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GRAND CHALLENGES IN CONCEPTUAL MODELING

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ABSTRACT

We highlight five grand challenges for simulation conceptual modeling: understanding the cognitive process of modeling, developing conceptual modelling frameworks, representation of conceptual models, linking research and practice, and education in conceptual modeling.

1 INTRODUCTION

Conceptual modeling is the activity of abstracting a simulation model from a real system. The importance of this activity has been recognized since the early days of computer simulation. In the 1960s, and motivated by improving execution speed, Tocher (1963) identified the benefits of simpler models and used 'flow diagrams' to represent the model concept. Whilst execution speed has become less of a hindrance over the last sixty years, there remains a strong argument for abstraction (simplification) of models. Beyond improving run-speed, simpler models also provide benefits with respect to quicker model development time, reduced data requirements, greater flexibility and improved understanding, among others.

Although the importance of conceptual modeling is well established, the activity of conceptual modeling is much less studied or understood. Over recent years there has been a steady but relatively small stream of work on conceptual modeling (Robinson 2020). It remains an underrepresented area in simulation research. In this discussion we identify five 'Grand Challenges' concerning conceptual modeling for simulation. The aim is to provoke progress and to provide some direction to future research in this field.

2 GRAND CHALLENGES IN CONCEPTUAL MODELING

Given the limited progress in the field, Robinson (2020) identifies three specific challenges in simulation conceptual modeling: conceptual modeling frameworks, conceptual model representation, and linking research and practice. We reprise those challenges here and expand the list with a further two challenges.

2.1 Grand Challenge 1: Understanding the Cognitive Process of Modeling

It is apparent that some simulation modelers are more effective at creating appropriate models than others. By appropriate we mean creating the simplest model possible to address the problem at hand. While some modelers resort to representing every known aspect of the system under study, others are able to focus on the decision at hand and abstract to a much simpler model. What we do not understand is how or why some modelers are more 'effective' than others. Detailed investigations of the cognitive process of modeling are needed to understand, explain and educate modelers in the art of conceptualizing a model.

2.2 Grand Challenge 2: Developing Conceptual Modelling Frameworks

Frameworks exist that guide modelers through the activity of conceptual modeling (e.g., Robinson 2008, Arbez and Birta 2016), but their efficacy is not fully established, and such frameworks have not been widely

adopted. Research is needed to test, adapt and create improved conceptual modeling frameworks, as well as to encourage their adoption in practice. Fruitful areas of study might be in domain specific frameworks (Monks et al 2017) and in model simplification methods (van der Zee 2019).

2.3 Grand Challenge 3: Representation of Conceptual Models

Every modeler seems to have his/her preferred way of representing the concept of the model. Process flow diagrams, petri nets, UML, SysML, to name but a few. Dissatisfied with current approaches, researchers frequently create new methods of representation. This lack of standardization has led to difficulties in communicating the structure and content of models. Each model is presented in a different format, requiring us to learn the syntax of the representation as well as the details of the model. This is not to say that a single representational approach should be adopted by all, as different methods provide different benefits. But surely we can do better than work with the current plethora of representational forms?

The answer in part hinges on understanding what and who the representation is for. Is it to communicate the essence of the model to the client in order to build confidence in the model? Is it to enable validation of the model concept with subject matter experts? Is it to provide details of the model content so a developer can create the computer model? Or is it all three of the above? These different purposes and audiences hint at needing quite different representational forms of the same conceptual model.

2.4 Grand Challenge 4: Linking Research and Practice

Perhaps it is in the field of conceptual modeling that we most need to link research and practice. Practitioners are confronted daily with the challenge of determining what to model and what not to model when faced with a decision problem. They also utilize means for communicating their model concepts to clients, subject matter experts and model developers, albeit not always effectively. Researchers have much to learn by observing practitioners at work and distilling key lessons for conceptual modeling. Alongside this, researchers could identify areas where conceptual modeling practice needs to be improved, and seek to develop approaches and tools that will better support conceptual modeling. In turn, researchers' contributions should be tested in practice. At its core, the art of conceptual modeling is practice based and research studies should therefore be based in practice.

2.5 Grand Challenge 5: Education in Conceptual Modeling

Improved education in conceptual modeling for students and modelers is important if we are to see a step change in the quality of simulation models (van der Zee et al 2018). Progress in all the above challenges is needed to develop the underlying knowledge and approaches that will provide the foundation for better conceptual modeling education.

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