Geographer designs computer model to predict crowd behavior

Patterns of human behavior and movement in crowded cities – the tipping point at which agitated crowds become anti-social mobs, the configuration of civic areas as defensible spaces that also promote free speech, the design of retail space that fosters active walking – are at the core of an immersive 3-D computational model under development by an Arizona State University geographer.

"Crowds are vital to the lifeblood of our cities, yet, crowd behavior is veiled to traditional academic inquiry," says Paul M. Torrens, an assistant professor in the School of Geographical Sciences.

It is impractical, Torrens says, "to establish live experiments with hundreds or thousands of people along busy streetscapes, to reproduce mob behavior during riots for the purposes of academic experimentation, or, to expect to replicate the life and death behavior under emergency situations in a fabricated fashion."

"You couldn’t stage a realistic rehearsal of an evacuation because people are not going to panic appropriately, or you could never bulldoze large sections of the city to see how it affects pedestrian flow," he says. Instead, Torrens is developing a realistic computer model that can be used to assist city planners, shopping center developers, public safety and health officials, and researchers in exploring the dynamics of individual pedestrian and crowd behavior in dense urban settings.

"The goal of this project is to develop a reusable and behaviorally-founded computer model of pedestrian movement and crowd behavior amid dense urban environments, to serve as a test-bed for experimentation. The idea is to use the model to test hypotheses, real world plans and strategies that are not very easy or are impossible to test in practice," Torrens says.

The current ways of measuring behavior that use statistical analysis or physics models have not proven to have the veracity that this model could potentially have, according to Torrens.

The new modeling approach will incorporate individual behavior and independent characteristics – age, sex, size, health, body language — while also taking into account crowd-level features such as panic, as well as characteristics of the environment, such as safety levels. The simulations will model both motion and emotion, Torrens says.

The model "will serve as an experimental, but wholly realistic, environment for exploring ‘what-if’ and unforeseen scenarios of relevance to cities and their citizens," Torrens says.

For example, the project will develop simulations to explore questions of sustainability in downtown settings: how cities can promote walking as an alternative to driving; how pedestrian flow can be better integrated with transit-oriented development.

Another set of scenarios will explore a range of health issues, for example, how might a pathogen be transmitted through mobile pedestrians over a short time period"

Urban and economic planners will be able to use scenarios to explore questions involving the positioning of anchor stores along main shopping streets, pedestrian flow past street entertainers and placement of tourist information sites.

In the areas of public safety and homeland security, the model can be used to examine questions asking how pedestrian interactions with cars can be minimized; what the early signs of anti-social behavior in large crowds are and how polarizing influences can be neutralized; and strategies that might be used to compel anti-social crowds into quiescence without the use of force.

A prototype of the model has already been developed and used to crowd dynamics following outbreak of a fire in a dense part of a city with only a single point of evacuation. Torrens explains: "When trying to evacuate, people start to run and panic. Jams will occur and the evacuation doesn’t proceed as efficiently as it might otherwise."

The prototype model records every state of every thing in the model every 60th of a second. Once those data are in the system, the model exports this information into a Geographic Information System where the data can be analyzed mathematically.

From this information, "we are able to study collective human dynamics in incredible detail and explore how pedestrian crowds form under a range of conditions; and then provide information on how crowds might be better managed," Torrens says.

"I can quantitatively and empirically benchmark what is normal behavior or what is a deviation from normal behavior and what could have caused somebody to panic in that situation. We’re able to look at panic levels and why people react to things the way that they do," Torrens says.

Torrens’s research will be aided by a National Science Foundation CAREER Award in the amount of $400,000 over five years. The award is the most prestigious award that the NSF grants to junior faculty. While highly sought after, the award is rarely given to geographers.

The inspiration for this NSF proposal came during Torrens’ research in the areas of large-scale urbanization and urban growth system dynamics, though he found the research at the microcosm to be much more challenging. "These are parts of geography that have very micro scale spatial and temporal dynamics that are on the edge of what we have theory for and very much on the cutting-edge of what we have the technology for," Torrens says.

"This award for Paul will launch an already young and distinguished career to leadership levels in our discipline and related disciplines, which make use of computational modeling and spatial technologies," says Anthony J. Brazel, acting director of ASU’s School of Geographical Sciences. "I would foresee his work impacting analyses in homeland security, urban and economic planning, sustainability, public safety, microscale analyses in geographic modeling and other areas, and will greatly advance our role for ASU in the GI Sciences arena on the national scale."

With the NSF grant Torrens plans to have hundreds of thousands of pedestrian agents and larger downtown areas within the model. "We can look quantitatively at the results of reconfiguring the urban environment, social environment, and ultimately, human behavior, which is something you can never do in the real world," he says.

Source: Arizona State University