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Using math to map social connections

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Mike Brzustowicz, a cybersecurity expert at Sandia National Laboratories, thinks a mathematical equation can help understand team dynamics and other social interactions between different people. Credit: Spencer Toy

Imagine being able to predict how a group of people will behave before they even know it themselves. From the dynamics of a sports team to the complexities of a nation, the ability to anticipate human interactions has long been a goal of scientists and analysts. Now, a team of researchers at Sandia National Laboratories is pioneering a new approach to social analysis.

Sandia cybersecurity expert Mike Brzustowicz believes a well-known mathematical function may provide the key to predicting that level of social interaction.

"The Fourier transform is a mathematical principle that very simply tells you the frequency—the count—of things that you're observing. A famous use of the principle is transforming sound waves and time into frequency," Brzustowicz explained. "We are working with the non-Abelian Fourier transform. This is a totally different thing. It tells you about combinations of entities. So instead of understanding what individual things are happening, it tells you what connections exist between groups of things."

The work builds upon what was started with one of Brzustowicz's collaborators, David Uminsky. Uminsky began the work at the University of San Francisco when trying to analyze genetic sequences and identify mutations. Eventually Uminsky and his team reached a point where they lacked the computing power to analyze large number sets and needed the computational capability that Sandia can offer.

"When you talk about a combination of things, there are almost infinitely many combinations of very small groups," Brzustowicz explained. "The basketball team idea is something my collaborator David Uminsky published a long time ago: There are 15 players on the bench and there are five on the floor at a time. And then with those five on the floor, you look at thousands of combinations of the different players."

But that is a small system to look at when compared to a community, a state or a nation, or groups of people that are not even geographically related.

"Ten years ago, it took forever to process that on a computer, and now it takes me like a second. But when you think of a social network, you may be thinking of hundreds or thousands of people," Brzustowicz said. "If you have 20 people together or 30 people, there are so many possible group combinations. You couldn't maybe write them all down because you wouldn't have enough memory on your computer, or you wouldn't be able to annotate them. If we wanted to look at social networks and understand how subgroups interact with social networks, we're barely getting there. So that's our challenge."

Now Brzustowicz and his team are trying to figure out how big a transform they can compute, and what kinds of groups they can predict.

"We're already doing stuff that's really cool," Brzustowicz said. "It's enviable that we can get to this level, but if we can go further, you know, like no one's doing this, the non-Abelian Fourier transform."

He added that Sandia is ideally positioned to figure out where the math goes next.

"I think that's what the national labs are good at," Brzustowicz concluded. "We're not academics, we're not industry. We're not bound by those two extremes, bounded by 'what can you do that will get published' and bound by, 'does this make the submit button at Google work better, or make the timeline at Facebook more appealing?' We're in the middle where we solve practical problems, but we have these huge resources available to us."

Provided by Sandia National Laboratories

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