CogniMem, a high-speed non-linear classifier

The practical merger and implementation of two re-known concepts

A non-linear classifier
(Restricted Coulomb Energy, 1982)
(Invented by Nobel prize Winner Leon Cooper and All, derived from Bruce Batchelor's work)

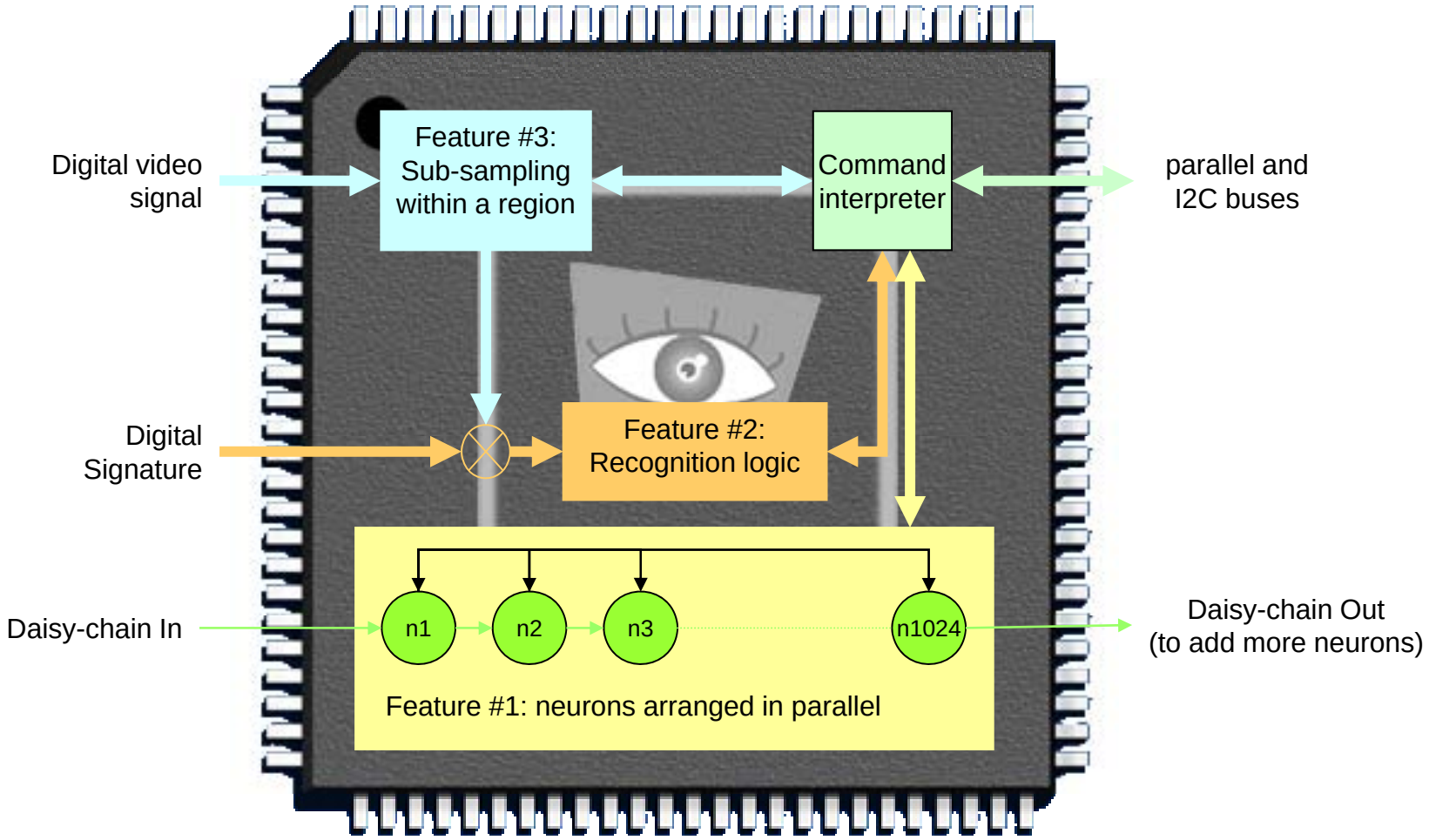
A hardwired parallel architecture
Designed for the CERN's UA1 experiment (1984)
Lead by Nobel prize winner Carlo Rubia

Try NeuroCar demo

Teach a car how to drive
On a race track in a few mouse clicks
(download from web)

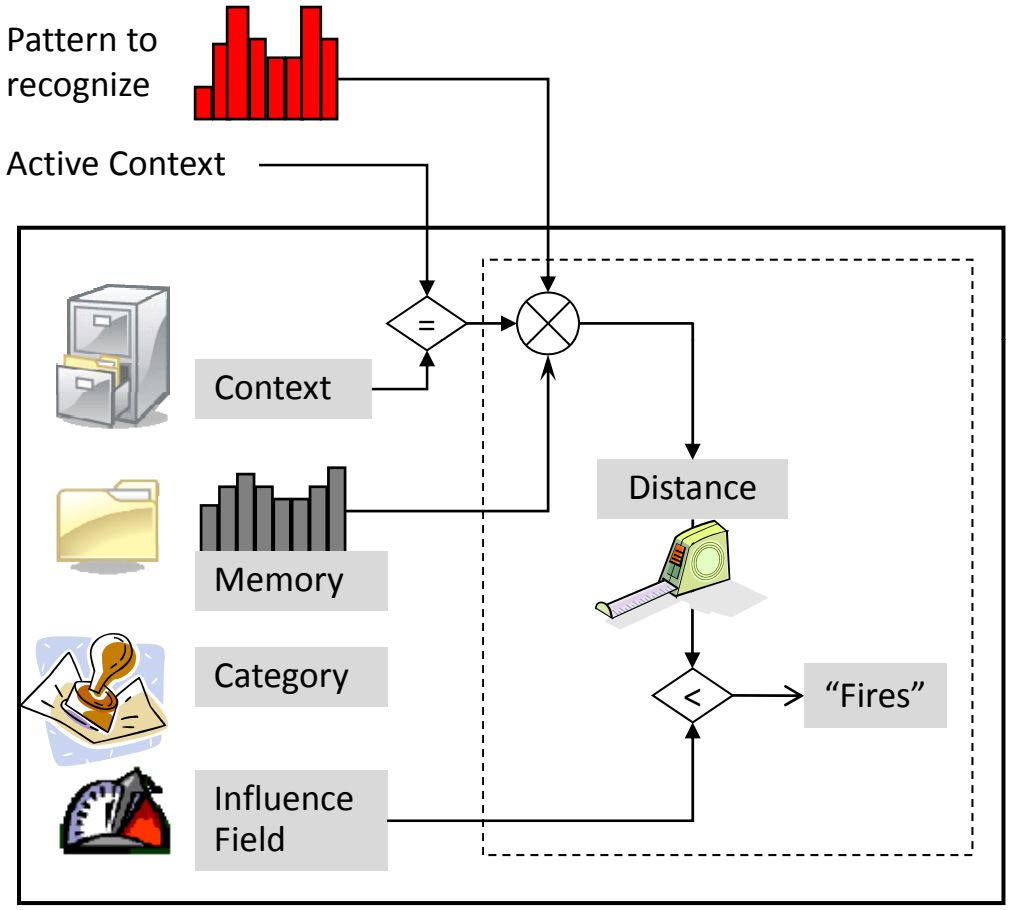
CM1K benefits
High-speed pattern recognition,
Expandable neural network
Trainability (supervised or unsupervised)
Low power consumption,
Compact (TQFP100), Low cost,
1st production batch released Jan 2008

CM1K, a network of neurons in parallel



What is a neuron?

A neuron is a reactive memory which can autonomously evaluate the distance between an incoming vector and a reference vector stored in its memory. If this distance falls within its current influence field, it returns a positive classification.

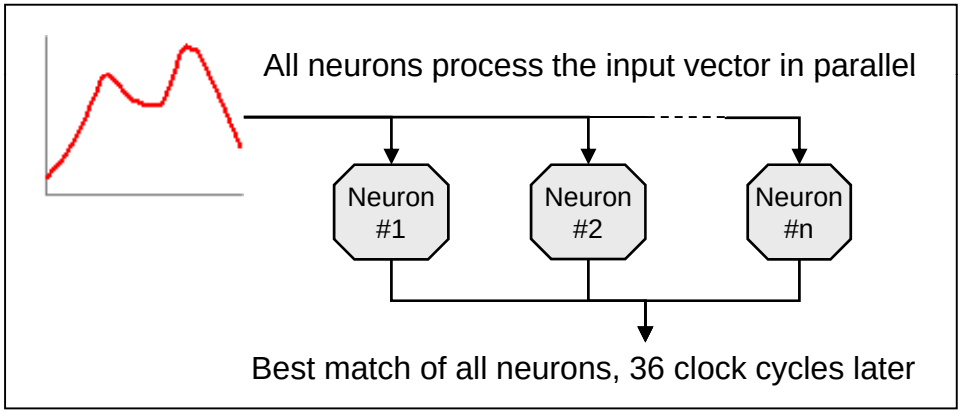


What is a neural network?

The true significance of a neuron is its arrangement into a parallel network which allows

-To learn and recognize a vector in a constant amount of time independent from the number of neurons

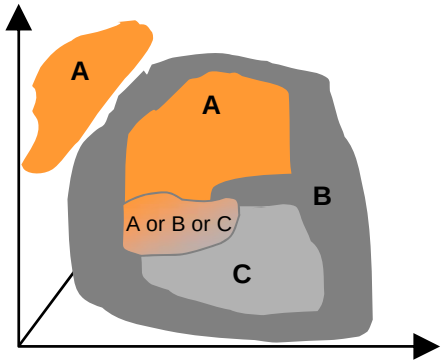
-To add neurons at will to the network



CM1K, an adaptive model generator

- Learn by examples (supervised or unsupervised)
- Map decision spaces by aggregate instead of hyper planes
- Cope with non-linear, convex, disjoints and embedded categories
- Possible modulation between conservative or moderate engine
- Multiple space generation using different context
- Save and restore the contents of the neurons
- Can append more training at any time

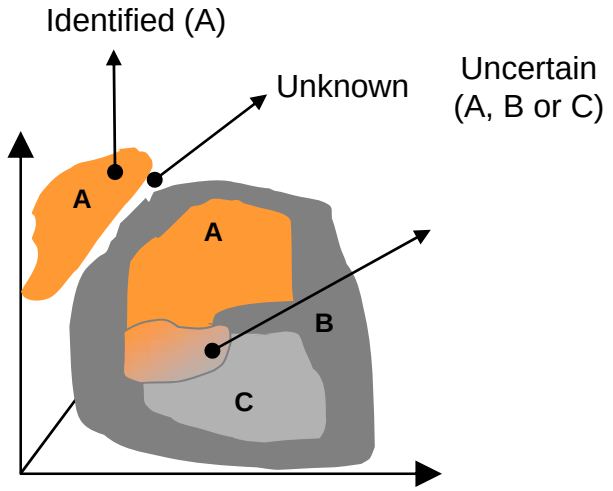
Learning = Building a **“decision spaces”** by learning examples



CM1K, a high-performance classifier

- Global response readout:
  - positively identified
  - identified with uncertainty
  - unknown
- Detailed response of all the firing neurons
  - -category and confidence level (or distance)
  - -retrieved per decreasing confidence

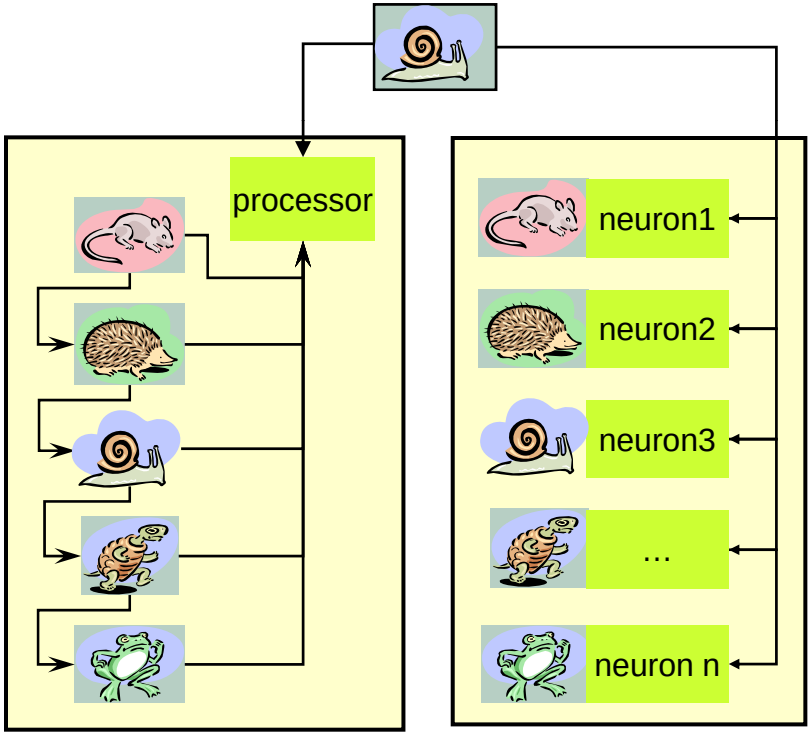
Recognition = where does the sample fall in the decision space?

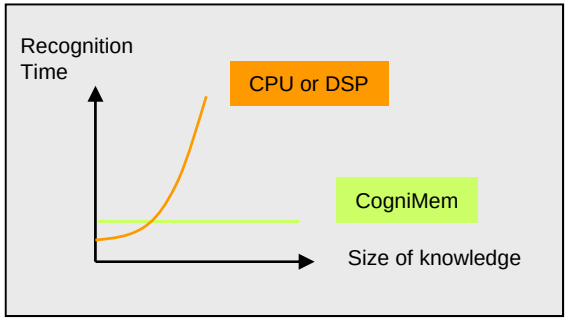


CM1K, high speed performance

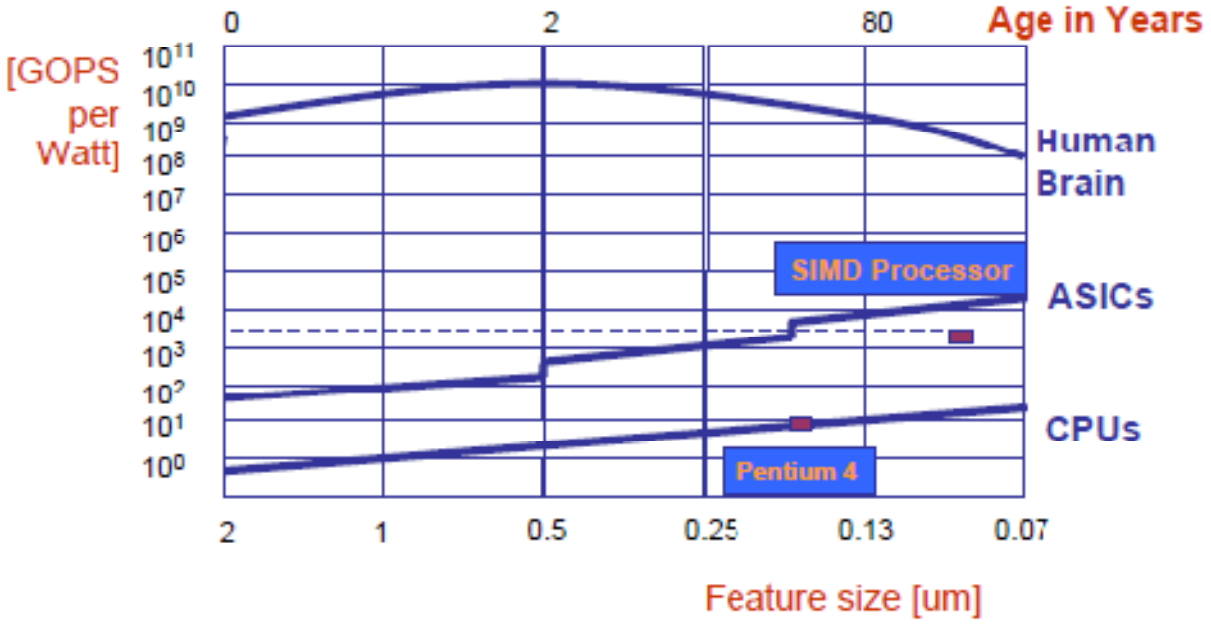
-Constant recognition time independent from the number of neurons in use

- 9.47 usec to broadcast a pattern of 256 bytes to all neurons (@ 27Mhz)
- 1.3 µsec to read to the best match





CM1K, low-power consumption



Targeted power for an embedded system < 1W

→Pentium IV – 2,4 GHz = 6 GOPs, peak consumption= 59W

→ 1 CM1K = 0.3 W → N CM1K in parallel = N*0.3 W

CM1K, enabler for new architectures

Simulation d'un réseau neuronal

PC pentium	DSP Shark	DSP Tiger	Processeur neuronal
2 GHz	100 MHz	300 MHz	27 MHZ
T= 1714 µs	T=7925 µs	T=949 µs	T=10 µs

- 170 times faster than a computer running at 2.4 Ghz
- Capable of **100.000 recognition of a 256-bytes vector /sec**
- 120 times less power than a Pentium (0.5w vs 60w)

Built-in recognition engine (optional use)

- Receive vector data directly on the digital input bus (8-bit data, ext clk, 2 sync lines)
- Bypass to the neurons in real-time
- Upon receipt of the last vector data
    - Recognition status in 4 clock cycles (74 ns @27Mhz)
    - Category of the neuron with the closest match in 37 clock cycles (1.3 usec)

- In the case of a video input, the CogniMem signature extraction can be selected
    - Sub-sampling of the pixels inside a region of interest to fit in a 256-byte vector
    - **Total recognition time = 10.80 µsec after each video frame (@27Mhz)**

Detailed Block Diagram