Simulation Optimization via Metamodeling Approach

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INTRODUCTION

Simulation optimization (SO) is the process of finding the best set of input variable values without explicitly evaluating each feasible set of these input variable values given an output criterion (Law, 2007; Fu, 1994). Input variables are called (controllable) inputs, parameter settings, values, variables, (proposed) solutions, designs, configurations, or factors (in design of experiments terminology). Outputs are called performance measures, criteria, or responses (in design of experiments terminology). Some of the outputs are used to form an objective function, and there is a constraint set on the inputs. Our aim is to optimize the objective function given below:

$$\min_{\theta \in \varnothing} f\left(\theta\right)$$

where $f(\theta)$ is the output criterion evaluated by simulation. θ is a controllable vector of p parameters. $\varnothing$ is a constraint set on θ.

SO has attracted many researchers. Because most real systems have numerous input variables and complex structure, evaluating each possible value of the input variables of such systems may become impossible. SO finds the best set of input variable values without explicitly evaluating each possible set of values.

In this chapter, we investigate SO techniques for infinite parameter space by focusing on metamodel-based approaches (see Figure 1). Here, we investigate discrete-event systems optimization for both continuous and discrete input variables (Nelson, 2010). In the following sections, we discuss two metamodeling approaches for the infinite parameter optimization procedure: Response Surface Methodology (RSM) and the Kriging metamodeling (KM).

BACKGROUND

SO evaluates the outputs in the form of a “what if” question. Recently, computer technology advancement enabled us to answer “How to” questions as well, seeking optimum values for the decision variables so that a given output variable is maximized or minimized. There are several studies written on SO.

A comprehensive review of SO is provided by Fu (1994a, b). Later, Carson and Maria (1997) present a general summary of SO. Azadivar,

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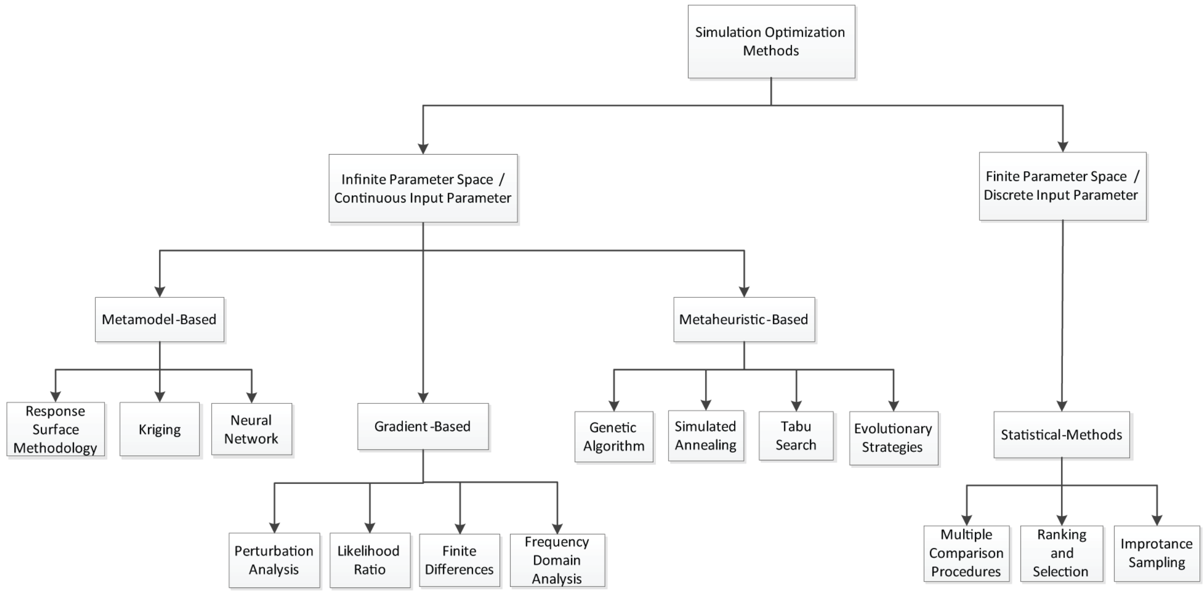
Figure 1. Simulation optimization methods



Shu, and Ahmad (1996) implemented an SO algorithm on Box's complex search method to optimize the locations and inventory levels in a production system. Pierreval and Tautou (1997) propose a new SO approach using evolutionary algorithms for manufacturing systems. Azadivar (1999) proposes a survey of issues on SO. Olafsson and Kim (2001) provide many techniques for considering discrete decision variables that have been suggested in solving SO problems. April, Glover, Kelly, and Laguna (2003) summarize some of the most relevant SO approaches and present an implementation for a real world project selection problem. Angelis, Felici, & Impelluso (2003) propose a methodology interactively using simulation, prediction of objective function and optimization to calculate and validate an optimal configuration of servers of a healthcare system.

Piera, Guasch, and Riera (2004) propose a petri net-based approach for SO which also uses information from the simulation model. Jung, Blau, Pekny, Reklaitis, and Eversdyk (2004) determine safety stock levels using deterministic planning and scheduling models to optimize customer satisfaction via an SO approach. Fu, Glover, and April (2005) provide a comprehensive review for SO. Fu, Chen, & Shi (2008) also present a tutorial introduction for SO. In that study, they classify the problem according to the decision variables and constraints, place the settings in the simulation context and summarize the approaches of SO.

There are also several studies completed for case studies using an SO method (Xi, Sioshansi, & Marano, 2013; Quan, Yin, Huing, & Lee, 2013; Lohndorf & Minner, 2013).

As mentioned previously, in this chapter, we focus on metamodeling and finite parameter optimization tools in SO. We also present the current studies in the literature on these topics in the relevant sections below.

METAMODELING SOLUTION PROCEDURES

Issues, Controversies, Problems

In most real cases there is usually large number of input variables and alternative configurations to simulate and compare. For instance, it is impossible to evaluate all alternative values of a continuous type of input variable. There will be