AFRL machine learning and AI experts develop models for COVID-19 decision-making

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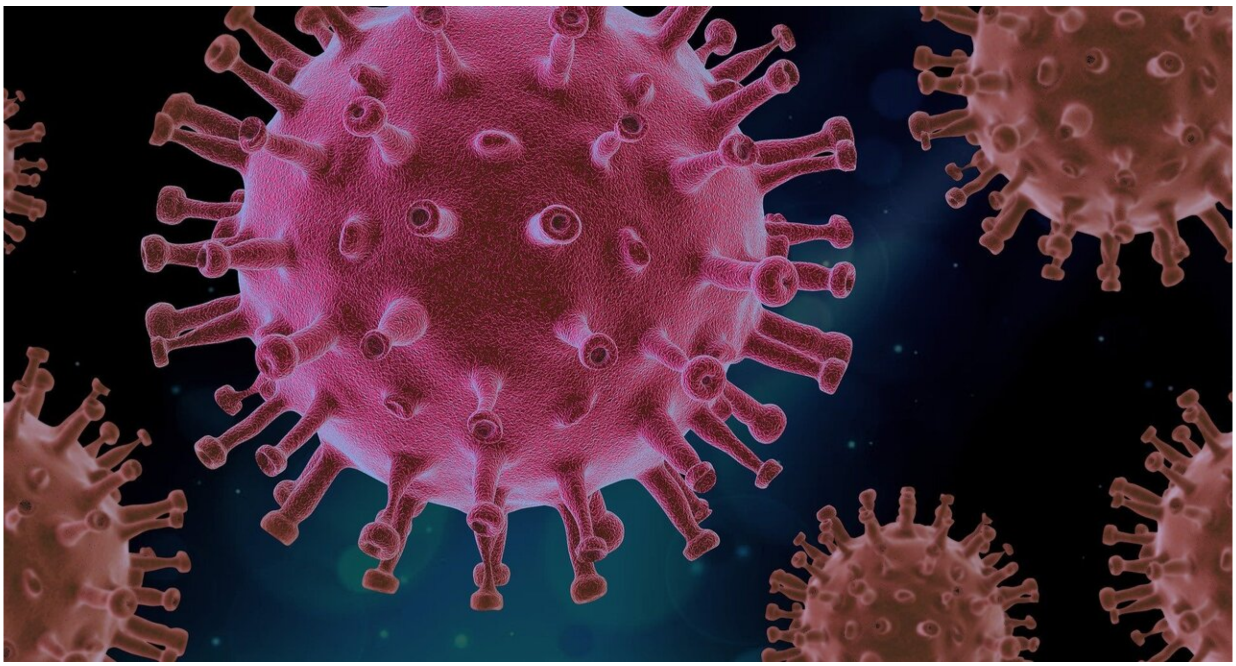

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Experts in the Air Force Research Laboratory are applying explainable machine learning and artificial intelligence approaches to develop thousands of models that could help federal, state and local decision makers as they make re-opening decisions during the COVID-19 pandemic.

These forecasting models, which represent military installations and counties across the United States, will be available in publicly assessible dashboards where leaders can interact with different simulations and examine various intervention strategies.

"This work is a perfect example of the S&T horsepower residing at AFRL and its 711th Human Performance Wing," said Dr. Rajesh Naik, 711 HPW chief scientist. "Our teams can quickly pivot and provide solutions for the current pandemic and other pop-up operational needs. Linking explainable AI with conventional epidemiological models provides decision makers with deeper insight and test the impact of interventions on future trends."

Dr. Ryan Kramer, the Explainable Artifical Intelilgence lead in AFRL's 711 HPW, explained that his team paid special attention to the modeling that was being used across the United States for explaining and predicting how to flatten the curve.

"Our goal was to complement these approaches by producing high fidelity models that dramatically reduce the cone of uncertainty," he said. "By helping to decipher signal from the noise, we knew we could help commanders identify real-time model divergences and act on them in earlier interventional timeframes."

Kramer went on to explain that his team's focus was to expand the current usage of epidemiological modeling to that of modeling used in gaming.

"You can utilize traditional epidemiological methods to define the transition states and dynamics of the models, but they sometimes overgeneralize the assumptions," he said. "We decided to create an advanced SIR model, which we call the SEI3Q2R model. It differs mostly in separating the infected class of individuals into three subpopulations: asymptomatic carriers; those who become symptomatic, but self-isolate in their homes; and those who require hospitalizations. We utilized graph network approaches to better simulate complex community structures.

The team has more than 30 different transition parameters in their models that all influence how COVID-19 spreads throughout a community.

The challenge, Kramer explained, is defining which sets of parameters are correct for a given county or region, especially given the complexity in transmission of a novel virus and the inherent biases in how the data is being reported across the country.

"To address this, we created a simulation library that sweeps across multiple ranges within each parameter thereby simulating every possible outcome that could happen within the model. When complete, we will have greater than 20 million models in our library, which allows us the ability to begin learning the unknown parameters that dictate transmission."

But models are just models without the real-world data. So by utilizing actual data that the team collected from multiple open data sources, they can identify which simulations are accurately describing what is happening on the ground.

"We utilize actual data to essentially fit county-level virus dynamics to the models within our library. We then utilize other advanced machine learning techniques that can account for social-distancing policy, adherence to policy, seasonal effects and underlying demographics to further refine the forecasts. Forecasts for individual counties can be aggregated for installation-level awareness, and at the state and national levels as well," Kramer said.

Kramer explained that the public and DoD versions of the dashboards will mirror one another with much of the same functionality. Access, however, will be one of the differences.

"The DoD dashboard will be available only with the Common Access Card authentication and will focus on visualizing data and forecasts to inform commander decision-making. This will include information related to the base workforce and potentially pull in social media alert information as well."

Projects like these, especially when time is of the essence, typically bring in many partners.

Dr. Naik stated that investments in in-house research as well as AFRL's ability to quickly assemble cross-disciplinary teams enables teams like Kramer's to examine problems in unique ways.

The primary EXAIL team was supported by the team's prime contractor KBR. Other partners include the Air Force Institute of Technology as well as Massachusetts Institute of Technology Lincoln Laboratories (MIT-LL). Working across AFRL directorates, the Materials and Manufacturing Hyperthought team brought some timely expertise to help accelerate capabilities. The EXAIL team also reached out to local industry to enhance transition efforts. Mile2, a local small business start-up, has successfully transitioned optimized user interfaces, Kramer said.

"The people that I get to work with everyday are immensely talented, and we pushed the limits in reimagining our capabilities to fight the COVID pandemic and enhance commander situational awareness," said Kramer. "We also quickly realized that we had the capacity to do even more. So we brought in our colleagues at AFIT to assist in statistical verification and validation efforts. Since many of the findings are completely novel as we begin to understand the intricacies in the spread of COVID-19, experts at AFIT are helping us to move this information quicker to the decision makers. I can't say enough about our partners in AFRL's Matrials and Manufacturing directorate. Their Hyperthought team was critical to early prototyping and demonstration efforts. Our collaborative network also expands to MIT's Lincoln Labs where we can interface with thought leaders across disciplines from supercomputing to reinforcement learning."

Kramer went on to praise his team and partnerships, but also to state that the models are very sobering.

"Behind every prediction, every visualization, every number—is a life. It is always a little surprising to me to reflect on what the data reflects, how this has impacted every one across our country, and this really motivates the need to continue to bring in advanced techniques that can potentially save lives."

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