

Tiziana Calamoneri
Irene Finocchi
Giuseppe F. Italiano (Eds.)

LNCS 3998

Algorithms and Complexity

6th Italian Conference, CIAC 2006
Rome, Italy, May 2006
Proceedings



Springer

Tiziana Calamoneri Irene Finocchi
Giuseppe F. Italiano (Eds.)

Algorithms and Complexity

6th Italian Conference, CIAC 2006
Rome, Italy, May 29-31, 2006
Proceedings



Volume Editors

Tiziana Calamoneri
Irene Finocchi
Dipartimento di Informatica
Università degli Studi di Roma “La Sapienza”
Via Salaria 113, 00198 Roma, Italy
E-mail: {calamo,finocchi}@di.uniroma1.it

Giuseppe F. Italiano
Dipartimento di Informatica, Sistemi e Produzione
Università di Roma “Tor Vergata”
Via del Politecnico 1, 00133 Roma, Italy
E-mail: italiano@disp.uniroma2.it

Library of Congress Control Number: 2006925893

CR Subject Classification (1998): F.2, F.1, E.1, I.3.5, G.2

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

ISSN 0302-9743
ISBN-10 3-540-34375-X Springer Berlin Heidelberg New York
ISBN-13 978-3-540-34375-2 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 is a part of Springer Science+Business Media

springer.com

© Springer-Verlag Berlin Heidelberg 2006
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11758471 06/3142 5 4 3 2 1 0

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

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

University of Dortmund, Germany

Madhu Sudan

Massachusetts Institute of Technology, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Moshe Y. Vardi

Rice University, Houston, TX, USA

Gerhard Weikum

Max-Planck Institute of Computer Science, Saarbruecken, Germany

Preface

The 6th International Conference on Algorithms and Complexity (CIAC 2006) was held in Rome, Italy during May 29–31, 2006. These proceedings contain all contributed papers presented at CIAC 2006, together with the invited lectures delivered at the conference. The Program Committee consisted of:

- Nicola Galesi, Univ. of Rome “La Sapienza”, Italy
- John Iacono, Brooklyn Polytechnic, USA
- Giuseppe F. Italiano (Chair), Univ. of Rome “Tor Vergata”, Italy
- Pascal Koiran, ENS Lyon, France
- Jaroslav Nešetřil, Charles University, Czech Republic
- Sotiris Nikoletseas, CTI and Univ. of Patras, Greece
- Stephan Olariu, Old Dominion Univ., USA
- Anna Ostlin Pagh, ITU, Denmark
- Andrzej Pelc, Université du Québec en Outaouais, Canada
- Peter Sanders, Universitaet Karlsruhe, Germany
- Bruno Simeone, Univ. of Rome “La Sapienza”, Italy
- Uri Zwick, Tel-Aviv Univ., Israel

In response to a call for papers, the Program Committee received 80 submissions, and selected 33 papers for inclusion in the scientific program. In addition to the contributed papers, Kurt Mehlhorn (MPI, Germany), Franco P. Preparata (Brown Univ., USA) and Pavel Pudlák (Academy of Sciences, Czech Republic) were invited to give plenary lectures at the conference. All the work of the Program Committee was done electronically. The selection was based on originality, quality and relevance to theoretical computer science. The submissions were refereed as carefully as time permitted; it is expected that many of them will appear in a more polished form in scientific journals in the future.

We wish to thank all authors who submitted papers for consideration, the Program Committee for its hard work, as well as those external reviewers who assisted the Program Committee in the evaluation process. A special thanks to the Organizing Committee for a very dedicated work.

May 2006

Tiziana Calamoneri
Irene Finocchi
Giuseppe F. Italiano

Organization

External Reviewers

Zoe Abrams
Alexander Ageev
Amitai Armon
Pablo Arrighi
Adi Avidor
Amotz Bar-Noy
Luca Becchetti
Stéphane Bessy
Philip Bille
Somenath Biswas
Maria Blesa
Avrim Blum
Jeremy Buhler
John Byers
Ioannis Caragiannis
Massimiliano Caramia
Nicolò Cesa-Bianchi
Marco Cesati
Bogdan Chlebus
Marek Chrobak
Andrea Clementi
Pierluigi Crescenzi
Gianluca De Marco
Christoph Dürr
Fritz Eisenbrand
Lene Favrholdt
Henning Fernau
Fedor Fomin
Dimitris Fotakis
Leszek Gąsieniec
Ricardo Gavalda
Inge Li Gørtz
Fabrizio Grandoni
Joachim Gudmundsson
Leonid Gurvits
Esben Rune Hansen
Michael Hoffmann
Jan Hubička
Costas Iliopoulos
Spiros Kontogiannis
Guy Kortsarz
Dimitris Koukopoulos
Dariusz Kowalski
Dan Král
Evangelos Kranakis
Jan Kratochvíl
Fabian Kuhn
Oliver Kullmann
Moshe Lewenstein
Chaim Linhart
Zvi Lotker
Rune Bang Lyngsø
Christos Makris
David Manlowe
Euripides Markou
Elvira Mayordomo
Xavier Messeguer
Pat Morin
Dhruv Mubayi
Marcin Mucha
Maurizio Naldi
Giri Narasimhan
Alantha Newman
Sara Nicološo
Rolf Niedermeier
Bengt J. Nilsson
Gianpaolo Oriolo
Andrea Pacifici
Rasmus Pagh
Viki Papadopoulou
Evi Papaioannou
Kunsoo Park
Christian N. S. Pedersen
David Peleg
Paolo Penna
Ugo Pietropaoli
David Pisinger
Tomasz Radzik

Peter Jonsson	R. Ravi
Alex Kaporis	Oded Regev
Jyrki Katajainen	Milan Ruzic
Claire Kenyon	Miklos Santha
Nicolas Schabanel	Peter Tiedemann
Elad Schiller	Jacobo Toran
Uwe Schöning	Ugo Vaccaro
Maria José Serna	Gabriel Valiente
Asaf Shapira	Tasos Viglas
Micha Sharir	Paola Vocca
Riccardo Silvestri	Magnus Wahlström
Maurizio Strangio	Michele Zito
Stéphan Thomassé	

Lecture Notes in Computer Science

For information about Vols. 1–3899

please contact your bookseller or Springer

- Vol. 3998: T. Calamoneri, I. Finocchi, G.F. Italiano (Eds.), *Algorithms and Complexity*. XII, 394 pages. 2006.
- Vol. 3994: V.N. Alexandrov, G.D. van Albada, P.M.A. Sloot, J. Dongarra (Eds.), *Computational Science – ICCS 2006*, Part IV. XXIX, 1094 pages. 2006.
- Vol. 3993: V.N. Alexandrov, G.D. van Albada, P.M.A. Sloot, J. Dongarra (Eds.), *Computational Science – ICCS 2006*, Part III. XXX, 1138 pages. 2006.
- Vol. 3992: V.N. Alexandrov, G.D. van Albada, P.M.A. Sloot, J. Dongarra (Eds.), *Computational Science – ICCS 2006*, Part II. XXIX, 1121 pages. 2006.
- Vol. 3991: V.N. Alexandrov, G.D. van Albada, P.M.A. Sloot, J. Dongarra (Eds.), *Computational Science – ICCS 2006*, Part I. CCXX, 1090 pages. 2006.
- Vol. 3990: J. C. Beck, B.M. Smith (Eds.), *Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems*. X, 301 pages. 2006.
- Vol. 3987: M. Hazas, J. Krumm, T. Strang (Eds.), *Location- and Context-Awareness*. X, 289 pages. 2006.
- Vol. 3986: K. Stølen, W.H. Winsborough, F. Martinelli, F. Massacci (Eds.), *Trust Management*. XIV, 474 pages. 2006.
- Vol. 3984: M. Gavrilova, O. Gervasi, V. Kumar, C.J. K. Tan, D. Taniar, A. Laganà, Y. Mun, H. Choo (Eds.), *Computational Science and Its Applications - ICCSA 2006*, Part V. XXV, 1045 pages. 2006.
- Vol. 3983: M. Gavrilova, O. Gervasi, V. Kumar, C.J. K. Tan, D. Taniar, A. Laganà, Y. Mun, H. Choo (Eds.), *Computational Science and Its Applications - ICCSA 2006*, Part IV. XXVI, 1191 pages. 2006.
- Vol. 3982: M. Gavrilova, O. Gervasi, V. Kumar, C.J. K. Tan, D. Taniar, A. Laganà, Y. Mun, H. Choo (Eds.), *Computational Science and Its Applications - ICCSA 2006*, Part III. XXV, 1243 pages. 2006.
- Vol. 3981: M. Gavrilova, O. Gervasi, V. Kumar, C.J. K. Tan, D. Taniar, A. Laganà, Y. Mun, H. Choo (Eds.), *Computational Science and Its Applications - ICCSA 2006*, Part II. XXVI, 1255 pages. 2006.
- Vol. 3980: M. Gavrilova, O. Gervasi, V. Kumar, C.J. K. Tan, D. Taniar, A. Laganà, Y. Mun, H. Choo (Eds.), *Computational Science and Its Applications - ICCSA 2006*, Part I. LXXV, 1199 pages. 2006.
- Vol. 3979: T.S. Huang, N. Sebe, M.S. Lew, V. Pavlović, M. Kölisch, A. Galata, B. Kisačanin (Eds.), *Computer Vision in Human-Computer Interaction*. XII, 121 pages. 2006.
- Vol. 3978: B. Hnich, M. Carlsson, F. Fages, F. Rossi (Eds.), *Recent Advances in Constraints*. VIII, 179 pages. 2006. (Sublibrary LNAI).
- Vol. 3976: F. Boavida, T. Plagemann, B. Stiller, C. Westphal, E. Monteiro (Eds.), *Networking 2006. Networking Technologies, Services, and Protocols; Performance of Computer and Communication Networks; Mobile and Wireless Communications Systems*. XXVI, 1276 pages. 2006.
- Vol. 3975: S. Mehrotra, D.D. Zeng, H. Chen, B. Thuraisingham, F.Y. Wang (Eds.), *Intelligence and Security Informatics*. XXII, 772 pages. 2006.
- Vol. 3970: T. Braun, G. Carle, S. Fahmy, Y. Koucheryavy (Eds.), *Wired/Wireless Internet Communications*. XIV, 350 pages. 2006.
- Vol. 3968: K.P. Fishkin, B. Schiele, P. Nixon, A. Quigley (Eds.), *Pervasive Computing*. XV, 402 pages. 2006.
- Vol. 3967: D. Grigoriev, J. Harrison, E.A. Hirsch (Eds.), *Computer Science – Theory and Applications*. XVI, 684 pages. 2006.
- Vol. 3966: Q. Wang, D. Pfahl, D.M. Raffo, P. Wernick (Eds.), *Software Process Change*. XIV, 356 pages. 2006.
- Vol. 3965: M. Bernardo, A. Cimatti (Eds.), *Formal Methods for Hardware Verification*. VII, 243 pages. 2006.
- Vol. 3964: M. Ü. Uyar, A.Y. Duale, M.A. Fecko (Eds.), *Testing of Communicating Systems*. XI, 373 pages. 2006.
- Vol. 3962: W. IJsselsteijn, Y. de Kort, C. Midden, B. Eggen, E. van den Hoven (Eds.), *Persuasive Technology*. XII, 216 pages. 2006.
- Vol. 3960: R. Vieira, P. Quaresma, M.d.G.V. Nunes, N.J. Mamede, C. Oliveira, M.C. Dias (Eds.), *Computational Processing of the Portuguese Language*. XII, 274 pages. 2006. (Sublibrary LNAI).
- Vol. 3959: J.-Y. Cai, S. B. Cooper, A. Li (Eds.), *Theory and Applications of Models of Computation*. XV, 794 pages. 2006.
- Vol. 3958: M. Yung, Y. Dodis, A. Kiayias, T. Malkin (Eds.), *Public Key Cryptography - PKC 2006*. XIV, 543 pages. 2006.
- Vol. 3956: G. Barthe, B. Gregoire, M. Huisman, J.-L. Lanet (Eds.), *Construction and Analysis of Safe, Secure, and Interoperable Smart Devices*. IX, 175 pages. 2006.
- Vol. 3955: G. Antoniou, G. Potamias, C. Spyropoulos, D. Plexousakis (Eds.), *Advances in Artificial Intelligence*. XVII, 611 pages. 2006. (Sublibrary LNAI).
- Vol. 3954: A. Leonardis, H. Bischof, A. Pinz (Eds.), *Computer Vision – ECCV 2006*, Part IV. XVII, 613 pages. 2006.
- Vol. 3953: A. Leonardis, H. Bischof, A. Pinz (Eds.), *Computer Vision – ECCV 2006*, Part III. XVII, 649 pages. 2006.
- Vol. 3952: A. Leonardis, H. Bischof, A. Pinz (Eds.), *Computer Vision – ECCV 2006*, Part II. XVII, 661 pages. 2006.

- Vol. 3951: A. Leonardis, H. Bischof, A. Pinz (Eds.), Computer Vision – ECCV 2006, Part I. XXXV, 639 pages. 2006.
- Vol. 3950: J.P. Müller, F. Zambonelli (Eds.), Agent-Oriented Software Engineering VI. XVI, 249 pages. 2006.
- Vol. 3947: Y.-C. Chung, J.E. Moreira (Eds.), Advances in Grid and Pervasive Computing. XXI, 667 pages. 2006.
- Vol. 3946: T.R. Roth-Berghofer, S. Schulz, D.B. Leake (Eds.), Modeling and Retrieval of Context. XI, 149 pages. 2006. (Sublibrary LNAI).
- Vol. 3945: M. Hagiya, P. Wadler (Eds.), Functional and Logic Programming. X, 295 pages. 2006.
- Vol. 3944: J. Quiñonero-Candela, I. Dagan, B. Magnini, F. d'Alché-Buc (Eds.), Machine Learning Challenges. XIII, 462 pages. 2006. (Sublibrary LNAI).
- Vol. 3943: N. Guelfi, A. Savidis (Eds.), Rapid Integration of Software Engineering Techniques. X, 289 pages. 2006.
- Vol. 3942: Z. Pan, R. Aylett, H. Diener, X. Jin, S. Göbel, L. Li (Eds.), Technologies for E-Learning and Digital Entertainment. XXV, 1396 pages. 2006.
- Vol. 3941: S.W. Gilroy, M.D. Harrison (Eds.), Interactive Systems. XI, 267 pages. 2006.
- Vol. 3940: C. Saunders, M. Grobelnik, S. Gunn, J. Shawe-Taylor (Eds.), Subspace, Latent Structure and Feature Selection. X, 209 pages. 2006.
- Vol. 3939: C. Priami, L. Cardelli, S. Emmott (Eds.), Transactions on Computational Systems Biology IV. VII, 141 pages. 2006. (Sublibrary LNBI).
- Vol. 3936: M. Lalmas, A. MacFarlane, S. Rüger, A. Tombros, T. Tsikrika, A. Yavansky (Eds.), Advances in Information Retrieval. XIX, 584 pages. 2006.
- Vol. 3935: D. Won, S. Kim (Eds.), Information Security and Cryptology - ICISC 2005. XIV, 458 pages. 2006.
- Vol. 3934: J.A. Clark, R.F. Paige, F.A. C. Polack, P.J. Brooke (Eds.), Security in Pervasive Computing. X, 243 pages. 2006.
- Vol. 3933: F. Bonchi, J.-F. Boulicaut (Eds.), Knowledge Discovery in Inductive Databases. VIII, 251 pages. 2006.
- Vol. 3931: B. Apolloni, M. Marinaro, G. Nicosia, R. Tagliaferri (Eds.), Neural Nets. XIII, 370 pages. 2006.
- Vol. 3930: D.S. Yeung, Z.-Q. Liu, X.-Z. Wang, H. Yan (Eds.), Advances in Machine Learning and Cybernetics. XXI, 1110 pages. 2006. (Sublibrary LNAI).
- Vol. 3929: W. MacCaull, M. Winter, I. Düntsch (Eds.), Relational Methods in Computer Science. VIII, 263 pages. 2006.
- Vol. 3928: J. Domingo-Ferrer, J. Posegga, D. Schreckling (Eds.), Smart Card Research and Advanced Applications. XI, 359 pages. 2006.
- Vol. 3927: J. Hespanha, A. Tiwari (Eds.), Hybrid Systems: Computation and Control. XII, 584 pages. 2006.
- Vol. 3925: A. Valmari (Ed.), Model Checking Software. X, 307 pages. 2006.
- Vol. 3924: P. Sestoft (Ed.), Programming Languages and Systems. XII, 343 pages. 2006.
- Vol. 3923: A. Mycroft, A. Zeller (Eds.), Compiler Construction. XIII, 277 pages. 2006.
- Vol. 3922: L. Baresi, R. Heckel (Eds.), Fundamental Approaches to Software Engineering. XIII, 427 pages. 2006.
- Vol. 3921: L. Aceto, A. Ingólfssdóttir (Eds.), Foundations of Software Science and Computation Structures. XV, 447 pages. 2006.
- Vol. 3920: H. Hermanns, J. Palsberg (Eds.), Tools and Algorithms for the Construction and Analysis of Systems. XIV, 506 pages. 2006.
- Vol. 3918: W.K. Ng, M. Kitsuregawa, J. Li, K. Chang (Eds.), Advances in Knowledge Discovery and Data Mining. XXIV, 879 pages. 2006. (Sublibrary LNAI).
- Vol. 3917: H. Chen, F.Y. Wang, C.C. Yang, D. Zeng, M. Chau, K. Chang (Eds.), Intelligence and Security Informatics. XII, 186 pages. 2006.
- Vol. 3916: J. Li, Q. Yang, A.-H. Tan (Eds.), Data Mining for Biomedical Applications. VIII, 155 pages. 2006. (Sublibrary LNBI).
- Vol. 3915: R. Nayak, M.J. Zaki (Eds.), Knowledge Discovery from XML Documents. VIII, 105 pages. 2006.
- Vol. 3914: A. Garcia, R. Choren, C. Lucena, P. Giorgini, T. Holvoet, A. Romanovsky (Eds.), Software Engineering for Multi-Agent Systems IV. XIV, 255 pages. 2006.
- Vol. 3911: R. Wyrzykowski, J. Dongarra, N. Meyer, J. Waśniewski (Eds.), Parallel Processing and Applied Mathematics. XXIII, 1126 pages. 2006.
- Vol. 3910: S.A. Brueckner, G.D.M. Serugendo, D. Hales, F. Zambonelli (Eds.), Engineering Self-Organising Systems. XII, 245 pages. 2006. (Sublibrary LNAI).
- Vol. 3909: A. Apostolico, C. Guerra, S. Istrail, P. Pevzner, M. Waterman (Eds.), Research in Computational Molecular Biology. XVII, 612 pages. 2006. (Sublibrary LNBI).
- Vol. 3908: A. Bui, M. Bui, T. Böhme, H. Unger (Eds.), Innovative Internet Community Systems. VIII, 207 pages. 2006.
- Vol. 3907: F. Rothlauf, J. Branke, S. Cagnoni, E. Costa, C. Cotta, R. Drechsler, E. Lutton, P. Machado, J.H. Moore, J. Romero, G.D. Smith, G. Squillero, H. Takagi (Eds.), Applications of Evolutionary Computing. XXIV, 813 pages. 2006.
- Vol. 3906: J. Gottlieb, G.R. Raidl (Eds.), Evolutionary Computation in Combinatorial Optimization. XI, 293 pages. 2006.
- Vol. 3905: P. Collet, M. Tomassini, M. Ebner, S. Gustafson, A. Ekárt (Eds.), Genetic Programming. XI, 361 pages. 2006.
- Vol. 3904: M. Baldoni, U. Endriss, A. Omicini, P. Torroni (Eds.), Declarative Agent Languages and Technologies III. XII, 245 pages. 2006. (Sublibrary LNAI).
- Vol. 3903: K. Chen, R. Deng, X. Lai, J. Zhou (Eds.), Information Security Practice and Experience. XIV, 392 pages. 2006.
- Vol. 3902: R. Kronland-Martinet, T. Voinier, S. Ystad (Eds.), Computer Music Modeling and Retrieval. XI, 275 pages. 2006.
- Vol. 3901: P.M. Hill (Ed.), Logic Based Program Synthesis and Transformation. X, 179 pages. 2006.
- Vol. 3900: F. Toni, P. Torroni (Eds.), Computational Logic in Multi-Agent Systems. XVII, 427 pages. 2006. (Sublibrary LNAI).

Table of Contents

Invited Talks

Reliable and Efficient Geometric Computing <i>Kurt Mehlhorn</i>	1
--	---

Beware of the Model: Reflections on Algorithmic Research <i>Franco P. Preparata</i>	3
--	---

On Search Problems in Complexity Theory and in Logic (Abstract) <i>P. Pudlák</i>	5
---	---

Session 1

Covering a Set of Points with a Minimum Number of Lines <i>Magdalene Grantson, Christos Levcopoulos</i>	6
--	---

Approximation Algorithms for Capacitated Rectangle Stabbing <i>Guy Even, Dror Rawitz, Shimon (Moni) Shahar</i>	18
---	----

In-Place Randomized Slope Selection <i>Henrik Blunck, Jan Vahrenhold</i>	30
---	----

Session 2

Quadratic Programming and Combinatorial Minimum Weight Product Problems <i>Walter Kern, Gerhard Woeginger</i>	42
--	----

Counting All Solutions of Minimum Weight Exact Satisfiability <i>Stefan Porschen</i>	50
---	----

Clause Shortening Combined with Pruning Yields a New Upper Bound for Deterministic SAT Algorithms <i>Evgeny Dantsin, Edward A. Hirsch, Alexander Wolpert</i>	60
---	----

Session 3

Network Discovery and Verification with Distance Queries <i>Thomas Erlebach, Alexander Hall, Michael Hoffmann, Matúš Mihalák</i>	69
---	----

Deciding the FIFO Stability of Networks in Polynomial Time <i>Maik Weinard</i>	81
Heterogenous Networks Can Be Unstable at Arbitrarily Low Injection Rates <i>Dimitrios Koukopoulos, Stavros D. Nikolopoulos</i>	93
Session 4	
Provisioning a Virtual Private Network Under the Presence of Non-communicating Groups <i>Friedrich Eisenbrand, Edda Happ</i>	105
Gathering Algorithms on Paths Under Interference Constraints <i>Jean-Claude Bermond, Ricardo Corrêa, Minli Yu</i>	115
On the Hardness of Range Assignment Problems <i>Bernhard Fuchs</i>	127
Session 5	
Black Hole Search in Asynchronous Rings Using Tokens <i>S. Dobrev, R. Královič, N. Santoro, W. Shi</i>	139
On Broadcast Scheduling with Limited Energy <i>Christian Gunia</i>	151
A Near Optimal Scheduler for On-Demand Data Broadcasts <i>Hing-Fung Ting</i>	163
Session 6	
Fair Cost-Sharing Methods for Scheduling Jobs on Parallel Machines <i>Yvonne Bleischwitz, Burkhard Monien</i>	175
Tighter Approximation Bounds for LPT Scheduling in Two Special Cases <i>Annamária Kovács</i>	187
Inapproximability Results for Orthogonal Rectangle Packing Problems with Rotations <i>Miroslav Chlebík, Janka Chlebíková</i>	199

Session 7

- Approximate Hierarchical Facility Location and Applications to the Shallow Steiner Tree and Range Assignment Problems
Erez Kantor, David Peleg 211

- An Approximation Algorithm for a Bottleneck Traveling Salesman Problem
Ming-Yang Kao, Manan Sanghi 223

- On the Minimum Common Integer Partition Problem
Xin Chen, Lan Liu, Zheng Liu, Tao Jiang 236

Session 8

- Matching Subsequences in Trees
Philip Bille, Inge Li Gørtz 248

- Distance Approximating Trees: Complexity and Algorithms
Feodor F. Dragan, Chenyu Yan 260

- How to Pack Directed Acyclic Graphs into Small Blocks
Yuichi Asahiro, Tetsuya Furukawa, Keiichi Ikegami, Eiji Miyano 272

Session 9

- On-Line Coloring of H-Free Bipartite Graphs
H.J. Broersma, A. Capponi, D. Paulusma 284

- Distributed Approximation Algorithms for Planar Graphs
Andrzej Czygrinow, Michał Hańćkowiak, Edyta Szymańska 296

- A New NC-Algorithm for Finding a Perfect Matching in d -Regular Bipartite Graphs When d Is Small
Raghav Kulkarni 308

Session 10

- Fixed-Parameter Tractability Results for Feedback Set Problems in Tournaments
Michael Dom, Jiong Guo, Falk Hüffner, Rolf Niedermeier, Anke Truß 320

XII Table of Contents

Parameterized Algorithms for HITTING SET: The Weighted Case <i>Henning Fernau</i>	332
Fixed-Parameter Tractable Generalizations of Cluster Editing <i>Peter Damaschke</i>	344
Session 11	
The Linear Arrangement Problem Parameterized Above Guaranteed Value <i>Gregory Gutin, Arash Rafiey, Stefan Szeider, Anders Yeo</i>	356
Universal Relations and $\#P$ -Completeness <i>Hervé Fournier, Guillaume Malod</i>	368
Locally 2-Dimensional Sperner Problems Complete for the Polynomial Parity Argument Classes <i>Katalin Friedl, Gábor Ivanyos, Miklos Santha, Yves F. Verhoeven</i>	380
Author Index	393

Reliable and Efficient Geometric Computing*

Kurt Mehlhorn

Max-Planck-Institut für Informatik, Stuhlsatzenhausweg 85,
66123 Saarbrücken, Germany

Reliable implementation of geometric algorithms is a notoriously difficult task. Algorithms are usually designed for the Real-RAM, capable of computing with real numbers in the sense of mathematics, and for non-degenerate inputs. But, real computers are not Real-RAMs and inputs are frequently degenerate.

In the first part of the talk we illustrate the pitfalls of geometric computing by way of examples [KMP⁺04]. The examples demonstrate in a lucid way that standard and frequently taught algorithms can go completely astray when naively implemented with floating point arithmetic.

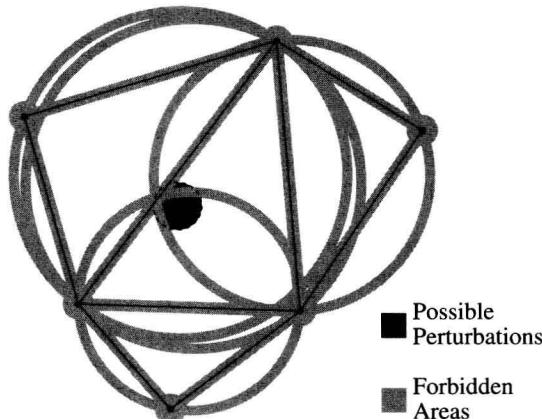


Fig. 1. The figure illustrates the concept of controlled perturbation for an incremental Delaunay diagram algorithm. A diagram of six points is already constructed and a seventh point t is to be inserted. The point is replaced by a random point t' in a δ disk centered at t . When t' is inserted, it is subject to sidedness tests with respect to edges of the current diagram and incircle tests with respect to faces of the current diagram. Each edge and each face defines a forbidden region for t' . The forbidden region is either a strip around the edge or an annulus around a circle. If t' lies outside the forbidden regions, the floating point evaluation of the geometric predicates gives the correct results. It is also necessary to guarantee a certain minimal distance between any pair of perturbed points.

In the second part of the talk, we discuss approaches to reliable and efficient geometric computing, in particular the controlled or active perturbation

* Partially supported by the IST Programme of the EU under Contract No IST-2005-TODO, Algorithms for Complex Shapes (ACS).

approach introduced by D. Halperin and co-workers [HS98, HR, HL03]. It proposes to slightly perturb the given input in a carefully chosen way so as to avoid degeneracies and so as to reduce the arithmetic demand. The exact solution on the perturbed input (not the original input!) is then computed. The scheme only applies when an approximate result suffices. This is the case whenever inputs are only approximately known.

We build on the work of Halperin et. al. and show that controlled perturbation is a general and simple technique for making a large class of geometric algorithms reliable. We also quantify the relation between the amount of perturbation and the precision of the floating point system. We exemplify the method on examples [FKMS05, MO]. Figure 1 illustrates the technique for the case of a Delaunay diagram computation.

References

- [FKMS05] S. Funke, Ch. Klein, K. Mehlhorn, and S. Schmitt. Controlled perturbation for Delaunay triangulations. *SODA*, pages 1047–1056, 2005. www.mpi-sb.mpg.de/~mehlhorn/ftp/ControlledPerturbation.pdf.
- [HL03] D. Halperin and E. Leiserowitz. Controlled perturbation for arrangements of circles. In *SoCG*, pages 264–273, 2003.
- [HR] D. Halperin and S. Raab. Controlled perturbation for arrangements of polyhedral surfaces with application to swept volumes. available from Halperin’s home page; a preliminary version appeared in *SoCG* 1999, pages 163–172.
- [HS98] Halperin and Shelton. A perturbation scheme for spherical arrangements with application to molecular modeling. *CGTA: Computational Geometry: Theory and Applications*, 10, 1998.
- [KMP⁺04] L. Kettner, K. Mehlhorn, S. Pion, S. Schirra, and C. Yap. Classroom examples of robustness problems in geometric computations. In *ESA*, volume 3221 of *LNCS*, pages 702–713, 2004. www.mpi-sb.mpg.de/~mehlhorn/ftp/ClassRoomExample.ps
- [MO] K. Mehlhorn and R. Osbild. Reliable and efficient computational geometry via controlled perturbation (extended abstract). www.mpi-sb.mpg.de/~mehlhorn/ftp/ControlledPerturbationGeneralStrategy.pdf

Beware of the Model: Reflections on Algorithmic Research

Franco P. Preparata

Department of Computer Science, Brown University
franco@cs.brown.edu

Over the past four decades the design and analysis of algorithms has been a vibrant area of computer science research, since it was early realized that adoption of a superior algorithm could achieve accelerations unattainable by conceivable technological improvements.

Evaluation of the performance of algorithms must dispense with the details of different platforms and refer to a sort of abstract machine that effectively captures the important features of concrete computers. This abstraction is the computation model, which is intended to be simple to ease formal analysis but at the same time reflective of reality to afford reliable predictions. Indeed, the dialectics of simplicity and reflectivity is the essence of model development.

The Random-Access-Machine (RAM) is the standard model of the sequential processor, and its simplicity has unleashed vigorous algorithmic research. However, simplification means selection of features to be represented in the model, so that details originally judged secondary or irrelevant are likely to reassert their significance when, under the pressure of technological innovations, the model reaches beyond its intended confines.

The first danger is that a model may take a life of its own, thereby becoming itself the reality and defining the “rules of the game”. An obvious illustration of this potential danger is the occasional misuse of the “asymptotic-analysis viewpoint”, whereby some algorithms declared “optimal” are unlikely to be ever translated into programs. However, there are more subtle shortcomings. Indeed, being remiss in critically scrutinizing the applicability of the model to specific situations may be the source of very serious disappointments. There are several such incidents in the history of algorithmic research. A sample is described below:

1. Computational Geometry adopted (with not much scrutiny) the model of the *real-RAM*, obtained by endowing the RAM with real-number (exact) arithmetic. Inaccurate results may result fatal in the evaluation of the sign of predicates. For example, the efficient BentleyOttmann algorithm for reporting the intersections of a set of segments in the plane, involves a predicate represented by the sign of a thirddegree polynomial in the coordinates. Inaccuracies may invalidate the result. The shortcoming may be avoided, however, by adding integer arithmetic capabilities of specified degree to the original RAM model, i.e., by adopting a sort of the bounded-degree-RAM.

2. The feasibility of parallel computation posed the question of the corresponding model. The discussion centered on the interconnection of modules of the RAM type and an important performance goal was the achievement of polylog-time computations (NC-class). As usual, processing elements were assumed to have unit-time arithmetic capabilities. In this context, Csanky's algorithm, achieving $O(\log^2 n)$ time for matrix inversion, was an exhilarating surprise. A closer look reveals that, since approximate arithmetic is not known or likely to be applicable to Csanky's method, integer arithmetic requires operand length of $O(n)$ bits for inverting $n \times n$ matrices. Here again, overlooking the arithmetic details of the model, leads to the invalidation of this result.
3. Very-Large-Scale-Integration opened up the possibility of massive parallelism, whose typical model was an interconnection of RAM-type processors with unit-time interprocessor communication. Therefore the emphasis was directed towards small-diameter networks, i.e., trees and hypercubes. However, the area-time theory of layouts reveals that such networks have links of length linear in the problem size. Since in future technologies transmission time is bound to grow with wirelength, hypercubic connections are manifestly nonscalable.
4. Finally, a case study from Computational Biology is not directly concerned with a computation model, but rather with the modeling of the process to which algorithmic research is applied. Sequencing-by-Hybridization was presented as a potential alternative for DNA-sequencing. A microarray containing a complete library of oligonucleotides of length k is the platform of a biochemical experiment intended to yield *all* substrings of length k of a target sequence. The algorithmic task is the reconstruction of the target from its substrings. A number of very interesting results were obtained based on the hypothesis of ideal "noiseless" hybridization: a substring is reported if and only if present in the target. A closer look at the biochemical behavior reveals an enormously more complex noisy reality, which casts a negative shadow on the future of the technology.