Photonics for Machine Learning and Quantum Control

Leads: Ryan Hamerly[hamerly@mit.edu] and Dirk Englund[englund@mit.edu]

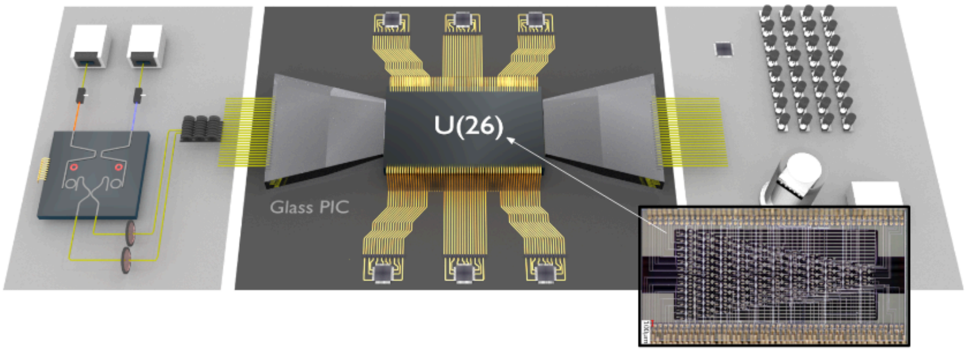

Illustration of the silicon "quantum photonic processor," which includes entangled photon pair sources (left), unitary state evolution (center), and a bank of superconducting detectors (right).

Large-scale photonic circuits have opened new research directions in machine learning and quantum information processing[1–5]. We have a position for researchers with strong backgrounds in optics, physics, and CS, with an interest in new forms of computing.

Do you have experience or wanna learn CMOS & photonics modeling & design for tapeouts with leading foundries to change the face of AI hardware and/or quantum control (it turns out the mixed-signal requirements for the two are very similar)?

Project descriptions:

1. Quantum machine learning is a new class of algorithms for solving hard problems in supervised/unsupervised classification and clustering of classical or quantum data [6]. The candidate will work with researchers at MIT and collaborators to develop such algorithms.
2. Deep Learning / Optical Neural Networks [5,7–11]
3. Programmable optics for quantum control of Rydberg atom arrays with collaborators [12,13]
4. Photonic device design: efficient spin-photon interfaces [14–16],
5. Photonic Neural Network Accelerators for Scalable Brain-Machine Interfaces
6. There's a possibility also for entrepreneurship & other forms of tech transition

Contact: For more information, send an application email with CV to Prof. Dirk Englund (englund at mit.edu) of the MIT EECS Department and Dr. Ryan Hamerly (rhamerly@mit.edu) of the Research Laboratory of Electronics. Please include "[position_inquiry]" into the subject line.

References

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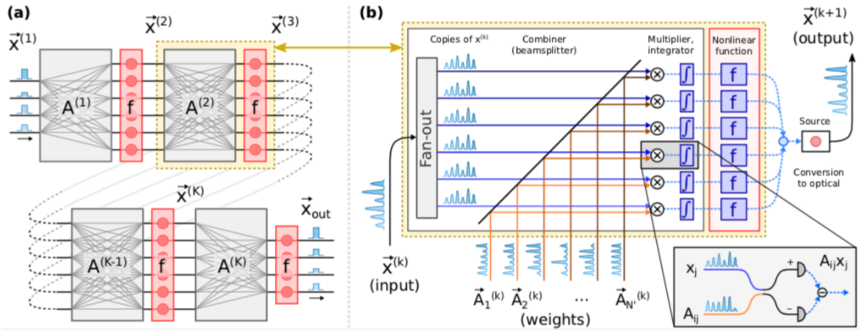
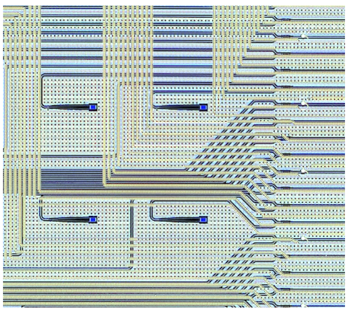
Time and Energy are the most important bottlenecks in modern Deep Learning [1]. As neural networks get bigger and Moore's Law grows more difficult to maintain, these bottlenecks will become more and more severe. We are developing Optical Neural Networks (ONNs) [2, 3] based on photonic integrated circuits that use the unique properties of light to circumvent the limits to Moore's Law and build a new generation of fast, low-energy photonic AI processors.





Left: a deep neural network decomposed into layers (activations plus matrix-vector multiply). Center: schematic of ONN based on coherent detection [3]. Right: false-color image of part of an ONN circuit.

Possible research directions:

- New architectures for optical machine learning acceleration [2-4]
- Develop large-scale photonic devices, e.g. modulator / detector / interferometer arrays.
- Optical hardware for non-DNN tasks, e.g. Ising machines [5-6]
- Benchmarking / system-level analysis and design.
- Quantum limits and potential use of quantum resources in ONNs [7]

Details / Contact:

- Location: MIT (Cambridge, MA) *or* NTT Research (Sunnyvale, CA) *or* remote as situation allows / requires.

- Work with leaders in the field: Dr. Ryan Hamerly (MIT / NTT) [rhamerly@mit.edu] and Prof. Dirk Englund (MIT) [englund@mit.edu].
- Graduate-level researchers (including recent graduates) welcome to apply.
- Supported by NTT Research Inc. appointment with a competitive stipend.

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