DAC YF

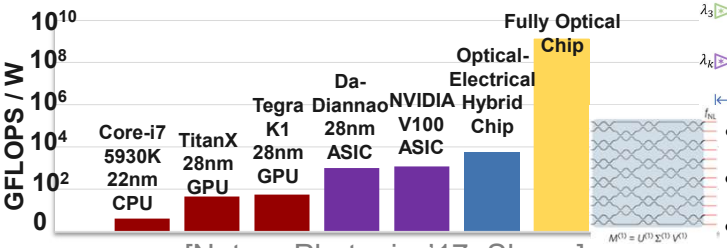
FLOPS: Efficient On-Chip Learning for Optical Neural Networks

Jiaqi Gu, Ray T. Chen and David Z. Pan, The University of Texas at Austin

1.Neural Networks and AI Acceleration

ML Applications and Photonic Acceleration





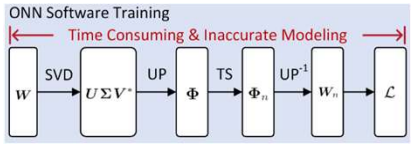
[Nature Photonics'17, Shen+]

2.Previous ONN Training Protocols

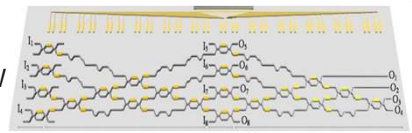
- **Software training**
  - Limited speed (>1 s)
  - Hardware-unaware

$$W = U\Sigma V^*$$

$$U(n) = D\prod_{i=n}^{2}\prod_{j=1}^{i-1} R_{ij}$$

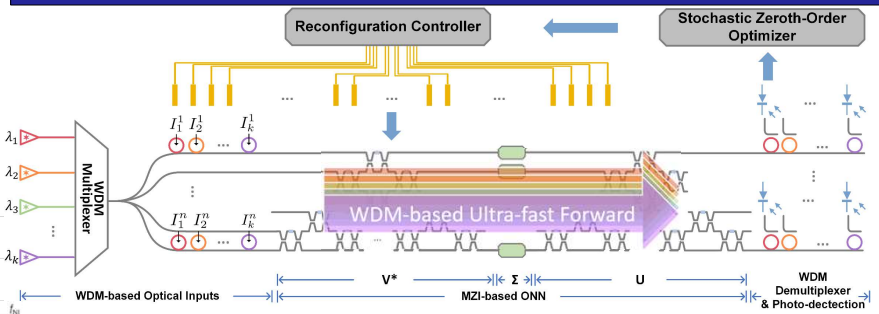


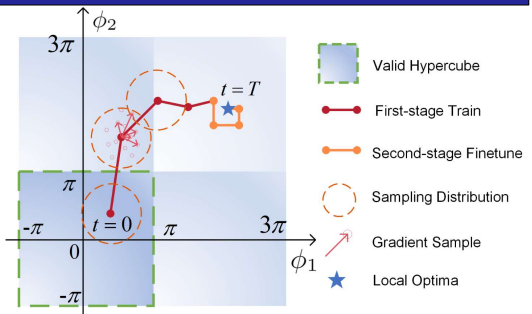
- **On-chip training**
  - Ultrafast (~1 ms)
  - 1000x faster than SW
  - Unscalable
  - Limited efficiency



[arXiv'19, Zhou+]

3.Proposed Method: FLOPS & FLOPS+



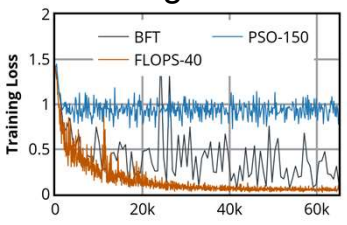


- **Stochastic zeroth-order optimization**
- **Efficiency:** WDM-based parallel gradient estimation
- **Accuracy:** Two-stage learning protocol with high accuracy
- **Robustness:** Robust learning under *in situ* device variations

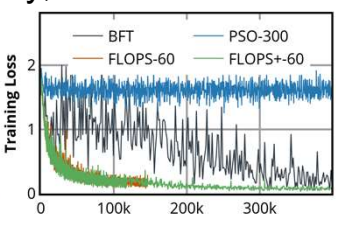
- FLOPS+ with ***SparseTune***
  - Sparse coordinate-wise fine-tuning
  - Improve Accuracy via searching
  - Sparsity guarantees efficiency

4.Experimental Results

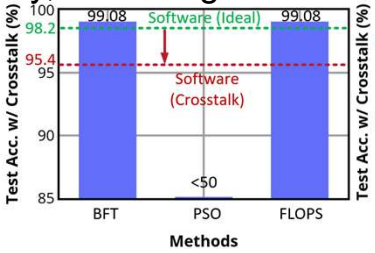
- **2-4x** higher efficiency; **10x** better scalability; **3-5%** higher robustness and accuracy



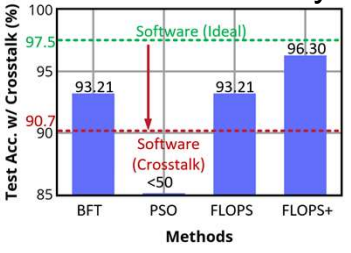
ONN config: 8-16-16-4 (448 MZIs)



ONN config: 10-24-24-6 (960 MZIs)



BFT: [Zhou+, 2019]



PSO: [Zhang+, 2019]