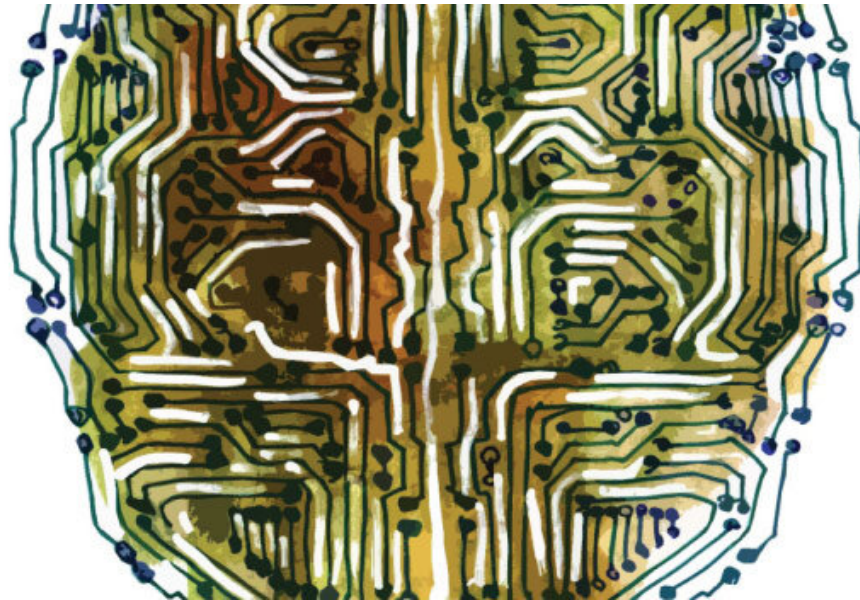


Brain-on-a-chip would need little training

April 20 2021



Advances in artificial intelligence technology is leading to the development of neural networks that mimic the biology of the brain. Credit: KAUST

A neural network that mimics the biology of the brain can be loaded onto a microchip for faster and more efficient artificial intelligence.

A biomimicking "spiking" neural network on a microchip has enabled KAUST researchers to lay the foundation for developing more efficient hardware-based [artificial intelligence](#) computing systems.

Artificial intelligence technology is developing rapidly, with an

explosion of new applications across advanced automation, [data mining](#) and interpretation, healthcare and marketing, to name a few. Such systems are based on a mathematical artificial neural network (ANN) composed of layers of decision-making nodes. Labeled data is first fed into the system to "train" the model to respond a certain way, then the decision-making rules are locked in and the model is put into service on standard computing hardware.

While this method works, it is a clunky approximation of the far more complex, powerful and efficient neural network that actually makes up our brains.

"An ANN is an abstract mathematic model that bears little resemblance to real nervous systems and requires intensive computing power," says Wenzhe Guo, a Ph.D. student in the research team. "A spiking neural network, on the other hand, is constructed and works in the same way as the biological nervous system and can process information in a faster and more energy-efficient way."

Spiking [neural networks](#) (SNNs) emulate the structure of the nervous system as a network of synapses that transmit information via [ion channels](#) in the form of action potential, or spikes, as they occur. This event-driven behavior, implemented mathematically as a "leaky integrate-and-fire model," makes SNNs very energy efficient. Plus, the structure of interconnected nodes provides a high degree of parallelization, which further boosts processing power and efficiency. It also lends itself to implementation directly in computing hardware as a neuromorphic chip.

"We used a standard low-cost FPGA microchip and implemented a spike-timing-dependent plasticity model, which is a biological learning rule discovered in our brain," says Guo.

Importantly, this biological [model](#) does not need teaching signals or

labels, allowing the neuromorphic computing system to learn real-world data patterns without training.

"Since SNN models are very complex, our main challenge was to tailor the neural network settings for optimal performance," says Guo. "We then designed the optimal hardware architecture considering a balance of cost, speed and energy consumption."

The team's brain-on-a-chip proved to be more than 20 times faster and 200 times more energy efficient than other neural [network](#) platforms.

"Our ultimate goal is to build a compact, fast and low-energy brain-like hardware computing system. The next step is to improve the design and optimize product packaging, miniaturize the chip and customize it for various industrial applications through collaboration," Guo says.

More information: Wenzhe Guo et al. Toward the Optimal Design and FPGA Implementation of Spiking Neural Networks, *IEEE Transactions on Neural Networks and Learning Systems* (2021). [DOI: 10.1109/tnnls.2021.3055421](#)

Provided by King Abdullah University of Science and Technology

Citation: Brain-on-a-chip would need little training (2021, April 20) retrieved 27 April 2024 from <https://techxplore.com/news/2021-04-brain-on-a-chip.html>

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