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Arnold Beckmann
Ulrich Berger
Benedikt Löwe
John V. Tucker (Eds.)

Logical Approaches to Computational Barriers

Second Conference on Computability in Europe, CiE 2006
Swansea, UK, June/July 2006
Proceedings



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Preface

CiE 2006: Logical Approaches to Computational Barriers Swansea, Wales, June 30 - July 5, 2006



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, and computational learning. Applications are everywhere, especially, in algebra, analysis and geometry, or data types and programming.

This volume, *Logical Approaches to Computational Barriers*, is the proceedings of the second in a series of conferences of CiE that was held at the Department of Computer Science, Swansea University, 30 June - 5 July, 2006.

The first meeting of CiE was at the University of Amsterdam, June 8–12, 2005, and its proceedings, edited by S. Barry Cooper, Benedikt Löwe and Leen Torenvliet, was published as *Springer Lecture Notes in Computer Science*, Volume 3526. We are sure that all of the 200+ mathematicians and computer scientists attending that 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. We believe the same is certainly true of the Swansea meeting.

CiE 2005 and CiE 2006 are at the start of a new conference series *Computability in Europe*. The series is coordinated by the CiE Steering Committee:

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

We will reconvene 2007 in Siena, 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 30 of the invited lectures and 39.7% 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*, and *Journal of Logic and Computation*.

Tutorials

Samuel R. Buss (San Diego, CA), *Proof Complexity and Computational Hardness*
 Julia Kempe (Paris), *Quantum Algorithms*

Invited Plenary Talks

Jan Bergstra (Amsterdam), *Elementary Algebraic Specifications of the Rational Function Field*
 Luca Cardelli (Cambridge), *Biological Systems as Reactive Systems*
 Martin Davis (New York), *The Church-Turing Thesis: Consensus and Opposition*
 John W. Dawson (York, PA), *Gödel and the Origins of Computer Science*
 Jan Krajíček (Prague), *Forcing with Random Variables and Proof Complexity*
 Elvira Mayordomo (Zaragoza), *Two Open Problems on Effective Dimension*
 István Németi (Budapest), *Can General Relativistic Computers Break the Turing Barrier?*
 Helmut Schwichtenberg (Munich), *Inverting Monotone Continuous Functions in Constructive Analysis*
 Andreas Weiermann (Utrecht), *Phase Transition Thresholds for Some Natural Subclasses of the Computable Functions*

Special Sessions

Proofs and Computation, organized by Alessandra Carbone and Thomas Strahm

Kai Brännler (Bern), *Deep Inference and Its Normal Form of Derivations*

Roy Dyckhoff (St. Andrews), *LJQ: A Strongly Focused Calculus for Intuitionistic Logic*

Thomas Ehrhard (Marseille), *Böhm Trees, Krivine's Machine and the Taylor Expansion of Lambda-Terms*

Georges Gonthier (Cambridge), *Using Reflection to Prove the Four-Colour Theorem*

Computable Analysis, organized by Peter Hertling and Dirk Pattinson

Margarita Korovina (Aarhus), *Upper and Lower Bounds on Sizes of Finite Bisimulations of Pfaffian Hybrid Systems*

Paulo Oliva (London), *Understanding and Using Spector's Bar Recursive Interpretation of Classical Analysis*

Matthias Schröder (Edinburgh), *Admissible Representations in Computable Analysis*

Xizhong Zheng (Cottbus), *A Computability Theory of Real Numbers*

Challenges in Complexity, organized by Klaus Meer and Jacobo Torán

Johannes Köbler (Berlin), *Complexity of Graph Isomorphism for Restricted Graph Classes*

Sophie Laplante (Paris), *Lower Bounds Using Kolmogorov Complexity*

Johann A. Makowsky (Haifa), *From a Zoo to a Zoology: Descriptive Complexity for Graph Polynomials*

Mihai Prunescu (Freiburg), *Fast Quantifier Elimination Means $P = NP$*

Foundations of Programming, organized by Inge Bethke and Martín Escardó

Erika Ábrahám (Freiburg), *Heap-Abstraction for an Object-Oriented Calculus with Thread Classes*

Roland Backhouse (Nottingham), *Datatype-Generic Reasoning*

James Leifer (Le Chesnay), *Transactional Atomicity in Programming Languages*

Alban Ponse (Amsterdam), *An Introduction to Program and Thread Algebra*

Mathematical Models of Computers and Hypercomputers, organized by Joel D. Hamkins and Martin Ziegler

Jean-Charles Delvenne (Louvain-la-Neuve), *Turing Universality in Dynamical Systems*

Benedikt Löwe (Amsterdam), *Space Bounds for Infinitary Computation*

Klaus Meer (Odense), *Optimization and Approximation Problems Related to Polynomial System Solving*

Philip Welch (Bristol), *Non-Deterministic Halting Times for Hamkins-Kidder Turing Machines*

Gödel Centenary: Gödel's Legacy for Computability, organized by Matthias Baaz and John W. Dawson

Arnon Avron (Tel Aviv), *From Constructibility and Absoluteness to Computability and Domain Independence*

Torkel Franzén † (Luleå), *What Does the Incompleteness Theorem Add to the Unsolvability of the Halting Problem?*

Wilfried Sieg (Pittsburgh, PA), *Gödel's Conflicting Approaches to Effective Calculability*

Richard Zach (Calgary, AB), *Kurt Gödel and Computability Theory*

Organization and Acknowledgements

The CiE 2006 conference was organized by the logicians and theoretical computer scientists at Swansea: Arnold Beckmann, Ulrich Berger, Phil Grant, Oliver Kullmann, Faron Moller, Monika Seisenberger, Anton Setzer, John V. Tucker; and with the help of S. Barry Cooper (Leeds) and Benedikt Löwe (Amsterdam).

The Programme Committee was chaired by Arnold Beckmann and John V. Tucker and consisted of:

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We are delighted to acknowledge and thank the following for their essential financial support: the Department of Computer Science at Swansea, IT Wales, the Welsh Development Agency, the UK's Engineering and Physical Sciences Research Council, the British Logic Colloquium, the London Mathematical Society, and the Kurt Gödel Society of Vienna. Furthermore, we thank our sponsors the Association for Symbolic Logic, the European Association for Theoretical Computer Science, and the British Computer Society.

The high scientific quality of the conference was possible through the conscientious work of the Programme Committee, the special session organizers 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:

Klaus Aehlig	Emmanuel Hainry	A. Pastor
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Of course, the conference was primarily an event, and a rather complicated event at that. We are delighted to thank our colleagues on the Organizing Committee for their many contributions and our research students for practical help at the conference. We owe a special thanks to Beti Williams, Director of IT Wales, and her team for invaluable practical work. For example, IT Wales arranged a “business breakfast” where the wider computing community was addressed on why the research of CiE might be intriguing and of value to them in the years to come: a special thanks to Jan Bergstra for undertaking the task of briefing our captains of industry at break of day.

Finally, we thank Andrej Voronkov for his Easy Chair system which facilitated the work of the Programme Committee and the editors considerably.

Swansea and Amsterdam, April 2006

Arnold Beckmann
 Ulrich Berger
 Benedikt Löwe
 John V. Tucker

After completing this volume, we heard the sad news that our invited Special Session speaker, Torkel Franzén, died on April 19, 2006. Torkel Franzén's work on the philosophy of logic and mathematics had gained more and more international recognition in recent years. His death is a huge loss for the scientific community and he will be very much missed at CiE 2006. Torkel Franzén did send us an abstract of his planned contribution to this conference which we have included in this volume.

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