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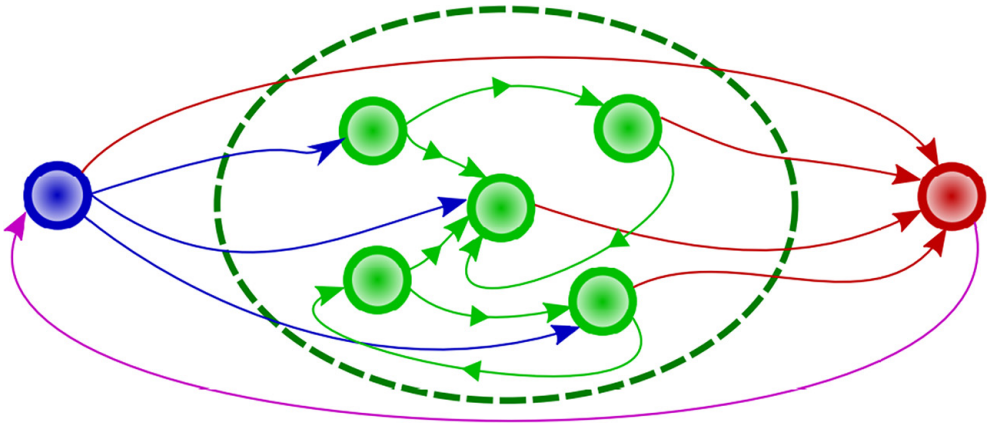
The utility of a network of Boolean nodes, with fading-memory property and real-valued input, has been demonstrated to predict the long-term behavior of a chaotic system.



Reservoir computing is a simple, fast and flexible approach to training recurrent neural networks, particularly for machine learning tasks involving intrinsically time-dependent systems, such as modeling of chaotic systems or interpreting human speech. However, reservoir computer time-series prediction rates are limited by the delays through the input, reservoir, and output layers. In Canaday et al. the authors coupled nodes using an autonomous, time-delay Boolean network configured on a field programmable gate array (FPGA).

The group had previously demonstrated a single Boolean node within a reservoir framework; now they have expanded this into a network of nodes. Fading memory is an important property for evaluating time-series data, and the group achieved this using reservoir nodes made from FPGA elements.

In order to test the new network, the team first needed to find a way to input real-valued data. Co-author Daniel Canaday described this as the "tricky part" of the process, but once achieved it was computationally simple to calculate the output through the FPGA from the Boolean network's binary code. The team tested their new network on a typical chaotic system — Mackay-Glass — and achieved comparable accuracy to state-of-the-art software, with an increased real-time prediction rate up to 160 megahertz.

"Constructing the network and realizing how to put in the real-valued data were the biggest steps in moving to this big network capable of doing complicated tasks like predicting the future of a chaotic system," said Canaday. The study is significant for combining techniques from machine learning with complex systems research. The team is now trying to use its Boolean reservoir network to step-beyond predicting behavior, to controlling fast, complicated systems.

Source: "Rapid time series prediction with a hardware-based reservoir computer," by Daniel Canaday, Aaron Griffith, and Daniel J. Gauthier, *Chaos: An Interdisciplinary Journal of Nonlinear Science* (2018). The article can be accessed at https://doi.org/10.1063/1.5048199.