S. Barry Cooper
Benedikt Löwe
Andrea Sorbi (Eds.)

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Computation and Logic in the Real World

Third Conference on Computability in Europe, CiE 2007
Siena, Italy, June 2007
Proceedings

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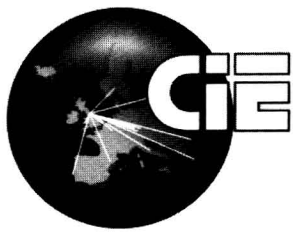
Preface

CiE 2007: Computation and Logic in the Real World
Siena, Italy, June 18–23, 2007



Computability in Europe (CiE) is an informal network of European scientists working on computability theory, including its foundations, technical development, and applications. Among the aims of the network is to advance our theoretical understanding of what can and cannot be computed, by *any* means of computation. Its scientific vision is broad: computations may be performed with discrete or continuous data by all kinds of algorithms, programs, and machines. Computations may be made by experimenting with any sort of physical system obeying the laws of a physical theory such as Newtonian mechanics, quantum theory, or relativity. Computations may be very general, depending upon the foundations of set theory; or very specific, using the combinatorics of finite structures. CiE also works on subjects intimately related to computation, especially theories of data and information, and methods for formal reasoning about computations. The sources of new ideas and methods include practical developments in areas such as neural networks, quantum computation, natural computation, molecular computation, computational learning. Applications are everywhere, especially, in algebra, analysis and geometry, or data types and programming. Within CiE there is general recognition of the underlying relevance of computability to physics and a broad range of other sciences, providing as it does a basic analysis of the causal structure of dynamical systems.

This volume, *Computation and Logic in the Real World*, is the proceedings of the third in a series of conferences of CiE that was held at the Dipartimento di Scienze Matematiche e Informatiche "Roberto Magari," University of Siena, June 18–23, 2007.

The first two meetings of CiE were at the University of Amsterdam, in 2005, and at the University of Wales Swansea in 2006. Their proceedings, edited in 2005 by S. Barry Cooper, Benedikt Löwe and Leen Torenvliet, and in 2006 by Arnold Beckmann, Ulrich Berger, Benedikt Löwe, and John V. Tucker, were published as *Springer Lecture Notes in Computer Science*, Volumes 3526 and 3988, respectively. As the editors noted in last year's proceedings, CiE and its

conferences have changed our perceptions of computability and its interface with other areas of knowledge. The large number of mathematicians and computer scientists attending those conference had their view of computability theory enlarged and transformed: they discovered that its foundations were deeper and more mysterious, its technical development more vigorous, its applications wider and more challenging than they had known. The Siena meeting promised to extend and enrich that process.

The annual CiE conference, based on the *Computability in Europe* network, has become a major event, and is the largest international meeting focused on computability theoretic issues. The series is coordinated by the CiE Conference Series Steering Committee:

Paola Bonizzoni (Milan)
Barry Cooper (Leeds)
Benedikt Löwe (Amsterdam, Chair)
Elvira Mayordomo (Zaragoza)
Dag Normann (Oslo)
Andrea Sorbi (Siena)
Peter van Emde Boas (Amsterdam).

We will reconvene in 2008 in Athens, 2009 in Heidelberg, and 2010 in Lisbon.

Structure and Programme of the Conference

The conference was based on invited tutorials and lectures, and a set of special sessions on a range of subjects; there were also many contributed papers and informal presentations. This volume contains 36 of the invited lectures and 29.9% of the submitted contributed papers, all of which have been refereed. There will be a number of post-proceedings publications, including special issues of *Theoretical Computer Science*, *Theory of Computing Systems*, *Annals of Pure and Applied Logic*, and *Journal of Logic and Computation*.

Tutorials

Pieter Adriaans (Amsterdam), *Learning as Data Compression*
Yaakov Benenson (Cambridge, Massachusetts), *Biological Computing*

Invited Plenary Talks

Anne Condon (Vancouver), *Computational Challenges in Prediction and Design of Nucleic Acid Structure*
Stephen Cook (Toronto), *Low Level Reverse Mathematics*
Yuri Ershov (Novosibirsk), *HF-Computability*
Sophie Laplante (Paris), *Using Kolmogorov Complexity to Define Individual Security of Cryptographic Systems*
Wolfgang Maass (Graz), *Liquid Computing*

Anil Nerode (Cornell), *Logic and Control*
Piergiorgio Odifreddi (Turin), *Conference Introductory Lecture*
Roger Penrose (Oxford), A talk on *Aspects of Physics and Mathematics*
Michael Rathjen (Leeds), *Theories and Ordinals in Proof Theory*
Dana Scott (Pittsburgh), *Two Categories for Computability* (Lecture sponsored by the European Association for Computer Science Logic.)
Robert I. Soare (Chicago), *Computability and Incomputability*
Philip Welch (Bristol), *Turing Unbound: Transfinite Computation*

Special Sessions

Doing Without Turing Machines: Constructivism and Formal Topology, organised by Giovanni Sambin and Dieter Spreen

Givanni Sambin (Padova) *Doing Without Turing Machines: Constructivism and Formal Topology*
Andrej Bauer (Ljubljana), *RZ: A Tool for Bringing Constructive and Computable Mathematics Closer to Programming Practice*
Douglas Bridges (Canterbury, NZ), *Apartness on Lattices*
Thierry Coquand (Göteborg), *A Constructive Version of Riesz Representation Theorem*
Maria Emilia Maietti (Padova), *Constructive Foundation for Mathematics as a Two Level Theory: An Example*

Approaches to Computational Learning, organised by Marco Gori and Franco Montagna

John Case (Newark, Delaware), *Resource Restricted Computability Theoretic Learning: Illustrative Topics and Problems*
Klaus Meer (Odense), *Some Aspects of a Complexity Theory for Continuous Time Systems*
Frank Stephan (Singapore), *Input-Dependence in Function-Learning*
Osamu Watanabe (Tokyo), *Finding Most Likely Solutions*

Real Computation, organised by Vasco Brattka and Pietro Di Gianantonio

Pieter Collins (Amsterdam), *Effective Computation for Nonlinear Systems*
Abbas Edalat (London), *A Continuous Derivative for Real-Valued Functions*
Hajime Ishihara (Tokyo), *Unique Existence and Computability in Constructive Reverse Mathematics*
Robert Rettinger (Hagen), *Computable Riemann Surfaces*
Martin Ziegler (Paderborn), *Real Hypercomputation*

Computability and Mathematical Structure, organised by Serikzhan Badaev and Marat Arslanov

Vasco Brattka (Cape Town), *Computable Compactness*
Barbara F. Csima (Waterloo), *Properties of the Settling-Time Reducibility Ordering*

Sergey S. Goncharov (Novosibirsk), *Computable Numberings Relative to Hierarchies*
Jiří Wiedermann (Prague), *Complexity Issues in Amorphous Computing*
Chi Tat Chong (Singapore), *Maximal Antichains in the Turing Degrees*

Complexity of Algorithms and Proofs, organised by Elvira Mayordomo and Jan Johannsen

Eric Allender (Piscataway, New Jersey), *Reachability Problems: An Update*
Jörg Flum (Freiburg), *Parameterized Complexity and Logic*
Michal Koucký (Prague), *Circuit Complexity of Regular Languages*
Neil Thapen (Prague), *The Polynomial and Linear Hierarchies in Weak Theories of Bounded Arithmetic*
Heribert Vollmer (Hannover), *Computational Complexity of Constraint Satisfaction*

Logic and New Paradigms of Computability, organised by Paola Bonizzoni and Olivier Bournez

Felix Costa (Lisbon), *The New Promise of Analog Computation*
Natasha Jonoska (Tampa, Florida), *Computing by Self-Assembly*
Giancarlo Mauri (Milan), *Membrane Systems and Their Applications to Systems Biology*
Grzegorz Rozenberg (Leiden), *Biochemical Reactions as Computations*
Damien Woods (Cork), (with Turlough Neary) *The Complexity of Small Universal Turing Machines*

Computational Foundations of Physics and Biology, organised by Guglielmo Tamburrini and Christopher Timpson

James Ladyman (Bristol), *Physics and Computation: The Status of Landauer's Principle*
Itamar Pitowsky (Jerusalem), *From Logic to Physics: How the Meaning of Computation Changed Over Time*
Grzegorz Rozenberg (Leiden), *Natural Computing: A Natural and Timely Trend for Natural Sciences and Science of Computation*
Christopher Timpson (Leeds), *What's the Lesson of Quantum Computing?*
Giuseppe Trautteur (Naples), *Does the Cell Compute?*

Women in Computability Workshop, organised by Paola Bonizzoni and Elvira Mayordomo

A new initiative at CiE 2007 was the adding of the Women in Computability workshop to the programme. Women in computer science and mathematics face particular challenges in pursuing and maintaining academic and scientific careers. The Women in Computability workshop brought together women in computing and mathematical research to present and exchange their academic and scientific experiences with young researchers. The speakers were:

Anne Condon (British Columbia)
Natasha Jonoska (Tampa, Florida)
Carmen Leccardi (Milan)
Andrea Cerroni (Milan)

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The Programme Committee was chaired by Andrea Sorbi and Barry Cooper and consisted of:

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Marat M. Arslanov (Kazan)
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Andrea Sorbi (Siena, Co-chair)
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Computing Research (CRA-W). We are pleased to thank our colleagues on the Organising Committee for their many contributions and our research students for practical help at the conference. Special thanks are due to Thomas Kent, Tommaso Flaminio, Luca Spada, Andy Lewis, and Franco Montagna for their precious collaboration, and the Congress Service of the University of Siena for the administrative aspects of the conference.

The high scientific quality of the conference was possible through the conscientious work of the Programme Committee, the Special Session organisers, and the referees. We are grateful to all members of the Programme Committee for their efficient evaluations and extensive debates, which established the final programme. We also thank the following referees:

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April 2007

Andrea Sorbi
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