# Simulated skiers reveal mountain traffic jams

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Credit: Dona Robbins

Millions of skiers and snowboarders escape to the mountains every winter, but some everyday stresses -- like traffic jams -- are unavoidable even on the slopes. In plenty of time to prepare for next season, a team of Swiss researchers has combined GPS tracking data and a skier traffic simulation to help reduce collisions between skiers on the mountain.

Modeling skier traffic requires a twofold approach: the team had to replicate not only physical forces, such as gravity and friction, but also "social" forces, such as each skier's tendency to avoid another and the edges of the ski run.

When added together, all of these forces determined the paths that

individual skiers took down the mountain. The researchers simulated thousands of skiers traveling down two slopes at a nearby resort to determine average speeds and densities.

"There are so many variables for any given run. Being able to model it is very difficult," said Pete Williams, a senior mountain planner at the design firm SE Group, who was not affiliated with the research.

To test their model, the team left the lab and hit the slopes. Thomas Holleczek, a graduate student in the wearable electronics group at the Swiss Federal Institute of Technology in Zurich and lead author of the research, handed out GPS-enabled phones to skiers at the local resort.

Compared to previous methods to track skier speed with video cameras, this approach was a breeze.

"You needed very expensive algorithms which detect the movement of skiers," Holleczek said. The new research was published this month in the journal Physical Review E.

Holleczek compared the GPS data with his simulation results and found that the computer model replicated behavior on the intermediate level run well. However, the simulation did not fully account for skiers' tendency to periodically stop and rest on the more advanced trail.

Nonetheless, insurance agents in Switzerland liked the idea of having such a model, said Holleczek. He believes that the model could help ski operators identify and fix congested areas, making resorts safer. Holleczek's research revealed unexpected bottlenecks on the two ski runs that could be missed by the untrained eye, and these areas could be widened to reduce congestion.

But not everyone is a believer. These bottlenecks typically arise in poorly

planned resorts, and operators can avoid congestion problems during the design process. Furthermore, little research has been devoted to applying traffic models to sports, and ski operators are skeptical of their usefulness. Williams discovered this aversion when he approached his clients with a similar model years ago.

"We asked ski area owners and operators if they were interested," said Williams. "They said, 'Why would I do that? Once it's up and running, there's no need to model it.'"

Consequently, Williams avoids detailed modeling of skier behavior in his analyses. Inconsistent difficulty ratings for ski runs are typically more detrimental to safety than congested trails, he said. Ski operators still want to avoid congestion because it degrades the visitor experience.

Unlike Holleczek's model, Williams' analyses can't always account for the randomness of skier behavior that may lead to pulses of higher traffic, he admits. Although models like Holleczek's may start to account for these pulses, Williams added that it's extremely difficult to include every important variable, ranging from weather conditions to psychological tendencies.

Engineers and computer scientists were greeted with similar skepticism when they first developed computer simulations for vehicular traffic in the 1970s. Nowadays, however, urban planners and government agencies have increasingly seen the benefit of these models.

Models can never account for all of the randomness of human behavior, but robust simulations can still be useful, said Ahmed Abdel-Rahim, a civil engineer specializing in traffic modeling at the University of Idaho.

"These models have continuously been improved and validated with data," said Abdel-Rahim.

Increasingly, ski resorts have been tracking the data needed to validate Holleczek's simulations. The ski resort where Holleczek collected his GPS data is developing a mobile application for skiers to track their movements on the slopes. In the U.S., several resorts have incorporated data tracking directly into lift passes.

Holleczek hopes to account for more variables in his simulations in the future. With more data from ski resorts, he hopes to further improve his models and convince resort operators of their usefulness.

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