Lecture Notes in Artificial Intelligence 2371

Subseries of Lecture Notes in Computer Science
Edited by J. G. Carbonell and J. Siekmann

Lecture Notes in Computer Science
Edited by G. Goos, J. Hartmanis, and J. van Leeuwen

Springer
Berlin
Heidelberg
New York
Barcelona
Hong Kong
London
Milan
Paris
Tokyo

Sven Koenig Robert C. Holte (Eds.)

Abstraction, Reformulation, and Approximation

5th International Symposium, SARA 2002
Kananaskis, Alberta, Canada August 2-4, 2002
Proceedings

Springer

Series Editors

Jaime G. Carbonell, Carnegie Mellon University, Pittsburgh, PA, USA
Jörg Siekmann, University of Saarland, Saarbrücken, Germany

Volume Editors

Sven Koenig
College of Computing, Georgia Institute of Technology
801 Atlantic Dr NW, Atlanta, GA 30332-0280, USA
E-mail: skoenig@cc.gatech.edu

Robert C. Holte
Universtity of Alberta, Department of Computing Science
2-21 Athabasca Hall, Edmonton, Alberta
T6G 2E8, Canada
E-mail: holte@cs.ualberta.ca

Cataloging-in-Publication Data applied for

Die Deutsche Bibliothek - CIP-Einheitsaufnahme

Abstraction, reformulation, and approximation : 5th international symposium ; proceedings / SARA 2002, Kananaskis, Alberta, Canada, August 2 - 4, 2002. Sven Koenig ; Robert C. Holte (ed.). - Berlin ; Heidelberg ; New York ; Barcelona ; Hong Kong ; London ; Milan ; Paris ; Tokyo : Springer, 2002
(Lecture notes in computer science ; Vol. 2371 : Lecture notes in artificial intelligence)
ISBN 3-540-43941-2

CR Subject Classification (1998): I.2, F.4.1, F.3

ISSN 0302-9743
ISBN 3-540-43941-2 Springer-Verlag Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

http://www.springer.de

© Springer-Verlag Berlin Heidelberg 2002
Printed in Germany

Typesetting: Camera-ready by author, data conversion by PTP-Berlin, Stefan Sossna e.K.
Printed on acid-free paper SPIN: 10870376 06/3142 5 4 3 2 1 0

Preface

It has been recognized since the inception of Artificial Intelligence (AI) that abstractions, problem reformulations, and approximations (AR&A) are central to human common-sense reasoning and problem solving and to the ability of systems to reason effectively in complex domains. AR&A techniques have been used to solve a variety of tasks, including automatic programming, constraint satisfaction, design, diagnosis, machine learning, search, planning, reasoning, game playing, scheduling, and theorem proving. The primary purpose of AR&A techniques in such settings is to overcome computational intractability. In addition, AR&A techniques are useful for accelerating learning and for summarizing sets of solutions.

This volume contains the proceedings of SARA 2002, the fifth Symposium on Abstraction, Reformulation, and Approximation, held at Kananaskis Mountain Lodge, Kananaskis Village, Alberta (Canada), August 2-4, 2002. The SARA series is the continuation of two separate threads of workshops: AAAI workshops in 1990 and 1992, and an ad hoc series beginning with the "Knowledge Compilation" workshop in 1986 and the "Change of Representation and Inductive Bias" workshop in 1988 with followup workshops in 1990 and 1992. The two workshop series merged in 1994 to form the first SARA. Subsequent SARAs were held in 1995, 1998, and 2000.

SARA's aim is to provide a forum for intensive interaction among researchers in all areas of AI with an interest in the different aspects of AR&A techniques. The diverse backgrounds of participants leads to a rich and lively exchange of ideas, and a transfer of techniques and experience between researchers who might otherwise not be aware of each other's work.

SARA has a tradition of inviting distinguished researchers from diverse areas to give technical keynote talks of a survey nature. SARA 2002 has two keynote speakers from established SARA areas: Sridhar Mahadevan will speak about abstraction and reinforcement learning and Derek Long about reformulation in planning. SARA 2002 also has two keynote speakers from areas that have not been strongly represented at previous SARAs: Bob Kurshan will survey the use of abstraction in model-checking and Aristide Mingozzi will survey state space relaxation and search strategies in dynamic programming.

The papers in this volume are representative of the range of AR&A techniques and their applications. We would like to thank the authors and the keynote speakers for their efforts in preparing high quality technical papers and presentations accessible to a general audience, and thank the program committee and anonymous reviewers for the time and effort they invested to provide constructive feedback to the authors. We are very grateful for the assistance we received in organizing SARA 2002 from Susan Jackson, Sunrose Ko, Yngvi Bjornsson, Rob Lake, and Shirley Mitchell. Judith Chomitz and Tania Seib at the Kananaskis Mountain Lodge were a pleasure to work with. We would like to express a special thanks to Berthe Choueiry for her advice, suggestions, and support.

Several organizations provided financial support or assistance which greatly enhanced the richness of the SARA experience, and for which all SARA 2002 participants owe thanks: the American Association for Artificial Intelligence (AAAI), NASA Ames Research Center, the Pacific Institute for the Mathematical Sciences (PIMS), the University of Alberta, and Georgia Institute of Technology. SARA 2002 is a AAAI affiliate.

July 2002

Sven Koenig
Robert C. Holte

Organization

Symposium Co-chairs

Sven Koenig, Georgia Institute of Technology
Robert C. Holte, University of Alberta

Program Committee

Ralph Bergmann, University of Hildesheim
Yngvi Bjornsson, University of Alberta
Craig Boutilier, University of Toronto
Berthe Y. Choueiry, University of Nebraska-Lincoln
Stefan Edelkamp, Albert-Ludwigs-Universität Freiburg
Tom Ellman, Vassar College
Boi V. Faltings, Swiss Federal Institute of Technology in Lausanne
Jeremy Frank, NASA Ames
Eugene C. Freuder, Cork Constraint Computation Centre
Mike Genesereth, Stanford University
Lise Getoor, University of Maryland
Fausto Giunchiglia, University of Trento and ITC-IRST
Henry Kautz, University of Washington
Terran Lane, MIT
Michael Lowry, NASA Ames Research Center
Hiroshi Motoda, Osaka University
Pandurang Nayak, PurpleYogi.com
Doina Precup, McGill University
Peter Revesz, University of Nebraska-Lincoln
Lorenza Saitta, Università del Piemonte Orientale
Bart Selman, Cornell University
Barbara Smith, University of Huddersfield
Marco Valtorta, University of South Carolina at Columbia
Jeffrey Van Baalen, University of Wyoming
Toby Walsh, University of York
Weixiong Zhang, Washington University (St. Louis)
Robert Zimmer, Goldsmiths College, University of London
Jean-Daniel Zucker, Université Pierre & Marie Curie

Steering Committee

Berthe Y. Choueiry, University of Nebraska-Lincoln
Tom Ellman, Vassar College
Mike Genesereth, Stanford University
Fausto Giunchiglia, University of Trento and ITC-IRST
Alon Halevy, University of Washington
Robert Holte, University of Alberta
Sven Koenig, Georgia Institute of Technology
Michael Lowry, NASA Ames Research Center

Pandurang Nayak, PurpleYogi.com
Jeffrey Van Baalen, University of Wyoming
Toby Walsh, University of York

Sponsoring Institutions

The American Association of Artificial Intelligence (AAAI)
NASA Ames Research Center
The Pacific Institute for the Mathematical Sciences (PIMS)
The University of Alberta
Georgia Institute of Technology

Table of Contents

Invited Presentations

Model Checking and Abstraction 1
Robert P. Kurshan (Cadence Design Systems)

Reformulaion in Planning 18
Derek Long, Maria Fox, Muna Hamdi (University of Durham)

Spatiotemporal Abstraction of Stochastic Sequential Processes 33
Sridhar Mahadevan (University of Massachusetts)

State Spate Relaxation and Search Strategies in Dynamic Programming 51
Aristide Mingozzi (University of Bologna)

Full Presentations

Admissible Moves in Two-Player Games 52
Tristan Cazenave (Université Paris 8)

Dynamic Bundling: Less Effort for More Solutions 64
Berthe Y. Choueiry, Amy M. Davis (University of Nebraska-Lincoln)

Symbolic Heuristic Search Using Decision Diagrams 83
Eric Hansen, Rong Zhou (Mississippi State University), Zhengzhu Feng (University of Massachusetts)

On the Construction of Human-Automation Interfaces by Formal Abstraction..... 99
Michael Heymann (Technion), Asaf Degani (NASA Ames)

Pareto Optimization of Temporal Decisions 116
Lina Khatib, Paul Morris, Robert Morris (NASA Ames)

An Information-Theoretic Characterization of Abstraction in Diagnosis and Hypothesis Selection 126
T.K. Satish Kumar (Stanford University)

A Tractable Query Cache by Approximation.....140
Daniel Miranker (University of Texas), Malcolm C. Taylor (Radiant Networks), Anand Padmanaban (Oracle)

An Algebraic Framework for Abstract Model Checking 152
Supratik Mukhopadhyay, Andreas Podelski (Max-Planck Institut für Informatik)

Action Timing Discretization with Iterative-Refinement.....170
Todd W. Neller (Gettysburg College)

Formalizing Approximate Objects and Theories: Some Initial Results 178
Aarati Parmar (Stanford University)

Model Minimization in Hierarchical Reinforcement Learning 196
Balaraman Ravindran, Andrew G. Barto (University of Massachusetts)

Learning Options in Reinforcement Learning 212
Martin Stolle, Doina Precup (McGill University)

Approximation Techniques for Non-linear Problems with Continuum of Solutions 224
Xuan-Ha Vu, Djamila Sam-Haroud, Marius-Calin Silaghi (Swiss Federal Institute of Technology)

Approximation of Relations by Propositional Formulas: Complexity and Semantics 242
Bruno Zanuttini (Université de Caen)

Abstracting Visual Percepts to Learn Concepts 256
Jean-Daniel Zucker, Nicolas Bredeche (Université Paris VI), Lorenza Saitta (Università del Piemonte Orientale)

Short Presentations

PAC Meditation on Boolean Formulas 274
Bruno Apolloni, Fabio Baraghini (Università degli Studi di Milano), Giorgio Palmas (ST Microelectronics)

On the Reformulation of Vehicle Routing Problems and Scheduling Problems 282
J. Christopher Beck (University College, Cork), Patrick Prosser, Evgeny Selensky (University of Glasgow)

The Oracular Constraints Method 290
T.K. Satish Kumar (Stanford University), Richard Dearden (NASA Ames)

Performance of Lookahead Control Policies in the Face of Abstractions and Approximations 299
Ilya Levner, Vadim Bulitko, Omid Madani, Russell Greiner (University of Alberta)

TTree: Tree-Based State Generalization with Temporally Abstract Actions 308
William T.B. Uther, Manuela M. Veloso (Carnegie Mellon University)

Ontology-Driven Induction of Decision Trees at Multiple Levels of Abstraction ... 316
Jun Zhang, Adrian Silvescu, Vasant Honavar (Iowa State University)

Research Summaries

Abstracting Imperfect Information Game Trees 324
Darse Billings (University of Alberta)

Using Abstraction for Heuristic Search and Planning 326
Adi Botea (University of Alberta)

Approximation Techniques in Multiagent Learning 328
Michael Bowling (Carnegie Mellon University)

Abstraction and Reformulation in GraphPlan 330
Daniel Buettner (University of Nebraska-Lincoln)

Abstract Reasoning for Planning and Coordination 331
Bradley J. Clement (Jet Propulsion Laboratory)

Abstraction Techniques, and Their Value 333
Irit Askira Gelman (The University of Arizona)

Reformulation of Non-binary Constraints 335
Robert Glaubius (University of Nebraska-Lincoln)

Reformulating Combinatorial Optimization as Constraint Satisfaction 336
T.K. Satish Kumar (Stanford University)

Autonomous Discovery of Abstractions through Interaction with an Environment 338
Amy McGovern (University of Massachusetts)

Interface Verification: Discrete Abstractions of Hybrid Systems 340
Meeko Oishi (Stanford University)

Learning Semi-lattice Codebooks for Image Compression 342
Yoshiaki Okubo (Hokkaido University), Xiaobo Li (University of Alberta)

Research Summary 344
Marc Pickett (University of Massachusetts)

Principled Exploitation of Heuristic Information 345
Wheeler Ruml (Harvard University)

Reformulation of Temporal Constraint Networks 347
Lin Xu (University of Nebraska-Lincoln)

Author Index 349