Computational Modeling of Organizations Comes of Age*

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Abstract

As they are maturing—i.e., as they are becoming validated, calibrated and refined—computational emulation models of organizations are evolving into: powerful new kinds of organizational design tools for predicting and mitigating organizational risks; and flexible new kinds of organizational theorem-provers for validating extant organization theory and developing new theory. Over the past 50 years, computational modeling and simulation have had enormous impacts on the rate of advancement of knowledge in fields like physics, chemistry and, more recently, biology; and their subsequent application has enabled whole new areas of engineering practice. In the same way, as our young discipline comes of age, computational organizational models are beginning to impact behavioral, organizational and economic science, and management consulting practice. This paper attempts to draw parallels between computational modeling in natural sciences and computational modeling of organizations as a contributor to both social science and management practice.

To illustrate the lifecycle of a computational organizational model that is now relatively mature, this paper traces the evolution of the Virtual Design Team (VDT) computational modeling and simulation research project at Stanford University from its origins in 1988 to the present. It lays out the steps in the process of validating VDT as a “computational emulation” model of organizations to the point that VDT began to influence management practice and, subsequently, to advance organizational science. We discuss alternate research trajectories that can be taken by computational and mathematical modelers who prefer the typical natural science validation trajectory—i.e., who attempt to impact organizational science first and, perhaps subsequently, to impact management practice.

The paper concludes with a discussion of the current state-of-the-art of computational modeling of organizations and some thoughts about where, and how rapidly, the field is headed.

Keywords: computational modeling and simulation, state-of-the-art, computational modeling in natural science, computational modeling in engineering, organizational engineering, synthetic experiments, validation, industrial application, Virtual Design Team

Introduction

Over the past 50 years, computational modeling and simulation have had enormous impacts on the rate of advancement of knowledge in fields like physics, chemistry and, more recently, biology; and their subsequent application has enabled whole new areas of engineering practice. In the same way, this paper asserts that computational modeling of organizations

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has come of age, having reached a level of maturity where our field is beginning to make significant contributions both to organizational science and management practice. As they are maturing—i.e., as they are becoming validated, calibrated and refined—computational simulation models of organizations are evolving into: powerful new kinds of organizational design tools for predicting and mitigating organizational risks; and flexible new kinds of organizational theorem-provers for validating extant organization theory and developing new theory.

The paper draws parallels between the way that computational modeling in the natural sciences enabled spectacular advances in experimentation and engineering practice over the past 50 years and the ways in which computational modeling of organizations is now beginning to contribute to both social science and management practice. It traces the evolution of the Virtual Design Team (VDT) computational modeling and simulation research project at Stanford University from its origins in 1988 to the present to illustrate the lifecycle of one relatively mature computational model of organizations. It lays out the steps in the process of developing and validating VDT as a “computational emulation” model of organizations to the point that VDT began to influence management practice and, subsequently, to advance organizational science. Alternate research trajectories are laid out for computational and mathematical modelers who prefer the typical natural science validation trajectory—i.e., who attempt to impact organizational science first and, perhaps subsequently, to impact management practice.

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Research Modalities in Natural Science and Engineering

Research in the natural sciences and engineering through the first half of the 20th-century followed the “3-legged stool” approach shown in figure 1: observation of empirical data; development of theory (generally in the form of sets of linear or differential equations); and physical scale modeling. The work of the Wright brothers in developing powered flight followed exactly this kind of 3-legged stool approach. Their applied science process in developing the science and practice of powered flight: iteratively studied and proposed extensions to the limited, extant theory of aerodynamics of the time; performed wind tunnel tests on scale models; and used heroic observations of the behavior of full-scale prototype systems—including themselves as passengers—to refine their scale model experiments and extend aerodynamic theory.

Engineers who translated the physical science theories of Isaac Newton and others into sophisticated engineering approaches for designing both static structures and increasingly sophisticated machines followed the same approach. Starting in the late 1950s, computers that had been developed for code breaking and ballistic calculations in World War II emerged on the scene as potential new computational tools for engineers. Their initial application was automating tedious mathematical computations, such as solving sets of linear equations by matrix inversion, or calculating approximate numerical solutions for sets of differential equations. The late Professor Charles L. Miller and his colleagues at MIT and elsewhere