Raoul Huys and Viktor K. Jirsa (Eds.)

Nonlinear Dynamics in Human Behavior

Studies in Computational Intelligence, Volume 328

Editor-in-Chief
Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

Further volumes of this series can be found on our homepage: springer.com

Vol. 306. Tru Hoang Cao
Conceptual Graphs and Fuzzy Logic, 2010
ISBN 978-3-642-14086-0

Vol. 307. Anupam Shukla, Ritu Tiwari, and Rahul Kala
Towards Hybrid and Adaptive Computing, 2010
ISBN 978-3-642-14343-4

Vol. 308. Roger Nkambou, Jacqueline Bourdeau, and Riichiro Mizoguchi (Eds.)
Advances in Intelligent Tutoring Systems, 2010
ISBN 978-3-642-14362-5

Vol. 309. Isabelle Bichindaritz, Lakhmi C. Jain, Sachin Vaidya, and Ashlesha Jain (Eds.)
Computational Intelligence in Healthcare 4, 2010
ISBN 978-3-642-14463-9

Vol. 310. Dipti Srinivasan and Lakhmi C. Jain (Eds.)
Innovations in Multi-Agent Systems and Applications – 1, 2010
ISBN 978-3-642-14434-9

Vol. 311. Juan D. Velásquez and Lakhmi C. Jain (Eds.)
Advanced Techniques in Web Intelligence, 2010
ISBN 978-3-642-14460-8

Vol. 312. Patricia Melin, Janusz Kacprzyk, and Witold Pedrycz (Eds.)
Soft Computing for Recognition based on Biometrics, 2010
ISBN 978-3-642-15110-1

Vol. 313. Imre J. Rudas, János Fodor, and Janusz Kacprzyk (Eds.)
Computational Intelligence in Engineering, 2010
ISBN 978-3-642-15219-1

Vol. 314. Lorenzo Magnani, Walter Carnielli, and Claudio Pizzi (Eds.)
Model-Based Reasoning in Science and Technology, 2010
ISBN 978-3-642-15222-1

Vol. 315. Mohammad Essaaidi, Michele Malgeri, and Costin Badica (Eds.)
Intelligent Distributed Computing IV, 2010
ISBN 978-3-642-15210-8

Vol. 316. Philipp Wolfrum
Information Routing, Correspondence Finding, and Object Recognition in the Brain, 2010
ISBN 978-3-642-15253-5

Vol. 317. Roger Lee (Ed.)
Computer and Information Science 2010
ISBN 978-3-642-15404-1

Vol. 318. Oscar Castillo, Janusz Kacprzyk, and Witold Pedrycz (Eds.)
Soft Computing for Intelligent Control and Mobile Robotics, 2010
ISBN 978-3-642-15533-8

Vol. 319. Takayuki Ito, Minjie Zhang, Valentin Robu, Shaheen Fatima, Tokuro Matsuo, and Hirofumi Yamaki (Eds.)
Innovations in Agent-Based Complex Automated Negotiations, 2010
ISBN 978-3-642-15611-3

Vol. 320. xxx

Vol. 321. Dimitri Plemenos and Georgios Miaoulis (Eds.)
Intelligent Computer Graphics 2010
ISBN 978-3-642-15689-2

Vol. 322. Bruno Baruque and Emilio Corchado (Eds.)
Fusion Methods for Unsupervised Learning Ensembles, 2010
ISBN 978-3-642-16204-6

Vol. 323. Yingxu Wang, Du Zhang, and Witold Kinsner (Eds.)
Advances in Cognitive Informatics, 2010
ISBN 978-3-642-16082-0

Vol. 324. Alessandro Soro, Vargiu Eloisa, Giuliano Armano, and Gavino Paddeu (Eds.)
Information Retrieval and Mining in Distributed Environments, 2010
ISBN 978-3-642-16088-2

Vol. 325. Quan Bai and Naoki Fukuta (Eds.)
Advances in Practical Multi-Agent Systems, 2010
ISBN 978-3-642-16097-4

Vol. 326. Sheryl Brahnam and Lakhmi C. Jain (Eds.)
Advanced Computational Intelligence Paradigms in Healthcare 5, 2010
ISBN 978-3-642-16094-3

Vol. 327. Slawomir Wiak and Ewa Napieralska-Juszczak (Eds.)
Computational Methods for the Innovative Design of Electrical Devices, 2010
ISBN 978-3-642-16224-4

Vol. 328. Raoul Huys and Viktor K. Jirsa (Eds.)
Nonlinear Dynamics in Human Behavior, 2010
ISBN 978-3-642-16261-9

Raoul Huys and Viktor K. Jirsa (Eds.)

Nonlinear Dynamics in Human Behavior

Springer

Raoul Huys
Theoretical Neuroscience Group
CNRS & Université de la Méditerranée, UMR 6233 “Movement Science Institute"
Faculté des Sciences du Sport
163 av. De Luminy
13288, Marseille cedex 09
France
E-mail: raoul.huys@univmed.fr

Viktor K. Jirsa
Theoretical Neuroscience Group
CNRS & Université de la Méditerranée, UMR 6233 “Movement Science Institute"
Faculté des Sciences du Sport
163 av. De Luminy
13288, Marseille cedex 09
France
and
Center for Complex Systems & Brain Sciences
Florida Atlantic University
777 Glades Road
Boca Raton FL33431
USA

ISBN 978-3-642-16261-9 e-ISBN 978-3-642-16262-6

DOI 10.1007/978-3-642-16262-6

Studies in Computational Intelligence ISSN 1860-949X

Library of Congress Control Number: 2010937350

© 2010 Springer-Verlag Berlin Heidelberg

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, reuse of illustrations, recitation, broadcasting, reproduction on microfilm 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.

The use of general descriptive names, registered names, trademarks, 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.

Typeset & *Cover Design:* Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Preface

In July 2007 the international summer school "Nonlinear Dynamics in Movement and Cognitive Sciences" was held in Marseille, France. The aim of the summer school was to offer students and researchers a "crash course" in the application of nonlinear dynamic system theory to cognitive and behavioural neurosciences. The participants typically had little or no knowledge of nonlinear dynamics and came from a wide range of disciplines including neurosciences, psychology, engineering, mathematics, social sciences and music. The objective was to develop sufficient working knowledge in nonlinear dynamic systems to be able to recognize characteristic key phenomena in experimental time series including phase transitions, multistability, critical fluctuations and slowing down, etc. A second emphasis was placed on the systematic development of functional architectures, which capture the phenomenological dynamics of cognitive and behavioural phenomena. Explicit examples were presented and elaborated in detail, as well as "hands on" explored in laboratory sessions in the afternoon. This compendium can be viewed as an extended offshoot from that summer school and breathes the same spirit: it introduces the basic concepts and tools adhering to deterministic dynamical systems as well as its stochastic counterpart, and contains corresponding applications in the context of motor behaviour as well as visual and auditory perception in a variety of typically (but not solely) human endeavours. The chapters of this volume are written by leading experts in their appropriate fields, reflecting ta similar multi-disciplinary range as the one of the students. This book owes its existence to their contributions, for which we wish to express our gratitude. We are further indebted to the Technical Editor Dr. Thomas Ditzinger for his advice, guidance, and patience throughout the editorial process, and the Series Editor Janusz Kacprzyk for inviting and encouraging us to produce this volume.

Contents

Dynamical Systems in One and Two Dimensions: A Geometrical Approach 1
Armin Fuchs

Benefits and Pitfalls in Analyzing Noise in Dynamical Systems – On Stochastic Differential Equations and System Identification 35
Andreas Daffertshofer

The Dynamical Organization of Limb Movements 69
Raoul Huys

Perspectives on the Dynamic Nature of Coupling in Human Coordination 91
Sarah Calvin, Viktor K. Jirsa

Do We Need Internal Models for Movement Control? 115
Frédéric Danion

Nonlinear Dynamics in Speech Perception 135
Betty Tuller, Noël Nguyen, Leonardo Lancia, Gautam K. Vallabha

A Neural Basis for Perceptual Dynamics 151
Howard S. Hock, Gregor Schöner

Optical Illusions: Examples for Nonlinear Dynamics in Perception 179
Thomas Ditzinger

A Dynamical Systems Approach to Musical Tonality 193
Edward W. Large

Author Index 213