Simulator computes evacuation scenarios for major events

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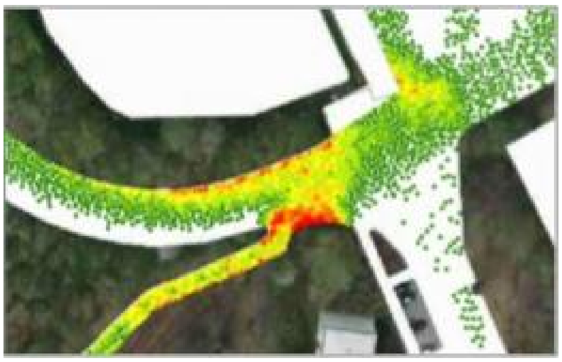

The new simulation program represents every individual in a ten-thousand crowd and shows color-coded crowd densities. Credit: REPKA / TU München

Predicting how large numbers of visitors to major events will behave is difficult. To prevent disasters, however, the police, rescue services and event organizers have to be able to identify dangerous bottlenecks, hidden obstacles and unexpected escape routes in advance. A research group with scientists from Technische Universitaet Muenchen (Germany) has developed a simulator that can be used to compute different scenarios. The program can simulate the behavior of tens of thousands of people.

At twenty past five on Saturday evening in the German city of Kaiserslautern, 40,000 rival soccer fans pour out of the Fritz-Walter stadium after the final whistle has been blown on a league game. All of the fans are either heading to the parking lots or train stations. Even without any incidents, this is a difficult situation for the police and security services. In emergencies or disasters, however, crowd management becomes a matter of life and death. Which is why organizers of major events have to plan meticulously in advance, determining where people will move to, what will happen if certain routes are cut off and how a venue can be evacuated as quickly as possible.

Finding answers to these questions, however, is difficult, even for events that are held on a regular basis. "Even supposedly minor obstructions can have a major impact on crowd dynamics," explains Angelika Kneidl from the Computational Modeling and Simulation Group at TUM. In future, however, the simulator developed by the scientists could help organizers identify these kinds of variables in advance. "We can use the program to run any number of 'what-if' simulations," states Kneidl.

The simulator has been developed by researchers from a number of universities and companies in collaboration with the authorities and security services in Kaiserslautern. The scientists had access to the topography of the area around the Fritz-Walter stadium as well as data on the fans and research findings on the behavior of large crowds. "We know, for example, that crowd formation varies in the event of a bottleneck depending on the width of a passage or route," confirms Kneidl. "We also know that people tend to follow other people." To better understand how pedestrians get from A to B in an unfamiliar city, the researchers sent 150 first semester students from the main TUM building to Munich's Hofbräuhaus. "The students took a wide variety of routes," relates Kneidl. "But they did provide us with useful patterns. The majority, for example, chose long, straight routes and used prominent locations as a guide."

The simulator is programmed on the basis of a force model in which destinations, obstacles and other people all exert a force on individual pedestrians. "One of the challenges was to model these forces in such a way that the program can be applied to all possible scenarios and behavior patterns," explains Professor André Borrmann, Head of the Computational Modeling and Simulation Group. This is because different people act in different ways. While some already know the routes they need to take, others first have to find their bearings. The researchers solved this problem by using the geometry of the area to generate an additional graph that represents the pedestrians' navigation options. In the graph, different routing algorithms represent the various patterns of movement. These are used to search for routes that take pedestrians past possible intermediate destinations.

The program is designed as a training simulator that users can operate themselves. The microscopic simulation represents every individual in a ten-thousand crowd, thus enabling security and emergency services to meticulously track the consequences of specific decisions in real-life situations. Color-coded crowd densities and real-time simulations make it a particularly user-friendly application, especially as conventional microscopic simulations usually require a long time to compute.

In the future, it should be possible to program a simulator like this for any major event where – as in the case of Kaiserslautern – visitors have specific destinations, and programmers have knowledge of topography of the area in question as well as the general size and composition of the crowd. The model cannot be applied to locations such as amusement parks, where visitors walk around without any specific destination. Similarly, it cannot be used to simulate panic situations, where people no longer act rationally. "Our aim, however," explains Kneidl, "is to prevent panic from breaking out in the first place through proactive planning."

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