AER Building Blocks for Multi-Layer Multi-Chip Neuromorphic Vision Systems

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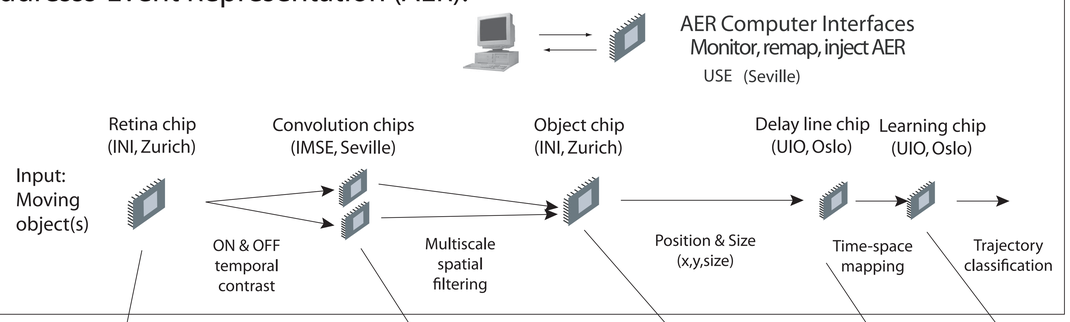
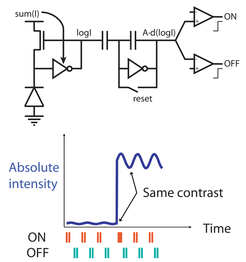
We describe the construction and characterization of an event-based hardware vision system (CAVIAR) that learns to classify spatio-temporal trajectories.

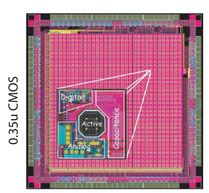
CAVIAR components emulate parts of biological visual pathways. They compute on incoming spikes and provide outgoing spikes. Cells are connected by asynchronous digital buses carrying their spike addresses using the Addresss-Event Representation (AER).



Retina chip

Retina output cells respond to relative intensity change (contrast)

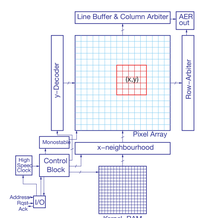


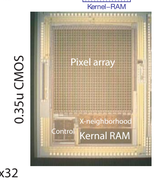


64x64
Pixel size (40u)^2, Fill factor 9%, Dark level, 1lux
1 Meps
2 mA chip, 20mA board

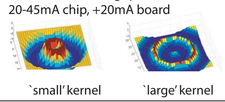
Convolution chip

Event-based convolution with arbitrary kernal size and 3 magnitude+1 sign bit weights





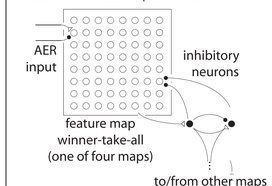
32x32
input 3-33 Meps, output 25Meps
"convolution throughput" 1-10^7
20-45mA chip, +20mA board

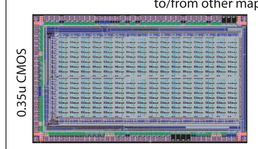


`small' kernel `large' kernel

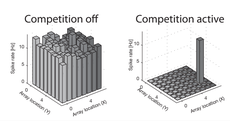
Object chip

Can decide winning feature and scale based on as few as 2 interspike intervals



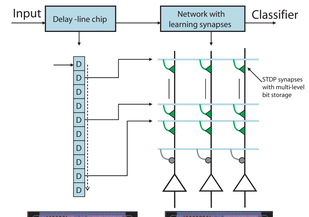


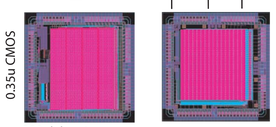
16x16 neurons x 8 dynamic synapses
input 10Meps
output 2Meps sustained, 10Meps peak
36mA chip, 120mA board



Delay Line chip, Learning Classifier chip

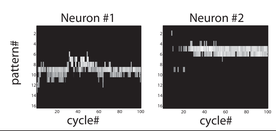
Learns to classify trajectories of feature space neurons using delays and unsupervised STDP learning network.





880 delay stages,
each holding 8 events
8mA chip+22mA board
10Meps peak

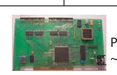
32 neurons x 64 synapses
global WTA inhibition
4mA chip+22mA board
input 0.5Meps



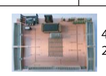
Digital components

eps=events per second

USB controlled monitor, mapper, sequencer
20 Meps



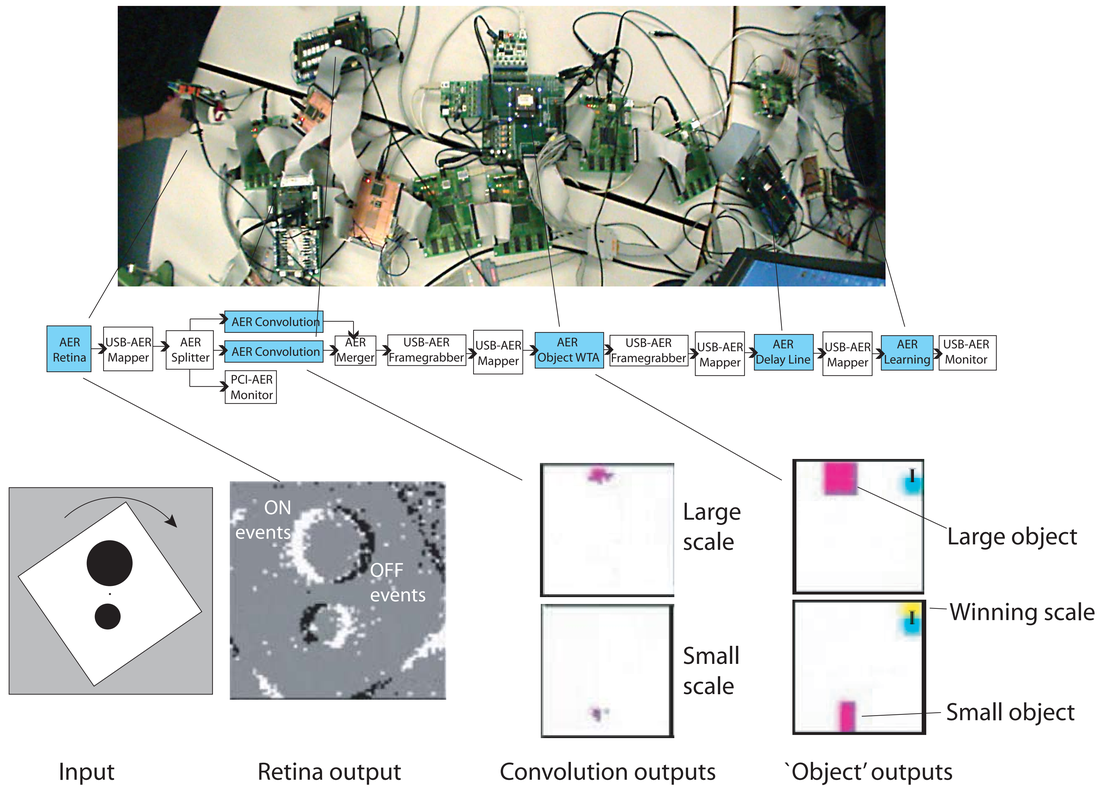
PCI-bus monitor/sequencer
~10Meps



4x merger/splitter
20Meps

Simple monitor
~120keps

Our characterization so far showed that stimuli of two different shapes on a rotating disk could simultaneously be discriminated and their position extracted at level of the object chip.



CAVIAR is the largest AER system yet assembled. It is a step towards efficient architectures for data-driven adaptive real time vision systems.

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