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CLASSIFICATION OF SIMULATION-OPTIMIZATION METHODS

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ABSTRACT

The possibilities of combining simulation and optimization are vast and the appropriate design highly depends on the problem characteristics. Therefore, it is very important to have a good overview of the different approaches. The classifications proposed in the literature cover a limited range of methods and overlook some important criteria. We provide a comprehensive classification that aims at giving an overview of the full spectrum of current simulation-optimization approaches. Our classification may guide researchers who want to use one of the existing methods, give insights into the cross-fertilization of the ideas applied in those methods and create a standard for a better communication in the scientific community.

1 MOTIVATION

Simulation-optimization approaches are increasingly popular due to the great possibilities that such hybridization allows for. Problems can be modelled in more detail and better quality solutions can be obtained. However, the resulting methods are typically much more demanding in terms of computational effort and hence the design of a good interaction between simulation and optimization is crucial.

For that reason and because the possibilities of combining them are so vast, it is very important to have a good overview of the different approaches. Thus, there is the need for a comprehensive classification that covers the full spectrum of these hybrid approaches.

Some classifications have been proposed in the literature (Shanthikumar and Sargent 1983, Fu 1994, Carson and Maria 1997, Ammeri, Hachicha, Chabchoub, and Masmoudi 2011). Nevertheless, the range of methods that are considered is limited and important criteria are overlooked. Therefore, we seek here to bridge that gap.

This study has the following main objectives:

- give an overview of the full spectrum of current simulation-optimization approaches, in order to provide some guidance for researchers who want to use one of the existing methods;
- explore the characteristics of current methods, giving insights into the cross-fertilization of ideas applied in those methods and showing gaps that may result in new approaches;
- create a standard for a better communication in the scientific community.

2 PROPOSED CLASSIFICATION

We aggregate several well-known approaches into main methods (the list is not exhaustive though), according to the applied techniques or underlying ideas. Each of these methods is then classified according to the proposed criteria.

The framework that combines simulation and optimization is probably the most defining aspect of these hybrid methods. We classify each method looking at both the purpose of the simulation component and the hierarchical structure that combines it with optimization (see Figure 1).

There are three main ways of using simulation (columns in the table):

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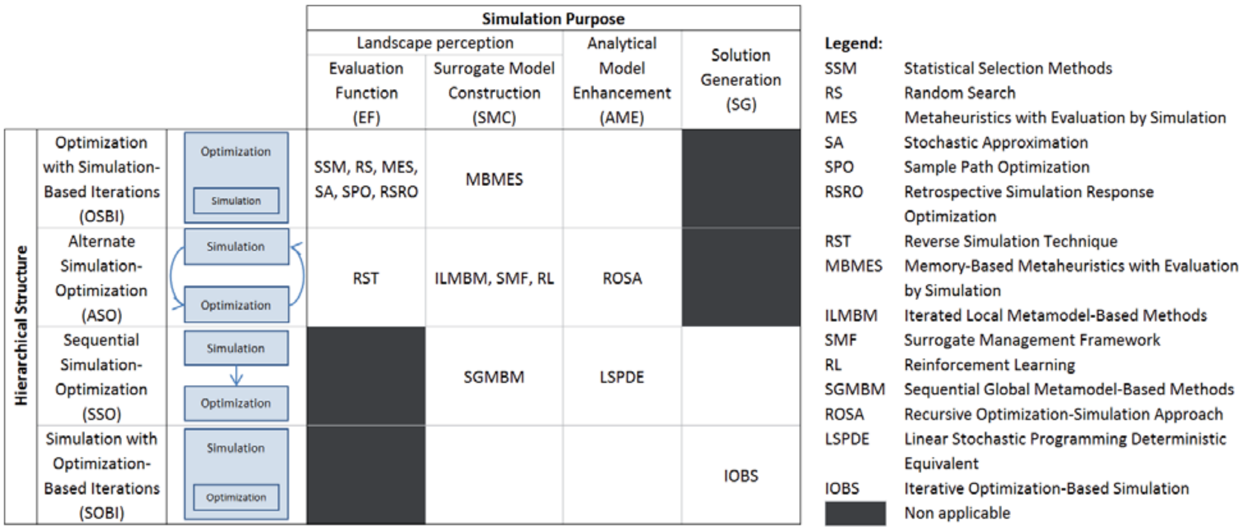

Figure 1: Classification according to the framework.

- to perceive the landscape of solutions (either evaluating one solution at a time or creating a surrogate model from different points, which will then guide the search);
- to improve an existing (problem-specific) analytical model, by refining its parameters or extending its scope (e.g. for different scenarios);
- or to simply generate the final solution (being supported by an optimization procedure in that task).

Another important characteristic is the search design that is applied. The design concerns both the search method and the search scheme, with respect to the series of solutions and sample paths (/realizations/replications) considered for evaluation. We divide methods in four main categories: analytical (A), discrete numerical (DN), derivative-based numerical (DBN) and other continuous numerical (OCN). The search scheme can be of three different types: one path for each solution (1P1S), multiple paths for each solution (MP1S) or one path for multiple solutions (1PMS).

Every simulation-optimization method proposed in the literature can then be classified according to the aforementioned criteria (e.g. a genetic algorithm that evaluates individuals by running different simulations for each is a MES method and can be classified as EF-OSBI/DN-MP1S).

There is not a single method that works well for a broad class of problems. Therefore, the choice of the former will highly depend on the characteristics of the latter. We provide a guide for selecting the appropriate design according to the characteristics of the problem (looking at each of our proposed criteria).

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