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AGENT-BASED SIMULATION

David Mendonça
New Jersey Institute of Technology
Information Systems Department, NJIT
Newark, NJ, USA
e-mail: mendonca@njit.edu

Abstract

Critical infrastructure systems such as telecommunications, water, electricity and even emergency services are now recognized as complex human-machine systems often operating interdependently. Indeed, a wealth of research over the last ten years has amply demonstrated that successful operation and restoration of these systems arises from a detailed understanding of humans, machines and the interactions between them, both within individual systems and across multiple, possibly interdependent, systems. This talks reviews and illustrates techniques in how to develop computer-executable models of human action within critical infrastructure systems.

There are both practical and theoretical reasons for wanting to improve understanding of the role of humans within critical infrastructure systems. Human ingenuity and expertise are frequently called upon to provide solutions to the novel problems that arise when the services provided by critical infrastructures are disrupted. Of course, it may also be argued that humans can also engender disruptions (e.g., through error). From a theoretical perspective, then, this understanding should contribute to what we know about human expertise (and the lack thereof) as exercises within complex socio-technical systems. From a practical perspective, improved understanding should produce better predictions about human action during both day-to-day and exceptional operating conditions.

A challenge for those wishing to generate predictions about human action in the management or restoration of critical infrastructures is the underlying complexity of the systems under study. Indeed, even under normal states of affairs, critical infrastructure systems are characterized by properties that do not lend themselves to analytic techniques. Computer-based simulation offers one alternative approach to analysis—albeit one with its own set of challenges. In the context of modeling of human action, agent-based approaches have their genesis in studies seeking to simulate how humans think and behave in the course of learning, problem solving, decision making, and communicating. They may be called upon when a realistic model of human action at either the individual or collective level is required.

This talk presents an overview and illustration of how agent-based simulation may be employed to increase understanding of humans and human-machine interaction within critical infrastructure systems. The focus is on modeling human action and human-machine interaction during post-disaster restoration of critical infrastructure systems. An example from the response to the 2001 World Trade Center attack introduces key concepts. A detailed case study - taken from a controlled experiment - then illustrates one approach to modeling the cognition and behavior of individuals acting as part of a small emergency response organization. Because models based on agent-based simulation engender a heavy responsibility on validation, this talk reviews and illustrates techniques for assessing model validity.