Programmable Silicon Photonic Neuron Enables Directional Control for Neuromorphic Computing

SHANNON, CLARE, IRELAND, September 1, 2026 /EINPresswire.com/ -- A new programmable silicon photonic neuron can control the direction and timing of optical spikes, opening a path toward more adaptable neuromorphic computing systems that process information using brain-inspired principles.

The device addresses a longstanding challenge in photonic neurons: conventional microresonators respond to light traveling in forward and reverse directions in closely linked ways. This makes it difficult to independently manage directionality, feedback and back-action between interconnected components. The new approach uses engineered non-Hermitian photonics to produce direction-dependent responses within a compact silicon device.

A key component is the Dynamically Reconfigurable Unified Microresonator (DRUM). Unlike a fixed photonic structure, DRUM allows electrical control over the coupling between optical modes traveling in opposite directions. The device can be configured to remain quiet, become excitable or operate in a more sensitive spiking state, without requiring any physical modification to its geometry.

This programmability gives the photonic neuron control over several characteristics associated with biological neurons. These include firing threshold, integration time and refractory period—the recovery interval following a spike during which another response is restricted. Adjusting the optical coupling conditions changes when the device begins spiking and how quickly it becomes ready to respond again.

The device can also perform temporal integration. When presented with successive optical pulses, it can accumulate energy until the threshold for producing a spike is reached. The timing of this response can be programmed by changing the coupling phase, providing another mechanism for controlling how information is processed.

Another important capability is control over back-action. Instead of treating backward-propagating signals only as unwanted interference, the architecture allows these signals to become an adjustable part of the photonic neuron’s operation. This could provide greater control over communication among interconnected photonic nodes.

At the network level, simulations of two connected photonic nodes produced behaviors including inhibition and synchronization. The network implementation has not yet been experimentally demonstrated, but the results indicate how programmable back-action could influence interactions between future photonic neurons.

The technology could support future heterogeneous photonic neural networks, where individual nodes are programmed with different thresholds, timing characteristics and feedback responses according to their role within a network.
Keywords: neuromorphic photonics; microring resonator; non-Hermitian system; integrated photonics

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Biasi S, Aslan B, Gretter S et al. Programmable directional photonic spiking neuron based on a non-Hermitian silicon microresonator. Opto-Electron Sci 5, 260038 (2026). DOI: 10.29026/oes.2026.260038

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