Cognition and Multi-Agent Interaction

From Cognitive Modeling to Social Simulation

This book explores the intersection between cognitive sciences and social sciences. In particular, it explores the intersection between individual cognitive modeling and modeling of multi-agent interaction. The two contributing fields – individual cognitive modeling (especially cognitive architectures) and modeling of multi-agent interaction (including social simulation and, to some extent, multi-agent systems) – have seen phenomenal growth in recent years. However, the interaction of these two fields has not been sufficiently developed. The interaction of the two may be more significant than either alone. They bring with them enormous intellectual capitals. These intellectual capitals can be profitably leveraged in creating true synergy between the two fields, leading to better understanding of both individual cognition and sociocultural processes. It is possible that an integrative field of study in cognitive and social sciences is emerging and we are laying the foundation for it.

Ron Sun is Professor of Cognitive Science at Rensselaer Polytechnic Institute. A well-known researcher in cognitive science, Ron Sun leads research projects investigating fundamental structures of the human mind. In particular, he recently published *Duality of the Mind*, exploring the interaction of implicit and explicit cognition. He is also the founding co-editor-in-chief of the journal *Cognitive Systems Research*, focusing on integrative cognitive research.

Cognition and Multi-Agent Interaction

From Cognitive Modeling to Social Simulation

Edited by
RON SUN
Rensselaer Polytechnic Institute

CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
40 West 20th Street, New York, NY 10011-4211, USA

www.cambridge.org
Information on this title: www.cambridge.org/9780521839648

First published 2006

Printed in the United States of America

A catalogue record for this publication is available from the British Library.

Library of Congress Cataloging in Publication Data

Cognition and multi-agent interaction : from cognitive modeling to social simulation /
edited by Ron Sun.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-521-83964-8 (hardback)
ISBN-10: 0-521-83964-5 (hardback)
1. Intelligent agents (Computer software) 2. Computer systems. 3. Cognition.
I. Sun, Ron, 1960–.
QA76.76.I58C635 2005
006.3 – dc22 2005014851

ISBN-13 978-0-521-83964-8 hardback
ISBN-10 0-521-83964-5 hardback

Contents

Contributors

William Adams
Naval Research Laboratory,
Code 5515
Washington, DC 20375-5337
adams@aic.nrl.navy.mil

John Anderson
Department of Psychology
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
ja@cmu.edu
http://act.psy.cmu.edu/

Brad Best
Micro Analysis and Design
6800 Thomas Blvd
Pittsburgh, PA 15208
bbest@mmad.com.

Dan J. Bothell
Department of Psychology
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
db30@andrew.cmu.edu

Derek P. Brock
Naval Research Laboratory,
Code 5513
Washington, DC 20375-5337
brock@itd.nrl.navy.mil

Boris Brodsky
Booz Allen Hamilton Inc
8283 Greensboro Drive
McLean, VA 22102
brodsky_boris@bah.com

Magdalena D. Bugajska
Naval Research Laboratory,
Code 5515
Washington, DC 20375-5337
magda@aic.nrl.navy.mil

Tom R. Burns
Department of Sociology
University of Uppsala
Box 624, 75126
Uppsala, Sweden
tom.burns@soc.uu.se

Nicholas L. Cassimatis
Department of Cognitive Science
Rensselaer Polytechnic Institute
Troy, NY 12180
cassin@rpi.edu

Cristiano Castelfranchi
Department of Communication
Sciences
University of Siena
Siena, Italy
cristian.castelfranchi@istc.cnr.it

William J. Clancey
NASA Ames Research Center
and Institute for Human and
Machine Cognition at UWF
Computational Sciences Division,
MS 269-3
Moffett Field, CA 94028
william.j.clancey@nasa.gov
http://bill.clancey.name

Bruce Damer
DigitalSpace Corporation
343 Soquel Avenue, Suite 70
Santa Cruz, CA 95062
damer@digitalspace.com
http://www.digitalspace.com

Nigel Gilbert
School of Human Sciences
University of Surrey
Surrey, GU2 7XH, UK
n.gilbert@soc.surrey.ac.uk
http://www.soc.surrey.ac.uk/
nigel_gilbert.htm

Jonathan Gratch
University of Southern California
13274 Fiji Way
Marina del Rey, CA 90292
gratch@ict.usc.edu
http://www.ict.usc.edu/~gratch

Laura M. Hiatt
Naval Research Laboratory,
Code 5515
Washington, DC 20375-5337
hiatt@aic.nrl.navy.mil

Nicholas R. Jennings
School of Electronics and
Computer Science
University of Southampton
Southampton SO17 1BJ, UK
nrj@ecs.soton.ac.uk

Randolph M. Jones
Colby College & Soar Technology
5857 Mayflower Hill
Waterville, ME 04901-8858
rjones@soartech.com

Christian Lebiere
Micro Analysis and Design
6800 Thomas Blvd
Pittsburgh, PA 15208
clebiere@maad.com
http://www.maad.com

Rajiv T. Maheswaran
Department of Computer Science
University of Southern California
3737 Watt Way
Los Angeles, CA 90089-0273
maheswar@usc.edu
http://pollux.usc.edu/~maheswar

Wenji Mao
University of Southern California
13274 Fiji Way
Marina del Rey, CA 90292
mao@ict.usc.edu

Stacy Marsella
University of Southern California
13274 Fiji Way
Marina del Rey, CA 90292
marsella@isi.edu
http://www.isi.edu/~marsella

Maja J Matarić
Computer Science Department
University of Southern California
941 West 37th Place, SAL 300
Los Angeles, California
mataric@usc.edu
http://robotics.usc.edu/~maja

Scott Moss
Centre for Policy Modelling
Manchester Metropolitan University
Manchester M1 3GH, UK
s.moss@mmu.ac.uk
http://cfpm.org/~scott

Isaac Naveh
Department of Computer Science
University of Missouri–Columbia
Columbia, MO 65211
yizchaknaveh@yahoo.com

Stefano Nolfi
Institute of Cognitive Sciences and Technologies
National Research Council
Viale Marx 15, 00137
Roma, Italy
s.nolfi@istc.cnr.it
http://gral.ip.rm.cnr.it/nolfi

Emma Norling
Department of Computer Science and Software Engineering
The University of Melbourne
Victoria 3010, Australia
norling@acm.org
http://www.cs.mu.oz.au/~ejn

Steven Okamoto
Department of Computer Science
University of Southern California
3737 Watt Way
Los Angeles, CA 90089-0273
stevenokamoto@yahoo.com

Pietro Panzarasa
Centre for Business Management
Queen Mary College, University of London
Mile End Road
London, E1 4NS, UK
p.panzarasa@qmul.ac.uk

Domenico Parisi
Institute of Cognitive Sciences and Technologies
National Research Council
Viale Marx 15, 00137
Roma, Italy
d.parsi@istc.cnr.it
http://gral.ip.rm.cnr.it/dparisi/

Dennis Perzanowski
Naval Research Laboratory
Washington, DC 20375-5337
dennisp@aic.nrl.navy.mil

Frank E. Ritter
School of Information Sciences and Technology
The Pennsylvania State University
University Park, PA 16802
frank.ritter@psu.edu
http://www.frankritter.com

Ewa Roszkowska
Faculty of Economics
University of Bialystok
Warszawska 63, 15-062
Bialystok, Poland
erosz@w3cache.uwb.edu.pl

Paul Scerri
Robotics Institute
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
pscerri@cs.cmu.edu
http://www.cs.cmu.edu/~pscerri

Alan C. Schultz
Naval Research Laboratory, Code 5515
Washington, DC 20375-5337
schultz@aic.nrl.navy.mil

Nathan Schurr
Department of Computer Science
University of Southern California
3737 Watt Way
Los Angeles, CA 90089-0273
schurr@usc.edu
http://teamcore.usc.edu/schurr

Dylan A. Shell
Computer Science Department
University of Southern California
941 West 37th Place, SAL 300
Los Angeles, California
shell@usc.edu
http://robotics.usc.edu/~dshell

Maarten Sierhuis
NASA Ames Research Center,
MS 269-1
Moffett Field, CA 94028
msierhuis@mail.arc.nasa.gov
http://home.comcast.net/
~msierhuis

Ron Sun
Department of Cognitive Science
Rensselaer Polytechnic Institute
Troy, NY 12180
rsun@rpi.edu
http://www.cogsci.rpi.edu/~rsun

Niels Taatgen
Department of Psychology
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213
taatgen@cmu.edu
http://www.ai.rug.nl/~niels

Milind Tambe
Department of Computer Science
University of Southern California
3737 Watt Way
Los Angeles, CA 90089-0273
tambe@usc.edu
http://teamcore.usc.edu/tambe

J. Gregory Trafton
Naval Research Laboratory,
Code 5515
Washington, DC 20375-5337
trafton@itd.nrl.navy.mil
http://www.aic.nrl.navy.mil/
~trafton/trafton.html

Robert L. West
Department of Psychology and
Institute of Cognitive Science
Carleton University
Ottawa, Ontario, Canada
robert_west@carleton.ca
http://www.carleton.ca/~rlwest/

Robert E. Wray
Soar Technology
3600 Green Court, Suite 600
Ann Arbor, MI 48105
wray@soartech.com
http://www.soartech.com

Preface

This book explores the intersection between the cognitive sciences and the social sciences. More specifically, it explores the intersection between individual cognitive modeling and modeling of multi-agent interaction. The two contributing fields – computational cognitive modeling (especially cognitive architectures) and modeling of multi-agent interaction (including social simulation and, to some extent, multi-agent systems) – have seen phenomenal growth in recent years. Both have been seen as breakthrough developments. However, the interaction of these two fields has not been sufficiently developed. We believe that the interaction of the two may be more significant than either alone. They bring with them enormous intellectual capitals. These intellectual capitals can be profitably leveraged in creating true synergy between the two fields, leading to more in-depth studies of both individual cognition and sociocultural processes. It is possible that an integrative field of study in cognitive and social sciences may be emerging.

This book is intended for researchers and students in cognitive, behavioral, and social sciences. It may also be read by interested laypersons and people whose primary scholarly interests are elsewhere – they can profit from general introductions to cognitive modeling (especially cognitive architectures) and examples of social simulations. The intellectual issues explored in the book are broad and significant, and thus the book may appeal to a sizable audience in philosophy, psychology, sociology, anthropology, education, economics, neuroscience, artificial intelligence, and so on. As these issues are central to the understanding of the human mind and human society, the book may prove to be of lasting theoretical and practical relevance.

We believe that investigation and simulation of social phenomena need cognitive science, because such endeavors need a better understanding, and better models, of individual cognition, which can provide a foundation for understanding social interaction. Conversely, cognitive science

also needs multi-agent systems, social simulation, and social sciences in general. Cognitive science is very much in need of new theoretical frameworks and new conceptual tools, especially for analyzing sociocultural aspects of cognition and cognitive processes involved in multi-agent interaction. Thus, there needs to be an integration (to some extent) of these two strands. In response to such a need, the present volume addresses the integration of the studies of the social and the cognitive.

This volume brings together cognitive scientists, social scientists, as well as AI researchers, with a wide range of background and expertise, to address the dual issue of understanding social processes through modeling individual cognition (especially through employing cognitive architectures) and understanding and modeling individual cognition through taking account of social processes. These two issues are of broad importance, especially in understanding the relationship between cognitive and social processes.

This volume consists of four parts. Part 1 contains one introductory chapter. Part 2 includes three chapters. They review some of the best cognitive architectures in existence, which form the basis of modeling individual cognition and may be extended for addressing collective processes. Part 3 develops models of cognition and social interaction using cognitive architectures as well as other approaches. Those models shed light on the relationship between cognitive modeling and multi-agent social simulation, as well as their synergy. To provide a better understanding of these models and approaches, Part 4 presents theoretical positions, arguments, and issues concerning various possibilities in integrating cognitive modeling and social simulation.

These chapters, written by leading researchers in various disciplines, provide provocative new insights into relevant issues, as well as solid research results pertinent to these issues.

I would like to thank all contributing authors. Many of them not only contributed chapters, but also participated in mutual reviews of drafts, thus helping to ensure the quality of this book.

Note that this volume is, in many ways, an outgrowth of the workshop on cognitive modeling of agents and multi-agent interaction, chaired by Ron Sun, held in Acapulco, Mexico, in the summer of 2003.[1] In this regard, I would like to thank members of the program committee of the workshop: Christian Lebiere, Cristiano Castelfranchi, Jan Treur, and Robert West, for their help in organizing the event. Thanks are also due to Greg Trafton, Catholijn Jonker, Pietro Panzarasa, Jonathan Gratch, Bill Clancey, Frank Ritter, Robert West, Joseph Giampapa, and a few others for their help in reviewing papers.

[1] For further information about this workshop, see the Web page at: http://www.cogsci.rpi.edu/~rsun/wsp03.html

I would like to thank Cambridge University Press for taking on this project. In particular, I would like to thank Phil Laughlin of Cambridge University Press for being such a helpful editor throughout the long process of putting together this book.

Ron Sun
Troy, New York