

Aligning Simulation Models: A Case Study and Results

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Abstract

This paper develops the concepts and methods of a process we will call “alignment of computational models” or “docking” for short. Alignment is needed to determine whether two models can produce the same results, which in turn is the basis for critical experiments and for tests of whether one model can subsume another. We illustrate our concepts and methods using as a target a model of cultural transmission built by Axelrod. For comparison we use the Sugarscape model developed by Epstein and Axtell.

The two models differ in many ways and, to date, have been employed with quite different aims. The Axelrod model has been used principally for intensive experimentation with parameter variation, and includes only one mechanism. In contrast, the Sugarscape model has been used primarily to generate rich “artificial histories,” scenarios that display stylized facts of interest, such as cultural differentiation driven by many different mechanisms including resource availability, migration, trade, and combat.

The Sugarscape model was modified so as to reproduce the results of the Axelrod cultural model. Among the questions we address are: what does it mean for two models to be equivalent, how can different standards of equivalence be statistically evaluated, and how do subtle differences in model design affect the results? After attaining a “docking” of the two models, the richer set of mechanisms of the Sugarscape model is used to provide two experiments in sensitivity analysis for the cultural rule of Axelrod’s model.

Our generally positive experience in this enterprise has suggested that it could be beneficial if alignment and equivalence testing were more widely practiced among computational modelers.

Keywords: Simulation, replication, computational models, alignment, culture.

1. Introduction

1.1. Motivation

If computational modeling is to become a widely used tool in social science research, it is our belief that a process we will call “alignment of computational models” will be an essential activity. Without such a process of close comparison, computational modeling will never provide the clear sense of “domain of validity” that typically can be obtained for mathema-

tized theories. It seems fundamental to us to be able to determine whether two models claiming to deal with the same phenomena can, or cannot, produce the same results.

Alignment is essential to support two hallmarks of cumulative disciplinary research: critical experiment and subsumption. If we cannot determine whether or not two models produce equivalent results in equivalent conditions, we cannot reject one model in favor of another that fits data better; nor are we able to say that one model is a special case of another more general one—as we do when saying Einstein's treatment of gravity subsumes Newton's.

Although it seems clear that there should be frequent efforts to show pairs of computer models to be equivalent, we are aware of only one such case (Anderson and Fischer 1986), and we know of no systematic analysis of the issues raised in trying to establish equivalence.

We have identified a few cases in which an older model has been reprogrammed in a new language, sometimes with extensions, by a later author. For example, Michael Prietula has reported¹ reimplementing a model from Cyert and March (1963) and Ray Levitt has reported a reimplementation of Cohen, March and Olsen (1972).² However, these procedures are not comparisons of different models that bear on the same phenomena. Rather they are "reimplementations," where a later model is programmed from the outset to reproduce as closely as possible the behavior of an earlier model. Our interest is in the more general and troublesome case in which two models incorporating distinctive mechanisms bear on the same class of social phenomena, be it voting behavior, attitude formation, or organizational centralization.

This paper therefore aims to achieve two goals: 1) to report a novel set of results from aligning two different computer models of cultural transmission; and 2) to report an informative case study of the process used to obtain these novel results.

1.2. Overview

The paper is organized into six sections. After this brief introductory section, Section 2 provides more detailed background on the two models necessary for understanding the results. The third section reports our procedures in aligning the two models and in collecting information for this case report. The fourth contains results from two comparison experiments. The fifth reports our observations on the model alignment process. The conclusion is the sixth section.

2. Background on the Two Models

Our objective has been to determine if a set of results obtained in a model of cultural transmission built by Robert Axelrod (1995), could also be obtained in the different setting of the Sugarscape model of Joshua M. Epstein and Robert Axtell (1995).³ Sugarscape differs from the Axelrod model in many ways. Most notably, culture is one of many processes that can be operative in the more general Sugarscape system, which has model agents who—among other things—move, eat, reproduce, fight, trade, and suffer disease. The Axelrod model has much simpler agents who do none of these things, but rather occupy fixed positions on a square plane, interacting only with their immediate neighbors to the North, South, East, and West.⁴