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The ODD protocol: A review and first update

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Abstract

The 'ODD' (Overview, Design concepts, and Details) protocol was published in 2006 to standardize the published descriptions of individual-based and agent-based models (ABMs). The primary objectives of ODD are to make model descriptions more understandable and complete, thereby making ABMs less subject to criticism for being irreproducible. We have systematically evaluated existing uses of the ODD protocol and identified, as expected, parts of ODD needing improvement and clarification. Accordingly, we revise the definition of ODD to clarify aspects of the original version and thereby facilitate future standardization of ABM descriptions. We discuss frequently raised critiques in ODD but also two emerging, and unanticipated, benefits: ODD improves the rigorous formulation of models and helps make the theoretical foundations of large models more visible. Although the protocol was designed for ABMs, it can help with documenting any large, complex model, alleviating some general objections against such models.

Introduction

Ecologists and social scientists have long been faced with the challenge of how to model the complexity inherent in many real-world ecological, social, or socio-ecological systems. One approach for exploring such systems is using agent-based models (we hereafter refer to such models generically as ABMs, and use the terms 'individual' and 'agent' interchangeably). ABMs focus on one or more of the following aspects because they are considered critical for explaining system-level behavior: heterogeneity of and among individuals, local interactions among individuals, and adaptive behavior of individuals (DeAngelis and Mooij, 2003, DeAngelis and Mooij, 2005, Grimm and Railsback, 2005).

ABMs were early criticized as generally being so poorly documented that the models could not be evaluated (e.g., Lorek and Sonnenschein, 1999). These criticisms motivated the ODD (Overview, Design concepts, Details) protocol (Grimm et al., 2006), which attempted to create a generic format and a standard structure by which all ABMs could be documented. The primary purpose of ODD is to make writing and reading model descriptions easier and more efficient. Moreover, ODD is expected to lead to more complete model descriptions, making ABMs easier to replicate and hence less easily dismissed as unscientific.

In the few years it has existed, ODD has been used in more than 50 publications. ODD was also evaluated by using it to compare three different agent-based social simulation models of land-use change (Polhill et al., 2008), and was discussed and included in the portfolio of approaches fostered by the Open ABM Consortium, which was constituted in 2007 (Janssen et al., 2008). Hence a critical mass of experience has been reached, enabling the first update of the ODD protocol. This update was anticipated by Grimm et al. (2006, p. 116): "once initiated, the protocol will hopefully evolve as it becomes used by a sufficiently large proportion of modelers." It was clear from the outset that the first version of a protocol designed to embrace the huge variety of ABM designs, complexity, scopes, or disciplines could not be optimal and that updates of the protocol would be needed.

Here we review the uses to date of ODD. This allows several observations to be made concerning the clarity and completeness of the protocol. An additional observation, however, was that the protocol has had unanticipated dividends that go beyond the expected practical benefits of providing a systematic documentation of models. That key benefit is that the protocol helps to promote a more rigorous formulation of models. The reason for this is that the ODD protocol provides a comprehensive checklist that covers virtually all of the key features that can characterize a model and that should be described. Because models are vehicles for applying theory to real-world situations, we believe that this also helps communicate clearly the theoretical background and assumptions of the model.

A further observation is that the application of the ODD protocol to model descriptions may be appropriate not only for the ABMs, but for large, complex models in general. The advantages and disadvantages of large, complex models in ecology have been reviewed and debated in many places (e.g., Jørgensen, 1992, Liebhold, 1994, Logan, 1995, DeAngelis and Mooij, 2003, May, 2004, Grimm et al., 2005), the debate often revolving about the level of detail necessary in a model, the tradeoff being between greater realism on the one hand and greater parsimony and transparency on the other. It is not our goal to enter that debate, but to suggest that ODD be used as a thorough and consistent framework for documenting models, which can help to make large, complex models as clear as possible to the reader and user (e.g., Müller et al., 2007). If substantial clarification of large, complicated ecological models can be achieved, then a major disadvantage in such models, that is, the difficulty in understanding them, may be overcome. We will center our comments here on application to ABMs, but broader use of ODD is implied.

The update of the ODD protocol and its description is based on a review of all model descriptions using the protocol that existed by December 2009, checking whether the protocol's terminology was consistently understandable. This assessment had to be based on our subjective assessment on whether or not ODD elements were used as described in Grimm et al. (2006) because a more quantitative assessment seemed not to be possible at this stage.

Our main conclusion from three years of ODD application is that, while the protocol itself does not need a major overhaul, an update of the description of the protocol is needed, as several elements and some important terms have proven unclear or were sometimes misinterpreted. In addition, experience has revealed important potential benefits of ODD that were not foreseen when it was developed. It is worth addressing these benefits to further increase the value of the ODD protocol in the scientific community.

In the following, we first present our review of ODD-based model descriptions. As a result of this review, we then present an updated description and explanation of the seven elements of ODD. We then discuss those features of ODD that have been criticized as well as important benefits that were not anticipated by Grimm et al. (2006).

Section snippets

Methods

We searched the 'Web of Science' reference data base (Thomson Scientific) for publications citing the original ODD publication (Grimm et al., 2006). We selected those publications that claimed to follow the ODD protocol in the model

descriptions. For each of the publications, we checked whether the ODD format was completely followed, which includes using exactly the identifiers and sequence of all seven elements of the ODD format. Then, for each of the elements of the protocol that was…

The ODD protocol: an updated definition

The following description and explanation of the seven elements of ODD is designed to fix the problems and ambiguities of the original protocol and its description. This updated ODD protocol fully replaces the original description given by Grimm et al. (2006), which is obsolete because of its ambiguities; however, the description of ODD's overall purpose and rationale given by Grimm et al. (2006) is still valid. The ODD protocol is defined by the seven elements described below, their labels or…

Discussion

We have provided an updated ODD protocol for describing individual-based and agent-based models. Our updated description of ODD provides questions that can serve as a checklist for describing ABMs. We also renamed a few ODD elements to improve clarity, and added two design concepts: Basic principles and Learning.

In the following, we discuss both the three most frequently raised critiques in the protocol and emergent benefits which were not anticipated by Grimm et al. (2006)….

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