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Intelligence for Nonlinear Dynamics and Synchronisation

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Preface

The fundamental issue in system analysis and modeling is about the identification of the systems dynamics including the external interactions that affect the systems behavior. Such identification aims at specifying the set of functions (rules or equations) that captures the factors that control the change of the systems behavior. Often when dealing with complex non-linear dynamical systems, the identification is obtained only by means of approximations and optimization. Hence, the relevance of Computational Intelligence (CI) techniques in the context of such systems becomes manifest. This does apply also for the other two facets of system modeling namely prediction and diagnostic, in the sense that both require computational techniques, in particular those stemming from the computational intelligence realm.

Because the application of such computational models is prompted by the optimization requirements, over the last years the appropriateness of CI in optimization tasks pertaining to complex nonlinear dynamic systems has become indubitable as attested by a large number of studies reporting on the successful application of CI models in nonlinear science especially in adaptive control applications, fault diagnostic, signal processing, chaos theory, medical diagnostic, pattern formation, living systems, etc. However, due to the complexity dimensions of nonlinear dynamic systems, there still exists a large spectrum of unsolved problems that go beyond the traditional intelligent control applications and where CI techniques can play a central role. That is the main purpose behind the present volume. It is mainly devoted to shed light on the application of some CI models in the context of nonlinear dynamic systems. Because of this general aim, the chapters do have a tutorial oriented structure and look self contained targeting large audience. The book is primarily dedicated to researchers interested in getting the general cues of some particular subjects related to the application of computational intelligence techniques to nonlinear systems.

The book is a collection of contributions and consists of three parts: (i) Computational Intelligence, (ii) Pattern Recognition and Nonlinear Systems Techniques, (iii) Application of CI in Nonlinear Dynamic Systems.

Comprising three chapters, the first part introduces in Chapter 1 by Bouchachia adaptive computational intelligence models in the context of dynamical systems. The notion of adaptivity is treated from the perspective of incrementality, in the sense that models should be online and continuously updated as new data becomes available, new operational mode changes, or the environmental conditions of the system change. Various modeling tasks are discussed from a system evolution perspective. These include dynamic prediction, diagnostic, optimization, and identification.

Chapter 2 by Araujo, Nedjah, and Mourelle proposes the application of a hybrid approach to synthesize finite state machines. The chapter discusses the main stages of for implementing a state machine starting from the specification passing by state reduction, state assignment, minimization of the control logic till the physical implementation. The hybrid approach proposed consists of combining two evolutionary algorithms with quantum computing to realize these the stages.

Motivated by the computational efficiency of the false nearest neighbors (FNN) method, Chapter 3 by Marin Carrion, Arias Antunez, Artigao Castillo and Miralles Canals introduces a set of interesting parallel implementations of the FNN method relying on various strategies: distributed, shared and hybrid memory architectures. In particular, the Single-Program, Multiple Data (SPMD) is adopted. The chapter discusses several experiments to assess the parallelized approaches of the FNN method.

The second part, entitled “Pattern Recognition and Nonlinear Systems Techniques, of the book consists also of three chapters (4, 5, and 6). Chapter 4 by Young discusses a nonlinear dynamical system based on kernel auto-regressive model for studying gene expression networks. Based on kernel methods, a nonlinear mapping among the gene expression dynamics is induced and a kernel recursive least squares is developed for building the autoregressive model and estimating its parameters. A number of experiments have been discussed in the chapter to reflect on the suitability of the nonlinear system proposed.

In Chapter 5 of the book by Kisku et al. discusses the application of Scale Invariant Feature Transform (SIFT) features in biometrics. In particular SIFT features are explored for face recognition, fingerprint verification, and interestingly in multimodal biometrics.

Chapter 6 by Hefnawy presents different methodologies for restoration of images. This

chapter focuses on spatial and spatial-temporal super resolution exhibiting nonlinearity issues of the restoration task. Examples are highlighted to make the ideas accessible.

Part three of the book deals with some applications of computational models for nonlinear dynamical systems in some domains. In fact, Chapter 7 by Vouldis discusses an interesting question, that is, whether nonlinear science can contribute in modeling and analyzing financial markets. The chapter provides a nice introductory overview of the application of various computational intelligence tools to various facets of the nonlinear financial analysis.

Chapter 8 by Radeva investigates various issues pertaining to nonlinear structural dynamics at seismic excitations, structural control systems, and regenerative force actuation network. The chapter shows in particular the application of computational intelligence (such as learning vector quantization, Kohonen self-organizing maps, fuzzy logic) to regenerative force actuation network to decision making regarding switching on actuators for structural control.

The last chapter by Momeni and Fathy is about vehicular ad hoc networks (VANET) and clustering. It discusses reactive location-based routing relying on the technique of directional cluster-based flooding (LORA-DCBF) for inter-vehicle communication. A comparative analysis between the LORA-DCBF approach and the location-based routing algorithm with cluster-based is also provided.

We hope that this book helps show some of the applications where computational intelligence techniques can be genuinely used to model nonlinear dynamical systems. At the end, we would like to gratefully acknowledge and sincerely thank all the reviewers for their insightful comments and criticism of the manuscripts. Our thanks go also to the authors for their contributions and collaboration. Finally, we are grateful to Atlantis Press for agreeing to publish this book.

A. Bouchachia, K. Kyamakya

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