graphics at the University of Utah and subsequently conducted research at the New York Institute of Technology and Xerox P A R C. He has published several papers on the use of implicit surfaces in modeling natural forms.

John Hart, PhD John is an assistant professor at Washington State University. He received his M S and Ph D through the Electronic Visualization Laboratory, University of Illinois at Chicago. Although his graduate research focused on 3 D fractals, John is currently researching general implicit surface applications.

Brian Wyvill, PhD Brian is a professor at the University of Calgary where he leads the GraphicsJungle research group. In addition to publishing several papers on modeling and animation, Brian has directed several animations (two shown at SIGGRAPH) that feature implicit surfaces.

Geoff Wyvill, PhD Geoff is a senior lecturer at the University of Otago, New Zealand, and director of Animation Research Ltd. His numerous computer graphics interests include CSG systems, high performance ray tracing, and the modeling of natural phenomena. Geoff serves on the editorial board of The Visual Computer and the editorial board of Visualization and Computer Animation.

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Course Schedule

Please note that the times are approximate

MORNING	
Overview	
Modeling Speakers Blinn, Bloomenthal, BAJAJ, G Wyvill	Algebraic Surfaces (60 min) Skeletal Primitives and Blends (30 min) Implicit Patches (30 min) Deformations (15 min) Constructive Solid Geometry (30 min)
AFTERNOON	
Visualization Speakers B Wyvill, Bloomenthal, Hart, G Wyvill	General Tiling Techniques (30 min) Unusual Visualization Techniques (30 min) Ray-tracing (30 min) Texturing (30 min)
Animation And Design Systems Speakers B Wyvill, Beier	Modeling (30 min) Commercial Applications (30 min)
Demonstrations Speaker Beier	Interactive Modeling System (30 min)

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Modeling	
1 1 to 1 22	A Generalization of Algebraic Surface Drawing by James Blinn Transactions on Graphics, July 1982
2 1 to 2 23	The Algebraic Properties of Homogeneous Second Order Surfaces by James Blinn in Mathematics of Computer Graphics course notes, SIGGRAPH 1984 and in Modeling with Implicit Surfaces course notes, SIGGRAPH 1990
3 1 to 3 15	Implicit Algebraic Surfaces & Free Form Deformations by Chanderjit Bajaj
4 1 to 4 7	Implicit Surfaces in CSG Systems by Geoff Wyvill (unpublished)
Polygonization	
5 1 to 5 8	Data Structure for Soft Objects by G Wyvill, C McPheeters, and B Wyvill The Visual Computer, August 1986
6 1 to 6 20	Polygonization of Implicit Surfaces by Jules Bloomenthal Computer Aided Geometric Design, November 1988
7 1 to 7 15	Evaluation of Implicit Surface Tilers by P Ning and J Bloomenthal Computer Graphics and Applications, to appear (1993)
8 1 to 8 6	Table Driven Polygonization by B Wyvill and D Jevans (unpublished)
Blending	
9 1 to 9 22	Using Implicit Surfaces to Blend Arbitrary Solid Models by Alyn Rockwood Transactions on Graphics, October 1989
10 1 to 10 6	Convolution Surfaces by J Bloomenthal and K Shoemake SIGGRAPH '91
11 1 to 11 3	Hand Crafted by Jules Bloomenthal Proc of the 4th Annual Western Computer Graphics Symposium, Banff, Alberta, April 1992

12 1 to 12 18 **Techniques for Implicit Modeling**
 by Jules Bloomenthal
 Xerox PARC Technical Report P89-00106
 (and in Modeling and Animating with Implicit Surfaces course notes,
 SIGGRAPH 1990)

Rendering

13 1 to 13-15 **Ray Tracing Implicit Surfaces**
 by John Hart (unpublished)

14-1 to 14 11 **Sphere Tracing**
 by John Hart (unpublished)

15-1 to 15 5 **Ray Tracing Soft Objects**
 by G Wyvill and A Trotman (unpublished)

16-1 to 16-5 **Texturing Implicit Surfaces**
 by Geoff Wyvill (unpublished)

17-1 to 17-7 **Solid Texturing of Soft Objects**
 by G Wyvill, B Wyvill, and C McPheeters
 Computer Graphics and Applications, December 1987

Interaction and Animation

18-1 to 18-8 **Interactive Techniques for Implicit Modeling**
 by J Bloomenthal and B Wyvill
 Computer Graphics, March 1990

19 1 to 19 10 **Metamorphosis of Implicit Surfaces**
 by Brian Wyvill (unpublished)

20-1 20-10 **Practical Uses for Implicit Surfaces in Animation**
 by Thad Beier (unpublished)

Recommended Reading (not included in course notes)

Free-Form Deformation of Solid Geometric Models
by Thomas Sederberg and Scott Parry, SIGGRAPH 1986

Smooth Piecewise Quadratic Surfaces
by W Dahmen, in Mathematical Methods in Computer Aided
Geometric Design, ed by T Lyche and L Schumaker
Academic Press, Boston, 1989

Electronic Models of the Human Anatomy
by Chanderrjit Bajaj
in Curves and Surfaces in Computer Vision and Graphics II,
Proc Symposium on Electronic Imaging Science & Technology,
vol 1610, Boston, 1991, p 230-237

**Interactions between Flexible Solids an Implicit Formulation
for a Precise Contact Modeling**
by Marie-Paule Gascuel, SIGGRAPH 1993