Large-Scale Photonic Homodyne Tensor Processor

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Weight-streaming photoelectric multiplication in homodyne arrays [1] promises to overcome the size and error-tolerance bottlenecks in photonic computing [2], while maintaining a strong $O(N)$ *vs* $O(N^2)$ energy efficiency advantage due to the use of time- and (optionally) wavelength-multiplexing [3]. Here, we propose and experimentally demonstrate a 256×256 coherent photoelectric matrix processor, consisting of a dense silicon-photonic homodyne crossbar coupled to a 64-channel thin-film lithium niobate modulator array [4]. We demonstrate 100% component yield across 256×100 detector channels, with computation at up to 7-bit precision at 20 GS/s, for a total potential throughput of 1,000 TOPS, with computational accuracy benchmarked by Qwen2.5-0.5 models as well as traditional MNIST / CIFAR image classification. Higher bit precision, enabled by combining channel equalization techniques and algorithm-hardware codesign, also points to promising use cases beyond deep learning, including scientific computing applications such as PDE solving and electromagnetic scattering [5].

References

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