Enhancing Evacuation Warning Responsiveness: Exploring the Impact of Social Interactions through an Agent-Based Model Approach

Alessandro Toledo Salazar Mathias Duque Medina Jorge E. Pesantez, PhD Project 2356
Matthew Medrano Julio Roa, PhD June 2024

Introduction

Evacuations are typically the preferred response to human- or natural-caused disasters. As evacuation processes include traffic planning, simulation models that evaluate the decision of people to evacuate provide city planners and control agencies with valuable information to plan for routes and traffic control.

The goal of this project is to apply a simulation model to determine the opinion of people about evacuating a threatened area or staying to face the threat. People must decide when/where/how to evacuate, and much of this decision-making is based on messages received from local authorities, but it is also affected by other sources such as social media. With this in mind, the research question is: will including sources of information change the opinion of people about evacuating their homes when facing a threat posed by a wildfire event?

Study Methods

The This project presents a social sciences concept, opinion dynamics, to model the opinion and decision-making of people threatened by a wildfire event. To demonstrate how individual opinions evolve with time, the simulation applies an agent-based model (ABM) that includes the interaction between an agency sending an evacuation message and the interaction of the affected population.

This project uses three sources of information involved in the the mathematical model of an opinion: (1) the global broadcasting message that a central agency sends to the affected population, (2) the interaction of people through their social media networks, (3)and observations of neighbors' actions. An agent in the model represents a household unit. The opinion value of each agent leads to a decision to evacuate if it overcomes a resistance threshold. This threshold is modeled as a random sample from a uniform distribution. By combining sources of

information, the model presents three scenarios, namely: global broadcasting only, global broadcasting and social media, and global broadcasting and neighbors' actions.

The agent-based model found that social media interactions and neighbors' actions delay the evacuation rate of a population affected by a wildfire event.

Findings

Assessing Results show that when global broadcasting is the only information available to agents, a decision to evacuate is unanimously reached after a short period. This finding provides valuable information to traffic agencies to start planning for full evacuation compliance when the only source of information is the message sent out by a central agency. However, when social media interactions are included, there is a delay in reaching a unanimous agreement to evacuate. Furthermore, when social media interactions are replaced by observing the actions of neighbors, there is no agreement to evacuate among the agents, and most of them decide to stay and see how the situation progresses.

The model output presents a computer-interactive tool where the user can adjust the input parameters to tailor the model to different social conditions and evaluate the compliance rate of the affected people evacuating a threatened area.

Policy/Practice Recommendations

This research project provides opportunities for planning and management of traffic conditions and route planning when an evacuation is expected but the number of people participating is unknown. The project's outcome may assist traffic agencies with a predicting model to evaluate local conditions regarding evacuation opinions. This approach could potentially be used to model for a variety of disasters and emergencies.

About the Authors

Alessandro Toledo is a Civil Engineering undergraduate student at California State University, Fresno. He has participated in multiple research projects around civil infrastructure, optimization, modeling, and data analysis. Under the guidance of Dr. Jorge Pesantez, he worked on the agent-based model to simulate the opinion dynamics of a population threatened by a wildfire event.

Matthew Medrano is a third-year undergraduate student at Fresno State University and majoring in Civil Engineering. He is a member of Fresno State's Lyles College of Engineering Honors Program and is involved in the ASCE student chapter. Matthew has an interest in transportation as well as modeling research and plans to attend graduate school in order to gain more knowledge about the engineering industry.

Mathias Duque is an international student from Ecuador who arrived at Fresno State in 2021 to pursue his bachelor's degree in civil engineering. He has previously assisted in the instruction of STEM classes and currently contributes to the Fresno State Transportation Institute.

Dr. Julio Roa currently serves as an Assistant Professor at California State University Fresno, a role he embraced in 2018. He earned his master's degree in 2008, focusing on Transportation Infrastructure, and later, his doctoral degree in 2018, specializing in Transportation Systems.

Dr. Jorge Pesantez led this project on the implementation of an Agent-based model using Opinion Dynamics theory. Dr. Pesantez has extensive work in simulation models for infrastructure analysis.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2356

MTI is a University Transportation Center sponsored by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology and by Caltrans. The Institute is located within San José State University's Lucas Graduate School of Business.