Docking Two Models of Insurgency Growth

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ABSTRACT

The use of agent-based simulations (ABS) in social science applications presents validation challenges. In this study, the authors use two theories for the growth of rebellion, one an ABS and the other implemented as a system of ordinary differential equations (ODEs). Epstein’s (2001) theory for the rise of rebellion serves as one conceptual model. The authors implement this theory in NetLogo, with several modifications. The second conceptual model likens the spread of an insurgency to that of an infectious disease, specifically the susceptible-infected-removed-susceptible (SIRS) model. The authors find that the similarity of the ODE model results to those obtained from certain parameters of the ABS implementation serves as a form of model validation. The term used for this type of validation is docking. In addition, other results obtained from the ABS – not directly attainable from the ODE model but which match observed phenomenon in socio-political systems – also demonstrates operational validity.

Keywords: Agent-Based Simulation, Docking, Insurgency, NetLogo, Rebellion, SIRS Model, Social Science Models, Validation

INTRODUCTION

Why men rebel and how they come to join violent opposition organizations is not completely understood. Causes of insurgencies and other forms of civil disobedience are sociological phenomenon about which various abstract theories have been posited. In the simplest case, civil disturbance is carried out between two sides engaged in a zero-sum conflict over a political space. Typically, competing theories differ by individual motivation and the dynamic interaction between actors.

For instance, Gurr (1970) theorizes that relative deprivation, the perceived discrepancy between one’s expectations and one’s capabilities, causes cognitive dissonance which can lead to violence. Leites and Wolf (1970) analyze insurgency as a system and claim that to be effective, insurgent movements require that certain inputs – obtained from either internal or external sources – be converted into various

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forms of violence. Tullock (1971) applies economics to investigate motivations for revolution and finds a compelling argument in private gains and byproduct public goods as foundations for rebellion. In later work, Tullock (1985) claims that private allegiance changes must be considered in the process by which disorder forms and grows. Kuran (1989) posits that preference falsification, or subordinating private beliefs to public pressures, can cause an apparently unshakeable government to fall, even due to insignificant events. McCormick and Owen (1996) feature rational actors making expected value calculations where group violence is used as a surrogate to estimate the size and relative prospects of an armed opposition. The struggle between the two sides is a dynamic interaction in which they mobilize and grow a base of support while attacking their opponent’s support. The side that displaces its opponent by filling the political space wins the contest. Epstein (2001) tracks individual agents considering their hardship and government legitimacy against an individual’s threshold for violence to determine whether or not to rebel. Others have modeled warfare, insurrections, and rebellion using mathematical models, typically ordinary differential equations (Castillo-Chavez & Song, 2003; Dietrichman, 1962; Lanchester, 1916; Udwadia & Leitmann & Lamberti, 2006).

Agent-based simulations have become popular in social science research because they can allow for the examination of complex systems by representing decentralized individual interactions in artificial environments or societies. The National Research Council (2008) defines agent-based modeling as “the computational study of systems that are complex in the following sense: (1) the systems are composed of multiple interacting entities and (2) the systems exhibit emergent properties—that is, properties arising from entity interactions that cannot be deduced simply by averaging or summing the properties of the entities themselves.” As such, insurgency theories seem well-suited for agent-based modeling and exploration.

Validating ABS is an important issue, particularly among the DoD community (DoD, 2008, 2009). Unlike the validation of physics-based models, validating agent-based implementations of abstract theories from sociology, particularly in the absence of validated empirical evidence, is a much more difficult prospect. The difficulty is compounded because the theory and practice of validating social science models and their implementations is a relatively new field; methods for performing ABS validation are neither well developed nor as yet generally accepted.

The literature reflects that establishing both conceptual validity and operational validity are necessary to the process of validating an ABS (Heath, Hill, & Ciarallo, 2009; Knepell & Arangno, 1993; Sargent, 2010). Conceptual validity determines that the theories and assumptions underlying the conceptual model are correct and that the model’s structure, logic, and causal relationships are “reasonable” for the intended purpose of the model (Robinson, 2008; Sargent, 2010). For the sake of replication, conceptual validity requires, at a minimum, a well documented model (Robinson, 2006). Operational validity – or external validity – refers to the accuracy and adequacy of the computational model in matching real world data (Carley, 1996). In the absence of such data, operational validity is accomplished by other means such as matching the results of two similar models, also known as docking (Axtell, Axelrod, Epstein, & Cohen, 1996; Burton, 2003; Parunak, Savit, & Riolo, 1998). Other forms of operational validity include animation, face validity, historical methods, parameter variability-sensitivity analysis, traces, etc. (Sargent, 2010).

EPSTEIN’S CIVIL VIOLENCE MODEL

Epstein (2001) presents an agent-based computational model of civil violence modeling a central authority’s efforts to suppress insurrection in its population. This model’s set of three behavioral agent rules represents an example of a well documented, conceptually valid model. This section describes an extension of
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