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ELECTRICAL & COMPUTER ENGINEERING

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2pm ~ ITE 336

Photonics Empowered Computing: From Efficient to Functional Data Movement

Dr. Yuyang Wang

Modern computing systems face increasing constraints due to the bandwidth and energy limitations of electrical interconnects as data needs to travel longer distances. This communication bottleneck not only slows down large-scale computational tasks like AI/machine learning and high-performance computing, but also incurs environmentally significant energy consumption, hindering the systems from scaling and supporting real-world applications such as climate modeling, drug discovery, banking, and defense. My research aims to address this challenge by developing high-bandwidth, energy-efficient photonic interconnects and exploring new computing paradigms that integrate computation within data movement.

In this talk, I will first present a silicon photonic optical input/output (I/O) technology that brings a remarkable 4 Tbps/mm bandwidth density into the computing socket while consuming less than 1 pJ/b energy. This optical I/O utilizes dense wavelength-division multiplexing (DWDM) driven by an optical frequency comb source to achieve unprecedented bandwidth density and energy efficiency—two orders of magnitude better than state-of-the-art co-packaged optical (CPO) transceiver solutions. I will discuss how a scalable link architecture and 3D electronic-photonic integration make this advancement possible. This approach demonstrates an attractive path towards future disaggregated data center architectures, where a distributed system spanning kilometer-wide can function as a single computing node without data locality constraints. I will then outline recent progress in extending this integrated photonics platform beyond classical data communications into the realm of computing accelerators, exemplified by a photonic-enabled multiply-accumulate (MAC) engine embedded within the DWDM optical I/O. By integrating data processing functionalities within data movement, this approach greatly reduces the energy and latency overhead of data shuttling between the processor and memory nodes. In the future, I envision photonics-empowered computing systems with unprecedented interconnect density achieved through three-dimensional routing and heterogeneous integration, with applications spanning from distributed computing to massive antenna arrays.

Bio:

Dr. Yuyang Wang is a postdoctoral research scientist at Columbia University, supervised by Professor Keren Bergman. His research focuses on the design of large-scale integrated photonic systems for future communication and computing paradigms. Prior to joining Columbia, he earned his Ph.D. in Electrical and Computer Engineering from the University of California, Santa Barbara, under the guidance of Professors Kwang-Ting (Tim) Cheng and John Bowers, where he made significant contributions to electronic-photonic design automation methodologies.

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