Chapter X

Swarm Intelligence and the Taguchi Method for Identification of Fuzzy Models

Arun Khosla, National Institute of Technology, Jalandhar, India

Shakti Kumar, Haryana Engineering College, Jagadhari, India

K. K. Aggarwal, GGS Indraprastha University, Delhi, India

ABSTRACT

Nature is a wonderful source of inspiration for building models and techniques for solving difficult problems in design, optimisation, and control. More specifically, the study of evolution, the human immune system, and the collective behaviour of insects/birds have guided the origin of evolutionary algorithms, artificial immune systems, and optimisation techniques based on swarm intelligence, respectively. In this chapter, we present the use of particle swarm optimisation (PSO) and the Taguchi method for the identification of optimised fuzzy models from the available data. PSO is a member of the broad category of swarm intelligence (SI) techniques based on the metaphor of social interaction. It has been used for finding promising solutions in complex search spaces through the interaction of particles in a swarm, and is especially useful when dealing
with a high number of dimensions and situations where problem-specific information is not available. However, caution needs to be exercised in selecting PSO, as the performance of PSO largely depends on their values. In this chapter, a systematic reasoning approach based on the Taguchi method is also presented to quickly identify PSO parameters. The Taguchi method is a robust design approach that helps in optimisation, and which requires relatively few experiments. Although we focus here on the use of PSO and the Taguchi method for fuzzy model identification, these techniques have much broader use and application. In order to validate our approach, data from the rapid Nickel-Cadmium (Ni-Cd) battery charger developed by the authors were used. The results are based on real data and illustrate the viability and efficiency of the approach.

INTRODUCTION

In recent years, the concept of fuzzy set theory has received considerable attention, both in academia and industry, due to its ability to handle ambiguous or vague concepts of human perception for complex systems problems, in which it is extremely difficult to describe the system models mathematically. Moreover, the concept of fuzzy set has been applied successfully in many disciplines.

The problem of fuzzy system modelling or fuzzy model identification is generally the determination of a fuzzy model for a system or process by making use of linguistic information obtained from human experts, and/or numerical information obtained from input-output measurements. The former approach is known as knowledge-driven modelling, while the latter is known as data-driven modelling. In this chapter, attention is focused on building fuzzy models from the available data using PSO, a relatively new optimisation technique.

The performance of PSO and other evolutionary algorithms, to a great extent, depends upon the choice of appropriate parameters. Generally, these parameters are selected through a hit-and-miss (trial-and-error) process, which is unsystematic and requires unnecessarily rigorous experimentation. In this chapter, we propose a systematic approach based on the Taguchi method for the identification of the optimal strategy parameters of PSO for fuzzy model identification.

The remainder of the chapter is structured as follows: The next section serves as a brief introduction to swarm intelligence and the PSO algorithm. Brief information about the fuzzy model identification problem is provided in the following section. Some details about the rapid Ni-Cd battery charger are then provided. A framework for fuzzy model identification through using the PSO algorithm is presented in the next section. The proposed framework has been applied to identify fuzzy models for a rapid Ni-Cd battery charger. A description of the Taguchi method, together with selection of appropriate parameters for the PSO algorithm for fuzzy model identification, is given in the next-to-last section. Here we also present a comparison of the computational efforts required by both the Taguchi method and the traditional approach, which involves exhaustive combinations of the PSO operating parameters. Concluding remarks are made in the final section.
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