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Tree-Structure Based Hybrid Computational Intelligence

Theoretical Foundations and Applications

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Preface

Computational intelligence is a well-established paradigm, where new theories with a sound biological understanding have been evolving. The current experimental systems have many of the characteristics of biological computers (brains in other words) and are beginning to be built to perform a variety of tasks that are difficult or impossible to do with conventional computers. In a nutshell, which becomes quite apparent in the light of the current research pursuits, the area is heterogeneous as being dwelled on such technologies as neurocomputing, fuzzy inference systems, artificial life, probabilistic reasoning, evolutionary computation, swarm intelligence and intelligent agents and so on.

Research in computational intelligence is directed toward building thinking machines and improving our understanding of intelligence. As evident, the ultimate achievement in this field would be to mimic or exceed human cognitive capabilities including reasoning, recognition, creativity, emotions, understanding, learning and so on. Even though we are a long way from achieving this, some success has been achieved in mimicking specific areas of human mental activity.

Recent research in computational intelligence together with other branches of engineering and computer science has resulted in the development of several useful intelligent paradigms. The integration of different learning and adaptation techniques, to overcome individual limitations and achieve synergetic effects through hybridization or fusion of some of these techniques, has in recent years contributed to a large number of new hybrid intelligent system designs.

Learning methods and approximation algorithms are fundamental tools that deal with computationally hard problems, in which the input is gradually disclosed over time. Both kinds of problems have a large number of applications arising from a variety of fields, such as function approximation and classification, algorithmic game theory, coloring and partitioning, geometric problems, mechanism design, network design, scheduling, packing and

covering and real-world applications such as medicine, computational finance, and so on.

In this book, we illustrate Hybrid Computational Intelligence (HCI) framework and it applications for various problem solving tasks. Based on tree-structure based encoding and the specific function operators, the models can be flexibly constructed and evolved by using simple computational intelligence techniques. The main idea behind this model is the flexible neural tree, which is very adaptive, accurate and efficient. Based on the pre-defined instruction/operator sets, a flexible neural tree model can be created and evolved. The flexible neural tree could be evolved by using tree-structure based evolutionary algorithms with specific instructions. The fine tuning of the parameters encoded in the structure could be accomplished by using parameter optimization algorithms. The flexible neural tree method interleaves both optimizations. Starting with random structures and corresponding parameters, it first tries to improve the structure and then as soon as an improved structure is found, it fine tunes its parameters. It then goes back to improving the structure again and, provided it finds a better structure, it again fine tunes the rules' parameters. This loop continues until a satisfactory solution is found or a time limit is reached.

This volume is organized into 6 Chapters and the main contributions are detailed below:

Chapter 1 provides a gentle introduction to some of the key paradigms in computational intelligence namely evolutionary algorithms and its variants, swarm intelligence, artificial neural networks, fuzzy expert systems, probabilistic computing and hybrid intelligent systems.

Chapter 2 exhibits the flexible neural tree algorithm development and is first illustrated in some function approximation problems and also in some real world problems like intrusion detection, exchange rate forecasting, face recognition, cancer detection and protein fold recognition. Further the multi-input multi-output flexible neural tree algorithm is introduced and is illustrated for some problem solving. Finally an ensemble of flexible neural trees is demonstrated for stock market prediction problem.

Chapter 3 depicts three different types of hierarchical architectures. First the design and implementation of hierarchical radial basis function networks are illustrated for breast cancer detection and face recognition. Further, the development of hierarchical B-spline networks is demonstrated for breast cancer detection and time series prediction. Finally, hierarchical wavelet neural networks are presented for several function approximation problems.

Building a hierarchical fuzzy system is a difficult task. This is because the user has to define the architecture of the system (the modules, the input variables of each module, and the interactions between modules), as well as the rules of each modules. **Chapter 4** demonstrates a new encoding and an automatic design method for the hierarchical Takagi-Sugeno fuzzy inference system with some simulation results related to system identification and time-series prediction problems.

Can we evolve a symbolic expression that can be represented as a meaningful expression, i.e., a differential equation or a transfer function and it can be easily addressed by using traditional techniques? **Chapter 5** exhibits a new representation scheme of the additive models, by which the linear and nonlinear system identification problems are addressed by using automatic evolutionary design procedure. First a gentle introduction to tree structural representation and calculation of the additive tree models is provided. Further an hybrid algorithm for evolving the additive tree models and some simulation results for the prediction of chaotic time series, the reconstruction of polynomials and the identification of the linear/nonlinear system is demonstrated.

Chapter 6 summarizes the concept of hierarchical hybrid computational intelligence framework introduced in this book and also provides some future research directions.

We are very much grateful to Dr. Thomas Ditzinger (Springer Engineering Inhouse Editor, Professor Janusz Kacprzyk (Editor- in-Chief, Springer *Intelligent Systems Reference Library* Series) and Ms. Heather King (Editorial Assistant, Springer Verlag, Heidelberg) for the editorial assistance and excellent cooperative collaboration to produce this important scientific work. We hope that the reader will share our joy and will find it useful!

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