

Artificial Neural Networks



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Outline

- Biological inspiration: architectures and learning
- Learning in the statistical framework
- Perceptrons
- Multilayer perceptrons
- Kernel machines
- Self-organizing maps
- Recursive neural networks
- Knowledge injection and extraction
- The applicative perspective, research issues, and open problems

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Biological inspiration: architecture and learning

- Problems with subsymbolic representations (examples): motivations to study neural nets
- Biological inspiration and neural architectures
- Supervised, reinforcement, and unsupervised learning
- Links with other disciplines

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Hystorical Notes

- 1956 Dartmouth Summer Research Project on AI (Minsky, McCarty, Rochester, Shannon, ...)
- 1959 Widrow ADALINE: application to ASR
- 1962 Rosenblatt's perceptron
- 1969 Minsky & Papert's seminal book
- '70 Anderson's associators, Kohonen's self-organizing maps
- 1982 Hopfield nets
- 1986 Backpropagation and the PDP ...

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Why to study artificial neural networks?

- *Perspective of cognitive science:* To understand the emerge of intelligence from the biological (especially human) brain
- *Perspective of artificial intelligence:* To face problems in which the input is composed of coordinates where there is no label with attached semantics.

The perspective of cognitive science

- Learning the English past tense (McClelland et al 1986)... a cognitive behavior in artificial neural nets takes place which reminds that of children
- Text to speech: NetTalk (Senjowski, 1987): the machine learns to talk and, in the earliest phases of the learning, balbetta like a baby

The perspective of artificial (computational) intelligence

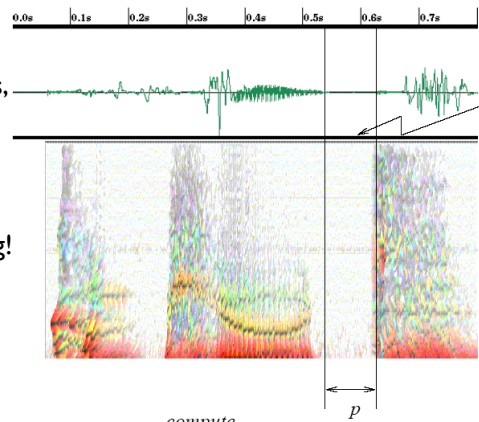
- We need to face the classic symbol grounding problem(Harnard, 1990)
- We need to conceive computational schemes which goes beyond conventional hard computing. In Zadeh's words:

Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty and partial truth. In effect, the role model for soft computing is the human mind. The guidance principle of soft computing is: Exploit tolerance for imprecision, uncertainty and partial truth to achieve tractability, robustness and low solution cost.

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Automatic Speech Recognition

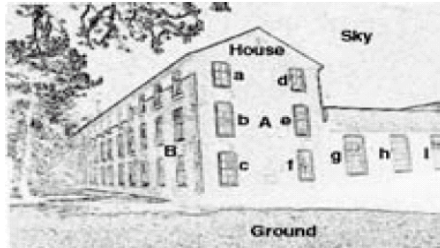
Problems with time warping, different speakers, noise ...



Segmentation: non-just Energy-based thresholding!

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Pattern analysis



Segmentation (again), classification, understanding ...

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License-plate recognition



Find the
number-plate from
the picture

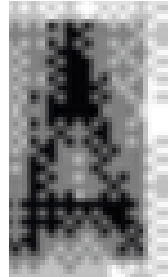
Before reading numbers one must locate the plate and,
subsequently, segment the characters

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Classification

An "A" perceived by a webcam

How can I provide a satisfactory statement to associate the picture with an "A"?



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Robotics

Perception of the world

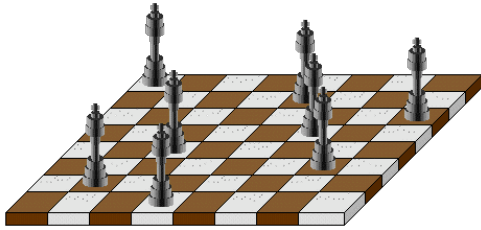
Motor control

Reasoning and strategies



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Qualitative reasoning



8-queens game:
discover non-attacking
configurations

Humans often provide qualitative solutions and are
unable to explain exactly they are reached ... can machines
do the same?

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Emulation the brain?

... Or simply inspiration?

I just want to point out that the componentry used in
The memory may be entirely different from the one that
Underlines the basic active organs.
John von Neumann, 1958

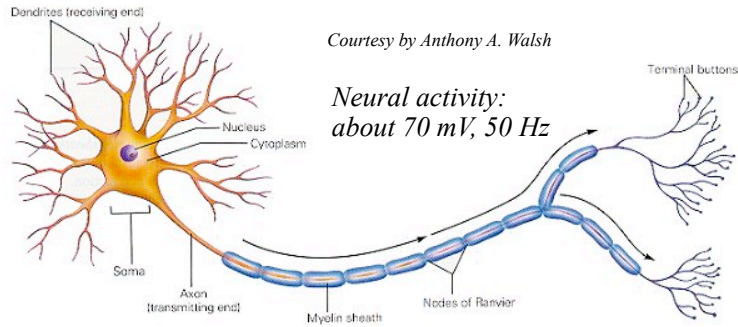
... Inspiration at the level of neurons
... Hard to go beyond!

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Neural organization

THE MAJOR STRUCTURES OF THE NEURON

The neuron receives nerve impulses through its dendrites. It then sends the nerve impulses through its axon to the terminal buttons where neurotransmitters are released to stimulate other neurons.

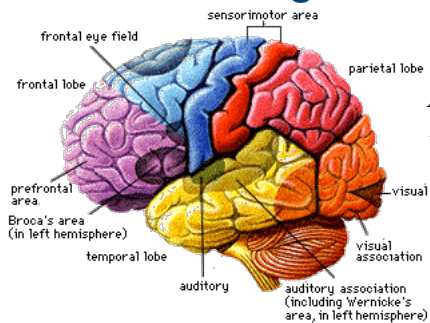


Courtesy by Anthony A. Walsh

Neural activity:
about 70 mV, 50 Hz

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Functional organization of the brain

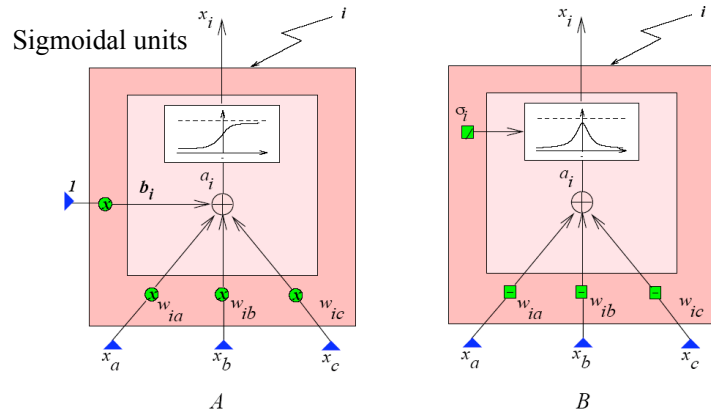


About 100 billion neurons,
10,000 interconnections

Learning corresponds
with the change of the
synaptic strength (weight)

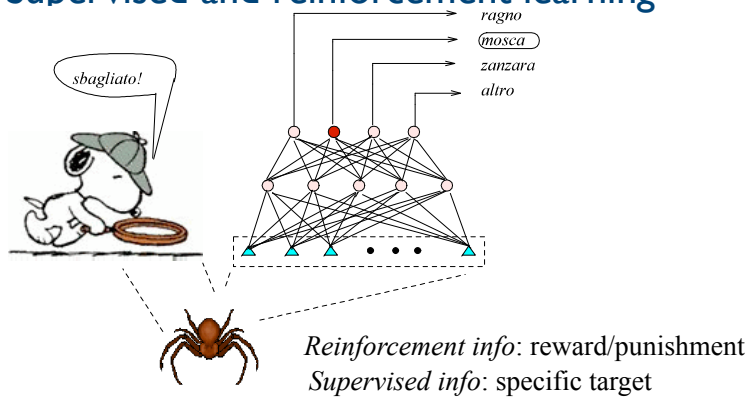
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Artificial neurons



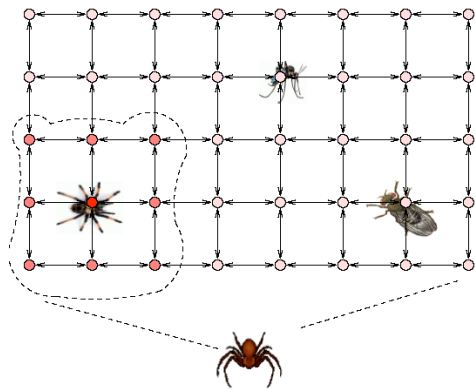
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Supervised and reinforcement learning



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Self-organizing maps



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Links with other disciplines

- At the crossroad of
 - Neuroscience
 - Psychology
 - Computer science
- Stimulation from the neurobiological metaphora

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Resources

- Textbook: Simon Haykin, "Neural Networks – a comprehensive foundation," Prentice-Hall, 1999
- This lecture:
 - Haykin's book, chapter 1.

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