Generalized Scalarizing Model
GENS in DSS WebOptim

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ABSTRACT

A web-based Decision Support System WebOptim for solving multiple objective optimization problems is presented. Its basic characteristics are: user-independent, multisolver-admissibility, method-independent, heterogeneity, web-accessibility. Core system module is an original generalized interactive scalarizing method. It incorporates a number of thirteen interactive methods. Most of the known scalarizing approaches (reference point approach, reference direction approach, classification approach etc.) could be used by changing the method’s parameters. The Decision Maker (DM) can choose the most suitable for him/her form for setting his/her preferences: objective weights, aspiration levels, aspiration directions, aspiration intervals. This information could be changed interactively by the DM during the solution process. Depending on the DM’s preferences form the suitable scalarizing method is chosen automatically. In this way the demands on the DM’s knowledge and experience in the optimization methods area are minimized.

Keywords: Decision Support Systems, Interactive Methods, Multi-Objective Decision Making, Optimization, Scalarizing Methods

1. INTRODUCTION

DSS WebOptim is designed to solve multiobjective optimization problems.

The multiobjective optimization problem (MOP) can be defined as:

Maximize \( f_k(x), \ k \in K \) \ (1.1)

subject to:

\( x \in X \) \ (1.2)

DOI: 10.4018/jdsst.2013070101
where \( f(x) = \{f_1(x), f_2(x), \ldots, f_k(x)\} \) is a vector of \( k \) concave objective functions, which must be simultaneously maximized.

A solution \( x = (x_1, x_2, \ldots, x_n) \) is a vector of \( n \) decision variables, belonging to non-empty feasible convex set \( X \subseteq \mathbb{R}^n \). The objective functions (1.1) constitute a \( k \)-dimensional subspace, called objective space \( F \subset \mathbb{R}^k, \quad F = \{f(x) \mid x \in X\} \).

It is expected that at least two among all objectives are in conflict, so that the problem (1.1-1.2) does not possess a unique optimal solution in the objective space. Instead a conception of Pareto optimality or non-domination is used - see for example (Branke et al., 2008; Miettinen, 1999; Steuer, 1986). Then a solution \( x^{(1)} \) is said to be Pareto optimal if and only if there does not exist another solution \( x \), such that \( f_k(x^{(1)}) \geq f_k(x) \) for each \( k \in K \) and for at least one index \( k \) a strict inequality holds. Sometimes a weak Pareto optimality conception is used that is a relaxation of Pareto optimality.

The Decision Maker (DM) chooses a final (best compromise) solution according his/her preferences from the set of found Pareto optimal solutions. In other words solving a MOP is a process of decision making with participation of a human factor.

The DSS WebOptim is a successor of the general-purpose software system MKO-2 (Vasilyev et al., 2008). Its main characteristics are:

- Useful to a wide variety of users from different professional backgrounds with different level of optimization competence.
- A user friendly customizable interface, reflecting the needs of different users and accessible worldwide via the Web;
- A set of solvers (unified in a generalized scalarizing method) which covers many MOP methods;
- Various solutions can be obtained applying different methods according to the same preferences;
- Designed to be easily extended by adding new solvers;
- Providing an API interface for external use by third party developers.

The system WebOptim consists of several modules, incorporated and supported by a common frame. The purpose of a frame is to ensure extensibility of the system, API interface and Web communication. The main parts of the WebOptim are the solvers. The basic solver is the generalized scalarizing interactive method (IM), called GENS-IM.

The paper is organized further as follows. In the next two sections we discuss the generalized scalarizing method GENS-IM. In the last sections we describe the software design of DSS WebOptim and the design of method GENS-IM within WebOptim.

2. GENERALIZED SCALARIZING PROBLEM

The Interactive Scalarizing Methods (ISMs) present a significant part among the methods for solving multiobjective optimization problems - see for example (Branke et al., 2008; Hwang & Masud, 1979; Miettinen, 1999; Steuer, 1986). ISMs differ in the way the DM gives his/her aspirations (Decision Phase) and in the way the Pareto optimal solutions are generated (Computation Phase). Further each ISM has its own strategy for scanning the Pareto surface. But the common in ISMs is that each of them in practice uses some kind of scalarizing optimization problem for generating Pareto solutions. On the other hand, when trying to solve MOP - for example using methods where the DM’s preferences are in terms of reference points (Korhonen & Laakso, 1986; Nakyama & Sawaragi, 1984; Wierzbicki, 1980, 1986), then in general case the computed solutions could differ for identical reference point. Therefore it is worthy of looking for ways to combine ISMs in a more general formulation. Thus the DM has the possibility to solve MOP using different strategies (methods). Another possibility is if
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