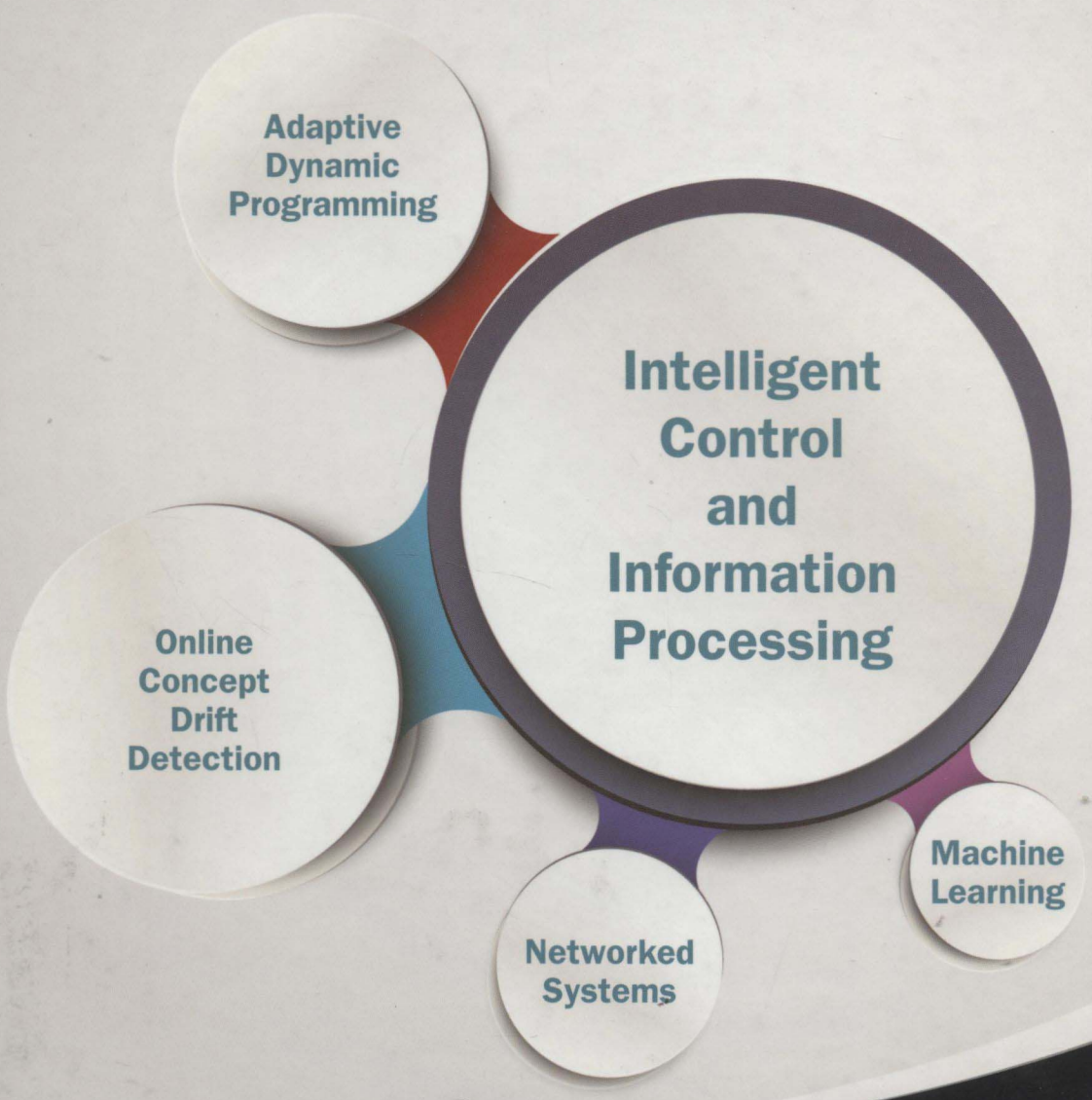
Frontiers of Intelligent Control and Information Processing

Derong Liu, Cesare Alippi,
Dongbin Zhao & Huaguang Zhang



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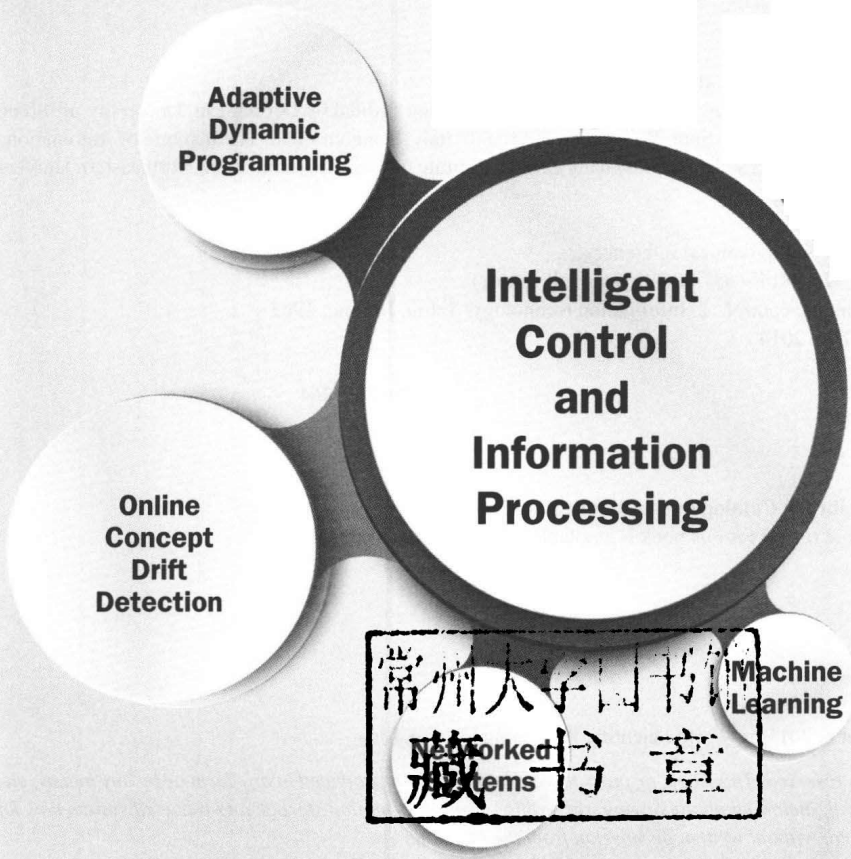

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Frontiers of Intelligent Control and Information Processing

Preface

Intelligence and cognition mechanisms represent the frontiers in control and information processing and define a mainstream where young researchers are invited to join the effort. In this direction the book aims to promote research in *Intelligent Control and Information Processing* by identifying some up-to-date research directions and challenges.

The book is composed of 17 chapters that cover hot research areas from intelligent control to intelligent information processing with a special focus on intelligent optimal control with adaptive/approximate dynamic programming and reinforcement learning, intelligent control and information processing of networked systems and machine learning techniques for big data.

The first six chapters focus on recent advances in intelligent optimal control with adaptive/approximate dynamic programming and reinforcement learning.

Chapter 1 by Abouheaf and Lewis, brings together discrete Hamiltonian mechanics, distributed multi-agent control, optimal control theory, game theory, and reinforcement learning techniques to formulate and solve the multi-agent graphical games problem. Ideas from cooperative control are used to attain synchronization among the agents' dynamics to leader's dynamics. The chapter lays the mathematical foundation for developing adaptive learning solutions for dynamic graphical games.

In Chapter 2, Yang, Liu, Wei, and Wang develop a reinforcement learning-based online adaptive control to deliver a desired tracking performance for a class of discrete-time (DT) nonlinear systems in the presence of unknown bounded disturbances. The research investigates multi-input-multi-output unknown nonaffine nonlinear DT systems. An action neural network is employed for both generating the optimal control signal and cancelling the nonlinearity of unknown DT systems. A critic neural network is then built to estimate the cost function, which satisfies the recursive equations derived from heuristic dynamic programming.

In Chapter 3, Ni, He, and Zhong investigate a data-driven heuristic dynamic programming architecture to tackle the partially observed Markov decision process. Specifically, they include a state estimator neural network to recover the full system information for the action network, so that the optimal control policy can still be achieved under partially observed environment.

In Chapter 4, Zhu and Zhao focus on online reinforcement learning for continuous state-action systems. Continuous state-space problems are more difficult than finite state ones since the number of states is infinite. Both the recursive least-square policy iteration method and the multi-samples in each cell approach have been studied and their performance is illustrated with examples.

In Chapter 5, He, Qin, and Wu propose a novel adaptive iterative learning algorithm for a class of constrained robotic manipulators with uncertainties and external disturbances. The controller design is based on a reduced form of the robot model. The uncertain parameters are estimated in time domain whereas the repetitive disturbances are compensated in the iterations. With the adoption of a saturated learning method, all signals in the closed loop are guaranteed to be bounded.

In Chapter 6, Xu, Sahoo, and Jagannathan develop a novel time-based finite horizon neural dynamic programming scheme for nonlinear networked control systems. Neural networks are used to generate the identifier, the critic and the action networks yielding optimal control policies in the presence of uncertain system dynamics due to communication network imperfections such as network-induced delays and packet losses.

A second group of chapters bridges between methodologies of intelligent control and information processing.

In particular, Chapter 7 by Yan and Wang investigates model predictive control (MPC) solutions which generate control signals by means of a real-time optimization of a performance index over a finite moving horizon of predicted future. Novel MPC approaches are developed for nonlinear systems with un-modeled dynamics based on neural networks.

In Chapter 8, Zhao and Liu propose a natural approach for packet-based communication and control co-design framework for networked control systems, which enables a sequence of control signals to be sent over the network simultaneously within one data packet. In turn, this makes it possible to actively compensate for the communication constraints in networked control systems with specially designed compensation mechanisms.

In Chapter 9, DasGupta and Srinivasan focus on privacy preserving computational models which are evidenced by distributed computing applications and game-theoretic settings, due to the increasingly widespread usage of sensitive data in networked environments. Since perfect privacy is often either impossible or too costly to achieve (e.g., it requires impractically extensive communication steps) they review various notions of approximate privacy.

The last group of chapters addresses some challenging topics in machine learning, deep learning, pattern recognition, dynamic optimization, and classification, and describes real world applications such as electromyography, smart grid, image encryption, and big data.

Chapter 10 by Alippi, Boracchi, Bu, and Zhao focuses on online detection of the occurrence of concept drift (i.e., structural changes) in datastreams, which represents a hot research topic with striking implications, e.g., network traffic monitoring and credit-card fraud detection, monitoring-based systems and big data applications. The chapter describes a change-detection method based on encoding-decoding mechanism, which is computationally simple, yet effective method for detecting concept drift in datastreams.

In Chapter 11, Ju, Ouyang, Wilamowska-Korsak, and Liu focus on the challenging problems of achieving a satisfactory rate for the surface electromyography pattern recognition, which is becoming a main issue in on-going research in rehabilitation and prosthetics. This chapter introduces nonlinear feature extractions and nonlinear classification solutions to efficiently identify different human hand manipulations based on surface electromyography signals.

In Chapter 12, Severini, Squartini, and Piazza investigate dynamic pricing policies as an effective asset at a micro-grid level, and propose a hybrid energy management scheme. With the nonlinear nature of a micro grid, neural-network forecasting abilities can provide a sustainable support under realistic operating conditions. Based on the forecast of solar energy production and grid energy prices and outdoor temperature, the optimization of tasks allocation is aimed to lower both the user costs and the grid burden while accounting for user's thermal comfort.

In Chapter 13, He and Yen introduce an ensemble method to compare six state-of-the-art multi-objective evolutionary algorithms designed specifically for many-objective optimization problems under a number of carefully crafted benchmark problems, by combining a number of performance metrics using double elimination tournament selection. The double elimination design allows characteristically poor performance of a quality algorithm to still be able to win it all.

In Chapter 14, Wen and Zeng concern about the problems of fuzzy modeling and synchronization of memristive Lorenz circuits with Chua's circuits. Considering the state-dependent properties of memristor, a new fuzzy model employing parallel distributed compensation gives a new way to analyze the complicated memristive circuits with only two subsystems. Several examples are also given to illustrate the effectiveness and potential applications in image encryption of the results.

In Chapter 15, Chen and Yang extend the original twin support vector machine and propose a novel graph embedded total margin twin support vector machine (GTM-TSVM). The central idea of GTM-TSVM is the plane of one class is required to be far away from the other class of samples. Moreover, the intra-class and inter-class graphs which respectively characterize the proximity relationships between samples of within and between classes are embedded into GTM-TSVM formulation so as to exploit the underlying manifold structure of data.

In Chapter 16, Zhou, Guo, and Chen investigate extensions of Kullback Leibler (KL) information measure. The proposed method goes under the framework of minimum description length principle. In the developed methods, regularization

parameters are selected by the criterion of minimization the KL divergence and approximated efficiently by second-order Taylor expansion.

In Chapter 17, Guo, Wang, and Wu study the impact of big data on evolutionary algorithms and propose a new design for evolutionary algorithms. Different from traditional ideas, the processing for big data should fully take account of data itself. An example of correlation analysis for big data in business intelligence is presented based on the evolutionary algorithms which demonstrates that the evolutionary algorithm is useful and helpful for e-business to make correct judgements for commodities storage, transfer and sales.

At last but not least, we wish to thank both authors and editors for having allowed us to finish the book within the set deadline. We would also like to thank Mr. Xiong Yang for his help in preparing the LaTeX manuscript. We believe readers will take advantage of the book content since it sets the frontiers of research. It requires everyone's effort to take the next steps so as to move the research frontier further.

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Contents