Chapter 12
Solving Fuzzy Optimization Problems of Uncertain Technological Coefficients with Genetic Algorithms and Hybrid Genetic Algorithms Pattern Search Approaches

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ABSTRACT

In this chapter a solution is proposed to a certain nonlinear programming difficulties related to the presence of uncertain technological coefficients represented by vague numbers. Only vague numbers with modified s-curve membership functions are considered. The proposed methodology consists of novel genetic algorithms and a hybrid genetic algorithm pattern search (Vasant, 2008) for nonlinear programming for solving problems that arise in industrial production planning in uncertain environments. Real life application examples in production planning and their numerical solutions are analyzed in detail. The new method suggested has produced good results in finding globally near-optimal solutions for the objective function under consideration.

INTRODUCTION

In order to deal with the vagueness of human thought, Zadeh (1965) first introduced fuzzy set theory. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership function which assigns to each object a grade of membership ranging between zero and one (Zadeh, 1965). A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or non-membership, whereas fuzzy sets allow partial membership. In other words, an element may partially belong to a fuzzy set (Ertugrul and Karakasoglu, 2006; Liang, 2008; Peidro et. al, 2010). Fuzzy sets and fuzzy logic are powerful mathematical tools for
modeling: uncertain systems in industry, nature and humanity; and facilitators for commonsense reasoning in decision making in the absence of complete and precise information. Their role is significant when applied to complex phenomena not easily described by traditional mathematical methods, especially when the goal is to find a good approximate solution (Bojadziev and Bojadziev, 1998; Zamirian et. al, 2009). Modeling using fuzzy sets has proven to be an effective way for formulating decision problems where the information available is subjective and imprecise (Zimmermann, 1992; Jimenez et. al, 2008).

A linguistic variable is a variable whose values are words or sentences in a natural or artificial language (Zadeh, 1975). As an illustration, Age is a linguistic variable if its values are assumed to be the fuzzy variables labeled young, not young, very young, not very young, etc. rather than the numbers 0, 1, 2, 3. (Bellman and Zadeh, 1977). The concept of a linguistic variable provides a means of approximate characterization of phenomena which are too complex or too ill-defined to be amenable to description in conventional quantitative terms. The main applications of the linguistic approach lie in the realm of humanistic systems—especially in the fields of artificial intelligence, linguistics, human decision processes, pattern recognition, psychology, law, medical diagnosis, information retrieval, economics and related areas (Zadeh, 1975).

In this paper a novel, genetic algorithm (GA) approach is reported that was successfully used for solving problems originating from the uncertainty of the technological coefficients in production planning in industrial engineering. The main reason for GA method is adopted in solving this problem is given below.

Some of the advantages of GA over classical optimization methods include (Deb, 2001):

1. GA is less susceptible to the complexity of the problem at hand than non-evolutionary methods;

2. They deal with multiple solutions in one run. This is useful to achieve solutions rapidly in the presence of a large number of parameters;

3. They allow the exploration of multiple local optima;

4. GAs have successfully been applied to various optimization problems that involve a large number of parameters, multiple criteria, and complex criteria relationships.

It is commonly believed that the main driving principle behind the natural evolutionary process is the Darwin’s survival-of-the-fittest principle (Eldredge, 1989). In most scenarios, nature ruthlessly follows two simple principles:

1. If by genetic processing an above-average offspring is created, it usually survives longer than an average individual and thus has more opportunities to produce offspring having some of its traits than an average individual.

2. If, on the other hand, a below-average offspring is created, it usually does not survive longer and thus gets eliminated quickly from the population.

The two important main characteristics of genetic algorithms are provided:

*Exploration*: The process of visiting entirely new regions of a search space, to see if anything promising may be found there. Unlike exploitation, exploration involves leaps into the unknown. Problems which have many local maxima can sometimes only be solved by this sort of random search.

*Exploitation*: When traversing a search space, exploitation is the process using information gathered from previously visited points in the search space to determine which places might be profitable to visit next. An example is hill climbing, which investigates adjacent points in the search space, and moves in the direction giving the greatest increase in fitness. Exploitation techniques