

Chapter 15

Evolutionary Computing Approaches to System Identification

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ABSTRACT

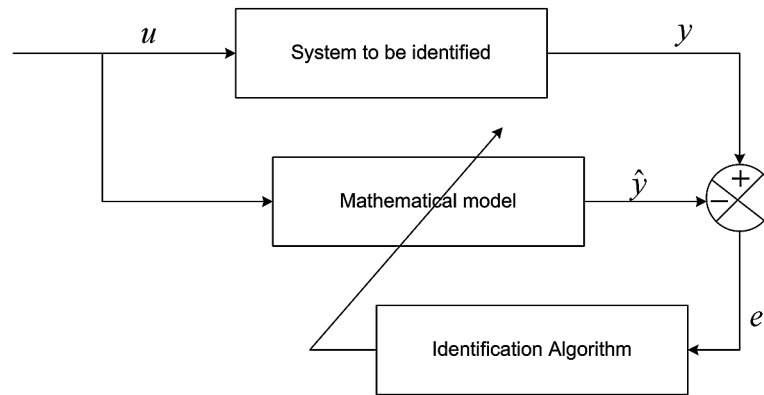
In this chapter, we describe an important class of engineering problem called system identification which is an essential requirement for obtaining models of system of concern that would be necessary for controlling, analyzing the systems. The system identification problem is essentially to pick up the best model out of the several candidate models. Thus, the problem of system identification or modeling building turns out to be an optimization problem. The chapter explain what are different evolutionary computing techniques used in the past and the state- of the art technologies on evolutionary computation. Then, some case studies have been included how the system identification of a number of complex systems effectively achieved by employing these evolutionary computing techniques.

1. INTRODUCTION

System identification or obtaining mathematical models of complex real-world is an important task in many fields of engineering. Identification of a dynamic system i.e. model building is essential for developing control, analysis, prediction, supervision and optimization. System parametric identification is usually achieved in two steps: the first step is selecting a model family from which a candidate model is produced by minimizing some error criterion. The second step is validating the identified candidate model in terms of verifying some performance indicators, such as noise independence, error auto-correlation, input/error correlation and real response following among others. If results do not satisfy some of the performance indicators, an alternative model must be produced over a different model family. Figure 1 describes the concept of system identification, where u is the input to the system,

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Figure 1. System identification



y is the system output, \hat{y} is the output of the identified model and e is the error between the actual and the identified model outputs.

An identification problem can be transformed into an optimization problem for which an evolutionary approach can be employed. Evolutionary computation uses computational models of evolutionary processes occur in nature as key elements in the design and implementation of computer-based problem solving systems. There are a variety of evolutionary computational methods that have been reported during the last three decades. These evolutionary algorithms share a common conceptual base of simulating the evolution of individual structures via processes of selection and reproduction. These processes depend on the performance (fitness) of the individual structures as defined by an environment. More precisely, evolutionary algorithms maintain a population of structures that evolve according to rules of selection and other operators, such as recombination and mutation. Each individual in the population receives a measure of its fitness in the environment. Selection focuses attention on high fitness individuals, thus exploiting the available fitness information. Recombination and mutation perturb those individuals, providing general heuristics for exploration. Figure 2 outlines a generic evolutionary algorithm (EA).

A population of individual structures is initialized and then evolved from generation to generation by repeated applications of evolutionary operators evaluation, selection, recombination, and mutation. The population size N is generally constant in an evolutionary algorithm. An evolutionary algorithm typically initializes its population randomly, although domain specific knowledge can also be used to bias the search. Evaluation measures the fitness of each individual according to its worth in some environment. Selection decides who become parents in the next generation and how many children the parents have. Children are created via recombination, which exchanges information between parents, and mutation, which further perturbs the children. The children are then evaluated. Finally, the survival step decides who survives in the population.

2. EVOLUTIONARY ALGORITHMS PARADIGMS

The origin of evolutionary algorithms has dated back to early fifties (Fraser, 1957; Box, 1957). The earliest EAs that predominated in many engineering and related applications are, GA, GP, ES and EP.

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