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Computing the chances of crowd chaos

Handling crowds at major events is a huge challenge for organisers. Could simulating crowds be one of the best shortcuts to safer sporting spectacles?

The logistics of routing large crowds in a safe manner in normal and emergency situations is one of the major tasks event security staff face when hosting any major sports event. To plan ahead for these situations, planners often use crowd simulations, helping to simulate what-if scenarios and their consequences.

There are many different approaches to modelling what crowds do. Some are macroscopic, and try to understand how groups of people move through an area. Modellers look at the quickest time it takes for a group of pedestrians to get from one place to another, which constitutes the minimum evacuation time. Microscopic approaches model every individual, examining the interaction between people and finding possible conflict points or bottlenecks.

Microscopic force models assume each individual is influenced by forces. A driving force sends people to their destination, and repelling forces push them away from obstacles and other pedestrians on the way to the destination. Modellers combine these forces and map where pedestrians would walk on this field towards their destination.

Microscopic agent-based models use artificial intelligence to model different behaviours for pedestrians. Each agent gets a set of parameters – for example,

age, gender, fatigue level or level of orientation skills – that are combined to predict individual preferences and behaviours. These models are best for simulating everyday situations and observing the interaction of different characters. Force-based approaches model large and dense crowds accurately and work well for simulating evacuations at major events.

In Germany, we have been working on a force-based training simulator. The objective was to simulate people's movements on the surroundings of a German football stadium for different scenarios. The case study we used was the following scenario:

At 17.20 hrs on Saturday evening in the German city of Kaiserslautern, 40,000 rival football fans pour out of the Fritz-Walter stadium after the final whistle has been blown on a league game. All of these 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, but in emergencies or disasters, crowd management becomes a matter of life and death.

Our simulator runs in real-time for thousands of simulated pedestrians. The user imports a map of the environment he or she wants to simulate, defines locations for arrival and destinations for the pedestrians and presses the start button. A window then displays an animation of the pedestrians navigating through the environment. Pedestrians are displayed in different colours depending on the density of the crowd and this gives planners immediate feedback.

> *"Great staff combined with a good simulation will improve the planning process significantly."*

When simulation results reveal potential bottlenecks and conflict areas, planners can act. They might put security staff at intersections to guide pedestrians towards less crowded areas, or they might close specific sections that are not safe for large crowds. None of this simulation will work, though, if the parameters used are inaccurate.

Modellers need a lot of information before they start:

- What is the demography of people visiting the event?
- Are people familiar with the venue?
- What are the logistics of transporting people to and from the event?
- How many people are going to visit the event and what are the arrival times?
- What is the exact geometry of the venue?

The best place to get this information is from experienced security staff. Great staff combined with a good simulation will improve the planning process significantly.

Simulations are not meant to reflect reality, but they do provide an approximation of what may happen and replicate trends and patterns of crowds. Precisely defined parameters and expertly interpreted results are the only way to get safer crowds.

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