

Lecture Notes in Artificial Intelligence 2752

Edited by J. G. Carbonell and J. Siekmann

Subseries of Lecture Notes in Computer Science

Springer

Berlin

Heidelberg

New York

Hong Kong

London

Milan

Paris

Tokyo

Gal A. Kaminka Pedro U. Lima
Raul Rojas (Eds.)

RoboCup 2002: Robot Soccer World Cup VI



Springer

Series Editors

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

Volume Editors

Gal A. Kaminka
Bar Ilan University, Computer Science Department
Ramat Gan, 52900 Israel
E-mail: galk@cs.biu.ac.il

Pedro U. Lima
Instituto Superior Técnico, Instituto de Sistemas e Robotica
Av. Rovisco Pais, 1, 1049-001 Lisbon, Portugal
E-mail: pal@isr.ist.utl.pt

Raul Rojas
Freie Universität Berlin, Fachbereich Mathematik und Informatik
Takustr. 9, 14195 Berlin, Germany
E-mail: rojas@inf.fu-berlin.de

Cataloging-in-Publication Data applied for

A catalog record for this book is available from the Library of Congress

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliographie;
detailed bibliographic data is available in the Internet at <<http://dnd.ddb.de>>.

CR Subject Classification (1998): I.2, C.2.4, D.2.7, H.5, I.5.4, J.4

ISSN 0302-9743

ISBN 3-540-40666-2 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 2003
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Olgun Computergrafik
Printed on acid-free paper SPIN: 10930656 06/3142 5 4 3 2 1 0

Preface

RoboCup 2002, the 6th Robot World Cup Soccer and Rescue Competitions and Conference, took place during June 19–25, 2002, at the Fukuoka Dome (main venue) in Fukuoka, Japan. It was, by far, the RoboCup event with the largest number of registered participants (1004 persons, distributed in 188 teams from 29 countries) and visitors (around 120,000 persons). As was done in its previous editions since 1997, the event included several robotic competitions and an international symposium. The papers and posters presented at the symposium constitute the main part of this book. League reports in the final section describe significant advances in each league and the results.

The symposium organizers received 76 submissions, among which 17 papers (22%) were accepted for oral presentation at the symposium (first section of the book), and 21 papers (29%) were accepted as posters (second section of the book). Most papers were evaluated by three reviewers each, chosen from the members of the International Program Committee (IPC). The IPC consisted of a balanced combination of regular RoboCup participants and researchers from outside this community. The reviewers worked hard to guarantee a fair review process – the result of their work was a high-quality symposium with very interesting presentations.

From the papers accepted for oral presentation, the IPC and the symposium chairs selected three finalists for the symposium prizes. The Scientific Challenge Award was given to the paper “RoboCupJunior: Learning with Educational Robotics,” by Elizabeth Sklar, Amy Eguchi, and Jeffrey Johnson. The Engineering Challenge Award was given to two papers: “MPADES: Middleware for Parallel Agent Discrete Event Simulation,” by Patrick Riley, and “Towards RoboCup Without Color Labeling,” by Robert Hanek, Thorsten Schmitt, Sebastian Buck, and Michael Beetz.

Five internationally renowned researchers accepted our invitation to give special talks at the symposium:

- “Humanoid Robots as Research Tools of Neuroscience,” by Mitsuo Kawato (ATR, Japan).
- “A Small Humanoid Robot SDR-4X for Entertainment Based on OPEN-R,” by Masahiro Fujita (DCL, SONY, Japan).
- “Cooperation by Observation,” by Yasuo Kuniyoshi (University of Tokyo, Japan).
- “A Research and Development Vision for Robot-Assisted Search and Rescue,” by John Blitch (CRASAR, USA).
- “Multi-robot Systems: Where We’ve Been and Where We’re Going,” by Lynne Parker (Oak Ridge National Laboratory and University of Tennessee, USA).

The last talk was delivered at a joint session with DARS-2002, the 6th International Symposium on Distributed Autonomous Robotic Systems.

The competitions were organized into seven leagues, the Rescue leagues (Simulation and Real Robots), the Soccer leagues (Simulation, Humanoids, Middle-Size, Small-Size, and 4-Legged), and the RoboCup Junior soccer and dance competitions for children, roughly in the age range 10–18 years old. The overview article at the beginning of the book summarizes all the competitions.

The editors of this book are grateful to the RoboCup Federation for all the logistic and financial assistance provided for the realization of the symposium. Minoru Asada carried the burden of organizing the printed edition of the preproceedings and the production of the respective CD. He did a great job organizing RoboCup 2002 and making the symposium possible. We are also grateful to our families who had to cope with our strange working hours, while we were sending e-mails and files back and forth across three time zones and three continents.

The next international RoboCup events will be held in Padua, Italy, in 2003, and in Lisbon, Portugal, in 2004.

May 2003

Gal Kaminka
Pedro U. Lima
Raul Rojas

RoboCup Federation

The RoboCup Federation, the governing body of Robocup, is an international organization that promotes science and technology in the field of mobile robots and software agents.

President

Minoru Asada, Osaka University, Japan

Board of Trustees

Hiroaki Kitano (Founding President), ERATO Kitano Symbiotic Systems Project, JST, Japan

Manuela Veloso (Vice-President), Carnegie Mellon University, USA

Enrico Pagello (Vice-President), University of Padua, Italy

Tucker Balch, Georgia Institute of Technology, USA

Hans-Dieter Burkhard, Humboldt University of Berlin, Germany

Silvia Coradeschi, Orebro University, Sweden

Itsuki, Noda, National Institute of Advanced Industrial Science and Technology, Japan.

Executive Committee (2002–2003)

The Executive Committee consists of members of the board of trustees, and representatives of each activity area:

Simulator League

Daniel Polani, University of Luebeck, Germany

Peter Stone, University of Texas at Austin, USA

Small Size (F180) League

Andreas Birk, International University Bremen, Germany

Raul Rojas, Free University of Berlin, Germany

Middle Size (F2000) League

Gerhard Kraetzschmar, University of Ulm, Germany

Pedro Lima, Instituto Superior Técnico, Portugal

Four-Legged Robot League

Masahiro Fujita, Sony Corp., Japan

Humanoid League

Dominique Duhaut, Robotic Laboratory of Paris, France

Thomas Christaller (observer), Fraunhofer Institute
for Autonomous Intelligent Systems – AiS, Germany

Education

Daniele Nardi, University of Rome “La Sapienza,” Italy
Paul Levi, University of Stuttgart, Germany

RoboCup Rescue

Satoshi Tadokoro, Kobe University, Japan
Adam Jacoff (observer), National Institute of Standards and Technology
– Intelligent Systems Division, USA

RoboCup Junior

Henrik Hautop Lund, University of Southern Denmark, Denmark
Elizabeth Sklar, Columbia University, USA

RoboCup 2002 Organization and Support

General Chair

Minoru Asada, Osaka University, Japan

Associate Chairs

Hitoshi Matsubara (Organizing Chair), Future University-Hakodate, Japan
Sho'ji Suzuki (Robotics Chair), Future University-Hakodate, Japan
Itsuki Noda (Simulation Chair), National Institute of Advanced Industrial Science and Technology, Japan

Simulator League Committee

Daniel Polani (Chair), University of Hertfordshire, UK
Masayuki Ohta (Local Chair), National Institute of Advanced Industrial Science and Technology, Japan
Patrick Riley, Carnegie Mellon University, USA
Oliver Obst, University of Koblenz, Germany

Small-Size Robot League (F180) Committee

Brett Browning (Chair), Carnegie Mellon University, USA
Yuki Nakagawa (Local Chair), National Museum of Emerging Science and Innovation, Japan
Paulo Costa, FEUP, Portugal

Middle-Size Robot League (F2000) Committee

Andrea Bonarini (Chair), Politecnico di Milano, Italy
Takayuki Nakamura (Local Chair), Wakayama University, Japan
Yasutake Takahashi (Local Chair), Osaka University, Japan
Mansour Jamzad, Sharif University of Technology, Iran
Pedro Lima, Instituto Superior Técnico, Portugal

Four-Legged Robot League Committee

Masahiro Fujita (Chair), Sony, Inc., Japan
Takeshi Ohashi, Kyushu Institute of Technology, Japan

RoboCup Junior Committee

Elizabeth Sklar (Chair), Columbia University, USA

Tairo Nomura (Local Chair), Saitama University, Japan

Emi Ami Eguchi, University of Cambridge, UK

Humanoid League Committee

Thomas Christaller (Chair), Fraunhofer Institute

for Autonomous Intelligent Systems – AiS, Germany

RoboCup Rescue Simulation League Committee

Tomoichi Takahashi (Chair), Chubu University, Japan

RoboCup Rescue Robot League Committee

Adam Jacoff (Chair), NIST, USA

Satoshi Tadokoro (Local Chair), Kobe University, Japan

Robin Murphy, USF, USA

Symposium Program Committee

Giovanni Adorni, Italy
Richard Alami, France
Tamio Arai, Japan
Minoru Asada, Japan
Ronald Arkin, USA
Minoru Asada, Japan
Tucker Balch, USA
Suzanne Barber, USA
Mike Bowling, USA
Henrik Christensen, Sweden
Brad Clement, USA
Jorge Dias, Portugal
Ian Frank, Japan
Dani Goldberg, USA
Claudia Goldman, Israel
Steffen Gutmann, Germany
Joao Hespanha, USA
Adele Howe, USA
Huosheng Hu, UK
Mansour Jamzad, Iran
Jeffrey Johnson, UK
Pieter Jonker, The Netherlands
Hyuckchul Jung, USA
Gerhard Kraetzschmar, Germany
Pradeep Khosla, USA
Sarit Kraus, Israel

Sanjeev Kumar, USA
Kostas Kyriakopoulos, Greece
Stacy Marsella, USA
Robin Murphy, USA
Ranjit Nair, USA
Daniele Nardi, Italy
Itsuki Noda, Japan
Masayuki Ohta, Japan
Daniel Polani, Germany
David Pynadath, USA
Martin Riedmiller, Germany
Alessandro Saffiotti, Denmark
Paul Scerri, USA
Sandeep Sen, USA
Onn Shehory, Israel
Roland Siegwart, Switzerland
Elisabeth Sklar, USA
Elizabeth Sonenberg, Australia
Peter Stone, USA
Katya Sycara, USA
Satoshi Tadokoro, Japan
Will Uther, USA
Tom Wagner, USA
Marco Wiering, The Netherlands
Laura Winer, Canada

Table of Contents

Introduction

An Overview of RoboCup 2002 Fukuoka/Busan	1
<i>Minoru Asada and Gal A. Kaminka</i>	

Technical Papers

Constraint-Based Landmark Localization	8
<i>Ashley W. Stroupe, Kevin Sikorski, and Tucker Balch</i>	
Improving Vision-Based Self-localization	25
<i>Hans Utz, Alexander Neubeck, Gerd Mayer, and Gerhard Kraetzschmar</i>	
Evaluation of Self-localization Performance for a Local Vision Robot in the Small Size League	41
<i>Daisuke Sekimori, Tomoya Usui, Yasuhiro Masutani, and Fumio Miyasaki</i>	
Fast Image Processing and Flexible Path Generation System for RoboCup Small Size League	53
<i>Shinya Hibino, Yukiharu Kodama, Yasunori Nagasaka, Tomoichi Takahashi, Kazuhito Murakami, and Tadashi Naruse</i>	
A Modified Potential Fields Method for Robot Navigation Applied to Dribbling in Robotic Soccer	65
<i>Bruno D. Damas, Pedro U. Lima, and Luis M. Custódio</i>	
Using Online Learning to Analyze the Opponent's Behavior	78
<i>Ubbo Visser and Hans-Georg Weland</i>	
Hidden Markov Modeling of Multi-agent Systems and Its Learning Method	94
<i>Itsuki Noda</i>	
Learning the Sequential Coordinated Behavior of Teams from Observations	111
<i>Gal A. Kaminka, Mehmet Fidanboyly, Allen Chang, and Manuela M. Veloso</i>	
Towards a Life-Long Learning Soccer Agent	126
<i>Alexander Kleiner, Markus Dietl, and Bernhard Nebel</i>	

Adaptive Synchronisation for a RoboCup Agent	135
<i>Jefferson D. Montgomery and Alan K. Mackworth</i>	
Team Formation for Reformation in Multiagent Domains Like RoboCupRescue	150
<i>Ranjit Nair, Milind Tambe, and Stacy Marsella</i>	
MPADES: Middleware for Parallel Agent Discrete Event Simulation	162
<i>Patrick Riley</i>	
Towards RoboCup without Color Labeling	179
<i>Robert Hanek, Thorsten Schmitt, Sebastian Buck, and Michael Beetz</i>	
Integration of Advice in an Action-Selection Architecture	195
<i>Paul Carpenter, Patrick Riley, Manuela M. Veloso, and Gal A. Kaminka</i>	
The Role of Motion Dynamics in the Design, Control and Stability of Bipedal and Quadrupedal Robots	206
<i>Michael Hardt and Oskar von Stryk</i>	
Multiagent Competitions and Research: Lessons from RoboCup and TAC	224
<i>Peter Stone</i>	
RoboCupJunior: Learning with Educational Robotics	238
<i>Elizabeth Sklar, Amy Eguchi, and Jeffrey Johnson</i>	
Posters	
A Rescue Robot Control Architecture Ensuring Safe Semi-autonomous Operation	254
<i>Andreas Birk and Holger Kenn</i>	
A Framework for Learning from Observation Using Primitives	263
<i>Darrin C. Bentivegna and Christopher G. Atkeson</i>	
Robosoccer-RU Open Simulation League: Principles and Algorithms	271
<i>D.E. Okhotsimsky, V.E. Pavlovsky, A.N. Touganov, A.G. Plakhov, V.V. Pavlovsky, S.S. Stepanov, and A.Yu. Zaslavsky</i>	
An Interactive Software Environment for Gait Generation and Control Design of Sony Legged Robots	279
<i>Dragos Golubovic and Huosheng Hu</i>	
Real-Time Randomized Path Planning for Robot Navigation	288
<i>James Bruce and Manuela M. Veloso</i>	
Towards an Optimal Scoring Policy for Simulated Soccer Agents	296
<i>Jelle Kok, Remco de Boer, Nikos Vlassis, and Frans C.A. Groen</i>	

Decision-Making and Tactical Behavior with Potential Fields	304
<i>Jens Meyer, Robert Adolph, Daniel Stephan, Andreas Daniel, Matthias Seekamp, Volker Weinert, and Ubbo Visser</i>	
Localization of Robots in F180 League Using Projective Geometry	312
<i>Jerome Douret, Ryad Benosman, Salah Bouzar, and Jean Devars</i>	
Reinforcement Learning in Large State Spaces	319
<i>Karl Tuyls, Sam Maes, and Bernard Manderick</i>	
Co-evolution of Morphology and Controller for Biped Humanoid Robot . . .	327
<i>Ken Endo, Funinori Yamasaki, Takashi Maeno, and Hiroaki Kitano</i>	
Towards Real-Time Strategic Teamwork: A RoboCup Case Study	342
<i>Kenichi Yoshimura, Nick Barnes, Ralph Rönquist, and Liz Sonenberg</i>	
MUREA: A MUlti-Resolution Evidence Accumulation Method for Robot Localization in Known Environments	351
<i>Marcello Restelli, Domenico G. Sorrenti, and Fabio M. Marchese</i>	
Direct Reward and Indirect Reward in Multi-agent Reinforcement Learning	359
<i>Masayuki Ohta</i>	
Relating the Entropy of Joint Beliefs to Multi-agent Coordination	367
<i>Mikhail Prokopenko and Peter Wang</i>	
Real-Time Decision Making under Uncertainty of Self-localization Results	375
<i>Takeshi Fukase, Yuichi Kobayashi, Ryuichi Ueda, Takanobu Kawabe, and Tamio Arai</i>	
KiRo – An Autonomous Table Soccer Player	384
<i>Thilo Weigel and Bernhard Nebel</i>	
Adaptive Methods to Improve Self-localization in Robot Soccer	393
<i>Ingo Dahm and Jens Ziegler</i>	
Team Coordination among Robotic Soccer Players	409
<i>Matthijs T.J. Spaan and Frans C.A. Groen</i>	
An Architecture for a National RoboCup Team	417
<i>Thomas Röfer</i>	
Probabilistic Vision-Based Opponent Tracking in Robot Soccer	426
<i>Thorsten Schmitt, Robert Hanek, Sebastian Buck, and Michael Beetz</i>	
Behavior Acquisition Based on Multi-module Learning System in Multi-agent Environment	435
<i>Yasutake Takahashi, Kazuhiro Edazawa, and Minoru Asada</i>	

League Reports

Simulation League – League Summary 443
Oliver Obst

RoboCup 2002 Small-Size League Review 453
Brett Browning

Medium Size League: 2002 Assessment and Achievements 460
Andrea Bonarini

Sony Four Legged Robot League at RoboCup 2002 469
Masahiro Fujita

RoboCupRescue Simulation League 477
Tomoichi Takahashi

RoboCupRescue Robot League 482
Satoshi Tadokoro

Lessons Learned from Fukuoka 2002 Humanoid League 485
Thomas Christaller

RoboCupJunior 2002: The State of the League..... 489
Elizabeth Sklar

Author Index 497