Photonics for artificial intelligence and neuromorphic computing

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Immense progress in artificial intelligence is rapidly transforming everyday life from autonomous vehicles and personalized medicine to language models that emulate human reasoning. Yet this transformation comes at a high energy cost. The exponential growth of AI workloads, driven by ever-higher data rates and ever-lower latency demands, is exposing the physical and economic limits of today's digital electronics. Sustaining this momentum requires not only new algorithms, but entirely new physical platforms for information processing.

Photonic computing using light rather than electrons to perform computations offers a compelling alternative. In integrated photonic circuits, optical signals play the role of currents and voltages in electronic chips, but they propagate at the speed of light, experience negligible loss, and generate minimal heat. This unique combination of speed, bandwidth, and energy efficiency opens up radically new opportunities for accelerating AI workloads.

In this talk, I will explore how photonic systems can implement machine learning directly in hardware. By leveraging interference and modulation within integrated photonic networks, we can realize optical equivalents of neural architectures that perform matrix–vector multiplications and other core AI operations at terahertz speeds. Beyond deterministic computation, probabilistic photonic processors embrace physical noise and randomness as intrinsic resources for reasoning under uncertainty, a hallmark of biological intelligence.

Recent advances in materials science, including nanoscale phase-change materials, and in photonic device engineering, such as microcombs and chaotic light sources, now enable massively parallel, in-memory photonic computation. These breakthroughs herald a new generation of brain-inspired processors capable of solving complex inference and optimization problems with high energy efficiency. By merging the physics of light with the principles of learning, photonic computing promises to reshape the landscape of artificial intelligence, holding promise for making it faster, more efficient, and ultimately more human-like in the way it computes.