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AN ADVANCED SIMULATION METHOD (ASM) FOR MULTIPLE OBJECTIVE PROBLEMS

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ABSTRACT

Proposed is an advanced simulation method (ASM) for multiple objective decision making (MODM) in an interactive optimization mode. It is an improvement over standard interactive simulation based on what if methods (WIM). Both methods are capable of solving MODM problems with numerous alternatives, however, by comparing solutions found with both methods the ASM was shown to be superior to traditional methods. A unique aspect of the ASM is its capability of reverse problem solving (RPS) wherein the decision-maker (DM) starts with a desired solution and works backward to determine the required inputs. In contrast, the WIM gives the results after the DM varies the inputs (a very time consuming process, since in most real problems there is an unlimited set of alternatives). The ASM is user friendly, considers non-linear objectives, allows the units of measurement of the various objectives to be different, and is more efficient than WIMs. A scaling algorithm adjusts for the diversity in impacts caused by MODM problems with heterogeneous objectives while a variable step size algorithm assists in finding the optimal solution.

WIMs are the easiest interactive simulation methods to design and use. There are numerous computer supported WIMs. Solutions are found in an interactive process where the user observes the outputs while continuously changing inputs until outputs are satisfactory. If the relationships among objectives and constraints are very complex the user may have difficulty in selecting ideal values for the inputs e.g. given the constraints some selections may not be feasible, changing inputs in attempts to improve one objective may cause other objectives to deteriorate, etc. In WIMs, however, an experienced user has the flexibility to rapidly ascend to the best solution, since the user can immediately select ideal values, if known, for the inputs.

THE ADVANCED SIMULATION METHOD

An interactive simulation method, the ASM searches the solution space for an optimal solution. *A* fundamental task is finding the best search direction, such as the gradient of the user’s utility function. If we assume that the overall objective function can be approximated by a weighted linear function the best direction of improvement of each objective function is the gradient. Therefore the best direction of improvement of the linear approximation for the user's utility function is the weighted combination of the individual objective gradients. Similar to other MODM methods the ASM involves the conversion of the MODM problem, with assumed objective weights, into an equivalent vector-maximization problem. An algorithm solves the vector-maximization problem using forces of effort supplied by the DM, to improve each objective.

The ASM provides as simple a method as possible for soliciting direction of improvement information, yet it lacks the limitations of ideal point knowledge and is parsimonious regarding inputs. Unlike other methods the user is not faced with the perplexing task of assigning weights to the various objectives and adjusting those weights as the environment changes.

Nor does the ASM present numerous complex decision choices or ranking questions to the user. Instead, it presents good, solutions and asks the user to choose the best, and to specify desired improvements in the chosen solution. When presented with a set of objective values for some alternative solution the user applies different amounts of force, which are perceived, as appropriately needed, to improve each respective objective. The system then calculates the feasible inputs that are needed. This intuitively appealing notion of applying efforts of force relative to the outcome desired, e.g. the more effort applied the more improvement gained, is more familiar to and preferred by the typical user. The gradient direction is deduced in a mariner similar to using the method of Geoffrion et al (1972). A major hypothesis of this method is that forces (DM’s relative desires for improvement) estimate up to a positive scalar constant the gradient direction of the DMs utility.

In MODM the DM wishes to simultaneously optimize several conflicting objective functions, which usually are measured in different units. Units of measurement may be dollars, number of items, number of workers, weight, days, etc. Before heterogeneous objectives can be combined they mist be scaled. Without scaling the ASM is virtually useless because it, like many other MODM methods, experiences a distortion due to the “magnitude of impact” problem. For example, if one objective is to minimize cost, measured in dollars, and another objective is to minimize inventory, measured in number of items on hand, there is considerable difference in the magnitudes of the units of measurement. Changes in inventory levels of inexpensive item will have a significant impact on the linear programming coefficient vector, while changes in cost elements will have little impact.

This diversity of impacts gives erroneous results in the linear programming maximization problem. This is a serious problem since it appears that users have a natural expectation that equal forces produce equal benefits. We therefore equalize the impact that each objective has on the LP coefficient vector with a scaling algorithm. The procedure provides values for an adjusting constant for each product (force of improvement and the respective objective gradient). The application of a force of improvement by the user will then increase the impact of the respective objective relative to the amount of force applied, without undue influence from its units of measurement.

A procedure that uses the sum percent change (SPC) of the objectives provides a basis for determining the interval search lengths. This procedure is based on the assumption that as the DM’ compromise solution approaches the optimal solution the amount of change in objective values diminishes with each iteration.

Summary

Although the number of trial solutions and the time required were significantly reduced when using the ASM solutions achieved were much better than with the WIM.