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Capturing the dual relationship between simulation models and their context

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Abstract

Simulation models are usually built in an objective-driven context. Capturing the relationship between a model and its context is a key issue in Modeling and Simulation (M&S). A better driving of the M&S life cycle requires the objectives, assumptions and constraints in disguise behind this relationship to be explicit. A sound systemic-based foundation is provided here to achieve this goal in a clear abstract form. To this end, we give a thorough development to the concept of experimental frames introduced by the DEVS framework, and we erect a specification hierarchy. An application to fire spreading is shown. This work points out several benefits: firstly, it becomes easier to capture and to manipulate some M&S fundamental and advanced concepts, and then to enhance our understanding about them. Secondly, a significant improvement is gained in the M&S process by systematically accompanying the specification of the system with the specification of the context. Lastly, the formal framework, with both system and context specification hierarchies, provides a methodological guide to the modeling process.

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1. Introduction

In the traditional M&S process, model building is done by specifying the abstraction retained to describe the system under study [9,16], without conducting simultaneously the same process for the context in which the system is studied. Yet, the validity of the model can be measured only in this context. Since a model is meaningless without its context, a sound M&S enterprise must drive the specification of both the model of the source system and of a companion model of the context of the study. Creating a model for the context is not a current practice in M&S. Which factors can characterize a context? According to [8], there is no agreed framework for these factors. There are similarities between the acts of specifying a model for a real system and that of specifying a context: only the most significant factors are retained and described. However, there is a common agreement to recognize that a model of context must make explicit at least the underlying objectives, assumptions and constraints of the study [6,8,17]. Such a specification makes it possible to identify models that may be relevant for (re-)use within a given context. Conversely, a given model can be checked for compatibility with various contexts. A formal framework in which contexts can be specified in their clear abstract forms can provide a powerful means to manipulate this compatibility concept and others that come under the model-context duality. The benefit of the present work is to provide a sound basis for such a framework.

The separation of concerns between a model and its simulator [25] is known to be a fundamental principle in the M&S process. We have formalized a similar separation between a model and its context, as a systematic part of the M&S process. The chosen approach is rooted in systems theory, the DEVS formalism, and the experimental frame methodology introduced by the multifaceted modeling and simulation framework [22,23,25]. The specification hierarchy introduced to this end provides an operational formulation of objectives, assumptions and constraints that govern any simulation modeling effort. As far as we know, few research works have dealt with this concern [7,12] and none with a general formalization like those provided by the work in progress [18,19].

Section 2 presents the modeling and simulation framework and emphasizes the process of translating the system/context pair into a model/frame pair, and then into a simulator/experimenter pair when necessary. The frame specification hierarchy is developed in Section 3 through three levels. It is applied to a fire spreading simulation, whose specification and visual results are presented in Section 4. A discussion is provided in Section 5 and concluding comments are given in Section 6.

2. Modeling and simulation framework

The System-Model-Simulator (SMS) view is a well-accepted framework in the M&S community. The SMS view defines the System, the Model and the Simulator as the key entities of the M&S enterprise. The two most fundamental relationships

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