

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Alfred Kobsa

University of California, Irvine, CA, USA

Friedemann Mattern

ETH Zurich, Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Germany

Madhu Sudan

Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbruecken, Germany

Komei Fukuda Joris van der Hoeven
Michael Joswig Nobuki Takayama (Eds.)

Mathematical Software – ICMS 2010

Third International Congress
on Mathematical Software
Kobe, Japan, September 13-17, 2010
Proceedings

Volume Editors

Komei Fukuda
Institute for Operations Research
and Institute of Theoretical Computer Science
ETH Zurich, 8092 Zurich, Switzerland
E-mail: fukuda@ifor.math.ethz.ch

Joris van der Hoeven
LIX, CNRS, École polytechnique
91128 Palaiseau cedex, France
E-mail: vdhoeven@lix.polytechnique.fr

Michael Joswig
TU Darmstadt, Fachbereich Mathematik
64289 Darmstadt, Germany
E-mail: joswig@mathematik.tu-darmstadt.de

Nobuki Takayama
Kobe University, Department of Mathematics
Rokko, Kobe, 657-8501, Japan
E-mail: takayama@math.kobe-u.ac.jp

Library of Congress Control Number: 2010933525

CR Subject Classification (1998): G.2, I.1, F.2.1, G.4, F.2, G.1

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

ISSN	0302-9743
ISBN-10	3-642-15581-2 Springer Berlin Heidelberg New York
ISBN-13	978-3-642-15581-9 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

springer.com

© Springer-Verlag Berlin Heidelberg 2010
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper 06/3180

Preface

The ICMS Developer's Meeting is an international congress for which the main theme is mathematical software. The 2010 meeting was the third of a series of meetings of similar theme, the first being held in Beijing, China in 2002, and the second in Castro-Urdiales, Spain in 2006.

The field of mathematics has numerous branches, and in each branch we find that algorithms, and also implementations and applications of software systems, are studied. Researchers who endeavor to make such studies also have international meetings within their specific branches of mathematics, and these meetings have made significant contributions to the fields in which they lie. The ICMS (International Congresses on Mathematical Software), on the other hand, is a general (not branch specific) meeting on mathematical software, which is held every four years, and is a rare opportunity for developers of mathematical software from different branches of mathematics, as well as mathematicians who are interested in mathematical software, to gather together.

Since the first meeting in Beijing, eight years have passed, and this is now a good occasion for us to ask this important question, and we beg the readers' indulgence for its bluntness: is this kind of general meeting useful? In order to have a productive meeting, the participants should have a base of common interests and knowledge. Do we have such common interests and knowledge? To help us consider this question, let us note the following points:

(1) We are interested in mathematics and want to explore the world of mathematics, regardless of whether we have the aid of a computer. The discovery or proof of a new mathematical fact is an exciting application of mathematical software. Certainly all of us would agree with this claim.

(2) Which objects in mathematics are computable, and which are not? To what degree can we be efficient in computation? Can we implement algorithms efficiently? All participants and authors of these proceedings will surely agree that these are fundamental questions, and will have a strong interest in answering them.

(3) All participants and authors know at least one programming language. For instance, most people will understand the programming language C and/or its derivatives. All participants are interested in using software environments to study mathematics.

(4) We understand that technology transfers from mathematics to industry and other fields are done primarily via software systems. We should be able to explain how our favorite algorithms are used in industrial applications.

We have listed above four points of common knowledge and interests, and certainly there are more. It is through points like these that we can exchange a wide variety of ideas and knowledge with each other, resulting in the advance-

ment of mathematical software. On the basis of points like these, we can give a resounding “yes” to the first blunt question above.

We believe that mathematics itself is a coherent whole, and there are copious examples of how the interplay between seemingly disparate branches of mathematics yields new results. In mathematical software, let us note some such examples that have come to fruition in the last eight years: software systems in tropical geometry have been produced using computer algebra and polyhedral geometry software as a base; applications of computer algebra have created a new area of research called “algebraic statistics.” There are many other cases as well, and a network of researchers from different disciplines has been an important foundation for this, leading to a wealth of interdisciplinary research.

The articles in these proceedings were written by speakers at the ICMS 2010 and reviewed by the Program Committee members and some external referees. No doubt the authors wish that not only their peers, but also researchers in other branches of mathematics, will become interested in their results and will apply their outcomes to those other branches. The authors also surely hope that mathematicians, scientists and engineers will read articles in this volume, and will then have a deeper understanding of what is going on at present in the study of mathematical software, and will in turn suggest new applications of mathematical software and also give new proposals for developing mathematical software.

The activities of the last two conferences are archived in proceedings, in software and document DVD’s, and in video format. This material can be accessed through <http://www.mathsoftware.org>. ICMS 2010 will also be archived in this way.

We hope that these proceedings will contribute to the advancement of a wide array of research directions, led by many researchers with varied backgrounds.

September 2010

Nobuki Takayama
Komei Fukuda
Joris van der Hoeven
Michael Joswig

Organization

ICMS 2010 was organized by the Department of Mathematics Kobe University, Rokko, Kobe, Japan.

Conference Chairs

General Chair	Nobuki Takayama (Kobe University, Japan)
Program Co-chairs	Komei Fukuda (ETH Zurich, Switzerland)
	Joris van der Hoeven (CNRS, École Polytechnique, France)
	Michael Joswig (Technische Universität Darmstadt, Germany)
Poster Session Chair	Raimundas Vidunas (Kobe University, Japan)
Local Organization Chair	Masayuki Noro (Kobe University, Japan)

Program Committee

Bettina Eick	Technische Universität Braunschweig, Germany
Anne Fruehbis-Krueger	Leibniz Universität Hannover, Germany
Komei Fukuda	ETH Zurich, Switzerland
Tatsuyoshi Hamada	Fukuoka University, Japan
John Harrison	Intel Corporation, USA
Joris van der Hoeven	CNRS, École Polytechnique, France
Tim Hoffmann	Technische Universität München, Germany
Andres Iglesias	University of Cantabria, Spain
Michael Joswig	Technische Universität Darmstadt, Germany
Paul Libbrecht	DFKI GmbH and University of Saarland, Germany
Steve Linton	University of St. Andrews, Scotland, UK
Hidefumi Ohsugi	Rikkyo University, Japan
Pawel Pilarczyk	University of Minho, Portugal
Michael Pohst	Technische Universität Berlin, Germany
Nathalie Revol	École Normale Supérieure de Lyon, France
Wayne Rossman	Kobe University, Japan
Michael Sagraloff	Max-Planck-Institut für Informatik, Germany
Bruno Salvy	INRIA Rocquencourt, France
Achill Schuermann	Delft University of Technology, The Netherlands
Vin de Silva	Pomona College, USA
Monique Teillaud	INRIA Sophia Antipolis, France
Shigenori Uchiyama	Tokyo Metropolitan University, Japan
Freek Wiedijk	Radboud University, The Netherlands
Chee Yap	New York University, USA
Afra Zomorodian	Dartmouth College, USA

Advisory Program Committee

Henk Barendregt	Radboud University, The Netherlands
Arjeh Cohen	Technische Universiteit Eindhoven, The Netherlands
Dan Grayson	University of Illinois, USA
Gert-Martin Greuel	University of Kaiserslautern, Germany
Jean Lasserre	LAAS-CNRS, France
Bernard Mourrain	INRIA Sophia Antipolis, France
Ken Nakamura	Tokyo Metropolitan University, Japan
Bernd Sturmfels	University of California Berkeley, USA
Jan Verschelde	University of Illinois, USA
Dongming Wang	CNRS, France

Session Organizers

Computational Group Theory

Bettina Eick (Technische Universität Braunschweig, Germany)

Steve Linton (University of St. Andrews, Scotland, UK)

Computation of Special Functions

Bruno Salvy (INRIA Rocquencourt, France)

Computer Algebra

Joris van der Hoeven (CNRS, École Polytechnique, France)

Nathalie Revol (École Normale Supérieure de Lyon, France)

Exact Numeric Computation for Algebraic and Geometric Computation

Chee Yap (New York University, USA)

Michael Sagraloff (Max-Planck-Institut für Informatik, Germany)

Monique Teillaud (INRIA Sophia Antipolis, France)

Formal Proof

John Harrison (Intel Corporation, USA)

Freek Wiedijk (Radboud University, The Netherlands)

Geometry and Visualization

Tim Hoffmann (Technische Universität München, Germany)

Wayne Rossman (Kobe University, Japan)

Groebner Bases and Applications

Anne Fruehbis-Krueger (Leibniz Universität Hannover, Germany)

Hidefumi Ohsugi (Rikkyo University, Japan)

Number Theoretical Software

Shigenori Uchiyama (Tokyo Metropolitan University, Japan)

Ken Nakamura (Tokyo Metropolitan University, Japan)

Michael Pohst (Technische Universität Berlin, Germany)

Reliable Computing

Joris van der Hoeven (CNRS, École Polytechnique, France)

Nathalie Revol (École Normale Supérieure de Lyon, France)

Software for Optimization and Polyhedral Computation

Achill Schuermann (Delft University of Technology, The Netherlands)

Komei Fukuda (ETH Zurich, Switzerland)

Michael Joswig (Technische Universität Darmstadt, Germany)

Sponsoring Institutions

1. Faculty of Science, Kobe University
2. Kakenhi 19204008, Japan Society of Promotion of Science
3. Team Hibi, Alliance for breakthrough between mathematics and sciences, Japan Science and Technology Agency

Table of Contents

Mathematical Software - ICMS 2010

Plenary

Computational Discrete Geometry	1
<i>Thomas C. Hales</i>	
Exploiting Structured Sparsity in Large Scale Semidefinite Programming Problems	4
<i>Masakazu Kojima</i>	
Reliable and Efficient Geometric Computing	10
<i>Kurt Mehlhorn</i>	
The Sage Project: Unifying Free Mathematical Software to Create a Viable Alternative to Magma, Maple, Mathematica and MATLAB	12
<i>Burin Ercal and William Stein</i>	

Computation of Special Functions (Invited)

Sollya: An Environment for the Development of Numerical Codes	28
<i>Sylvain Chevillard, Mioara Joldeş, and Christoph Lauter</i>	
Validated Special Functions Software	32
<i>Annie Cuyt, Franky Backeljauw, Stefan Becuwe, and Joris Van Deun</i>	
The Dynamic Dictionary of Mathematical Functions (DDMF)	35
<i>Alexandre Benoit, Frédéric Chyzak, Alexis Darrasse, Stefan Gerhold, Marc Mezzarobba, and Bruno Salvy</i>	
Reliable Computing with GNU MPFR	42
<i>Paul Zimmermann</i>	

Computational Group Theory (Invited)

Simplicial Cohomology of Smooth Orbifolds in GAP	46
<i>Mohamed Barakat and Simon Görtzen</i>	
Computing Polycyclic Quotients of Finitely (L-)Presented Groups via Groebner Bases	50
<i>Bettina Eick and Max Horn</i>	

Constructive Membership Testing in Black-Box Classical Groups	54
<i>Sophie Ambrose, Scott H. Murray, Cheryl E. Praeger, and Csaba Schneider</i>	

Computational Group Theory (Contributed)

Towards High-Performance Computational Algebra with GAP	58
<i>Reimer Behrends, Alexander Konovalov, Steve Linton, Frank Lübeck, and Max Neunhöffer</i>	
An Improvement of a Function Computing Normalizers for Permutation Groups	62
<i>Izumi Miyamoto</i>	
A GAP Package for Computation with Coherent Configurations	69
<i>Dmitrii V. Pasechnik and Keshav Kini</i>	

Computer Algebra (Invited)

CoCoALib: A C++ Library for Computations in Commutative Algebra ... and Beyond	73
<i>John Abbott and Anna M. Bigatti</i>	
LINBOXFounding Scope Allocation, Parallel Building Blocks, and Separate Compilation	77
<i>Jean-Guillaume Dumas, Thierry Gautier, Clément Pernet, and B. David Saunders</i>	
FGb: A Library for Computing Gröbner Bases	84
<i>Jean-Charles Faugère</i>	
Fast Library for Number Theory: An Introduction	88
<i>William B. Hart</i>	

Exact Numeric Computation for Algebraic and Geometric Computation (Invited)

Controlled Perturbation for Certified Geometric Computing with Fixed-Precision Arithmetic	92
<i>Dan Halperin</i>	
Exact Geometric and Algebraic Computations in CGAL	96
<i>Menelaos I. Karavelas</i>	
On Solving Systems of Bivariate Polynomials	100
<i>Fabrice Rouillier</i>	

Accurate and Reliable Computing in Floating-Point Arithmetic	105
<i>Siegfried M. Rump</i>	

Exact Numeric Computation for Algebraic and Geometric Computation (Contributed)

Deferring Dag Construction by Storing Sums of Floats Speeds-Up Exact Decision Computations Based on Expression Dags	109
<i>Marc Mörig</i>	

The Design of Core 2: A Library for Exact Numeric Computation in Geometry and Algebra	121
<i>Jihun Yu, Chee Yap, Zilin Du, Sylvain Pion, and Hervé Brönnimann</i>	

Formal Proof (Invited)

Introducing HOL Zero (Extended Abstract)	142
<i>Mark Adams</i>	

Euler's Polyhedron Formula in mizar	144
<i>Jesse Alama</i>	

Building a Library of Mechanized Mathematical Proofs: Why Do It? and What Is It Like to Do?	148
<i>Rob D. Arthan</i>	

Linear Programs for the Kepler Conjecture (Extended Abstract)	149
<i>Thomas C. Hales</i>	

A Formal Proof of Pick's Theorem (Extended Abstract)	152
<i>John Harrison</i>	

Formal Proof (Contributed)

Evaluation of Automated Theorem Proving on the Mizar Mathematical Library	155
<i>Josef Urban, Krystof Hoder, and Andrei Voronkov</i>	

Geometry and Visualization (Invited)

On Local Deformations of Planar Quad-Meshes	167
<i>Tim Hoffmann</i>	

Construction of Harmonic Surfaces with Prescribed Geometry	170
<i>Matthias Weber</i>	

Geometry and Visualization (Contributed)

A Library of OpenGL-based Mathematical Image Filters	174
<i>Martin von Gagern and Christian Mercat</i>	
MD-jeep: An Implementation of a Branch and Prune Algorithm for Distance Geometry Problems	186
<i>Antonio Mucherino, Leo Liberti, and Carlile Lavor</i>	
TADD: A Computational Framework for Data Analysis Using Discrete Morse Theory	198
<i>Jan Reininghaus, David Günther, Ingrid Hotz, Steffen Prohaska, and Hans-Christian Hege</i>	

Groebner Bases and Applications (Invited)

Introduction to Normaliz 2.5	209
<i>Winfried Bruns, Bogdan Ichim, and Christof Söger</i>	
Computer Algebra Methods in Tropical Geometry	213
<i>Thomas Markwig</i>	

Groebner Bases and Applications (Contributed)

A New Desingularization Algorithm for Binomial Varieties in Arbitrary Characteristic	217
<i>Rocío Blanco</i>	
An Algorithm of Computing Inhomogeneous Differential Equations for Definite Integrals	221
<i>Hiromasa Nakayama and Kenta Nishiyama</i>	
New Algorithms for Computing Primary Decomposition of Polynomial Ideals	233
<i>Masayuki Noro</i>	
An Automated Confluence Proof for an Infinite Rewrite System Parametrized over an Integro-Differential Algebra	245
<i>Loredana Tec, Georg Regensburger, Markus Rosenkranz, and Bruno Buchberger</i>	
Operadic Gröbner Bases: An Implementation	249
<i>Vladimir Dotsenko and Mikael Vejdemo-Johansson</i>	

Number Theoretical Software (Invited)

Magma - A Tool for Number Theory	253
<i>John Cannon, Steve Donnelly, Claus Fieker, and Mark Watkins</i>	

Number Theoretical Software (Contributed)

Enumerating Galois Representations in Sage	256
<i>Craig Citro and Alexandru Ghitza</i>	
NZMATH 1.0	260
<i>Satoru Tanaka, Naoki Ogura, Ken Nakamura, Tetsushi Matsui, and Shigenori Uchiyama</i>	

Software for Optimization and Polyhedral Computation (Invited)

Removing Redundant Quadratic Constraints	270
<i>David Adjiashvili, Michel Baes, and Philipp Rostalski</i>	
Traversing Symmetric Polyhedral Fans	282
<i>Anders Nedergaard Jensen</i>	
C++ Tools for Exploiting Polyhedral Symmetries	295
<i>Thomas Rehn and Achill Schürmann</i>	
<i>isl</i> : An Integer Set Library for the Polyhedral Model	299
<i>Sven Verdoolaege</i>	

Software for Optimization and Polyhedral Computation (Contributed)

The Reformulation-Optimization Software Engine	303
<i>Leo Liberti, Sonia Cafieri, and David Savourey</i>	
Generating Smooth Lattice Polytopes	315
<i>Christian Haase, Benjamin Lorenz, and Andreas Paffenholz</i>	

Reliable Computation (Invited)

Mathemagix: Towards Large Scale Programming for Symbolic and Certified Numeric Computations	329
<i>Grégoire Lecerf</i>	
Complex Inclusion Functions in the CoStLy C++ Class Library	333
<i>Markus Neher</i>	
Standardized Interval Arithmetic and Interval Arithmetic Used in Libraries	337
<i>Nathalie Revol</i>	

Reliable Computation (Contributed)

Efficient Evaluation of Large Polynomials	342
<i>Charles E. Leiserson, Liyun Li, Marc Moreno Maza, and Yuzhen Xie</i>	
Communicating Functional Expressions from <i>Mathematica</i> to C-XSC . . .	354
<i>Eugenija D. Popova and Walter Krämer</i>	
Author Index	367