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Inspired by early biomimetic approaches, Kerem Çamsarı's work evokes features of neural connectivity

By harnessing the power of randomness, Kerem Çamsarı and his research team are paving the way for technology that mimics the human brain.

Çamsarı, an associate professor in electrical and computer engineering, and his team — doctoral students Navid Anjum Aadit, Shaila Niazi, Kemal Selçuk and Nihal Sanjay Singh and postdoctoral researcher Shuvro Chowdhury — has received the prestigious Misha Mahowald Prize in Neuromorphic Engineering. The team was honored for their work on stochastic neuromorphic computing with probabilistic bits, including a $10,000 cash prize.

Named after the late Misha Mahowald, who pioneered the field of biomimicry, the award honors his legacy of research into systems designed to emulate natural processes.

The human brain operates through networks of neurons that enable both communication and computation. Çamsarı, director of the Orchestrating Physics for Unconventional Systems (OPUS) Lab, explained that his lab's central challenge is to design electronic circuits and systems that capture certain aspects of this functionality. In their work on probabilistic bits (p-bits), the team draws inspiration from early biomimetic approaches, but intentionally adopts a model that is simplified compared to the intricate behavior of biological neurons. In this way, while the systems evoke some features of neural connectivity, they are not intended to fully replicate the complexity of biological neural circuits.

Çamsarı’s lab has attracted considerable attention for developing and applying p-bits to address high-order optimization problems with enhanced speed and energy efficiency compared to traditional computing methods. In words of appreciation for the award, Çamsarı acknowledged the pioneering contributions of both Misha Mahowald and her mentor, Caltech professor Carver Mead.

A central concept in Çamsarı’s research is network sparsity. In many machine-learning models, he noted, every neuron is connected to every other neuron — a configuration that is manageable in software but poses significant challenges for hardware because of the extensive wiring it requires. He explained that like the phenomenon of“six degrees of separation”: although individuals in a community may not be directly acquainted, they remain only a few introductions away from any other person. Similarly, in a sparse network, each p-bit is not directly connected to every other p-bit yet remains accessible through a limited number of intermediary connections.

Their research also focuses on quantum simulation, specifically on determining which problems truly require qubits (quantum bits) and which can be addressed effectively using p-bits. That consideration, Çamsarı explained, is particularly relevant for tasks such as simulating molecular properties, a critical step in drug design. By making it possible to simulate and test new molecular configurations without resorting to costly experimental setups, these approaches highlight the complementary roles of p-bit and quantum-based methods. While p-bits can efficiently tackle a range of optimization problems, he acknowledged, certain challenges, such as those in drug discovery, molecular prediction and chemical simulations, where quantum computers remain indispensable. This ongoing dialogue continues to shape the field.

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