Guest editorial: Evolving learning and adaptive modelling approaches to prediction, forecasting and control—preface to the special issue

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1 Introduction

Prediction and forecasting is the one of the most important topics in almost all academic disciplines from the natural and social sciences to the engineering, humanities, government and business. Prediction and forecasting methods include a most wide varieties of applications from the critical issues related to human wellbeing such as global climate change and economic growth, to the key issues to the government and business such as government budget forecasting and business sale prediction, as well as the routine forecasting in our daily life such as whether forecasting and traffic flow prediction. The academic importance and wide applications of prediction and forecasting methods and applications are the main motivation behind this special session of Evolving Systems Journal.

Despite of the wide ranges of different approaches available for prediction and forecasting, evolving learning and adaptive modelling approaches (Kasabov and Song 2002; Angelov 2002; R. Yager 2006; Angelov and Filev 2004) have an important and unique role to play for the reasons as follows:

- many relationships and systems in applications are time varying systems in the sense that their system structure, parameters and environments are changing with the time and system states. The prediction and forecasting in such circumstance require evolving learning and adaptive modeling approaches which can follow the

dynamic changing of the system structure, parameters and environments;

- the availability of the massive streaming data makes the evolving learning and adaptive modeling approaches unavoidable or more efficient in many applications. For example, in the forecasting and algorithmic trading of stock and electronic financial markets, it requires the learning algorithms to process the thousands of transactions per second within the fast changing trading environment. In this case, it is impossible to store all historical data and process the off-line learning to identify the structure and parameters to meet the demand of the learning and high-frequency computer trading. In these situations, on-line evolving learning and adaptive modeling approaches are the only feasible opinion;
- the evolving learning and adaptive modelling approaches provide the effective alternatives and more user-friendly tools for prediction and forecasting of the highly nonlinear and complex systems. For example, when applying fuzzy systems and neural networks to prediction and forecasting, it requires rich experiences and expertise to determine the system architecture and configuration and involve complicated nonlinear optimization problems which the existing algorithms often fail to find the best structure and global optimal parameters. The former makes the usability of these approaches beyond the ability to non-expert users, whereas the latter leads to the sub-optimal systems whose quality and behavior is unpredictable. As the alternatives, evolving learning and adaptive modelling approaches are much more accessible by non-expert users due to their capability of automatically identifying the system structure and parameters. Further, evolving learning and adaptive modelling approaches

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focus on learning and forecasting a system around its current or updated state and environment, it leads to simpler and better quality forecasting models.

2 Overview on this special issue

This special issue includes five papers in evolving learning and adaptive modelling methods and applications.

The first paper in this special issue, titled “Evolving fuzzy systems for pricing fixed income options,” by Leandro Maciel, Andre Lemos, Fernando Gomide, and Rosangela Ballini, is a typical representative of this special issue. It introduces a new evolving fuzzy system modeling approach to estimate prices of fixed income options, which is one of the most important fields in financial engineering. The two distinctive features of this paper are that, firstly, it shows that the evolving system approach are especially suitable and effective to option and stock pricing forecasting; secondly, different to many existing evolving fuzzy systems, the participatory evolving approach is proposed and enhanced in the paper with the arousal mechanism, which monitors the performance of the system by observing the compatibility of the current model with the new observations and accordingly updating the structure/parameters of the identified system.

The paper “An improved approach of self-organising fuzzy neural network (SOFNN) based on similarity measures” by Gang Leng, Xiao-Jun Zeng, and John A. Keane is another typical paper for this special session. In the paper, the authors improve and enhance the existing SOFNN method (Leng et al. 2006) to avoid fuzzy neural networks becoming more and more complicated along the evolving learning process. In addition to the pruning strategy of removing redundant rules, the paper introduces the similarity measures between fuzzy rules to identify the similarity degree of fuzzy rules and merge those rules with high degree of similarity. Such an integrated approach has the advantages of reducing model overfitting, enhancing interpretability and improving computing effectiveness. Benchmark examples are presented for comparative analysis of model accuracy and compactness.

As an application of the evolving approach to manufacturing systems, in the paper “A multi-objective evolutionary approach to scheduling for evolving manufacturing systems,” by Benjamin Klopper, Jan Patrick Pater, Shiniichi Honiden, and Wilhelm Dangelmaier, a multi-objective evolutionary approach for evolving manufacturing systems is proposed. This is a research work responding to the new challenge regarding the scheduling in new paradigm of service oriented and self-optimizing manufacturing systems to meet the requirement to adapt to changing

production programs due to shorter product life-cycles or individualized manufacturing. The proposed hierarchical task network planning and evolutionary multi-objective scheduling as an evolving manufacturing system has showed its promising and effectiveness by numerical experiments with the implemented prototype.

Following the principle of evolving learning and adaptive modelling approaches, two papers related to predictive and adaptive control are included in the special issue. In the first paper “Adaptive unified predictive control applied to first-order-plus-dead-time processes to eliminate unknown class of deterministic disturbance” by S. K. Lin and A. C. Lee, an adaptive unified predictive control method is developed for systems with unknown disturbances. The method includes two key components: the first component includes the online recursive least square method with forgetting factor and the variable regression estimation method to identify the time-varying and noise disturbed systems; the second component is the adaptive unified predictive control scheme designed based on the online estimated system model from the first component to form an indirect self-tuning regulator. With four simulation cases, it is shown that this scheme is very effective in controlling first order-plus-dead-time control systems with uncertainties. Different to the above paper, the paper “Fuzzy adaptive control for a class of nonlinear systems with unknown control gain” by Salim Labiod and Thierry Marie Guerra presents a different approach. The basic idea is that, rather than trying to estimate the control system model and then designing the corresponding control, a direct adaptive control with the explicit system estimation is designed. Through the mathematical proof and simulation example, it is shown that such a direct adaptive control based on online state feedback is capable of achieving the control goal of asymptotic convergence of the tracking error (i.e., the convergence of the state variables to their desired trajectories). Therefore this paper shows an alternative approach of evolving learning and adaptive modelling.

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