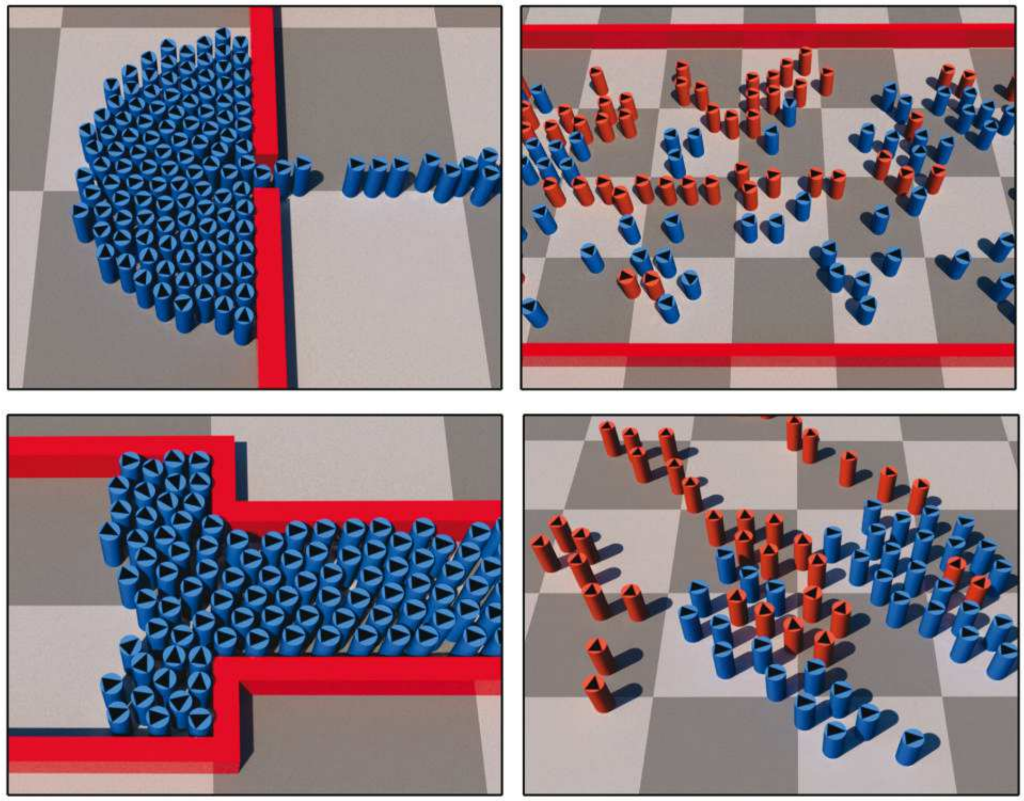


# CROWD COMPUTING

## THE CROWD RESEARCHER IOANNIS KARAMOUZAS TALKS ABOUT HOW PEOPLE MOVE IN MASSES.

BY MICHAEL CANNELL

**ABOVE**
Crowd researchers use computer modeling to study how pedestrians navigate bottlenecks and intersections.

IOANNIS KARAMOUZAS

Public places are pedestrian obstacle courses. You know the hazards—slowpokes sauntering three abreast, rambling cell-phone talkers, ninth-inning crowds pressing for exits. Stadium and intersection, plaza and park, all require a choreography of small-scale negotiations.

The feints and shuffling maneuvers of foot traffic might seem random, but there is a mathematical order to the madness of the crowd. The growing field of crowd analysis and simulation—commonly known as crowd science—reduces human interactions to algorithms, with an eye toward helping designers and engineers make pedestrian spaces flow more efficiently and more safely.

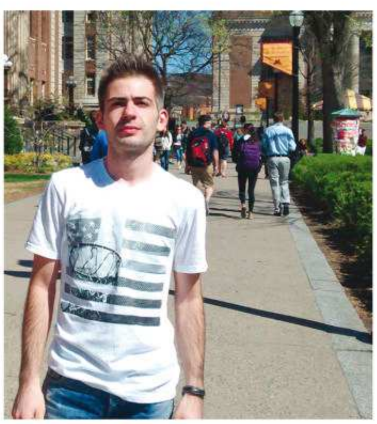
In December, three researchers, led by Ioannis Karamouzas, a postdoctoral associate in the Department of Computer Science and Engineering at the University of Minnesota who studies crowd science, published a study in *Physical Review Letters* arguing that pedestrian movement is guided by the need to avoid collisions. In other words, we subconsciously calculate other people's velocities and adjust our own for avoidance. They came to this conclusion after analyzing 32 minutes of video and computer simulations containing 1,500 pedestrian trajectories. We spoke with Karamouzas about the law of the crowd.

**How does your discovery change our understanding of public space?**
Researchers have always assumed that pedestrians behave like charged particles: When they get too close, they feel a repulsive force pushing them away from each other. Now we know that's not the case. Consider, for example, two friends walking side by side. Though they may walk close, they don't feel the need to diverge. In fact, by analyzing real-life behavior, we found that pedestrian interactions are fundamentally anticipatory. As

we move through a crowd, we constantly extrapolate into the future and calculate how far we are from a collision. The closer we come to impact, the more uncomfortable we feel, and the more energy we expend to avoid it. So when we look at the utility of a public space, the primary question we need to ask is whether it accounts for the anticipatory nature of human motion. How often will uncomfortable situations arise? What design choices lead to less-stressful walking conditions?

**How did you collect data?**

We analyzed 1,500 pedestrian trajectories videotaped on college campuses, commercial streets, and bottlenecks. We focused on the time it takes for pedestrians to collide, assuming they don't change course. We found that the level of discomfort, or "interaction energy," increases drastically as collisions become imminent. In fact, it increases by a factor of four when the projected time to collision is halved.



ABOVE
Ioannis Karamouzas is a postdoctoral associate in the Department of Computer Science and Engineering at the University of Minnesota.

This simple anticipatory law allows for a variety of efficient behaviors. For example, on a congested sidewalk we tend to adapt our speed to that of the person in front of us. This leads to the spontaneous formation of lanes that allow pedestrians to resolve collisions in an efficient manner.

**Do you consider your work a hybrid of psychology and physics?**

Our law captures how people adapt their movements in response to others around them. These adaptations directly follow from the psychology of anticipation. As we move through a crowd, we typically experience a complex system of competing forces. We're trying to reach our destination; at the same time we're trying not to bump into other people. To make matters more complicated, we usually walk in pairs or groups of friends. Our brains account for all these factors. It's the interaction between our individual goals and our law of crowd motion that allows pedestrians to make complex formations and maneuvers—lanes, clogging, vortex-like paths, etc.

**How can computer modeling help designers?**

I'm a big NBA fan. I go to a lot of Timberwolves games here in Minneapolis. I'm always frustrated by the time it takes for everyone to exit the Target Center using a single escalator bank. Our newly identified law provides a simple, yet accurate, model of pedestrian behavior that can improve sports arenas and other public places. We can now measure crowd discomfort by running computer simulations of people moving through building schematics. We can use these simulations to anticipate stampedes and other possible dangers at sporting events and festivals and increase the efficiency of ingress and egress. Modeling can also help with small-scale design decisions—whether pillars improve crowd flow in a shopping area or the best way to place food stands in a stadium without causing congestion.

**Are some public spaces particularly instructive?**

A recent documentary compared the Roman Colosseum's egress to that of modern arenas. It would be fun to perform similar comparisons using our new crowd simulation model. I'm also eager to study behavior in public spaces filled with complex interactions, like Tokyo's Shibuya Crossing and London's Oxford Circus. I'd also love to get crowd data from Times Square and the Grand Central Station. It fascinates me how in such places people avoid collisions while talking on the phone, texting, and interacting with their friends and traffic.

**Why is crowd analysis a growing field?**

Crowd analysis and simulation have evolved enormously, partially because advances in camera technology have allowed for large-scale pedestrian tracking. I believe it will soon be possible to analyze real-time crowd videos at mass gatherings—concerts, sports events, protests—and warn authorities before dangerous situations arise. Real-time analysis may also be used to regulate crowd flow. For example, stadium signs could direct spectators to the least-congested exits.

In addition, video games, training simulators, and animated movies are now populated with lifelike crowds. As a result, companies like Pixar are helping to advance the technology of crowd rendering and animation.

MICHAEL CANNELL IS THE AUTHOR OF *THE LIMIT: LIFE AND DEATH ON THE 1961 GRAND PRIX CIRCUIT.*

BOBBY DAVIS