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The Sims Meet Science

by George Lawton

The tools for simulating people have been evolving along parallel tracks. In the entertainment industry, animators have been improving the way people look and move for movies and computer games. In the engineering world, the focus has been on the reliability and accuracy of simulating movements through public spaces. Now these two worlds are converging in the evolution of pedestrian-simulation software.

Today these tools are used to improve railways, airports, shopping malls, and business districts, and they're gaining traction as a design presentation tool for decision makers. In the future, experts believe they could help direct the flow of people in public spaces and find more widespread use in the consumer world.

Alex Schmid, managing director of Savannah Simulations, said that pedestrian simulation started in the 1950s, using models built on fluid simulation. In the mid-1990s, agent-based technologies were introduced, which enabled systems to simulate the behavior of every individual. With this improvement, engineers began using pedestrian simulation as an important engineering tool.

Leading pedestrian-simulation packages include Quadstone Paramics' Urban Analytics Framework (UAF), Savannah Simulations' SimWalk, and Legion's Pedestrian Simulation. They cost from $10,000 for the basic systems up to $100,000 for higher end packages with advanced features and consulting services.

The last couple of years have brought improvements in integrating with traffic measurement, agent-based intelligence, model calibration, and 3D modeling. As the

validity of results and ease of use increased, urban planners have become more interested, said Schmid.

Richard Millington, managing director of Quadstone Paramics, said that urban planners want to use the applications to get more people out of their cars and onto safer streets. He said, "Many streets were designed 30 to 40 years ago. The big push in the UK and US is shared space, where vehicles intersect with pedestrians at predefined points, but no one owns the space."

UAF was the first developer to fully integrate both pedestrian and vehicular traffic in one application. Legion is working on allowing a similar integration with its partner Traffic Simulation Systems.

More Intelligence

A big part of making the simulations more accurate lies in increasing the intelligence of individual agents representing pedestrians. Xiaolin Hu, assistant professor at Georgia State University, said that most of the widely used pedestrian-simulation engines are very simple in the sense that each agent is simulated as a particle moved by physical forces. Now people want to add more human intelligence and psychological motors to these systems. For example, in the case of a panic, the behavior will change. Behavior could also be affected by whether a person is walking individually or with their family.

The engineering challenge lies in figuring out how to balance complexity, accuracy, and performance. To create more accuracy, researchers want to make the decision-making model of the agents more complex, but this affects performance. Hu said, "You may end up where you add all this extra computation on the decision-making part, but don't gain much from the results point of view."

As more options are added for each agent, the processing power for calculating the simulation increases. Hu said performance issues are a big challenge, especially if you have thousands or millions of those agents. The traditional way to model this is using a

time-based approach in which every agent makes a decision every time step. An emerging approach is to use discrete-event simulation algorithms, where every agent decides its movement on the basis of changes in the environment.

Discrete event simulation has been around for a while and used in different domains, but the applications to pedestrian simulation are just beginning. Bernie Zeigler, professor at the University of Arizona, said that simulators are much more efficient with discrete event modeling than they are with time stepping, in which every particle moves in lock step. In the discrete event approach, each agent makes its own decisions and can project ahead as far as it can move while still taking account of the environment's state and so maintain accuracy with the real world.

In some cases, a discrete event simulation can provide a tenfold performance increase over continuous time step modeling, noted Mohammad Obaidat, professor at Monmouth University. But the implementations require caution to maintain the model's validity. On average, discrete event techniques provide a twofold improvement for accurate models, Obaidat said. "You can do discrete event simulation and expedite the speed, but you need to make sure you validate the model."

Calibration

Validating and calibrating pedestrian-simulation results with the real world is key to their value as an engineering tool. Consequently, tools must keep up with differences among groups of people, even at different times of the day or year.

"There is no such thing as a standard or global pedestrian," explained Kevin Mannion, CEO of Legion. "One size does not fit all. When you need to know how a pedestrian space will work in a particular part of the world, you need to have the measurement data from that part of the world. Otherwise, how can you have confidence in your simulations?"

Schmid said it's important for users to be able to plug live data into the model from a variety of sources. Consequently, pedestrian-simulation applications are being integrated

with tools for measuring pedestrian movements, such as those using camera feeds and electronic eyes installed on ticket machines in train stations.

In addition to improving the model's accuracy, better integration between people-counting applications and simulation could also be used for prediction and control. In dynamic data-driven simulations, the model could use real-time data to predict how a system will change by estimating its current state and calibrating the simulation model to adjust itself dynamically.

Hu has been applying this technique to estimating the spread of wildfires. Now he's looking at how to integrate those results into a model of crowd behavior that could be used as a tool for evacuation planning. Having fast models to try out different scenarios could make a big difference in situations such as the Katrina evacuation.

Another emerging frontier in real-time simulation lies in applications to improve the settings of escalators, gates, and other movement controllers, said Schmid.

Creating the Model OS

At the moment, all commercial pedestrian-simulation packages are proprietary and run on a Windows PC. But researchers are looking at ways to abstract away the different modeling system levels to give modelers the same freedom that computer operating systems give programmers across different hardware implementations.

For example, Zeigler's team is working on the Discrete Event System Specification (DEVS), which could allow models to be run on various hardware platforms, including multicore processors, the Web, and compute grids. This approach lets the modeler concentrate on the models, while another team could focus on improving the modeling environment's performance on different classes of hardware.

3D Animation

One of the more exciting trends combines pedestrian simulation with 3D animation. More illustrative and realistic uses of pedestrian simulation could help improve the architectural process by showing a decision maker how people move through a building. Schmid explained, "First and foremost, these are engineering tools designed for runtime analysis. The graphics are added on after the simulation to make it easier to sell a concept or new design alternative."

Traditional pedestrian-simulator interfaces used a 2D animation to show dots that move in an environment. Schmid said 3D is used mostly for presentation because it doesn't improve the analysis but it does make it easier for nonengineers to understand how a structure or urban layout will affect pedestrian movement.

Toward this end, the pedestrian simulators are improving their integration with 3D tools. For example SimWalk relies on compatibility with 3dsMax and VRML. UAF can interface with Google Earth and Google SketchUp.

Schmid believes that pedestrian-simulation technology could wind up in consumer applications for house layouts or in retail planning for analyzing shopping behavior to improve the shopping experience and drive sales.

This trend could move commercial games, such as Electronic Arts' The Sims, toward more practical applications. "Everywhere where you think realistic movement is required," he said, "you could use preconfigured pedestrians that move realistically in your home or building."