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TOWARDS AUTOMATICALLY GENERATING SIMULATION EXPERIMENTS

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ABSTRACT

Simulation studies make use of various types of simulation experiments. Specifying these experiments is a demanding task since the specification depends on the experiment type and the idiosyncrasies of the used tools. Thus, we present an automatic experiment generation procedure that uses experiment schemas to describe simulation experiments in a tool-independent manner. We apply the concepts to two different domains of modeling and simulation (M&S) to illustrate how simulation experiment specifications go beyond specific tools and applications.

1 INTRODUCTION

Simulation studies are intricate processes that intertwine the model building steps with diverse simulation experiments, either used for calibration, validation, or simply exploration of the built models. For users, specifying these experiments is a demanding task since each specification depends on the experiment type, used methods, and idiosyncrasies of the used tools. Therefore, we develop an automatic experiment generator to partly relieve the user from the presented challenges. Automatically generating simulation experiments however requires explicit representations of the various types of experiments and their ingredients. The last decade has seen an increasing interest in capturing simulation experiments explicitly to facilitate their reuse and replication, e.g., model- (Teran-Somohano et al. 2015) and template-based approaches (Ruscheinski et al. 2018), or experiment specification via domain-specific languages (Waltemath et al. 2011; Ewald and Uhrmacher 2014). Our work takes this further by including a variety of application domains and tools.

2 BEYOND APPLICATION DOMAINS AND TOOLS

To support users in conducting simulation studies we introduce an automatic experiment generation process that makes simulation experiments and their ingredients explicit based on experiment schemas and templates, thereby contributing to the growing body of knowledge in M&S. In particular, our approach generates simulation experiments at two levels of abstraction. At the first level, schemas represent the key structure of a simulation experiment, making the central elements of a simulation experiment and the dependencies between them explicit. Filling an experiment schema with inputs results in an abstract simulation experiment specification that describes the experiments in terms of the used methods and parameters. Thus it is independent of the concrete implementations in the different M&S tools. At the second level, the abstract experiment specification is mapped to template fragments which, composed together, produce a concrete experiment specification in the specification language of a selected M&S backend. This simulation experiment specification can directly be executed, e.g., automatically as an additional step at the end of the experiment generation process. Figure 1 illustrates this two-level process. A more thorough discussion of the underlying ideas as well as detailed examples can be found in the full paper (Wilsdorf et al. 2019).

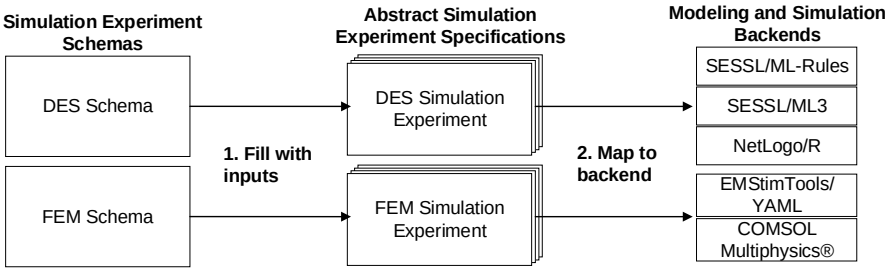

Figure 1: Automatically generating simulation experiments using a two-level approach.

In a case study, we apply our concepts for experiment generation to two different domains of M&S, showing that simulation experiment specifications go beyond specific tools and applications. We begin by developing schema, template fragments, and mappings for the domain of stochastic discrete-event simulation (DES), based on the M&S literature. Using the same schema, we are able to generate simulation experiment specifications for multiple backends, i.e., SESSL/ML-Rules, SESSL/ML3, or NetLogo/R. The collection of schemas and templates is easily expanded, even to fundamentally different domains of M&S, which naturally require an entirely different set of inputs. To demonstrate this versatility, we apply our concepts to finite element method (FEM) simulation of electrical cell stimulation (Budde et al. 2019), and generate simulation experiments for FEM platforms like the FEniCS-based EMStimTools or COMSOL Multiphysics®. Further, we develop schemas for experiment designs to move from "basic" to more complex simulation experiments. These new schemas are composable and reusable across the various M&S domains which we show by generating sensitivity analysis experiments for both the DES domain and the FEM domain.

In ongoing work, we will put the defined schemas and templates to work, e.g., to automatically (re-) validate the simulation model at several points during the simulation study. To achieve this, the experiment generator has to be combined with information retrieval approaches that automatically derive suitable inputs to fill the experiment schemas based on other sources.

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