A Fully Programmable Two-Dimensional Photonic Chip for Machine Learning

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On-chip photonic-neural-network processors offer potential benefits in both speed and energy efficiency but have not yet reached the scale to compete with electronic processors. The dominant paradigm involves building integrated photonic processors using relatively bulky discrete components, such as directional couplers and phase shifters, connected by single-mode waveguides. A far more compact alternative is to avoid explicitly defining any components and instead sculpt the continuous substrate of the photonic processor to directly perform the computation using waves freely propagating in two dimensions. In this talk, I will present our recent work [1] on experimentally realizing this approach with a device whose refractive-index as a function of space, n(x,z), can be rapidly reprogrammed. This device combines photoconductive gain with the electro-optic effect in a lithium niobate slab waveguide. We directly trained the refractive-index distribution using physics-aware training [2] to perform neural-network inference with up to 49-dimensional input vectors in a single pass.

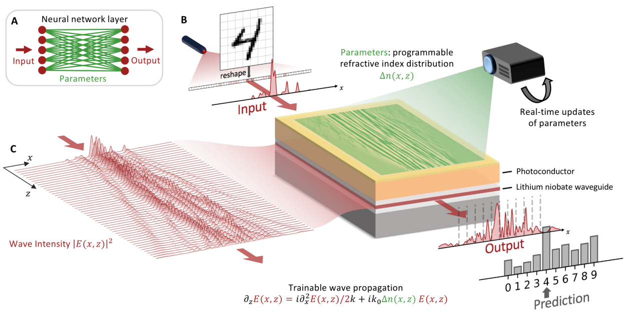

Figure 1: Machine learning with multimode wave propagation in a 2D-programmable waveguide

References

[1] T Onodera, M M Stein, B A Ash *et al.*, arXiv:2402.17750 (2024)

[2] L G Wright, T Onodera, M M Stein, T Wang, T Schachter, Z Hu and P L McMahon, Nature **601**, 549 (2022)