Poster: In search of sound 'in silico' research – validating a complex system simulation

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Abstract

In logic, an argument is valid if true premises cannot be associated to a false conclusion. However, this criterion is hardly appliable to real-world complex systems, hence it needs to be weakened: critical systems engineering, for example, requires acceptability rather than truth. Validity is not a dichotomous property, but one that has to be considered within a context and related to a specific set of requirements.

We present here work directed towards developing a structured argument of validity for a complex systems simulation – part of a plant ecology case-study. Firstly, we define the difficulties of claiming validity for complex systems simulations. We then proceed to analysing the spectrum of assumptions and abstractions that were involved into constructing the biological model and simulation, and how these influence the scope of our validity claim.

Finally, we provide an initial structured argument for the simulation's validity, using critical systems techniques.

1 Poster introduction

The CoSMoS project[1] aims to build capacity in generic modelling tools and simulating techniques for complex systems. One such contribution relates to the study of validity in this complex systems context and the construction of sound validity arguments that may accompany computer models and simulations.

In logic, claiming an argument's validity implies being able to evaluate the truth value of its premises and conclusions. However, in real life, this is not always a straightforward (or even possible) process, hence other domains are looking for acceptability rather than truth. When dealing with complex system, the problem becomes even more difficult.

Validity is a purpose-oriented concept [1] – in the case of a simulation, it stands between its purpose and its actual realisation. To date, there have been published many validity tests and guidelines, but they are rarely applied and some are even less relevant to this purpose-orientation. In addition, as far as the authors are aware, there are no examples of complex systems simulations being supported by comprehensive validity arguments addressing their theory,

[1] http://www.cosmos-research.org, Complex System Modelling and Simulation Infrastructure

underlying model and software architecture, rather then mostly evaluating their outputs.

Here we present work on validating an existant simulation model [2] of plant ecology. We start from the primary sources of information forming the theoretical background and we analyse the relations between the domain, the model and the simulation. A particular focus is placed on how domain information is transformed through operations such as assuming, distorting or simplifying, and the way the simulation's relevance towards addressing the purpose is influenced. Here there are relevant incompatibilities between the high-level purpose of the simulation and various modelling decisions and these help reconsidering the simulation's scope.

We finally construct a visual argument of validity, using the Goal Structuring Notation (GSN) [3]. In accomplishing this, we build on previous work dedicated to building equivalence arguments for complex systems simulations [4]. Our claim is not general, but depends on the purpose of the simulation and its scope. Its support is provided by qualitative and quantitative evidence, making thus validity a subjectively acceptable property, a continuous discussion between the author of the argument and its evaluators.

References

[1] Stanislaw, H.: Tests of computer simulation validity: what do they measure? Simul. Gaming **17** (1986) 173–191

[2] Bown, J.L., Pachepsky, E., Eberst, A., Bausenwein, U., Millard, P., Squire, G.R., Crawford, J.W.: Consequences of intraspecific variation for the structure and function of ecological communities: Part 1. model development and predicted patterns of diversity. Ecological Modelling **207** (2007) 264–276

[3] Kelly, T.P.: Arguing safety – a systematic approach to managing safety cases. PhD thesis, Department of Computer Science, University of York (1999)

[4] Ghetiu, T., Alexander, R.D., Andrews, P., Polack, F.A.C., Bown, J.: Equivalence arguments for complex systems simulations - a case-study. In Stepney, S., Welch, P., Andrews, P., Timmis, J., eds.: Complex Systems Simulation and Modelling Workshop (CoSMoS 2009), Frome, United Kingdom, Luniver Press (2009) 101–129