S. Barry Cooper
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Leen Torenvliet (Eds.)

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New Computational Paradigms

First Conference on Computability in Europe, CiE 2005
Amsterdam, The Netherlands, June 2005
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Preface

CiE 2005: New Computational Paradigms

`http://www.illc.uva.nl/CiE/`

The cooperation *Computability in Europe* (**CiE**) is an informal European network covering computability in theoretical computer science and mathematical logic, ranging from application of novel approaches to computation to set-theoretic analyses of infinitary computing models. The cooperation consists of eleven main nodes and includes over 400 researchers; it is coordinated from Leeds (UK). More information about **CiE** can be found in Barry Cooper's introductory paper to this volume (p. 1) and at

`http://www.amsta.leeds.ac.uk/pure/staff/cooper/cie.html`

CiE 2005 was a conference on the special topic "New Computational Paradigms" and was held in Amsterdam in June 2005. It was initiated by and served as a focus point for the informal cooperation **CiE**. The topic of "New Computational Paradigms" covers connections between computation and physical systems (e.g., quantum computation, neural nets, molecular computation) but also higher mathematical models of computation (e.g., infinitary computation or real computation).

Computability theory is central to large areas of theoretical computer science and mathematical logic. Traditionally, the computational model of the Turing machine (or mathematically equivalent models) has been used to reason about computation or computability. For general computability inquiries (with unbounded resources), the choice of the model of computation hardly matters (this fact is encapsulated in the so-called "Church-Turing thesis"); this could change as soon as questions of efficiency are investigated. In all areas of computability theory, alternative models of computation have been investigated, ranging from the most abstract (generalized recursion theory, Infinite Time Turing Machines) to the very concrete (physical constructions of quantum computers, applications in neuroscience and learning theory, fine-grained parallelism, swarm intelligence, neural nets, agents, games).

We understand **CiE 2005** as an interdisciplinary venue for researchers from computer science and mathematics to exchange ideas, approaches and techniques

in their respective work, thereby generating a wider community for work on new computational paradigms that allows uniform approaches to diverse areas, the transformation of theoretical ideas into applicable projects, and general cross-fertilization transcending disciplinary borders. The goal to reach out to both computer scientists and mathematicians resulted in many surprises for both communities: after many years and decades of experience in academia, we were astonished about the differences in general practice between two research communities that seem to be so close in content:

- Mathematicians issue a *Call for Papers* at a conference asking for submissions and publish a proceedings volume after the conference (in most cases, these will not appear until several years after the conference); in contrast, computer scientists distribute a proceedings volume at a conference.
- As a consequence, mathematical conferences have a submission deadline for abstracts about six to eight weeks before the conference, and computer science conferences need about half a year to prepare the proceedings volume.
- Also, the typical mathematical submission to a conference is between two lines and half a page describing the general idea of the talk, whereas in computer science submissions are papers of ten pages length.
- It is customary in mathematics that submitted abstracts are just checked cursorily to weed out nonsensical submissions – as a consequence, the acceptance rate is typically between 95% and 100%, the real quality control happens after the conference when the submissions for the proceedings volume are refereed up to journal standards; in computer science, acceptance rates have to be below 50%, and the lower the acceptance rate the higher the quality of the conference.
- For a mathematician, it is only invited talks and publications that count as an indicator of academic standing, a standard mathematical CV of a reasonably senior researcher wouldn't even mention contributed talks at conferences (many mathematicians consider submissions to conferences as something that only PhD students and recent graduates would do); in computer science, the list of conferences at which you have presented papers is a prime indicator of your success.

Depending on whether the reader is a mathematician or computer scientist, he or she will have nodded at some of the points just mentioned and wrinkled his or her forehead at others. One of the biggest surprises of our work was how little the two communities know about the practice of the other. Our Programme Committee consisted of mathematicians and computer scientists, and all members spent a considerable amount of time trying to understand the workings of the other community, with all the puzzlement, perplexity, irritations, and the exciting impression of pioneering that this involves.

It is obvious that bringing together two communities with so diametrically opposed ways of organizing conferences would require compromises and a lot of innovative ideas on how to make things work. We tried to walk on the ridge between the two communities and accommodate the needs of both.

As a consequence, this volume only contains the invited papers and a selection of 47.2% of the submitted papers. This may sound like a high percentage to computer scientists, but has to be seen in the context of the inter-community aspect of this conference project. As a result, we are proud to have produced such a high-quality volume that truly stands as a testament to the interdisciplinary nature of the conference. In the style of mathematics conferences, there will be several *postproceedings* publications that will be reviewed according to journal standards. There will be a monograph of edited papers entitled *New Computational Paradigms* (edited by B. Cooper, B. Löwe, and A. Sorbi) that contains surveys and expository papers. For the research papers, we will have three special issues of journals: a special issue of *Theoretical Computer Science C* (edited by T. Bäck and B. Löwe) focusing on computation and the natural sciences, a special issue of *Mathematical Structures in Computer Science* (edited by B. Cooper, B. Löwe, and D. Normann) focusing on the more mathematical aspects, and a special issue of *Theory of Computing Systems* (edited by B. Cooper, B. Löwe, and P. van Emde Boas). We shall invite the authors of the best papers at the conference to submit their full versions to these special issues and referee them to the high standards of the respective journals.

For the most current information about the conference, we refer the reader to our webpage

`http://www.illc.uva.nl/CiE/`

The **CiE** enterprise will continue to thrive: we already received enthusiastic feedback from the members of the **CiE** cooperation, and **CiE 2005** developed into a conference series that is already being planned for the years 2006 to 2009. The next **CiE** conference is planned for Swansea (UK) from June 30 to July 5, 2006; after that, we'll reconvene in Siena (Italy) in June 2007. This volume is just the beginning of a larger project bringing mathematics and computer science back together by trying to accommodate the special styles of both communities. We felt that there was a need for this, and the positive feedback proves that we were right.

Scientific Structure of the Conference

The template for the scientific organization of **CiE 2005** was the meetings of the *Association for Symbolic Logic* with tutorials, plenary talks and special sessions. The Programme Committee invited speakers for two tutorials (three hours each), eight plenary talks (one hour each) and organizers for six special sessions (with four talks of half an hour each). The special session organizers were then asked to invite their four speakers. All 35 invited speakers were asked to contribute either an abstract or a paper to this proceedings volume, and most did.

Our tutorial speakers were Harry Buhrman (Universiteit van Amsterdam, CWI; p. 68) and Klaus Weihrauch (FernUniversität Hagen; p. 530). Plenary talks were given by Samson Abramsky (Oxford University), Joel D. Hamkins (City University of New York; p. 180), Ulrich Kohlenbach (Technische Universität

Darmstadt; p. 233), Jan van Leeuwen (Universiteit Utrecht), Yuri Matiyasevich (Steklov Institute of Mathematics; p. 310), Yiannis Moschovakis (Ethnikon and Kapodistriakon Panepistimion Athinon, and University of California at Los Angeles: p. 350), Gheorghe Paun (The Romanian Academy, Bucharest; p. 396), and Uwe Schöning (Universität Ulm; p. 429).

The topics of the six special sessions were selected by the Programme Committee in a way to involve mathematical logic and computer science at the same time as offering the methodological foundations for models of computation. The speakers were invited by the special session organizers:

Special Session on Biological Computation, *organized by T. Bäck (Leiden):*

Paola Bonizzoni (Milan; with Clelia De Felice & Giancarlo Mauri; p. 65), Marian Gheorghe (Sheffield; with Francesco Bernardini, Natalio Krasnogor, German Terrazas; p. 49), Tero Harju (Turku; p. 188), Natalio Krasnogor (Nottingham; with German Terrazas, Francesco Bernardini, Marian Gheorghe, Steve Diggle, Miguel Cámara; p. 479).

Special Session on Complexity, *organized by Elvira Mayordomo Cámara (Zaragoza):*

Ricard Gavaldà (Barcelona/Montréal, QC; p. 150), Jack Lutz (Ames, IA; p. 299), Peter Bro Miltersen (Aarhus; p. 342), Jacopo Torán (Ulm; p. 495).

Special Session on Epistemology and Methodology of Computing, *organized by Hartmut Fitz (Amsterdam) and Guglielmo Tamburrini (Pisa):*

Angelo Cangelosi (Plymouth; p. 69), Artur d'Avila Garcez (London; p. 139), Wilfried Sieg (Pittsburgh, PA; p. 440), Giuseppe Trautteur (Naples; p. 507).

Special Session on Proofs and Computation, *organized by A. Beckmann (Swansea) and L. Crosilla (Florence):*

Ulrich Berger (Swansea; p. 23), Thierry Coquand (Göteborg; p. 86), Jan Johannsen (Munich), Stan Wainer (Leeds; with Geoff E. Ostrin; p. 378).

Special Session on Real Computation, *organized by A. Edalat (London):*

Amin Farjudian (Tehran; p. 128), André Lieutier (Aix-en-Provence/Grenoble; p. 297), Milad Niqui (Nijmegen; p. 368), Dirk Pattinson (Munich; p. 385), Ning Zhong (Cincinnati, OH; p. 552).

Special Session on Relative Computability, *organized by B. Cooper (Leeds) and A. Sorbi (Siena):*

Denis Hirschfeldt (Chicago, IL; p. 209), Iskander Kalimullin (Kazan; p. 221), Andrew E. M. Lewis (Leeds; p. 275), Andrey Morozov (Novosibirsk; p. 349).

A number of 62 contributed talks were accepted for presentation at this conference of which the best appear in the volume. In addition to this, we allowed researchers to announce *informal talks* in the style of mathematics conferences. Abstracts or extended abstracts of all talks not included in this volume will be published in a booklet appearing in the *ILLC Publications.*

Among the papers that will appear in that additional booklet are the following:

- José L. Balcazar, *Query Learning of Horn Formulas Revisited*;
- Giulia Battilotti, Paola Zizzi, *The Internal Logic of Bell's States*;
- Yi-Xiang Chen, Jie Zhou, *Fuzzy Interval-Valued Processes Algebra*;
- Carmen Graciani, Agustín Riscos-Núñez, *Looking for Simple Common Schemes to Design Recognizer P Systems with Active Membranes That Solve Numerical Decision Problems*;
- Vince Grolmusz, *Defying Dimensions Modulo 6*;
- Miguel Ángel Gutiérrez-Naranjo, Mario Pérez-Jiménez, Francisco José Romero-Campero, *Solving* **SAT** *with Membrane Creation*;
- Montserrat Hermo, Joxe Gaintzarain, Marisa Navarro, *Learning Conjunctions of* Horn$^{\supset}$ *Clauses*;
- Eiju Hirowatari, Kouichi Hirata, Tetsuhiro Miyahara, Setsuo Arikawa, *On the Prediction of Recursive Real-Valued Functions*;
- Paulin Jacobe de Naurois, Olivier Bournez, Felipe Cucker, Jean-Yves Marion, *Logical Characterizations of* **P** *and* **NP** *over an Arbitrary Structure* K;
- Viv Kendon, William J. Munro, *Entanglement and Its Role in Shor's Algorithm*;
- Tien D. Kieu, *Hypercomputability in Quantum Mechanics*;
- Branimir Lambov, *Complexity in a Type-1 Framework for Computable Analysis*;
- Pierluigi Minari, *Proof-Theoretical Methods in Combinatory Logic and Lambda-Calculus*;
- Erich Monteleone, *On the Infinitary Formal Systems and Infinite Time Turing Machines*;
- Marcin Mostowski, *Potential Infinity and the Church Thesis*;
- Benedek Nagy, *An Interval-Valued Computing Device*;
- Stela Nikolova; *On the Notion of* $\forall$*-definedness of Non-deterministic Programs*;
- Harumichi Nishimura, Tomoyuki Yamakami, *Quantum Minimal One-Way Information for Combinatorial Tasks*;
- Igor Potapov, Oleksiy Kurganskyy, *Universality of Walking Automata on a Class of Geometric Environments*;
- Dimiter Skordev, *A Computability Notion for Locally Finite Lattices*;
- Boris Solon, *Non-total Enumeration Degrees*;
- Haibin Sun, Wenhui Li, *Rules-Based Spatial Reasoning Combining Topological and Cardinal Directional Relations*;
- John V. Tucker, Edwin Beggs, *Newtonian Systems, Bounded in Space, Time, Mass and Energy Can Compute All Functions*;
- Raymond Turner, *Computability in Specification*;
- Puzarenko Vadim, *Computable Principles in Admissible Structures*;
- Andreas Weiermann, *A Very Slow Growing Hierarchy for the Howard Bachmann Ordinal*;
- Paola Zizzi, *Computability at the Planck scale.*

Organization and Acknowledgements

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The Programme Committee consisted of K. Ambos-Spies (Heidelberg), A. Atserias (Barcelona), J. van Benthem (Amsterdam), B. Cooper (Leeds, *Chair*), P. van Emde Boas (Amsterdam), S. Goncharov (Novosibirsk), B. Löwe (Amsterdam, *Chair*), D. Normann (Oslo), H. Schwichtenberg (Munich), A. Sorbi (Siena), I. Soskov (Sofia), L. Torenvliet (Amsterdam), J. Tucker (Swansea), and J. Wiedermann (Prague).

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S.B. Cooper
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