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Pitfalls in Modeling and Simulation

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Abstract

Scholars use models and modeling e.g. to examine, explain or demonstrate ideas or phenomena. Modeling combines discipline specific traditions and general methods of modeling together. The interdisciplinary nature of modeling and simulation can sometimes cause challenges to a scientist. This paper identifies eight typical pitfalls a researcher may encounter in a modeling study. The study explains the pitfalls and connects them to the different phases of the modeling cycle. The purpose of the article is to provide some guidance for scientists how to avoid the general traps of modeling and simulation.

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Keywords: Modeling, Simulation, Modeling cycle, Pitfalls of modeling

1. Introduction

Modeling is a powerful tool for developing and testing theories and it is applied in many different fields of study. Modeling together with simulation, combines general methodological developments to many specific application fields. The interdisciplinary nature of modeling and simulation offers huge possibilities but it can also cause some challenges to scientists who should be able to combine mathematical, computer science as well as modeling and simulation tradition to his or her field of study.

This paper concentrates on possible pitfalls in modeling and simulation research. The aim of the paper is to provide some guidance for young scientists planning and implementing their scientific work based on modeling and simulation.

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The paper starts in Section 2 with a short introduction to principles of models and modeling in science. Section 3 concentrates on developing and applying scientific models. The special attention here is on the iterative nature of the model development. Section 4 discusses the identified pitfalls of modeling and simulation. Discussion is organized according to the modeling cycle developed and explained in the previous Section. Section 5 contains the conclusions of the study.

2. Models and Modeling

Scientists attempt to produce knowledge about the world via numerous methods and models are of central importance in that work. There is a large number of things that are commonly referred to as models including but not limited to physical objects, fictional objects, set-theoretic structures, descriptions, equations, or combinations of some of these [14]. Teller [19] goes even further as he points out that *"in principle, anything can be a model, and that what makes a thing a model is the fact that it is regarded or used as a representation of something by the model users"*. Models can be classified to two major categories: physical or symbolic [18]. Physical models can be e.g. a model of an airplane or a building. Symbolic models instead are typically based on natural or formal languages or a set of mathematical equations. In this paper, discussion is limited to the symbolic scientific models and their implementations.

In the real world, we observe various phenomena and behaviors, which can be either natural in origin or produced by artifacts. With symbolic scientific models, we are able to move from this real world to the conceptual world. This conceptual world is the world of the mind. There we try to understand what is going on in our real, external world. [11].

Fig. 1 describes the relationship between the real and the conceptual worlds. In the conceptual world, we first observe events in the real world. Then in the modeling phase, we analyze the observations and create models typically either to explain the results observed or to predict the future results.

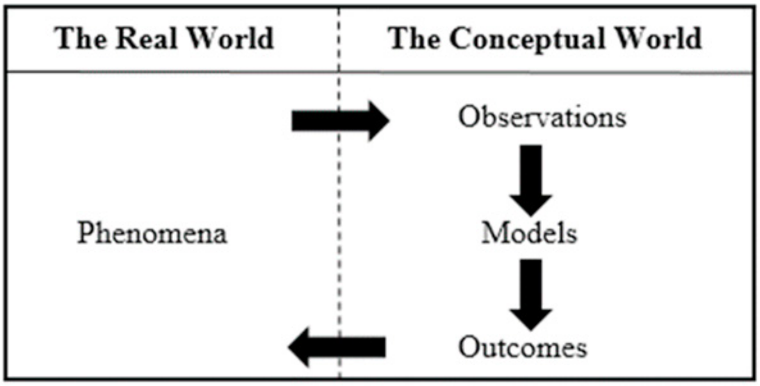

Fig. 1. The real and conceptual worlds of modeling (Modified from [11].

2.1. Simplification and modeling

The conceptual world is always a simplified version of the real world. Simplification is an extremely essential part of modeling which is clearly highlighted by Luis Borges' classical example of a map. A useful map must be a simplified geographical model and a map with a scale 1:1 is totally useless [5].

There are many reasons for simplification. First, we must bear in mind that the purpose of the scientific model is to promote understanding. Simple models enable scientists and other stakeholders to understand links between inputs, assumptions and outputs. Additional complexity can prevent us to see the essential components of the system and the relationships between them. Second, a model has to provide tractability [9]. Otherwise, verification and validation of the model is jeopardized. There are many additional reasons for simplification including lack of calculation power, efficient use of resources, and missing data to mention just a few.