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Chapter XVII

An Integrated Intelligent System Model and Its Applications in Virtual Product Design and Development

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Abstract

In this chapter, a novel integrated intelligent framework is first proposed for virtual engineering design and development based on the soft computing and hybrid intelligent techniques. Then, an evolutionary neuro-fuzzy (EFNN) model is developed and used for supporting modeling, analysis and evaluation, and optimization tasks in the design process, which combines fuzzy logic with neural networks and genetic algorithms. The developed system HIDS-EFNN provides a unified integrated intelligent environment for virtual engineering design and simulation. The focus of this chapter is to present a hybrid intelligent approach with evolutionary neuro-fuzzy modeling and its applications in virtual product design, customization, and simulation (product performance prediction). Case studies are provided to illustrate and verify the proposed model and approach.

Introduction

Design process is an iterative and highly interactive task. The designer has to consider countless constraints with usually opposing goals in the design process. Automatic design, analysis, evaluation, modification, and optimization of design parameters are important issues to be addressed during the design process. Thus, design is a process that includes not just the use of a quantitative technique but also the use of a qualitative technique. Over the past two decades, artificial intelligence (AI) techniques seem to have emerged as the main contender for conventional design techniques. Many efforts have been made to apply AI techniques such as expert system, fuzzy logic, neural network, and genetic algorithms to help accomplish some design tasks (Dagli, 1994; Wang & Takefuji, 1993; Zha, 2004b). While these techniques have produced encouraging results, the design problem is too complex to be solved by a single AI technique alone.

Each AI technique has particular strengths and weaknesses that make them suited for particular problems and not for others (Medesker, 1995). For instance, while neural networks are good at recognizing patterns, they are generally not good at explaining how they reach their decisions. On the other hand, fuzzy systems are good at explaining their decisions, but they cannot automatically acquire the rules they use to make those decisions. Thus, according to Goonatilake and Khebbal (1995), hybrid intelligent systems (HIS) may have to be used in which two or more AI techniques are integrated to overcome the limitations of each individual technique or in which different intelligent modules are used to collectively solve all the problems, with each solving the parts at which it is best. Here, the author prefers to use hybrid intelligent system (HIS) other than intelligent hybrid systems (IHS) as a hybrid system is in some cases referred to as a combination/integration of continuous and discrete systems. The high complexity and the inherent heterogeneity of many real world problems is one of the major challenges of current AI techniques. Due to the necessity of using different problem solving techniques, the interest in HIS is rapidly growing. HIS has been applied to many areas including process control, process fault diagnosis, prediction of economic data, and so forth. However, there is relatively little work on applying HIS to the design process.

This chapter aims to develop a hybrid intelligent model for supporting computational intelligent design and simulation. An evolutionary neuro-fuzzy or fuzzy neural network (EFNN) model is proposed with an integration of the neural networks, fuzzy logic, and genetic algorithms techniques for virtual product design, simulation, and customization.

The remaining parts of this chapter are organized as follows. The next section provides an overview of hybrid intelligent design systems. Then, a soft computing based integrated and hybrid intelligent framework for engineering design is proposed, followed by discussion of the evolutionary neuro-fuzzy (EFNN) model. After that, the implementation of the HIDS-EFNN design system is outlined and case studies for design and simulation using the developed model and system are provided. Finally the chapter is summarized and concluded.