Technology Offer

Low-power Scalable Multilayer Optoelectronic Neural Network Enabled with Incoherent Light

File no.: MI-0104-6464-GÖ-IT

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 Munich
Germany

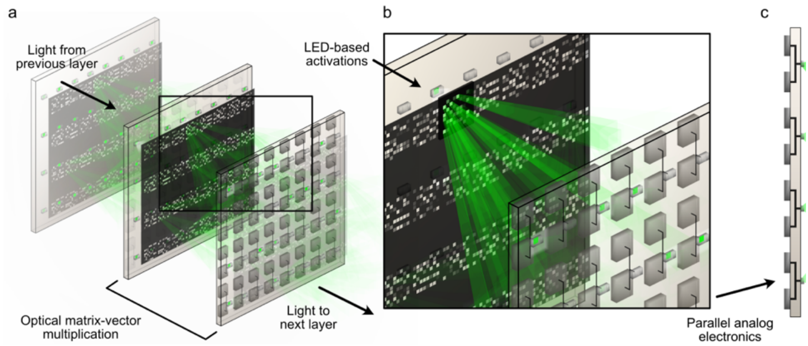
Phone: +49 (89) 29 09 19 - 0
Fax: +49 (89) 29 09 19 - 99
info@max-planck-innovation.de
www.max-planck-innovation.de

Contact
Gökce Özyurt
Phone: +49 (89) 29 09 19 - 18
oezyurt@max-planck-innovation.de

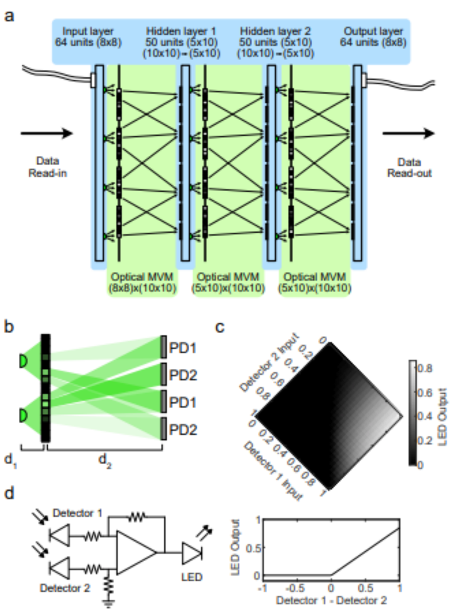
Background

Optical and opto-electronic computing devices have been widely explored due to the potential for large-scale, fast, and energy efficient deployments. Optical and opto-electronic devices are particularly suited for performing the large-scale repetitive computations used in artificial neural networks such as matrix-vector multiplications (MVM) and convolution mathematical operations.
We provide a low-power opto-electronic computing device that is capable of implementing multiple layers or portions of multiple layers of an artificial neural network which is scalable enough to accommodate operation speeds required by modern artificial neural networks.

Technology



The multilayer opto-electronic neural network uses a series of interleaved optical and electronic layers (a) to implement matrix multiplication and nonlinearity, respectively. The inset (b) illustrates a non-negative fully connected MVM that is implemented dynamically using a 2D array of incoherent LEDs, each encoding a neuron activation in our system. Each LED is associated with a 2D sub-array of amplitude-encoded weights that map onto a 2D array of photodiodes. (PDs) (c) An electronic board contains a parallel array of neurons each associated with a pair of PDs representing the positive and negative inputs to the neuron.



The figure on the left shows the schematic of our multi-layer opto-electronic neural network implementation with optical operations (green) and electronic operations (blue). (a) Data is read-in electronically to an Input layer with 64 units arranged on an 8x8 array of LEDs. A fully connected MVM maps light from these units to a 10 × 10 array of PDs. Hidden layer 1 combines pairs of values from the PDs to drive a 5x10 array of LEDs. A second MVM and hidden layer implement Hidden layer 2 and a third MVM is mapped onto an 8x8 array of PDs of the Output Layer. (b) Ray-tracing illustrates how a fully-connected MVM operation is performed. (c) Amplitude weights are non-negative, and a pair of PDs are fed into an analog electronic circuit that performs a differencing operation before driving an LED. (d) Example output LED response to a pair of detector inputs. Negative currents in the circuit are truncated by the LED, effectively implementing a linear rectification.

Patent Information: PCT Application PCT/EP2024/057434