PRELIMINARY PROGRAM

SIAM Conference on Geometric Modeling and Robotics

July 15–19, 1985 • Hilton Hotel • Albany, New York

SURFACE AND SOLID MODELING

• Approximation of Surfaces and Solids • Mathematical Aspects of Shape • Scattered Data Interpolation • Computation of Surface-to-Surface and Solid-to-Solid Intersections • Sculptured Surface Modeling Techniques

ROBOTICS

• Motion Planning and Control • Collision Avoidance • Model Uncertainty • Locomotion • Robotics Programming and Control • Computer Vision • Compliant Motion • Task Planning • Assembly • Flexible Mechanisms

MEETING HIGHLIGHTS

Invited Presentations

Keynote Address

Monday, July 15, 9:00 AM
Invited Presentation 1

THE ROLE OF MODELING IN ENGINEERING DESIGN AND MANUFACTURING

Great progress is being made in automating engineering design and manufacturing. The ultimate is an integrated system for the analysis, design, and production of new products. It requires a single model that drives all aspects of the manufacturing cycle. To achieve this objective, surface and solid models must be developed that are capable of representing the wide range of applications arising in such areas as computer-aided design and robotics. Implicit is a single representation that will support reasoning about the manipulation of physical objects, as well as the analysis, design, testing, and manipulation of mechanical and electrical parts.

The speaker will examine the state-of-the-art of automated engineering design and production, and identify the basic requirements to support the modeling, robotics, and other components of future automation in manufacturing.

John E. Hopcroft
Department of Computer Science
Cornell University
Ithaca, NY

Monday, July 15, 9:45 AM
Invited Presentation 2
THE ROLE OF SURFACES IN SOLID MODELING

Providing free form surfaces for solid modelers is a challenging task for applied mathematicians. The challenge is greater than in surface modeling because the surfaces of model solids must synonomously:

- Provide a skin that completely encloses a volume.
- Allow accurate design of geometric features such as blended edges and corners.
- Support the Boolean operations of modeling.
- Enable quick and accurate computation of a solid's volume, moments of inertia, and surface area.
- Serve as a basis for calculating clearances between modeled objects including moving objects, and for automatically generating finite element meshes, e.g., for structural and heat dissipation analysis.
- Fit within the speed and space capabilities of modern computers.

The speaker will discuss the role of surfaces in solid modeling, describe the major kinds of available surface representations in light of their suitability for modeling solids and their role in supporting the types of engineering analysis that are based on the geometric data provided by solid modelers.

Ronald N. Goldman
Computer Integrated Manufacturing
Control Data Corporation
Arden Hills, MN

Tuesday, July 16, 9:00 AM
Invited Presentation 3
MOTION PLANNING AND COLLISION AVOIDANCE — THE CONFIGURATION SPACE APPROACH

Carrying out tasks, such as assembly, with a robot requires the specification of a large number of individual motions. In realistically complex environments, these motions are tightly constrained by geometry — for example, the motions must avoid collisions with other objects in the environment.

Existing robot languages specify the robot motions explicitly. Their effect on the task is left implicit. The goal of model-based task level robot languages is to enable the explicit specification of the desired effects of robot motions on a task and then synthesize automatically the motion specifications for the robot from this description.

A command such as "insert pin A into hole B", for example, should produce a program in grasp pin A, move it to hold B without collisions, and reliably insert the pin into the hole using a sensor-based strategy.

The speaker will discuss the alternative approaches to achieving model-based task-level planning systems for robots, describe the configuration space approach to collision-free task planning and grasping.

Tomas Lozano-Perez
Artificial Intelligence Laboratory
Massachusetts Institute of Technology
Cambridge, MA

Tuesday, July 16, 9:45 AM
Invited Presentation 4
ADVANCES IN THE DEVELOPMENT OF NON-TENSOR PRODUCT SURFACES

Since the theory of multivariate splines was developed, researchers in computer-aided geometric design have hoped to obtain from that theory new and useful tools for the representation and handling of sculptured surfaces. The speaker will survey the geometric construction of multivariate B-splines as well as the geometric interpretation of algorithms to compute them.

Wolfgang Boehm
Technische Universität Braunschweig
Federal Republic of Germany

Tuesday, July 16, 2:00 PM
Invited Presentation 5
LEGGED LOCOMOTION — THE ROBOTICS OF RUNNING

Humans and animals use balance to move with speed and mobility but little is known of their control mechanisms. Legged robots with comparable abilities have still to be built.

To understand the principles of legged locomotion, the speaker has studied machines that run on just one leg. The goal has been to focus on balance with emphasis on the dynamic aspects of the problem. For systems that run by hopping on one leg, balance and dynamics are central issues, while interleg coordination is of little concern. A simple set of control algorithms that decompose the problem into three parts has been found — one that regulates hopping height, one that controls forward running speed, and one that maintains the posture of the body. Symmetric motions of the body and legs play a central role in balance.

In experiments, a physical 3-D one legged machine hopped in place, traveled at a specified rate, followed a simple path, and maintained balance when disturbed. Current efforts address the possibility of extending the results from systems with one leg to the control of systems with several legs. In preliminary experiments, a four-legged running machine has been found to run in balance using generalizations of the one-legged control algorithms.

The speaker will present results obtained in studies of single and multiple legged mechanical machines.

Marc H. Raibert
Department of Computer Science and Robotics Institute
Carnegie-Mellon University, Pittsburgh, PA

Wednesday, July 17, 9:00 AM
Invited Presentation 6
PROCEDURES FOR FINE MOTION PLANNING AND CONTROL

One of the major tasks in robot manipulation is

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CONFERENCE COMMITTEE

FUNDING SOURCES

SIAM is conducting this conference with the partial support of the Air Force Office of Scientific Research, the Army Research Office, the Department of Energy and the National Science Foundation.

Photographs graciously provided by the Rensselaer Polytechnic Institute Office of Instructional Media and the Albany County Convention and Visitors Bureau.

the automated assembly of parts, e.g. mechanical assembly. Successful assembly of two parts can be hindered by even a small variation in the shape and location of a part. Since assembly implies contact, the forces of impact, friction, and constraint can further complicate the task.

The most effective assembly strategies turn these forces to advantage, using the mechanical interactions between the parts to guide the motions. Sensors are used to guide motions and to help decide between alternative actions. Fine-motion strategies must be constructed anew for each assembly task, including construction of subgoals, selection of motion commands, and interpretation of sensors. All of these elements must be tailored to the mechanical behavior arising from the interaction of the controller, the manipulator, and the parts.

The speaker will formulate the problems, discuss the solutions, and present some provably correct and complete procedures for the construction of fine-motion strategies.

Matthew T. Mason
Department of Computer Science
Carnegie-Mellon University Pittsburgh, PA

Wednesday, July 17, 9:45 AM
Invited Presentation 7
COMPUTATIONAL GEOMETRY FOR SOLID MODELING AND ROBOTICS

The practical use of computational geometry has progressed from the representation of drawings and figures to representations with high semantic content, e.g., the representation of solid objects, an important application in automated engineering design. Solid modeling also has application in robotics where it enables the representation of robots, their work space, and the parts to be manipulated as volume solid objects, and leads to the automated synthesis of robot motions.

Many difficult problems arise in computational geometry that limit the performance of solid modeling systems and, in turn, the applications built on them. The problems range from philosophical ones to more specific ones concerned with numerical error and computational complexity.

The speaker will discuss the nature of the problems, review current progress, and assess directions for future research.

Michael A. Wesley
Manufacturing Research Center
IBM-T. J. Watson Research Center
Yorktown Heights, NY

Wednesday, July 17, 2:00 PM
Invited Presentation 8
B-NET BASICS

The B(ernstein, -ézier, or -arycentric) form for a polynomial of several variables is reviewed to bring out the essential mathematical features that make this form such an appropriate tool for the study of smooth multivariate piecewise polynomial functions.

Carl de Boor
Mathematics Research Center
University of Wisconsin Madison, WI

Thursday, July 18, 9:00 AM
Invited Presentation 9
MODELING TOLERANCES AND ERRORS FOR SYMBOLIC REASONING IN ROBOT PROGRAMMING

The methods used in modeling surfaces and solids should be applicable to off-line robotic programming. However, for such applications, the methods must also accommodate the representations of parts tolerances and control and sensing errors, an area of research where there has been little progress.

The speaker will discuss how such representations might be used to generate robot programs automatically from models of parts and tasks, and indicate the requirements for the representations.

Rodney A. Brooks
Department of Electrical Engineering and Computer Science
Massachusetts Institute of Technology
Cambridge, MA

Thursday, July 18, 9:45 AM
Invited Presentation 10
MATHEMATICAL ASPECTS OF THE MULTIDIMENSIONAL APPROXIMATION

Methods for approximating surfaces should preserve the qualitative properties of the given data, e.g. smoothness, monotonicity, and convexity. Moreover, the approximate representation of the surface should be easy to compute, allow local refinement, and conform to complicated geometries.

The speaker will survey some of the existing techniques with special emphasis on shape-preserving surface fitting and interpolation of irregularly distributed data. In particular, he will describe the use of the Bezier net for constructing piecewise polynominal approximants and discuss the interplay between smoothness restrictions and accuracy.

Klaus Hollig
Mathematics Research Center
University of Wisconsin Madison, WI

Friday, July 19, 9:00 AM
Invited Presentation 11
GEOMETRIC AND CONTROL ISSUES IN THE OPERATION OF FLEXIBLE ROBOTS

Typical commercial robots are capable of lifting about 1/100th of their weight. The only way to improve that ratio seems to be to build robots that can tolerate much larger elastic deformations under load than current robots can. This elasticity makes it more difficult to achieve accurate position and velocity sensing. More thorough instrumentation of the robot is needed such as placing sensors in more locations and using different types of sensors.

The speaker will discuss the motion planning and feedback control considerations needed in designing flexible robot systems. The mathematics necessarily involves non-linear ordinary differential equations, coupled with linear partial differential equations in a control setting.

Roger W. Brockett
Division of Applied Science
Harvard University Cambridge, MA

Friday, July 19, 9:45 AM
Invited Presentation 12
MATHEMATICAL AND ALGORITHMIC PROBLEMS IN COMPUTER VISION

The automatic control of a body requires information that will enable a device to make the necessary interpretations and steer the body accordingly. The subject of computer vision has to do with extracting information about body identity, position, and orientation from digitalized television images and making those interpretations. Either standard images or specialized "depth" images can be used.

The problem of "model-based" computer vision, i.e. the matching of a partially observed body surface to one of a finite collection of assumed model bodies raises many mathematical and algorithmic problems. Since it is necessary to search over an orientation space of as many as six dimensions, efficient techniques are essential.

The speaker will describe various approaches to solving the matching problem, which involves elements of differential geometry and the use of the Fast Fourier Transform.

Jacob T. Schwartz
Courant Institute of Mathematical Sciences
New York University New York, NY

Minisymposia

1. **THE "INDUSTRIAL TOOL KIT"**
   David R. Ferguson
   Boeing Computer Services, Seattle, WA
2. **METHODS OF ALGEBRAIC GEOMETRY FOR SURFACE AND SOLID MODELLING**
   Thomas W. Sederberg
   Brigham Young University, Provo, UT
3. **SHAPE DEFINITION PROBLEMS**
   Gerald Farin
   University of Utah, Salt Lake City, UT
4. **APPLICATIONS OF SOLID MODELING**
   Ming C. Leu
   Cornell University, Ithaca, NY
5. **THE REPRESENTATION OF DATA IN THREE OR MORE DIMENSIONS**
   Robert E. Barnhill
   University of Utah, Salt Lake City, UT
6. **IMPLEMENTATION STRATEGIES FOR ROBOT MOTION PLANNERS**
   Tomas Lozano-Perez
   Massachusetts Institute of Technology, Cambridge, MA
7. **SHAPE PRESERVING METHODS**
   John A. Roulier
   University of Connecticut, Storrs, CT
8. **PLANNING FINITE MOTIONS FOR ROBOTS**
   Matthew P. Mason
   Carnegie-Mellon University, Pittsburgh, PA
9. **DYNAMICS OF FLEXIBLE MECHANISMS AND ROBOTICS**
   Iradj G. Tadjbakhsh
   Rensselaer Polytechnic Institute, Troy, NY
10. **NEW KINDS OF SURFACE PATCHES FOR SOLID MODELING**
    Thomas W. Jensen
    Evans & Sutherland Computer Corp., Salt Lake City, UT
11. **RECENT ADVANCES IN COMPUTATIONAL GEOMETRY**
    William Randolph Franklin
    Rensselaer Polytechnic Institute, Troy, NY
12. **MATHEMATICAL PROBLEMS IN THE USE OF SOLID MODELS**
    David A. Field
    General Motors Research Laboratories, Warren, MI
13. **ALGORITHMIC MOTION PLANNING — THEORETICAL ISSUES AND COMPLEXITY**
    Chee K. Yap
    Courant Institute of Mathematical Sciences, New York University, New York, NY

Special Functions

Welcoming Reception
Sunday, July 14, 8:00 pm
Prefunction Area, Ballroom Level

Wine and Cheese Party
Monday, July 15, 6:15 pm
Renssalaer Polytechnic Institute
$10.00

Dinner and Ballet
Wednesday, July 17, 5:15 pm

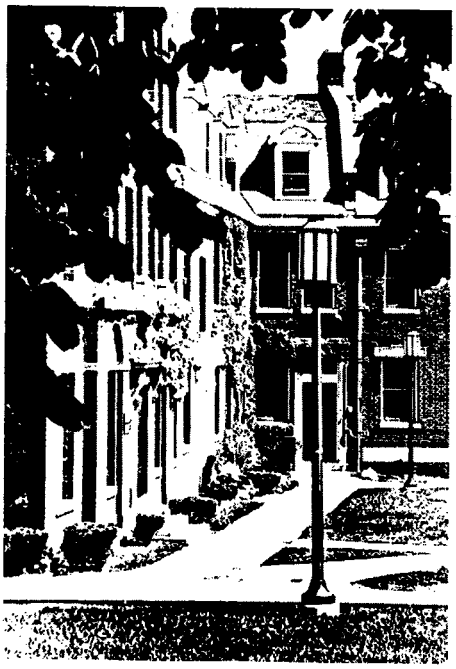
Join us at the beautiful outdoor Saratoga Performing Arts Center for dinner and the New York City Ballet's Four Temperaments, choreography by George Balanchine, the world premiere of Peter Martins' new ballet and a Gershwin concerto. SIAM has purchased a limited number of tickets (covered seats) which are available on a first come, first served basis. This promises to be a lovely evening.
$32.00 (dinner, wine, ballet, transportation)

SUNDAY, JULY 14/PM

5:00 PM
Registration Opens
Prefunction Area, Ballroom Level

8:00 PM
Welcoming Reception
Prefunction Area, Ballroom Level
No-Host Bar

10:00 PM
Registration Closes



MONDAY, JULY 15/AM

7:30 AM
Registration Opens
Prefunction Area, Ballroom Level

8:30 AM/Ballroom A
Opening Remarks

9:00 AM/Ballroom A
Invited Presentations 1 and 2
Chairman: Carl de Boor
Mathematics Research Center
University of Wisconsin-Madison, Madison, WI

Keynote Address
THE ROLE OF MODELING IN ENGINEERING DESIGN AND MANUFACTURING
John E. Hopcroft
Department of Computer Science
Cornell University, Ithaca, NY

THE ROLE OF SURFACES IN SOLID MODELING
Ronald N. Goldman
Computer Integrated Manufacturing
Control Data Corporation, Arden Hills, MN

10:30 AM/Coffee
11:00 AM/CONCURRENT SESSIONS

Minisymposium 1/Ballroom C
THE "INDUSTRIAL TOOL KIT"
Chairman: David R. Ferguson
Boeing Computer Services, Seattle, WA

Minisymposium 2/Ballroom A
METHODS OF ALGEBRAIC GEOMETRY FOR SURFACE AND SOLID MODELLING
Chairman: Thomas W. Sederberg
Brigham Young University, Provo, UT

MONDAY, JULY 15/PM

12:30 PM/Lunch

2:00 PM/CONCURRENT SESSIONS

Minisymposium 3/Ballroom A
SHAPE DEFINITION PROBLEMS
Chairman: Gerald Farin
Department of Mathematics
University of Utah, Salt Lake City, UT

Minisymposium 4/Ballroom C
APPLICATIONS OF SOLID MODELING
Chairman: Ming C. Leu
Department of Mechanical and Aerospace Engineering
Cornell University, Ithaca, NY

3:30 PM/Coffee

4:00 PM/CONCURRENT SESSIONS

Contributed Papers 1/Ballroom D
SOLID MODELING
Chairman: G. Peter Wever
Engineering Computing Systems
Boeing Commercial Airplane Company
Seattle, WA

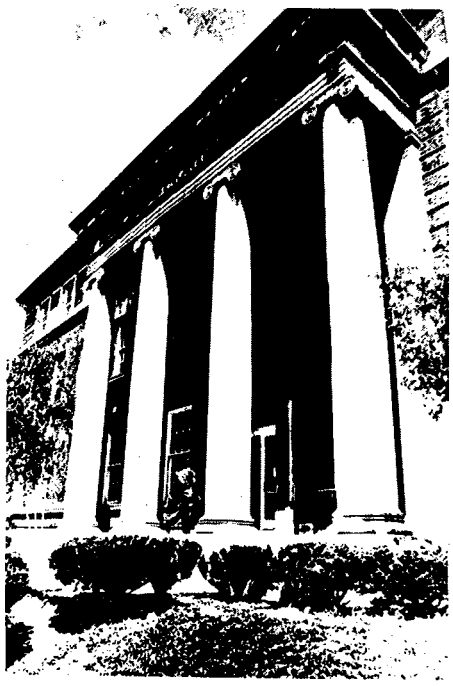
Contributed Papers 2/Ballroom A
PATH PLANNING
Chairman: Mukai S. Krishnamoorthy
Department of Computer Science
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 3/Ballroom C
SURFACES AND CURVES (Constructive Theory) I
Chairman: Alan K. Jones
Boeing Computer Services, Tukwila, WA

Contributed Papers 4/Meeting Room 1
DATA STRUCTURES
Chairman: David Spooner
Department of Computer Science
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 5/Ballroom E
APPLICATIONS
Chairman: Richard D. Fuhr
Engineering Computing Systems
Boeing Commercial Airplane Company
Seattle, WA

6:15 PM
Wine and Cheese Party
Rensselaer Polytechnic Institute



TUESDAY, JULY 16/AM

9:00 AM/Ballroom A
Invited Presentations 3 and 4
Chairman: Ramon F. Sarraga
General Motors Research Laboratories, Warren, MI

MOTION PLANNING AND COLLISION AVOIDANCE—THE CONFIGURATION SPACE APPROACH
Tomas Lozano-Perez
Artificial Intelligence Laboratory
Massachusetts Institute of Technology, Cambridge, MA

ADVANCES IN THE DEVELOPMENT OF NON-TENSOR PRODUCT SURFACES
Wolfgang Boehm
Technische Universität Braunschweig
Federal Republic of Germany

10:30 AM/Coffee

11:00 AM/CONCURRENT SESSIONS

Minisymposium 5/Ballroom A
THE REPRESENTATION OF DATA IN THREE OR MORE DIMENSIONS
Chairman: Robert E. Barnhill
Department of Mathematics
University of Utah, Salt Lake City, UT

Minisymposium 6/Ballroom C
IMPLEMENTATION STRATEGIES FOR ROBOT MOTION PLANNERS
Chairman: Tomas Lozano-Perez
Massachusetts Institute of Technology, Cambridge, MA

TUESDAY, JULY 16/PM

12:30 PM/Lunch

2:00 PM/Ballroom A
Invited Presentation 5
Chairman: John E. Hopcroft
Department of Computer Science
Cornell University, Ithaca, NY

LEGGED LOCOMOTION—THE ROBOTICS OF RUNNING
Marc H. Raibert
Department of Computer Science and Robotics Institute
Carnegie-Mellon University, Pittsburgh, PA

2:45 PM/Coffee

3:15 PM/CONCURRENT SESSIONS

Contributed Papers 6/Ballroom A
SURFACES AND CURVES (Constructive Theory) II
Chairman: Robert E. Barnhill
Department of Mathematics
University of Utah, Salt Lake City, UT

Contributed Papers 7/Ballroom D
CONTROL
Chairman: James A. Voytuk
Department of Mathematical Sciences
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 8/Ballroom C
COMPUTATIONAL GEOMETRY
Chairman: George J. Habetler
Department of Mathematical Sciences
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 9/Ballroom E
IMAGE PROCESSING AND VISION
Chairman: Michael Skolnick
Department of Computer Science
Rensselaer Polytechnic Institute, Troy, NY

Poster Presentation 1/Meeting Room 1

7:30 PM/Ballrooms A, C, D, E
Informal Discussion Groups

WEDNESDAY, JULY 17/AM

9:00 AM/Ballroom A
Invited Presentations 6 and 7
Chairman: Michael Wozny
Center for Interactive Graphics
Rensselaer Polytechnic Institute, Troy, NY

PROCEDURES FOR FINE MOTION PLANNING AND CONTROL
Matthew T. Mason
Department of Computer Science
Carnegie-Mellon University, Pittsburgh, PA

COMPUTATIONAL GEOMETRY FOR SOLID MODELING AND ROBOTICS
Michael A. Wesley
Manufacturing Research Center
IBM—T. J. Watson Research Center, Yorktown Heights, NY

10:30 AM/Coffee

11:00 AM/*CONCURRENT SESSIONS*

Minisymposium 7/Ballroom A
SHAPE PRESERVING METHODS
Chairman: John A. Roulier
Department of Mathematics
University of Connecticut, Storrs, CT

Minisymposium 8/Ballroom C
PLANNING FINITE MOTIONS FOR ROBOTS
Chairman: Matthew P. Mason
Department of Computer Science
Carnegie-Mellon University, Pittsburgh, PA

Minisymposium 9/Ballroom E
DYNAMICS OF FLEXIBLE MECHANISMS AND ROBOTICS
Chairman: Iradj G. Tadjbakhsh
Department of Civil Engineering
Rensselaer Polytechnic Institute, Troy, NY

WEDNESDAY, JULY 17/PM

12:30 PM/Lunch

2:00 PM/Ballroom A
Invited Presentation 8
Chairman: Peter Alfeld
Department of Mathematics
University of Utah, Salt Lake City, UT

B-NET BASICS
Carl de Boor
Mathematics Research Center
University of Wisconsin-Madison
Madison, WI

3:00 PM/Break

5:15 PM
Buses leave hotel for dinner and ballet at Saratoga Springs Performing Arts Center

THURSDAY, JULY 18/AM

9:00 AM/Ballroom A
Invited Presentations 9 and 10
Chairman: David R. Ferguson
Boeing Computer Services, Seattle, WA

MODELING TOLERANCES AND ERRORS FOR SYMBOLIC REASONING IN ROBOT PROGRAMMING
Rodney A. Brooks
Department of Electrical Engineering and Computer Science
Massachusetts Institute of Technology, Cambridge, MA

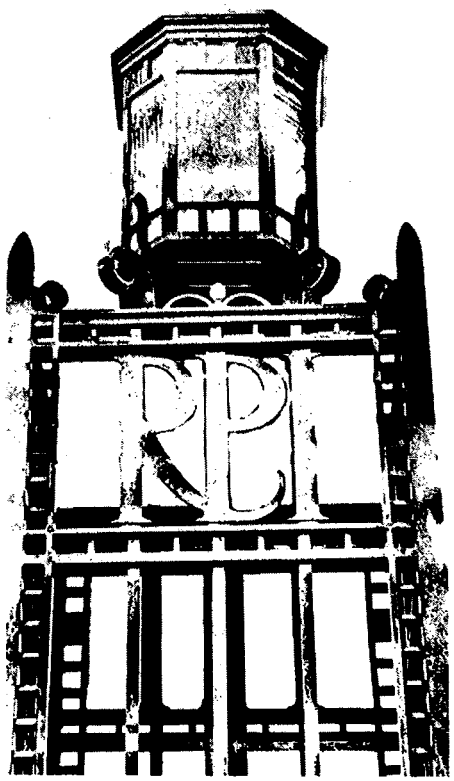
MATHEMATICAL ASPECTS OF THE MULTIDIMENSIONAL APPROXIMATION OF SURFACES
Klaus Hollig
Mathematics Research Center
University of Wisconsin-Madison, Madison, WI

10:30 AM/Coffee

11:00 AM/*CONCURRENT SESSIONS*

Minisymposium 10/Ballroom A
NEW KINDS OF SURFACE PATCHES FOR SOLID MODELLING
Chairman: Thomas W. Jensen
Research Division
Evans & Sutherland Computer Corp., Salt Lake City, UT

Minisymposium 11/Ballroom C
RECENT ADVANCES IN COMPUTATIONAL GEOMETRY
Chairman: William Randolph Franklin
Department of Electrical, Computer, and Systems Engineering
Rensselaer Polytechnic Institute, Troy, NY



THURSDAY, JULY 18/PM

12:30 PM Lunch

2:00 PM/*CONCURRENT SESSIONS*

Minisynposium 12/Ballroom A
MATHEMATICAL PROBLEMS IN THE USE OF SOLID MODELS
Chairman: David A. Field
General Motors Research Laboratories, Warren, MI

Minisymposium 13/Ballroom C
ALGORITHMIC MOTION PLANNING—THEORETICAL ISSUES AND COMPLEXITY
Chairman: Chee K. Yap
Courant Institute of Mathematical Sciences
New York University, New York, NY

3:30 PM/Coffee

4:00 PM/*CONCURRENT SESSIONS*

Contributed Papers 10/Ballroom A
SPACES AND CURVES (Computation and Analysis)
Chairman: Kenneth W. Bosworth
Department of Mathematics
Utah State University, Logan, UT

Contributed Papers 11/Ballroom D
MANIPULATORS, LINKAGES, AND KINEMATICS
Chairman: Iradj G. Tadjbakhsh
Department of Civil Engineering
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 12/Ballroom C
WORKSPACE ANALYSIS
Chairman: David Isaacson
Department of Mathematics and Department of Computer Science
Rensselaer Polytechnic Institute, Troy, NY

Contributed Papers 13/Ballroom E
IMAGE RENDERING
Chairman: E. Lee
Boeing Commercial Airplane Company
Seattle, WA

Contributed Papers 14/Meeting Room 1
MISCELLANEOUS CONTRIBUTIONS
Chairman: Barry L. Zaslove
Department of Mathematics
Northeastern University, Boston, MA

FRIDAY, JULY 19/AM

9:00 AM/Ballroom A
Invited Presentations 11 and 12
Chairman: Leon H. Seitelman
Pratt & Whitney Aircraft, East Hartford, CT

GEOMETRIC AND CONTROL ISSUES IN THE OPERATION OF FLEXIBLE ROBOTS
Roger W. Brockett
Division of Applied Science
Harvard University, Cambridge, MA

MATHEMATICAL AND ALGORITHMIC PROBLEMS IN COMPUTER VISION
Jacob T. Schwartz
Courant Institute of Mathematical Sciences
New York University, New York, NY

10:30 AM/Coffee

11:00 AM
Panel Discussion

1:00 PM Adjourn

MINISYMPOSIA

Monday, July 15/*11:00 AM*
Minisymposium 1/*Ballroom C*
THE "INDUSTRIAL TOOL KIT"

Providing software for design is one class of problems that is being addressed in the development of automated engineering. Another consists of those functions a design engineer often needs to perform on a part after design is completed, such as finding the intersection of two surfaces, offsetting, scaling, and rotating. In developing such tools, important questions of efficiency and consistency arise. Mathematical algorithms are needed to perform such functions and the representation of the design must accommodate the algorithms.

CHAIRMAN AND ORGANIZER
David R. Ferguson
Boeing Computer Services
Seattle, WA

What Should the Industrial Tool Kit Contain?
Speaker to be announced

Line Surfaces Operations at GM/EDS
Constantine Sevici
General Motors Research Laboratories
Warren, MI

Machine Rulable Surfaces for Numerically Controlled Milling
M.H. Steinberg
Northrup Corporation
Hawthorne, CA

Monday, July 15/*11:00 AM*
Minisymposium 2/*Ballroom A*
METHODS OF ALGEBRAIC GEOMETRY FOR SURFACE AND SOLID MODELLING

Researchers in geometric modelling have drawn heavily from numerical analysis, approximation theory, and differential geometry, but until recently have virtually ignored the tools of algebraic geometry and computer algebra. The speakers will report on recent activities in applying concepts of algebraic geometry to problems of surface and solid modelling, including past successes and current problems.

CHAIRMAN AND ORGANIZER
Thomas W. Sederberg
Brigham Young University
Provo, UT

Power Series Development About a Regular Point of an Algebraic Curve and Its Application to Geometric Modelling
Wayne Tiller and Yves de Montaudouin
Structural Dynamics Research Corporation
Milford, OH

Computer Algebra as a Tool for Computer-Aided Geometric Design
Dennis Arnon
Xerox PARC
Palo Alto, CA

Algebraic vs Parametric Surfaces
To be presented by the chairman

Monday, July 15/*2:00 PM*
Minisymposium 3/*Ballroom A*
SHAPE DEFINITION PROBLEMS

As human beings, we have developed an intuitive notion of the concept of shape as it is applied to a surface. However, we are a long way away from translating these notions into mathematical statements that can be implemented in CAD systems for the development of geometric models. Two important generic problems are discussed: 1) proper mathematics definitions, and 2) analytic representations of these definitions.

CHAIRMAN AND ORGANIZER
Gerald Farin
Department of Mathematics
University of Utah
Salt Lake City, UT

Shape Definition Problems
To be presented by the chairman

Shape Interrogation
Frederick C. Munchmeyer
School of Naval Architecture and Marine Engineering
University of New Orleans
New Orleans, LA

Techniques of Visual Continuity
Gary Herron
Computer Science Department
Colorado State University, Fort Collins, CO

Monday, July 15/*2:00 PM*
Minisymposium 4/*Ballroom C*
APPLICATIONS OF SOLID MODELING

Solid modeling technology has grown rapidly to become a powerful tool for describing and representing the geometry of objects for engineering, drafting, design, and manufacturing. The speakers will discuss applications of solid modeling techniques to more practical aspects of industrial automation including manufacturing cell layout, NC program verification, off-line robot progamming, and various other engineering problems.

CHAIRMAN AND ORGANIZER
Ming C. Leu
Department of Mechanical and Aerospace Engineering
Cornell University
Ithaca, NY

Applications of Solid Modeling to Large Computer Systems Design
Jon F. Larson
IBM Poughkeepsie Laboratory
Poughkeepsie, NY

Modeling of Three-Dimensional Moving Objects and Application to Automated Machining
W. P. Wong
General Electric Company
Schenectady, NY

Solid Modeling-Based Robot Simulation
To be presented by the chairman

Tuesday, July 16/*11:00 AM*
Minisymposium 5/*Ballroom A*
THE REPRESENTATION OF DATA IN THREE OR MORE DIMENSIONS

Engineers and scientists are finding an increasing number of problems where it is necessary to represent data in more than one variable, e.g. aircraft performance. These data are often characterized by high dimensionality and/or by being scattered about a given domain. There has been substantial recent progress in finding ways to represent such data, for example—the use of multidimensional surfaces and scattered data interpolation techniques. The speakers will discuss the methods and the algorithms.

CHAIRMAN AND ORGANIZER
Robert E. Barnhill
Department of Mathematics
University of Utah
Salt Lake City, UT

Surfaces for the Representation of Data in Three or More Dimensions
To be presented by the chairman

Approximation of Scattered Data for Weather Applications
Richard Franke
Department of Mathematics
Naval Postgraduate School
Monterey, CA

Surface Representations for the Graphical Display of Multidimensional Data
Sarah E. Stead
Computational Research and Technology Branch
NASA Ames Research Center
Moffett Field, CA

Tuesday, July 16/*11:00 AM*
Minisymposium 6/*Ballroom C*
IMPLEMENTATION STRATEGIES FOR ROBOT MOTION PLANNERS

A number of important decisions arise in implementing motion planning algorithms in robotics. The most important consideration is the representation of motion constraints generated by obstacles. The speakers in this session will present new efficient representations of these motion constraints in configuration space. Representations for both polyhedra with six degrees of freedom and manipulators will be discussed.

CHAIRMAN AND ORGANIZER
Tomas Lozano-Perez
Massachusetts Institute of Technology
Artificial Intelligence Laboratory
Cambridge, MA

An Efficient Implementation of Motion Planning for Revolute Manipulators
To be presented by the chairman

Representations for Configuration Space-Constraints
John F. Canny
Massachusetts Institute of Technology
Artificial Intelligence Laboratory
Cambridge, MA

Discussion
The speakers will respond to questions from the audience. Audience participation is invited.

DISCUSSION LEADER:
Matthew P. Mason
Department of Computer Science
Carnegie-Mellon University
Pittsburgh, PA

Wednesday, July 17/*11:00 AM*
Minisymposium 7/*Ballroom A*
SHAPE PRESERVING METHODS

The interpolation of convex data frequently leads to surfaces that have irregular shapes inconsistent with the data. Designs dependent on such shapes are often not usable. In such problems, an appropriate definition of convex, a suitable mathematical model of the notion of convex, and appropriate computation techniques are required.

In this minisymposium, the speakers will discuss problems such as those that are associated with the interpolation of convex data with a convex surface.

CHAIRMAN AND ORGANIZER
John A. Roulier
Department of Mathematics
University of Connecticut
Storrs, CT

Constraint Spline Interpolation of One and Two Variable Data
Richard K. Beatson
Department of Mathematics
University of Connecticut
Storrs, CT

Cardinal Basis for Convexity Preserving Curves and Surfaces
Larry D. Irvine and Philip W. Smith
Old Dominion University
Norfolk, VA
and
Samuel P. Marin
General Motors Research Laboratories
Warren, MI

The Representation of Data in Two or More Dimensions
Yates Fletcher and David S. McAllister
North Carolina State University
Raleigh, NC

Wednesday, July 17/*11:00 AM*
Minisymposium 8/*Ballroom C*
PLANNING FINITE MOTIONS FOR ROBOTS

Uncertainty in the position of a robot relative to external objects is always present during robot manipulation. Much of robotics is devoted to reducing this uncertainty. The speakers will explore in depth an approach to planning robot motions that can be guaranteed to accomplish their goal even in the presence of significant uncertainty.

CHAIRMAN AND ORGANIZER
Matthew P. Mason
Department of Computer Science
Carnegie-Mellon University
Pittsburgh, PA

Fine Motion Planning: Correctness and Completeness
To be presented by the chairman

Backprojections and Pre-Images in Fine Motion Planning
Michael A. Erdmann
Massachusetts Institute of Technology
Artificial Intelligence Laboratory
Cambridge, MA

Discussion
The speakers will respond to questions from the audience. Audience participation is invited.

DISCUSSION LEADER:
Tomas Lozano-Perez
Massachusetts Institute of Technology
Artificial Intelligence Laboratory
Cambridge, MA

Wednesday, July 17/*11:00 AM*
Minisymposium 9/*Ballroom E*
DYNAMICS OF FLEXIBLE MECHANISMS AND ROBOTICS

The role of flexibility in the dynamics of high-speed mechanisms and robots becomes more important as the drive for increased industrial productivity acquires greater momentum. From an engineering standpoint, it is desirable to develop analytical and numerical procedures that enable the design of mechanisms and robots which perform given functions with a specified reliability and minimum mass. Flexibility offers the advantages of savings in materials of systems, while at the same time it introduces a more complex kinematics and physical behavior. The questions of control, efficiency, the stability and predictability of a performance acquire greater degree of importance than in the case of rigid systems.

CHAIRMAN AND ORGANIZER
Iradj G. Tadjbakhsh
Department of Civil Engineering
Rensselaer Polytechnic Institute
Troy, NY

Dynamic Instability in Flexible Mechanical Systems
To be presented by the chairman

Lumped Parameter Models for Rotational Elastic Dynamics
John Baillieul
Department of Aerospace & Mechanical Engineering
Boston University
Boston, MA

Parametric Stability Investigations in High-Speed Elastic Machine Systems
Rick I. Zadoks
and
Ashok Midha
School of Mechanical Engineering
Purdue University
West Lafayette, IN

Thursday, July 18/*11:00 AM*
Minisymposium 10/*Ballroom A*
NEW KINDS OF SURFACE PATCHES FOR SOLID MODELLING

Currently, there does not exist a single parametric patch sufficient for all solid or surface modelling applications. However, efforts to generalize existing solid modelers and develop new systems capable of representing and manipulating more general geometries have added impetus to the search for new, more general and tractable elements.

Each of the speakers will discuss a particular class of elements, such as rectangular elements, triangular elements and implicit patches, describe the state of the art, and possibly present new results. The minisymposium will conclude with a dialogue about what further work is needed.

CHAIRMAN AND ORGANIZER
Thomas W. Jensen
Research Division
Evans & Sutherland Computer Corp.
Salt Lake City, UT

New Triangular Elements for Solid and Surface Modelling
To be presented by the chairman

Blending Surfaces in Solid Geometric Modelling
Alyn P. Rockwood and John C. Owen
Shape Data Ltd.
Cambridge, England

Blending Surface Construction
Christoph Hoffman and John Hopcroft
Department of Computer Science
Cornell University
Ithaca, NY

Thursday, July 18/*11:00 AM*
Minisymposium 11/*Ballroom C*
RECENT ADVANCES IN COMPUTATIONAL GEOMETRY

Geometrical problems have driven the development of mathematics since the Egyptians needed to remeasure their fields after the annual flooding by the Nile. In recent years, however, traditional geometry, considered to be absolute, has been largely neglected in school curricula.

Recently, work in computer-aided design and robotics has inspired new interest in geometry; new areas for research have appeared. Operations such as polyhedra intersection have special cases that are simple to describe, but lead to long and complex computer programs. Some algorithms such as the point-set description of polyhedra intersection are not constructive. Some Euclidean constructions have no known efficient implementation. Numerical accuracy problems cause topological inconsistencies. The problems become more serious with data bases that have internal correlations.

CHAIRMAN AND ORGANIZER
William Randolph Franklin
Department of Electrical, Computer, and Systems Engineering
Rensselaer Polytechnic Institute
Troy, NY

Geometric Complexity and Computer Graphics: Does Theory Apply in Practice?
David B. Dobkin
Department of Computer Science
Princeton University
Princeton, NJ

A Workbench to Compute Unobstructed Shortest Paths in Three-Space
Varol Akman
Department of Electrical, Computer, and Systems Engineering
Rensselaer Polytechnic Institute
Troy, NY
and the chairman

Visibility Problems for Simple Polygons
D. P. Lee
Department of Electrical Engineering and Computer Science
Northwestern University, Evanston, IL

Thursday, July 18/*2:00 PM*
Minisymposium 12/*Ballroom A*
MATHEMATICAL PROBLEMS IN THE USE OF SOLID MODELS

Solid modelling is still in its infancy. There are many problems to be addressed—some developmental and some fundamental.

From the inception of quadric based solid modelers, the determination of intersection curves has persisted as a messy and often difficult issue. The speakers will examine recent progress in using analytic and numerical approaches for determining surface intersections of algebraic surfaces, including quadric, tangencies and error tolerances, as well as extensions of these issues to solids having sculptured surfaces or solids defined by sweeping.

Certain applications of solid modeling have been slow to develop for lack of a proper mathematical framework. The speakers will describe a mathematical foundation for solid offsetting consistent with quadric and toroidal-based solid modelers. Algorithmic issues as well as mathematical properties of solid offsetting will be discussed.

CHAIRMAN AND ORGANIZER
David A. Field
Mathematics Department
General Motors Research Laboratories
Warren, MI

Overview
To be presented by the chairman

Offsetting Operations in Solid Modelling
Jaroslow R. Rossignac and Aristides A. Requicha
College of Engineering and Applied Science
University of Rochester, Rochester, NY

Computing Intersection Curves for Algebraic Surfaces
Hans-Ulrich Pfeifer
Metals Laboratory
Technical Research Center of Finland
Espoo, Finland

A Differential-Geometric Approach to Numerical Surface Intersection
Igor Nojfeld and Gordon Wade
Computer Vision Corporation, Bedford, MA

Thursday, July 18/*2:00 PM*
Minisymposium 13/*Ballroom C*
ALGORITHMIC MOTION PLANNING—THEORETICAL ISSUES AND COMPLEXITY

Motion planning is a fundamental task in robotics concerned with the global issue of planning paths of a robot subject to constraints. The problem addressed here is concerned with precise (non-heuristic), combinatorial (non-numeric), and asymptotically efficient algorithms.

Although the usual treatment in such research is theoretical, we believe it provides invaluable insights for actual implementations. Significant advances have been made recently.

The speakers will review some of this work as well as report on continuing progress.

CHAIRMAN AND ORGANIZER
Chee K. Yap
Courant Institute of Mathematical Sciences
New York University
New York, NY

Planning Shortest Paths
Speaker to be announced

Existence of Obstacle-Avoiding Paths
Gordon Wilfong
AT&T Bell Laboratories
Murray Hill, NJ

Techniques in Motion Planning and Examples
To be presented by the chairman

CONTRIBUTED PAPERS

Monday, July 15/*4:00 PM*
Contributed Papers 1/*Ballroom D*
SOLID MODELING
Chairman: G. Peter Wever, Engineering Computing Systems, Boeing Commercial Airplane Company, Seattle, WA

Applications of Boolean Operators to Solids Bounded by Curved Surfaces
Yehuda E. Kalay, School of Architecture and Environmental Design, State University of New York at Buffalo, Buffalo, NY

An Approach to Sculptured Surface Representation in a Polyhedral Solid Modeling System
Marcel Samek and Larry Lichten, Manufacturing Engineering Program, University of California, Los Angeles, CA

General Implicit Surfaces in Solid Modeling
Alyn P. Rockwood and John C. Owen; Shape Data Ltd., Cambridge, England

Integral Property Calculations for Analytic Solid Models
Malcolm S. Casale, PDA Engineering, Santa Ana, CA

A General Algorithm for Performing Polyhedral Set Operations
Alain F. Lanusse, A. I. Lab, Massachusetts Institute of Technology, Cambridge, MA

Spatial Set Operations On Manifolds
Jacques Strowels and Pat Hanrahan. Computer Graphics Laboratory, New York Institute of Technology, Old Westbury, NY

Monday, July 15/*4:00 PM*
Contributed Papers 2/*Ballroom A*
PATH PLANNING
Chairman: Mukai S. Krishnamoorthy, Department of Computer Science, Rensselaer Polytechnic Institute, Troy, NY

On Path Planning For A Planar Robot Arm With Uncertainty
Vladimir J. Lumelsky, Department of Electrical Engineering, Yale University, New Haven, CT

Shortest Paths with Unit Clearance among Polygonal Obstacles
Brenda S. Baker, AT&T Bell Laboratories, Murray Hill, NJ

Tree-Graph Model of Free-Space for Global Collision-Avoidance Algorithms
Joan Ilari i Valentí, Carme Torras i Genís, and Rafael Huber Garrido, Institut de Cibernetica, Barcelona, Spain

Generalized Unfoldings for Shortest Paths in Euclidean 3-Space
C. Bajaj, Department of Computer Science and T. T. Moh, Department of Mathematics; Purdue University, West Lafayette, IN

Collision Avoidance With Translations: A Linear Time Algorithm For Elliptic Objects
B. John Oommen and Irwin Reichstein, School of Computer Science, Carleton University, Ottawa, Ontario, Canada

Point-to-Point Dynamic Trajectory Planning for Robot Manipulators with an Acceleration Constraint
William M. Self, Department of Mathematics and Statistics, University of New Mexico, Albuquerque, NM

Monday, July 15/*4:00 PM*
Contributed Papers 3/*Ballroom C*
SURFACES AND CURVES (Constructive Theory) I
Chairman: Alan K. Jones, Boeing Computer Services, Tukwila, WA

Weighted Bicubic Spline Interpolation to Rapidly Varying Data
Thomas A. Foley, Department of Computer Science, Arizona State University, Tempe, AZ

An n-Dimensional Clough-Tocher Element
Andrew J. Worsey, Department of Mathematics, University of Utah, Salt Lake City, UT

Boundary Codes Consisting of Spiral Surfaces between Radial Probes
Yong C. Chen, Department of Mathematical Sciences, Purdue University Calumet, Hammond, IN; Thom Grace, Department of Computer Science, Illinois Institute of Technology, Chicago, IL

The Wilson-Fowler Spline is a nu-Spline
Frederick N. Fritsch, Computing Research & Development Division, Lawrence Livermore National Laboratory, Livermore, CA

Determining a Set of Bezier Control Vertices to Generate an Interpolating Surface with Tangent Restrictions
Brian Kuttner, Computer Tool and Die Systems, Inc., Ann Arbor, MI; and Michael A. Lachance, Department of Mathematics, University of Michigan, Dearborn, MI

An Implementation of Clash Detection by Four-Dimensional Intersection Tests
Stephen A. Cameron, McDonnell Douglas Research Laboratories, Artificial Intelligence Research Group, St. Louis, MO

Monday, July 15/*4:00 PM*
Contributed Papers 4/*Meeting Room 1*
DATA STRUCTURES
Chairman: David Spooner, Department of Computer Science, Rensselaer Polytechnic Institute, Troy, NY

The Relations and Transformations between Quadtree Encoding and Switching Function Representation
Moshe Shpitalni, Center for Manufacturing Systems and Robotics, Faculty of Mechanical Engineering, Technion-Israel Institute of Technology, Haifa, Israel

Non-Cartesian Interpretations of Quadtree and Octree Structures
Yong C. Chen, Department of Mathematical Sciences, Purdue University Calumet, Hammond, IN; Thom Grace, Department of Computer Science, Illinois Institute of Technology, Chicago, IL

Geometric Reasoning for Geometric Modeling
Farhad Arbab and Jeannette M. Wing, Department of Computer Science, University of Southern California, Los Angeles, CA

Polytree—A Data Structure for Geometric Modeling
Ingrid Caribom, Schlumberger-Doll Research, Ridgefield, CT

An Oct-Tree Representation for Three-Dimensional Motion and Collision Detection
Michael N. Boaz and John W. Roach, Department of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, VA

Interactive Solid Modeling with Octree-Based Hardware
Donald J. Meagher, Phoenix Data Systems, Inc., Albany, NY

Monday, July 15/*4:00 PM*
Contributed Papers 5/*Ballroom E*
APPLICATIONS
Chairman: Richard D. Fuhr, Engineering Computing Systems, Boeing Commercial Airplane Company, Seattle, WA

Geometric Modeling of BTA Cutting Tools for Computer Simulation of Grinding by Robot
Vojislav N. Latinovic and Antonio D'Amore, Department of Mechanical Engineering, Concordia University, Montreal, Quebec, Canada

The Application of Geometric Modeling in Architectural Engineering and Construction
Deborah L. LaPay, Edward Sullivan, and Patricia E. Vaughn, Computer Aided Engineering, Westinghouse Electric Corporation, Pittsburgh, PA

Seeing Robots
Mysore Narayanan, Manufacturing Engineering Department, Miami University, Oxford, OH

Design of a Solid Modeling Application Using a Software Toolbox
John Francini, Boeing Computer Services, Systems Development, Seattle, WA

A Graphic Simulation of Industrial Robots
C. D. Crane, J. Staudhammer, and J. Duffy, Center for Intelligent Machines and Robotics, University of Florida, Gainesville, FL

STARCODE: A Hybrid Robot Modeling System with Collision Detection
John K. Myers, Robotics Laboratory, SRI International, Menlo Park, CA

Solid Modeling and Graphical Display Needs from an NC Program Verification View
Geof Goldbogen, Center for Manufacturing Productivity; Warren De Vries, Department of Mechanical Engineering; and Mark Steiner, Center for Manufacturing Productivity, Rensselaer Polytechnic Institute, Troy, NY

Tuesday, July 16/*3:15 PM*
Contributed Papers 6/*Ballroom A*
SURFACES AND CURVES (Constructive Theory) II
Chairman: Robert E. Barnhill, Department of Mathematics, University of Utah, Salt Lake City, UT

Global Multivariate Piecewise Polynomial Interpolation
Peter Alfeld, Department of Mathematics, University of Utah, Salt Lake City, UT

Applications of Multiple Valued Functions
Frederick J. Almgren, Jr., Department of Mathematics, Princeton University and The Institute for Advanced Study, Princeton, NJ

Shape Control of Curves and Surfaces through Constrained Optimization
Alan K. Jones, Boeing Computer Services, Engineering Technology Applications Division, Tukwila, WA

Shape Preserving Curve and Surface Fitting
Kenneth W. Bosworth, Department of Mathematics, Utah State University, Logan, UT

A Useful Variant of McLaughlin's Interpolant
William H. Frey, Department of Mathematics, General Motors Research Laboratories, Warren, MI

The Convex Smoothing Spline
Larry Dean Irvine, Department of Mathematical Sciences, Old Dominion University, Norfolk, VA

Tuesday, July 16/*3:15 PM*
Contributed Papers 7/*Ballroom D*
CONTROL
Chairman: James A. Voytuk, Department of Mathematical Sciences, Rensselaer Polytechnic Institute, Troy, NY

Learning Control of Robot Manipulators
Masaki Togai and Osamu Yamano, AT&T Bell Laboratories, Holmdel, NJ

On the Near Minimum Time Problem for Robotic Manipulators
Suhada Jayasuriya, Department of Mechanical Engineering, Michigan State University, East Lansing, MI

Linearization of Nonlinear Control Systems
Mladen Luksic, Department of Mathematics and Renjeng Su, Department of Electrical Engineering, Texas Tech University, Lubbock, TX; Louis R. Hunt, Programs in Mathematical Sciences, The University of Texas at Dallas, Richardson, TX

Adaptive Optimization of a Robot Control System with the Application of Orthogonal Expansion of Control Signals
Richard R. Gawronski, Systems Science Department, University of West Florida, Pensacola, FL

Optimization of Robotic Motion with Redundancy
Abraham Berman, Department of Mathematics, Technion-Israel Institute of Technology, Haifa, Israel; Avinoam Livni, Elbit Computers Ltd., Haifa, Israel; Zvi Har'El, Department of Mathematics, Technion-Israel Institute of Technology, Haifa, Israel and AT&T Bell Laboratories, Murray Hill, NJ

An Adaptive Control Scheme for Flexible Robots
Riccardo Marino and Salvatore Nicosia, Seconda Università di Roma, Dipartimento di Ingegneria Elettronica, Roma, Italy

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Tuesday, July 16/*3:15 PM*
Contributed Papers 8/*Ballroom C*
COMPUTATIONAL GEOMETRY
Chairman: George J. Habetler, Department of Mathematical Sciences, Rensselaer Polytechnic Institute, Troy, NY

An Extremely Fast Minimum Spanning Circle Algorithm
B. John Oommen, School of Computer Science, Carleton University, Ontario, Canada

An Interactive Voronoi Data Structure for Surface Fitting
Brian L. Carrihill, Schlumberger-Doll Research, Ridgefield, CT

Computational Geometry in Prolog
Wm. Randolph Franklin and Peter Y. F. Wu, Department of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY

Applying Galois Theoretic Algebraic Methods to Geometric Optimization Problems
Chanderjit Bajaj, Department of Computer Science, Purdue University, West Lafayette, IN

Instabilities in Some Fast B-spline Algorithms
E. Lee, Boeing Commercial Airplane Co., Seattle, WA

The Computation of the Distance Between Polyhedra in 3-Space
M. Orlowski, Mathematics and Dynamic Meteorology Division, NRIMS CSIR, Pretoria, South Africa

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Tuesday, July 16/*3:15 PM*
Contributed Papers 9/*Ballroom E*
IMAGE PROCESSING AND VISION
Chairman: Michael Skolnick, Department of Computer Science, Rensselaer Polytechnic Institute, Troy, NY

A Colour Photometric Stereo Vision System
Y. Mahdavieh, Shape Data Ltd., Cambridge, England

Single-Image Model-Based Stereovision Algorithm
Mitchell E. Sundt, The MITRE Corporation, Satellite and Computer Systems, McLean, VA

Use of Computer Vision Imitation in the Motion Planning of a Robotic Arm
V. I. Fabrikant and T. S. Sankar, Department of Mechanical Engineering, Concordia University, Montreal, Quebec, Canada

A Syntactic Approach to Image Feature Extraction and Image Enhancement, The Queen Victoria Algorithm
James R. Holten III and Matthew Kabrisky, Department of Electrical and Computer Engineering, Air Force Institute of Technology, Wright-Patterson AFB, OH

3-D Object Representation Utilizing Intrinsic Surface Properties
B. C. Vemuri, A. Mitiche, and J. K. Aggarwal, Laboratory for Image and Signal Analysis, The University of Texas at Austin, Austin, TX

Invariants Under Imaging
Lars Nielsen, Department of Automatic Control, Lund Institute of Technology, Lund, Sweden

Fast Computer Vision Processing Using Small Generating Kernels
Joseph V. Fritz and Peter D. Scott, Department of Electrical and Computer Engineering, State University of New York at Buffalo, Amherst, NY

Thursday, July 18/*4:00 PM*
Contributed Papers 10/*Ballroom A*
SPACES AND CURVES (Computation and Analysis)
Chairman: Kenneth W. Bosworth, Department of Mathematics, Utah State University, Logan, UT

An Algorithm for Subdividing Bezier Curves and Surfaces
Arthur J. Schwartz, Department of Mathematics, University of Michigan, Ann Arbor, MI

Surface Intersection Algorithms
R. T. Farouki, General Electric Company, Corporate Research & Development, Schenectady, NY

Geometric Aspects of Robot Sensory Processing
John P. Greschak, Department of Electrical and Computer Engineering, State University of New York at Buffalo, Buffalo, NY; George C. Verghese, Massachusetts Institute of Technology, Cambridge, MA

Elimination Techniques for Geometric Intersection Problems
Vijaya Chandru and Bipin Kochar, School of Industrial Engineering, Purdue University, West Lafayette, IN

General Boundary Definition and Calculating Intersections in Modeling with B-Spline Surfaces
John C. Chen and Tulga M. Ozsoy, Department of Mechanical Engineering and Mechanics, Lehigh University, Bethlehem, PA

A Comparison of Algebraic and Analytic Algorithms For Finding Surface Intersections in GMSOLID
Alexander P. Morgan, Department of Mathematics, General Motors Research Laboratories, Warren MI

Thursday, July 18/*4:00 PM*
Contributed Papers 11/*Ballroom D*
MANIPULATORS, LINKAGES, AND KINEMATICS
Chairman: Iradj G. Tadjbakhsh, Department of Civil Engineering, Rensselaer Polytechnic Institute, Troy, NY

A Vector-Algebra Approach to Modeling and Solving Robot Arm Kinematics and Its Applications to Puma-560
Masaki Togai, AT&T Bell Laboratories, Holmdel, NJ

Displacement Space of Spatial n-R Open-Loop System by the Direction Cosine Matrix Method
Youngil Youm and Ta-chung Yih, Department of Mechanical Engineering, The Catholic University of America, Washington, DC

The Kinematic Spaces of Planar n-R Open-Loop System with Rotating Base
Youngil Youm and Ta-chung Yih, Department of Mechanical Engineering, The Catholic University of America, Washington, DC

Redundant Robot and the Null Space
J. Y. S. Luh, Department of Electrical and Computer Engineering, Clemson University, Clemson, SC; Y. L. Gu, School of Engineering and Computer Science, Oakland University, Rochester, MI

A Least Squares Technique to Determine Linkage Parameter Errors in Open Kinematic Chains
N. Duke Perreira, Systems Engineering Program, University of Nevada-Reno, Reno, NV

Generalized Inverses for Robot Manipulators
Michael Tucker, Department of Electrical Engineering and N. Duke Perreira, Systems Engineering Program, University of Nevada-Reno, Reno, NV

Simulation of Kinematics and Dynamics of Robots Using a Symbolic Manipulation System
J. Z. Sasiadek, Department of Mechanical & Aeronautical Engineering, Carleton University, Ottawa, Ontario, Canada

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Thursday, July 18/*4:00 PM*
Contributed Papers 12/*Ballroom C*
WORKSPACE ANALYSIS
Chairman: David Isaacson, Department of Mathematics and Department of Computer Science, Rensselaer Polytechnic Institute, Troy, NY

Efficient Motion Planning for a Planar Manipulator Based on Dexterity and Workspace Geometry
Harvey Lipkin and Joseph Duffy, Center for Intelligent Machines and Robotics, University of Florida, Gainesville, FL; L. E. Torfason, Department of Mechanical Engineering, University of New Brunswick, Fredericton, N. B., Canada

Goal Oriented Task Planning for Robotic Manipulators
R. J. Schilling and E. A. Fessenden, Department of Electrical and Computer Engineering, Clarkson University, Potsdam, NY

Kinematic Geometry for Computer Drawing of Orientational Workspace Envelopes for Robots
Joseph K. Davidson, Department of Mechanical & Aerospace Engineering, Arizona State University, Tempe, AZ

Analysis of Spatial Uncertainty
Randall C. Smith and Peter Cheeseman, Robotics Laboratory, SRI International, Menlo Park, CA

Dexterity of the Planar 3R, RPR Robots and Corresponding Spatial Robot Manipulators
G. H. Lovell and Joseph Duffy, Center for Intelligent Machines and Robotics, University of Florida, Gainesville, FL

Thursday, July 18/*4:00 PM*
Contributed Papers 13/*Ballroom E*
IMAGE RENDERING
Chairman: E. Lee, Boeing Commercial Airplane Company, Seattle, WA

Contributed Papers

A Raster Oriented Algorithm for Visualization of Parametrically Defined Surfaces
Rossen Ivanov Jordanov, Electroproject, CAD Group, Bulgaria; Kenneth B. Evans, Division of Electrical Engineering, National Research Council of Canada, Ontario, Canada; Dion Gildenhuys, Department of Mathematics, McGill University, Montreal, Canada; John Goldak, Department of Mechanical Engineering, Carleton University, Ontario, Canada

Modelling of Surfaces of Revolution
V. I. Fabrikant and T. S. Sankar, Department of Mechanical Engineering, Concordia University, Montreal, Quebec, Canada

Multi-Dimensional Graphics
Alfred Inselberg, IBM Scientific Center, Los Angeles, CA; and Department of Computer Science, University of California, Los Angeles, CA

Generation of Synthetic Digital Images Using A Scene Description Language
Kalyan Dutta, Lockheed Palo Alto Research Laboratory, Palo Alto, CA

Thursday, July 18/*4:00 PM*
Contributed Papers 14/*Meeting Room I*
MISCELLANEOUS CONTRIBUTIONS
Chairman: Barry L. Zaslove, Department of Mathematics, Northeastern University, Boston, MA

Applications of Z-Transforms to Financial Analysis
David J. Eaton, Systems Operations Division, Perkin-Elmer Corporation, Danbury, CT

Mathematics of A Physical Wave
Peter Nwoye O. Mbaeyi, Division of Theoretical Chemistry, University of Tubingen, Tubingen, West Germany

EXORcist and Robotics
K. Demys and C. Muses, Mathematics & Morphology Research Centre, Editorial & Research Offices, Miramonte, CA

Integrating Robotics Into Manufacturing Engineering Curriculum
Mysore Narayanan, Manufacturing Engineering Department, Miami University, Oxford, OH

A General Collapsing Technique for Three-Dimensional Algebraic Grid Generation II
Guillermo Marshall and Patricia Binaghi, Centro de Cálculo Científico, Comisión Nacional de Energía Atómica, Buenos Aires, Argentina

Automata in Finsler March
Barry L. Zaslove, Department of Mathematics, Northeastern University, Boston, MA

POSTER PRESENTATIONS

Tuesday, July 16/*3:15 PM*
Poster Presentation 1/Meeting Room 1

Singularities, Configurations and Displacement Functions for Manipulators and Linkages
Faydor L. Litvin, Mechanical Engineering Department and Robotics and Automation Laboratory, University of Illinois, Chicago, IL

Robot Path Planning Using an Almost Euclidean Medial-Axis Derived by Grassfire
John R. Crosscope and Michael N. Huhns Department of Electrical and Computer Engineeering, University of South Carolina, Columbia, SC

An Adaptive Technique for Approximating Line Drawings with Cubic Splines
J. P. Bixler, L. T. Watson, and J. P. Sanford, Department of Computer Science, Virginia Tech, Blacksburg, VA

Visual Surface Interpolation: A Comparison of Two Approaches
Terrance E. Boult, Department of Computer Science, Columbia University, New York, NY

Computer-Faces: The Human Lorenz Matrix
Wilfried A. Musterle and Otto E. Rossler, Institut fur Theoretische und Physikalische Chemie, Universitat Tubingen, Tubingen, West Germany

Multi-Dimensional Graphics
Alfred Inselberg, IBM Scientific Center, Los Angeles, CA; and Department of Computer Science, University of California, Los Angeles, CA

Upcoming SIAM Conferences

October 28–30, 1985
SIAM Fall Meeting
Arizona State University
Tempe, Arizona

November 18–21, 1985
SIAM Conference on Parallel Processing
Omni Hotel
Norfolk, Virginia

May 14–16, 1986
Third SIAM Conference on Discrete Mathematics
Clemson University
Clemson, South Carolina

July 21–25, 1986
SIAM 1986 National Meeting
Boston Park Plaza Hotel
Boston, MA

TRANSPORTATION INFORMATION

By Air

PARKWAY TRAVEL has been selected to be the official agent for the conference and will guarantee the lowest rates available to Albany. Call their number Toll Free: 1-800-235-6500. BE CERTAIN TO MENTION THAT YOU ARE ATTENDING THE SIAM CONFERENCE IN ALBANY. They will mail you tickets or arrange for them to be waiting for you at the airport of your choice.

Special Discount

US Air has been chosen as the official carrier for the conference. They have agreed (through Parkway Travel) to offer special discounts for our group, thereby giving you the lowest fare possible. These fares will not be available through any agency other than Parkway Travel. In any event, Parkway Travel will guarantee you the best available fare no matter which carrier you choose. Call 1-800-235-6500.

In order to get the flight of your choice, we suggest making reservations as soon as possible.

From the Airport

Taxis $10.00
Red badges will be mailed to conferees to identify them as attendees at the SIAM conference and to facilitate cab pooling.

Public transportation will be augmented by hotel limousines and private van service. Transport will be prompt and very cheap.

By Car

From the Airport
Take the Airport Drive (Albany—Shaker Road) to the intersection of Route 87 South. Take 87 South to I-90 East. Follow I-90 East to 787 South. Take the Clinton Avenue exit and turn left at the light onto Broadway. Go three blocks to State Street and turn right. The hotel will be four blocks on the right.

From New York City and the Turnpike
Take Route 87 to Exit 23 and proceed to Route 787 North. Follow 787 North to the Empire State Plaza exit. Go thru the tunnel onto Swan Street to State Street. Turn right on State and the hotel will be three blocks on the left.

Car Rental

Budget Car Rental is the official agency for the SIAM Conference on Geometric Modeling and Robotics. The specially discounted rate for all sizes of cars is $32.00 per day, unlimited mileage. You must have an advance reservation to qualify for the discounted rate. **Call 1-518-456-8561.** BE CERTAIN TO IDENTIFY YOURSELF AS AN ATTENDEE AT THE SIAM CONFERENCE ON GEOMETRIC MODELING AND ROBOTICS.

- Cars must be picked up and dropped off at the airport.
- You must call at least one week in advance to guarantee availability and to qualify for the discounted rate.
- You must have one of the following credit cards to rent a car: AMEX, MC, VISA, DC, Sears.
- You must be at least 21 years old.
- If you make a reservation at least two weeks prior to the conference, Budget will send you a confirmation.

HOTEL INFORMATION

Albany Hilton
State and Lodge Streets
Albany, New York 12207

SIAM is holding a block of rooms at the conference site, the Albany Hilton, on a first come, first served basis. Specially discounted room rates are $50.00 per single and $60.00 per double. These rooms will be held for our exclusive use only until July 1, 1985, after which availability cannot be guaranteed.

We urge you to make your reservations promptly by telephoning 1-518-462-6611, or via the adjacent Albany Hilton Reservations Request Form (domestic mail only). When making reservations by telephone, be certain to obtain the discounted rate by identifying yourself as an attendee at the SIAM Conference on Geometric Modeling and Robotics.

Late Arrival Policy: If you plan to arrive after 6:00 pm, you must guarantee payment by either Diner's Club card, AMEX, or a check for one night's deposit.

If you need to change or cancel your reservation, be certain to contact the hotel by 3:00 pm Albany time on your stated day of arrival.

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RESERVATIONS REQUEST FORM

ALBANY HILTON

SIAM Conference on Geometric Modeling and Robotics, July 15–19, 1985

Specially discounted rooms will be held for our exclusive use only until July 1, 1985. After that, reservations will depend on availability. Your reservation is not confirmed until acknowledged in writing by the hotel or verified by phone.

When making reservations by phone, be certain to identify yourself as an attendee at the SIAM Conference on Geometric Modeling and Robotics. Telephone: 1-518-462-6611.

Name _____
PLEASE PRINT

Address _____

City _____ State _____ Zip _____ Phone _____

Please guarantee my room for late arrival* _____

Diner's Club _____ AMEX _____

My credit card number is _____ Expiration Date _____

Deposit $ _____ (for late arrival only)

Please reserve: Single ($50) _____ Double ($60) _____

Arrival date _____ Arrival time _____ Check out date _____

** If you send cash or list your credit card number, please enclose this card in an envelope and mail to:* Reservations, Albany Hilton, State and Lodge Streets, Albany, New York, 12207

REGISTRATION INFORMATION

The registration desk will be located in the Prefunction Area on the Ballroom Level of the hotel and will be open as listed below:

Sunday, July 14 **5:00 pm–10:00 pm**
Monday, July 15–Friday, July 19 **7:30 am–6:00 pm**

		SIAM Member	Non Member	Full-time Student
Registration Fees	Advance	$105	$125	$20
	On Site	$140	$160	$20

Wine and Cheese Party
Monday, July 15, 6:15 pm
Rensselaer Polytechnic Institute
$10.00

Banquet and Ballet
Wednesday, July 17, 5:15 pm
Saratoga Springs Performing Arts Center
$32.00 (including transportation)

Non-member registrants are encouraged to join SIAM in order to obtain the member rate for conference registration and enjoy all other benefits of SIAM membership.

Special Note:
There will be no prorated fees. There will be no refunds after the conference starts. SIAM does not accept credit cards.

Telephone Messages:
The telephone number at the Albany Hilton is 1-518-462-6611. They will either connect you to the SIAM desk or forward a message.

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ADVANCE REGISTRATION FORM

SIAM Conference on Geometric Modeling and Robotics

*** Advance registration form must be received at the SIAM office by July 11, 1985**

		SIAM Member	Non-Member	Full-time Student
Registration Fees	Advance	$105	$125	$20
	On Site	$140	$160	$20
Registration amount enclosed		$ ____	$ ____	$ ____
Wine and Cheese Party, $10.00 Monday, July 15, 6:15 pm		$ ____	$ ____	$ ____
Banquet and Ballet, $32.00 Wednesday, July 17, 5:15 pm		$ ____	$ ____	$ ____
TOTAL AMOUNT ENCLOSED		$ ____	$ ____	$ ____

Name _____

Dept. _____

Affiliation _____

Telephone _____

Address _____

City _____ State _____ Zip _____

Local Address in Albany _____

I am a member of: ☐ SIAM ☐ Other(s) _____

☐ **Please send me information about membership in SIAM.**

Detach card and enclose with payment in the envelope provided (domestic mail only), and mail to: SIAM, 117 South 17th Street, 14th floor, Philadelphia, PA 19103-5052
Telephone: 215-564-2929

SIAM
117 South 17th Street
14th Floor
Philadelphia, PA 19103-5052
U.S.A.

Nonprofit
Organization
U.S. Bulk
Postage-Paid
SIAM

POSTMASTER PLEASE DELIVER TO:

From:

PLACE
STAMP
HERE

TO: Reservations
Albany Hilton At Ten Eyck Plaza
State And Lodge Streets
Albany, NY 12207