FROM ANALOGUE TO DIGITAL COMMAND AND CONTROL DECISION-MAKING: THE LAW OF REQUISITE VARIETY AND FUZZY METHODS IN QUANTIFYING SITUATION ASSESSMENT

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Abstract

Ashby's law of requisite variety (LoRV) has been a recognized theoretical framework for system thinking and cybernetics to assess and regulate a system. The LoRV can innovatively be applied to adaptively seek successful outcomes during decision-making. An analogue to digital transformation can be achieved by combining LoRV with fuzzy methods to quantify situation assessment variables that drive successful mission outcomes. In so doing, the LoRV is viewed as a mathematical description of command and control (C2).

The novel approach used in this research achieves four goals and advances the LoRV application that facilitates successful solutions to real-world issues. First, use the law in a mathematical form as the regulator of quantitative information to compare a system's variety (all possible states achievable) against the variety of responses (all possible decisions). A simulated wildland firefighting C2 environment was the experimental context. Understanding the relationship between the two opposing forces, the fire's states and the firefighters' decisions is critical to C2. Second, develop quantitative inputs as numerical representations for human perceptions of the contextual environment using fuzzy methods. In accordance with Ashby's description of LoRV, the human decision-maker defines the system, the regulator, and the varieties of each variable. Third, use the quantified perceptions to define the inputs into the agent-based simulation, run the competing forces against one another, and gather data on the behaviors which produce quantitative results. Finally, evaluate the results through the LoRV to provide a requisite variety frontier, that effectively separates the controller's successful and unsuccessful results. This evaluation provided a numerical representation for both the fire (density, probability of spread, and wind) and firefighting variables (number, detection range, and extinguishing area) which were then plotted as a representation of the controller's effectiveness in achieving the goal in relation to the frontier, and as a measure of current and future success/failure.

This research demonstrates the utility of the LoRV in a quantitative manner, enabling exploration of applications in real-world contexts.

Keywords: law of requisite variety, cybernetics, systems thinking, system control, command and control, decision-making, fuzzy methods, wildland firefighting