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# The Nature of Computation

Logic, Algorithms, Applications

9th Conference on Computability in Europe, CiE 2013  
Milan, Italy, July 1-5, 2013  
Proceedings



Springer

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ISSN 0302-9743

e-ISSN 1611-3349

ISBN 978-3-642-39052-4

e-ISBN 978-3-642-39053-1

DOI 10.1007/978-3-642-39053-1

Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2013940615

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

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

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*Typesetting:* Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

# Preface

## CiE 2013: The Nature of Computation



Computability in Europe 2013 (CiE 2013) followed the *Turing Centenary Conference* CiE 2012 in celebrating the enormous influence of Turing's work on the specific focus of the CiE conference series: the development of a multi-disciplinary and modern view of computation and computability. The interest for computation in nature (which was also the motivation for Turing's work on biological pattern formation) as reflected in the title of CiE 2013, *The Nature of Computation*, connects biology and computer science and has given rise to modern disciplines of research as well as new perspectives on computation.

In particular, CiE 2013 was focused on the unexpected changes that studies on nature have brought to several areas of mathematics, physics, and computer science. Two complementary research perspectives pervade the *Nature of Computation* theme. One is focused on the understanding of new computational paradigms, inspired by processes occurring in the biological world and resulting in a deeper and modern understanding of the theory of computation. The other perspective is on our understanding of how computations really occur in nature, on how we can interact with these computations, and their applications.

CiE 2013 was the ninth meeting in the conference series *Computability in Europe* organized by the Association CiE. The association promotes the development of computability-related science, ranging from mathematics, computer science and applications in various natural and engineering sciences, such as physics and biology, as well as the promotion of related fields, such as philosophy and history of computing. In particular, the conference series successfully brings together the mathematical, logical, and computer sciences communities that are interested in developing computability-related topics. This year this scope was strengthened by the co-location of CiE 2013 with UCNC 2013 (*Unconventional Computation and Natural Computation*), with Giancarlo Mauri as Chair of the Programme Committee.

The two conferences, CiE 2013 and UCNC 2013, were held at the University of Milano-Bicocca in Milan, Italy. They shared one plenary invited talk, given by Endre Szemerédi (Budapest and Piscataway NJ), winner of the Abel Prize in 2012, and two tutorials, one by Grzegorz Rozenberg (Leiden and Boulder CO) and one by Gilles Brassard (Montréal QC). Moreover, some satellite events were organized around the two conferences.

The eight previous CiE conferences were held in Amsterdam (The Netherlands) in 2005, Swansea (Wales) in 2006, Siena (Italy) in 2007, Athens (Greece) in 2008, Heidelberg (Germany) in 2009, Ponta Delgada (Portugal) in 2010, Sofia (Bulgaria) in 2011, and Cambridge (UK) in 2012. The proceedings of these meetings were all published in the Springer series *Lecture Notes in Computer Science*. The annual CiE conference has become a major event and is the largest international meeting focused on computability theoretic issues. The next meeting in 2014 will be held in Budapest (Hungary).

The series is coordinated by the CiE Conference Series Steering Committee consisting of Luís Antunes (Porto, Secretary), Arnold Beckmann (Swansea), Laurent Bienvenu (Paris), Natasha Jonoska (Tampa FL), Viv Kendon (Leeds), Benedikt Löwe (Amsterdam and Hamburg, Chair), Mariya Soskova (Sofia and Berkeley CA), and Peter van Emde Boas (Amsterdam).

The Programme Committee of CiE 2013 was responsible for the selection of the invited speakers, the special session organizers and for running the reviewing process of all submitted regular contributions.

The Programme Committee invited six speakers to give plenary lectures: Ulle Endriss (Amsterdam), Lance Fortnow (Atlanta GA), Anna Karlin (Seattle WA), Bernard Moret (Lausanne), Mariya Soskova (Sofia and Berkeley CA), and Endre Szemerédi (Budapest and Piscataway NJ; joint invitee of CiE 2013 and UCNC 2013).

These plenary speakers were invited to publish abstracts or papers in this volume. Karlin's lecture was the *2013 APAL Lecture* funded by Elsevier, Fortnow's lecture was the *2013 EACSL Lecture* funded by the *European Association for Computer Science Logic*, and Szemerédi's lecture was funded by the Department of Mathematics and its Applications of the University of Milano-Bicocca. In addition to the plenary lectures, the conference had two tutorials by Gilles Brassard (Montréal QC) and Grzegorz Rozenberg (Leiden and Boulder CO).

Springer-Verlag generously funded two awards that were given during the CiE 2013 conference. Nicolas de Rugy-Altherre was awarded the *Best Student Paper Award* for his paper "Determinant Versus Permanent: Salvation via Generalization?" Shankara Narayanan Krishna, Marian Gheorghe, and Ciprian Dragomir were awarded the *Best Paper on Natural Computing Award* for their paper "Some Classes of Generalised Communicating P Systems and Simple Kernel P Systems."

CiE 2013 had six special sessions: two sessions, *Computational Molecular Biology* and *Computation in Nature*, were devoted to the special focus of CiE 2013. In addition to this, new challenges arising in computations in the real world were faced in the session on *Data Streams and Compression*. The remaining

three sessions were on *Algorithmic Randomness*, *Computational Complexity in the Continuous World*, and *History of Computation*. Speakers in these special sessions were selected by the special session organizers and could contribute a paper to this volume.

We received 82 submissions which were reviewed by the Programme Committee and many expert referees. In the end, 31.7% of the submitted papers were accepted for publication in this volume. Without the help of our expert referees, the production of the volume would have been impossible. We would like to thank all the subreviewers for their excellent work; their names are listed in an appendix of this preface.

All authors who contributed to this conference were encouraged to submit significantly extended versions of their papers with unpublished research content to *Computability—The Journal of the Association CiE*.

The conference CiE 2013 was organized by Stefano Beretta (Milan), Paola Bonizzoni (Milan), Gianluca Della Vedova (Milan), Alberto Dennunzio (Milan), Riccardo Dondi (Bergamo), Giancarlo Mauri (Milan), Yuri Pirola (Milan), and Raffaella Rizzi (Milan).

The Steering Committee of the conference series CiE is concerned about the representation of female researchers in the field of computability. In order to increase female participation, the series started the *Women in Computability* (WiC) program in 2007, first funded by the *Elsevier Foundation*, then taken over by the publisher *Elsevier*. We were proud to continue this program with its successful annual WiC workshop and a grant program for junior female researchers in 2013.

The organizers of CiE 2013 would like to acknowledge and thank the following entities for their essential financial support (in alphabetic order): the *Association for Symbolic Logic* (ASL), the *Department of Mathematics and its Applications* and the *Department of Informatics, Systems and Communication*, both of the University of Milano-Bicocca, *Elsevier B.V.*, the *European Association for Computer Science Logic* (EACSL), the *European Association for Theoretical Computer Science* (EATCS), *IOS Press*, *Springer-Verlag* and the *University of Milano-Bicocca*. We would also like to acknowledge the support of our non-financial sponsors, the *Association Computability in Europe* (CiE).

May 2013

Paola Bonizzoni  
Vasco Brattka  
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*Organizers.* Akitoshi Kawamura (Tokyo) and Robert Rettinger (Hagen).

*Speakers.* Mark Braverman (Princeton NJ), Daniel S. Graça (Faro), Joris van der Hoeven (Palaiseau), Chee K. Yap (New York NY).

## Computational Molecular Biology

*Organizers.* Alessandra Carbone (Paris) and Jens Stoye (Bielefeld).

*Speakers.* Sebastian Böcker (Jena), Marília D.V. Braga (Duque de Caxias), Andrea Pagnani (Torino), Laxmi Parida (Yorktown Heights NY).

## Computation in Nature

*Organizers.* Mark Delay (London ON) and Natasha Jonoska (Tampa FL).

*Speakers.* Jerome Durand-Lose (Orléans), Giuditta Franco (Verona), Lila Kari (London ON), Darko Stefanovic (Albuquerque NM).

## Data Streams and Compression

*Organizers.* Paolo Ferragina (Pisa) and Andrew McGregor (Amherst MA).

*Speakers.* Graham Cormode (Florham Park NJ), Irene Finocchi (Rome), Andrew McGregor (Amherst MA), Marinella Sciortino (Palermo).

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*Organizers.* Gerard Alberts (Amsterdam) and Liesbeth De Mol (Ghent).

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**Ivan Nikolaev Soskov**  
**(23 September 1954 – 5 May 2013)**



During the preparations for CiE 2013, the shocking news reached the *Computability in Europe* community that our colleague Ivan Soskov had unexpectedly died. Ivan had been one of the important forces behind the CiE conference series, from its very beginnings as an informal European network, and his death will affect the conference series. We lost one of our staunch supporters, a very dear colleague and a good friend.

Ivan Soskov was born on 23 September 1954 in the southern Bulgarian city of Stara Zagora and went to the *National High School of Mathematics and Sciences* “Академик Любомир Чакалов”, a school founded by the Faculty of Mathematics of Sofia University to offer an introduction to mathematics at the highest level to talented pupils. After his graduation, he studied at Sofia University where he graduated in 1979 with a degree in Mathematical Logic. He became a doctoral student of Dimiter Skordev and defended his PhD thesis entitled *Computability in Partial Algebraic Systems* in 1983.

Ivan spent his career at Sofia University, starting as a programmer in the *Computing Laboratory* of Sofia University, then becoming an Assistant Professor in the *Laboratory of Applied Logic*, later at the Faculty for Mathematics and Computer Science. In 1991, he was promoted to Associate Professor and spent two years at the University of California at Los Angeles (1991–1993). After he had obtained the higher doctorate (DSc) in 2001, he was promoted to Full Professor in 2005. He was head of the Department for Mathematical Logic and Applications from 2000 to 2007 and Dean of the Faculty of Mathematics and Computer Science from 2007 until his death. For many years, he has played a major role in the research administration of Sofia University, fulfilling many important tasks such as that of the chair of the Council of Deans of the University.

Ivan’s research field was classical computability theory, in particular degree spectra and enumeration degrees. He has supervised 15 Master’s students in subjects related to his research expertise and had three doctoral students, Stela Nikolova (1992), Vessela Baleva (2002), and Hristo Ganchev (2009); three

additional doctoral students were still working under Ivan's supervision at the time of his death. Ivan always encouraged his students to participate in CiE conferences, and in the lists of authors of papers accepted at our conferences, we repeatedly find the names of Ivan's students.

Ivan's involvement with CiE started with his role as the *coordinator* of the Bulgarian node in the informal CiE network that was formed in 2004 and developed into the conference series and association. He served as a member of the Programme Committee for the first five CiE conferences: Amsterdam in 2005, Swansea in 2006, Siena in 2007, Athens in 2008, and Heidelberg in 2009. Together with his colleagues in Sofia, he offered to host CiE 2011 in Sofia: Ivan served as one of the co-chairs of the Programme Committee for this seventh edition of CiE. His commitment to the conference series was not restricted to Programme Committees work; for this year's conference, CiE 2013, Ivan submitted a paper which is printed in this volume. Sadly, we will not be able to hear him present it in Milan. We shall miss him.

S. Barry Cooper (*President Association CiE*)  
Benedikt Löwe (*Chairman Steering Committee CiE-CS*)  
Stela Nikolova (*Sofia University*)

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