Dissertation Defense

Analysis and Simulation of Dynamics of Complex Social Systems

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Online via Zoom

Abstract

The dynamics of complex social systems have been successfully applied to many fields, for instance, management, economy, politics, and public health. Studying this topic is challenging since it usually involves many variables and configurations of human properties, social relationships, cultural or environmental factors, etc., which cannot be explored with intuition or simple calculation. Moreover, it also needs many theories and methodologies from multiple fields including social science, behavioral science, complexity science, computer science. This research aims to reveal and explore the hidden dynamics in time-varying complex social systems at both individual and collective levels through three studies, the state dynamics of temporal networks, the dynamics of collective leadership, and the dynamics of group effectiveness.

Study one developed a new method to detect and examine state dynamics in temporal networks that abstract the time-varying complex social systems. Through analyzing the change of connectivity in social contact networks, this method revealed distinct system states of students' and teachers' activities in a primary school and of attendee's physical contacts at an academic conference, which matched the sequence of the real-world events well and outperformed the recently proposed approach. This study can be used to simplify the interpreting, predicting, or managing of complex social systems. For example, the evolution of online social networks, state dynamics of disease spreading, detecting system states in transportation systems, etc. Study two constructed an agent-based model (ABM) regarding the dynamics of leader emergence and leadership perception in initially leaderless groups. Simulation results suggested that talkativeness may be the most significant and instantaneous predictor for leader emergence. In terms of group performance, smaller groups may outperform larger groups regarding their problem-solving ability in the beginning, but their performance tends to be of no significant difference in the long run. These results match the empirical literature and offer a mechanistic, operationalized description of the collective leadership processes. Building on study two, study three investigated the dynamics of group performance in the group decision-making process, and how it can be impacted by the size of group, task complexity, timing, and other minor change in individual behaviors. This study developed an agent-based model (ABM) using bounded rational agents, which describes the complex process of collaborative group decision-making on problem-solving tasks. It theoretically explained those conflicting experimental observations in group performance based on simple assumptions. These two agent-based models are mechanistic, operationalized descriptions of the

group decision-making process, which allow for exploring other questions of interest using different variables or varying assumptions that are challenging to apply using field studies or lab experiments. This research, overall, enhances our understanding of the collective dynamics and emergent phenomena of complex social systems, improves the effectiveness of social systems.