

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, Lancaster, 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, Zürich, Switzerland

John C. Mitchell

Stanford University, Stanford, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Dortmund, Germany

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbrücken, Germany

More information about this series at <http://www.springer.com/series/7407>

Arnold Beckmann · Laurent Bienvenu
Nataša Jonoska (Eds.)

Pursuit of the Universal

12th Conference on Computability in Europe, CiE 2016
Paris, France, June 27 – July 1, 2016
Proceedings

Editors

Arnold Beckmann
Computer Science
Swansea University
Swansea
UK

Nataša Jonoska
Mathematics and Statistics
University of South Florida
Tampa, FL
USA

Laurent Bienvenu
IRIF
Université Paris-Diderot - Paris 7
Paris
France

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-319-40188-1 ISBN 978-3-319-40189-8 (eBook)
DOI 10.1007/978-3-319-40189-8

Library of Congress Control Number: 2016940339

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Preface

CiE 2016: Pursuit of the Universal
Paris, France, June 27 – July 1, 2016



This year Computability in Europe (CiE) honored the 80th anniversary of A. Turing’s paper introducing the Universal Turing Machine. In this context the conference sought better understanding of universal computational frameworks ranging from mathematics, computer science, through various natural sciences such as physics and biology. CiE provides a forum for exchanging ideas on broad aspects of “computability” striving to understand the essence of computation through studies of theoretical models of new paradigms, information processing, encryption, philosophy and history of computing as well as computability in natural and biological systems. This year’s CiE conference was held in Paris and through a sequence of tutorials, plenary lectures, and special sessions allowed in-depth discussions and novel approaches in pursuit of the nature of computability. Similarly to previous CiE conferences in this series, CiE 2016 had a broad scope promoting the development of computability-related science.

The conference series is organized under auspices of the Association CiE. The association promotes the development of all areas of mathematics, computer science, as well as natural and engineering sciences that study the notion of “computability,” including its philosophical and historical developments. The conference series is a venue where researchers in the field meet and exchange the most novel features of their findings.

CiE 2016 was organized jointly by Université Paris 13 and Université Paris 7, chaired by Paulin de Naurois at Université Paris 13. The 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, Cambridge (UK) in 2012, Milan (Italy) in 2013, Budapest (Hungary) in 2014, and Bucharest (Romania) in 2015. The proceedings containing the best submitted papers as well as extended abstracts of invited speakers for all these meetings are published in the Springer series *Lecture*

Notes in Computer Science. The annual CiE conference has risen to be the largest international meeting focused on computability theory issues. CiE 2017 will be held in Turku, Finland. The leadership of the conference series recognizes that there is under-representation of female researchers in the field of computability and therefore incorporates a special session of Women in Computability (WiC) in every CiE conference. WiC was initiated in 2007, and was first funded by the Elsevier Foundation, later taken over by the publisher Elsevier. This year's program, organized by Liesbeth De Mol, besides the regular workshop also provided travel grants for junior female researchers and a mentorship program.

The 39-member Program Committee of CiE 2016 was chaired by Laurent Bienvenu (IRIF, CNRS, and Université Paris 7, France), and Nataša Jonoska (University of South Florida, Tampa, USA). The committee selected the plenary speakers and the special session organizers, and ran the reviewing process of all the regular contributions submitted. We received 40 non-invited contributed paper submissions. Each paper received at least three reviews by the Program Committee and additional reviewers. About 45 % of the submitted papers were accepted for publication in this volume. In addition, this volume contains 19 extended abstracts/papers contributed by plenary speakers and speakers of the invited sessions. The production of the volume would have been impossible without the diligent work of all of the Program Committee members and our expert reviewers. We are very grateful to all the Program Committee members and the reviewers for their excellent work.

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.

This year the conference started with a special session honoring the memory of Barry Cooper, one of the initiators and founders of the conference as well as a driving force behind the organization of CiE, including the presidency of the association. The session was organized by Mariya Soskova and the contributors were Theodore Slaman (University of California Berkeley), Andrea Sorbi (University of Siena), Dag Norman (University of Oslo), and Ann Copestake (Cambridge University).

Two tutorials were given by Bernard Chazelle from Princeton University, USA, and Mikolaj Bojanczyk from University of Warsaw, Poland. In addition, the Program Committee invited seven speakers to give plenary lectures: Natasha Alechina (University of Nottingham, UK), Vasco Brattka (Universität der Bundeswehr München, Germany), Delaram Kahrobaei (The City University of New York, USA), Steffen Lempp (University of Wisconsin, USA), André Nies (University of Auckland, New Zealand), Dominique Perrin (Université Paris-Est Marne-la-Vallée, France), and Reed Solomon (University of Connecticut, USA).

Springer generously funded two awards this year, the Best Student Paper Award and Best Paper Award. The winner of the Best Student Paper Award this year was Mikhail Andreev for his contribution "Busy Beavers and Kolmogorov Complexity." The Best Paper Award was given to Olivier Bournez, Nachum Dershowitz and Pierre Neron for their contribution "An Axiomatization of Analog Algorithms."

CiE 2016 has six special sessions: two sessions, Cryptography and Information Theory and Symbolic Dynamics, were organized for the first time in the conference series. The other four special sessions covered new developments in areas previously covered by the conference series: Computable and Constructive Analysis, Computation in Biological Systems, Weak Arithmetic, and History and Philosophy of Computing. Speakers in these special sessions were selected by the special session organizers and were invited to contribute a paper to this volume.

Computable and Constructive Analysis

Organizers. Daniel Graça and Elvira Mayordomo.

Speakers. Mathieu Hoyrup (Inria and University of Lorraine), Arno Pauly (University of Cambridge), Vela Velupillai (New School for Social Research in New York City and University of Trento), Martin Ziegler (KAIST, Daejeon).

Computation in Biological Systems

Organizers. Alessandra Carbone and Ion Petre.

Speakers. Daniela Besozzi (University of Milan-Bicocca), Eugen Czeizler (Åbo Akademi University), Vincent Moulton (University of East Anglia), Eric Tannier (Inria and University of Lyon).

Cryptography and Information Theory

Organizers. Danilo Gligoroski, and Carles Padro.

Speakers. Ludovic Perret (Université Pierre et Marie Curie, France), Ignacio Cascudo (Aarhus University in Denmark), Oriol Farras (Universitat Rovira i Virgili, Spain), Danilo Gligoroski (Norwegian University of Science and Technology - Trondheim).

History and Philosophy of Computing

Organizers. Alberto Naibo and Ksenia Tatarchenko

Speakers. Maël Pégny (IHPST, Paris), Pierre Mounier-Khun (CNRS), Simone Martini (University of Bologna), Walter Dean (University of Warwick).

Symbolic Dynamics

Organizers. Jarkko Kari and Reem Yassawi.

Speakers. Valérie Berthé (University of Paris 7), Emmanuel Jeandel (University of Lorraine), Irène Marcovici (University of Lorraine), Ronnie Pavlov (Denver University).

Weak Arithmetic

Organizers. Lev Beklemishev and Stanislav Speranski.

Speakers. Pavel Pudlák (Academy of Sciences of the Czech Republic), Alexis Bès (University of Paris 12), Leszek Kołodziejczyk (University of Warsaw), Albert Visser (University of Utrecht).

The organizers of CiE 2016 would like to acknowledge and thank the following for their financial support (in alphabetical order): the Association for Symbolic Logic (ASL), the European Association for Theoretical Computer Science (EATCS), and Springer. We would also like to acknowledge the support of our non-financial sponsor, the Association Computability in Europe (CiE).

April 2016

Arnold Beckmann
Laurent Bienvenu
Nataša Jonoska

Organization

Steering Committee

Arnold Beckmann	Swansea University, UK, Chair
Laurent Bienvenu	LIAFA, CNRS and Université de Paris, France
Paola Bonizzoni	Università di Milano-Bicocca, Italy
Alessandra Carbone	Université Pierre et Marie Curie, France
Nataša Jonoska	University of South Florida, USA
Benedikt Löwe	Universiteit van Amsterdam, The Netherlands
Florin Manea	Christian-Albrechts-Universität zu Kiel, Germany
Dag Normann	The University of Oslo, Norway
Mariya Soskova	Sofia University, Bulgaria
Susan Stepney	University of York, UK

Program Committee

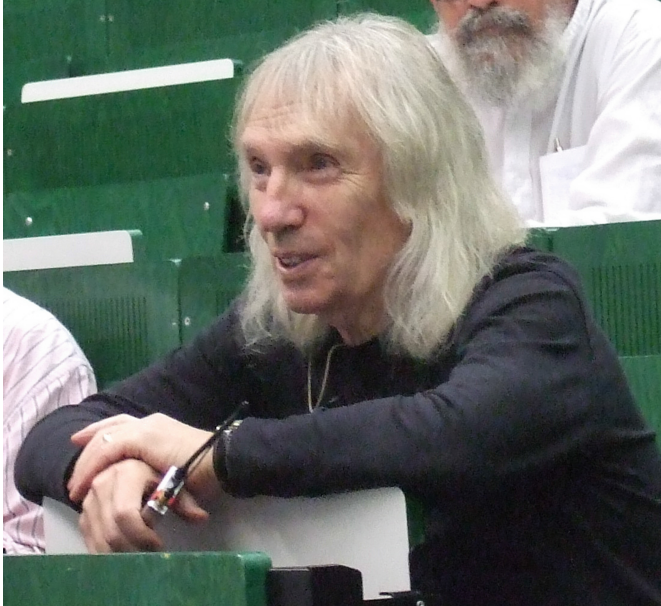
Marcella Anselmo	University of Salerno, Italy
Nathalie Aubrun	CNRS, Inria, UCBL, Université de Lyon, France
Georgios Barmpalias	Chinese Academy of Sciences, China
Marie-Pierre Béal	Université Paris-Est, France
Arnold Beckmann	Swansea University, UK
Laurent Bienvenu	LIAFA, CNRS, Université de Paris 7, France
Paola Bonizzoni	Università di Milano-Bicocca, Italy
Alessandra Carbone	Université Pierre et Marie Curie, France
Douglas Cenzer	University of Florida, USA
Liesbeth De-Mol	CNRS, Université de Lille 3, France
Volker Diekert	University of Stuttgart, Germany
David Doty	California Institute of Technology, USA
Jérôme Durand-Lose	LIFO, Université D'Orléans, France
Martin Escardo	University of Birmingham, UK
François Fages	Inria Paris-Rocquencourt, France
Enrico Formenti	Nice Sophia Antipolis University, France
Daniela Genova	University of North Florida, USA
Noam Greenberg	Victoria University of Wellington, New Zealand
Hajime Ishihara	JAIST, Japan
Paulin Jacobé De Naurois	CNRS, LIPN, Université Paris 13, France
Nataša Jonoska	University of South Florida, USA
Jarkko Kari	University of Turku, Finland
Lila Kari	University of Western Ontario, Canada
Margarita Korovina	A.P. Ershov Institute of Informatics Systems, Russia

Marta Kwiatkowska	University of Oxford, UK
Karen Lange	Wellesley College, USA
Benedikt Löwe	Universiteit van Amsterdam, The Netherlands
Florin Manea	Christian-Albrechts-Universität zu Kiel, Germany
Keng Meng Selwyn Ng	Nanyang Technological University, Singapore
Arno Pauly	University of Cambridge, UK
Mario Perez-Jimenez	University of Seville, Spain
Ion Petre	Åbo Akademi University, Finland
Alexis Saurin	PPS and Inria Pi.R2, France
Shinnosuke Seki	University of Electro-Communications, Tokyo, Japan
Paul Shafer	Ghent University, Belgium
Alexander Shen	LIRMM CNRS and University of Montpellier 2, France
Alexandra Sосkova	Sofia University, Bulgaria
Mariya Sосkova	Sofia University, Bulgaria
Peter van Emde Boas	ILLC-FNWI-Universiteit van Amsterdam, The Netherlands

Additional Reviewers

Asher, Nicholas	Kim, Hwee	Rizzi, Romeo
Barash, Mikhail	Kleinberg, Samantha	Romashchenko, Andrei
Bauwens, Bruno	Kreuzer, Alexander P.	Salo, Ville
Besson, Tom	Kudinov, Oleg	Shafer, Paul
Bodirsky, Manuel	Kuyper, Rutger	Shlapentokh, Alexandra
Calvert, Wesley	Manzoni, Luca	Sibeliuss, Patrick
Cherubini, Alessandra	Melnikov, Alexander	Sieweck, Philipp
Crabbé, Benoit	Michel, Pascal	Steiner, Rebecca
Cramer, Marcos	Minnes, Mia	Stephan, Frank
Cristescu, Ioana	Monin, Benoît	Szymanik, Jakub
Delacourt, Martin	Nemoto, Takako	Towsner, Henry
Dolce, Francesco	Papazian, Christophe	van Leeuwen, Jan
Ehlers, Thorsten	Paskevich, Andrei	Vatev, Stefan
Fokina, Ekaterina	Petre, Luigia	Westrick, Linda Brown
Hirschfeldt, Denis	Place, Thomas	Yokoyama, Keita
Johannsen, Jan	Porreca, Antonio E.	Zandron, Claudio
Jolivet, Timo	Raimondi, Franco	Ziegler, Martin
Kach, Asher	Rin, Benjamin	

S. Barry Cooper
1943 – 2015



Barry Cooper at the opening of CiE 2009 in Heidelberg.
Photo taken by Peter van Emde Boas, July 2009.

Barry Cooper, founding member and former president of the Association Computability in Europe, died on October 26, 2015, shortly after his 72nd birthday. Born on October 9, 1943, Barry was a leading figure in the UK logic scene all of his academic life, a major figure in computability theory, and in particular degree theory. Most relevant in the context of CiE 2016 is of course that Barry was the driving force of Computability in Europe and without him, our association would not exist. This text is focused on Barry in relation to the Association Computability in Europe, it is based on a short obituary by Benedikt Löwe and Dag Normann [1], and borrows from it with due permission of the authors.

Barry retired from the office of President of the Association CiE in summer 2015, and had the chance to close the association AGM in Bucharest in July 2015 with a speech reminiscing about the history of the association. Barry was very fond of telling the ironic tale of how our association comprising more than a thousand members grew out of a rejected application for European funding.

In order to discuss the negative feedback of the referees, it was decided to have a conference in Amsterdam, which became the first CiE conference. Barry's vision and guidance pushed us along the way, to subsequent CiE conferences and finally to the

formal formation of this association in 2008. In 2007 and 2012, he personally co-chaired the Program Committees of the CiE conferences in Siena and Cambridge; the fact that these two events were the two largest CiE conferences to date is a testament to Barry's infectious enthusiasm and inclusive attitude. Barry also realized the potential of the Turing Centenary and made sure that the 100th birthday of Alan Turing was appropriately celebrated during the Alan Turing Year, not just in the UK, but all across the globe; at Turing's alma mater in Cambridge, Barry was one of the organizers of a six-month Turing-related research program at the Isaac Newton Institute for Mathematical Sciences culminating on Turing's 100th birthday, June 23, 2012, on the lawn in front of King's College. In the years after the centenary, Barry renamed the Alan Turing Year to Alan Turing Years. As the media attention to Alan Turing grew, partly due to the Academy-award winning movie *The Imitation Game*, Barry became one of Alan Turing's spokespeople on Twitter and in opinion pieces for *The Guardian*.

A comprehensive account of Barry's impact on Computability in Europe by Benedikt Löwe [2] has been published in the association's journal *Computability*.

Barry was very influential in shaping our thinking about computability in much broader, interdisciplinary terms, which was key to the success of the movement Computability in Europe. His vision will continue to live in us; his stimulating remarks and kindness will be very much missed.

April 2016

Arnold Beckmann

Laurent Bienvenu

Nataša Jonoska

References

- [1] Löwe, B., Normann, D.: Barry Cooper (1943–2015). Obituary published on the website of the Association CiE, 28 October 2015
- [2] Löwe, B.: Barry Cooper (1943–2015): The Engine of Computability in Europe. *Computability* **5**(1), 3–11 (2016)

Contents

Invited Papers

Verifying Systems of Resource-Bounded Agents	3
<i>Natasha Alechina and Brian Logan</i>	
Effective S -adic Symbolic Dynamical Systems	13
<i>Valérie Berthé, Thomas Fernique, and Mathieu Sablik</i>	
Reaction-Based Models of Biochemical Networks	24
<i>Daniela Besozzi</i>	
Comparative Genomics on Artificial Life	35
<i>Priscila Biller, Carole Knibbe, Guillaume Beslon, and Eric Tannier</i>	
Computability and Analysis, a Historical Approach	45
<i>Vasco Brattka</i>	
The Brouwer Fixed Point Theorem Revisited	58
<i>Vasco Brattka, Stéphane Le Roux, Joseph S. Miller, and Arno Pauly</i>	
Secret Sharing Schemes with Algebraic Properties and Applications	68
<i>Ignacio Cascudo</i>	
Squeezing Feasibility	78
<i>Walter Dean</i>	
Recent Advances in Non-perfect Secret Sharing Schemes	89
<i>Oriol Farràs</i>	
A Computational Approach to the Borwein-Ditor Theorem	99
<i>Aleksander Galicki and André Nies</i>	
Semantic Security and Key-Privacy with Random Split of St-Gen Codes	105
<i>Danilo Gligoroski and Simona Samardjiska</i>	
The Typical Constructible Object	115
<i>Mathieu Hoyrup</i>	
Computability in Symbolic Dynamics	124
<i>Emmanuel Jeandel</i>	
Using Semidirect Product of (Semi)groups in Public Key Cryptography	132
<i>Delaram Kahrobaei and Vladimir Shpilrain</i>	

Towards Computational Complexity Theory on Advanced Function Spaces in Analysis	142
<i>Akitoshi Kawamura, Florian Steinberg, and Martin Ziegler</i>	
Ergodicity of Noisy Cellular Automata: The Coupling Method and Beyond	153
<i>Irène Marcovici</i>	
Types in Programming Languages, Between Modelling, Abstraction, and Correctness: EXTENDED ABSTRACT.	164
<i>Simone Martini</i>	
AFCAL and the Emergence of Computer Science in France: 1957–1967	170
<i>Pierre-Éric Mounier-Kuhn and Maël Pégny</i>	
Computable Reductions and Reverse Mathematics.	182
<i>Reed Solomon</i>	
Contributed Papers	
Busy Beavers and Kolmogorov Complexity	195
<i>Mikhail Andreev</i>	
The Domino Problem for Self-similar Structures	205
<i>Sebastián Barbieri and Mathieu Sablik</i>	
Axiomatizing Analog Algorithms	215
<i>Olivier Bournez, Nachum Dershowitz, and Pierre Neron</i>	
Generalized Effective Reducibility.	225
<i>Merlin Carl</i>	
Lightface Π^0_3 -Completeness of Density Sets Under Effective Wadge Reducibility	234
<i>Gemma Carotenuto and André Nies</i>	
Program Size Complexity of Correction Grammars in the Ershov Hierarchy . . .	240
<i>John Case and James S. Royer</i>	
Automorphism Groups of Substructure Lattices of Vector Spaces in Computable Algebra	251
<i>Rumen Dimitrov, Valentina Harizanov, and Andrei Morozov</i>	
Parameterized Complexity and Approximation Issues for the Colorful Components Problems	261
<i>Riccardo Dondi and Florian Sikora</i>	
A Candidate for the Generalised Real Line.	271
<i>Lorenzo Galeotti</i>	

Finitely Generated Semiautomatic Groups	282
<i>Sanjay Jain, Bakhadyr Khoussainov, and Frank Stephan</i>	
The Boolean Algebra of Piecewise Testable Languages	292
<i>Anton Konovalov and Victor Selivanov</i>	
On the Lattices of Effectively Open Sets	302
<i>Oleg V. Kudinov and Victor L. Selivanov</i>	
On the Executability of Interactive Computation	312
<i>Bas Luttik and Fei Yang</i>	
Circuit Satisfiability and Constraint Satisfaction Around Skolem Arithmetic	323
<i>Christian Glaßer, Peter Jonsson, and Barnaby Martin</i>	
The Complexity of Counting Quantifiers on Equality Languages.	333
<i>Barnaby Martin, András Pongrácz, and Michał Wrona</i>	
Baire Category Theory and Hilbert’s Tenth Problem Inside $\mathbb{Q}$	343
<i>Russell Miller</i>	
Partial Orders and Immunity in Reverse Mathematics	353
<i>Ludovic Patey</i>	
A Direct Constructive Proof of a Stone-Weierstrass Theorem for Metric Spaces	364
<i>Iosif Petrakis</i>	
Author Index	375