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BOOK REVIEW

DIFFERENTIAL NEURAL NETWORKS FOR ROBUST NONLINEAR CONTROL—IDENTIFICATION, STATE ESTIMATION AND TRAJECTORY TRACKING,
A. S. Poznyak, E. N. Sanchez and W. Yu, World Scientific, 2001, 410 pages, ISBN 981-02-4624-2

1. INTRODUCTION

Though it is known that model-based control is superior than non-model-based control, given a nonlinear system, it may be fair to say that it is more difficult to obtain a realistic model than to design a working control system in reality. This is especially true for complex nonlinear systems. The technically beautiful control system design methods based on the structural properties, such as linear-in-the-parameters, of the systems could only be used when the systems are checked to be indeed satisfying the assumptions made. In addition, all models have a limited domain of validity, and modelling errors do exist. In fact, a law of nature is a mathematical model with a large domain of validity, but it is still limited. Thanks to the perseverance, persistence and brain cracking sleepless nights of many researchers, many fundamental contributions have been made in the areas of control design and system identification based on approximation techniques including neural networks (wavelets), fuzzy logic, polynomials. As approximation based control, non-model based control, enters its accepted paradigm though not maturity as yet, several text books systematically documented the recent advances [1–7], as well as the one being reviewed here.

Due to the big enthusiasm generated by successful applications, the use of static (feedforward) neural networks/fuzzy systems in automatic control is well established [1–7]. However, they do not have memory in the sense that their outputs are uniquely determined by the current values of their inputs and weights, this is in high contrast to biological neural systems which always have feedback in their operation such as the cerebellum and its associated circuitry, and the reverberating circuit. Feedback is the basis for many of the nervous system activities. As a natural extension of using static neural networks to approximate nonlinear functions, dynamic (differential) neural networks can be used to approximate the dynamic behaviour of dynamic nonlinear systems as detailed in the book under review.

2. THE BOOK

Though dynamic neural networks are good candidate for modelling and control of general nonlinear systems, there are only a handful of research results on dynamic neural networks for systems modelling and control. This book is dedicated to the use of a class of dynamic (differential) neural networks as a tool for system identification, control system design, and applications by utilizing its property of approximating the dynamic behaviour of dynamic nonlinear systems. The error convergence and its bound analysis are provided using Lyapunov synthesis. The effectiveness of the approach is illustrated by applications to various physical systems including chaotic systems, robots, chemical processes and among others.

This book consists of two distinct parts: theoretical study and neurocontrol applications. The former is the foundation of the book, and ranges from Chapters 1 to 6, while the latter, from Chapters 7 to 10, helps readers to appreciate the theoretical applications in solving practical problems.

In Chapter 1, the book gives a very concise and clear account of different types of neural networks. It walks the reader from biological neural networks, neuron models, through neural structures, and ends at neural networks in control. Then the book devotes the remaining chapters in Part I to system identification, state estimation and control system design in sequence. In Chapter 2, adaptive nonlinear system identification is presented under the assumption that states are measurable. For simplicity, the ideal cases, exact neural network matching with the system, are presented, and followed by the more realistic cases, bounded modelling error cases, for both single layer and multi-layer differential neural networks. To handle the problem of bounded disturbances, sliding mode techniques are used for robust system identification in Chapter 3. In Chapter 4, the authors demonstrate that dynamic neural networks can also be used to construct observers after the briefing of nonlinear systems and observers, and robust nonlinear observers. For control system design, different techniques can be used. Chapter 5 is devoted to neural control based on passivity, while Chapter 6 is on neural tracking control using Lyapunov synthesis. Apparently, other techniques remain to be explored including learning control, and variable structure control.

After the theoretical development in Part I, Part II is mainly concerned with applications. Chapter 7 is on neural control of chaotic systems including the Lorenz system, Duffing equation, and Chua's circuit. In Chapter 8, after the introduction of robot dynamics, neural control with state observer are presented, followed by simulation studies. Chapter 9 gives detailed accounts of process modelling, neural observer design, and system identification of chemical processes. Neural control of distillation column is detailed in Chapter 10. Chapter 11 concludes the book followed by a few useful appendices.

3. CONCLUSION

The book is the result of many years of research and publications by the authors. Overall, it is a good one that could benefit the researchers and practitioners in the field of intelligent nonlinear control systems. Design methods and analytical results are well presented and substantiated by closely-related simulation examples and engineering applications. Despite a few typographical inconsistencies, the book is a very good addition to the libraries of those interested in the subject. It is also qualified to be used as a postgraduate-level reference.

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