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Neural network image sensor for ultrafast machine vision

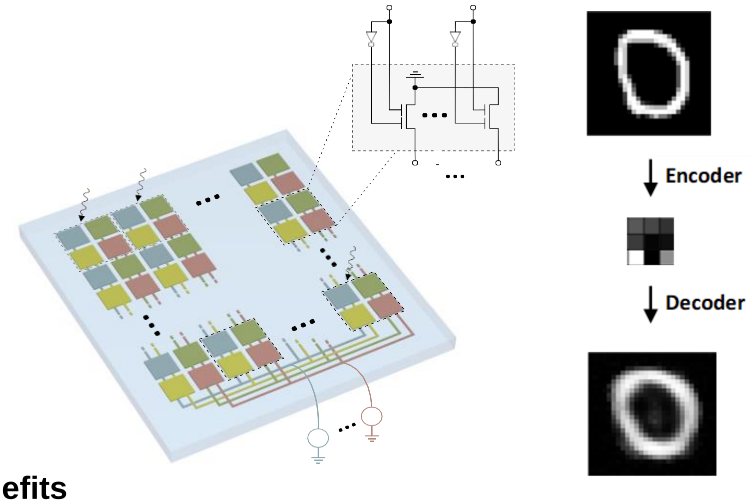
An image sensor itself constitutes an artificial neural network. The sensor can simultaneously sense and process optical images that are projected onto the chip without latency. The device is based on a reconfigurable semiconductor photodiode array, with the synaptic weights of the network being stored in a continuously tunable photoresponsivity matrix.

Background

Machine vision technology has taken huge leaps in recent years, and is now becoming an integral part of various intelligent systems, including autonomous vehicles and robotics.
Usually, visual information is captured by a frame-based camera, converted into a digital format and processed afterwards using a machine-learning algorithm such as an artificial neural network. The large amount of (mostly redundant) data passed through the entire signal chain, however, results in low frame rates and high power consumption.
Although much progress has been made in efficient neuromorphic processing of electrical or optical signals, the conversion of optical images into the electrical domain remains a bottleneck, particularly in time-critical applications. Imaging systems that mimic neuro-biological architectures may allow us to overcome these disadvantages.

Methodology

The sensor performs a real-time multiplication of the projected image with a photoresponsivity matrix. Training of the network requires setting the photoresponsivity value of each pixel individually.
A novel type of photodetector was used that offers the possibility of external tunability of the potential profile in the device - and hence its photosensitivity - by electro-static doping using multi-gate electrodes.
Both supervised and unsupervised learning and training the sensor to classify and encode images with a throughput of 20 million bins per second was achieved. That’s orders of magnitude faster than current state-of-the-art.



Benefits

- orders of magnitude faster than current implementations
- operation is self-powered; electrical energy is consumed only during training
- may also be employed in spectroscopy for the detection/classification of spectral events/feature

REFERENCE
M030/2020

POTENTIAL APPLICATIONS
Ultrafast machine vision, real-time imaging, smart sensors, self-powered sensors, optical spectroscopy

KEYWORDS
Machine vision, vision sensors, smart sensors, artificial neural networks, machine learning

IPR
International patents pending

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