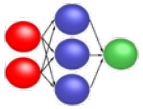
CM1K, the merger of 2 concepts

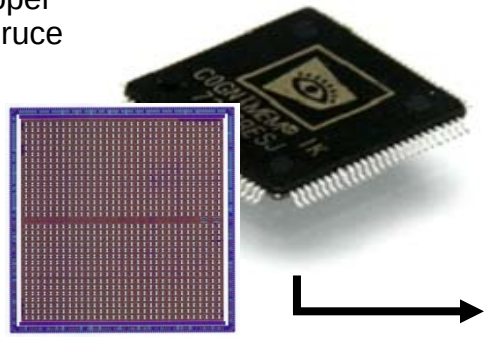
Non-linear classifier



Restricted Coulomb Energy invented in 1982 by Nobel prize Winner Leon Cooper and All, derived from Bruce Batchelor's work.

Hardwired parallel architecture

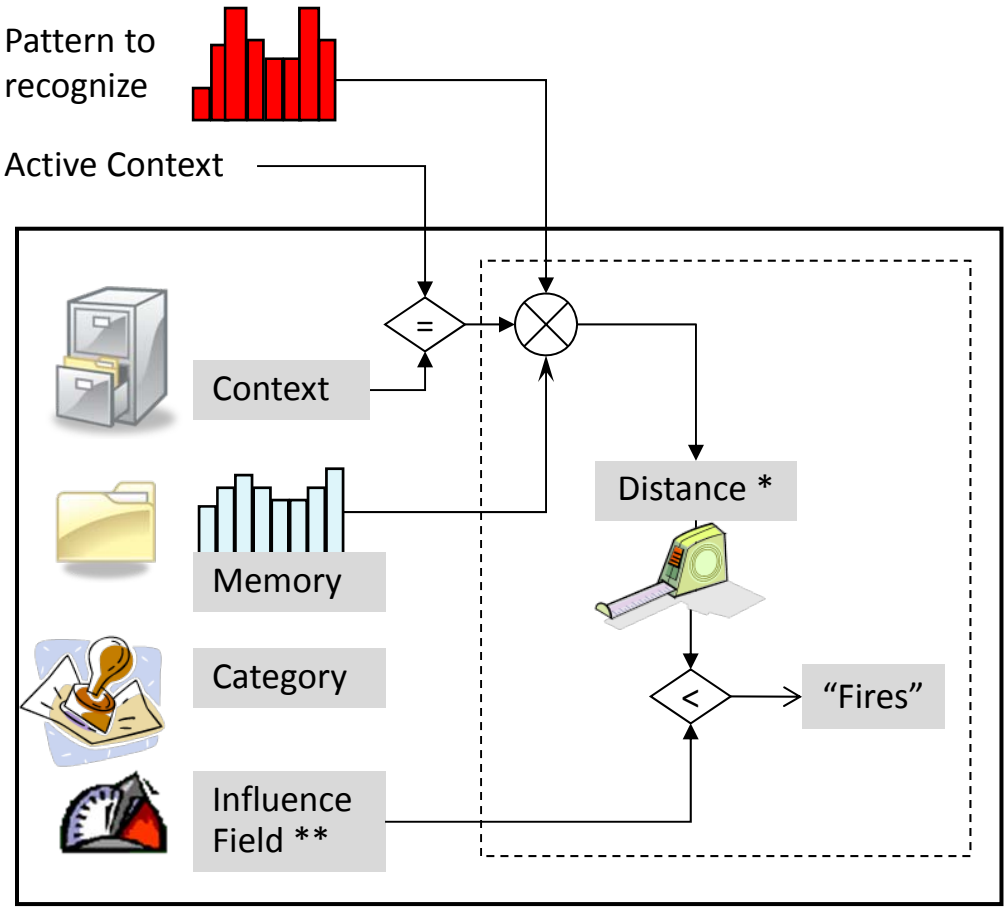
Implemented for the CERN's UA1 experiment in 1984, lead by Nobel prize winner Carlo Rubbia



High-speed pattern recognition
Expandable,
Trainable (real-time or off-line)
8x8 mm2, 0.5 Watts

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.



• Calculated by the neuron during the broadcast of the input vector
•** Updated during the learning, if applicable

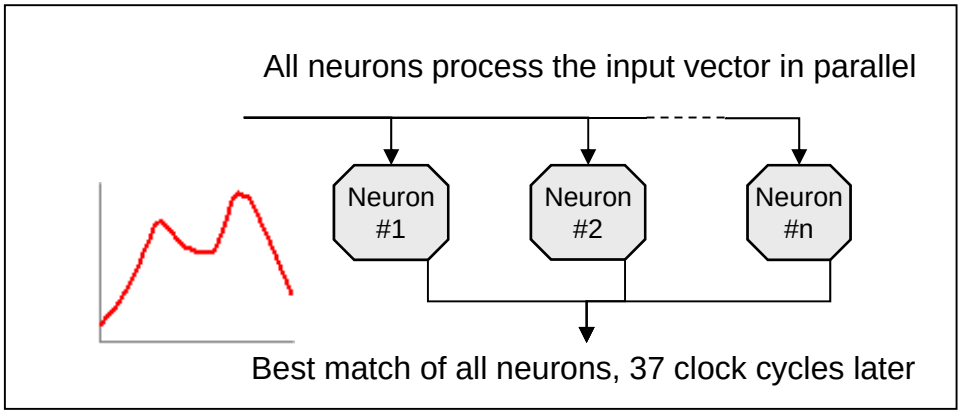
What is a neural network?

The true significance of a neuron is its arrangement into a parallel network and ability to Search-And-Sort for best match without sequential access.

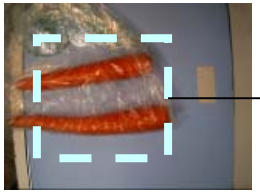
The Winner takes All

→ Learn and recognize a vector in a constant amount of time independent from the number of neurons

→ Network can be expanded at will

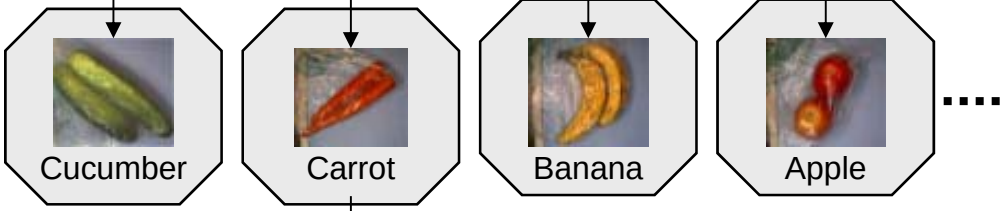


Neurons= Cognitive Memories



New pattern
broadcasted to all
neurons at once

Chain of neurons



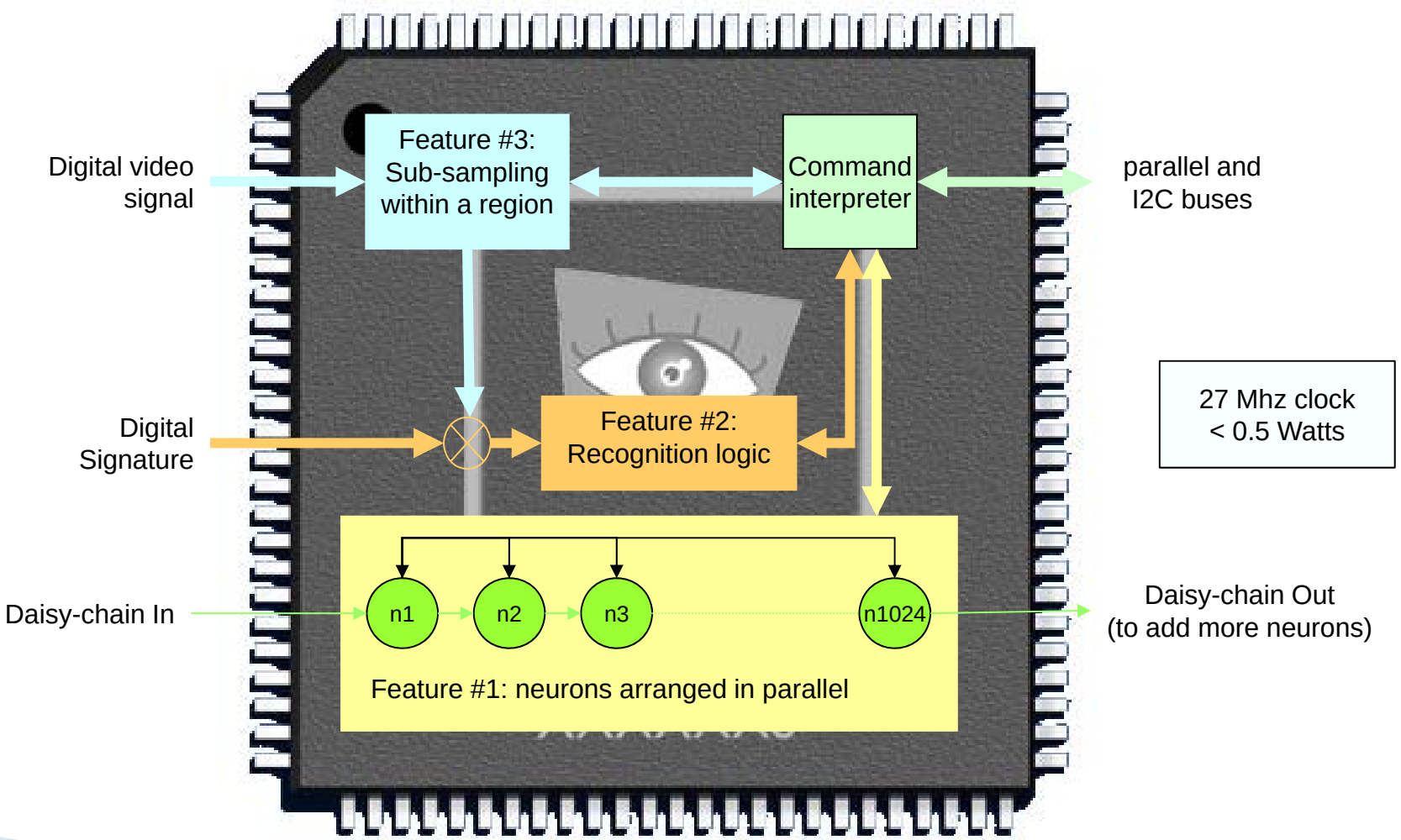
Carrots: $1.33/lbs

Recognition: Category
of the neuron with best match

Neurons = A component with memory storage and reactive logic to learn and recognize

Neural network = A bank of neurons operating together

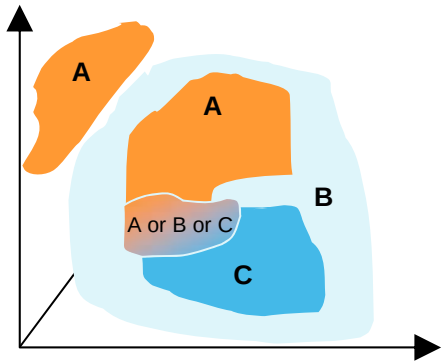
A network of neurons in parallel



An adaptive model generator

- Learn by examples (supervised or unsupervised)
- Map decision spaces by aggregates instead of hyper planes
- Cope with non-linear, convex, disjoints and embedded categories
- Possible modulation between conservative and liberal decision spaces with zones of uncertainties
- Save and restore the contents of the neurons
- Can append more training at any time

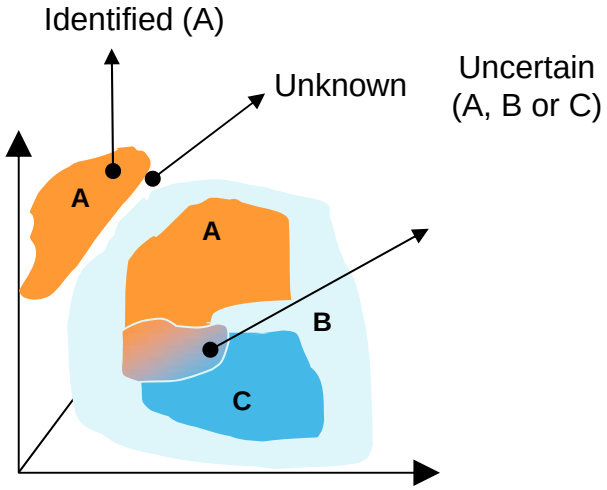
Learning = Building a **“decision space”** by teaching examples



A high-performance classifier

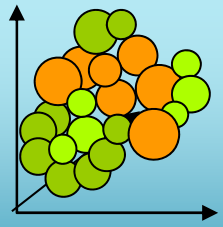
- Global response readout:
  - positively identified
  - identified with uncertainty
  - unknown
- Detailed response of all the firing neurons
  - -category and confidence level (or distance)
  - -retrieved per decreasing confidence

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



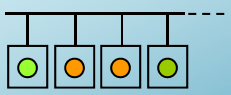
CM1K Benefits

Easy to use



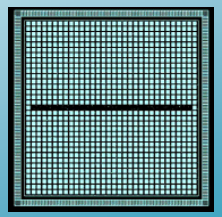
- Trained by examples
- Automatic model generator
- Adaptive non-linear classifier
- Knowledge traceability and portability

High-Speed



- Recognition time independent from number of neurons
- Expandable parallel neural network
- Equivalent to >90 DSP @300Mhz

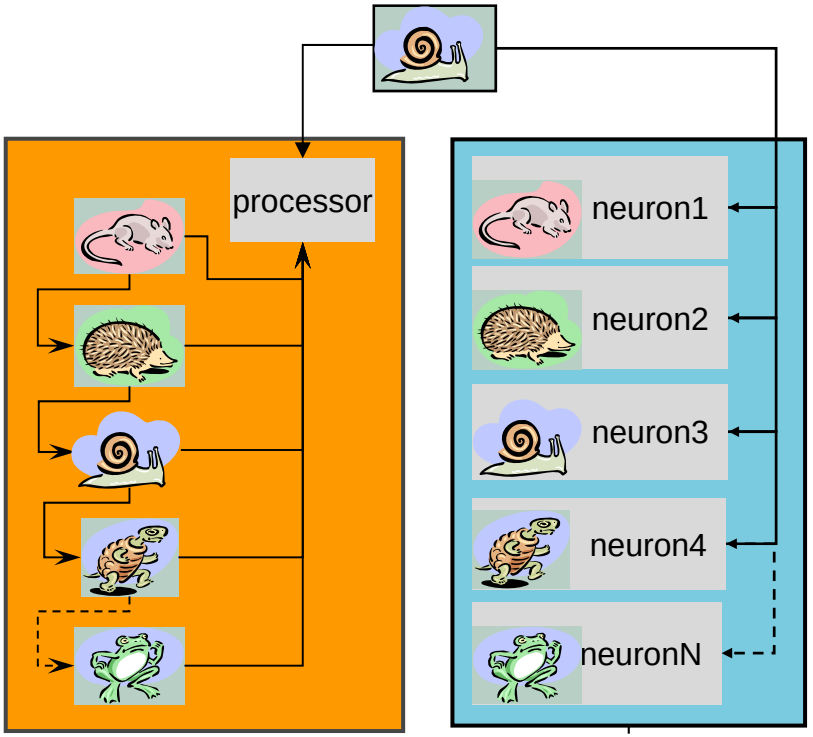
Easy to integrate

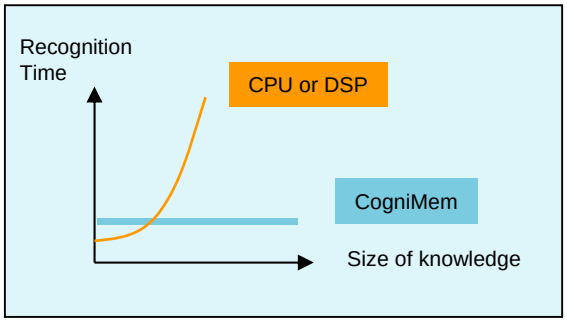


- Low clock frequency
- Low power
- Low pin count connectivity
- Cascadability

High speed, Low-power

Find the snail…





Peak power consumption

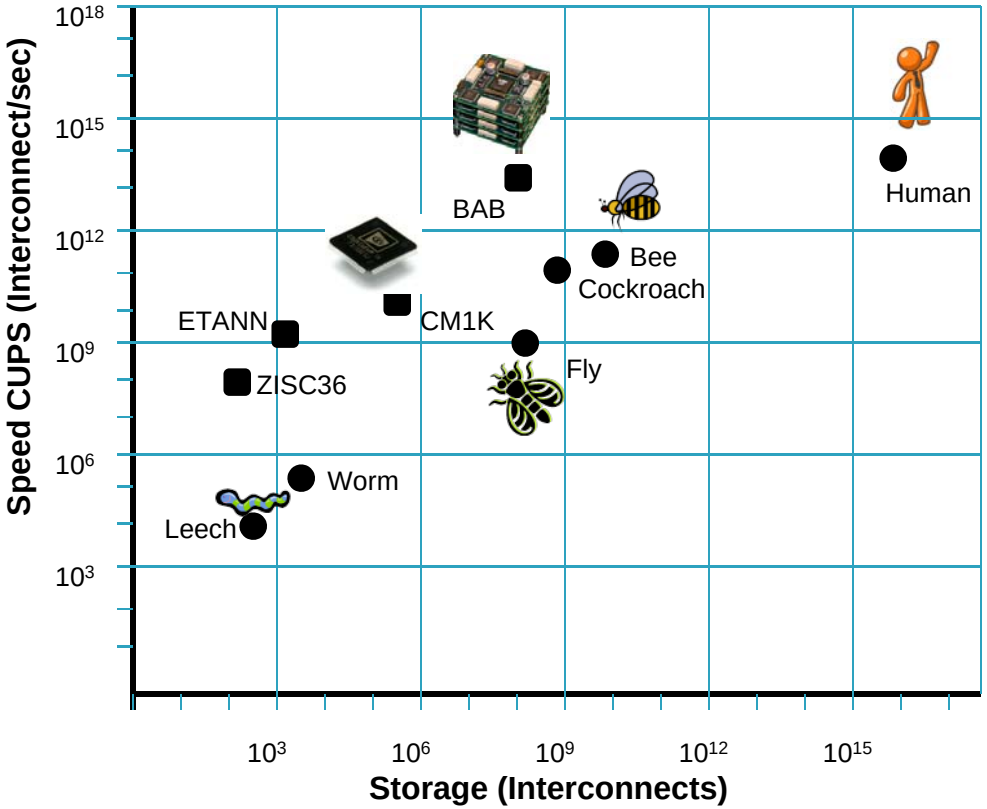
→Pentium IV @ 2.4GHz → 59W

→CM1K @27Mhz → 0.5 W
→ N CM1K in parallel = N*0.5 W

CM1K @ 27Mhz
- 9.47 usec to broadcast a pattern of 256 bytes
-1.3 µsec to find o the best match among N

Enabler for new architectures

@27 Mhz, the recognition of a 256-bytes vector takes 10.9 µsec., equivalent to 91,617recognition /sec.



Legend:
Interconnects:
CM1K= 256 * 1024,
BAB= 1000 CM1K
CUPS= Connection Update Per Second

Endless possibilities from Sensors to Servers

Neurons directly connected to a sensor output for real-time recognition at low-cost and low power

Thousand of neurons assembled in parallel for high-speed data mining