Efficiency experts seek to save precious minutes in deploying ambulances

June 17 2008

From left, Huseyin Topaloglu, Mateo Restrepo and Shane Henderson in Henderson's office in Rhodes Hall. The laptop shows a simulation of ambulance calls that the researchers are working to perfect. Credit: Anne Ju/Cornell Chronicle

Every extra second it takes an ambulance to get to its destination can mean life or death. But how, besides driving faster, can ambulances get emergency services to people in need as efficiently as possible, every day? It's a classic operations research question that three Cornell researchers are tackling in groundbreaking ways.

A National Science Foundation grant of almost $300,000 is allowing associate professor of operations research Shane Henderson, assistant professor of operations research Huseyin Topaloglu and applied mathematics Ph.D. student Mateo Restrepo to work on this problem. They are seeking to perfect a computer program that estimates how best to spread ambulances across a municipality to get maximum coverage at all times.

The researchers are working on a computerized approach to take such available information as historical trends of types and incidences of calls, geographical layout and real-time locations of ambulances to figure out where ambulance bases should be, and where ambulances should be sent once finished with a call.

The whole process is not unlike the puzzle game Tetris, Restrepo said. The easy part is knowing what an ideal system should look like. The hard part is anticipating various outcomes in a limited period of time, like the falling blocks in the video game.

Using their program, the researchers are recommending that ambulance organizations break the traditional setup of assigning ambulance crews to various bases and sending them back to their assigned locations once finished with a call.

Going back to base isn't necessarily the best option for maximum efficiency, say the operations researchers. It might be better to redeploy an idle ambulance to where coverage is lacking, even though no calls have yet been placed there.

"If everyone is constantly going back to the base assigned, they're ignoring what's going on in real time in the system," Henderson explained.

The concept is easy enough, but the solution is tricky, especially because of the enormous amount of uncertainty involved.

The field of operations research that deals with making decisions over time in the face of uncertainty is called dynamic programming, in which Topaloglu is an expert. The key is coming up with what's called a value function, a mathematical construction that estimates the impact of a current decision on the future evolution of the system. In this case, it's the impact of current ambulance locations on the number of future calls that are served on time.

"When you're trying to make a decision, you have to select the locations of your ambulances so the performance predicted by the value function is as good as possible," Topaloglu explained. "But it turns out that computing that function is very difficult, especially if you're talking about the scale of the problem we're trying to solve."

Henderson has more than 10 years of experience working on such problems, using a technique called simulation optimization, which is modeling different scenarios of what could happen in any given industrial system.

He and a colleague have already commercialized an earlier generation of emergency medical system planning, which now forms the basis for the technology used by the New Zealand ambulance company Optima.

Source: Cornell University