An Interdisciplinary Agent-based Evacuation Modeling Framework: Seeking Convergence of Social, Natural, and Engineered Systems to Improve Life Safety and Infrastructure Resilience

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Abstract: This project supported by the NSF-CMMI HDBE program (Award #1563618, #1826407, #1902888) develops fundamental understanding of how an interdisciplinary agent-based modeling framework can integrate social, natural, and engineered systems to seek convergence to improve life safety and infrastructure resilience under threat of multi-hazards. The targeted scenario is a magnitude 9.0 earthquake and tsunami from the Cascadia Subduction Zone, threatening communities along 1,000 miles of the US Pacific Northwest coastline. This project integrates the disciplines of social science, civil engineering, and computer science to investigate multiple forms of tsunami information and its potential impact on evacuation decision-making by the general public and the unique professional community responsible for coastal visitor safety. The project objectives are (1) to identify the cognitive and social factors that influence multimodal evacuation decision-making behavior; (2) to utilize an Agent-Based Modeling framework to provide realistic/credible hypothetical scenarios for near-field tsunamis hazards; and (3) to determine the usability/acceptability of social science-informed agent-based modeling for understanding evacuation decision-making. This project develops close collaboration with a number of organizations responsible for public safety during the response to extreme natural hazards, including the Oregon Department of Transportation, Oregon Office of Emergency Management, Oregon Parks and Recreation, and Oregon Sea Grant. This work will therefore improve understand of how decision-making affects life safety, with broad outreach to diverse audiences both to assess the feasibility of this approach and for purposes of outreach. One of the most exciting and novel components of this project is the creation of a Tsunami exhibit by integrating the modeling engine ABTEM with an interactive multi-touch table for informal tsunami education at the Hatfield Marine Science Center. Continuous advancements have been implemented into the model including (1) a more credible population distribution; (2) an agent-to-agent interaction (decision-making and physical) and communication model; (3) unplanned network disruption and interdependency modeling; and (4) integration of NetLogo and RNetLogo for iterative Monte Carlo simulation. These enhancements have enabled us to investigate how the following factors affect mobility and life safety: (1) heterogeneous decision-making under external social influences; (2) systematic characterization of each link's contribution to network resilience; (3) the impacts of unplanned network disruptions; (4) the phase transition in the emergent social and infrastructure networks; and (5) multimodal trajectory modeling.

Bio: Dr. Haizhong Wang is an Associate Professor of Transportation Engineering within the School of Civil and Construction Engineering at Oregon State University, Corvallis, OR. Dr. Wang's research interests include (1) Interdisciplinary Disaster Resilience: use the ABM framework to evaluate the impacts of heterogeneous decision-making behavior on life safety under unplanned infrastructure network disruptions; (2) Critical Resilient Interdependent Lifeline and Infrastructure Networks: system resilience characteristics and dependency/interdependency modeling; (3) Heterogeneous Traffic Flow Modeling and Simulation: deterministic and stochastic fundamental diagram of traffic flow, hysteresis, and stochastic capacity analysis; and (4) Connected Automated Vehicle (CAV): mobility and safety analysis in a mixed traffic flow environment under varying levels of market penetrations.