Chapter IX
Evolutionary Computing in Engineering Design

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ABSTRACT

This chapter presents an overview of the application of evolutionary computing for engineering design. An optimal design may be defined as the one that most economically meets its performance requirements. Optimisation and search methods can assist the designer at all stages of the design process. The past decade has seen a rapid growth of interest in stochastic search algorithms, particularly those inspired by natural processes in physics and biology. Impressive results have been demonstrated on complex practical optimisation of several schools of evolutionary computation. Evolutionary computing unlike conventional technique, have the robustness for producing variety of optimal solutions in a single simulation run, giving wider options for engineering design practitioners to choose from. Despite limitations, the act of finding the optimal solution for optimisation problems has shown a substantial improvement in terms of reducing optimisation process time and cost as well as increasing accuracy. The chapter aims to provide an overview of the application of evolutionary computing techniques for engineering design optimisation and the rational behind why industries and researchers are in favor of using it. It also presents the techniques application trend rise in the past decade.

INTRODUCTION

The use of evolutionary computing (EC) to solve many optimisation problems in engineering design is becoming more and more popular among computational and data intensive scientific and engineering application areas. Examples of such computational and data intensive applications are engineering design optimisation, bioinformatics, pharmaceutical and particle physics simulations, and many others. Additionally, since EC techniques mimic nature through natural selection, knowledge-driven problem solving environments (PSEs) are ideal frameworks for optimisation problems using EC.

This chapter will focus on how evolutionary computing techniques can be used for engineering design within a large range of engineering disciplines.

The concept of design was born the first time an individual created an object to serve human needs (Hernandez & Fontan, 2002). Today design is still the ultimate expression of the art and science of engineering. From the early days of engineering, the goal has been to improve design so as to achieve the best way of satisfying the original need, within the available needs.

The design process can be described in many ways; however, there are certain elements in the process that any description must contain: recognition of need, an act of creation, and a selection of alternatives. Traditionally, the selection of the "best" alternative is the phase of design optimisation (Chinyere, 2000). Optimisation is the act of obtaining the best result under given circumstances (Jun, Tischler, & Venkayya, 2002). In design, construction, and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is either to minimise the effort required or to maximise the desired benefit. Since the effort required or the benefit desired in any practical situation can be expressed as a function of certain decision variables, *optimisation* can be defined as the process of finding the conditions that give the maximum or minimum value of a function (Singiresu, Xiong, & Ying, 2000).Today, however, the complexity of this process is alleviated by the introduction of *artificial intelligence* and advancement of computing so as the availability of more powerful optimisation techniques. It also gives the opportunity to designers to choose a technique that is relevant to the particular design problems in finding the "best" alternative.

TAXONOMY OF ENGINEERING DESIGN OPTIMISATION

It is imperative to understand the organisational structure or *taxonomy of engineering design optimisation*. This orderly classification allows engineers to understand design optimisation problems according to certain characteristics and problem solving philosophy and facilitates organisation and reuse of knowledge in the design process. It also enhances the representation of knowledge and capturing of the reasoning schemes behind designs. Taxonomies help engineers to compare different design methods and tools and come up with suggestions on how best to use computer aided systems in designs. Ullman and D'Ambrosio (1995) propose four classifications starting with structure of engineering design optimisation, problem focus, and range of independence and level of support. Structure of engineering design optimisation consists of four sub classes, namely, decision space, which consists of problem completeness, abstraction level, and determinism, preference model which consists of objective function, preference model which consists of consistency and completeness of engineering design, and belief model which is concerned with dimension and belief completeness of the design.

Tiwari (2001) proposes a number of classification schemes for engineering design optimisation