# ABSTRACT

## Cortex-Inspired Optical Computing Enabled by Photonic Metasurfaces

Authors:

Muliang Zhu, School of Electrical and Computer Engineering, Georgia Tech
Yashar Kiarashinejad, School of Electrical and Computer Engineering, Georgia Tech
Sajjad Abdollahramezani, School of Electrical and Computer Engineering, Georgia Tech
Tianren Fan, School of Electrical and Computer Engineering, Georgia Tech
Ali Adibi, School of Electrical and Computer Engineering, Georgia Tech

This poster builds on the initial results that were partially supported by CRNCH fellowship. Optical neural networks (NNs) have strength of bandwidth (e.g., gigapixel-scale input layers) rather than depth. While convolutional networks may be used to process wide networks, such processing is typically limited by data transfer bandwidth. Subwavelength-scale optical metamaterials (MMs) have been demonstrated extraordinary flexibility in spatial light control. The combination of the linear MM layers (for providing the weights and addition of the weighted sums of the neuron outputs) and the nonlinear MM layers (for implementing the activation function) is essential for implementation of neural-inspired computing that optics can implement. The first step can be the study of the nonlinear layer of the multi-layer metamaterial structure. An option for the nonlinear layer is metasurfaces (MSs) based on lithium niobate (LiNbO3) using second-order nonlinearity to avoid changing the wavelength between different layers. The nonlinear process is optimized by using a pulsed pump at wavelength λ/2 for input/output signal at wavelength λ. Numerically simulated nonlinear MSs discussed in this poster are designed to have resonances at both (pump and signal) wavelengths to enhance nonlinear interactions and compare for low-power operation. We envision a complete simulation platform for the study of the complete system through propagation of an optical beam through multiple layers of the proposed computing platform. And we propose to leverage our patented weak-learning-based technique to develop a robust computing platform against fabrication imperfection of the array of linear, nonlinear, and potentially reconfigurable photonic MSs. Motivated by the processing paradigm in the human visual cortex with compressed number of giga-pixelated information channels for post-processing of perceptual images, the research will pave a way for the realization of a brain-inspired computing paradigm with the development of the combined optical and electronic domains.

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