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Decision Support

Quality control system design through the goal programming model and the satisfaction functions

Mohamed Sadok Cherif [a], Habib Chabchoub [a], Belaïd Aouni [b,*]

[a] *Unité de recherche LOgistique, Gestion Industrielle et Qualité (LOGIQ), Institut Supérieur de Gestion Industrielle, Université de Sfax pour le Sud, Sfax, Tunisia*
[b] *Decision Aid Research Group, School of Commerce and Administration, Laurentian University, Sudbury, Ontario, Canada P3E2C6*

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Abstract

The goal programming (GP) model has been utilized for designing a quality control system (QCS) where several features are simultaneously considered. In the context of the quality control, the parameters can be imprecise and expressed through intervals. The aim of this paper is to propose two formulations for designing a QCS based on the imprecise GP model. The concept of satisfaction functions will be utilized to integrate explicitly the decision-maker's preference. The developed formulations are illustrated through an example of a paper factory.

Keywords: Quality control system; Goal programming; Fuzzy goal programming; Imprecise goals; Satisfaction function; Decision-maker's preferences

1. Introduction

The design of a quality control system (QCS) in presence of certain features is a complex decision-making process. The process consists of fixing the levels of inputs and variables that meet the required output specifications. When single-characteristic output is considered, this problem can be solved by using conventional statistical tools. However, difficulty arises when multiple-characteristic outputs are considered and each of these characteristics has to satisfy a number of specifications. To solve such a problem, it requires a multidimensional model that can simultaneously take into account the quality constraints as well as the decision-maker's (DM) preferences. The goal programming (GP) model and the concept of the satisfaction functions (Martel and Aouni, 1990) can be a powerful tool to aggregate simultaneously several quality characteristics and integrate explicitly the DM's preferences. The aim of this paper is to present an imprecise GP model for designing a QCS within an imprecise environment by integrating explicitly the DM's preferences.

* Corresponding author.
E-mail address: baouni@laurentian.ca (B. Aouni).

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2. Imprecise GP model with satisfaction functions

The standard GP model considers the objective aspiration levels (goals) as precise and deterministic. However, there are some decision-making situations where the model parameters can be fuzzy, imprecise or stochastic. In the literature we notice three GP variants that deal with the imprecision and the fuzziness of the goal values, namely: the fuzzy GP (FGP) (Narasimhan, 1980; Hannan, 1981; Tiwari et al., 1986), the GP with intervals (GPI) (Charnes and Cooper, 1977; Kvanli, 1980; Romero, 1984; Can and Houck, 1984; Inuiguchi and Kume, 1991; Jones and Tamiz, 1995), and the GP with satisfaction functions (Martel and Aouni, 1990). However, the FGP and GPI formulations do not take into account explicitly the DM's preferences. In the next sections we will discuss some shortcomings of the FGP and GPI.

Shortcomings of FGP and GPI

Ignizio (1982) and Martel and Aouni (1998) have raised some issues in relation to the analytical form of the membership functions in the FGP. Martel and Aouni (1998) highlighted the fact that the membership function of triangular form has some bias to the central values of the objective achievement levels. In fact, Narasimhan (1980), Hannan (1981) and Tiwari et al. (1986) have only considered the case where the fuzzy measures have membership functions of particular forms (triangular and symmetric functions). Kim and Whang (1998) solved partially this problem by suggesting a tolerance approach for FGP problems with pre-emptive structure that can be applied in the case where unbalanced triangular membership functions are associated with some goals. The membership functions in GP are utilized for modelling the goal fuzziness rather than integrating the DM's preferences.

The membership functions introduced by Narasimhan (1980) and Hannan (1981), do not express the DM's preference structure. In fact, their effort is far from responding adequately to the DM's expectation to have input during the problem formulation stage by expressing his/her degree of satisfaction regarding the achievement levels of objectives with imprecise goals (Martel and Aouni, 1996). The GP formulation with intervals proposed by Inuiguchi and Kume (1991) is not free from the inconvenience of linearity and symmetry of the objective function (penalty function). Furthermore, their formulation favors central values of the intervals. Therefore, it is as if the goals associated with various objectives were crisp and equal to the central value of each interval (see Fig. 1a). Since the goal values are fuzzy and expressed through intervals, the DM should be indifferent regarding solutions within the limits defining the interval (see Fig. 1b). Consequently, this formulation does not involve the DM in the decision making process. In other words, the DM's preference structure has not been explicitly incorporated in the GPI formulation (Martel and Aouni, 1996).

GP with satisfaction functions

As we have seen so far, generally the FGP model and the GPI models deal with situations where the membership and the penalty functions are linear and symmetric. In addition, these functions favour the central value of the goal deviations. These models put more emphasis on the imprecision of the goals and less on

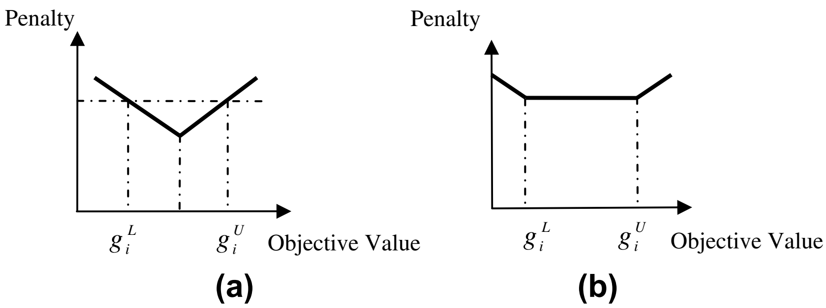

Fig. 1. Penalty function.