Sistemas Inteligentes Distribuidos

Distributed Intelligent Systems

Introduction

2022

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Who am I

- **Ulises Cortés**
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Organization

Theory

Slides and readings

Practical Assignment

Programming assignments

Communication

Racó (official communication means)

E-mail (fastest way)

Varia

Exam (Theory + Concepts learnt in the practical assignments)

Organization (2)

Reading

See Racó (3 in average)

Slides

See Racó

Practical Assignment

Programming assignments

A single problem, many situations

Group assignment

$$NT = [max(Npar, NEx1) + NEx2] / 2$$

$$NF = NT * 0.5 + NP * 0.2 + NL * 0.3$$

Semana	Día	Tema - Teoría	Tema - Laboratorio Jueves	Entregables
1	14/02/2022	Introducción	Introducción a JADE	
2	21/02/2022	Agentes	Teoría?	
3	28/02/2022	Agentes	Teoría?	
4	07/03/2022	Agentes	Enunciado práctica	**P1: Agente termostato**
5	14/03/2022	Ontologías	Razonamiento BDI	
6	21/03/2022	Ontologías	Razonamiento BDI	
7	28/03/2022	Coordinación/Comunicación	PARCIALES	PARCIALES
8	04/04/2022	PARCIALES	Ontologías - OWL/SPARQL	PARCIALES
9	11/04/2022	SEMANA SANTA	SEMANA SANTA	SEMANA SANTA
10	18/04/2022	SEMANA SANTA	Ontologías - OWL/SPARQL	**P2: Razonamiento BDI**
11	25/04/2022	Coordinación/Cooperación	Comunicación: ACL	
12	02/05/2022	Cooperación	Algoritmos de cooperación	**P3: Ontología**
13	09/05/2022	Cooperación	Algoritmos de cooperación	
14	16/05/2022	Negociación	Algoritmos de negociación	**P4: Algoritmos de coordinación**
15	23/05/2022	Soporte a práctica	Soporte a práctica	
16	30/05/2022	Soporte a práctica	EXAMENES	**L: Práctica Multi-Agentes**

Artificial Intelligence

Too many definitions

> The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Artificial Intelligence

Too many definitions

Artificial intelligence is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent *beings*.

The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience.

Artificial Intelligence

Too many definitions

> *"Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.*
>
> *European Commission's Communication on AI*

Artificial Intelligence (HLEG-AI)

Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, **act in the physical or digital dimension by perceiving their environment through data acquisition**, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and **deciding the best action(s) to take to achieve the given goal**. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions.

Thinking fast, thinking slow

"... it's very difficult to imagine that with sufficient data there will remain things that only humans can do.

…

I don't think that there is very much that we can do that computers will not eventually be programmed to do."

Daniel Kanehman

Cognitive Architectures

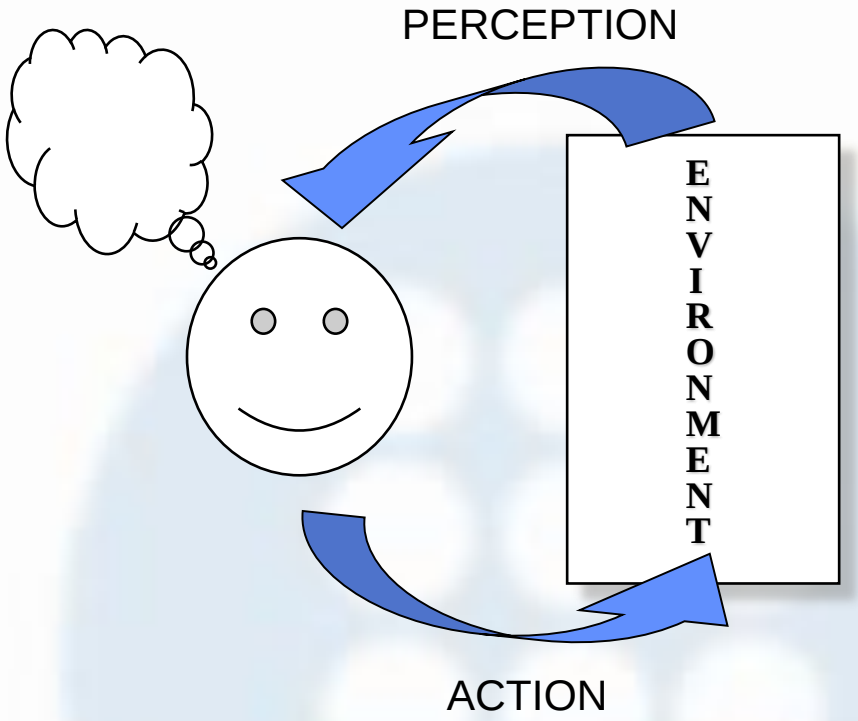
- **In this course we aim to have a holistic view of Artificial Intelligence: its methods, techniques, and how to combine them into intelligent systems.**
- **But… what is an intelligent system?**
- **One way to characterize the behaviour we *think* as *intelligence* is through the study of the architectures providing such behaviour.**
- **We call Cognitive Architectures the ones that use symbols to represent the environment.**

Cognitive Architectures

- **Architectures are described by the description of their foundations and the methods used to achieve an *intelligent behaviour*.**
- **Cognitive architectures are based on computational entities, but this does not imply that intelligence should come always from the computer.**
- **A metaphor typically used in Cognitive Architectures to cover both human and machine intelligence is the one of the *intelligent agent*.**

Intelligent Agent

- ***An* agent *is a computer system capable of* autonomous action *in some environment in order to meet its* design objectives**
- **An agent should be able to perceive and act in the environment**
- **Usually the environment is *complex* and *dynamic*, and agents should interact with it in real time.**



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Cognitive AI Paradigms

- **In AI, paradigmas can be characterized by the metaphor used to model intelligence:**
  - **Logics**
  - **Search in a State Space**
  - **Knowledge-Based (*rules, patterns, experiences*)**
  - **Evolutionary**
  - **Social**

Cognitive AI Foundations

- **PHILOSOPHY**
  - **Can rules be used to extract valid conclusions?**
  - **How mind emerges from the physical brain?**
  - **Where does Knowledge come from?**
  - **How can Knowledge lead to action?**

Cognitive AI Foundations

- **MATHEMATICS/LOGICS**
  - **Which are the formal rules to extract valid conclusions?**
  - **Which things are computable?**
  - **How to reason with Knowledge that is uncertain and/or vague and/or incomplete?**

Cognitive AI Foundations

- **NEUROSCIENCES**
  - **How is information processed by the brain?**
- **PSICOLOGY**
  - **How do animals and humans think and act?**
- **SOCIOLOGY/ETOLOGY/ECONOMICS**
  - **How collective (social/organizational) behaviour can be generated from individual (animal/human) behaviour?**
- **CONTROL THEORY**
  - **How can self-controlled artifacts behave/act?**

George Herbert Mead (1863-1931)

Mind, Self, and Society

- The self is an object to itself.
- The self is a social structure.
- Self arises from social experience.
- Self arises from language and interaction with others.
- The conversation of gestures is the beginning of communication.
- The inner conversation is the beginning of self (self-realization).

George Herbert Mead (1863-1931)

Mind, Self, and Society

- One inevitably seeks communication with others.
- Communication requires planning.
- **Thinking** becomes preparatory to social action.
- The process of **thinking is an inner conversation**.

- **Symbols are essential for communication and the development of the self**.

George Herbert Mead (1863-1931)

Mind, Self, and Society

- The *complete self* reflects the unity of the social process; and each of the *elementary selves* reflects the complete social process of self-reflection and interaction with others.

- Stages of the development of the self:
  1. Play stage: dyatic relationships.
  2. Game stage: multiple relationships.

- ***Game playing*** requires a realization of the *generalized other*: assuming the statuses and roles of all involved.

George Herbert Mead (1863-1931)

Mind, Self, and Society

- The self-conscious individual assumes the organized social attitudes of the social group.

- The self is not so much a substance as a process, continually changing and adapting to social processes.

George Herbert Mead (1863-1931)

Mind, Self, and Society

- **The "*me*" is the accumulated awareness of "*the generalized other*."**
- **The "*I*" is the more personal. It is the reflector or observer.**
- ***The human mind arises solely through social experience*. It represents the thinking process of internalized communication.**

MIND

Motivation

- What is human mind and how does it work?
- How do we recognize objects and scenes?
- How do we use words and languages.
- How do we achieve goals?
- How do we learn ?
- How does common sense work?

MIND

An individual ant is not very bright, but ants in a colony, operating as a collective, do remarkable things.

A single neuron in the human brain can respond only to what the neurons connected to it are doing, but all of them together can be Albert Einstein.

Deborah M. Gordon (Stanford University)

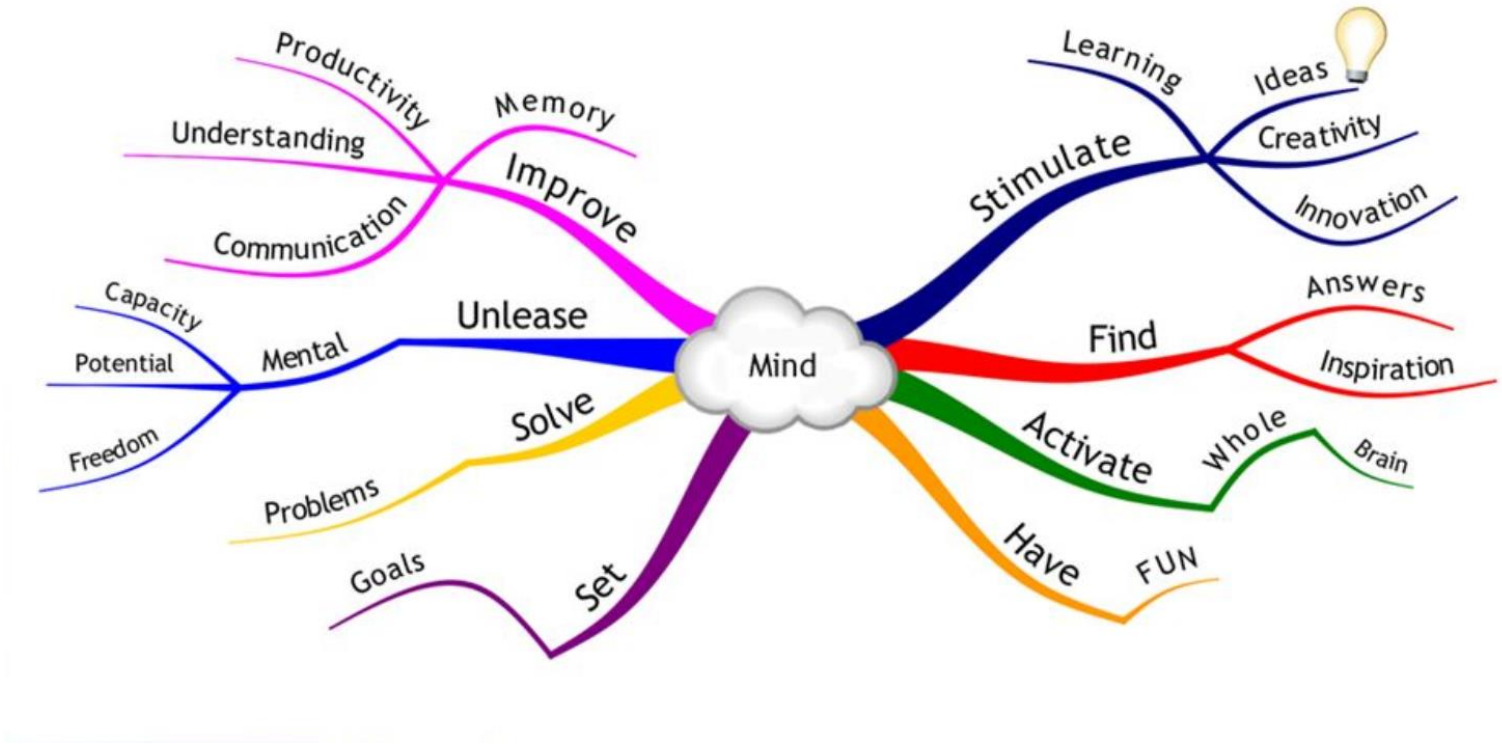
Analogy: An ants society

- Some social systems in Nature can present an *intelligent collective behaviour* although they are composed by simple individuals.
- The intelligent solutions to problems naturally *emerge* from the self-organization and *communication* of these individuals.
  - Carrying large items,
  - Forming bridges,
  - Finding the shortest routes from the nest to a food source,
  - Prioritizing food sources based on their distance and ease of access.

Analogy: An ants society

- Individual ants are simple insects with *limited* memory and capable of performing *simple* actions. However, an ant colony expresses a ***complex*** collective behaviour.
  - How do they know which task to perform?
  - How can they manage to find the shortest path (Goal)?
  - How did the Ants communicate with each other?
  - How do they form such huge colonies?
- Ants have dealt with the same kind of questions which we have set out with.

MIND


Mind
Improve
Memory
Productivity
Understanding
Communication
Unlease
Mental
Capacity
Potential
Freedom
Solve
Problems
Set
Goals
Stimulate
Learning
Ideas
Creativity
Innovation
Find
Answers
Inspiration
Activate
Whole
Brain
Have
FUN

The Society of Mind (Marvin Minsky)

- **Background:**

  The functions performed by the brain are the products of the work of thousands of different, specialized sub-systems, the intricate product of hundreds of millions of years of biological evolution. We cannot hope to understand such an organization by emulating the techniques of those particle physicists who search for the simplest possible unifying conceptions. ***Constructing a mind is simply a different kind of problem****—of how to synthesize organizational systems that can support a large enough diversity of different schemes, yet enable them to work together to exploit one another's abilities.*

  [Minsky, M.: Logical vs. Analogical or Symbolic vs. Connectionist or Neat vs. Scruffy.]

- **Aim: to create a theory of human cognition**

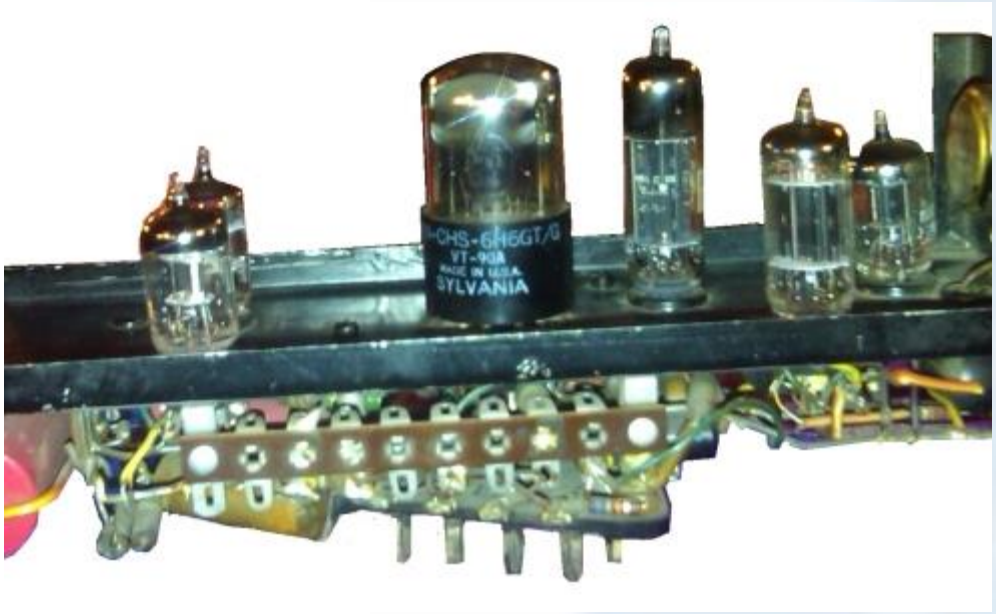
The Society of Mind (Marvin Minsky)

- **Background:**
  - How can intelligence emerge from nonintelligence?
  - Society of the Mind a scheme in which each mind is made of many smaller processes
  - An agent is a *small* process
  - Ideas rely on *encapsulated* agents
  - Intelligence is a combination of *simpler* things (*agents*)

Stochastic Neural Analog Reinforcement Computer (SNARC, 1951)

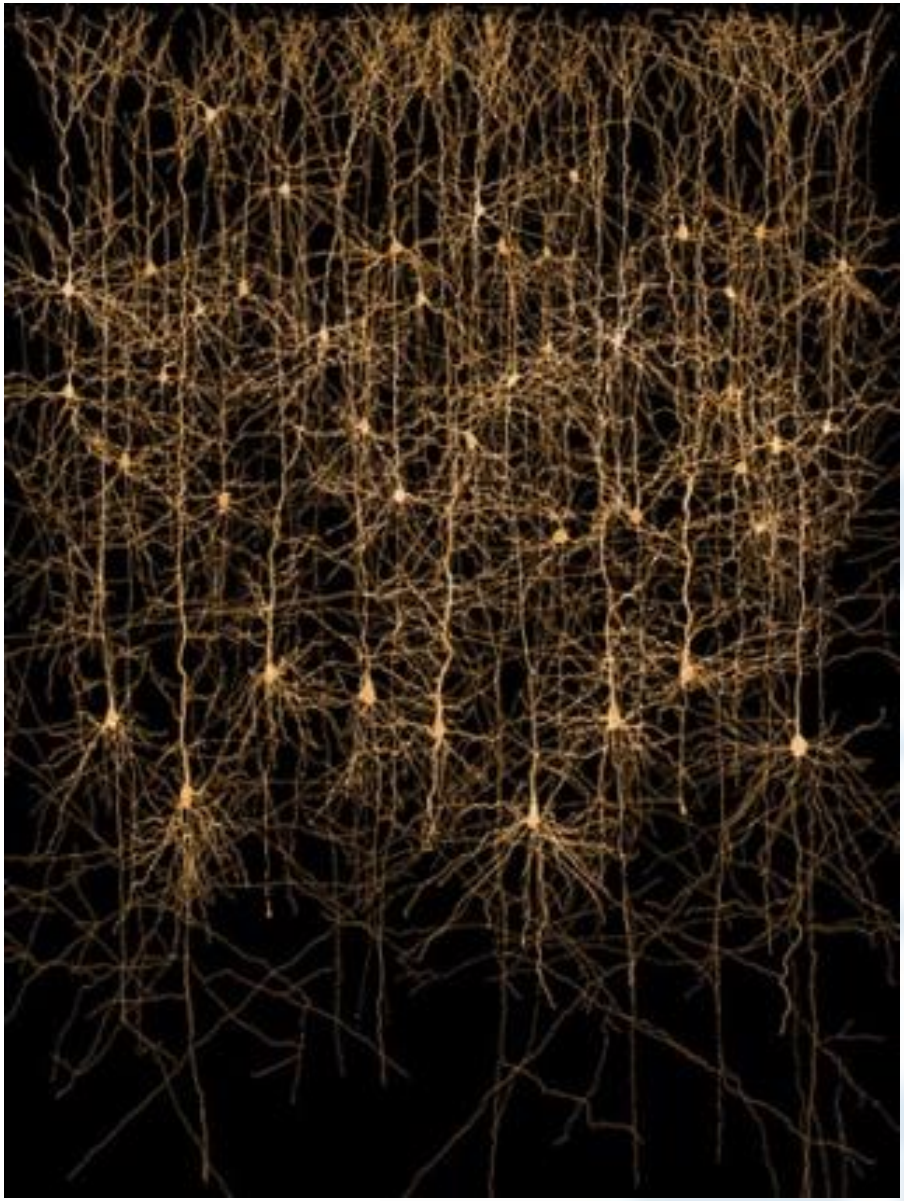
Key idea: producing machines which could learn by providing them with memory neurones connected to synapses; the machine would also have to possess past memory in order to function efficiently when faced with different situations.

Stochastic Neural Analog Reinforcement Computer (SNARC, 1951)



The Society of Mind (Marvin Minsky)

- **Approach:** A Cognitive Architecture composed by thousands of individual agents.
- **Idea:** Human intelligence is built layer by layer from the interactions of simple parts called ***agents***, which are themselves mindless.
- Theory covers processes such as ***language***, **memory, learning, consciousness, the sense of self, and free-will**
- Very flexible. Based on integration. Scalable.
- **Point of view:** constructivist and organicist.
- **Technical perspective:** Parallelism, different types of Knowledge bases, compatibility between the symbolic and sub-symbolic levels.



The Society of Mind: a revolutionary proposal

- **It takes into account and tries to explain cognitive development.**
- **It takes into account evolution**
- **It takes into account emotions**
- **Flexible behaviour depending on the environment**
- **Exhibiting some rationality**
- **Operating in real time**

Which kind of Cognitive Architectures are we looking for?

- **Capable to operate in rich and complex environments**
- **Capable of using symbols and abstractions**
- **Use of *natural* and *artificial* languages**
- **Learn from the environment and the experience**

What about the nature of the brain?

- **Human minds are not perfect decision-makers, but by and large they are *very* good.**
- **Brains are not as modular as software**
- **Brains may are to *intelligence* as wings to *flying*.**
  Mimesis is not always the best idea
- **Lessons learned: memory and simulation (planning) are good to decision making**

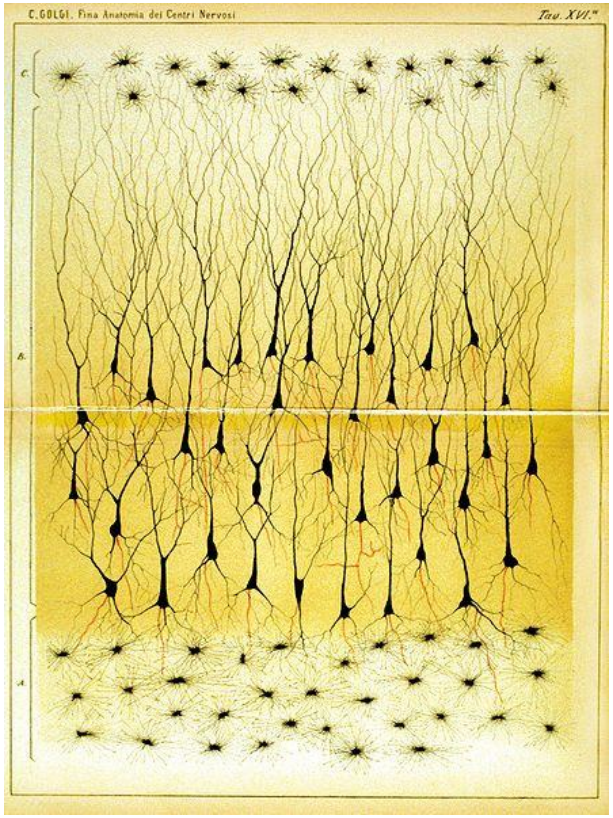
Which kind of Cognitive Architectures are we looking for?

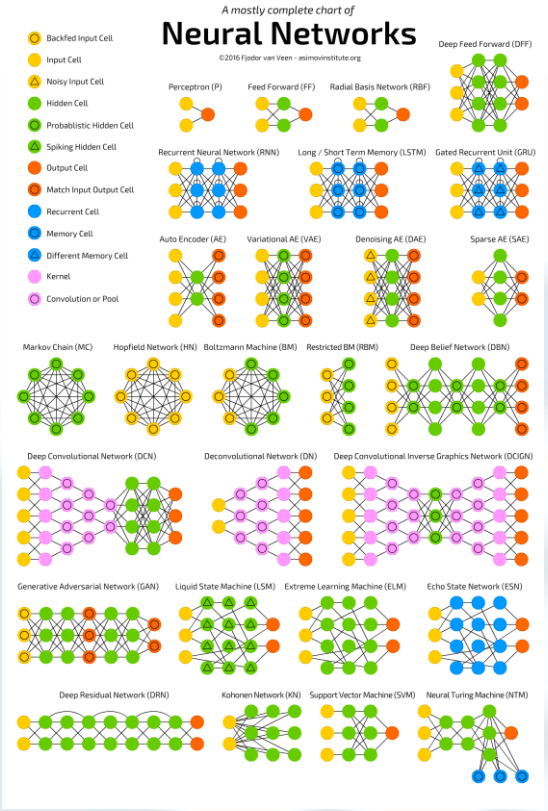
- **Get capabilities during execution time (adaptation)**
- **Operate in an autonomous way, but being social**
- **Be self-conscious**
- **Be built from (artificial) neurons**
- **Emerge from evolution**

Architectures for reactive systems

- These systems make decision at run time based on limited information and simple situation action rules.
- These architectures were often called behaviour based, situated or reactive.
- **Brooks with Subsumption architecture denied the need for symbolic representation of the world, instead the systems make their decisions based on the inputs**.
- The decision of reactive architectures are partly guided by Simon's hypothesis states that that the *complexity of the behaviour of the system can be a reflection of the complexity of the environment rather than the reflection of the system's complex internal design*.

Ensembles of neurons vs Neural Networks





Markovian analysis reveals dynamic changes in the sequential behaviour of dorsal horn neuronal activity induced by nociceptive stimulation. (Martin et al, 2017).
***Front. Comput. Neurosci*. | doi: 10.3389/fncom.2017.00032**

Cognitive Architectures : Parameters

- **Generality**
- **Versatility**
- **Rationality**
- **Learning**
- **Psychological Validation**
- **Applicability**
- **Scalability**
- **Reactivity**
- **Efficiency**

Cognitive Architectures: Open issues

- **Which is the *best* of all Architectures?**
- **Will we ever get complete architectures?**
- **Which kind of intelligence will we get?**

Cognitive Architectures = Agents? Open Issues

- **Which is the *best* of all Architectures?**
- **Will we ever get complete architectures?**
- **Which kind of intelligence will we get?**
- **How can agents solve problems?**

Cognitive Architectures: Functional aspects

- **Engineering methodology (*how* to develop them)**
- **Capability to tackle a wide range of complex tasks**
- **Efficiency when acting on the environment**
- **Autonomy**

Course objetives

- **Understand the basic roles of...**
  - **Knowledge representation**
  - **Machine learning methods**
  - **Problem solving**
  - **Distributed solutions (?)**

  ... when building intelligent systems.

- **To be able to build an *intelligent system* to solve some kind of problem.**

What kind of AI?

Think like people	**Think rationally**
Act like people	**Act rationally**

Rational Decisions

- **Rational**: maximally achieving pre-defined goals
- Rationality only concerns what decisions are made
- Goals are expressed in terms of utility (of outcomes)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Looking for the ultimate intelligent machine

I think the big problem is that we're not smart enough to understand which of the problems we're facing are good enough. Therefore, we have to build super intelligent machines like HAL.

Marvin Minsky

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