# Lecture Notes in Artificial Intelligence

5040

Edited by R. Goebel, J. Siekmann, and W. Wahlster

Subseries of Lecture Notes in Computer Science

Minoru Asada John C.T. Hallam Jean-Arcady Meyer Jun Tani (Eds.)

# From Animals to Animats 10

10th International Conference on Simulation of Adaptive Behavior, SAB 2008 Osaka, Japan, July 7-12, 2008 Proceedings



### Series Editors

Randy Goebel, University of Alberta, Edmonton, Canada Jörg Siekmann, University of Saarland, Saarbrücken, Germany Wolfgang Wahlster, DFKI and University of Saarland, Saarbrücken, Germany

### Volume Editors

Minoru Asada

Osaka University, Graduate School of Engineering, Adaptive Machine Systems JST ERATO Asada Synergistic Intelligence Project

2-1 Yamadaoka, Suita, Osaka 565-0871, Japan

E-mail: asada@ams.eng.osaka-u.ac.jp

John C.T. Hallam

University of Southern Denmark, The Mærsk Mc-Kinney Møller Institute Campusvej 55, 5230 Odense M, Denmark

E-mail: john@mmmi.sdu.dk

Jean-Arcady Meyer

Université Pierre et Marie Curie - CNRS, AnimatLab 104 Avenue du Président Kennedy, 75016 Paris, France

E-mail: jean-arcady.meyer@upmc.fr

Jun Tani

RIKEN, Brain Science Institute, Laboratory for Behavior and Dynamic Cognition 2-1. Hirosawa, Wako, Saitama 351-0198, Japan

E-mail: tani@brain.riken.jp

Cover illustration by Jean Solé

Library of Congress Control Number: 2008929600

CR Subject Classification (1998): I.2.11, I.2, I.6, F.1.1-2, K.4, H.5, J.4

LNCS Sublibrary: SL 7 – Artificial Intelligence

ISSN 0302-9743

ISBN-10 3-540-69133-2 Springer Berlin Heidelberg New York ISBN-13 978-3-540-69133-4 Springer 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. Violations are liable to prosecution under the German Copyright Law.

Springer is a part of Springer Science+Business Media

springer.com

© Springer-Verlag Berlin Heidelberg 2008 Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India Printed on acid-free paper SPIN: 12279081 06/3180 5 4 3 2 1 0

### **Preface**

Welcome to the proceedings of the Tenth International Conference on Simulation of Adaptive Behavior (SAB 2008). A symbolic creature in the SAB 2008 poster is based on GAKUTENSOKU, Japan's first modern robot created in 1928 by Makoto Nishimura. The robot, Gakutensoku (or "learning from natural law"), "was 7' 8" tall, painted gold, could open and close its eyes, could smile, could puff out its cheeks, and at the beginning of each performance would touch its mace to its head and then begin to write (from http://www.robmacdougall.org/index.php/2008/04/gakutensoku/)." Gakutensoku was actuated by pneumatics and seems to have been "a sort of early Japanese animatronics." Designed 80 years ago, it still stimulates researchers' minds.

This year, we received 110 submissions, among which we selected 30 for oral presentations and 21 for posters. In the main conference, we had four very interesting plenary talks: "Modelling Adaptive and Intelligent Behaviour: Some Historical and Epistemological Issues" by Roberto Cordeschi, "Insect-Machine Hybrid System for Understanding an Adaptive Behavior" by Ryohei Kanzaki, "Body Shapes Brain – Emergence and Development of Behavior and Mind from Embodied Interaction Dynamics" by Yasuo Kuniyoshi, and "Thinking and Learning Close to the Sensory-Motor Surface Creates Knowledge That Transcends the Here and Now" by Linda Smith. On the second day, we had a special joint session with the British Council featuring special talks by Giacomo Rizzolatti and Ron Chrisley followed, by a panel discussion. After the main conference, we had a workshop and two tutorials.

Minoru Asada Jun Tani

# **Organization**

From Animals to Animats 10: The Tenth International Conference on the Simulation of Adaptive Behavior (SAB 2008) was organized by the JST ERATO Asada Project and ISAB (International Society for Adaptive Behavior).

## **Executive Committee**

General Chair Minoru Asada, Osaka University, Japan

Program Chair Jun Tani, RIKEN, Japan

General Co-chairs John Hallam, University of Southern Denmark,

Denmark

Jean-Arcady Meyer, University of Paris 6 – CNRS,

France

### **Program Committee**

Hussein Abbass	Gillian Hayes	Ryohei Nakano
Alberto Acerbi	Phil Husbands	Chrystopher L. Nehaniv
Ronald Arkin	Fumiya Iida	Stefano Nolfi
Angelo Arleo	Hiroyuki Iizuka	Tetsuya Ogata
Minoru Asada	Auke Jan Ijspeert	Pietro Pantano
Gianluca Baldassarre	Takashi Ikegami	Frank Pasemann
Christian Balkenius	Akio Ishiguro	Jan Peters
Luc Berthouze	Koji Ito	Rolf Pfeifer
Aude Billard	Masato Ito	Eric Postma
Eleonora Bilotta	Naoto Iwahashi	Tony Prescott
Joanna Bryson	Frederic Kaplan	Miki Sagara
Seth Bullock	Kuniaki Kawabata	Matthew Schlesinger
Angelo Cangelosi	Toshiyuki Kondo	Gregor Schoner
Thomas Collett	Robert Kozma	Noel Sharkey
Nikolaus Correll	Jeffrey L. Krichmar	Tomohiro Shibata
Kerstin Dautenhahn	Hanspeter Mallot	Olivier Sigaud
Marco Dorigo	Davide Marocco	Olaf Sporns
Michael Dyer	Alcherio Martinoli	Kenji Suzuki
Dario Floreano	Gianluca Massera	Jun Tani
Luca Gambardella	Mariagiovanna Mazzapioda	Charles Taylor
Philippe Gaussier	Chris Melhuish	Tim Taylor
Agnes Guillot	Jean-Arcady Meyer	Guy Theraulaz
John Hallam	Marco Mirolli	Vadim Tikhanoff
Osam Hanagata	Francesco Mondada	Peter Todd
Inman Harvey	Kazuyuki Murase	Vito Trianni

## VIII Organization

Kazuo Tsuchiya Elio Tuci Richard Vaughan Paul Vogt Hiroaki Wagatsuma Janet Wiles Myra S. Wilson Rachel Wood Tom Ziemke

# **Table of Contents**

The Animat Approach to Adaptive Behaviour	
Extended Homeostatic Adaptation: Improving the Link between Internal and Behavioural Stability	1
Evolution of Valence Systems in an Unstable Environment	12
Flexible Control Mechanism for Multi-DOF Robotic Arm Based on Biological Fluctuation	22
Neural Noise Induces the Evolution of Robust Behaviour by Avoiding Non-functional Bifurcations	32
Integration of an Omnidirectional Visual System with the Control Architecture of Psikharpax	42
Evolution	
Stability of Coordination Requires Mutuality of Interaction in a Model of Embodied Agents	52
Internal and External Memory in Neuroevolution for Learning in Non-stationary Problems	62
Evolving Vision Controllers with a Two-Phase Genetic Programming System Using Imitation	73
Embodiment and Perceptual Crossing in 2D: A Comparative Evolutionary Robotics Study	83
Navigation and Internal World Models	
Adaptive Optimal Control for Redundantly Actuated Arms	93

Monostable Controllers for Adaptive Behaviour	103
Bifurcation Angles in Ant Foraging Networks: A Trade-Off between Exploration and Exploitation?	113
Episodes in Space: A Modeling Study of Hippocampal Place Representation	123
Modelling the Cortical Columnar Organisation for Topological State-Space Representation, and Action Planning	137
Adaptive Olfactory Encoding in Agents Controlled by Spiking Neural Networks	148
Theta Phase Coding and Acetylcholine Modulation in a Spiking Neural Network	159
Interest of Spatial Context for a Place Cell Based Navigation Model  Nicolas Cuperlier, Philippe Gaussier, and Mathias Quoy	169
Linked Local Visual Navigation and Robustness to Motor Noise and Route Displacement	179
Second Order Conditioning in the Sub-cortical Nuclei of the Limbic System	189
Perception and Control	
Synthesising Novel Movements through Latent Space Modulation of Scalable Control Policies	199
Incremental Evolution of Animats' Behaviors as a Multi-objective	210
Optimization	210

XI

Integrating Epistemic Action (Active Vision) and Pragmatic Action (Reaching): A Neural Architecture for Camera-Arm Robots	220
Neural Coding in the Dorsal Visual Stream  Eris Chinellato and Angel P. del Pobil	230
Learning and Adaptation	
Modeling the Bat LSO Tonotopical Map Refinement during  Development  Bertrand Fontaine and Herbert Peremans	240
A Reinforcement Learning Technique with an Adaptive Action Generator for a Multi-robot System	250
A Multi-cellular Developmental System in Continuous Space Using Cell Migration	260
Toward a Theory of Embodied Statistical Learning	270
Closing the Sensory-Motor Loop on Dopamine Signalled Reinforcement  Learning	280
Mutual Development of Behavior Acquisition and Recognition Based on Value System	291
Cognition, Emotion and Behaviour	
Improving Situated Agents Adaptability Using Interruption Theory of Emotions	301
Dynamical Systems Account for Meta-level Cognition	311
A Computational Model of the Amygdala Nuclei's Role in Second Order Conditioning	321
Acquiring a Functionally Compositional System of Goal-Directed Actions of a Simulated Agent	331

Learning to Generalize through Predictive Representations: A  Computational Model of Mediated Conditioning	342
Detection of Weak Signals by Emotion-Derived Stochastic Resonance	352
The Influence of Asynchronous Dynamics in the Spatial Prisoner's  Dilemma Game	362
A Study of Off-Line Uses of Anticipation	372
Collective and Social Behaviours	
An Individual-Based Model of Task Selection in Honeybees	383
Distributed Adaptation in Multi-robot Search Using Particle Swarm Optimization	393
Homeotaxis: Coordination with Persistent Time-Loops	403
Noise-Induced Adaptive Decision-Making in Ant-Foraging	415
Division of Labour in Self-organised Groups	426
Social Control of Herd Animals by Integration of Artificially Controlled Congeners	437
Aggregating Robots Compute: An Adaptive Heuristic for the Euclidean Steiner Tree Problem	447
Emergence of Interaction among Adaptive Agents	457
Adaptive Behaviour in Language and Communication	
Acquisition of Human-Robot Interaction Rules via Imitation and Response Observation	467
On Modeling Proto-Imitation in a Pre-associative Babel	477

Applied Adaptive Behaviour	
Evolution of General Driving Rules of a Driving Agent	488
BehaviorSim: A Learning Environment for Behavior-Based Agent Fasheng Qiu and Xiaolin Hu	499
Adaptive Behavioural Modulation and Hysteresis in an Analogue of a Kite Control Task	509
Self-adaptive Agent-Based Dynamic Scheduling for a Semiconductor Manufacturing Factory	519
Author Index	529

Table of Contents XIII