

Chapter 35

Genetic Algorithm for FGP Model of a Multiobjective Bilevel Programming Problem in Uncertain Environment

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ABSTRACT

This chapter describes a Genetic Algorithm (GA) based Fuzzy Goal Programming (FGP) model to solve a Multiobjective Bilevel Programming Problem (MOBLPP) with a set of chance constraints within a structure of decentralized decision problems. To formulate the model, the chance constraints are converted first to their crisp equivalents to employ FGP methodology. Then, the tolerance membership functions associated with fuzzily described goals of the objective functions are defined to measure the degree of satisfaction of Decision Makers (DMs) with achievement of objective function values and also to obtain the degree of optimality of vector of decision variables controlled by upper-level DM in the decision system. In decision-making process, a GA scheme is adopted to solve the problem and thereby to obtain a proper solution for balancing execution powers of DMs in uncertain environment. A numerical example is provided to illustrate the method.

INTRODUCTION

In a bilevel programming problem (BLPP), two DMs (leader and follower), are involved at two hierarchical decision levels and each independently controls a vector of decision variables to optimize individual objective functions, where objective functions frequently conflict among themselves in making decision.

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Actually, it is a special case of multilevel programming problem (MLPP) having multiple objectives in a decentralized decision system.

The modeling aspect of a BLPP was first studied by Fortuny-Amat, & McCarl (1981) and Candler, & Townsley (1982). Then, different methods for BLPP have been presented by Bard (1981), Bialas, & Carwan (1982, 1984) and others.

However, it may be noted that leader's decision is dominated by follower's decision is paradoxically raised for the uses of classical approaches. To avoid such situations, fuzzy programming (FP) method (Zimmermann, 1978, 1987), based on fuzzy sets (Zadeh, 1965), was extended (Slowinski, 1986; Hulsurkar, Biswal, & Sinha, 1997) to solve problems with imprecise data. The FP approaches to hierarchical optimization problems have also been studied by Tiryaki (2006). But, the difficulty with the use of FP method to BLPP is that re-evaluation of the problem with elicited membership values of objectives to be made repeatedly to reach optimal solution owing to conflict nature of objectives with regard to optimizing them. To avoid such difficulty, FGP (Pal, Moitra, & Maulik, 2003) approaches to hierarchical decentralized problems have been presented by Pal, & Biswas (2007), Pal, & Chakraborti (2013) among others in the area of study.

Now, most of the methodological developments made for BLPPs and MLPPs in the past are mainly concerned with optimization of hierarchical problems with one objective function at each level. But, it is to be observed that most of the hierarchical decision problems involve multiple objectives at each decision level. An iterative method for solving classical MOBLPP has been presented by Shi, & Xia (1997). The use of FGP to solve MOBLPPs have been proposed by Biswas, & Pal (2007), Pal, & Biswas (2007) in the past. But, in contrast to single-objective BLPP (Malhotra, & Arora, 2000), methodologies for solving MOBLPPs are yet to be studied deeply to solve practical problems.

However, in a practical decision situation, it may be mentioned that DM is frequently faced with problem of uncertainty of incorporating values of model parameters, which is inherent to resource utilization in a decision environment.

The most prominent method to solve problems with probabilistic data is stochastic programming (SP). In SP method, the uncertain model parameters are described by random variables rather than crisp description of them (Rao, 1979). Actually, SP is based on theory of probability (Charnes, & Cooper, 1959) and called chance constrained programming (CCP). The field of SP has been studied (Liu, 2000, 2002) extensively and applied to practical problem (Bravo, & Ganzalez, 2009). Again, SP methods for solving real-world optimization problems like economics, industry, military operations have become increasingly important in the current multiobjective decision making (MODM) world.

Further, in actual practice, it is to be observed that fuzzy as well as probabilistic data are inherently involved to practical problems. Eventually, both the FP and SP modelling aspects need be taken into account in the framework of executable model of a problem in uncertain environment. An optimization model with fuzzy and probabilistic data was first presented by Luhandjula (1983). Thereafter, various fuzzy stochastic programming (FSP) approaches studied in the field have been surveyed (Luhandjula, 2006). Although, FSP methods to BLPPs have been presented (Gao, & Liu, 2005; Yang, & Zhang, 2007) previously, deep study in this area is at an early stage. Further, the study on FGP approaches to probabilistically defined BLPPs is yet to circulate widely in the study area.

Now, the use of GA (Goldberg, 1989; Deb, 2002) as a global solution search approach in the field of bio-inspired computing to MODM problems has been studied by Pal, & Gupta (2008) and others. The use of GA to FGP model of a BLPP has also been discussed by Pal, & Chakraborti (2013). But, the study on implementation of GA tool to MOBLPPs is very thin.

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