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A multiobjective evolutionary approach for linearly constrained project selection under uncertainty

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Abstract

In the project selection problem a decision maker is required to allocate limited resources among an available set of competing projects. These projects could arise, although not exclusively, in an R&D, information technology or capital budgeting context. We propose an evolutionary method for project selection problems with partially funded projects, multiple (stochastic) objectives, project interdependencies (in the objectives), and a linear structure for resource constraints. The method is based on posterior articulation of preferences and is able to approximate the efficient frontier composed of stochastically nondominated solutions. We compared the method with the stochastic parameter space investigation method (PSI) and illustrate it by means of an R&D portfolio problem under uncertainty based on Monte Carlo simulation.

Keywords: Multi-objective optimization; Project selection; Multi-objective evolutionary algorithms

1. Introduction

In the project selection problem a decision maker allocates limited resources to a set of competing projects. In addition, while selecting projects and allocating resources, the decision maker must take into consideration one or more corporate goals or objectives.

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There are two major taxonomies of the project selection literature. The first taxonomy is based on the application context. Within this classification, the project selection problem arises primarily in the context of research and development (R&D) [1,15,19,33,34], information technology (IT) [25,28,29,37–40,43], and capital budgeting [17,31,48,49]. The second taxonomy is based on the nature of the tools used for solving the project selection problem. This taxonomy classifies project selection models into one of two streams: the management science stream and the financial optimization stream. For more information about the project selection problem refer to [18].

In this paper, we propose a method for solving any project selection problem with the following characteristics:

1. *Partially funded projects.* Projects can be partially funded, or conversely, fully or not funded at all (i.e., zero-one). The proposed method allows the decision maker to engage in partially funded projects. For a sample of zero-one project selection refer to [22,39].
2. *Multiple objectives.* The decision maker may wish to simultaneously satisfy several corporate goals (e.g., minimize time-to-market and maximize economic return). Often, these goals will be in conflict, resulting in a more complicated, yet realistic, decision making process. The proposed model takes into consideration multiple (possibly conflicting) objectives.
3. *Posterior articulation of preferences.* The methods for multiobjective project selection can be classified based on how the decision maker expresses his/her preferences in the decision making process. Some methods have been proposed based on *prior* [23] and *progressive* [36] articulation of preferences, but few based on *posterior* articulation of preferences. The proposed method, based on posterior articulation of preferences, requires the least amount of information from the decision maker and could be completely automated.
4. *Uncertainty in the objectives.* Some elements of the project selection process may be uncertain. For instance, some uncertain elements that could affect a project's evaluation are interest rates, opportunity cost, risk, revenues, inflation, and cash flows, among others. During project evaluation, the proposed method allows uncertain elements in the objectives to be included as random coefficients in complex expressions (even nonlinear). Moreover, the method also allows the treatment of the whole project as a black-box. In this case, the method simulates the project and evaluates its performance measures (objectives) subject to random events.
5. *Project interdependencies.* In the project selection literature, there are mainly three types of interdependencies: resource, benefit, and technical interdependencies [38]. Interdependencies preclude the linearity of the models. For example, suppose there are two projects, A and B, with interdependent benefits of \$500 and \$1000, respectively. The benefits of implementing both projects could exceed \$1500 (=\$500 + \$1000) due to the additional benefits accrued from a pooling effect. This benefit interdependence could be modeled using non-linear terms as in [15,38]. The proposed model allows project interdependencies to be modelled in the objective functions.
6. *Linearly-constrained resources.* Project selection problems are constrained by their use of scarce resources (e.g., capital, labor, space requirements, and personnel, among others). Linear optimization models [12] have been popular due in part to the fact that many problem conditions are suitable to be expressed in linear form. The proposed method uses common, yet expressive, linear relations to model the restrictions on the various resources.

The stochastic parameter space investigation (PSI) method [35] is able to solve the project selection problem with the above characteristics. The stochastic PSI proceeds as follows: (1) project allocations are generated based on box constraints on the variables representing them (i.e., lower and upper bounds); (2) if a project allocation does not satisfy the constraints on the resources, that configuration is discarded; (3) if a project allocation is feasible, the objectives are simulated and evaluated; (4) statistics of central tendency