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Ananya Palivela

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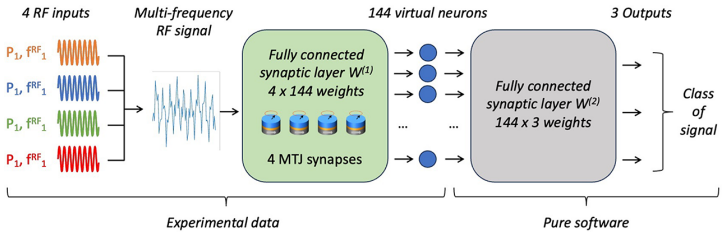
Magnetic tunnel junctions are used as both synapses and neurons to create an extreme learning hardware system.



Analyzing radio frequency (RF) signals is vital for many applications, including radar and medical monitoring. The conventional analysis process involves digitizing the signals and passing them through a neural network, which can be time-consuming and energy-intensive on conventional computer hardware.

Magnetic tunnel junctions (MTJs) are spintronic nano-devices that can convert RF signals to an electrical signal, and vice versa, making them ideal candidates for RF signal analysis. Leroux et al. employed MTJs in a physical extreme learning neural network to more efficiently analyze multifrequency RF signals.

Since MTJs can emit, receive, and process RF signals without digitization, they can significantly reduce the time and energy required to perform machine learning tasks.

With MTJs, the conversion from RF signals to direct currents is proportional with a tunable multiplication factor, enabling their use as synapses. Conversely, the conversion from direct currents to RF signals is nonlinear, making it possible to also use them as neurons.

The team constructed an extreme learning network with four MTJs as the first layer of synapses and 2 MTJs that were time-multiplexed to create the hidden layer of 144 virtual neurons. The second layer of synapses was created in software. While extreme learning lacks backpropagation and multiple hidden layers, the simple architecture gives it a fast training speed.

“Unfortunately, this method does not scale to complex tasks,” said author Frank Mizrahi. “However, it is a good way to benchmark new hardware.”

In tests, the team’s network achieved accuracy comparable to an equivalent software-based network.

“Our goal is to go beyond extreme learning and use MTJs in typical neural networks,” Mizrahi said.

Source: “Classification of multi-frequency RF signals by extreme learning, using magnetic tunnel junctions as neurons and synapses,” by Nathan Leroux, Danijela Marković, Dédalo Sanz-Hernández, Juan Trastoy, Paolo Bortolotti, Alejandro Schulman, Luana Benetti, Alex Jenkins, Ricardo Ferreira, Julie Grollier, and Frank Alice Mizrahi, *APL Machine Learning* (2023). The article can be accessed at https://doi.org/10.1063/5.0155447.