# 3D Photonic and Electronic Neuromorphic Artificial Intelligence

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## ABSTRACT

Researchers at the University of California, Davis have developed an artificial intelligence machine that uses a combination of electronic neuromorphic circuits and photonic neuromorphic circuits.

## FULL DESCRIPTION

The human brain serves as inspiration for a new artificial intelligence machine that uses neuromorphic computing. The artificial intelligence machine combines low-noise, scalability, wavelength-parallelism, high-throughput, and intelligent photonic memristive plasticity of photonics, and high-density, agility, and intelligent ionic plasticity of electronics to provide a novel three-dimensional neural network. This technology integrates electronic neuromorphic circuits and photonic (optoelectronic) neuromorphic circuits in three dimensions to provide 3D Electronic Photonic Integrated Circuitry (3DEPIC). The 3DEPIC offers high density and high connectivity while supporting hierarchical learning in optical macro-circuits and electronic micro-circuits.The 3DEPIC supports scalability, high-density, and high-throughput overcoming the noise limitations commonly seen in analog electronic circuits while addressing bio-inspired intelligence through co-design of algorithms, materials, architectures, circuits, and systems. In particular, the photonic synaptic interconnects help achieve global learning exploiting massively parallel and low energy interconnection in temporal, spatial, and wavelength domains, while the electronic interconnects achieve extremely high-density and local learning.

## APPLICATIONS

- Artificial Intelligence machines
- High density, efficient, large-scale computing systems
- Biologically realistic neuromorphic computing

## FEATURES/BENEFITS

- High density and high connectivity
- Supports hierarchical learning in optical macro-circuits and electronic micro-circuits
- Enables human-like hierarchical learning capability
- Scalable interconnections of 100 billion neurons
- Attempts energy-efficiency comparable to the human brain
- Integrates electronic and photonic neuromorphic computing circuits
- Solves scalability issues common in traditional neuromorphic computing circuits
- Improves energy efficiency in AI hardware

## PATENT STATUS

Patent Pending

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## INVENTORS

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## OTHER INFORMATION

### KEYWORDS

3D circuits, neural networks, nanophotonics, spiking, reservoir computing, photonic neural networks, reconfigurable, optical interconnects, optical switching, neuromorphic computing

### CATEGORIZED AS

- **Optics and Photonics**
  - All Optics and Photonics
- **Computer**
  - Hardware
- **Engineering**
  - Engineering
- **Nanotechnology**
  - Electronics
- **Semiconductors**
  - Design and Fabrication
  - Materials
- **Sensors & Instrumentation**
  - Scientific/Research

### RELATED CASES

2023-561-0

## ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Higher-Speed and More Energy-Efficient Signal Processing Platform for Neural Networks
- Crystal Orientation Optimized Optical Frequency Shifter
- Hyperspectral Compressive Imaging
- Athermal Nanophotonic Lasers
- Photonic-Electronic Convolutional Neural Networks
- Ultra-High Resolution Multi-Platform Heterodyne Optical Imaging
- Multi-Wavelength, Laser Array
- Optical Interposers for Embedded Photonics Integration
- Ultrahigh-Bandwidth Low-Latency Reconfigurable Memory Interconnects by Wavelength Routing
- Development of a CMOS-Compatible, Nano-photonic, Laser
- Energy Efficient and Scalable Reconfigurable All-to-All Switching Architecture
- Compressive High-Speed Optical Transceiver
- All-Optical Regenerators
- Tensorized Optical Neural Network Architecture
- Silicon Based Chirped Grating Emitter for Uniform Power Emission
- Energy-Efficient All-Optical Nanophotonic Computing
- All-To-All Interconnection With Wavelength Routing Devices
- Adapting Existing Computer Networks to a Quantum-Based Internet Future

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