The Role of Intentional Decision-Making in the Context of Complex Systems and Information Technologies

Nuno David
Department of Information Science and Technology, ISCTE, Lisbon, Portugal
Nuno.David@iscte.pt

Jaime Simão Sichman
Intelligent Techniques Laboratory, University of São Paulo, São Paulo, Brazil
Jaime.Sichman@poli.usp.br

Helder Coelho
Department of Informatics, University of Lisbon, Lisbon, Portugal
hcoelho@di.fc.ul.pt

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1. Introduction

The analysis of complex systems has been pursued through the use of increasingly more sophisticated information technologies. In particular, after the consolidation of the multi-agent paradigm in computer science, the use of computer simulation acquired a renewed importance for analysing societies as complex systems. The sources of analogies between agent-based technologies and models of actual social systems have created an intense interdisciplinary effort, opening new interfaces of research across the computer and the social sciences, under the umbrella of a recent scientific field, which may be called agent-based social simulation.

There are several reasons to make a philosophical analysis of this scientific domain. In general, simulation has been contributing for an inter- and multi-disciplinary scientific praxis, which contributes to establishing new alternatives to traditional scientific methodologies. This should lead to the elaboration of new philosophical perspectives about the rules of the game as they are currently played in simulation. More specifically, the simulation of social theories and phenomena determines the encounter of two scientific logics, with prima facie distinct methodological grounds: on the one hand, the formal and empirical logic of computer science and, on the other hand, the descriptive and interpretative logic of the social sciences.

1 See e.g. Conte, R; Gilbert, N (1995). “Introduction: Computer Simulation for Social Theory”. In Artificial Societies, (Gilbert, N; Conte, R, editors), London: UCL Press.
2 See also e.g. Conte, R; Gilbert, N and Sichman, J (1998). “MAS and Social Simulation; A Suitable Commitment”. Multi-Agent Systems and Agent-Based Simulation (Sichman, J; Gilbert, N; Conte, R, editors), Lecture Notes in Artificial Intelligence, v.1534, Springer-Verlag, pp.1-9.
3 About the interdisciplinary structure of the scientific community of agent-based social simulation, see David, N; Marietto, M; Sichman, J; Coelho, H (2004). “The Structure and Logic of Interdisciplinary Research in Agent-Based Social Simulation”. Journal of Artificial Societies and Social Simulation (JASSS), v.7, n.3.
Within the scientific community itself, the existence of methodological aspects that deserve better analysis is quite recognized\(^6\). For some, the use of formal models resulting from the computational nature of simulation has been considered not only an addition to the established methods but the basis for the emergence of proper social sciences\(^7\). For others, the classical theory of computation does not support an adequate model of reality for simulation in the social sciences and therefore the formal tradition of computation is not enough\(^8\). At any rate, the difficulties in constructing and analyzing simulations, even the most simplified, have been underlined in the literature, which raises some interesting questions around the kind of scientific knowledge that simulation is providing.

There are at least two innovative methodological aspects that have not received analysis. On the one hand, the *experimental reference* of simulation remains ambiguous, insofar as the logic of its method turns computer programs into something more than a tool in the social sciences, defining them as the experimental object itself; it is programs, and not the social phenomena they presumably represent, that are executed and tested. On the other hand, the *formal tradition* of the classic theory of computation creates a semantic gap between the formal interpretation of program executions, derived from the Turing-Church thesis, and the stakeholders’ informal interpretations, acquired through direct observation of simulations.

In sum, although there are diverse methodological dilemmas that have deserved discussions in the field, from an epistemological point of view they suffer from the absence of alternative visions as to the role played by information technologies – and social simulation in particular – in scientific knowledge. How are we to reconcile the methodologically diverse and multiparadigmatic social sciences with an information and computer science that has been able to attain a larger consensus in regard to the conception of scientific truth or validity? Insofar as the knowledge acquired through simulation must be recognized according to the interpretative character of the social sciences, we should attempt to evaluate whether simulation implies an additional perspective in the way that one can understand the concepts of computer programs and computation.

The goal of our presentation in CSS’05 is to characterize the actual practice of computation for modelling social theory and phenomena, especially with reference to its epistemological basis and the particular kind of scientific knowledge that the field is providing. We demonstrate that the logic of social simulation implies at least three distinct types of program verification in computer science, which reflect an epistemological distinction in the kind of knowledge one can have about programs or simulations. Whereas such knowledge may ultimately be characterized as merely interpretative, the role of complexity sciences suggests a further categorization beyond the traditional borders of formal and empirical knowledge, reflecting three distinct contexts of scientific practice and knowledge: formal, empirical and intentional knowledge.

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\(^6\) See E.g. subscripts number 1, 2, 3, 7, 8. See also e.g. Edmonds, B (2000). “The Use of Models – Making MABS more Informative”. *Multi-Agent-Based Simulation*, (Moss, S; Davidsson, P, editors), Lecture Notes in Artificial Intelligence, v.1979, Springer-Verlag, pp.15-31.


\(^8\) David, N; Sichman J; Coelho H (2005). “Intentional Adequacy of Computer Programs as the Experimental Reference of Agent-Based Social Simulations.” Accepted to *Fourth International Joint Conference on Autonomous Agents and Multiagent Systems*, Utrecht University, 25 - 29 July, 2005. See also subscript number 5.
2. The Structure of Our Argument

Given the limited space in this abstract, our goal is to outline very briefly the structure of our philosophical argument. It is comprised of four parts. The first and the second parts will be the core part of our presentation. The third part draws on our previous work\(^9\). The fourth part goes over the whole argument, discussing the roles that intentional decision making may be able to play in a more participative information society.\(^{10}\)

First Part: FDE refutation

The first part consists of characterizing the unsatisfactory role of the classical theory of computation\(^ {11}\) in complexity sciences, particularly in social simulation. Traditional scientific methodologies often characterize the concept of program execution as a process of formal inference. In the philosophy of complexity sciences, the notion of program execution has been not only described as a formal inference procedure but actually as a formal deductive procedure itself.\(^ {12}\)

To some extent, this recalcitrant tradition results from conflating the terms “program computation” and “program execution” into one single meaning, conveying the same ontological status to two fundamentally distinct processes. Considerations of brevity and simplicity led us to call this tradition the FDE argument, as per Formal Deduction through Execution. Notwithstanding, our goal is quite the opposite, namely to demonstrate that simulation shall not be legitimized under the presumption of being an outcome of a calculus of formal inference. Having this in mind, we first define what we consider to be a “limitation in principle” and a “limitation in practice.” Subsequently, we will set up the conditions to refute the FDE argument by reducing it to the argument of formal program verification in

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\(^9\) See subscript number 5.
\(^{10}\) The entire argument can be found in David, N. (2005). “Verificação Empírica e Intencional de Programas em Simulação Social Baseada em Agentes”, Tese de Doutoramento (PhD), Universidade de Lisboa (in Portuguese).
\(^{11}\) The classical theory of computation is also known as the Turing-Church thesis.
computer science\textsuperscript{13}, which has proved to have serious limitations both in principle and in practice.

The FDE refutation suggests yet another objection to the current philosophical thinking in the literature: the objection to characterizing simulation as a basic and new epistemic conception of empirical methodology, such as deduction or induction\textsuperscript{14}. Whereas social simulation seems to represent a new kind of experimental science, the multiparadigmatic character of the social sciences requires that simulation be understood beyond the traditional characterizations of empirical sciences.

Second Part: The role of programming languages in simulation

The second part of our argument analyses the role of programming languages as embedded models in social simulations, which seem to play different roles when compared to those played in traditional computer science and artificial intelligence. The goal is to describe the methodological aspects of simulation that may or may not be characterized within the scope of an empirical science. We first recall that computer programs have a semantic significance related to their causal capability that scientific theories do not seem to possess\textsuperscript{15}. Notwithstanding, whereas the formal and causal role of programming languages in computer science may be well characterized, the informal role of programming languages in social simulation seems to play a distinct function.

The informal character of social simulation suggests that its methods highlight the presence of more outstanding intentional aspects in programming and interaction with computers than might be expected\textsuperscript{16}. Even though most of the results are outcomes of experimental processes, they do not represent “material conditions of necessity” between facts about the corresponding program behaviours. As an alternative, the analysis of “conditions of intentionality,” with regard to program behaviours in computers, led us to the third part of our argument.

Third Part: The double interpretative character of simulation

One way to understand the role of experimentation in social simulation is to realize that theories in simulation are \textit{doubly contingent}, interpreted according to two distinct references: the program behaviour and the targeted social theory or phenomenon. Note, however, that the former cannot be interpreted as a model of the latter, at least in the context of the classical theory of computation. According to the Church-Turing thesis, all computation that


\textsuperscript{14} This is an objection to Axelrod’s claim, that simulation is as a third way of doing science, in contrast to both induction and deduction”: Axelrod, R (1997). “Advancing the Art of Simulation in the Social Sciences”. \textit{Simulating Social Phenomena} (Conte, R; Hegselmann, R; e Terna, P, editors), Springer Verlag, pp.21-40.


\textsuperscript{16} See subscript number 5.
terminates can be simulated by a first-order language. But insofar as social theories and models can hardly be described by first-order languages, it is possible to show that there are two complementary scientific logics at stake in social simulation. One is based on the formal and empirical logic of program verification, in which *necessary conditions* about the behaviour of programs are specified and verified empirically, and another based on the experimental logic of program verification, in which *intentionality conditions* about the behaviour of programs are specified and verified experimentally, albeit not empirically, according to a limited community of observers. This distinction is thus associated with two kinds of program verifications, which we call empirical and intentional verification of programs.

*Fourth Part: Complex systems, participative simulation, and democratic decision making*

Insofar as the logic of social simulation implies at least three distinct types of program verifications (formal, empirical and intentional), it reflects an epistemological distinction in the kind of knowledge one can have about programs or simulations. Whereas such knowledge may ultimately be characterized as merely interpretative, the role of complexity sciences suggests a further categorization beyond the traditional borders of formal and empirical knowledge, reflecting three distinct contexts of scientific practice and knowledge: formal, empirical and intentional knowledge. Accordingly, the final part of our argument draws some conclusions and challenges from the role of intentional decision-making in the context of an increasingly participative society.