Researchers develop highly accurate modeling tool to predict localized COVID-19 risk

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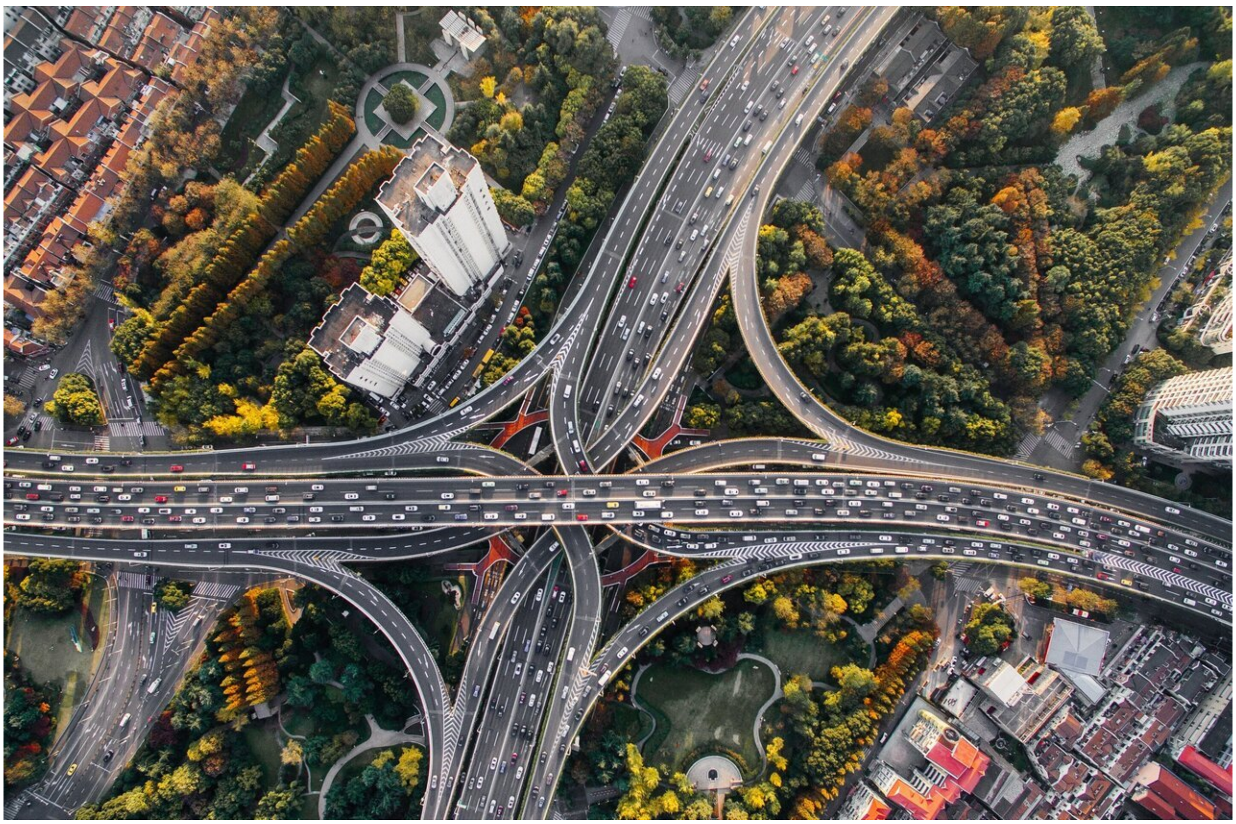

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As new coronavirus variants emerge and quickly spread around the globe, both the public and policymakers are faced with a quandary:

Maintaining a semblance of normality, while also minimizing infections. While digital contact tracing apps offered promise, the adoption rate has been low, due in part to privacy concerns.

At USC, researchers are advocating for a new approach to predict the chance of infection from COVID-19: Combining anonymized cellphone location data with mobility patterns—broad patterns of how people move from place to place.

To produce "risk scores" for specific locations and times, the team used a large dataset of anonymous, real-world location signals from cell phones across the US in 2019 and 2020. The system shows a 50% improvement in accuracy compared to current systems, said the researchers.

"Our results show that it is possible to predict and target specific areas that are high-risk, as opposed to putting all businesses under one umbrella. Such risk-targeted policies can be significantly more effective, both for controlling COVID-19 and economically," said lead author Sepanta Zeighami, a computer science Ph.D. student advised by Professor Cyrus Shahabi.

"It's also unlikely that COVID-19 will be the last pandemic in human history, so if we want to avoid the chaos of 2020 and the tragic losses while keeping daily life as unaffected as possible when the next pandemic happens, we need such data-driven approaches."

To address privacy concerns, the mobility data comes in an aggregated format, allowing the researchers to see patterns without identifying individual users. The data is not being used for contact tracing, identifying infected individuals, or where they are going, said the researchers.

"Our approach relies on anonymized aggregate data," said Shahabi, study co-author and Helen N. and Emmett H. Jones Professor in Engineering and Professor of Computer Science, Electrical and Computer Engineering, and Spatial Sciences. "It is the same as traffic data, where an individual's information is not revealed, but the aggregate data will help you to make a decision on whether to use a certain freeway at a certain time."

The paper will appear in *ACM Transactions on Spatial Algorithms and Systems* and is available for early access.

Data-driven approaches

According to the researchers, existing risk score tools do not provide enough detailed information about infection rates at specific places, or they make unrealistic assumptions about how populations mix.

"The risk of infection varies a lot based on the location, and having a single policy, for instance, at a county level, ignores how some areas are riskier than others," said Zeighami.

So, using real-world mobility data and existing knowledge about the spread of COVID-19, the team created a simulator to generate realistic infection patterns. In the simulation, some "agents" are initially infected and spread the disease as they move around.

Then, the researchers created a Hawkes process-based model, which assigns risk scores based on location density and mobility patterns at a given time and place. Using the simulator, the researchers tested the model to determine if it could accurately predict the number of infections at different locations. It turned out, the risk scores were indeed a reliable metric for tracking infections in cities across the US, including San Francisco, New York, Chicago and Los Angeles.

The researchers found, predictably, that popular destinations in a city are riskier. But they also found that incorporating the infection mobility—how people move—as opposed to just relying on the popularity of an area helped to improve infection prediction. This, said the researchers, underscores the importance of bringing together mobility patterns and infection spread prediction models to generate risk scores.

There are two key ways the system could be used in the real world, said the researchers. The more straightforward case is to make neighborhood-level policy decisions: For instance, bars in Santa Monica, CA, should close today due to high risk in that neighborhood.

"Instead of making these decisions at the county level, public health experts can make those decisions at city, neighborhood or zip code levels." Cyrus Shahabi.

For more targeted locations, such as a specific concert stadium event, the system would crunch the mobility data from similar concerts in the past to learn how the infection risk changes in the area following this type of event. Then, using the researchers' model and current mobility data across LA, the system could make predictions and assign risk scores.

Going forward, the team plans to develop user-specific, yet still privacy-preserving risk scores, and to include long-term forecasting capabilities for several weeks into the future.

"The very high resolution of this mobility data, as well as our scalable approach, will enable us to estimate risk scores at a very fine-grain spatial and temporal resolution, for example, a specific restaurant at dinner time, or a shopping mall at lunchtime," said Shahabi.

"As an individual, you may want to avoid areas deemed high-risk, and policymakers could warn the public to avoid an area known to be a potential hotspot of infection. The scores can also be used for closure or reduced capacity decisions. Instead of making these decisions at the county level, public health experts can make those decisions at city, neighborhood or zip code levels."

More information: Sirisha Rambhatla et al, Toward Accurate Spatiotemporal COVID-19 Risk Scores Using High-Resolution Real-World Mobility Data, *ACM Transactions on Spatial Algorithms and Systems* (2022). DOI: 10.1145/3481044

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