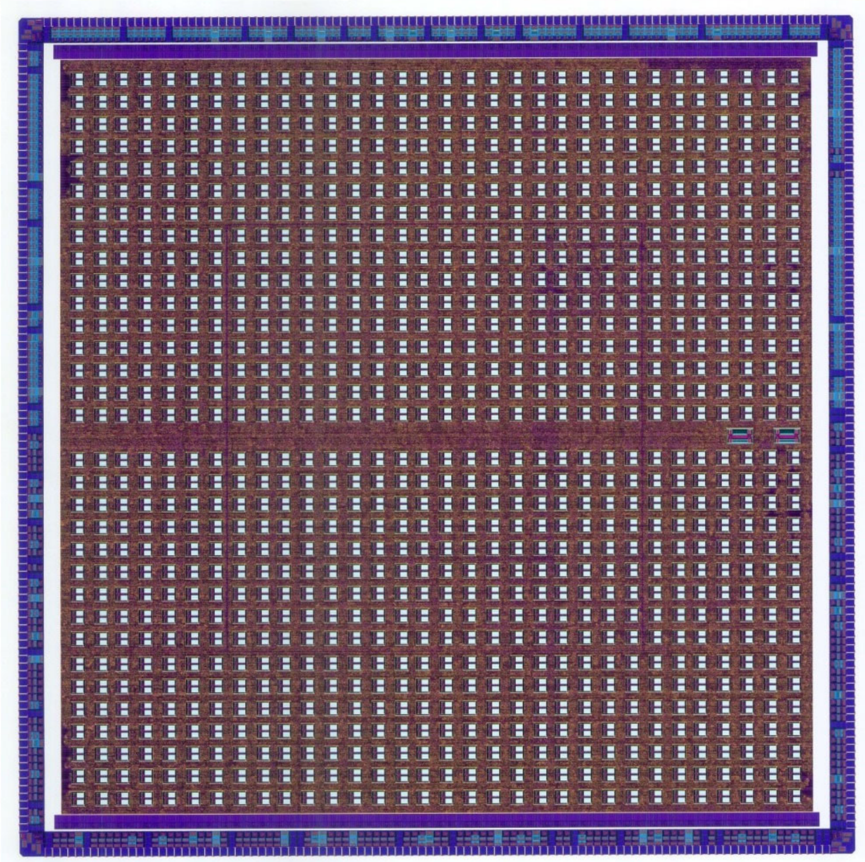
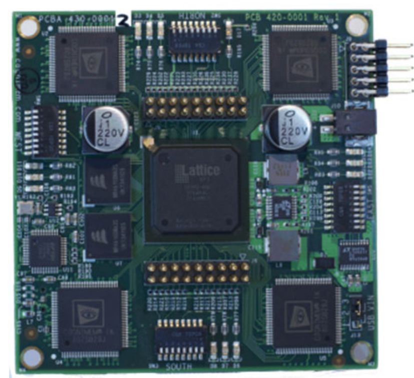


NEUROMEM , NEUROMORPHIC IC

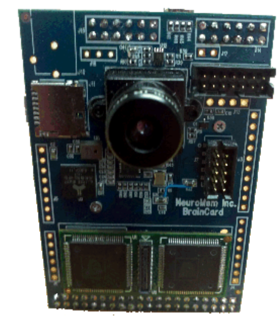
NATIVELY PARALLEL ZISC-BASED ARCHITECTURE (ZERO INSTRUCTION SET FOR LEARNING/RECOGNITION)

General Vision

- Inventor and owner of the NeuroMem CM1K
- Business Model
  - IP licensing
  - Evaluation platforms
  - Consulting Services
    - Technology Transfer Program
    - Hardware design
    - API development
    - Application demonstrators
  - Collaborations:
    - Asahi Glass(4yrs), 22 intl joint patents
    - Intel (2yrs), outcome: IP License
    - Anurag, FPGA blackbox license



NeuroStack



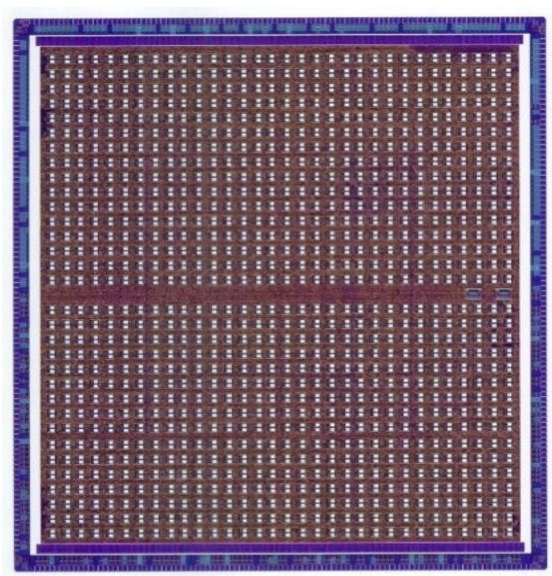
BrainCard
(front & back)

How is NeuroMem different?

NeuroMem
CM1K IC

- RCE and KNN chip
- Match 1 among N in 500 ns to 2.5 µsec
- Highly scalable

- Regular architecture, just neurons
- No fetch and decode
- Patented WTA bus (no cross bar)
- Low power (<0.5 watts)
- Self trainable
- Orthogonal inter-chip connectivity
- Commercially available (IC, Source and FPGA IP)



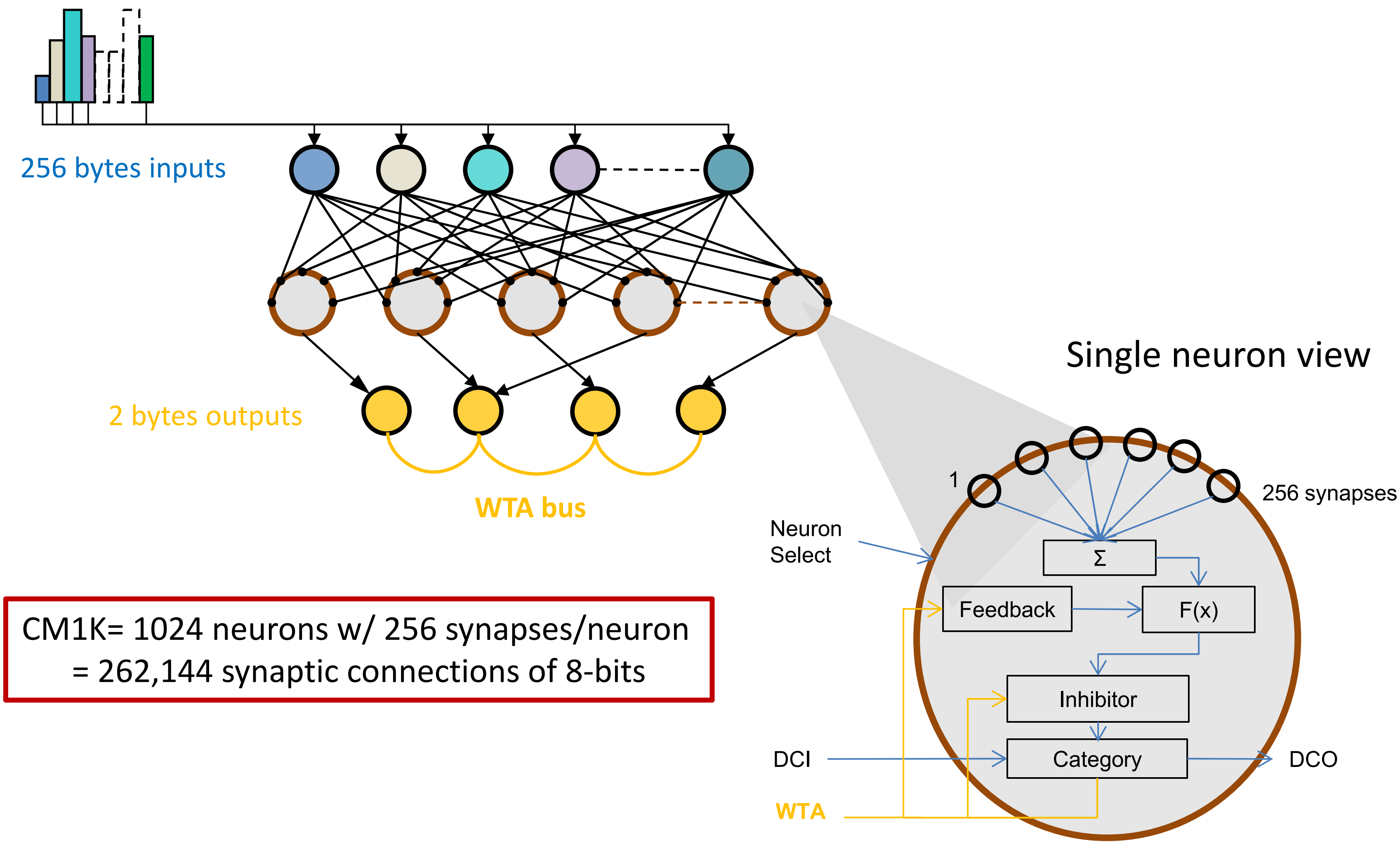
🡐 1024 identical neuromorphic memories, all interconnected (intra & inter hip)

The pillars of neuromorphic model…

- **Broadcast Mode :** query/stimulus is broadcasted to all the neurons simultaneously
- **Deterministic search time:** Firing time does not increase with the scaling up of the network
- **Winner takes all:** Inhibit the weak responders autonomously in the same deterministic time
- **Uncertain response:** Sort responses autonomously in order of "lesser confidence" when multiple conflicting neurons fire
- **Unknown response:** Enable the dynamic addition of new knowledge
- **Back propagation of error:** Inhibit erroneous spiking neurons autonomously
- **No fetch and decode of program instruction:** Software is definitively contrary to the biological model, else it's simulation, not neuromorphic…
- **Beyond biology:** Fast upload download enabling knowledge proliferation (some dream of it).

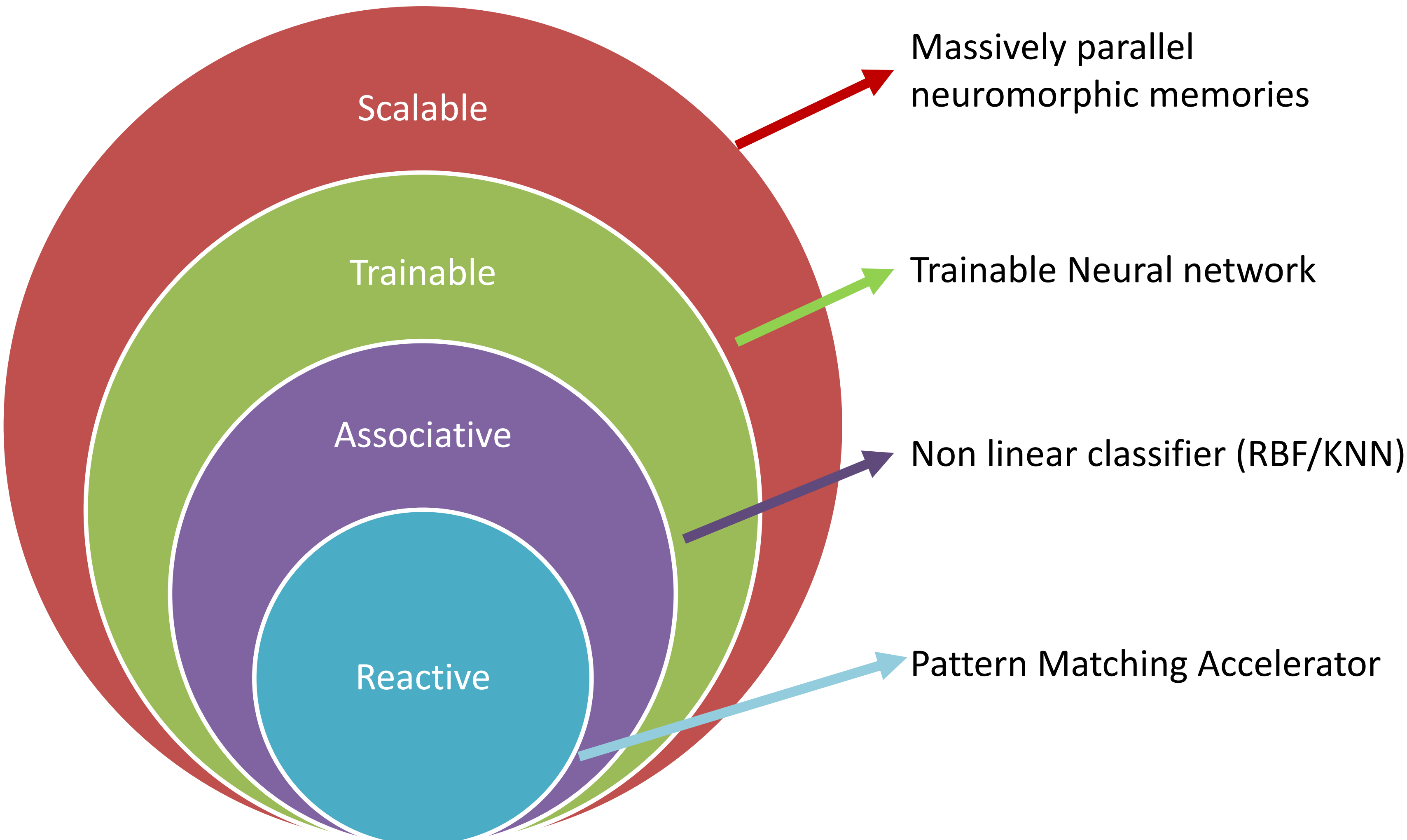
All implemented in the NeuroMem CM1K IC (continued…)

NeuroMem CM1K seen as a 3-layer NN

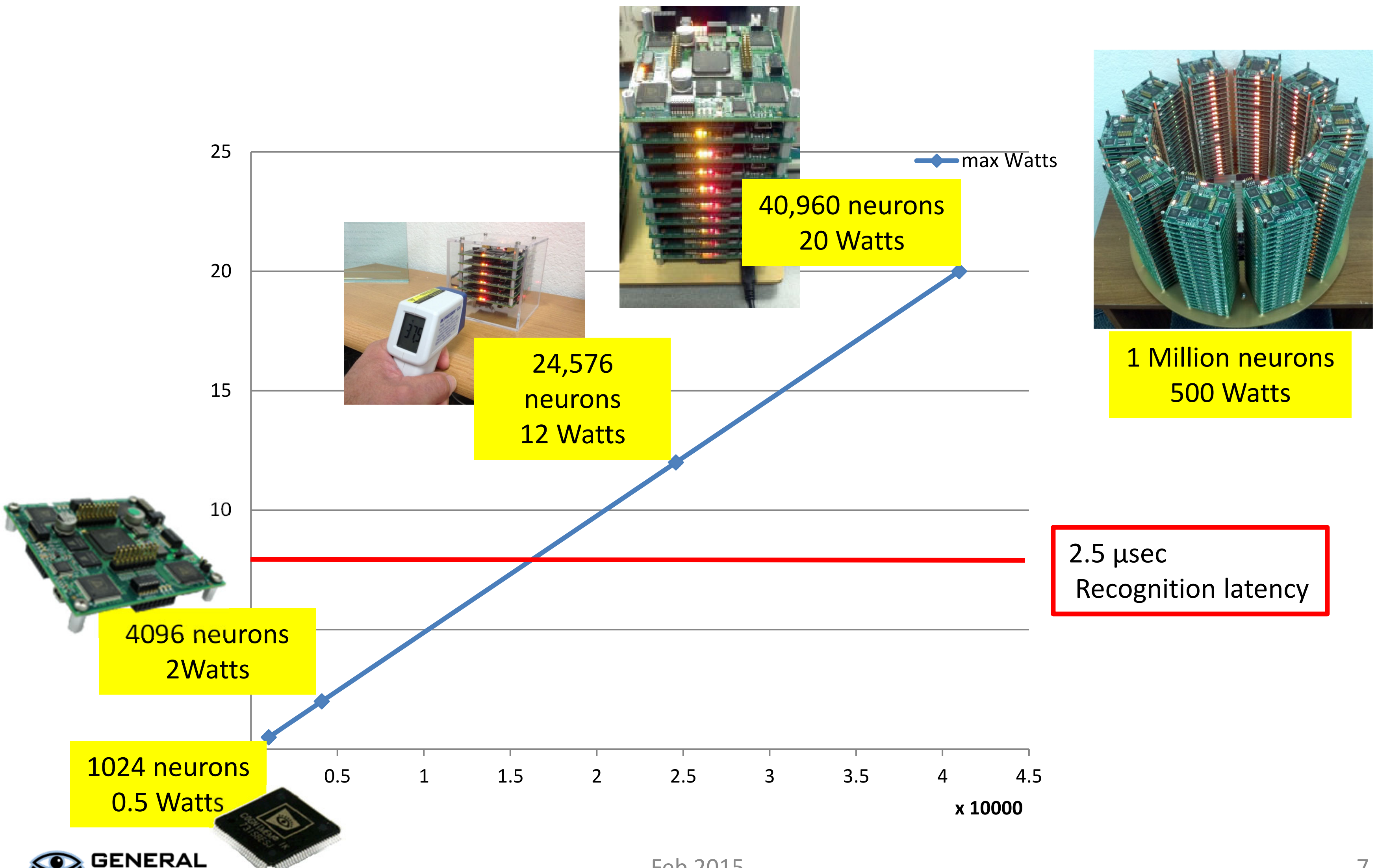


CM1K= 1024 neurons w/ 256 synapses/neuron
= 262,144 synaptic connections of 8-bits

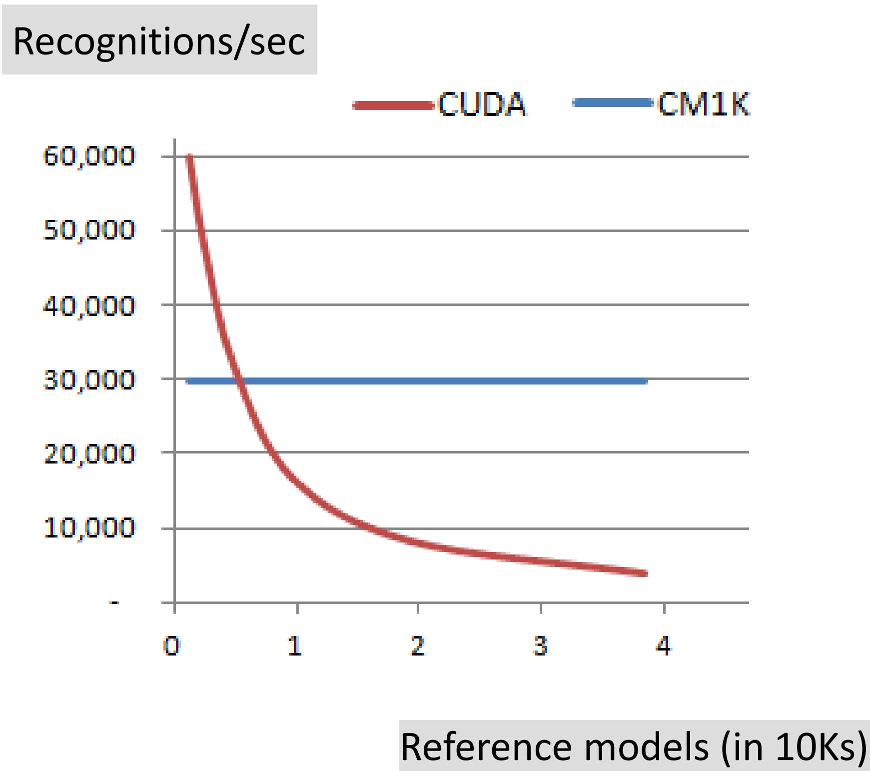
The functional facets of the NeuroMem memories



Demonstrated Scalability



K-Nearest Neighbor (KNN) Benchmarking



CUDA

- Intel Pentium 4 **@3.4GHz** with 2GB DDR2
- Nvidia GeForce 8800GTX with 768MB DDR3 and 16 multiprocessors interfaced thru PCI express 1.1

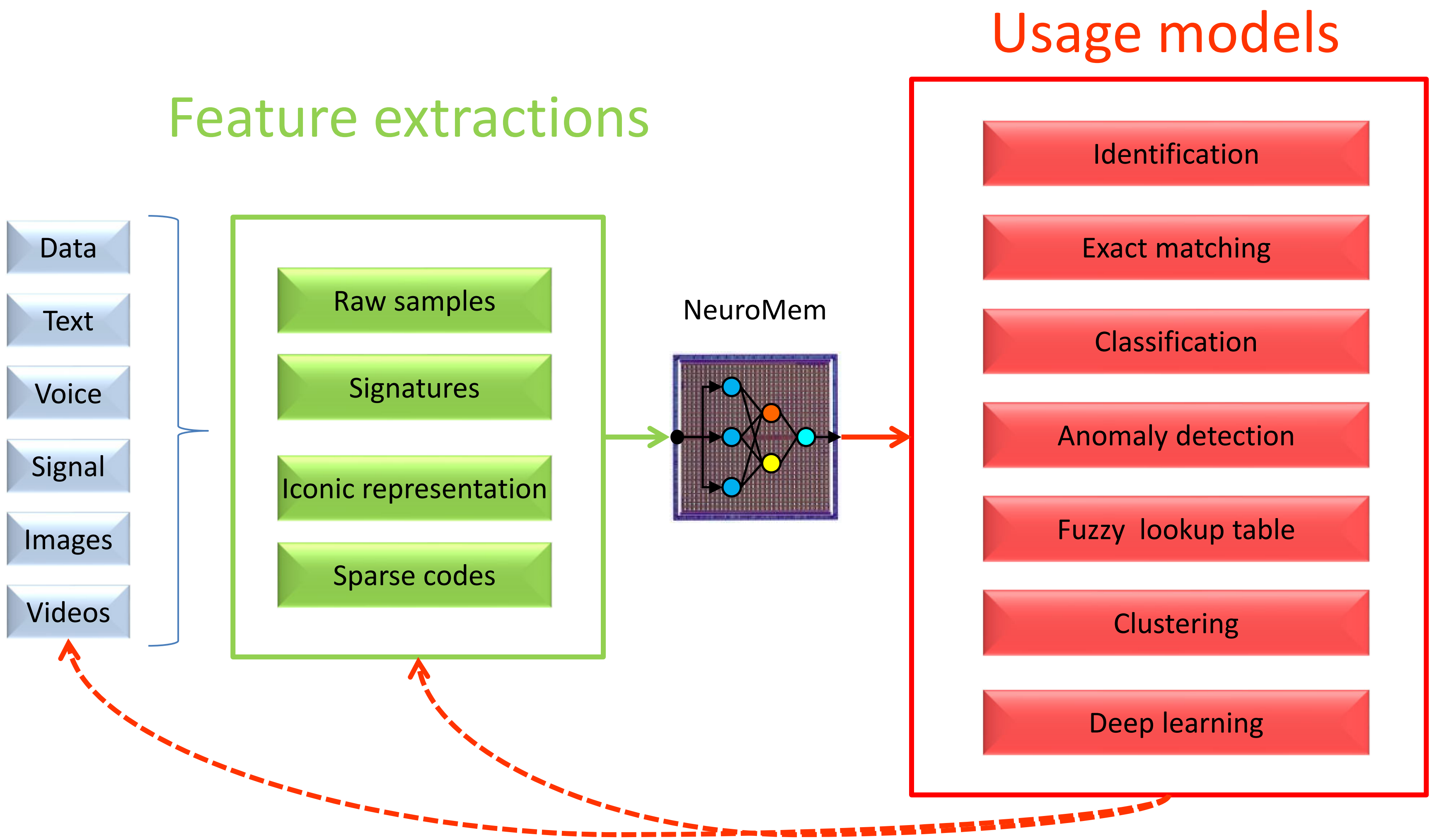
Source: Universite de Nice-Sophie Antipolis/CNRS

vs.

CM1K **@16Mhz**

CONCLUSION: CM1K outperforms CUDA by an increasing factor as the number of reference models gets bigger because CUDA is highly impacted by this value when CM1k is not

Usage Models



Deployed Applications with CM1K

- Deployed and non confidential
  - Fish inspection (GV, 2003)
  - Surface inspection (GV, 2009)
  - Adaptive Optics (ISL, 2011)
  - Face recognition (ANURAG, 2011)
- In progress
  - Network intrusion detection (Argonne Natl Lab)
  - Self Organizing Map (Synaptics.org)
  - Deep learning for traffic sign recognition (GV)
  - MVED (ISL)
  - CM1K as restricted Bolzman machine (ITT New Delhi)
  - IntelliGlass (GV & Asahi Glass)

Industrial off-shore fish inspection

AI Magazine Volume 29 Number 1 (2008) (© AAAI)

Fish Inspection System Using a Parallel Neural Network Chip and the Image Knowledge Builder Application

Anne Menendez and Guy Paillet

■ *A generic image learning system, CogniSight, is being used for the inspection of fishes before filleting offshore. More than 30 systems have been deployed on seven fishing vessels in Norway and Iceland over the past three years. Each CogniSight system uses four neural network chips (a total of 312 neurons) based on a natively parallel, hard-wired architecture that performs real-time learning and nonlinear classification (RBF). These systems are trained by the ship crew using Image Knowledge Builder, a "show*

The fish industry is very competitive. Fleet owners are very interested in filling their boats as fast as possible with the fewest and most qualified personnel, thus reserving maximum occupancy for their refrigerated storage. During an expedition, which can last between one to two weeks, the fish processing machinery operates around the clock (figure 1). Typically, fishes are brought on the boat and dropped into metal pockets that convey them through cleaning, cutting, and filleting machines. Anomalies, which

frame grabbers, PCs, and image-processing software. None of these attempts have led to a usable offshore system because of the high nonlinearity of the problem.

A neural network approach was the only possible way to deliver a system that could be both adaptive and trainable by the fishers themselves. A hardware neural network was the best way to deliver a reliable and fast system that featured both a small footprint and affordable cost. Typical fish species to be recognized include ill-defined herrings or mackerels.

Adaptive Optics

ISL

GENERAL VISION

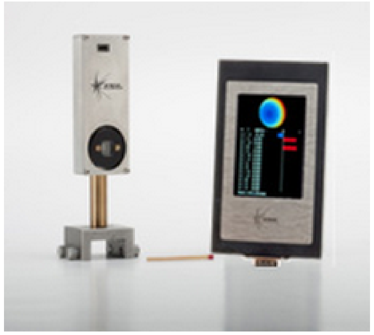
Conseil Général Haut-Rhin

Quick Links

ISL

Wavefront sensing: the neural approach

Real-time wavefront measurement by embedded artificial intelligence:
No computer required for operation



Current prototype features

- Commercial Micro-lens array: 150 µm pitch
- 11 x 11 micro-lens cells sampled
- Calculation of one Zernike polynomial: ~80 µs
- Resolution : 0.05 lambda (wavelength)
- Numerical and bar-graph results display
- Reconstructed wave front pseudo-color plot
- ISL modified V1KU camera from General Vision.

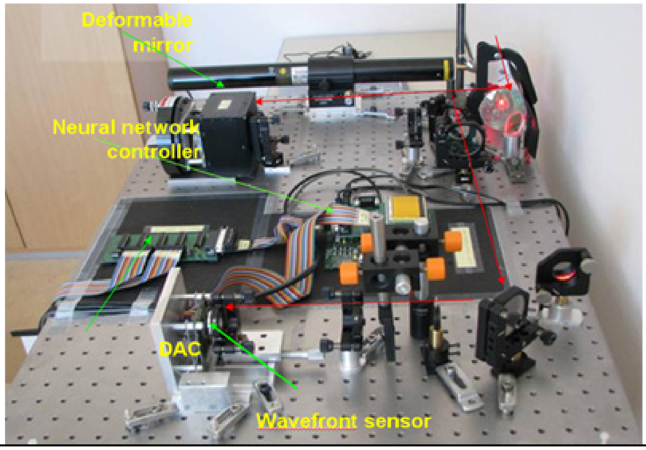
First experimental layout of a neural network-based adaptive optics controller type

Features

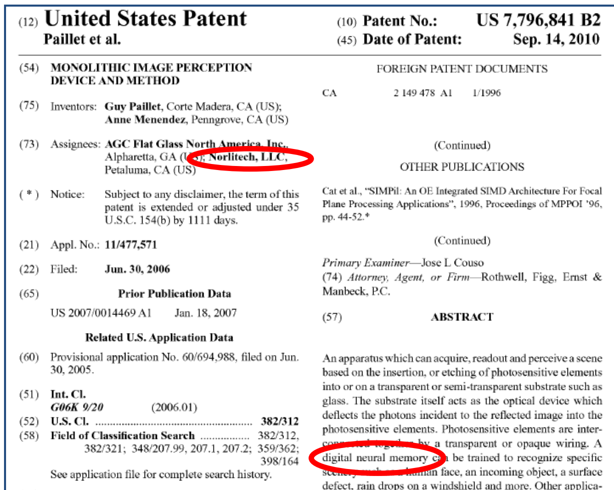
- 37 channel mirror
- 11 x 11 microlens array
- 8 bit DAC
- 60 fps, i.e. 18 ms / loop

Performances

- All-electronic control time: 1.2 ms
- 830 Hz loop rate may be expected with high-speed camera interface: in development.



IntelliGlass collaboration



(12) **United States Patent**
Paillet et al.

(10) **Patent No.:** **US 7,796,841 B2**
(45) **Date of Patent:** **Sep. 14, 2010**

(54) **MONOLITHIC IMAGE PERCEPTION DEVICE AND METHOD**

(75) Inventors: **Guy Paillet**, Corte Madera, CA (US); **Anne Menendez**, Penngrove, CA (US)

(73) Assignees: **AGC Flat Glass North America, Inc.**, Alpharetta, GA (US); **Norlitech, LLC**, Petaluma, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1111 days.

(21) Appl. No.: **11/477,571**

(22) Filed: **Jun. 30, 2006**

(65) **Prior Publication Data**

US 2007/0014469 A1 Jan. 18, 2007

Related U.S. Application Data

(60) Provisional application No. 60/694,988, filed on Jun. 30, 2005.

(51) **Int. Cl.**
G06K 9/20 (2006.01)
(52) **U.S. Cl.** **382/312**
(58) **Field of Classification Search** 382/312, 382/321; 348/207.99, 207.1, 207.2; 359/362; 398/164
See application file for complete search history.

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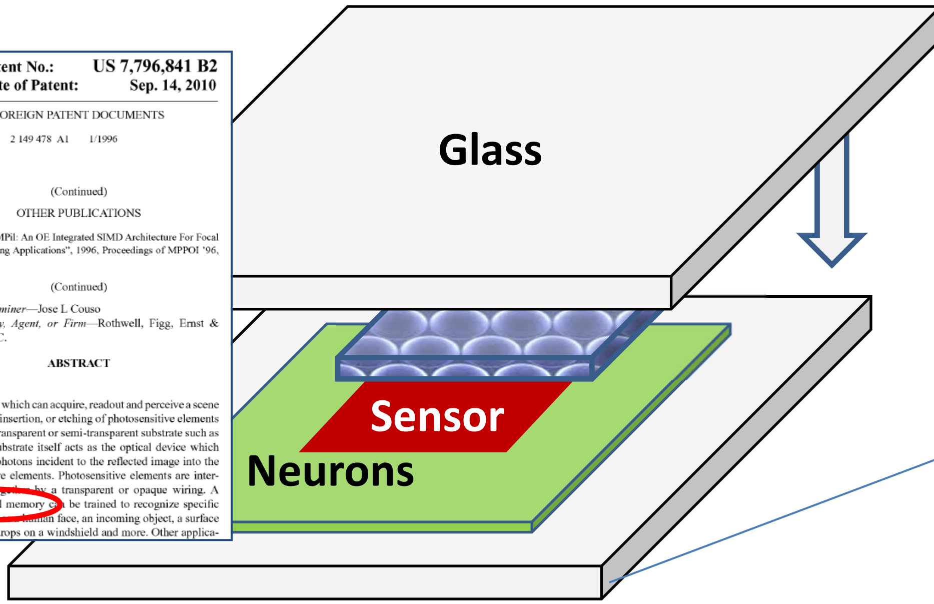
Cat et al., "SIMPil: An OE Integrated SIMD Architecture For Focal Plane Processing Applications", 1996, Proceedings of MPPOI '96, pp. 44-52.*

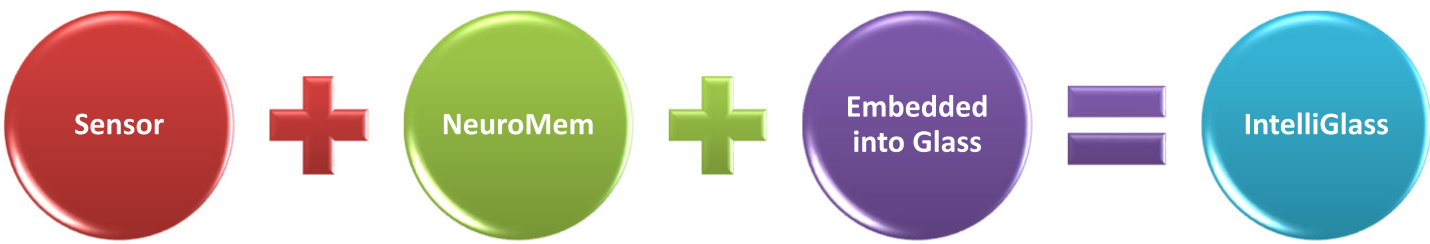
(Continued)

Primary Examiner—Jose L Couso
(74) *Attorney, Agent, or Firm*—Rothwell, Figg, Ernst & Manbeck, P.C.

(57) **ABSTRACT**

An apparatus which can acquire, readout and perceive a scene based on the insertion, or etching of photosensitive elements into or on a transparent or semi-transparent substrate such as glass. The substrate itself acts as the optical device which deflects the photons incident to the reflected image into the photosensitive elements. Photosensitive elements are interconnected together by a transparent or opaque wiring. A digital neural memory can be trained to recognize specific scenery, such as a human face, an incoming object, a surface defect, rain drops on a windshield and more. Other applica-





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