FINAL TECHNICAL REPORT

The Fifth Biennial SIAM Conference on Geometric Design was held in Nashville, TN from November 3-6, 1997. The conference brought together researchers and practitioners from industry, government, and academia to discuss the mathematical and computational problems in the application of geometry to current problems of design, manufacturing, and the sciences. A large percentage of the attendees came from overseas, and the percentage from industry was very high.

The themes of the conference included the traditional themes of curve and surface design, solid modeling, CAD/CAM, geometric algorithms, and reverse engineering, but also industrial applications, multiresolution analysis, robotics, and visualization.

The eight invited speakers (listed in the appendix below) were chosen to reflect the themes of the conference while at the same time providing broad coverage of some of the hottest topics in the area. The speakers were chosen to provide a balance between industry and academia, and between domestic and international researchers. Minisymposia were solicited to complement the invited presentations, and were selected to cover subjects where major new developments have occurred in the two years since the last conference. This year's minisymposia dealt with CAD systems issues, computational geometry and topology, geometric accuracy, subdivision, CAGD in kinematics and robotics, scientific visualization, computers and education, reverse engineering, curve and surface fairing, and shape optimization.

At previous conferences there had been up to four parallel sessions for minisymposia and contributed sessions. Conference attendees strongly requested that this parallelism be reduced, and that in addition, the length of the conference be shortened to four days, providing more free time for informal discussions. The meeting tried to accommodate these concerns by

1) reducing the number of parallel sessions to two,
2) scheduling six focus sessions which included an introductory lecture by a junior moderator, followed by short contributed presentations and a general half-hour discussion,
3) including a plenary evening poster session.

The poster session was very well-attended, and two prizes were awarded for the best posters. The meeting also included nine standard contributed papers sessions consisting of over fifty presentations.

Preceding the conference there was a short course entitled "Wavelets for Geometric Modeling and Computer Graphics". Course instructors were Tony DeRose, Hughes Hoppe, Peter Schroeder, Wim Sweldens, and Joe Warren.

DISCLAIMER

Conference Summary:

The Geometric Design Conference attracted over 250 researchers from both academia and industry. All sessions were well-attended, and considerable discussion and interaction seems to have taken place.

Submitted by:

Tony DeRose
Larry L. Schumaker
Conference Co-chairs

Society for Industrial and Applied Mathematics
3600 University City Science Center
Philadelphia, PA 19104-2688

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Attachment to Report

Invited Presentations:

"Life After NURBS: Adventures with a Triangular Surface Modeler"
David Gossard
Massachusetts Institute of Technology

"Classical Geometry and CAGD"
Wendelin L. F. Degen
University of Stuttgart, Germany

"Subdivision Schemes for Variational Problems"
Joe Warren
Rice University

"Conservative Perturbations"
John Canny
University of California, Berkeley

"Scalar Fields, Isosurfaces and Geometric Modeling"
William Lorensen
GE Corporate Research and Development

"Hierarchical Methods in Computer Graphics"
Hans-Peter Seidel
Universitat Erlangen, Germany

"Scattered Data Modeling"
Morten Daehlen
SINTEF, Norway

"On NURBS and Triangles"
Paul Besl
Alias/Wavefront, Inc.

CONF-9711208--Absts.

FINAL PROGRAM AND ABSTRACTS

Fifth SIAM Conference on

GEOMETRIC DESIGN 97

November 3-6, 1997

Loews Vanderbilt Plaza Hotel

Nashville, Tennessee

Sponsored by SIAM Activity Group on Geometric Design

And immediately preceding the conference...

SIAM Short Course on Wavelets in Computer Aided Geometric Design and Graphics

November 2, 1997, Loews Vanderbilt Plaza Hotel, Nashville, Tennessee

Conference Themes

- CAD/CAM
- Curve and Surface Fitting
- Geometric Algorithms
- Industrial Applications
- Multiresolution Analysis
- Reverse Engineering
- Robotics
- Solid Modeling
- Visualization

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Society for Industrial and Applied Mathematics

http://www.siam.org/meetings/gd97/gd97home.htm

Contents

Get-Togethers

- **Welcoming Reception**
  Sunday, November 2, 1997
  6:00 PM-7:30 PM
  Belmont Room
- **Old-Fashioned Southern BBQ/Country Music Show**
  Tuesday, November 4, 1997
  6:30 PM-9:30 PM
  Vanderbilt University Stadium Club
  Cost: $39
- **Poster Session and Reception**
  Wednesday, November 5, 1997
  6:15 PM-8:00 PM
  Belmont Room
- **Business Meeting: SIAM Activity Group on Geometric Design**
  Wednesday, November 5, 1997
  8:00 PM-8:30 PM
  Belmont Room

Funding Agency

SIAM thanks the Department of Energy and the National Science Foundation for their support in conducting this conference.

A Message from the Conference Organizers...

Dear Colleagues:

Welcome to Nashville and the Fifth SIAM Conference on Geometric Design, sponsored by the SIAM Activity Group on Geometric Design.

The program includes 8 invited presentations, 9 minisymposia on topics of special current interest, 6 focus sessions with an emphasis on audience participation, 9 contributed sessions, and a poster session. While it will still be difficult to choose, this time there are never more than two simultaneous sessions.

The success of this meeting depends on you, the participant. You can help make it a success by actively participating in the discussions and attending the poster session (which will include refreshments, and two prizes for the best presentations).

Remember the evening events: the welcoming party on Sunday, the BBQ/Country Music blowout on Tuesday, and the poster session and reception followed by the SIAG/GD business meeting on Wednesday.

Many thanks to the members of the organizing committee for their help in planning and organizing this conference, and to all of you who are making presentations, moderating focus sessions, or chairing contributed sessions.

Tony DeRose and Larry Schumaker
Co-chairs, Conference Organizing Committee

Audiovisual Notice

Two standard overhead projectors and two screens will be provided in every meeting room. Speakers with special audiovisual equipment needs should inform SIAM of their specific requirements by Friday, October 10, 1997. If we do not hear from speakers by that date, it is understood that a standard overhead projector is all that is needed. October 10 is a firm deadline.

If a speaker sends a request for special audiovisual equipment and decides not to use the requested equipment after it has been installed, or does not show up to give her/his presentation, the speaker is responsible for paying the rental fee.

Some examples of special audiovisual equipment and rental fees are:

LCD Panel	$250	26" Data Monitor	$200
35mm Slide Projector	$38	Shure Mixer	$25
Video Projector	$500	IBM PC Computer	$225
1/2" VHS VCR	$55	Xenon 35mm Projector	$200

Organizing Committee

Tony DeRose, Co-chair
Pixar Animation Studios

Larry Schumaker, Co-chair
Vanderbilt University

Richard H. Bartels
University of Waterloo, Canada

Wolfgang Boehm
Technische Universität Braunschweig, Germany

Rosemary E. Chang
Silicon Graphics Computer Systems

Nira Dyn
Tel-Aviv University, Israel

Miriam Lucian
The Boeing Company

Helmut Pottmann
Technische Universität Wien, Austria

Andrew J. Worsey
Middle Tennessee State University

Program Overview

Following are subject classifications for the sessions. The codes in parentheses designate session type and number. The session types are contributed presentations (CP), focus sessions (FS), invited presentations (IP), and minisymposia (MS). The poster session will take place on Wednesday evening.

CAD/CAM

CAD Systems Issues (MS1)
Geometric Accuracy (MS3)
Geometry Extraction (FS1)
Life After NURBS: Adventures with a Triangular Surface Modeler (IP1)
Medial Axis Transforms and Offsets (CP5)
On NURBS and Triangles (IP8)
Reverse Engineering (MS8)
Surface Processing (CP6)

Curve/Surface Design

Blending and Cyclides (CP9)
Classical Geometry and CAGD (IP2)

Program Overview (continued)

Computers and Education (MS7)
Curve/Surface Fairing and Shape Optimization (MS9)
Curve and Surface Construction (CP1)
Curve Interpolation and Approximation (CP7)
Developable Surfaces (FS4)
Geometry Construction (FS5)
Geometry Extraction (FS1)
Hierarchical Methods in Computer Graphics (IP6)
Reverse Engineering (MS8)
Scattered Data Modeling (IP7)
Subdivision (MS4 and FS3)
Subdivision Schemes for Variational Problems (IP3)
Scattered Data Fitting (FS6)
Scalar Fields, Isosurfaces and Geometric Modeling (IP5)

Geometric Algorithms

Computational Geometry and Topology (MS2)
Computers and Education (MS7)
Geometric Accuracy (MS3)
Geometry Extraction (FS1)
Geometry Construction (FS5)
Medial Axis Transforms and Offsets (CP5)
Surface Processing (CP6)
Subdivision (MS4)
Scalar Fields, Isosurfaces and Geometric Modeling (IP5)

Multiresolution Methods

Hierarchical Methods in Computer Graphics (IP6)
Multiresolution Methods (CP2)
Rendering and Imaging (CP4)
Subdivision Schemes for Variational Problems (IP3)

Robotics

CAGD in Kinematics/Robotics (MS5)
Conservative Perturbations (IP4)

Solid Modeling

Geometric Accuracy (MS3)
Solids I and II (CP3 and CP8)

Visualization

Hierarchical Methods in Computer Graphics (IP6)
Rendering and Imaging (CP4)
Scientific Visualization (MS6)

SIAM Short Course on Wavelets in Computer Aided Geometric Design and Graphics

Sunday, November 2, 1997

Loews Vanderbilt Plaza Hotel, Nashville, Tennessee

Organizer

Tony DeRose, Pixar Animation Studios

Description

Wavelets are powerful new mathematical tools for hierarchically decomposing functions. They are becoming increasingly important in computer graphics and geometric modeling. They have, for instance, recently been applied to image editing and compression, automatic level-of-detail control for editing and rendering curves and surfaces, surface reconstruction from contours, and fast methods for solving simulation problems in global illumination and animation.

The course offers: a broadly accessible introduction to the underlying theory of wavelets, a survey of a wide range applications to problems such as those listed above, and an overview of a number of advanced topics.

Who Should Attend?

The course was designed to be of interest to practitioners, teachers, and researchers in computer graphics, geometric modeling, CAD/CAM, and scientific computing.

Recommended Background

No prior knowledge of wavelets is assumed. A good working knowledge of linear algebra is helpful, as is familiarity with simple curve and surface interpolation methods.

Course Instructors

Tony DeRose
Pixar Animation Studios

Hugues Hoppe
Microsoft Research

Peter Schröder
California Institute of Technology

Wim Sweldens
Lucent Technologies, Bell Laboratories

Joe Warren
Rice University

Program

Morning

8:30 AM	**Registration**
9:00 AM-9:15 AM	**Introduction** *Tony DeRose*
9:15 AM-10:15 AM	**The Basics, Part I** *Peter Schröder and Wim Sweldens*
10:15 AM-10:45 AM	**Coffee**
10:45 AM-11:30 AM	**The Basics, Part II** *Peter Schröder and Wim Sweldens*
11:30 AM-12:30 PM	**Applications** *Tony DeRose*

Afternoon

12:30 PM -2:00 PM	**Lunch**
2:00 PM-3:00 PM	**Theory of Surface Wavelets** Joe Warren
3:00 PM-4:00 PM	**Spherical Wavelets** Peter Schröder and Wim Sweldens
4:00 PM-4:30 PM	**Coffee**
4:30 PM-5:30 PM	**Progressive Meshes** Hugues Hoppe
5:30 PM-6:00 PM	**Multiresolution Meshing** Peter Schröder

SIAM Short Course on Wavelets in Computer Aided Geometric Design and Graphics (continued)

Biographies

Tony DeRose

Tony DeRose is currently a member of the Tools Group at Pixar Animation Studios. He received a BS in Physics in 1981 from the University of California, Davis; in 1985 he received a Ph.D. in Computer Science from the University of California, Berkeley. He received a Presidential Young Investigator award from the National Science Foundation in 1989, and in 1995 he was selected a finalist in the Discover Awards for Technological Innovation Discover Awards.

From September 1986 to December 1995 Dr. DeRose was a Professor of Computer Science and Engineering at the University of Washington. From September 1991 to August 1992 he was on sabbatical leave at the Xerox Palo Alto Research Center and at Apple Computer. He has served on various technical program committees including SIGGRAPH, and from 1988 through 1994 was an associate editor of ACM Transactions on Graphics.

His research has focused on mathematical methods for surface modeling, object reconstruction from range data, and more recently in the use of multiresolution and wavelet techniques in computer graphics.

Hugues Hoppe

Hugues Hoppe is a researcher in the Computer Graphics Group of Microsoft Research. His main area of interest is geometric modeling. Recently, his efforts have focused on level-of-detail (multiresolution) representations for storage, transmission, and rendering of complex polygonal models. Hugues has also done research on the reconstruction of geometric models from 3D scanned data, using meshes, subdivision surfaces, and B-spline surfaces. He received a BS summa cum laude in electrical engineering in 1989 from the University of Washington, and a MS and PhD in computer science and engineering from the University of Washington in 1991 and 1994 respectively.

Peter Schröder

Peter Schröder currently holds an appointment as assistant professor of computer science at the California Institute of Technology. Prior to Caltech and a short stint as postdoctoral research fellow at Interval Corporation (summer 1995) he was a postdoctoral research fellow at the University of South Carolina department of mathematics and a lecturer in the computer science department, where he worked with Prof. Björn Jawerth and Dr. Wim Sweldens. He received his PhD in computer science from Princeton University in 1994 for work on "Wavelet Methods for Illumination Computations." Prior to Princeton he was a member of the technical staff at Thinking Machines, where he worked on graphics algorithms for massively parallel computers. In 1990 he received an MS degree from MIT's Media Lab. He did his undergraduate work at the Technical University of Berlin in computer science and pure mathematics. He has also held an appointment as a visiting researcher with the German national computer science research lab (GMD) and its visualization group.

Prof. Schröder is a world expert in the area of wavelet based methods for computer graphics. He helped pioneer the use of fast wavelet solvers for illumination computations and developed (with Dr. Sweldens) the first practical spherical wavelet transform. Multiresolution techniques have been the subject of many invited lectures and courses he has given in Europe and North America for academic and industrial audiences; he is one of the invited plenary speakers at this year's SIAM conference. His publications record ranges from WIRED magazine to Siggraph conferences and special scientific journal issues on wavelets. In 1995 he was awarded a prestigious NSF CAREER award and named a Sloan Fellow.

Wim Sweldens

Wim Sweldens is a researcher at the Mathematics Center of Lucent Technologies, Bell Laboratories. (Lucent Technologies is the former systems and technology part of AT&T.) He received his PhD in May 1994 from the Katholieke Universiteit Leuven, Belgium, for his work on wavelet constructions and applications in numerical analysis. Until May 1995 he was a postdoctoral research fellow at the University of South Carolina. In his PhD dissertation he introduced the notion of "Second Generation Wavelets," a generalization of classical wavelets which allows wavelet transforms for irregularly sampled data and data defined on complex geometries. Later he discovered the "Lifting Scheme," a very general and easy to implement construction of Second Generation Wavelets, which can also be used to introduce wavelets without the use of Fourier analysis. More recently, his work has been concerned with the application of wavelets to computer aided geometric design and computer graphics. He has lectured widely on wavelets and their applications throughout Europe and the United States as well as in three SIGGRAPH courses. He is the founder and current editor of the Wavelet Digest, a newsletter on the Internet concerned with wavelets.

Joe Warren

Joe Warren received his B.A. from Rice University in Mathematics and Computer Science in 1983. He received his Ph.D. from Cornell University in Computer Science in 1986. His general interests include geometric modeling, geometric design, computational geometry, and computer graphics. His current research focuses on the relationship between partial differential equations, wavelets, and subdivision. Dr. Warren is an associate professor of Computer Science at Rice University.

Registration

Registration fees for the short course include course notes, lunch, and coffee breaks.

Monday, November 3

MORNING

7:30 AM-4:00 PM Registration

Room: Centennial Ballroom Foyer

8:15 AM-8:30 AM

Welcoming Remarks and Announcements
Tony DeRose and Larry Schumaker, Co-Chairs
Room: Belle Meade

IP1
Life After NURBS: Adventures with a Triangular Surface Modeler

8:30 AM-9:15 AM

Chair: Rosemary E. Chang, Silicon Graphics Computer Systems

Room: Belle Meade

Summary not received at press time.

David Gossard
Department of Mechanical Engineering
Massachusetts Institute of Technology

IP2
Classical Geometry and CAGD

9:15 AM-10:00 AM

Chair: Miriam Lucian, The Boeing Company

Room: Belle Meade

In the past, powerful methods to solve theoretical problems were developed in classical geometry but little attention was paid to explicit calculation and approximation of geometric objects. The speaker will present some of these methods, show their usefulness for CAGD purposes, and discuss practical tools that can be derived from them. In particular, the principle of invariance upon a certain transformation group, some tools of projective (differential) geometry applied to rational curves and surfaces and the classical geometries of Moebius, Laguerre and Lie, taking place in projective model spaces of higher dimensions and recently being introduced into CAGD research to solve problems of reflections and offsets, will be discussed.

Wendelin L. F. Degen
University of Stuttgart, Germany

10:00 AM-10:30 AM Coffee

Room: Centennial Ballroom Foyer

MS1
CAD Systems Issues

This session on CAD Systems Issues has been cancelled. A new session is being organized by Robert Blomgren, Silicon Graphics. Information on the new session, and speakers will be on a separate flyer to be distributed at the conference.

10:30 AM-12:30 PM

Room: Belle Meade

MS2
Computational Geometry and Topology

10:30 AM-12:30 PM

Room: Cheekwood

The traditional view of computational geometry is that it studies algorithms for discrete geometric problems such as computing the convex hull of a set of points. The emphasis is on combinatorial methods and algorithms with fast asymptotic running time. A more recent development is the study of discrete topological problems motivated by questions of connectivity and continuity, a development that complements traditionally strong numerical research.

This minisymposium offers an introduction to the wide spectrum of research in computational geometry and topology. The speakers will present leading edge research in geometric algorithm design and demonstrate the continuity between geometry and topology.

Organizer: Herbert Edelsbrunner
University of Illinois, Urbana-Champaign

10:30 Kinetic Data Structures
Leonidas J. Guibas, Stanford University

11:00 Maintaining Delaunay Complexes under Motion in R^3
Michael A. Facello, Raindrop Geomagic Inc., Urbana, IL

11:30 Minimization of Mathematical Energies for Surfaces
John Sullivan, University of Minnesota, Minneapolis

12:00 Computing Homology Groups of Simplicial Complexes
Sumanta Guha, University of Wisconsin, Milwaukee

AFTERNOON

12:30 PM-1:45 PM Lunch (Attendees will be on their own)

MS3
Geometric Accuracy

1:45 PM-3:45 PM

Room: Belle Meade

Accuracy in geometric models has important consequences. Accuracy affects not only data transfers, but, more seriously, internal consistency of geometry. Inaccuracies are, however, a natural result of geometric construction and processing algorithms. Experience shows that no geometry system can eliminate all inaccuracies. Thus, geometry systems must manage errors. This requires that concepts be precisely understood and defined. In this minisymposium, the speakers will discuss some possibilities for dealing with these problems.

Organizer: Miriam L. Lucian
The Boeing Company

1:45 Gaps and Discontinuities - Accuracy Issues
Miriam L. Lucian, Organizer

2:15 Understanding and Managing Errors in Geometric Modeling
David R. Ferguson, The Boeing Company

2:45 Topology and Semantics Relative to Geometric Accuracy
Thomas J. Peters, University of Connecticut, Storrs

3:15 Title to be announced
Leon Seitelman, Independent Consultant

CP1
Curve and Surface Construction

1:45 PM-3:45 PM

Chair: John Roulier, University of Connecticut, Storrs

Cheekwood Room

1:45 Planar Interpolating G^2 Composite Bézier Curves
Richard R. Patterson, Indiana University-Purdue University, Indianapolis; Marco Paluszny and Francisco Tovar, Universidad Central de Venezuela, Venezuela

2:05 Producing Smooth Convex Curves with Feature Point Constraints
Hui Guan and Tatsuo Torii, Nagoya University, Japan

Monday, November 3

2:25 Freeform Curve Design Using Implicit Polynomial Models
Zhibin Lei and David B. Cooper, Brown University

2:45 Mesh Simplification with Smooth Surface Reconstruction
Oleg Volpin, Alla Sheffer, Michel Bercovier, and Leo Joskowicz, The Hebrew University, Israel

3:05 Conic Rescue of Rational Cubic Splines with Interval Tension
M. Sarfraz and H. M. Aiyaz, King Fahad University of Petrolium and Minerals, Saudi Arabia

3:25 Iterative Methods for Constructing Tension Splines
B. I. Kvasov and P. Sattayatham, Suranaree University of Technology, Thailand

3:45 PM-4:15 PM Coffee

Room: Centennial Ballroom Foyer

FS1

Geometry Extraction

4:15 PM-6:15 PM

Moderators: Tomas Varady, Hungarian Academy of Sciences, Hungary; and Bert Jüttler, Technische Universität Darmstadt, Germany

Belle Meade Room

Finding the Exact Topological Structure Determined by a Set of Curves
Paulo C. P. Carvalho, Instituto de Matemática Pura e Aplicada, Brazil; Luiz Henrique de Figueiredo, Laboratório Nacional de Computacão Científica, Brazil; and Paulo Roma Cavalcanti, Universidade Federal do Rio de Janeiro, Brazil

An Algorithm for Determining and Classifying Triangular Quadric Patches
Gudrun Albrecht, Technische Universität München, Germany

A New Approach to the Surface Intersection Problem
Thomas Grandine, The Boeing Company

A Fast Algorithm for Computing the Degenerate Intersections of Two Quadric Cones
Ching-Kuang Shene, Michigan Technological University

Degenerate Normal Vectors of Tensor Product Surfaces
Yasushi Yamaguchi, University of Tokyo, Japan

Multisurface Geodesic Curve Generation Utilizing Computational Geometric Tools
James D. Marlar, Northrop Grumman Corporation, Pico Rivera, California

FS2

CAD Editing

4:15 PM-6:15 PM

Moderators: Gerald E. Farin, Arizona State University; and Hans Wolters, SDRC, Milford, Ohio

Cheekwood Room

A Design Intent Representation Scheme for Dimension-driven Geometry
Ashok V. Kumar and Rohit Chandra, University of Florida

Using Farin Points for Rational Bezier Surfaces
Holger Theisel, University of Rostock, Germany

NURBS Based Advanced Surface Editing Tools for Design Engineers
Chris K. So and James D. Marlar, Northrop Grumman Corporation, Hawthorne, California

Surface Building/Editing with Triangular-Quadrilateral Mesh Simplification
Oleg Volpin, Tanya Matskewich, and Michel Bercovier, The Hebrew University, Israel

Constructing Faithful Geometrical Features on Composite Surfaces Using a Global Reparametrization Scheme
Paul Stewart and *Yifan Chen*, Ford Motor Company

New Challenges Arising from Haptic Rendering of Mathematical CAD Models
Paul J. Stewart, Yifan Chen, and Pietro Buttolo, Ford Motor Company

Tuesday, November 4

MORNING

7:30 AM-4:00 PM Registration

Room: Centennial Ballroom Foyer

IP3

Subdivision Schemes for Variational Problems

8:30 AM-9:15 AM

Chair: Tony DeRose, Pixar Animation Studios

Room: Belle Meade

The original theory of splines grew out of the study of simple variational problems. A spline was a smooth function that minimized some notion of energy subject to a set of interpolation constraints. A more recent method for creating splines is subdivision. In this framework, a spline is the limit of a sequence of functions, each related by a simple averaging rule.

The speaker will show that the two ideas are intrinsically related. Specifically, the solution space to a wide range of variational problems can be captured as a spline space defined through subdivision.

Joe Warren
Department of Computer Science
Rice University

IP4

Conservative Perturbations

9:15 AM-10:00 AM

Chair: Richard H. Bartels, University of Waterloo, Canada

Room: Belle Meade

Symbolic perturbation is a handy technique for moving a geometric problem away from a singular case. But symbolic perturbation has a bad name for two reasons: BN1: It is very expensive, and BN2: The perturbed problem is structurally different from the original problem, and its unclear how to get the solution to the original problem from it.

In this presentation, the speaker will review some methods for dealing with BN1 and BN2. For BN1 (efficiency) he has developed a software library called APU that does perturbation in lazy fashion using differentiation. A developer writes code to solve the generic case of the geometry problem, using a special arithmetic package. The symbolic differentiation happens inside the arithmetic pack-

Tuesday, November 4

age and is hidden from the developer. The lazy differentiation requires no additional steps to solve a non-singular instance. For singular instances, the computational cost increases with the degree of the singularity.

To deal with BN2, the speaker will describe "conservative perturbation" as a means to transform a singular problem instance (e.g. an entire geometric model)to a non-singular instance *with the same geometric properties*. Conservative perturbation is really a family of techniques, not a formal method. However, some version of it should be applicable to most geometric problems. Properties such as connectedness and topological type can be preserved by the perturbation, and an exact solution obtained to the original problem by a limit-taking process. He will give some examples of conservative perturbation, hopefully illuminating how it can be used in general.

John Canny
Department of Computer Science
University of California, Berkeley

10:00 AM-10:30 AM Coffee
Room: Centennial Ballroom Foyer

MS4
Subdivision

10:30 AM-12:30 PM
Room: Belle Meade

Subdivision algorithms produce, from a given polygonal net, a sequence of polygons with increasingly more and denser lying vertices. Usually a next polygon in such a sequence is obtained by simple affine combinations which accounts for the attractiveness of subdivision schemes. For certain subclasses of subdivision schemes on regular nets, the convergence and the smoothness of the limiting curves or surfaces has been investigated and is well understood. More recently, the C^k-analysis for subdivision schemes on non-regular nets has been completed and attempts have been made to construct wavelets for some subdivison schemes. The speakers will discuss recent work in these topics.

Organizer: Hartmut M. Prautzsch
Universität Karlsruhe, Germany

10:30 Constructing Variationally Optimal Curves Through Subdivision
Leif Kobbelt, University of Erlangen-Nurnberg, Germany

11:00 Hermite-Type Interpolatory Subdivision Schemes
Nira Dyn and D. Levin Tel-Aviv University, Israel

11:30 C^k Analysis of Subdivision Algorithms and Applications
Georg Umlauf, Universität Karlsruhe, Germany

12:00 Interpolatory Subdivision and Biorthogonal Wavelets
Sherman D. Riemenschneider, University of Alberta, Canada; and Zouwei Shen, National University of Singapore, Singapore

MS5
CAGD in Kinematics/ Robotics

10:30 AM-12:30 PM
Room: Cheekwood

Computer-aided geometric design techniques are applied to the shape of objects — but the same techniques can also be used for motion design. In recent years, new methods have been developed for addressing engineering problems that involve motion, such as control of robots and numerically controlled machine tools and the analysis of kinematics of mechanisms and machines. Still other applications of motion design methods are visualization of rigid body motions, the generation of camera movements, and virtual reality. The speakers in this minisymposium will discuss different aspects of motion design, motion description, and applications.

Organizer: Josef Hoschek
Technische Hochschule Darmstadt, Germany

10:30 Spline Interpolation for Industrial Robots and its Application
Thomas Horsch, Schlossgrabenstr. 4, Germany; and *Bert Jüttler*, University of Technology, Germany

11:00 Automatic Fairing of Position Sets
Michael G. Wagner, Vienna University of Technology, Austria

11:30 Constructing Robot Trajectories Using CAGD and Lie Groups
Bahram Ravani, University of California, Davis

12:00 CAGD in C-space Generation
Myung-Soo Kim, POSTECH, South Korea

12:30 Neurotron 1000: A Robotic System for Stereotactic Radiosurgery
Mohan Bodduluri, Accuray Incorporated, Sunnyvale, CA

AFTERNOON

12:30 PM-1:45 PM Lunch (Attendees will be on their own)

CP2
Multiresolution Methods

1:45 PM-3:45 PM
Chair: Peter Schröder, California Institute of Technology
Belle Meade Room

1:45 Multiresolutional Approximation of Planar Curves
Lakshman Prasad, Ramana L. Rao, and George Zweig, Los Alamos National Laboratory

2:05 Locally Finite B-Spline Decompositions
Steve Klassen, Missouri Western State College

2:25 Synthesis of Human Faces by Wavelet Transform
Andrei Doncescu and Jean-Paul Gourret, University of La Rochelle, France

2:45 Multi-Resolution Modelling Applied to Prosthetics
Rowland Travis, Imperial College of Science, Technology and Medicine, United Kingdom

3:05 Automatic Generation of Hierarchical Geometric Representations
Maryann Simmons and Carlo H. Séquin,University of California, Berkeley

CP3
Solids I

1:45 PM-3:45 PM
Chair: Michael J. Pratt, Rensselaer Polytechnic Institute
Cheekwood Room

1:45 Point Membership Classification for Sweeps and Unsweeps
Horea T. Ilies and *Vadim Shapiro*, University of Wisconsin, Madison

2:05 SIF: The Emerging Solids Interchange Format
Sara A. McMains and Carlo H. Séquin, University of California, Berkeley

2:25 Orienting Transverse Fiber Products
Julien Basch, Stanford University; and *Lyle Ramshaw*, Digital Equipment Corporation, Palo Alto

2:45 Minkowski Sums of Solids Defined by Real Functions
Pasko A., The University of Aizu, Japan; Okunev O., Universidad Nacional Autonoma de Mexico, Mexico; and Savchenko V., The University of Aizu, Japan

Tuesday, November 4

3:45 PM-4:15 PM Coffee

Room: Centennial Ballroom Foyer

FS3 Subdivision

4:15 PM-6:15 PM

Moderators: Mike Neamtu, Vanderbilt University; and Dan Gonsor, The Boeing Company

Belle Meade Room

Free-form Curve Generation by Recursive Subdivision of Polygonal Complexes
Ahmad H. Nasri, American University of Beirut, Lebanon

A Variational Method for Constructing Subdivision Schemes over Irregular Grids
Henrik Weimer and Joe Warren, Rice University

Freeform Splines
Hartmut Prautzsch, Universität Karlsruhe, Germany

Dynamic Catmull-Clark Subdivision Surfaces
Chhandomay Mandal, Hong Qin and Baba C. Vemuri, University of Florida

Parallel Algorithms for Subdivision Surfaces
Lucia Maddalena and *Giovanni Schmid*, National Research Council, Italy

FS4 Developable Surfaces

4:15 PM-6:15 PM

Moderators: Bahram Ravani, University of California, Davis and Michael Wagner, Technical University of Vienna, Austria

Cheekwood Room

Approximation by Cylinder Surfaces
Thomas Randrup, Odense Steel Shipyard Ltd., Denmark

Rotational and Helical Surface Approximation for Reverse Engineering
Helmut Pottmann, Technische Universität Wien, Austria; and Thomas Randrup, Odense Steel Shipyard Ltd., Denmark

Cone Spline Surfaces
Stefan Leopoldseder and *Helmut Pottmann*, Vienna University of Technology, Austria

Surfaces of Revolution of Geometric Degree Three and Their Bézier Like Control
Marco Paluszny, Universidad Central de Venezuela, Venezuela; and Omar Villasmil, Intergraph de Venezuela, Venezuela

B-Spline Developable Surface
Takashi Maekawa and Julie S. Chalfant, Massachusetts Institute of Technology

EVENING

Old Fashioned Southern BBQ/Country Music Show

6:30 PM-9:30 PM

Vanderbilt University Stadium Club

(At 6:15 PM, assemble at the hotel lobby to meet the Vanderbilt University guide who will walk with you to the University Stadium Club for the dinner and show).

Wednesday, Nov. 5

MORNING

7:30 AM-4:00 PM Registration

Room: Centennial Ballroom Foyer

IP5 Scalar Fields, Isosurfaces and Geometric Modeling

8:30 AM-9:15 AM

Chair: Andrew J. Worsey, Middle Tennessee State University

Room: Belle Meade

Isosurface techniques combined with innnovative scalar field generation provide powerful geometric modeling tools. Two basic concepts: slicing and clipping provide the basis for the tools. The speaker will describe real-world applications from medical, CAD, and scientific visualization. He will discuss removal envelopes, implicit modeling, fast slicing and clipping, and creating models from sensor data.

William Lorensen
GE Corporate Research and Development

IP6 Hierarchical Methods in Computer Graphics

9:15 AM-10:00 AM

Chair: Wolfgang Boehm, Technische Universität Braunschweig, Germany

Room: Belle Meade

A central problem in computer graphics is the enormous size of the data sets that need to be processed. With the development of ever more powerful modeling and simulation tools and with the increasing availability of high-resolution 3D scanners and advances in medical imaging, this problem will become even more severe in the future.

In order to deal with these huge amount of data, hierarchical methods, multiresolution representations, and wavelets are currently evolving into a core technique in computer graphics. Their power lies in the fact that they only require a small number of coefficients to represent complex functions and large data sets accurately. This leads to new compression algorithms and efficient computations by exploiting smoothness

Wednesday, November 5

and coherence. Examples of their use in computer graphics include: curve and surface modeling; automatic smoothing of surfaces; mesh simplification; global illumination computations; and volume visualization.

The speaker will present several examples from ongoing projects to illustrate the approach and demonstrate the strength of the underlying concepts.

Hans-Peter Seidel
Computer Graphics Group
Universität Erlangen, Germany

10:00 AM-10:30 AM Coffee
Room:Centennial Ballroom Foyer

MS6
Scientific Visualization

10:30 AM-12:30 PM
Room: Belle Meade

The success of scientific visualization is mainly due to the soundness of the fundamental premise behind it using computer-generated pictures to gain understanding from data and relationships. The speakers in this session will discuss some of the research challenges in scientific visualization with special regard for the potential use of computer-aided geometric design techniques. Two important subareas of scientific visualization, volume visualization and flow visualization will be covered in this session. The discussions on volume visualization will include the topics of volume rendering, surface based techniques, volume modeling and applications in the medical field. The discussions on flow visualization will include the topics of topological graphs, higher order critical points, multiresolution models for curvilinear grids and incremental methods for particle advection.

Organizer: Gregory M. Nielson
Arizona State University

10:30 Overview of Session and Volume Modeling
Gregory M. Nielson, Arizona State University

11:00 The Development, History and Application of Marching Cube Technics
William Lorensen, GE Corporate Research and Development, Schenectady, NY

11:30 An Index Theorem for Polynomial Vector Fields
Gerik Scheuermann, Hans Hagen, and Heinz Kruger, University of Kaiserslautern, Germany

12:00 Computing the Index of a Three Dimensional Vector Field
Alyn Rockwood, Arizona State University

MS7
Computers and Education

10:30 AM-12:30 PM
Room: Cheekwood

This minisymposium will explore various aspects of how computers can be used effectively to enhance education at all levels. A wide spectrum of topics, including Euclidean and computational geometry, modern physics, and engineering will be discussed. The speakers, professionals with backgrounds in computer science, physics, and engineering, will discuss questions such as: What is the best mathematical and computational paradigm for teaching modern physics? Is programming an appropriate subject to teach to engineers? How effectively can computers perform standard proofs in Euclidean geometry?

Organizer: Ron Goldman
Rice University

10:30 Computers in Engineering Education
Goranka Bjedov, Purdue University

11:00 An Interactive Tutorial on Curves and Surfaces
Alyn Rockwood, Arizona State University

11:30 GRACE — Graphical Ruler and Compass Editor
Aaron Hertzman, New York University

12:00 Unifying Algebra with Geometry in Education and Geometric Design
David Hestenes, Arizona State University

AFTERNOON

12:30 PM-1:45 PM Lunch (Attendees will be on their own).

CP4
Rendering and Imaging

1:45 PM-3:45 PM

Chair: Carlo H. Séquin, University of California, Berkeley

Belle Meade Room

1:45 Efficient Display of Triangular Bézier Surfaces
Subodh Kumar, Johns Hopkins University

2:05 Interactive Rendering: A Time-Based Approach
Jörg Meyer, Steffen Gelder, Jürgen Kronz, Hans Hagen, University of Kaiserslautern, Germany

2:25 Projective Harmonic Analysis in Computer Vision
Jacek Turski, University of Houston-Downtown

2:45 Smooth Anatomical Modeling of Structures of Arbitrary Topology
John K. Johnstone and Kenneth R. Sloan, University of Alabama, Birmingham

3:05 Feature-based Isotopy for Volumetric Shapes
Kikuo Fujimura, Ohio State University, Columbus

3:25 Hierarchical Triangle Strips
Luiz Velho, IMPA — Instituto de Matemática Pura e Aplicada, Brazil; Luiz Henrique de Figueiredo, LNCC — Laboratório Nacional de Computacão Científica, Brazil; and Jonas Gomes, IMPA — Instituto de Matemática Pura e Aplicada, Brazil

CP5
Medial Axis Transforms and Offsets

1:45 PM-3:45 PM

Chair: Rida T. Farouki, University of Michigan, Ann Arbor

Cheekwood Room

1:45 Topology Change in Shelling Operation
Jack Liang, SDRC Operations, Inc., Milford, Ohio

2:05 New Algorithm for Offset Curve Computation via MAT
Hyeong In Choi, Hwan Pyo Moon, Kyeong-Hah Roh, and Chang Yong Han, Seoul National University, Korea

2:25 Quarternion Representation of Pythagorean-Hodograph Space Curves
Kenji Ueda, Ricoh Company, Ltd., Japan

2:45 Curve Offsetting Based on Legendre Series
Yong-Ming Li and Vivian Y. Hsu, Intergraph Corporation, Huntsville, Alabama

3:05 Skeletonization of Discretized Shapes by Delaunay Triangulations
Lakshman Prasad, Ramana L. Rao, and George L. Zweig, Los Alamos National Laboratory

3:45 PM-4:15 PM Coffee
Room: Centennial Ballroom Foyer

Wednesday, November 5

CP6
Surface Processing

4:15 PM-6:15 PM

Chair: Ken Joy, University of California, Davis

Belle Meade Room

4:15 Crack-free Tesselation of Parametric Surface Models
Zicheng Liu, Silicon Graphics Computer Systems, Mountain View

4:35 Repairing CAD Models
Gill Barequet and *Subodh Kumar*, Johns Hopkins University

4:55 Anisotropic Bubble Mesh Generation
Kenji Shimada, Carnegie Mellon University

5:15 Fast Interference Detection Using Oriented Bounded Box Hierarchies
S. Gottschalk, *Ming C. Lin*, and Dinesh Manocha, University of North Carolina, Chapel Hill

5:35 Mathematical Modeling of Using Different Endmills and Tool Placement Problems in CAD/CAM Systems for 5-Axis NC Sculptured Surface Machining
Yuan-Shin Lee, North Carolina State University

5:55 Spline-Galerkin-Approximation of Elliptic Problems
Andreas Kipp, Universität Stuttgart, Germany

CP7
Curve Interpolation and Approximation

4:15 PM-6:15 PM

Chair: Eugene Lee, Alias/Wavefront, Seattle

Cheekwood Room

4:15 Geometric Interpolation for Practical Applications
Jürgen Koch and Hans-Ulrich Becker, CoCreate Software GmbH, Germany

4:35 Circular Arcs Approximation By Quintic Polynomial Curves
Lian Fang, EDS Unigraphics, Cypress, California

4:55 Near-Interpolating Spline Curves
Scott Kersey, University of Wisconsin, Madison

5:15 A Practical Method for Minimax Approximation of NURBS Curves and Surfaces
Gary Silverman, Perfit Corporation, Los Angeles; and Leon Lasdon, University of Texas, Austin

5:35 A Companion Matrix for Bernstein Polynomials
Joab R. Winkler, University of Sheffield, United Kingdom

5:55 Parametric l_1 —, l_2 —, and l_infinity — Approximation
Bert Jüttler, University of Technology Darmstadt, Germany

EVENING

Poster Session and Reception

6:15 PM-8:00 PM

Belmont Room

Information on how to prepare a poster can be found at http://www.siam.org/siamnews/general/poster.htm and http://www.siam.org/meetings/guidhome.htm

Poster presenters can post and set up their poster materials starting at 12:00 noon on Wednesday. They should be with their poster boards, available to present their work and interact with attendees beginning at 6:15 PM Wednesday. Each poster presenter should remove his/her poster materials from the poster boards immediately at the end of the session at 8:00 PM on Wednesday. Any materials left on the boards after that time will be removed and discarded. SIAM is not responsible for any materials that are left on the board at the end of the poster session.

For more information about poster presentations, please refer to Participants" at *http://www.siam.org/meetings/guidhome.htm and http://www.siam.org/siamnews/general/poster.htm.*

Poster Presentations

Geometric Theory for Designing Optical Binary Amplitude and Binary Phase-Only Filters
Mustafa M. Matalgah, SPRINT, Kansas City, Missouri

A Complete Closed-form Solution to the 2,3,4-Variable Orthogonal Regression Model
Michael J. Wilt, Precision Measuring Service Inc., Newport, Pennsylvania

Approximating a Convex Polyhedron
Walter W. Wilson, Computer Sciences Corporation, Fort Worth, Texas

The Symmetric Analogue of the Power Basis for Geometry Processing
Javier Sanchez-Reyes, Polytechnic University of Catalonia, Spain

3D Graphics Editting of Arbitrary Geometry Models
KaMan Cheang, Jiankun Li, and C.-C. Jay Kuo, University of Southern California

Interactive Modeling using Surface Splines
Jorg Peters, Purdue University, West Lafayette

Multiresolution Compression of Arbitrary Geometry Models
Jiankun Li and C.-C. Jay Kuo, University of Southern California

Modeling Bathymetric Data with Fuzzy B-splines
Marcello A. Anile, Università di Catania, Italy; Bianca Falcidieno, Consiglio Nazionale delle Ricerche, Italy; *Giovanni Gallo*, Università di Catania, Italy; Michela Spagnuolo, Consiglio Nazionale delle Ricerche, Italy; and Salvatore Spinello, Università di Catania, Italy

The Algorithm for Testing Convexity of Steiner Surface Patches
Kestutis Karciauskas, Vilnius University, Lithuania

Some New Schemes for n-Sided Patches
Kestutis Karciauskas, Vilnius University, Lithuania

Shape Preserving Space Curve Design
Bruce Piper, Rensselaer Polytechnic Institute; and Caroline Labenski, Merrimack College

IG: A Simple Constraint-based Geometrical Construction System
Siome K. Goldenstein and *Paulo C. P. Carvalho*, Instituto de Matemática Pura e Aplicada, Brazil; and Luiz Henrique de Figueiredo, Laboratório Nacional de Computacão Científica, Brazil

Minimum-Length Geodesic Computation
William L. Anderson, Elements Research, Charlotte, North Carolina

Discrete Gaussian Curvature for Analysis of B-spline Modeled Cornea
Marc Daniel, Ecole Centrale de Nantes, France; and Brian A. Barsky, University of California, Berkeley

A Simple Method of Finding Bounds for Scaling Transition Curves
Sasipalli V. S. Rao, Hiroshima University, Japan

Spline Wavelet Image Compression
Y. Latoria Thomas and Camille Daniel, Spelman College

Projective Geometry in Mathematica
Dana S. Scott, Carnegie Mellon University

A Method for the Construction of Trimmed B-Spline Surfaces Matching Given Boundaries
Adi Levin, Cimatron Ltd., Israel and Tel-Aviv University, Israel

Wednesday, Nov. 5

Business Meeting: SIAM Activity Group on Geometric Design

8:00 PM-8:30 PM

Room: Belmont

8:00 PM Poster Session closes. All poster materials must be removed from the poster boards.

Thursday, November 6

MORNING

7:30 AM- 12:00 PM Registration

Room: Centennial Ballroom Foyer

IP7

Scattered Data Modelling

8:30 AM-9:15 AM

Chair: Nira Dyn, Tel-Aviv University, Israel

Room: Belle Meade

The construction of geometry from scattered data brings together the problem of data approximation and the problem of geometric design. Most algorithms for scattered data approximation have limited flexibility for incorporating design issues suited for specific application areas, e.g. cartography. For some problems this can be done by introducing constraints in the geometry construction, however, providing the user with flexible software tools seems equally important. The speaker will focus on selected scattered data problems using constrained and composite methods, and the design of numerical software for scattered data modelling using object oriented techniques.

Morten Daehlen
Applied Mathematics
SINTEF, Norway

IP8

On NURBS and Triangles

9:15 AM-10:00 AM

Chair: Helmut Pottmann, Technische Universität Wien, Austria

Room: Belle Meade

Mature CAD/CAM technology exists to convert from design concepts to production-quality geometric models to physical parts. In this "forward" process, it is not unusual for various triangle mesh approximations to be computed for display and NC machining purposes, and then discarded. The corresponding "reverse" technology to convert physical parts to production-quality geometric models (to allow design modifications or computerized replication) is not nearly as mature despite advances in recent years. Further developments are needed to attain most of the potential productivity advantages.

A critical problem is representation. Production-quality geometric models usually consist of trimmed and untrimmed NURBS surfaces with carefully arranged topological and geometric relationships. When 3d points are acquired from physical surfaces, the output is points, polylines, or triangles at best. The conversion of this acquired data into production surfaces is still primarily manual and typically somewhat unfaithful to either the 3d point data, or the design intent, or both.

The speaker will delve into key problems in this reverse engineering area and discuss relationships to NURBS tessellators with specific focus on the nearly identical forms of surfaces tessellated to manufacturing tolerances and filtered triangle meshes derived from 3d scanner data.

Paul Besl
Alias/Wavefront, Inc.
Farmington Hills, Michigan

10:00 AM-10:30 AM Coffee

Room: Centennial Ballroom Foyer

MS8

Reverse Engineering

10:30 AM-12:30 PM

Room: Belle Meade

Creating free-form surfaces is a challenging task even with advanced geometric modeling systems. Optical scanners offer a promising alternative to model acquisition—the 3D scanning of existing parts or clay maquettes. In the context of Computer-Aided Geometric Design, reverse engineering refers to the problem of converting the dense point sets produced by scanners into useful geometric models. One of the main applications of reverse engineering is to allow existing manufactured parts to be incorporated or modified into new designs. The speakers, from academia and industry, will present new developments in this field.

Organizer: Hugues H. Hoppe
Microsoft Research, Redmond, Washington

10:30 The Past, Present, and Future of Reverse Engineering
Paul J. Besl, Alias/Wavefront, Inc., Farmington Hill, MI

11:00 Building Complex Models from Range Images
Brian Curless and Marc Levoy , Stanford University

11:30 Constrained B-Spline Surface Approximation of Irregular Distributed Data
Josef Hoschek and Ulrich Dietz, Technical University Darmstadt, Germany

12:00 VPL: The Virtual to Physical Link
Sarvajit Sinha, Pradeep Seneviratne; and Thawach Sripradisvarakul, Imageware Inc, Ann Arbor, MI

Thursday, November 6

MS9
Curve/Surface Fairing and Shape Optimization

10:30 AM-12:30 PM

Room: Cheekwood

The problem of "fairness" has become of central importance in the design of free-form curves/surfaces in CAD/CAM. A curve/surface is characterized as "fair" either if it has a visual pleasing shape, a smooth shape or if it satisfies certain continuity requirements. Various mathematical definitions of "fairness" lead to different techniques for the design of "fair" curves and surfaces. Variational methods incorporate the fairness criterion as a constraint in the design process and post-processing fairing methods apply to a given curve/surface in order to improve its shape. Both techniques make more and more use of non-linear constraints. The speakers in this minisymposium will report on recent achievements in the use of linear and non-linear "fairness" constraints for shape optimization and the use of smooth Pythagorean-Hodograph curves for the design and manufacturing of high-speed cams. The industrial application of these results will be illustrated by several examples.

Organizer: Stefanie Hahmann
INP University of Grenoble, France

10:30 Shape-Preserving Fairing of Tensor-Product B-spline Surfaces
P. D. Kaklis, G.D. Koras and T.P. Gerostathis, National Technical University of Athens (NTUA), Greece

11:00 Shape Optimization Using the PDE Method
Malcolm I. G. Bloor and Michael J. Wilson, University of Leeds, United Kingdom

11:30 Design and Manufacture of High-Performance Rational Cams with Pythagorean-Hodograph Curves
Rida T. Farouki, Uiversity of Michigan, Ann Arbor

12:00 Shape Optimization by Using Masks
Stefanie Hahmann, Organizer

AFTERNOON

12:30 PM-1:45 PM Lunch (Attendees will be on their own).

CP8
Solids II

1:45 PM-3:45 PM

Chair: Dinesh Manocha, University of North Carolina, Chapel Hill

Belle Meade Room

1:45 The Boundary Surfaces of Trivariate Solids
Kenneth I. Joy, University of California, Davis

2:05 Efficient and Accurate B-rep Generation of Low Degree Sculptured Solids using Exact Arithmetic
John Keyser, Shankar Krishnan, and Dinesh Manocha, University of North Carolina, Chapel Hill

2:25 Open Kernel System for Modeling Non-manifold Models Based on Partial Elements
Kang-Soo Lee, Kunwoo Lee, Younghyun Han, Jinwoong Hong, Sangkun Park, Jeonghoon Hur, and Seong Joon Kwak, Seoul National University, Korea; Jaehong Ahn, KIST, Korea; Gyeongjin Lee, Samsung Aerospace Industries Co., Ltd., Korea; Sunghwan Kim, Seoul Polytech University, Korea; Sanghun Lee, Kookmin University, Korea; Youngjin Kim, University of Illinois, Urbana; and Jinpyung Jung, Massachusetts Institute of Technology

2:45 Interactive Boundary Computation of Boolean Combinations of Sculptured Solids
S. Krishnan, M. Gopi, D. Manocha, and M. Mine, University of North Carolina, Chapel Hill

3:05 Boundary Representation Variance in Solid Modeling
Srinivas Raghothama and Vadim Shapiro, University of Wisconsin, Madison

CP9
Blending and Cyclides

1:45 PM-3:45 PM

Chair: Alyn Rockwood, Arizona State University

Cheekwood Room

1:45 An Introduction to Quartic Supercyclides
Michael J. Pratt, Rensselaer Polytechnic Institute and National Institute of Standards & Technology

2:05 Constructing Tubular Surfaces from Dupin Cyclides
Ching-Kuang Shene, Michigan Technological University

2:25 Toric Approach to Low-Degree Rational Surfaces
R. Krasauskas, Vilnius University, Lithuania

2:45 Blending, Smoothing and Interpolation of Irregular Meshes Using N-Sided Varady patches
Xuefu Wang and *Fuhua (Frank) Cheng*, University of Kentucky; and Brian A. Barsky, University of California, Berkeley

3:05 Negation Invariant Blending in Solid Modeling
Janos Vida, University of Veszprem, Hungary

3:45 PM-4:15 PM Coffee

Room: Centennial Ballroom Foyer

FS5
Geometry Construction

4:15 PM-6:15 PM

Moderator: Jorg Peters, Purdue University, West Lafayette

Belle Meade Room

Connecting Gordonesque Surfaces
Marshall Walker, York University, Canada

Surface Interpolation with Triangular Patches
Stephen Mann, University of Waterloo, Canada

Piecewise Quadric C^1-Interpolation - a Geometric Approach
Claudia Bangert and Hartmut Prautzsch, Universität Karlsruhe, Germany

Curvature-Continuous Curve and Surface Extensions
William A. Denker, Spatial Technology, Inc., Boulder, Colorado

New Solutions to a Common Surface Construction
William A. Denker, Spatial Technology, Inc., Boulder, Colorado

Surface Design with Modified SBB Patches
Serena Morigi, Vanderbuilt University and University of Bologna, Italy; Larry L. Schumaker, Vanderbuilt University

FS6
Scattered Data Fitting

4:15 PM-6:15 PM

Moderators: Robert Barnhill, University of Kansas; and Dianne Hansford, Arizona State University

Cheekwood Room

***h* and *p* Versions for Nested Families of Triangular Finite Elements Spaces**
Alain Le Méhauté, Université de Nantes, France

A Linear Approach to Convexity Preserving Surface Approximation using Iterative Knot Insertion
Frans Kuijt and Ruud van Damme, University of Twente, The Netherlands

Interpolation of Scattered Data on a Sphere
Leonardo Traversoni, Universidad Autonoma Metropolitana (Iztapalapa), Mexico

Modelling Surfaces with Discontinuities using Splines on Triangulations
Christian Tarrou, University of Oslo, Norway

Representing Cuts in Elastic Surfaces and Volumes
A. Ardeshir Goshtasby, Wright State University

6:15 PM Conference adjourns

General Information

Hotel Information

Loews Vanderbilt Plaza Hotel has the convenience of being at the center of Nashville's business, medical and educational districts, just steps from Vanderbilt University

Dining

Loews Vanderbilt Plaza has two fine restaurants-Ruth's Chris Steak House and Snaffles Cigar Bar and lobby lounge.

Recreational Facilities

The hotel has a fully equipped fitness center that is complimentary to SIAM attendees.

Parking

Loews Vanderbilt Plaza will provide complimentary parking to SIAM Geometric Design attendees during the conference.

Fax & E-mail Capabilities

There will be a Computer Room at the conference. However, SIAM cannot offer E-mail or Internet access capabilities for individual attendees. We suggest you bring your own laptop and use phone line in your hotel room. If you do not have a personal computer the hotel business office offers services at a nominal fee.

Weather

Nashville has a moderate climate in November with average temperature of 60 to 65 degrees. Light weight clothing with a coat will be most comfortable for the night air. Remember to bring a sweater for the meeting rooms in case the air conditioning is too cool.

Telephone Messages

The telephone number of the Loews Vanderbilt Plaza Hotel is 615-320-1700. The hotel will either connect you with the SIAM registration desk or forward a message to the attendee's room.

Transportation Information

Ground Transportation

Shuttle Service

Loews Vanderbilt Plaza Hotel does not provide complimentary transportation to and from the airport. Airport shuttle service is provided by Gray Line Tours which leaves the airport (ground transportation level at foot of escalators) approximately every 15 minutes. The shuttle leaves the hotel approximately every 1/2 hour, beginning at 6:15 a.m. until 11:15 p.m. Shuttle service is available on call after 11:15 p.m. The fare per person one way is $9; round trip is $15.

Car Rentals

Several car rental companies have offices inside the airport terminal. You can make your arrangements when you arrive at the airport or you can make them through Event Travel Services or your own travel agent. Event Travel can make your car rental reservations at the same time you make your flight reservations. Call 888-383-6844 or 609-853-1919, or fax your reservations to 609-853-0411, or via their on-line reservation system at 74117.620@compuserve.com. Be sure to mention that you are attending SIAM's Fifth Conference on Geometric Design.

Registration Information

Registration Fees

Registration fees for the Short Course include lunch and short course notes. Registration fees for the conference include

- Admission to all Technical Sessions
- Admission Poster Session & Welcoming Reception
- Coffee and Refreshments
- Use of Computer Room
- Admission to SIAG/GD Business Meeting & Reception

Special Evening Event

Old Fashioned Southern BBQ/Country Music Show

Tuesday, November 4, 1997
6:30 PM-9:30 PM

Cost: $39.00/person

Come and enjoy the fun and flavor of the old South. Vanderbilt University Stadium Club is proud to feature some of the oldest barbeque recipes in the south. Dinner will consist of barbeque pork and chicken, an assortment of salads and beans, hot buttered rolls, an assortment of southern desserts and beverages. It's all you can eat! Upon arrival, you'll be greeted with country music by the band "Country Song", a cocktail get-together with colleagues and friends. Dinner will be served at 7:00 p.m. After dinner, join in for some line dancing — just for the fun of it!

SIAM Corporate Members

Non-member attendees employed by the following institutions are entitled to the SIAM member registration fees.

- Aerospace Corporation
- Amoco Production Company
- AT&T Laboratories-Research
- Bell Communications Research
- Bell Laboratories
- The Boeing Company
- Center for Computing Sciences, a division of Institute for Defense Analyses
- Cray Research, Inc.
- E.I. du Pont de Nemours & Company
- Eastman Kodak Company
- Exxon Research and Engineering Company
- General Motors Corporation
- IBM Corporation
- ICASE
- IDA Center for Communications Research, La Jolla
- MacNeal-Schwendler Corporation
- Mathematical Sciences Research Institute
- National Security Agency
- NEC Research Institute
- Oak Ridge National Laboratory managed by the Lockheed Martin Energy
- Research Corporation for the Department of Energy
- United Technologies Corporation

Non-SIAM Members

Join SIAM today and save on your registration as a member! A special 15-month membership application form is available for attendees of the GD97 conference. As a member, you will receive free subscriptions to *SIAM Review* and *SIAM News*, and substantial discounts on SIAM books and journal subscriptions, Join SIAM now! Ask a SIAM staff at the SIAM registration desk, or contact SIAM Customer Service for an application form at telephone: 215-382-9800; 800-447-7426 (U.S. only); fax: 215-386-7999; mail: SIAM, 3600 University City Science Center, Philadelphia, PA 19104-2688; WWW at *http:www.siam.org/meetings/gd97/memgd97.htm.*

Program-at-a-Glance

Times allowed for each presentation, including questions and answers:

• CP = Contributed Presentations (20 minutes) • FS = Focus Session (a two-hour moderated session) • IP = Invited Plenary Presentations (45 minutes) • MS = Minisymposium (30 minutes)

For papers with multiple authors, the speaker is shown in italics if known at press time. The conference organizers expect every speaker of a scheduled presentation to register and attend the conference. If it becomes necessary for a speaker to cancel the presentation, the speaker is expected to find an alternate presenter immediately, preferably one of the speaker's co-authors. The speaker should inform the SIAM Conference Department of any change to his/her scheduled presentation. A "no-show" or canceled presentation can cause serious inconvenience to the attendees and conference organizers.

Information regarding audiovisual needs can be found at *http://www.siam.org/meetings/gd97/avnotice.htm.*

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
7:30 AM		**Registration** *Room: Centennial Ballroom Foyer*	**Registration** Room: Centennial Ballroom Foyer	**Registration** *Room: Centennial Ballroom Foyer*	**Registration** *Room: Centennial Ballroom Foyer*
8:00 AM	**8:00 AM-7:30 PM Registration** *Room: Centennial Ballroom Foyer*				
8:15 AM		**8:15 AM Welcoming Remarks and Announcements** Tony DeRose, Pixar Animation Studios; and Larry Schumaker, Vanderbilt University, Co-chairs *Room: Belle Meade*			
8:30 AM		**IP1 Life After NURBS: Adventures with a Triangular Surface Modeler** David Gossard, Massachusetts Institute of Technology Chair: Rosemary E. Chang, Silicon Graphics Computer Systems *Room: Belle Meade*	**IP3 Subdivision Schemes for Variational Problems** Joe Warren, Rice University Chair: Tony DeRose, Pixar Animation Studios *Room: Belle Meade*	**IP5 Scalar Fields, Isosurfaces and Geometric Modeling** William Lorensen, GE Corporate Research and Development Chair: Andrew J. Worsey, Middle Tennessee State University *Room: Belle Meade*	**IP7 Scattered Data Modelling** Morten Daehlen, SINTEF, Norway Chair: Nira Dyn, Tel Aviv University, Israel *Room: Belle Meade*
9:00 AM	**9:00 AM-10:15 AM Short Course** *Room: Neely, Mezzanine Level*				
9:15 AM		**IP2 Classical Geometry and CAGD** Wendelin L. F. Degen, University of Stuttgart, Germany Chair: Miriam Lucian, The Boeing Company *Room: Belle Meade*	**IP4 Conservative Perturbations** John Canny, University of California, Berkeley Chair: Richard H. Bartels, University of Waterloo, Canada *Room: Belle Meade*	**IP6 Hierarchical Methods in Computer Graphics** Hans-Peter Seidel, Universität Erlangen, Germany Chair: Wolfgang Boehm, Technische Universität Braunschweig, Germany *Room: Cheekwood*	**IP8 On NURBS and Triangles** Paul Besl, Alias/Wavefront, Inc. Chair: Helmut Pottmann, Technische Universität Wien, Austria *Room: Belle Meade*
10:00 AM		**Coffee** *Room: Centennial Ballroom Foyer*	**Coffee** *Room: Centennial Ballroom Foyer*	**Coffee** *Room:Centennial Ballroom Foyer*	**Coffee** *Room: Centennial Ballroom Foyer*
10:00 AM	**10:15 AM-10:45 AM Coffee** *Room: Centennial Ballroom Foyer*				
10:30 AM		**Concurrent Sessions** **MS1 CAD Systems Issues** (This session has been cancelled. A new session is being organized to replace it). Organizer: Robert Blomgren *Room: Belle Meade* **MS2 Computational Geometry and Topology** Organizer: Herbert Edelsbrunner, University of Illinois, Urbana-Champaign *Room: Cheekwood*	**Concurrent Sessions** **MS4 Subdivision** Organizer: Hartmut M. Prautzsch, Universität Karlsruhe, Germany *Room: Belle Meade* **MS5 CAGD in Kinematics/Robotics** Organizer: Josef Hoschek, Technische Hochschule Darmstadt, Germany *Room: Cheekwood*	**Concurrent Sessions** **MS6 Scientific Visualization** Organizer: Gregory M. Nielson, Arizona State University *Room: Belle Meade* **MS7 Computers and Education** Organizer: Ron Goldman, Rice University *Room: Cheekwood*	**Concurrent Sessions** **MS8 Reverse Engineering** Organizer: Hugues H. Hoppe, **Microsoft Research** *Room: Belle Meade* **MS9 Curve/Surface Fairing and Shape Optimization** Organizer: Stefanie Hahmann, University of Grenoble, France *Room: Cheekwood*
10:45 AM	**10:45 AM-12:30 PM Short Course** *Room: Neely, Mezzanine Level*				

12:30 PM	**Lunch (Short Course attendees only)** *Room: McTeire, Mezzanine Level*	**Lunch (Attendees will be on their own)**	**Lunch (Attendees will be on their own)**	**Lunch (Attendees will be on their own)**	**Lunch (Attendees will be on their own)**
1:45 PM		**Concurrent Sessions** **MS3 Geometric Accuracy** Organizer: Miriam L. Lucian, The Boeing Company *Room: Belle Meade* **CP1 Curve and Surface Construction** Chair: John Roulier, University of Connecticut, Storrs *Room: Cheekwood*	**Concurrent Sessions** **CP2 Multiresolution Methods** Chair: Peter Schröder, California Institute of Technology *Room: Belle Meade* **CP3 Solids I** Chair: Michael J. Pratt, Rensselaer Polytechnic Institute *Room: Cheekwood*	**Concurrent Sessions** **CP4 Rendering and Imaging** Chair: Carlo H. Sequin, University of California, Berkeley *Room: Belle Meade* **CP5 Medial Axis Transforms and Offsets** Chair: Rida T. Farouki, University of Michigan, Ann Arbor *Room: Cheekwood*	**Concurrent Sessions** **CP8 Solids II** Chair: Dinesh Manocha, University of North Carolina, Chapel Hill *Room: Belle Meade* **CP9 Blending and Cyclides** Chair: Alyn Rockwood, Arizona State University *Room: Cheekwood*
3:45 PM		**3:45 PM-4:15 PM Coffee** *Room: Centennial Ballroom Foyer*	**3:45 PM-4:15 PM Coffee** *Room: Centennial Ballroom Foyer*		
3:45 PM				**Coffee** *Room: Centennial Ballroom Foyer*	**Coffee** *Room: Centennial Ballroom Foyer*
4:00 PM	**Coffee** *Room: Centennial Ballroom Foyer*				
4:15 PM		**Concurrent Sessions** **FS1 Geometry Extraction** Moderators: Tomas Varady, Hungarian Academy of Sciences, Hungary; and Bert Jüttler, Technische Universität Darmstadt, Germany *Room: Belle Meade* **FS2 CAD Editing** Moderators: Gerald Farin, Arizona State University; and Hans Wolters, SDRC, Milford, Ohio *Room: Cheekwood*	**Concurrent Sessions** **FS3 Subdivision** Moderators: Mike Neamtu, Vanderbilt University; and Dan Gonsor, The Boeing Company *Room: Belle Meade* **FS4 Developable Surfaces** Moderators: Bahram Ravani, University of California, Davis; and Michael Wagner, Technical University of Vienna, Austria *Room: Cheekwood*	**Concurrent Sessions** **CP6 Surface Processing** Chair: Kenneth Joy, University of California, Davis *Room: Belle Meade* **CP7 Curve Interpolation and Approximation** Chair: Eugene Lee, Alias/Wavefront, Seattle *Room: Cheekwood*	**Concurrent Sessions** **FS5 Geometry Construction** Moderator: Jörg Peters, Purdue University, West Lafayette *Room: Belle Meade* **FS6 Scattered Data Fitting** Moderators: Robert E. Barnhill, University of Kansas; and Dianne Hansford, Arizona State University *Room: Cheekwood*
4:30 PM	**Short Course continues** *Room: Neely, Mezzanine Level*				
6:00 PM	**Short Course adjourns** **Welcoming Reception** *Room: Belmont*				
6:15 PM				**Poster Session and Reception** *Room: Belmont*	**6:15 PM Conference adjourns**
6:30 PM			**Old Fashioned Southern BBQ/Country Music Show** Vanderbilt University Stadium Club Cost: $39/person		
8:00 PM				**Business Meeting** SIAM Activity Group on Geometric Design *Room: Belmont* **Poster Session closes.** All poster materials must be removed from the poster boards.	

SATURDAY

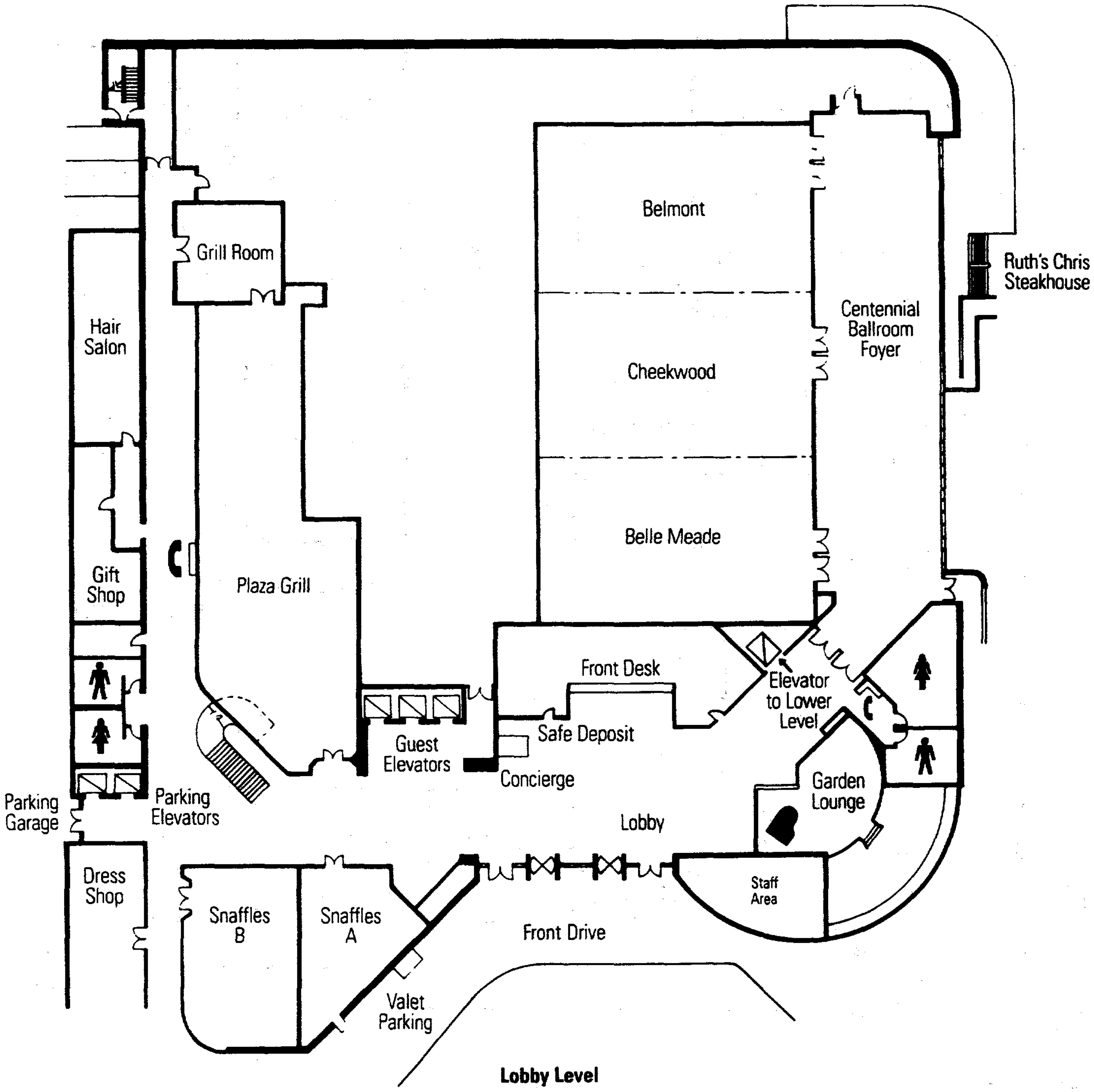
5:00 PM-7:30 PM Registration
Room: Hotel Lobby by Guest Elevators

Speaker Index

Conference Map

LOEWS VANDERBILT PLAZA

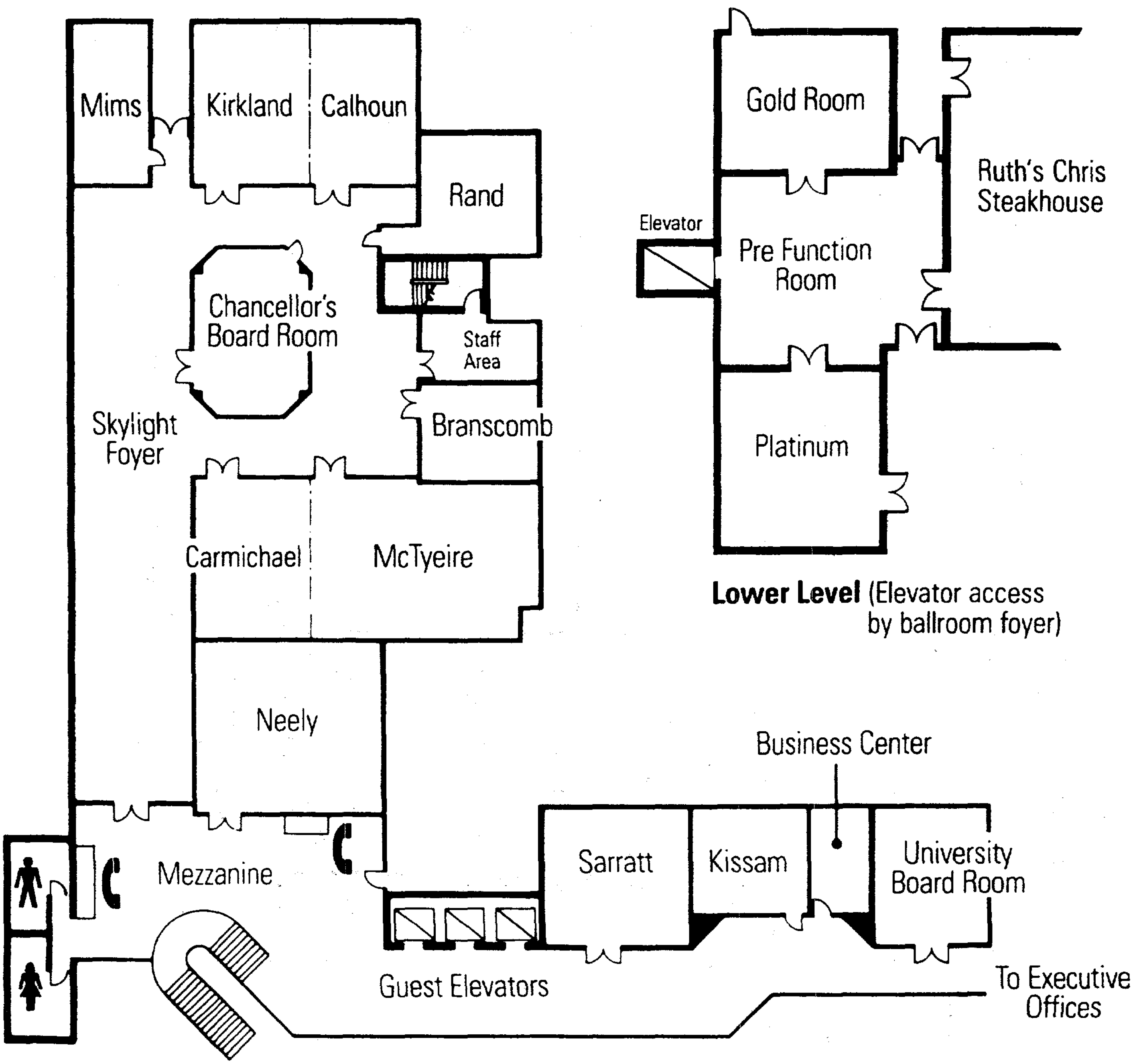
H O T E L



Lobby Level

Conference Map

LOEWS VANDERBILT PLAZA
H O T E L



Mezzanine Level

Abstracts

Fifth SIAM Conference on

Geometric Design 97

November 3-6, 1997
Loews Vanderbilt Plaza Hotel
Nashville, Tennessee

CP01

Producing Smooth Convex Curves with Feature Point Constraints

This paper presents an interactive method for designing smooth convex curves, based on a B-spline formulation and a recursive subdivision manner. The algorithm ensures that the highest point of the resulting curve occurs only at that of the ideal curve in the user's mind. Also, it suggests a class of convex B-spline curves that share the same highest point and have different curvatures at the point, providing the user with an interactive control of shape.

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CP01

Iterative Methods for Constructing Tension Splines

Hyperbolic tension splines and thin plate splines are defined as solutions of differential multipoint boundary value problems. For computations we use a difference approximation of that problems and apply iterative methods. This permits to avoid calculations of hyperbolic functions, however, the extension of a mesh solution will be a discrete tension spline. We consider the basic computational aspects of this approach and illustrate its main advantages.

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CP01

Freeform Curve Design Using Implicit Polynomial Models

Implicit polynomial 2D curves and 3D surfaces are potentially among the most useful object or data representations for use in computer vision and graphics. This paper studys and compares various fitting algorithms in a unified framework of stability analysis. It presents a new robust *3L fitting* method that is repeatable, numerically stable and computationally fast and can be used for high degree implicit polynomials to capture complex object structure. With this, we lay down a foundation that enables a technology based on implicit polynomial curves and surfaces for applications to indexing into pictorial databases, robot vision, CAD for free-form shapes, etc.

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CP01

Planar Interpolating G^2 Composite Bézier Curves

We present an algorithm for creating G^2 spline curves using rational Bézier cubic segments. The splines interpolate a sequence of points, tangents, and curvatures. In addition each segment has two more geometric shape handles. The individual segments are convex, but zero curvature can be assigned at a junction point. Hence inflection points can be placed where desired, but cannot occur otherwise.

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CP01

Conic Rescue of Rational Cubic Splines with Interval Tension

A C^2 interpolatory rational cubic spline with interval tension was utilized, by Gregory and Sarfraz, for the construction of design curves to be used in CAD/CAGD. This paper describes a conic solution to this rational cubic method. The conic description, like the rational cubic, involves same amount of data points and one control weight in each interval which can be used to fine tune the curve segments locally. An algorithm has also been designed to manipulate the conic scheme which produces as competent as rational cubic curves.

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CP01

Mesh Simplification with Smooth Surface Reconstruction

A new method for surface reconstruction is introduced, which simplifies the original object mesh and then builds a G^1 surface on top of it. First, the surface is subdivided into simple regions with restricted curvature deviation. A boundary-conforming quadrilateral mesh of each region is generated. Finally, a G^1 surface is constructed over the simplified mesh using a plate energy method. Some of the major advantages of the method are: It can handle freeform original models, as well as polygonal; It generates a quad mesh which is more suitable for analysis; The original topolgy is fully preserved; And the deviation of the reconstructed surface from the original can be estimated and bounded.

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CP02

Synthesis of Human Faces by Wavelet Transform

We present in this abstract the possibility to synthesis a 3D Star-shaped objects using faces with the same properties: a vertex is connected to the end of three edges. This properties is important if the calculus of deformation is achieved with the finite element method. Our model associates the particularity the number of rigid modes given by the modal analysis is equal to the number of 1D finite elements, which is also the half of the number of Degrees of Freedom. The possibility to apply *FEM* to the objects with 3-Connected Meshes where the faces are not planar solve the problem of extraordinary points and the calculus of deformation is homogenous. To synthesis a 3D objects (in our application Human Faces) 3-Connected we have used the projection of a sphere on scanned face. A algorithm based on Wavelet Transform deduces other levels of meshing. The construction of filters associated to Wavelet basis allows to have: a reversible transform, to smooth the surfaces and to change the details passing from high levels to low levels.

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CP02

Locally Finite B-Spline Decompositions

Locally finite decompositions of univariate spline spaces on uniform knot sequences are constructed and adapted to a bounded interval. As with spline wavelets, the spline space is decomposed into complementary subspaces spanned by the translates of a B-spline on a coarser knot sequence and another complementary spline function. The coefficient sequences of the decomposition are finitely supported but the complement function does not satisfy the orthogonality conditions associated with wavelets. Decomposition and reconstruction using the locally finite approach is compared to the corresponding spline wavelet algorithms for bounded intervals.

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CP02

Multiresolutional Approximation of Planar Curves

We present an adaptive algorithm based on the discrete Haar wavelet transform for the discrete approximation of planar curves at any desired level of detail (resolution). The multiresolutional property of the wavelet transform is exploited to pick morphologically significant points from the parametric representation of the curve. The polygonization can be tuned for fine or coarse approximations by a user-specified threshold parameter. The algorithm is linear in the number of curve points.

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CP02

Automatic Generation of Hierarchical Geometric Representations

A unified approach is introduced for automatically generating multi-resolution, hierarchical object representations for a variety of geometric tasks. A voxel-based representation provides spatial filtering at the desired feature resolution. From this an Axial Shape Graph is extracted, which is then decomposed into a well-balanced tree illustrating the overall shape structure of the object as a hierarchy of subcomponents. Various task specific representations can then be constructed from this generic object description. This prototype has been tested on an application that produces representations specialized for the task of collision detection in 2D environments. The extension to 3D is in progress.

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CP02

Multi-Resolution Modelling Applied to Prosthetics

Intimately fitted devices, as used in prosthetics and similar disciplines, have individual shape, personal to the patient concerned. A significant advantage can be derived from multi-resolution modelling because intimately fitted devices require modification of anatomical shape by prescribed rules (some local, others global) to determine the shape of the device. Multi resolution modelling is ideal, because manipulation at different resolutions is a key possibility. The adaption and application of multi resolution modelling to this field will be demonstrated.

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CP03

Point Membership Classification for Sweeps and Unsweeps

Sweeps are one of the basic representation schemes in solid modeling, and have numerous applications in graphics, geometric modeling, mechanical design and manufacturing, and motion planning. We recently proposed a new operation of unsweep which is dual to the sweep and has attractive computational properties. We will show that the PMC tests for general sweeps and unsweeps reduce to classifying the trajectories of certain points against the generator of the sweep or unsweep.

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CP03

SIF: The Emerging Solids Interchange Format

We present the current state of the NSF-sponsored development of a new Solid Interchange Format, SIF, a simple and clean language for use as a digital interface for Solid Freeform Fabrication, and of associated checking and conversion tools. SIF is a terse, human readable ASCII format providing process- and resolution-independent ideal shape specification, explicit design intent and topological information; it also addresses issues of precision and tolerancing.

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CP03

Minkowski Sums of Solids Defined by Real Functions

Minkowski sum operations are considered in the context of geometric modeling with real functions. The problem is to find a real function $f_3(X)$ for the Minkowski sum of two objects defined as $f_1(X) \geq 0$ and $f_2(X) \geq 0$. We formulate the Minkowski sum in terms of other operations: the Cartesian product with R-functions resulting in a higher dimensional object and a mapping to the initial space. We apply Minkowski sums to implement offsetting and metamorphosis between set-theoretic solids with curvilinear boundaries.

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CP03

Orienting Transverse Fiber Products

Suppose that we represent regions in the plane (or in a space of higher dimension) by giving their oriented boundaries and that we want to compute the Minkowski sums of our regions. To find boundary points on a Minkowski sum, we must match up boundary points on the two summands at which the tangent lines (or tangent hyperplanes) are parallel. This matching process is an example of a *fiber product.* It is well known that a transverse fiber product of smooth manifolds is again a smooth manifold. We study rules for orienting that fiber-product manifold, given orientations on the factor manifolds.

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CP04

Feature-based Isotopy for Volumetric Shapes

The problem is considered for construction an isotopy for 2D and 3D shapes that preserve given a set of features and their trajectories. Intermediate shapes are homeomorphic to the initial shape and the deformation is a homotopy. Its potential application domain for isotopic deformation is large including medical surgery planning, shape fabrication in computer aided design, and modeling biological processes. Two algorithms are presented. Computational complexity is analyzed and experimental results are included.

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CP04

Smooth Anatomical Modeling of Structures of Arbitrary Topology

We will present our latest research on the construction of smooth surface models of anatomy from CT/MR data, as needed for nonvisualization tasks such as virtual surgery, prosthetic design, and flow simulation. We have recently been concentrating on the reconstruction of branching data: the identification of branching structure and the construction of canyons at these branches. We will also comment on the applications of our anatomical models.

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CP04

Efficient Display of Triangular Bézier Surfaces

We present efficient techniques for rendering surface models with triangular Bézier surfaces. Each triangular surface is dynamically triangulated using uniform domain tessellation. The density of tessellation depends on the position of the user. The overall algorithm includes efficient visibility

computation and use of coherence to perform incremental tessellation. The algorithm allows models to consist of both triangular and tensor-product surfaces and generates triangulations without cracks at surface boundaries. In addition, techniques to convert degenerate tensor-product surfaces to triangular form are presented. Generalization of the tessellation algorithm to n-sided domains are also presented.

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CP04

Interactive Rendering: A Time-Based Approach

Interactive rendering of large data sets requires fast algorithms and rapid hardware acceleration. Both can be improved, but none of this ensures interactive response times. If a scene is too complex, performance decreases, and neither faster algorithms nor speeding up the hardware can guarantee interactive behavior. Certain timing characteristics should be incorporated in order to support such properties. In our new approach we propose an interactive rendering pipeline with special timing predicates. We apply this technique to medical imaging, where large data sets derived from CT or MRI scans and CAD designs must be rendered in real-time with immediate monitoring feedback. Interactive behavior enables the user to manipulate and adjust the visualization straight on demand.

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CP04

Projective Harmonic Analysis in Computer Vision

We present a projective analogue of the (Euclidean) Fourier analysis and discuss its applications in image processing. We confirm the projective characteristics of the analysis by computational tests, in which using the inverse projective Fourier transform of a pattern's grey-level function, we reconstruct the pattern's *any* projectively distorted image from the only *one* projective Fourier transform of the original (undistorted) pattern. The results show that the projective Fourier analysis is an important tool in developing an automated perspective-independent object recognition system.

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CP04

Hierarchical Triangle Strips

In this paper we introduce a method to construct hierarchical triangle strips that completely cover surfaces given in parametric or implicit form. The representation generated by our method can be exploited with advantages in many applications of geometric modeling and computer graphics.

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CP05

New Algorithm for Offset Curve Computation via MAT

We present a new algorithm for computing the offset curves of a plane domain. Our algorithm is based on the earlier work of the first two authors, S.W. Choi, and N.-S. Wee on finding the medial axis transform. The main idea behind of this talk is the method of decomposing a domain into very simple subdomains called the monotonic fundamental domain. Other important aspect of our work is an appropriate data structure and operations on it to keep track of the domain decomposition information.

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CP05

Topology Change in Shelling Operation

The major restriction of most shelling algorithms is that topology of the offset solid shouldn't be different from the original solid. We describe varieties of possible topology changes in shelling because of the interferences between the offset faces. An algorithm to detect and process some kind of topology changes during shelling is presented with examples created from I-deas solid modeler.

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CP05

Curve Offsetting Based on Legendre Series

Curve offsetting is one of the most important geometric operations in CAD/CAM systems due to its immediate applications to NC machining. Although offset curves to Pythagorean-hodograph curves are rational, offset curves to generic rational curves are non-rational and hence incompatible with NURBS representation – a standard in most CAD systems. For this reason, approximation techniques have been widely used for curve offsetting. From Neumann theorem it is known that Legendre series converges to an analytic function defined over $[-1, 1]$. Based on the use of Legendre series, we present a stable and efficient method for offsetting planar B-spline curves. Our approach provides users with easy control of approximation accuracy and flexibility to determine the degree of an offset curve.

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CP05

Skeletonization of Discretized Shapes by Delaunay Triangulations

We present a new morphological transform called the *Chordal Axis Transform* for planar shapes, leading to a constructive definition of the *skeleton* of a discretized shape. We describe an efficient algorithm based on the *Delaunay Triangulation* of polygons for skeletonizing the shape. The resulting skeleton is connected and faithfully captures the structure of the shape. Moreover, the algorithm allows hierarchical pruning of the skeleton of a shape to capture its essential structure at various resolutions.

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CP05

Quarternion Representation of Pythagorean-Hodograph Space Curves

It is well known that complex representations of plane curves facilitate the investigation of Pythagorean-hodograph plane curves. Hamilton's quarternion is an extension of the complex plane. As quarternion operations provides a way of doing arithmetic on four-dimensional quantities, a subset of quarternions can be used for expressing spatial manipulation. It is shown that quarternion representations of space curves also facilitate the investigation of Pythagorean-hodograph space curves.

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CP06

Spline-Galerkin-Approximation of Elliptic Problems

The Spline-Galerkin Approximation (SGA) is a new method which uses B-Splines as basis functions in suitable variational formulations of elliptic boundary value problems. By representing the boundary data by a penalty term, the boundary approximation becomes unnecessary and the domain is discretized by an orthogonal uniform grid. This approach combines techniques from geometric modelling and finite element analysis and yields a considerable simplification for domains with complicated boundary. As an example we consider the Poisson equation with Dirichlet boundary conditions. The minimization of a suitable functional with penalty term based on the least-squares method yields an approximant with optimal order of convergence.

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CP06

Repairing CAD Models

We describe an algorithm for repairing CAD models that have errors like cracks, degeneracies, duplications, holes, and overlaps. Such errors hamper further processing like finite element analysis, radiosity, rapid prototyping, etc. Our algorithm consists of two major steps. First, we construct a list of unification candidates (vertices and edges). Second, we sequentially merge vertices and edges that are deemed to be topologically adjacent. After the merging phase polygonal holes may remain in the model; these may be triangulated at the option of the user. We provide visualization of the error-correction process which allows the user to make local changes to the topology for obtaining the desired model.

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CP06

Mathematical Modeling of Using Different Endmills and Tool Placement Problems in CAD/CAM Systems for 5-Axis NC Sculptured Surface Machining

This paper presents the mathematical models and methods of finding instantaneous cutting profiles to compute cutter placement and machined surface error problems for 5-axis free-form surface machining. Different types of endmills are used in this study. A generalized tool description with tool collision variables is developed for 5-axis machining. A method of deciding tool orientation to avoid rear tool collision using global geometry information is also presented. The techniques presented in this paper can be used to eliminate errors in CAD/CAM systems for 5-axis machining of free-form surfaces.

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CP06

Fast Interference Detection using Oriented Bounding Box Hierarchies

We present a data structure and an algorithm for efficient and exact interference detection amongst complex models undergoing rigid motion. The algorithm is applicable to all general polygonal models. It pre-computes a hierarchical representation of models using tight-fitting oriented bounding box trees (OBBTrees). At runtime, the algorithm traverses two such trees and tests for overlaps between oriented bounding boxes based on a separating axis theorem, which takes less than 200 operations in practice. It has been implemented and we compare its performance with other hierarchical data structures. In particular, it can robustly and accurately detect all the contacts between large complex geometries composed of hundreds of thousands of polygons at interactive rates.

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CP06

Crack-free Tesselation of Parametric Surface Models

High performance graphics workstations have elevated the visulization of CAD models from being simple tools using wireframe renditions to becoming vital components in the design process by fully exploiting smoothly shaded image rendering. The most efficient approach in visualizing CAD models is to first break the surfaces into polygons and then displaying the polygons with specialized rendering hardware. One disturbing consequence with the polygonalization process is the introduction of cracks between adjacent surfaces due to inconsistent tessellations. As far as we know, there is no published or demonstrated solution to this problem prior to this work. In this talk, we present an efficient solution to the crack problem which maintains very good image quality and controls the number of polygons produced. We show test results on actual CAD models.

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CP06

Anisotropic Bubble Mesh Generation

Most automatic mesh generators are designed to create an isotropic mesh. In some FEM analysis, however, an anisotropic mesh is more efficient in terms of computational time and solution accuracy. We present a new method for graded, anisotropic meshing in which anisotropy is given as a vector field over the domain to be meshed. The method consists of two steps: (1) close packing of ellipsoidal bubbles in the domain, and (2) connecting bubble centers by the anisotropic Delaunay triangulation.

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CP07

Parametric l_1-, l_2-, and $l_\infty-$Approximation

This talk compares l_1-, l_2-, and $l_\infty-$approximation of discrete data by polynomial spline curves and surfaces. Unlike the l_2 case, the l_1 and l_∞ objective functions do not split into independent terms for the components of the coordinates. It is shown how approximate l_1 and l_∞ approximations can be found iteratively by solving a sequence of linear programming problems, where usually only a very small number of iterations is required.

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CP07

Near-Interpolating Spline Curves

The near-interpolating spline curve minimizes a certain (standard) quadratic functional, under the constraint of near-interpolation, and over a space of sufficiently smooth curves. The minimizers are necessarily parametric spline curves but with variable knots, and moreover, are smoothing splines in the sense of Schoenberg and Reinsch but with weights corresponding to Lagrange multipliers of the dual problem. An extension to Hermite type near-interpolants will also be discussed.

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CP07

Geometric Interpolation for Practical Applications

We present a simple C^1 interpolation scheme for planar curves based on cubic polynomial splines. In contrast to standard Hermite interpolation, the length of the tangent vector is not prescribed and a third point with its tangent direction inside the segment is interpolated. The method is similar to the G^2 cubic Hermite, due to de Boor, Höllig Sabin and generalises the midpoint Hermite cubic provided by Dokken, Dæhlen, Lyche, Mørken to approximate circles and Floater to approximate conic sections. Numerical computations in context of parametric marching suggest the approximation order $\mathcal{O}(h^6)$ and yield remarkable data reduction.

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CP07

A Practical Method for Minimax Approximation of NURBS Curves and Surfaces

This paper treats the minimax approximation of curves and surfaces from discrete sets of points. If is a difficult non-linear problem and is further complicated by the minimizing parameter value (mpv), the value of the parameter at which the closest distance between a point and the curve is attained in the usual R2 or R3 sense. So, if 1000 points are to be approximated, then 1000 mpv's must be included as solution variables. The large numbe of variables and the highly non-linear nature of the problem makes it intractable. The method described here separates the solution of the curve from the determination of the mpv's. It also dramatically reduces the number of degrees of freedom required in the basis from other methods such as least squares, which also simplifies the problem. The solution method is a linearization which takes advantage of the two properties above.

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CP07

A Companion Matrix for Bernstein Polynomials

A companion matrix **M** for a Bernstein polynomial $p(x)$ is constructed, and matrix norms are used to place upper bounds on the magnitude of the roots of $p(x)$. It is shown that the expressions for these bounds are more involved than are their equivalents for a power basis polynomial. Lower bounds on the magnitude of the roots of $p(x)$ are obtained by considering $\mathbf{M}^{-1}$, thereby restricting the roots of $p(x)$ to an annulus of the complex plane.

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CP08

The Boundary Surfaces of Trivariate Solids

A parametric equation of the form

$$\mathbf{P}(u, v) = (x(u, v, w), y(u, v, w), z(u, v, w))$$

for $u \in [u_a, u_b]$, $v \in [v_a, v_b]$, and $w \in [w_a, w_b]$ represents a solid model in 3-dimensional space – a trivariate solid. These solids are a direct extension of the surface patch, which in its B-spline form, is widely used in modeling of complex objects in computer graphics and geometric modeling. Visualizing these solid objects depends upon the determination of the boundary surfaces of the object: some which can be determined directly from the parametric definition of the solid, and some which are analytically defined. We present methods to determine the boundary surfaces of the model, to detect when they can be represented parametrically, and to construct the non-parametric boundary surfaces.

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CP08

Efficient and Accurate B-rep Generation of Low Degree Sculptured Solids using Exact Arithmetic

We present efficient representations and algorithms for exact boundary computation on low degree sculptured CSG solids using exact arithmetic. We generalize previous work using exact arithmetic, which was restricted to polyhedral models, to higher order objects composed of rational parametric surfaces. We describe the algorithms necessary for computing the geometry and topology of the boundary representation efficiently, and describe the results of a preliminary implementation of these algorithms.

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CP08

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

Conventional solid or surface modeling systems cannot represent both the complete solid model and the abstract model in a unified framework. Recently, researches on non-manifold modeling system have been performed to solve this problem. This paper describes the open kernel system for modeling non-manifold models which has been developed during last three years at Seoul National University. 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. This system is developed using the C++, the OpenGL and the X window on SGI workstation.

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CP08

Boundary Representation Variance in Solid Modeling

One of the key unsolved problems in parametric solid modeling is a robust update of the solid's boundary representation, given a specified change in the solid's parameter values. The fundamental difficulty lies in determining the mapping between boundary representations for solids in the same parametric family. We use tools from algebraic topology to define the notion of Boundary Representation (BR-)variance for solids in the same parametric family, based on the assumption of continuity, and arrive at the necessary conditions which must be satisfied by any mapping between solids in the same parametric family.

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CP09

Blending, Smoothing and Interpolation of Irregular Meshes Using N-Sided Varady patches

A unified method for blending, smoothing and interpolation of irregular meshes with arbitrary topological type is presented. The new approach treats all these problems as a surface fitting problem by first restructuring the given mesh to obtain a new mesh suitable for network curves construction, and then filling all the n-sided holes framed by the network curves with n-sided Varady patches. The smoothness of the resulting surface is achieved through a global energy minimization process. The resulting surface is C^1 continuous.

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CP09

Toric Approach to Low-Degree Rational Surfaces

We define a real toric (RT) surface as a real (possibly nonstandard) part of a complex toric surface. The class of RT surfaces includes: all quadrics, cones over rational curves, all non-parabolic cyclides, surfaces of revolution with a conic generatrix etc. We prove that any RT surface has: (1) Universal parameterization (earlier introduced by the author—it is used for modeling Bézier patches on the surface); (2) Control net: for example, 5 control points define a principle patch of a cyclide (instead of 9 points of a biquadratic scheme).

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CP09

An Introduction to Quartic Supercyclides

This paper further studies some quartic surfaces recently investigated by Degen, having potential for CAGD use in blending and free-form surface design. There are four subclasses. Parametric and algebraic forms are given for all of them, and the major subclass is shown to belong to a class of surfaces first studied by Kummer. These surfaces include projective transformations of the Dupin cyclides, and the name *supercyclides* has been proposed for them.

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CP09

Constructing Tubular Surfaces from Dupin Cyclides

In this talk, a method of joining sections of Dupin cyclides together will be presented. Its shape can be modified through changing control points and the radius of an initial sphere. More sophisticated shape controls such as adding and removing sections of Dupin cyclides will also be discussed. While adding more sections is always possible, removing a section or replacing several adjacent sections requires a modified double cyclide blending procedure.

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CP09

Negation Invariant Blending in Solid Modeling

Negation invariance helps define both the geometry and topology of blends on solid models, especially in the regions or vertices of mixed convexity. Negation invariance,

in itself, is a useful but not a vital feature of a modelling operation: it makes easier to design counterparts that fit together. Considering some properties of offsets and rolling ball blends, and requiring symmetrical negation invariance, lead to a solution made up of channel and Voronoi surface pieces.

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CP19

Circular Arcs Approximation By Quintic Polynomial Curves

This paper will present a simple method for approximating circular arcs with high accuracy using quintic polynomial curves. In addition to the positions and the tangents at the ends of the arc being approximated, the approximating curve also interpolates the end curvatures of the arc. This ensures that curves approximating circular arcs of same radii but different angular spans can be joined with G^2 continuity. Numeric result shows that the approximation error is about 4.15×10^{-6} for a quadrant circle of unit radius and in general the approximation is about eighth order accurate.

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FS01

An Algorithm for Determining and Classifying Triangular Quadric Patches

An easy algorithm for determining, if a given rational triangular Bézier patch of degree 2 lies on a quadric surface, and if so, for establishing the quadric's affine type, is presented. First, the question whether the patch is a quadric patch is solved by means of the related Veronese surface in five–dimensional projective space. Once established that the patch lies on a quadric, its Gaussian curvature yields the projective type of the quadric. Then, the quadric's affine type is obtained by means of the quadric's intersection with the plane at infinity. The algorithm is illustrated for several examples.

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FS01

Finding the Exact Topological Structure Determined by a Set of Curves

We examine the problem of determining, when possible, the exact topological adjacency structure of the planar subdivision induced by a set of curves, given in implicit form, over a given rectangle. This means finding the number of points of intersection of the curves and the way curve segments are linked to determine regions. We use a recursive method based on estimates given by interval or affine arithmetic together with conditions under which topology can be exactly determined.

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FS01

A New Approach to the Surface Intersection Problem

Planar cut and surface intersection software is an important component of any CAD system. This talk present two new ideas in the numerical solution of such problems. The first is the notion of topology resolution. In this process, the structure of the intersection curves, including the identification of closed interior loops, is determined prior to their actual numerical solution. The second idea is to compute the intersection curves by solving numerically a differential-algebraic equation.

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FS01

Multisurface Geodesic Curve Generation Utilizing Computational Geometric Tools

Mathematically, a geodesic is a curve on surface having zero geodesic curvature (ZGC): the shortest distance between two points. Presented are computational algorithms for generating geodesic curves across multiple surfaces, given the differing boundary conditions of 1) starting point and starting vector, or 2) two ending points. The algorithms employ commonly used computational geometric tools to generate a set of tolerance points which are then curve-fit. A method of generating near parallel geodesics across multiple surfaces is demonstrated.

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FS01

A Fast Algorithm for Computing the Degenerate Intersections of Two Quadric Cones

A fast and simple algorithm for computing all degenerate intersection curves of two quadric cones will be presented. Detecting and computing the degenerate intersections of two quadric cones are important since it is the foundation of the conic correspondence and reconstruction problem in computer vision and serves as a single criterion for determining if there exists a blending projective Dupin cyclide for two surfaces that have quadric tangent cones (*e.g.*, revolutionary and canal surfaces and their projective images).

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FS01

Degenerate Normal Vectors of Tensor Product Surfaces

One of the essential properties of a surface is its normal vector. Surface rendering, surface-surface intersection, and offset surface generation all require normal vectors. A normal vector at a point on a tensor product surface is usually obtained by taking a cross product of the two partial derivatives. However a normal vector can sometimes degenerate so the cross product yields a zero vector. This talk proposes a method for computing degenerate normal vectors of a tensor product surface.

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FS02

Construct Faithful Geometrical Features on Composite Surfaces Using a Global Reparametrization Scheme

The Direct Surface Manipulation method provides direct shape control over user-specified features on a single parametric surface. A global surface reparametrization scheme was developed, extending the method to multiple surfaces. This scheme reparametrizes multiple surfaces into a shared two-dimensional space. The result is a uniform parametric domain serving as a global space for surface of different topologies, dimensions, and shapes. Defining features in this domain allows them to span multiple surfaces. Spherical projection is applied to perform the reparametrization because of its ability to reduce the effect of variable surface curvatures on the results.

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FS02

A Design Intent Representation Scheme for Dimension-driven Geometry

An architecture for capturing and representing the design intent during the creation of geometry is presented. This enables the geometry to be edited by modifying its dimensions or by editing the design intent directly. When a modification is made, the geometry can be regenerated automatically such that the design intent is maintained. The representation scheme presented here enables user-defined features and parts to be created by assembling pre-defined features using a declarative approach. Whereas, the design intent of the pre-defined features are represented in a procedural fashion. This scheme enables algorithms for fast regeneration of the geometry to be implemented.

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FS02

NURBS Based Advanced Surface Editing Tools for Design Engineers

We present several methods based on Non-Uniform Rational B-spline formulation to refit, edit, smooth, and combine adjacent B-surfaces, that have been used to preprocess surfaced models for solid modeling. We developed the software to run as a User Function application in Unigraphics. Underlying surfaces must be connected corner-to-corner and end-to-end. An underlying surface is first refitted with a B-surface to within a set of user specified tolerances, then the vertices are aligned across the common boundary by matching vertices and knot insertion on one or both sides. The smooth and combine tools are then used to remove the triple knot boundary and form a single surface.

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FS02

New Challenges Arising from Haptic Rendering of Mathematical CAD Models

Haptic interaction is the process of physical communication through the sense of touch. The research described focuses on the tactile force-feedback communication between a human and a mathematical CAD model made possible with a robotic device consisting of six actuated degrees of freedom. The development of this research has presented a new set of problems in real-time geometrical computation that must be solved in order to simulate the action of a point probe interacting with a mathematical model. These problems will be presented and initial solutions discussed.

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FS02

Using Farin Points for Rational Bezier Surfaces

Farin points (weight points, frame points)are a useful tool for handling the weights of rational Bezier curves. Unfortunately, their straightforward extension to Bezier triangles leads to an overdefinition of the weights. We present a scheme of Farin points which defines the weights of all Bezier points in a triangular Bezier net uniquely and where the Farin points are independent to each other. Finally we present a Farin point scheme with the same properties for rectangular Bezier nets.

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FS02

Surface Building/Editing with Triangular-Quadrilateral Mesh Simplification

This work presents a method for the construction of a smooth (G^1) surface approximating the initial mesh and such that it reduces the data size and provides a possibility of the local refinement. First, the refinement of the initially large triangular/rectangular mesh into relatively small quadrilateral mesh is done. Second, a G^1 surface is constructed over the simplified mesh using a plate energy method. Finally the possibility to improve the quality of of the resulting surface by the local refinement is provided. Only local recalculation have to be applied for such purpose. The method is illustrated by the approximation of the few complicated triangular meshes by smooth surface with relatively small number of the elements. The possibility of the local refinement is demonstrated.

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FS03

Optimal Interpolatory Subdivision Schemes in Multidimensional Spaces

We analyse the approximation and smoothness properties of fundamental and refinable functions that arise from interpolatory subdivision schemes in multidimensional spaces. In particular, we provide a general way for the construction of bivariate interpolatory refinement masks such that the corresponding fundamental and refinable functions attain the optimal approximation order and smoothness order. In addition, these interpolatory refinement masks are minimally supported and enjoy full symmetry. Several examples are explicitly computed.

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FS03

Dynamic Catmull-Clark Subdivision Surfaces

We present a new dynamic subdivision surface model which inherits the attractive properties of the Catmull-Clark subdivision scheme as well as that of the physics-based modeling paradigm. This new model provides a direct and intuitive means of manipulating geometric shapes, a fast, robust, and hierarchical approach for recovering complex geometric shapes from range and volume data with fewer degrees of freedom. We provide an analytic formulation and introduce the physical quantities required to develop the dynamic subdivision surface model which can be interactively deformed by applying simulated forces in real time. The governing dynamic differential equation is derived using Lagrangian mechanics and the finite element method.

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FS03

Free-form Curve Generation By Recursive Subdivision of Polygonal Complexes

We present a method for generating free-form curves as the limit of subdivision of polygonal complexes. A polygonal strip complex P_s in R^3 is a homeomorphic image of a Jordan domain $\overline{\Delta}$ split into n-gons. One essential advantage of this technique over the control-polygon based scheme is its practical use in the domain of curve interpolation by subdivision surfaces. We also formulate this problem and establish the general mathematical theory involved to develop construction algorithms that extend the type of interpolated curves to intersecting curves at an interior or a boundary point of the interpolating surface.

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FS03

Freeform Splines

A simple method to construct a regularly parametrized G^2-spline surface of arbitrary topology from one control net is presented. The surface is piecewise bisextic around extraordinary points and bicubic elsewhere. Furthermore, the bisextic representation of the surface allows for subdivision algorithms. The underlying ideas can also be used to construct subdividable G^k-splines of bidegree $2k+2$.

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FS03

Parallel Algorithms for Subdivision Surfaces

We present parallel algorithms for the evaluation of subdivision surfaces in MIMD distributed memory environments. The parallelization strategy is that of *domain decomposition*, where the set of starting points is subdivided into several subsets and each subset is assigned to a different processor which constructs its local part of the surface. Choosing a proper decomposition of the domain it is possible to obtain efficient and scalable parallel algorithms, as it is confirmed by numerical experiments carried out on an Intel iPSC/860 and on an Intel Paragon.

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FS03

A Variational Method for Constructing Subdivision Schemes over Irregular Grids

Subdivision curves and surfaces emerged as an alternative means for representing curved shapes. In this framework a curve or surface is defined as the limit of a repeated averaging process of control points. We present a method for deriving the averaging masks for a subdivision process from a set of differential operators. The resulting limit will minimize the variational problem defined by the given differential operators. In particular a computational method for deriving such averaging masks for irregular grids will be presented in this talk.

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FS04

B-Spline Developable Surface

First we present a method such that n Bézier developable surfaces, whose two directrices lie on parallel planes, are strung together by joining them along their end rulings with C^2 continuity so that they can be represented as a single B-spline surface. Second, we explore the case when the two directrices are 3D space curves that do not necessarily lie on parallel planes. Finally, the computation of geodesics and inflection lines on developable surfaces are discussed.

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FS04

Surfaces of Revolution of Geometric Degree Three and Their Bezier Like Control

Every graphics station is born with a demo showing how to construct a surface of revolution: just click in some points and revolve the resulting Bezier curve around an axis. The geometric degree of this surface is twice the degree of the Bezier curve. So for a cubic we get a surface of degree six. In this paper we present a method for the construction and shape control of a connected piece of a surface of revolution of degree three joining two given circles with prescribed contacts along them. The control of the surface is enforced through an auxiliary Bezier cubic which is closely connected to the surface.

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FS04

Cone Spline Surfaces

We approximate developable surfaces with segments of right circular cones which are smoothly joined with G^1 continuity. These cone spline surfaces are well-suited for applications: They possess degree 2 parametric and implicit representations. Bending sequences and the development can be computed without numerical integration and the offsets are of the same type. The algorithm chooses an appropriate sequence of rulings plus tangent planes of the given developable surface. Then each pair of consecutive rulings plus tangent planes can be interpolated by a smoothly joined pair of right circular cones, which involves known results on planar and spherical biarcs. Another approximation method is presented in generalization to osculating arc splines of Meek and Walton.

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FS04

Rotational and Helical Surface Approximation for Reverse Engineering

Given a surface in 3-space or scattered points from a surface, we investigate the problem of deciding whether the data may be fitted well by a surface of revolution or a helical surface. Furthermore, we show how to compute an approximating surface and put special emphasis to basic shapes used in computer aided design. The algorithms apply methods of line geometry to the set of surface normals in combination with techniques of numerical approximation.

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FS04

Approximation by Cylinder Surfaces

We present a new method for approximation by cylinder surfaces. By use of a weighted Gaussian image of the given surface, we determine a projection plane. In the orthogonal projection of the surface onto this plane, a reference curve is determined by use of methods for thinning of binary images. The cylinder surface then can be derived with its directrix in the projected area and rulings perpendicular to the projection plane. Application of the method in ship design is given.

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FS05

Piecewise Quadric C^1-Interpolation - a Geometric Approach

In this talk we will present a geometric approach to piecewise quadric C^1-Interpolants which were constructed algebraically by Dahmen in 1989. These piecewise quadrics interpolate the vertices of a triangular net and prescribed normals. In Dahmens's construction certain free parameters were set to arbitrarily chosen constants. Our approach provides a geometric interpretation of those constants. While Dahmen's interpolant depends globally on the input data we present a slightly modified construction of a piecewise quadric interpolant which depends only locally on the input data.

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FS05

Curvature-Continuous Curve and Surface Extensions

It is often necessary to evaluate parametric curves and surfaces outside their basic domain of definition. Simply ignoring the domain boundaries and evaluating at any given parameter value is sometimes feasible, but problems can arise when this is done. One particular problem is that the geometry can behave badly outside the domain: a cubic B-spline is a good example, when evaluated far away from the basic parameter range. One solution to this problem is to extrapolate beyond the boundary by following the tangent vector, resulting in a C^1 or G^1 join. At least one C^2 extension method has been published. Each of these methods has advantages and disadvantages in terms of the continuity at the original boundary, behavior for both small and large extensions, and ease of implementation. We present a method of extending geometry that performs well with regard to all of these criteria. It provides a true C^2 extension, is easy to implement, and behaves well in practice for both small and large extensions.

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FS05

New Solutions to a Common Surface Construction

This paper addresses a problem that arises quite often in surface construction, and has received much attention over the years: Given one surface patch, construct a second surface that meets the first with tangent-plane continuity along one edge, and whose cross-boundary derivatives match given directions at the two ends of the common edge. If the given surface is a polynomial of degree n, then in the general case a degree $n+1$ surface is required for the interpolation. A second surface of the same degree can be fit only under certain stringent conditions. This paper reviews the history of this problem, determines exactly why a degree n surface is insufficient, and analyzes the conditions under which a degree n surface will fit. We then present a rational surface of degree n that is able to solve the problem in the general case. We also show that even when the original surface is rational, a second rational surface of the same degree can always be constructed to satisfy the constraints.

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FS05

Surface Interpolation with Triangular Patches

There are many schemes for interpolating a triangulated set of points. These schemes can be classified in a variety of ways based on the type of data they interpolate (functional, spherical, parametric, etc), by the type of surface patch they construct (polynomial, rational, etc), by the amount of data they use to fit a patch to a particular triangle of data (local or global), and by the level of continuity between patches. Most of the local schemes suffer from severe shape defects. After meeting their continuity conditions, these techniques set a large number of degrees of freedom in their construction using simple heuristics. In this talk, I will describe a local parametric scheme that has improved surface shape. This improvement is a result of improved settings of the crossboundary free-parameters.

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FS05

Surface Design with Modified SBB Patches

SBB patches defined on spherical triangles were introduced and studied in and have been shown to be useful for fitting scattered data on the sphere. They do not seem to be so well-suited for design purposes. We introduce a modification of the SBB patches which is motivated by recent results on p-Bezier curves and show that they are much more useful for design purposes. In particular, we estab-

lish a deCasteljau algorithm, subdivision, degree raising, and show that the control net has a triangular piecewise planar structure which accurately models the shape of the surface patch. An additional feature is that even order patches produce an exact model for the sphere.

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FS05

Connecting Gordonesque Surfaces

A Gordon-like surface derived from a form of univalent Catmull-Rom interpolation is proposed which interpolates an arbitrary rectangular mesh and for which it is possible specify cross-boundary tangents along mesh lines, thereby permitting one such surface to be attached with G^1 continuity along a mesh line to a curve in another. The proposed surface also possesses local control and the property that the degree of global continuity is limited only by that of the mesh

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FS06

Representing Cuts in Elastic Surfaces and Volumes

Because of the increased use of range and tomographic images in industry and medicine, the need for representing free-form surfaces and volumes that contain cuts has become critical. An effective representation for complex free-form surfaces and volumes that contain cuts is developed using the rational Gaussian formulation. This representation allows association of nonuniform elasticities to surfaces and volumes, and enables simulation of cuts.

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FS06

A Linear Approach to Convexity Preserving Surface Approximation using Iterative Knot Insertion

A linear algorithm for convexity preserving surface approximation of scattered bivariate data using tensor product B-splines is presented. A method for linearisation of the convexity constraints is proposed. A linear programming problem is created by a specific L_1-approximation technique based on least squares, which leads to a suitable knot insertion algorithm. The resulting surface is guaranteed to be convex and comes arbitrarily close to the given data, using this algorithm.

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FS06

h and p Versions for Nested Families of Triangular Finite Elements Spaces

A nested sequence of finite elements provides obviously a natural setting for a multiresolution approach of surfaces reconstruction based on scattered data points. For this purpose it is necessary to build hierarchical bases for the finite element interpolants. We present some families of triangular and quadrilateral elements which are relevant, contrarily of those usually involved for the numerical solution of PDE's. A multilevel approach can be provided through two versions of the finite element approximation. In the first one, the (classical) h-version, the sequence of sets is obtained by successive refinements of the original triangular grid.A second approach is related to the p-version of the finite element method, where the triangulation is kept once for all, but the order of the polynomials is increased. Error bounds are also investigated.

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FS06

Modelling Surfaces with Discontinuities using Splines on Triangulations

The purpose of this talk is to present a strategy for reconstructing surfaces from scattered data containing discontinuity information. The surfaces are represented as polynomial splines over arbitrary triangulations. But, instead of working with splines that possess the same smoothness over all triangle edges, we define spline spaces allowing functions to have a variable order of smoothness across these edges. Such spaces are then used for modelling scattered data with discontinuity information given as polygonal lines. In particular, we show several examples of surface reconstruction from faulted geological data.

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FS06

Interpolation of Scattered Data on a Sphere

A method of tessellation over the sphere, without mappings is presented. It is based in the 3D Voronoi tessellation determined by the data set. To perform it a dual construction called Covering Spheres is used and the result is the covering circles in the surface of the sphere which circumscribe the spherical Delaunay triangles, obtained this many interpolations may be constructed and we choose Sibson's interpolant due to its numerical advantages.

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MS02

Computing Homology Groups of Simplicial Complexes

We discuss some recent developments in computing homology groups of simplicial complexes. These are based on taking algebraic topological techniques that apply to the corresponding computations for manifolds, and adapting them to the discrete setting of simplicial complexes.

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MS02

Maintaining Delaunay Complexes under Motion in $\Re^3$

Dynamically changing point sets play a key role in various types of problems, including many design and simulation problems. Problems in unstructured mesh design and computer-aided design involve such point sets. The Delaunay complex provides key geometric and topological information about the point set. We describe algorithms for maintaining the Delaunay complex of a changing point set modeled by a series of snapshots. The algorithms have been implemented, and performance statistics will be presented.

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MS02

Kinetic Data Structures

Suppose we are simulating a collection of continuously moving bodies, rigid or deformable, whose instantaneous motion follows known laws. As the simulation proceeds, we are interested in maintaining certain quantities of interest (for example, the separation of the closest pair of objects), or detecting certain discrete events (for example, collisions — which may alter the motion laws of the objects). In this talk we will present a general framework for addressing such problems and tools for designing and analyzing relevant algorithms, which we call kinetic data structures. The resulting techniques satisfy three desirable properties: (1) they exploit the continuity of the motion of the objects to gain efficiency, (2) the number of events processed by the algorithms is close to the minimum necessary in the worst case, and (3) any object may change its 'flight plan' at any moment with a low cost update to the simulation data structures.

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MS02

Minimization of Mathematical Energies for Surfaces

With Brakke's Evolver we can interactively minimize geometric energies associated to surfaces in space. Originally, surface area was minimized (as in soap bubbles or foams), but we have extended the Evolver to work with other energies. Willmore's elastic bending energy for surfaces can model lipid vesicles; it can also be used to fair surface design or drive a sphere eversion. Repulsive-charge knot energies can untangle complicated space curves, and are also defined for surfaces.

John Sullivan
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MS03

Understanding and Managing Errors in Geometric Modeling

Experience has shown that no CAD system can eliminate all geometric inaccuracies. In light of these naturally occurring inaccuracies, geometry systems must have methods for managing errors. We discuss what these methods must achieve and how their use would affect algorithm development and downstream applications.

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MS03

Gaps and Discontinuities - Accuracy Issues

Mathematical concepts aquire a certain "uncertainty" as they are used in CAD systems. We examine how this affects the generation of errors and prevents effective error management. This will be done by examining two important CAD functions - surface/surface intersection and continuity analysis . Possibilities for precise definitions of the concepts involved will be discussed and analyzed.

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MS03

Topology and Semantics Relative to Geometric Accuracy

New conceptual approaches are needed for semantic consistency between floating point values for geometry and the symbolic representations for topology within CAGD algorithms. Possibilities for improved formal models are:

1. tolerance neighborhoods defined by appropriate metrics,
2. intersection of neighborhoods versus informal 'equality' of points
   (to avoid paradoxical loss of transitivity for equivalent points)

3. 'nowhere dense' sets to model 'degenerate geometry',
4. families of homeomorphisms for topological equivalence.

The role of these concepts relative to Parts 42 and 43 of STEP will be discussed.

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MS04

Constructing Variationally Optimal Curves Through Subdivision

Subdivision is a powerful paradigm for the generation of curves and surfaces. It is easy to implement, computationally efficient, and useful in a variety of applications because of its intimate connection with multiresolution analysis. An important task in computer graphics and geometric modeling is the construction of curves which interpolate a given set of points and minimize a fairness functional (variational design). In the context of subdivision, fairing leads to special schemes requiring the solution of a (banded) linear system at every step. We present several examples of such schemes including one which reproduces non-uniform interpolating cubic B-splines. By implementing variational schemes in a wiring diagram formalism we find associated wavelets and efficient algorithms to perform the corresponding decomposition and reconstruction transformations. The computational costs are low enough for interactive applications.

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Peter Schröder
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MS04

Interpolatory Subdivision and Biorthogonal Wavelets

We present the ideas from our paper *Multidimensional interpolatory subdivision schemes* (to appear in SIAM J. Numerical Analysis) in which we give explicit constructions of two dimensional interpolatory subdivision masks with increasing smoothness. We will also indicate how that construction can be used to find biorthogonal compactly supported wavelet families with one of the families generated by common elementary box splines and with choices for the other family of increasing smoothness.

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Zouwei Shen
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MS04

Hermite-Type Interpolatory Subdivision Schemes

The theory of matrix subdivision schemes provides tools for the analysis of general uniform stationary matrix schemes. The special case of Hermite-interpolatory subdivision schemes deals with refinement algorithms for the function and the derivatives' values, with matrix masks depending upon the refinement level, i.e., non-stationary matrix masks. Here we show that a Hermite-interpolatory subdivision scheme can be transformed into a stationary process. Then, using special schemes for generating some Hermite-type divided differences, we give the theory and the tools for analyzing the convergence and the smoothness of Hermite-type interpolatory subdivision schemes. In geometric design these schemes provide a tool for the interpolation of given normals, tangents or curvatures at the control points.

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MS04

C^k Analysis of Subdivision Algorithms and Applications

We present an analysis of subdivision surfaces of arbitrary topology. Assuming certain properties of the subdivision scheme we present conditions for the eigenvalues and eigenvectors of the subdivision matrix to yield C^k surfaces. Using this criterion we construct subdivision algorithms for quadrangular nets that produce C^2 surfaces. This method is also applied to construct interpolatory algorithms for triangular nets which generate in the limit C^1 surfaces.

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MS05

Neurotron 1000: A Robotic System for Stereotactic Radiosurgery

Neurotron 1000 was developed by Accuray Incorporated as a computer-controlled robotic instrument to accurately deliver high doses of radiation to brain tumors with minimal damage to the surrounding tissue in a noninvasive fashion. The system exploits the flexibility of the robot arm carrying a 300 pound 6 MV linear accelerator to deliver conformal dose distributions. Two low powered X-ray sources and cameras are employed as the vision system to track the patient movements. A fully integrated treatment planning system is used to design the robot paths and the corresponding doses to achieve desired dose distributions. This system has been operational at five different installations in US under investigational device exemption from FDA.

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MS05

Spline Interpolation for Industrial Robots and Its Application

Using rational spline motions it is possible to apply many of the powerful methods of Computer Aided Geometric Design (as Bézier or B-spline techniques) for solving problems from Kinematics and Robotics. We present an algorithm which generates such a motion from a sequence of given positions, e.g., of teach points. It can be used as a real-time interpreter scheme. The spline scheme has been developed as part of a prototype of a new controller for the industrial robots of Reis Robotics, Obernburg, Germany.

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MS05

CAGD in C-space Generation

Given a moving object A and an obstacle B, the Minkowski sum $B \oplus (-A)$ represents the Configuration space obstacle. Even if A and B are planar objects bounded by polynomial curves, the boundary of $B \oplus (-A)$ is generally not polynomial or rational. Generalizing conventional offset curve approximation methods in CAGD, this talk will present various techniques to approximate the boundary of $B \oplus (-A)$ with polynomial/rational curves.

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MS05

Constructing Robot Trajectories Using CAGD and Lie Groups

In this talk we show that several problems in robotic path planning can be formulated as the common CAGD problem of constructing smooth curves. The only difference is that such curves have to be constructed on the rotation group SO(3) or on the group of rigid body motions SE(3). We first consider SO(3) as a Lie group with a bi-invariant Riemanian metric, and apply the coordinate invariant methods of Riemanian geometry. We develop a deCasteljau's type algorithm for constructing smooth robot trajectories that would interpolate a set of control wrist center points and the associated rotations about each such points. We develop a computational method for this that minimizes a measure of the angular acceleration of the end-effector. We then consider the same problem for SE(3) and present a computational algorithm for solving the corresponding boundary value problem. At the end, we present several applications of these algorithms ranging from robotic arc welding and surface scanning to the application of robotics in roadway repairs and aerospace flight simulations.

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MS05

Automatic Fairing of Position Sets

This talk deals with the problem of fairing a given set of positions of a moving rigid body. Based on affine difference geometry local and global fairness criteria are derived which yield a simple affine invariant method for smoothing point sets. By applying the twist representation of spatial displacements, a robust and computationally inexpensive algorithm is deduced which allows real time position fairing. The results are illustrated in some examples.

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MS06

Computing the Index of a Three Dimensional Vector Field

The indices of the singularities of a vector field are critical to understand its behavior and visualize it. We discuss the meaning of this index in a three dimensional and higher dimensional vector field, and show how to compute the index using tools from Geometric Algebra, which is also briefly introduced Alyn Rockwood

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MS06

An Index Theorem for Polynomial Vector Fields

The visualization of vector fields is one of the most important topics in visualization. Of special interest over the last years have been topology-based methods. We present a theorem helping analysing polynomial vector fields. This is especially useful for dealing with critical points of nonlinear type in the field. The idea is based on Clifford algebra and complex analysis giving more topological information directly from the formulas than the usual cartesian description.

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MS07

Computers in Engineering Education

Every engineering program around has some level of integration of computer education into its courses. Typically, this integration takes the form of a high level computer programming language taught in the first year of studies and some "application programming" in the junior and senior year. Interstingly enough, computer programming is not a skill that engineers report using in their careers. A vast array of different tools available on the market has been curiously absent from engineering curricula, but has found its application in engineering practice. This talk addresses several of the relevant issues: what do the students really know about computers and computer programming, what should be taught in the courses, and what can be done to improve the current situation?

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MS07

GRACE – Graphical Ruler and Compass Editor

We demonstrate GRACE, an interactive ruler and compass construction editor for use in teaching geometry and proofs to high school students. Applying GRACE's powerful graphical user interface, students may define a construction, such as circumcenter or midpoint, and then develop proofs about the correctness of the construction, which will be automatically verified by the system. GRACE may be run in any Java-compatible WWW browser — see "http://www.cs.rice.edu/ jwarren/grace/".

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MS07

Unifying Algebra with Geometry in Education and Deometric Design

Geometric Algebra (GA) provides coordinate-free representations of geometric concepts. It incorporates quaternions and standard vector algebra seamlessly into a larger computational system that applies to any dimension. In 2D it automatically unifies vectors with complex numbers. This makes it possible to integrate high school geometry with algebra and trigonometry. Moreover, it facilitates the application of mathematics to physics, and it generalizes to coordinate-free methods for 3D geometric design and computation.

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MS07

An Interactive Tutorial on Curves and Surfaces

A tutorial is introduced for providing the student with interactive figures and animations in conjunction with minimal text, convenient for consumption on the computer, and appropriate for a quick introduction that supports a strong visual vocabulary of the subject. Issues are discussed such as presentation style, order, depth and rigor.

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MS08

The Past, Present, and Future of Reverse Engineering

Optical 3D scanners have been able to generate more points than most computer-aided design systems can handle for almost two decades. However, as low-end computers become more powerful and as more CAD systems accept input from these 3D scanners, many people are seriously considering cost-effective "cloud data" applications that were rejected as unrealistic just a few years ago. This talk will survey the evolution of reverse engineering and related applications, and discuss what potential improvements in scanner technology and computer software might bring in the coming years.

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MS08

Building Complex Models from Range Images

A number of techniques have been developed for reconstructing surfaces by integrating groups of aligned range images. A desirable set of properties for such algorithms includes: incremental updating, representation of directional uncertainty, the ability to fill gaps in the reconstruction, and robustness in the presence of outliers. Prior algorithms possess subsets of these properties. In this talk, we present a volumetric method for merging range images that possesses all of these properties. Using this method, we are able to merge a large number of range images (as many as 70) yielding seamless, high-detail models of up to 2.6 million triangles.

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MS08

Constrained B–Spline Surface Approximation of Irregular Distributed Data

Irregular distributed data points (measurement points of a laser scan) without any boundary informations will be approximated by tensor–product B–Spline surfaces. Adaptive changes of parametrization and of energy constraints avoid oscillations in regions without point informations. The boundaries of the approximated data sets are described by trimming curves of the approximation surface. The method can be extended to the approximation of data sets with a required distribution of isophotes (as quality control) or to the filling of n-sided holes in patch structures.

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MS08

VPL: The Virtual to Physical Link

We have built a Computer Aided Reverse Engineering system called Surfacer which allows conversion of three-dimensional measurements of physical prototypes and hand worked parts into NURBS-based CAD models. The software provides a number of mathematical algorithms that simplify the task of converting 3D data into surfaces. Some are: alignment of data to free form shape; efficient buildup of NURBS surfaces directly from measured data; the update of NURBS models when areas have been hand worked. The software and its algorithms are the focus of this presentation.

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MS09

Shape Optimization using the PDE Method

The paper presents some recent developments in automatic shape optimization. The approach adopted in the work uses the PDE Method to generate a generic geometry for a particular object. The boundary-value nature of this method allows for an efficient and concise parametrization of the overall shape. Appropriate analyses can be carried out and linked to an optimization process so that an optimal shape, within the domain covered by the design parameters, can be found. The examples presented will highlight some of the difficulties that can be encountered in the optimization process.

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MS09

Design and Manufacture of High-Performance Rational Cams with Pythagorean-Hodograph Curves

The dynamic performance of high-speed cams depends critically on identifying profiles that have smooth higher-order derivatives, and are compatible with precision CNC machining. Current practice, based on "backing out" cam profiles from prescribed displacement functions, yields transcendental curves requiring discrete G code approximations for machining. We show that Pythagorean-hodograph curves can be used to design rational cams of excellent dynamic performance, that are compatible with real-time CNC interpolators capable of machining cams from their analytic descriptions.

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MS09

Shape Optimization by Using Masks

An automatic and local fairing algorithm for bicubic B-spline surfaces is presented. A local fairness criterion selects the knot, where the spline surface has to be faired. A fairing step is than applied, which locally modifies the control net by a constrained least-squares approximation. It remains to use a mask on a sequence of subsets of control points. Some extensions of this method are also presented, which show how to build further methods by the same basic fairing principle.

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MS09

Shape-Preserving Fairing of Tensor-Product B-spline Surfaces

We consider the problem of fairing tensor-product B-spline surfaces under constraints on the sign of the Gaussian curvature in user-specified 2D subdomains of their parameter domain of definition. The employed shape-constraints are non-linear with regard to the control vertices of the surface and are obtained by generalizing the method devised by Floater (1994) for the non-parametric case. These constraints are then combined with quadratic as well as strongly non-linear fairness functionals, e.g., those proposed by Rando & Roulier (1994). The numerical performance of the so resulting alternative fairing schemes is tested and compared for several industrial data sets.

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PS

Minimum-Length Geodesic Computation

A geodesic is the analog of a straight line on a curved surface. It is a solution of a system of nonlinear ODEs. Both initial-value and two-point boundary-value problems are important. The shortest path between two points is a geodesic, but in general, the converse is false. Minimum-length geodesic computation compares non-unique solutions. A geodesic depends on both the manifold and the imposed metric. Non-Euclidean metrics model special problems, like optimization on a multidimensional constraint manifold. Geodesic computation uses software based on *Geodes* in *Netlib*. Visualization examples are presented.

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PS

IG: A Simple Constraint-based Geometrical Construction System

We present an interactive system for building and manipulating geometrical constructs with constraints. Unlike other systems, this system describe its models in a user friendly language that allows the user to create scenes using both direct manipulation and textual description. The language allows scenes to be created procedurally and declaratively. The system is being used in educational software to provide support for dynamical euclidean constructions.

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PS

3D Graphics Editting of Arbitrary Geometry Models

3D graphics editing plays an important role in applications such as computer aided design and animation. Tranditional techniques require users to modify a set of control points in order to achieve the overall effect of changing a part of an object. In this work, we propose a novel strategy: to construct a hierarchical structure for an arbitrary mesh. This will allow us to provide users with a simple click-and-drag interface for changing an arbitrary portion of an object while perserving its general topological structure.

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PS

Discrete Gaussian Curvature for Analysis of B-spline Modeled Cornea

A technique for modeling the anterior surface of the cornea has been developed that uses biquintic B-splines. Furthermore, color maps derived from Gaussian curvature have been established to show corneal shape and to discover pathalogical conditions such as keratoconus, a small corneal protrusion. These ideas are based on the study of variations of Gaussian curvature. To provide automatic analysis, we investigate the theory of discrete curvature of polyhedral surfaces applied to a triangulation of the control net. Under appropriate conditions, if the area of all the triangles approaches 0, then the polyhedral surface tends to a smooth surface and the discrete Gaussian curvature at any vertex approaches its corresponding true Gaussian curvature on the surface. This property allows us to quickly evaluate the key characteristics of the modeled cornea.

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PS

Modeling Bathimetric Data with Fuzzy B-Splines

We present a new technique to model bathimetric data with B-splines. Since bathimetric data are noisy and uncertain, classical splines are not suitable for the construction of useful models. We generalize the interval B-splines proposed by Patrikalakis et al. with the use of fuzzy numbers. Fuzzy arithmetic provides a powerful way to take into account uncertainty and subjective presumption levels of the data. We give algorithms to build a fuzzy surface model of the data. The model can be subsequently interrogated in 1D and 2D using Interval Newton Methods.

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The Algorithm for Testing Convexity of Steiner Surface Patches

We present a simple algorithm, testing if a triangular rational quadratic Bézier patch is convex or not. It takes even more simple form for integral patches. The algorithm is based on formulas, derived with the help of MAPLE's symbolic computations facilities, and the recent classification of quadratically parametrizable surfaces, due to A. Coffman, A.J. Schwartz and C. Stanton (CAGD, 1996, v.13, N3). We discuss also the possibilities of constructive use of derived formulas for creating convex triangular quadratic Bézier patches.

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Some New Schemes for n-Sided Patches

We present two rational schemes of n-sided patches. Both are constructed using $nk(k+1)/2+1$ basic functions, where k is a degree of boundary Bézier curves. The functions we use are linearly independent in contrast to S-patch of Ch. Loop and T. DeRose. The other advantage is more natural topological structure of the control points net. Triangular and four-sided patches posses some specific properties. For the pentagonal patch we develop two additional schemes with the same control points net.

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PS

A Method for the Construction of Trimmed B-Spline Surfaces Matching Given Boundaries

We present a two stage algorithm for creating trimmed B-Spline surfaces matching given boundaries. The first stage employs Radial Basis Functions, and the second stage is an approximation to a B-Spline surface. Two applications of this algorithm are presented. The first application creates a surface given it's closed boundary contour, and additional curves or points inside the domain for shape-control. The second application modifies a given surface in order to close gaps between neighboring surfaces.

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PS

Multiresolution Compression of Arbitrary Geometry Models

A multiresolution coding method which encodes a 3D geometry model into an embedded bit stream is investigated in this research. The coder first encodes the coarsest resolution of the model, and then includes the information of finer details gradually, according to their visual importance. The embedding property allows the decoder to terminate the decoding at an arbitary position in the compressed bit stream, and more accurate model can be obtained when more bits are decoded. Numberical experiments are conducted to demonstrate that the method has both multiresolution property and excellent rate-distortion performance.

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PS

Geometric Theory for Designing Optical Binary Amplitude and Binary Phase-Only Filters

The work of this paper is to firmly establish an analytic solution for the design of optimal binary amplitude filters (BAFs) for any object. The paper deals with finding an analytic solution for the optimal BAFs in terms of maximizing the field strength at the origin in the correlation plane. We have found that the design of optimal BAFs for optical processing is a simple geometric problem. It is shown that the construction of a convex polygon out of a phase-ordered phasors set of the object's Fourier transform leads eventually to an exact solution for the optimal BAF problem. Design examples of computer simulation and applications in fingerprints identification are given.

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PS

Interactive Modeling using Surface Splines

Examples of the use of surface splines in exploratory modeling are given. This includes real time deformation, moment calculation and use of deformability for topological animation.

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PS

Shape Preserving Space Curve Design

The poster will present a variety of shape preserving space curve design algorithms which interpolate a sequence of points as piecewise "coils", which are space curves of non-strict geometric order three. The definition of a coil gives rise to "fill-in regions" which are regions where additional points can be added and the coil shape maintained. The fill-in regions are used in the interpolation algorithms and to help provide tools for the user interface.

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PS

A Simple Method of Finding Bounds for Scaling Transition Curves

Clothoids or cornu spirals are used to combine circles of different radii, forming trnsition curves, in various situations of highway design. The transition between those circles usually consists of more than one spiral segment. The possibility of using single spiral segment where many spirals form transition curve is checked, then the bounds or range for the scaling of such single spirals are found through the bounds of the arc-length of the spiral avoiding non-linear equations.

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PS

The Symmetric Analogue of the Power Basis for Geometry Processing

Applications of a new polynomial basis over the unit interval are explored. The new form is the symmetric analogue of the power form, because it can be regarded as a Hermite two-point expansion. As polynomials in this basis are amenable for algebraic manipulation, certain geometry processing operations have much simpler formulations in this basis than in the standard Bernstein basis. Examples are to obtain integral approximations of rational curves and surfaces, or rational approximations of offsets.

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PS

Projective Geometry in Mathematica

For some years the author has been developing an introductory course in plane projective geometry and algebraic curves using a Mathematica implementation he devised. The idea is to represent projective duality by using two ranked spaces of polynomials: the one consistes of the ordinary homogeneous polynomials (of the various degrees) and the other consists of the homogeneous polynomials in a dual set of variables where the duality is expressed by *interpreting the dual polynomials as partial differential operators*. This method is directly related to the procedure of blossoming, where polynomials are turned into multilinear functionals. The Mathematica implementation not only makes it possible to do some large computations, but it also allows for proofs to be carried out symbolically by using variables standing for (general) polynomials. The method of computation also links well with Mathematica graphics.

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PS

Spline Wavelet Image Compression

Wavelet transforms can be used to compress digital images and display them on a need-to-know basis as in progressive image transmission. We first investigate the normalized Haar wavelet transform, which employs simple averaging and differencing, and use this transform to derive "lossy" compressed versions of monochrome images using Matlab software. We then attempt to improve this compression using linear, quadratic, and cubic B-spline wavelets. Finally, we extend our techniques for use with color images.

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PS

Approximating a Convex Polyhedron

This presentation describes an algorithm to approximate a convex polyhedron. We compute a polyhedron with fewer vertices and faces that (1) is also convex and (2) contains the original shape, without being too much larger. Our approach is to represent the input polyhedron as the intersection of planar half-spaces and then let the approximation be a subset of those half-spaces. At each step the algorithm eliminates the half-space causing least surface deviation.

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PS

A Complete Closed-form Solution to the 2,3,4-Variable Orthogonal Regression Model

By employing a mathematically equivalent constraint to

the orthogonal model, a closed-form solution is found which yields an optimum line/plane/surface that is invariant to rigid rotations of the data set and independent of the choice of the dependent variable. This allows physical geometric characteristics of a sample to be determined regardless of orientation. The solutions are applicable to linear and non-linear curves/surfaces of two, three or four variables.

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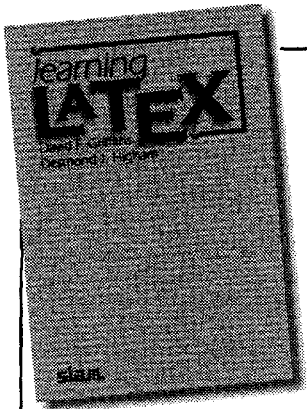

Learning LaTeX

David F. Griffiths
and Desmond J. Higham

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Order Code OT55

Complete tables of contents and additional information about SIAM publications are available through the World Wide Web ***(http://www.siam.org)***.

Here is a short, well-written book that covers the material essential for learning LaTeX without any unnecessary detail. It includes incisive examples that teach LaTeX in a powerful yet abbreviated fashion. This is the handbook to have if you don't want to wade through extraneous material. This manual includes the following crucial features:

- numerous examples of widely used mathematical expressions;
- complete documents illustrating the creation of articles, reports, and overhead projector slides;
- troubleshooting tips to help you pinpoint an error;
- details of how to set up a bibliography and an index;
- information about LaTeX resources available on the Internet.

Why do you need to learn LaTeX? LaTeX has become an extremely popular typesetting system and is widely used throughout the sciences. As a student you may need to typeset reports and theses in LaTeX (particularly if you are a graduate student in any mathematics or computer science discipline). Or you may be someone who had planned to "eventually" get around to learning LaTeX, but you are still using older systems and methods of typesetting. Procrastinate no more!

The authors have elected to cover LaTeX 2_ε, the latest standard version at the time of publication. The old and new versions are very similar and it is clear that the LaTeX 2_ε version will soon dominate. An appendix discusses the differences between 2_ε and the older version, 2.09.

Contents

Audience

Readers must know how to produce ASCII files with an editor and have LaTeX 2_ε available. The material is accessible for beginners, and the book covers enough material to be of use to the majority of potential LaTeX users.

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