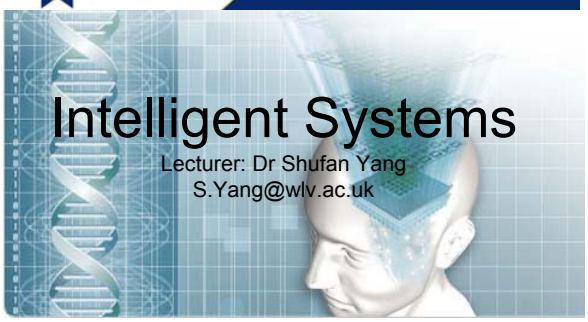

If you're so smart...what exactly is intelligence?

Some ideas

"Intelligence is the ability to recognize connections." - Carolus Slovinec

"To respond like a human being" -Alan Turing

"The entropy of control responses" - G.N. Saridis

Outline

Symbolic Artificial Intelligence

Computational Intelligence

Intelligent Cognitive Systems

- ✓ **Personal robots**
- ✓ **Neuroprosthetics devices**

Conclusions and perspectives

The history of Artificial Intelligence begins with the following article:

A. M. Turing, "Computing Machinery and Intelligence",

Mind, (New Series), 59, 1950, pp. 433-460.

I propose to consider the question, 'Can machines think?' . . .

- In the early days of AI, it was conjectured that theorem-proving could be used for common sense reasoning.
- Basic problem: such systems do not allow for the phenomenon of uncertainty.

Accordingly, a more flexibly interpreted version of the 'rule-based' approach quickly established itself as the dominant.

paradigm in AI:

If <conditions>

Then <action>

Artificial Intelligence: A Modern Approach by Russell and Norvig.

One of the major drawbacks of rule-based systems is that they typically lack a clear semantics

If C then X

If D then Y

. . .

Okay, so now what?

"Chinese Room"

The "Chinese room" experiment developed by John Searle in 1980 attempts to show that a symbol-processing machine like a computer can never be properly described as having a "mind" or "understanding", regardless of how intelligently it may behave.

With the "Chinese room" John Searle argues that it is possible to pass the Turing Test, yet not (really) think.

Source: http://en.wikipedia.org/wiki/Chinese_room

The "Chinese room" experiment proceeds as follows:

- Searle, a human, who does not knows Chinese, is locked in a room with an enormous batch of Chinese script.
- Slips of paper with still more Chinese script come through a slot in the wall.
- Searle has been given a set of rules in English for correlating the Chinese script coming through with the batches of script already in the room.

"Chinese Room" (2)

The result:

- It seems clear that Searle nevertheless does *not* understand the questions or the answers.
- But Searle is behaving just a computer does, "performing computational operations on formally specified elements".

Hence, manipulating formal symbols, which is just what a computer running a program does, is not sufficient for understanding or thinking

AI Challenges

Reference List:

E.A. Feigenbaum (1977). "The Art of Artificial Intelligence: Themes and Case Studies of Knowledge Engineering," Proceedings of the International Joint Conference on Artificial Intelligence, Cambridge, MA, 1977

George F. Luger (2005) "Artificial Intelligence – Structures and Strategies for Complex Problem Solving" Addision- Wesley, 2005, Fifth edition

A. Turing (1950). "Computing Machinery and Intelligence", Mind LIX (236): 433–460, Ocotober, 1950.

What is “Intelligence”?

- Being "intelligent" means to be able to cognitively grasp phenomena, being able to judge, to trade of between different possibilities, or to be able to learn.

What is “Intelligence”?

- Intelligence manifests itself in logical thinking, computations, the memory capabilities of the brain, through the application of words and language rules or through the recognition of things and events.
- The combination of information, creativity, and new problem solutions is crucial for acting "intelligent".

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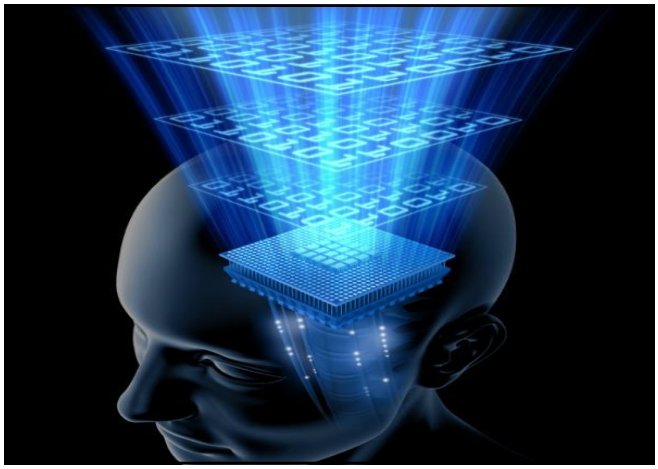
Conclusions and perspectives



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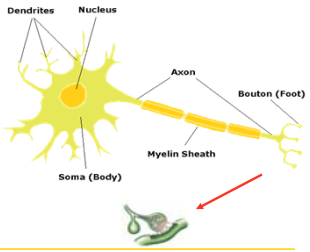
Neurons

- Multiple inputs (dendrites)
- Single output (axon)
- Digital “spike”
- Fires at 10Hz to 100Hz
- Output connects to many targets
- Synapse at input/output connection



(www.ship.edu/~cgboeree/theneuron.html)

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Neurons

A flexible biological control component

- very simple animals have a handful
- bees: 850,000
- humans: 10^{11}

Video neuron animation: https://www.youtube.com/watch?v=LT3VKAr4roo

Processing

- Leaky integrate-and-fire model
  - inputs are a series of spikes
  - total input is a weighted sum of the spikes
  - neuron activation is the input with a “leaky” decay
  - when activation exceeds threshold, output fires
  - habituation, refractory period, …?

$$Vm(n) = \begin{cases} Vm(n-1) + Vs(n) - Vleaky(\tau) & \text{if } Vm < Vthresold \\ Vreset & \text{otherwise} \end{cases}$$

Where Vm is the membrane potential, $Vm(n-1)$ is the membrane potential at the previous time instant, $Vleaky(\tau)$ is the exponentially decreasing leaky voltage with time constant τ. The equation for $Vs(n)$ synaptic integration is:

$$Vs(n) = \sum_{i=1}^{Ns} WiXi(n)$$

where Vs is the synaptic input contribution to the membrane potential, Ns is the number of synapse, Wi are the synaptic weights, and $Xi(n)$ denotes the arrival of per synaptic spike on input i at time n.

Communication

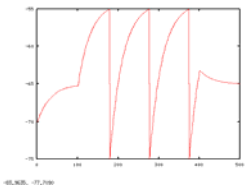
Spikes

biological neurons communicate principally via ‘spike’ events asynchronous

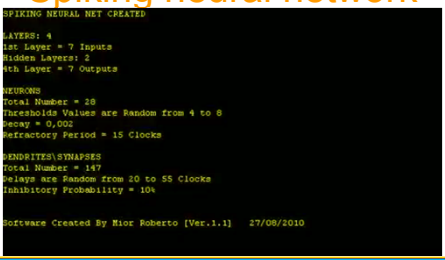
information is only:

which neuron fires, and

when it fires



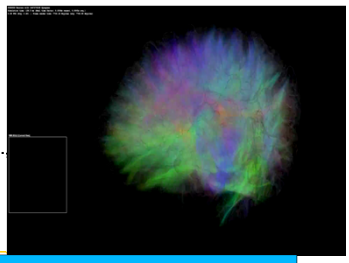
Spiking neural network



Source: https://www.youtube.com/watch?v=lhIdisK7akI

Spike Fun

Simulation of the mammal thalamocortical system with 8 million neurons and1.4 billion synapses using SpikeFun demo simulation (Binzegger et al., 2004).



Source:
www.dimkovic.com/
https://www.youtube.com/watch?v=u28ijlP6L6M

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Conclusions and perspectives

Personal Robots

- AI deals with the development of robots as autonomous and intelligent systems.
- Robotic covers many sub-areas of AI and involves interdisciplinary work including mechanic and electrical design and cognitive areas.
- Enable people to make themselves more productive at home and at work.

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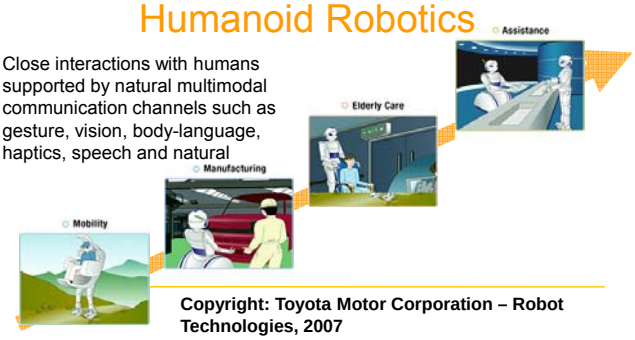
Humanoid Robotics

Close interactions with humans supported by natural multimodal communication channels such as gesture, vision, body-language, haptics, speech and natural



Copyright: Toyota Motor Corporation – Robot Technologies, 2007

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http://www.youtube.com/watch?v=R8UeT9r4cmg

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Humanoid Robot ASIMO

Source : http://www.youtube.com/watch?v=R8UeT9r4cmg

Robotic vision

- **How it can be reached**
  - **With hands**
  - **With eyes**

Where it is

In the visual space

In the somatosensory (body) space

In the auditory space

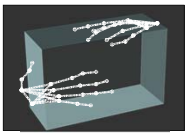
Robotic vision (Con't)

- Position of objects can be coded in terms of the action required to reach it.
- Trajectory of objects can be coded in terms of "collision trajectory" (which body part is going to hit).
- Size can be coded in terms of "grasp type" (small is whatever can be grasped with a pinch grasp).

One can express size with gestures: how big it is?

Robotic vision (Con't)

- How relevant is "action" in recognizing objects?
- Can the visual system exploit the view of haptic exploration to extract shape information of the explored object?



Vision as an embodied process

Understanding as a perceptual process → Understanding as a motor process (goal-driven)

A chair is whatever gives a goal to my sitting action

Understanding with your eyes

Understanding with your bottom

The iCub platform

The iCub is a full humanoid robot sized as a three and half year-old child.

The total height is 104cm.

It has 53 degrees of freedom, including articulated hands to be used for manipulation and gesturing.

The robot will be able to crawl and sit and autonomously transition from crawling to sitting and vice-versa.

The robot is GPL/FDL: software, hardware, drawings, documentation, etc.

Degrees of freedom

Head: vergence required + 3 dof neck

Arms: 7 dof each

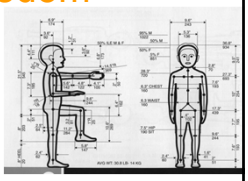
- 3 shoulder, elbow, 3 wrist

Hands: 9 dof each ▸ 17 joints

- 5 fingers ► underactuated

Legs: 6 dof each

- 3 hip, knee, 2 ankle



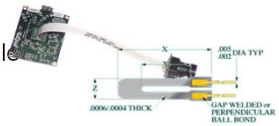
Body cover: concept

Sensors…

Cameras

640x480 color - Remote head
Very small but otherwise standard

Skin/tactile



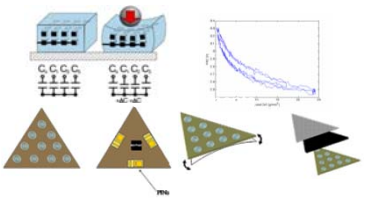
Small (0.67mm)
Designing force/torque sensor
Fingertip 3-axis sensor
Joint torque measurement
Conductive paint…
QTC: rubber-like material
Tension sensors?
Organic FETs?

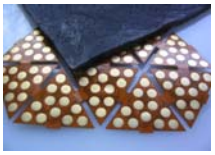
Gyros/inertial

Microphones

Standard, condenser electret

Artificial sensorized skin





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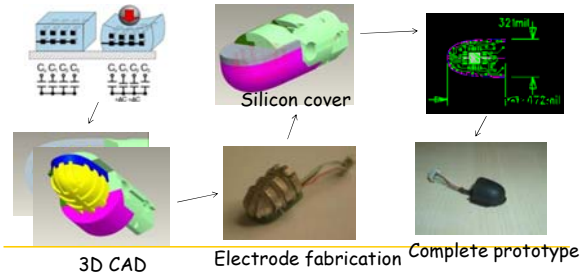
Fingertip



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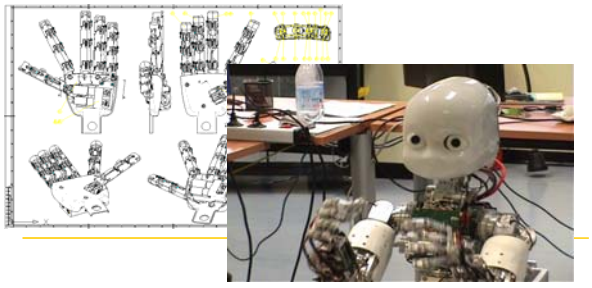
Hands are key!



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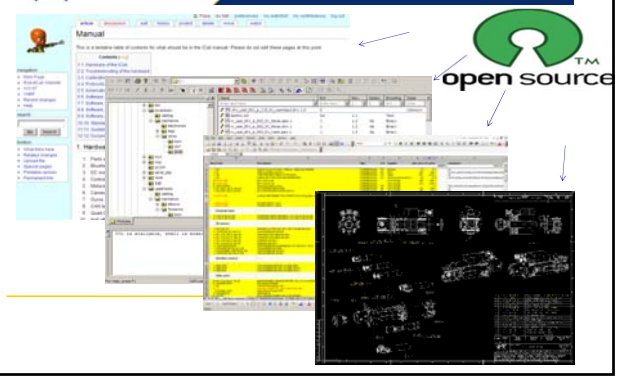

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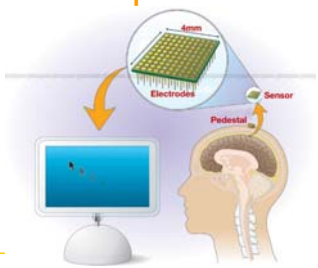
Conclusions and perspectives

BrainGate Chip

Monitors brain activity in the patient and converts the intention of the user into computer commands

This can be used to control a robot arm or a cursor on a screen



BrainGate Chip

100 hair thin electrodes to sense the electro-magnetic signature of neurons firing in specific areas of the brain

BrainGate Chip

Monitored signature is translated into electrically charged signals

Signals are then sent and decoded using a program to move cursor, robot arm, etc.

BrainGate Chip

Video: Thought control of robotic arms using the BrainGate system

http://www.youtube.com/watch?v=QRt8QCx3BCo

EEG-Based Systems

Human BCI experience until recently has been confined almost entirely to EEG recordings.

Studies have mainly evaluated the use of sensorimotor rhythms, slow cortical potentials, and P300 evoked potentials derived from the EEG.

EEG based BCI platform

Sensorimotor Cortex Rhythms

In awake individuals, primary sensory or motor cortical areas typically display 8–12 Hz EEG (called activity μ rhythm) when they are not processing sensory input or producing motor output

Beta activity is typically associated with 18–26 Hz beta rhythms.

Movement or preparation for movement is typically accompanied by a decrease in μ and beta activity over sensorimotor cortex.

Slow Cortical Potentials

Slow changes in EEG potentials that are centered at the vertex and occur over periods of several seconds.

Negative SCPs are usually associated with movement and other functions involving cortical activation.

Positive SCPs are usually associated with reduction in such activations.

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Conclusions and perspectives

Conclusions

- "Intelligence denotes the ability of an individual to adapt his thinking to new demands; it is the common mental adaptability to new tasks and conditions of life" (Stern, 1912)

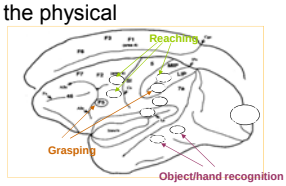
Stern William (1921) The Psychological Methods of Intelligence Testing (1912)

Solutions for intelligent systems

- Cognitive modelling, i.e., the simulation of cognitive processes through information processing models.
- The construction of “intelligent systems” that make certain aspects of human cognition and reasoning available.

Solutions for intelligent systems

Intelligent manipulation depends as much on how the controller works (mind) as on the physical properties of the muscles



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Interesting website

1. **iCub simulator:**
https://eris.liralab.it/wiki/Main_Page
2. **ROS**
https://www.ros.org
3. **Open Source Brain**
https://www.opensourcebrain.org
4. **Alllen Brain Atlas**
https://www.brain-map.org

Thank you! &
Any question?