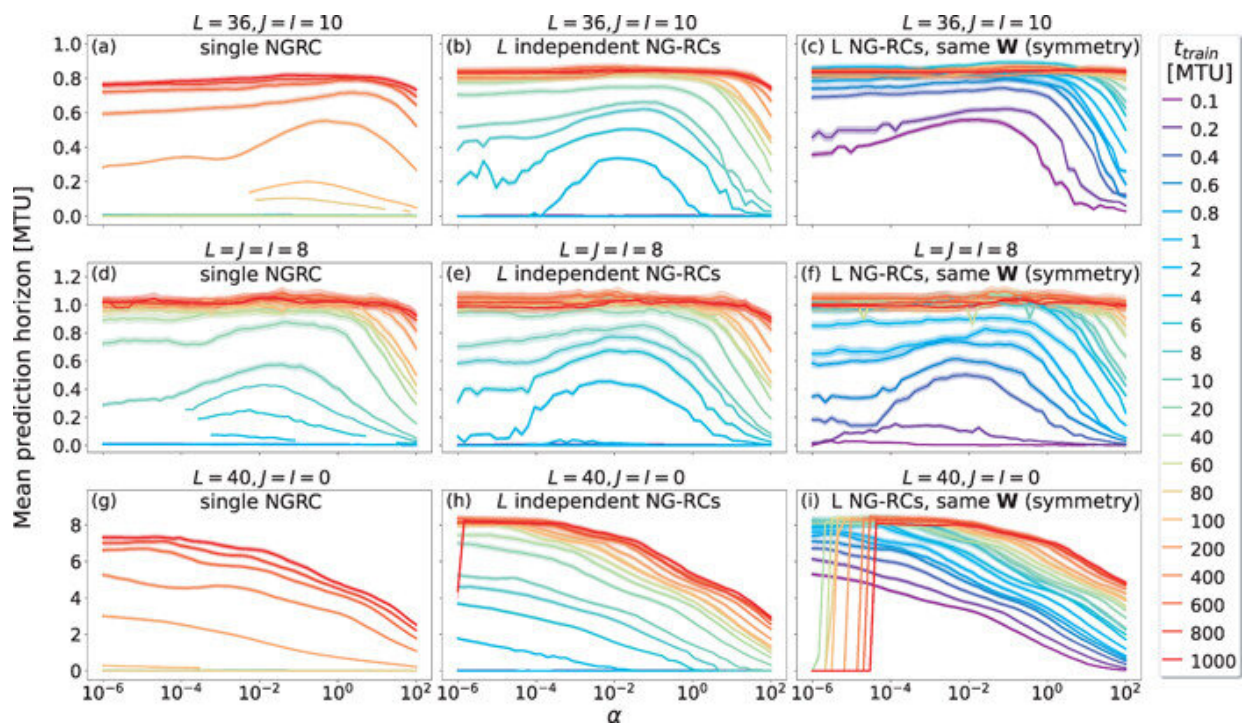


Machine learning helps scientists peer (a second) into the future

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Ridge parameter optimization for the results shown in Figs. 5, 6, and 8. Mean prediction horizon as a function of the ridge parameter α for different training times (see the legend color code) for the Lorenz96 system with $L=36, J=I=10$ [(a)–(c)], $L=J=I=8$ [(d)–(f)], and $L=40, J=I=0$ [(g)–(i)]. For each case, optimizations for a single NG-RC, L independent NG-RCs, and L NG-RCs using translational symmetry are presented. The colored area around the curves represents the standard deviation of the mean. Credit: *Chaos: An Interdisciplinary Journal of Nonlinear Science* (2022). DOI: 10.1063/5.0098707

The past may be a fixed and immutable point, but with the help of machine learning, the future can at times be more easily divined.

Using a new type of machine learning method called next generation reservoir computing, researchers at The Ohio State University have recently found a new way to predict the behavior of spatiotemporal chaotic systems—such as changes in Earth's weather—that are particularly complex for scientists to forecast.

The study, published today in the journal *Chaos: An Interdisciplinary Journal of Nonlinear Science*, utilizes a new and highly [efficient algorithm](#) that, when combined with next generation reservoir computing, can learn spatiotemporal chaotic systems in a fraction of the time of other machine learning algorithms.

Researchers tested their [algorithm](#) on a complex problem that has been studied many times in the past—forecasting the behavior of an atmospheric weather model. In comparison to traditional machine learning algorithms that can solve the same tasks, the Ohio State team's algorithm is more accurate, and uses 400 to 1,250 times less training data to make better predictions than its counterpart.

Their method is also less computationally expensive; while solving complex computing problems previously required a supercomputer, they used a laptop running Windows 10 to make predictions in about a fraction of a second—about 240,000 times faster than traditional machine learning algorithms.

"This is very exciting, as we believe it's a substantial advance in terms of data processing efficiency and prediction accuracy in the field of machine learning," said Wendson De Sa Barbosa, lead author and a postdoctoral researcher in physics at Ohio State. He said that learning to predict these extremely chaotic systems is a "physics grand challenge,"

and understanding them could pave the way to new scientific discoveries and breakthroughs.

"Modern machine learning algorithms are especially well-suited for predicting dynamical systems by learning their underlying physical rules using [historical data](#)," said De Sa Barbosa. "Once you have enough data and [computational power](#), you can make predictions with machine learning models about any real-world complex system." Such systems can include any [physical process](#), from the bob of a clock's pendulum to disruptions in power grids.

Even [heart cells](#) display chaotic spatial patterns when they oscillate at an abnormally higher frequency than a normal heartbeat, said De Sa Barbosa. That means this research could one day be used to provide better insight to controlling and interpreting [heart disease](#), as well as a bevy of other "real-world" problems.

"If one knows the equations that accurately describe how these unique processes for a system will evolve, then its behavior could be reproduced and predicted," he said. Simple movements, like the swing position of a clock, can be predicted easily using only its current position and velocity. Yet more complex systems, like Earth's weather, are far more difficult to foresee due to how many variables actively dictate its chaotic behavior.

To make precise predictions of the entire system, scientists would have to have [accurate information](#) about every single one of these variables, and the model equations that describe how these many variables are related, which is altogether impossible, said De Sa Barbosa. But with their machine learning algorithm, the almost 500,000 historical training data points used in previous works for the atmospheric weather example used in this study could be reduced to only 400, while still achieving the same or better accuracy.

Going forward, De Sa Barbosa aims to further his research by using their algorithm to possibly speed up spatiotemporal simulations, he said.

"We live in a world that we still know so little about, so it's important to recognize these high-[dynamical systems](#) and learn how to more efficiently predict them."

More information: Wendson A. S. Barbosa et al, Learning spatiotemporal chaos using next-generation reservoir computing, *Chaos: An Interdisciplinary Journal of Nonlinear Science* (2022). [DOI: 10.1063/5.0098707](#)

Provided by The Ohio State University

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