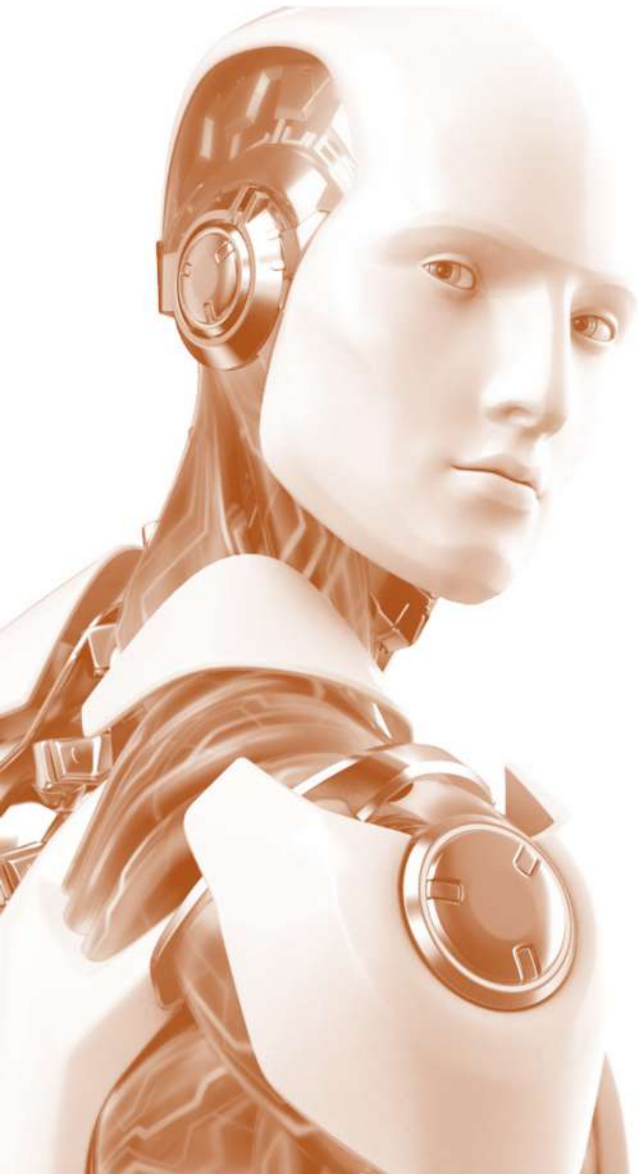

Introduction to AI

Lecture 2 - AI Principles and History

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LaRoCS – Laboratory of Robotics and Cognitive Systems

UNICAMP

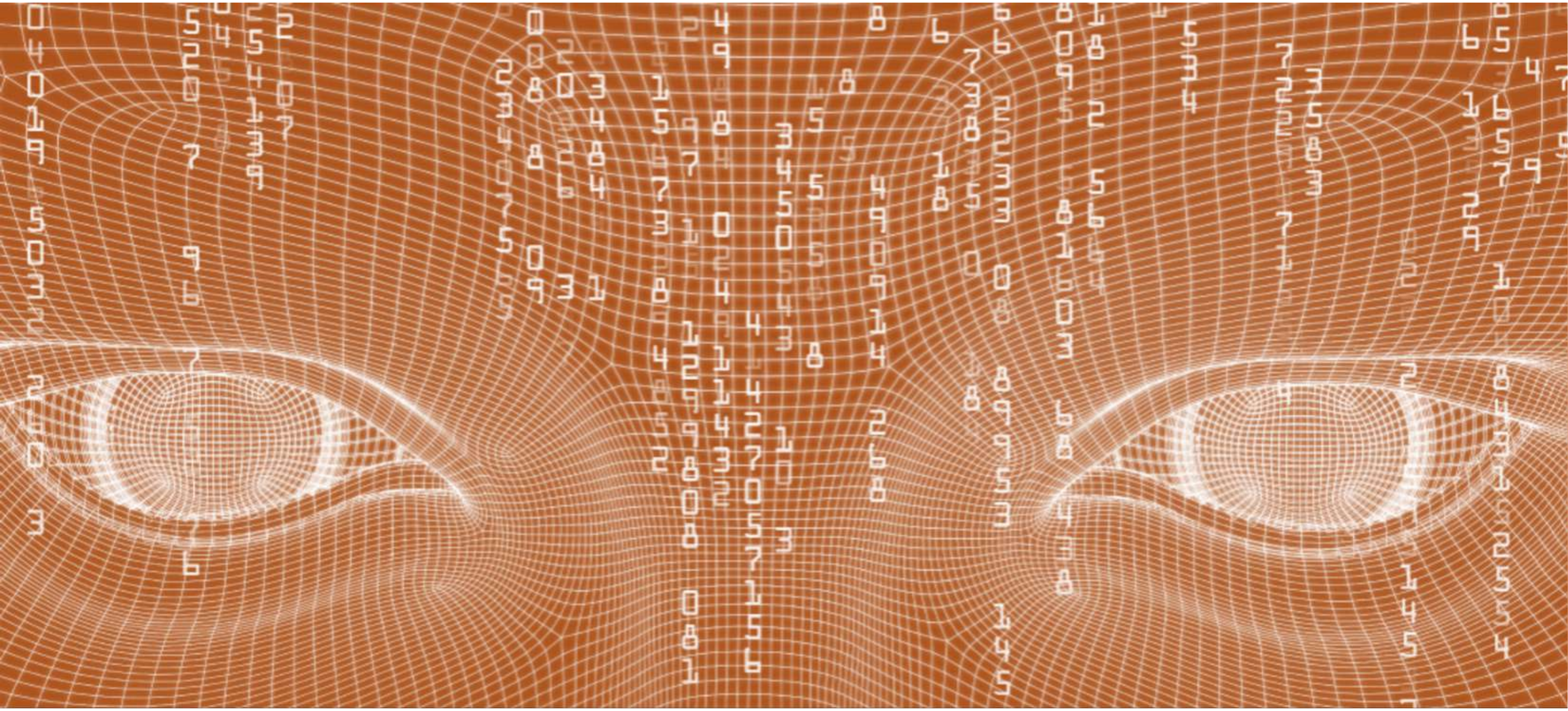
Advanced Institute for Artificial Intelligence

AI - Last Lecture

- What is AI?
- What is it for?
- Why AI?

Summary

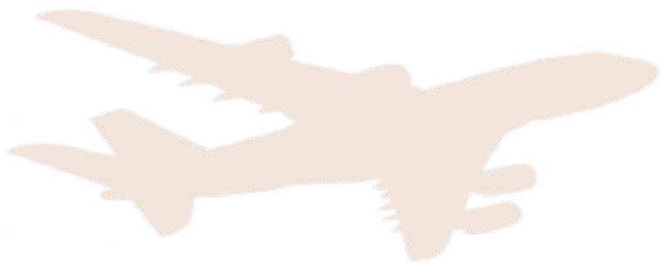
- Principles
- Definitions
- History
- Applications
- Machine Learning
- Robotics
- An introduction to agents



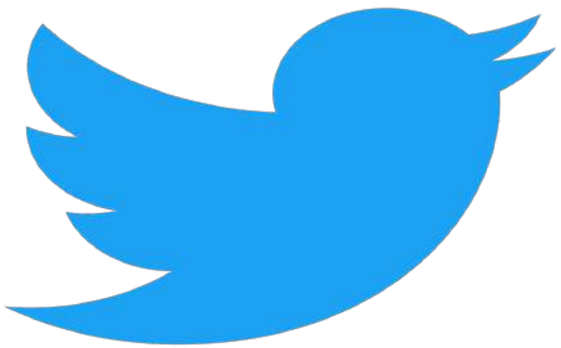
A little about AI

What, why, since when?

Principles

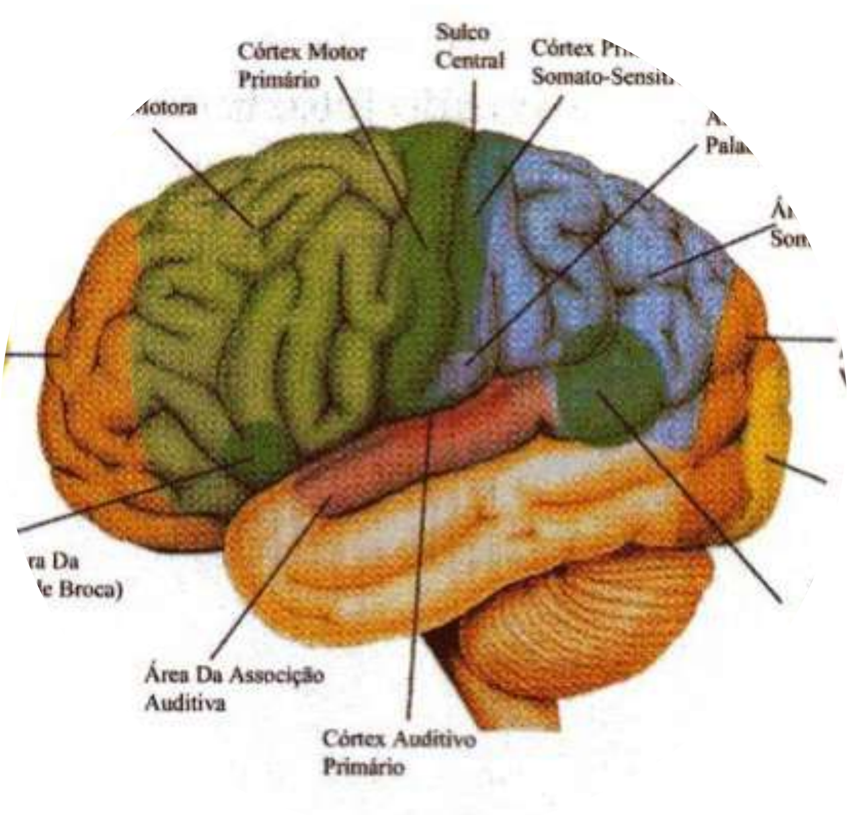


x



Artificial Intelligence

Principles



X

Homo sapiens

The inspiration

Homo sapiens

Mental abilities of great importance

How can a handful of matter perceive, understand, predict and manipulate the world much bigger and more complicated than itself?

Artificial intelligence

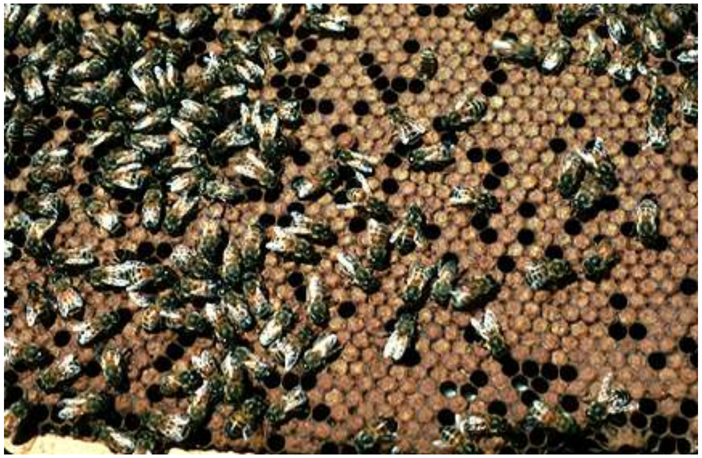
Try not only to understand, but also to build intelligent systems

- “It is the science or the ability to internally link what is captured. It can be defined as the mental capacity to reason, plan, solve problems, abstract ideas, understand ideas and languages, and can be learned and / or trained. The ability to apprehend the truth. ” Informal dictionary
- According to Merriam-Webster:
  - "the ability to learn or understand or to deal with new or trying situations: REASON”
  - “the skilled use of reason”
  - “the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (such as tests)”

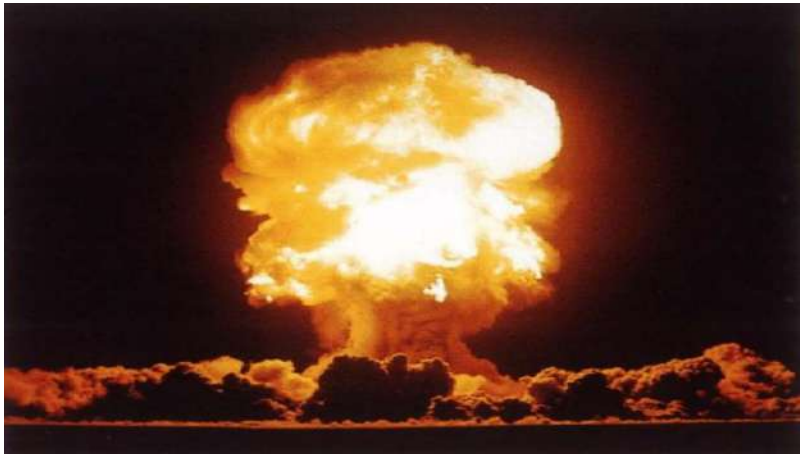
Intelligence

Studies show that elephants have self-awareness

The dog in the experiment depicted can accurately discriminate between photos of dogs and photos of landscapes - an indication that the dog was able to form the concept of "dog".



Intelligence test shows that bees can learn to solve tasks of other bees



????

How to discuss what is intelligence?

- Insight
- Psychological Experiments
- Brain observation

Definitions and Principles

Thought

- Cognitive psychology
  - Modeling mental processes
  - Viewing the brain as an information processing device

Construction

- Computer engineering and neuroscience
  - Build a brain

Invention

- Mathematical logic
  - Model irrefutable argumentation processes
  - Aristotle's syllogisms
  - Representation
  - AI goal: invent programs to implement them

Behavior

- Behavioral psychology
  - Perceptions (stimuli) and the resulting actions (responses)

Study

- Cognitive science
  - Computational models and experimental techniques to build theories about processes in the human mind

Imitation

- Biology
  - Copy natural processes
  - Build brain pieces (neuroscience) and build creatures with natural behavior

Artificial Intelligence: Definition

The term "Artificial Intelligence" was coined by John McCarthy in 1956 during the Darthmouth seminar ... where he also participated: Marvin Minsky, Claude Shannon, Allen Newell, Herbert Simon, etc.

"(...) the study of ideas that allow computers to be intelligent"

(Winston, 1984)

"(...) [science] trying to understand intelligent entities"

(Russel e Norvig, 1995)

"AI is the study of mental faculties through the use of computational models."

(Charniak & McDermott , 1987)

"(...) the art of creating machines that perform functions that require intelligence when performed by people"

(Kurzweil, 1990)

" A branch of computer science dealing with the simulation of intelligent behavior in computers. The capability of a machine to imitate intelligent human behavior"

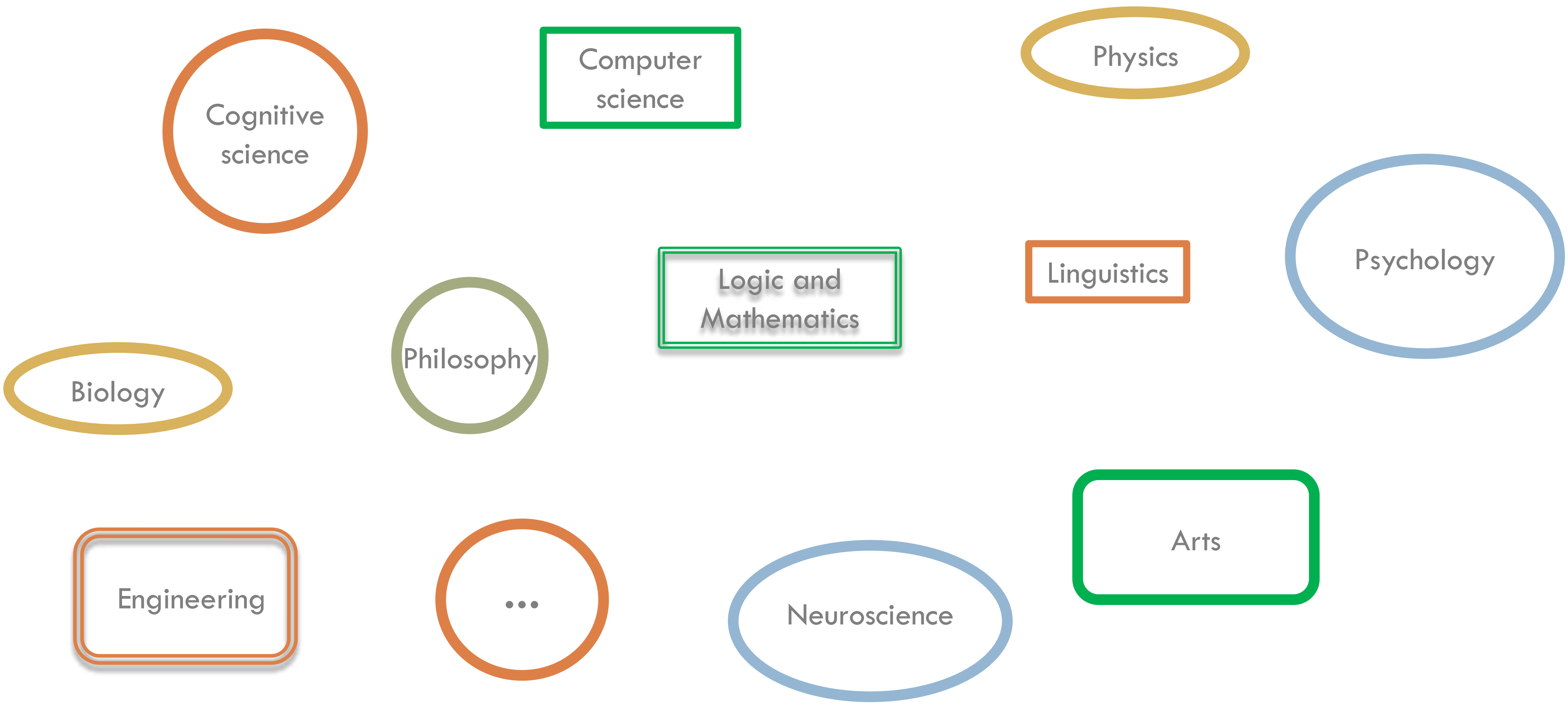
Merriam-Webster

"Artificial Intelligence is the study of how to make computers do things that people currently do better."

(Elaine Rich & Kevin Knight, 1993)

Foundations

AI



Categories of AI definitions

Cognitive modeling

Thinking

Laws of thought

"Systems that think like humans"

"Systems that think rationally"

Humanly

Rationally

"Systems that act like humans"

"Systems that act rationally"

Turing test

Rational Agent

Acting

Categories of AI definitions

- Rationality
  - Doing the right thing given current knowledge
- Thinking Rationally
  - Greek philosopher Aristotle: one of the first to try to elaborate irrefutable reasoning processes. His study started the field called logic
  - 19th century logicians: they developed a precise notation for mathematical logic. Propositional Logic and First Order Logic.
  - Logicist Tradition: "Discover statements about all kinds of things in the world and the relationships between them".
    - Difficulties with this approach: one is when knowledge is less than 100% certain and another is due to the difference between solving a theoretical problem and a practical one.

Categories of AI definitions

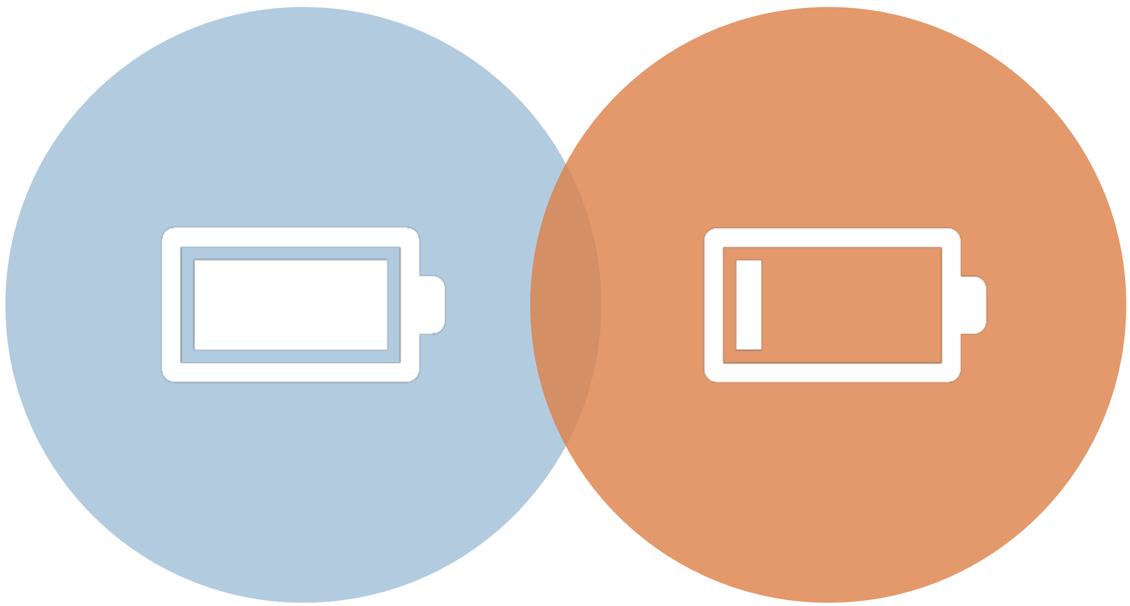
- Acting Rationally
  - An agent is simply something that acts.
  - Attributes of an agent: autonomous control, perceiving its environment, persisting for a long time, adapting to changes and assuming the goals of others.
  - **Rational Agent:** one who acts to achieve the best result or, when there is uncertainty, the best expected result.

Strength

AI

Strong AI

argues that it is possible to create intelligent or self-conscious computer-based machines that are capable of reasoning and solving problems

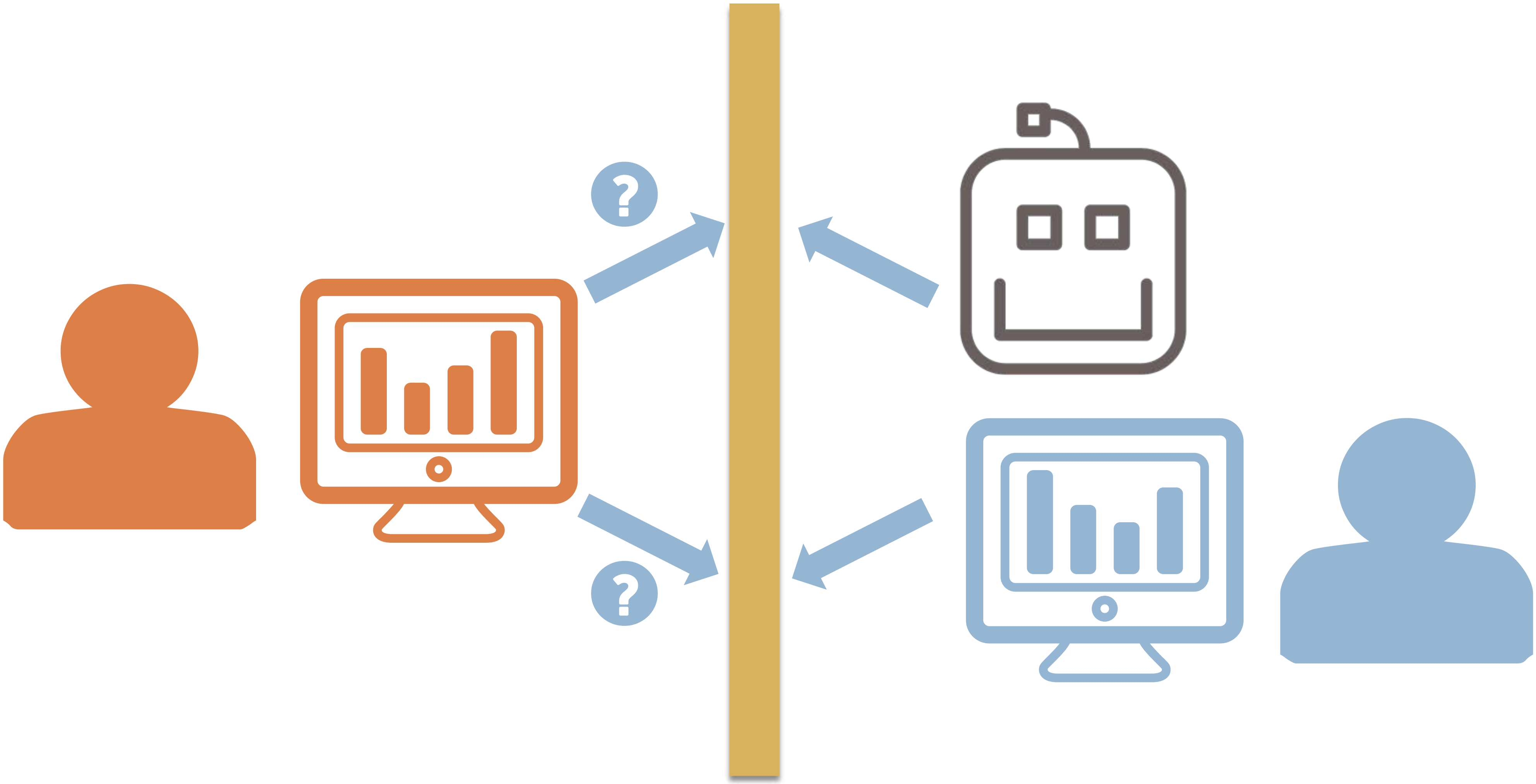


Weak AI

presents the computer only as a useful tool for making simulations, without necessarily being able to produce a conscious being

Turing Test (1950)

A. Turing, Computing Machinery and Intelligence, in The Philosophy of AI, M. Boden ed.1990
http://cogprints.org/499/00/turing.html



The Chinese Room Argument

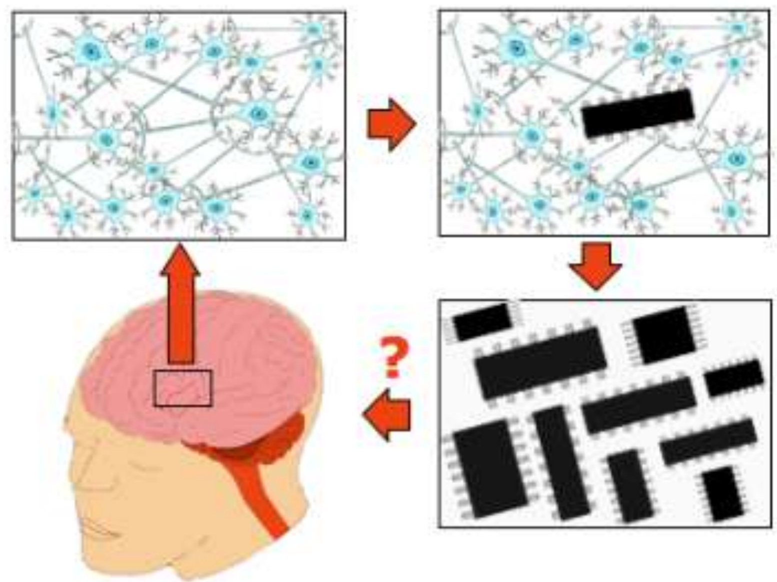
Searle, 1980

- The argument of the Chinese room shows that:
  - Programs are totally syntactic (computer like Turing machine);
  - Minds have semantic capacity;
  - Syntax is not the same as semantics, nor is it, in itself, sufficient to guarantee semantic content.
- Therefore, programs are not minds (at least with the model currently adopted).
  - It refutes the strong AI thesis that a properly programmed computer would have genuine cognitive states.

The Brain Prosthesis Argument

Searle e Moravec, 1980/1988

- Assumptions:
  - Perfect understanding of all connections between neurons;
  - Development of miniaturized electronic devices capable of replacing a neuron;
  - Existence of a miraculous surgical technique capable of carrying out the implant;
- Question: Is consciousness affected?



Means or end?

Why study AI?

A way of creating artificial inteligent creatures (Strong AI)

X

A tool for simulating and testing theories of intelligence (Weak AI)

To try to build smart entities

To learn more about ourselves and to answer questions like:

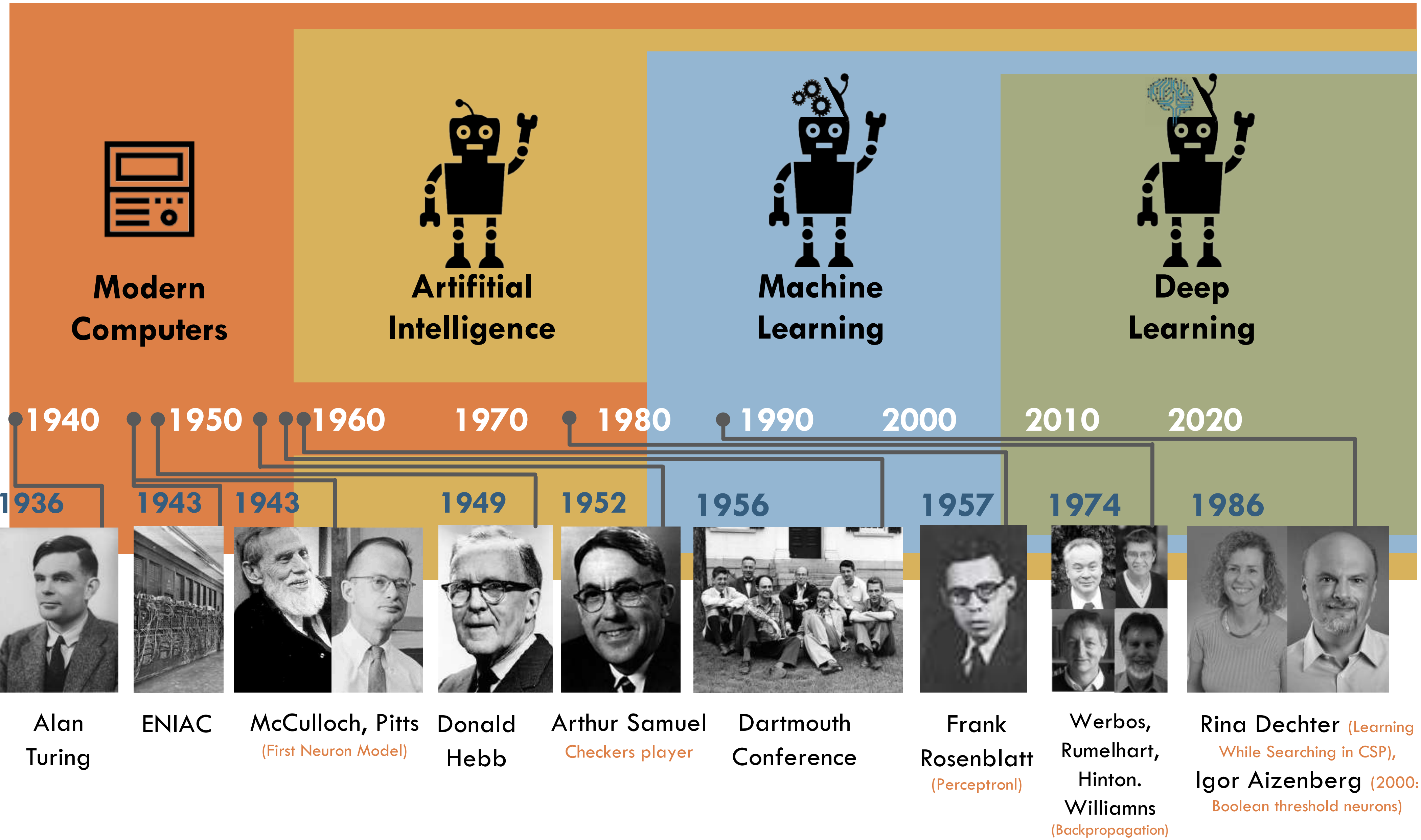
- *What is "conscience"?*
- *Are there forms of intelligence greater than that of humans?*

Because the techniques developed in this study can be applied to different segments of daily life

Consensus: Machines with human-level (or greater) intelligence could have a strong impact on the form of everyday life and the course of civilization.

Historical Perspective

Since when?



Historical Perspective

- Birth (1943-1955): Artificial neurons and first neural networks
  - 1943: McCulloch and Pitts proposed the first mathematical model for a biological neuron
  - 1949: Hebb developed a learning rule for artificial neurons
  - 1950: Turing proposes an intelligence test published in his article "Computing Machinery and Intelligence"
- 1953: Skinner and radical (anti-mentalist) behavior
  - In 1955, George Miller published "The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information"
  - Study of representations and mental processes and discussions about consciousness return to the intellectual scene
- The Birth (1956): Darthmouth Conference

- Enthusiasm (1952-1969): Enthusiasm with many neural networks, the Shakey robot, chess player
  - Computers breaking successive barriers;
  - Main trend: theories and methods based on logic.
  - Typical domain: micro worlds;
  - LISP (1958), General Problem Solver (1957), Shakey (1966)
  - Hypothesis of physical symbols: "a system of physical symbols has the necessary and sufficient means for general intelligent action"
- Neural networks:
  - 1962: Widrow perfects the learning method (delta rule, neuron with linear output);
  - 1962: Rosenblatt proposes the perceptron;

- Reality (1966-1973): very complex AI problems and very expensive computers with little memory
  - Experiment with different combinations of steps until you find the solution: a strategy that works in micro worlds;
  - Inability to live with combinatorial explosion
  - Minsky and Papert publish the book “perceptrons”. Neural networks were still unable to learn the XOR function;
  - Drastic cut in government support for A.I research
- Expert systems (1969-1979): First attempt to use a large data set to infer knowledge

Historical Perspective

- Renaissance (1980-?): Industrial use of specialist systems
  - R1 becomes the first successful commercial system.
    - The R1 program (internally called XCON, for eXpert CONfigurer) was a production rules-based system written in OPS5 by John P. McDermott of CMU in 1978 to assist in the sale of DEC's VAX computer systems by automatically selecting computer system components according to customer requirements.
- 1980: Rumelhart, Hinton and Williams: error backpropagation algorithm (generalized delta rule for a multi-layered perceptron); Explosion of the use of connectionist models
- 1997: Deep Blue wins chess player Garry Kasparov;
- Re-approximation of I.A. with other areas of knowledge (information theory, stochastic, control, linguistics, etc.)

Paradigms

How AI is divided

Symbolic

linguistic metaphor
ex. production systems, agents, planning, learning

Connectionist

brain metaphor
ex. neural networks and reinforcement learning

Evolutionist

metaphor of nature
ex. genetic algorithms, artificial life and collective intelligence

Statistical / Probabilistic

uncertainty metaphor
ex. Bayesian networks and fuzzy systems

The base of the areas

Would it be just one area of AI capable of solving the AI problem?

Area	Origin	Key algorithm
Symbolic	Logic, philosophy	Reverse deduction
Connectionist	Neuroscience	Backpropagation
Evolutionist	Evolutionary Biology	Genetic programming
Bayesian	Statistics	Probabilistic Inference
Analogy	Psychology	Kernel machines

SRC: Pedro Domingos ACM Webinar Nov 2015
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwi3qd3Dw_jgAhWDF7kGHWV6AWMQFjAAegQIC
RAC&url=http%3A%2F%2Fhomes.cs.washington.edu%2F~pedrod%2Fsmlr.pptx&usg=AOvVaw2I6eYY9Ek9gab9QcJOiXXA

Deduction

uses premises / arguments to reach a conclusion. The conclusion makes explicit knowledge that already exists in the premises.

Socrates is human
\+ Humans are mortal
= ?

Induction

it is the reasoning that, after considering a sufficient number of particular cases, concludes a general truth.

Socrates is human
\+ ?
= Socrates is mortal

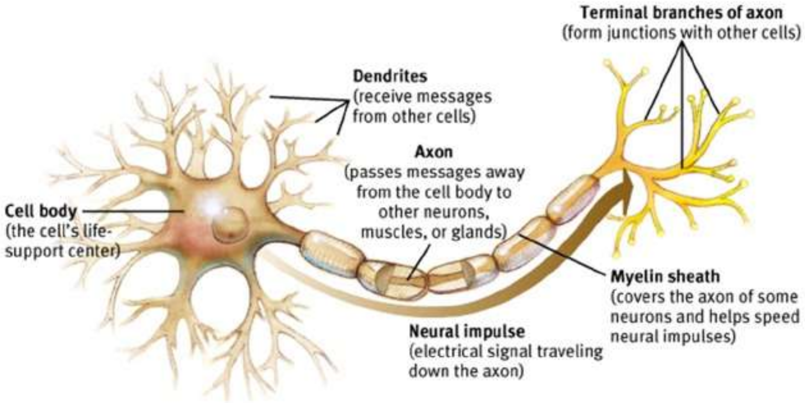
Tom Mitchell

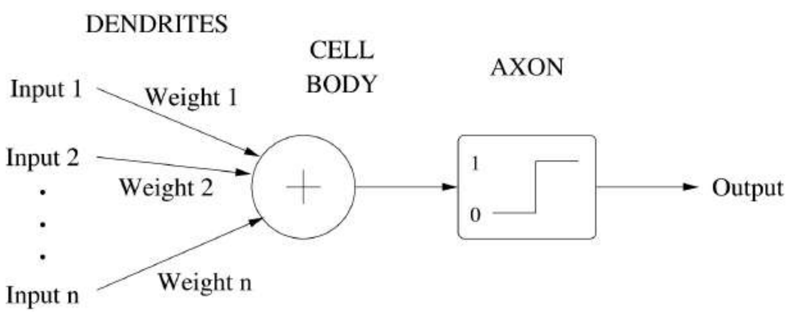
Steve Muggleton

Ross Quinlan

SRC: Pedro Domingos ACM Webinar Nov 2015
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwi3qd3Dw_jgAhWDF7kGHWV6AWMQFjAAegQIC RAC&url=http%3A%2F%2Fhomes.cs.washington.edu%2F~pedrod%2Fsmlr.pptx&usg=AOvVaw2I6eYY9Ek9gab9QcJOiXXA

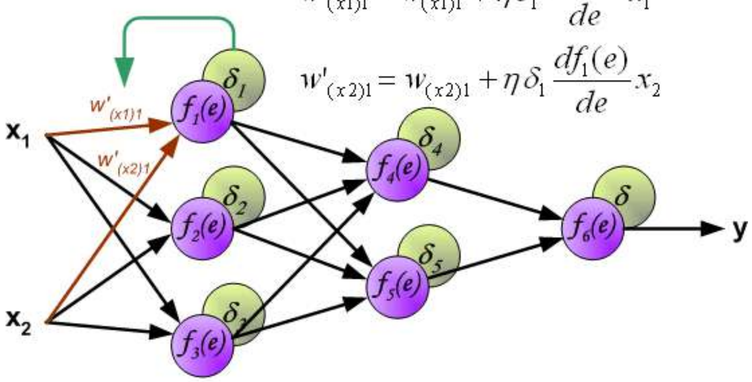
Connectionist





$$w'_{(x1)1} = w_{(x1)1} + \eta\delta_1 \frac{df_1(e)}{de} x_1$$

$$w'_{(x2)1} = w_{(x2)1} + \eta\delta_1 \frac{df_1(e)}{de} x_2$$



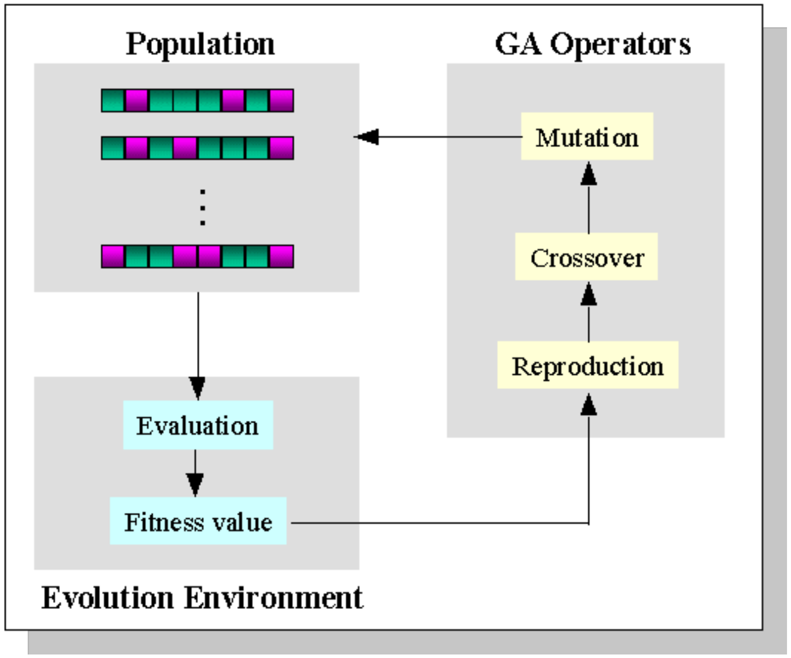

Yann LeCun

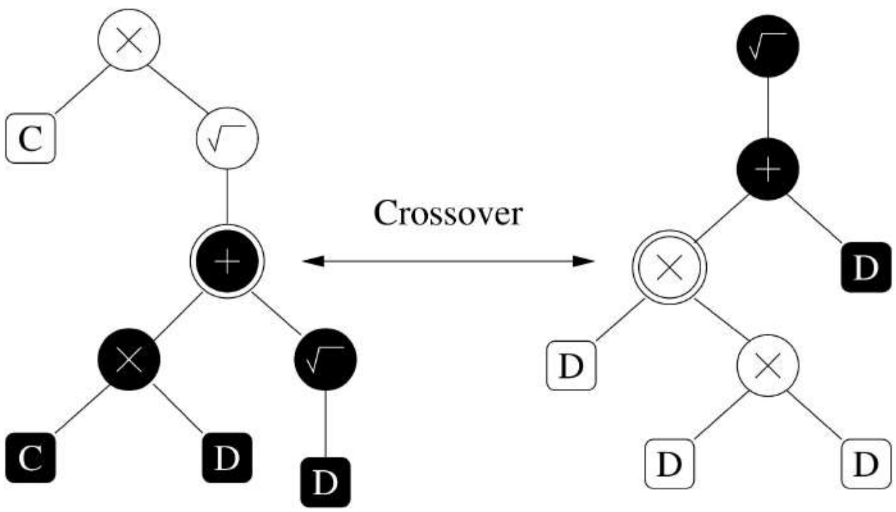

Geoff Hinton


Yoshua Bengio

SRC: Pedro Domingos ACM Webinar Nov 2015

Evolutionists





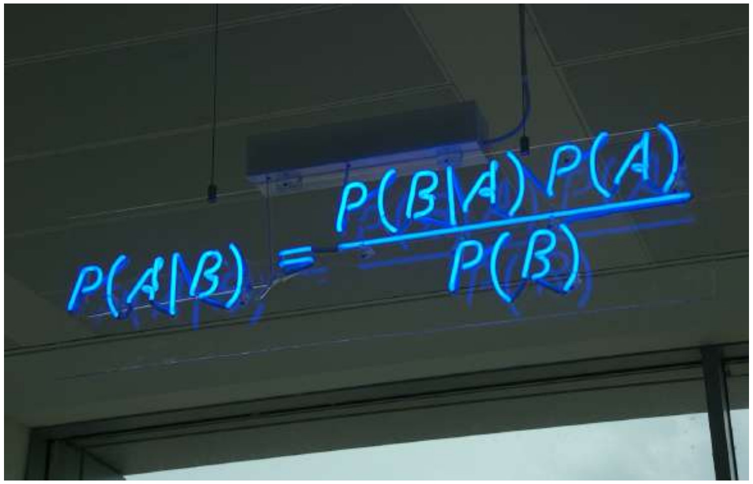

John Koza

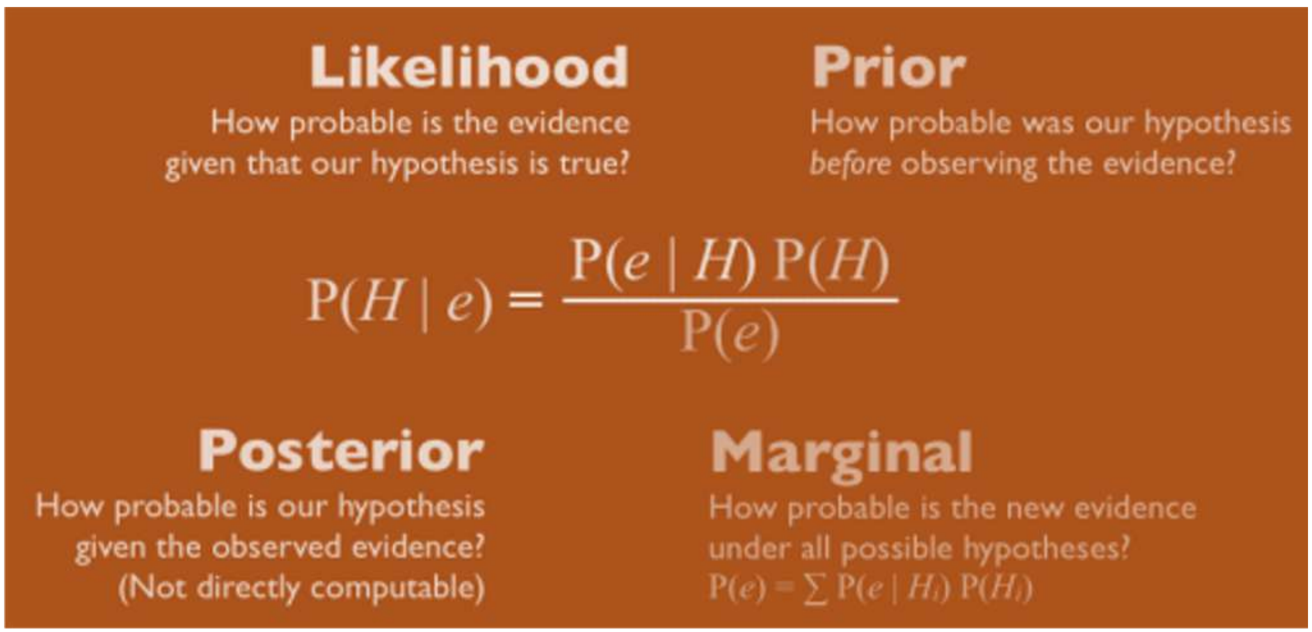

John Holland

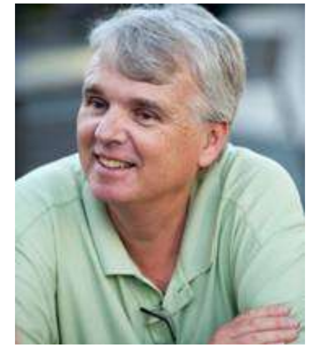

Hod Lipson

SRC: Pedro Domingos ACM Webinar Nov 2015

Bayesians







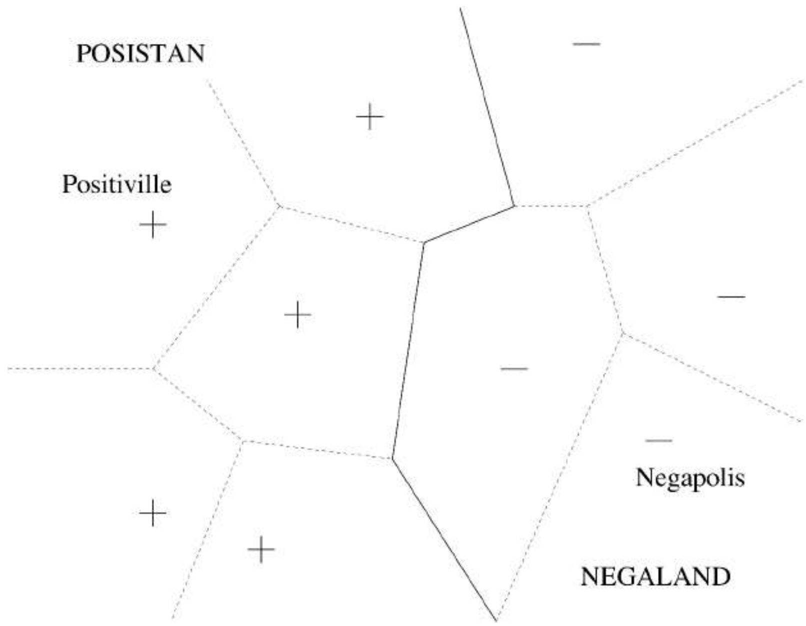
David Heckerman

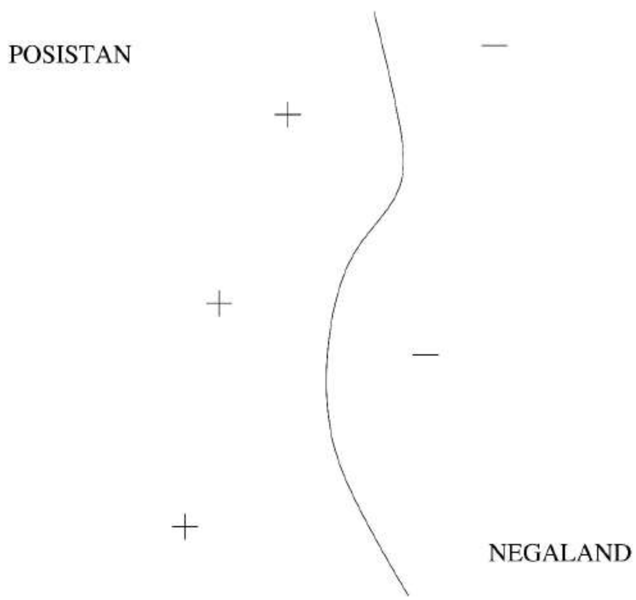
Judea Pearl

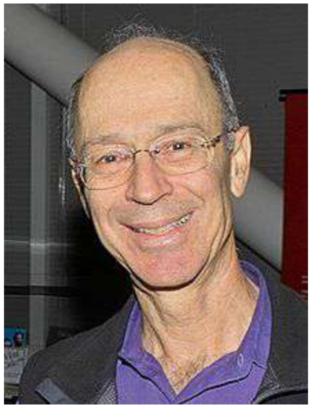
Michael Jordan

SRC: Pedro Domingos ACM Webinar Nov 2015

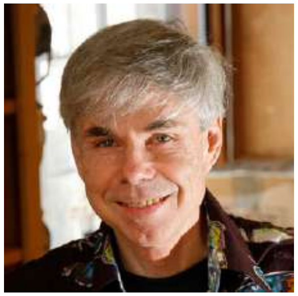
Analysts






Peter Hart


Vladimir Vapnik


Douglas Hofstadter

The Big Picture

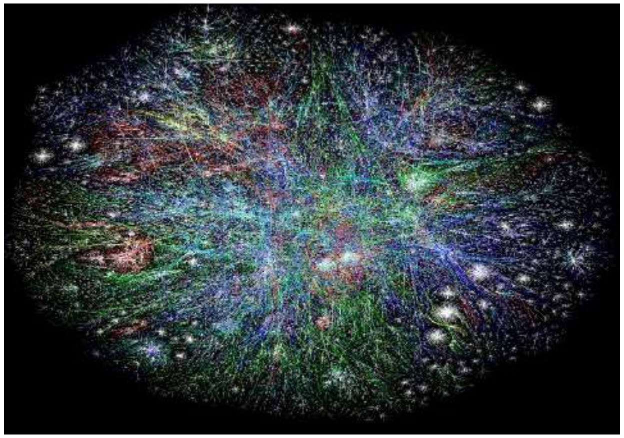
Area	Origin	Key algorithm
Symbolic	Logic, philosophy	Reverse deduction
Connectionist	Neuroscience	Backpropagation
Evolutionist	Evolutionary Biology	Genetic programming
Bayesian	Statistics	Probabilistic Inference
Analogy	Psychology	Kernel machines

But what we really need is
a single algorithm that solves all five!

Aggregating areas

- Representation
  - Probabilistic logic (for example, Markov logical networks)
  - Weighted formulas $\longrightarrow$ Distribution over states
- Evaluation
  - Posterior probability
  - User-defined objective function
- Optimization
  - Formula discovery: genetic programming
  - Weight learning: Backpropagation

What would a universal AI system be capable of?



Controversies about AI

- Intelligent Systems:
  - Systems that use some or some paradigms of Artificial Intelligence
- Knowledge-Based Systems:
  - Intelligent knowledge-intensive system
- Computational Intelligence:
  - It encompasses the Connectionist, Evolutionary and Probabilistic paradigms
- Hybrid Smart Systems:
  - Systems that use two or more paradigms in their constitution

- There is no consensus on these definitions among AI researchers

Sub-areas of AI

- Computational Intelligence
  - Neural networks
  - Fuzzy Logic
  - Reinforcement Learning
  - Collective Intelligence
  - Evolutionary Algorithms
  - Hybrid Systems
  - others

Sub-areas of AI

- Symbolic Artificial Intelligence
  - Knowledge Representation
  - Logical reasoning
  - Planning
  - Inductive learning
  - Case-Based Reasoning
  - Multi-Agent Systems
  - Computer vision
  - Natural Language
  - Satisfaction of Restrictions
  - others

Capacity

What an AI system is capable of

An IA system is capable of:

- *Data storage*
- *data manipulation*
- *knowledge acquisition, representation, and manipulation*

For this:

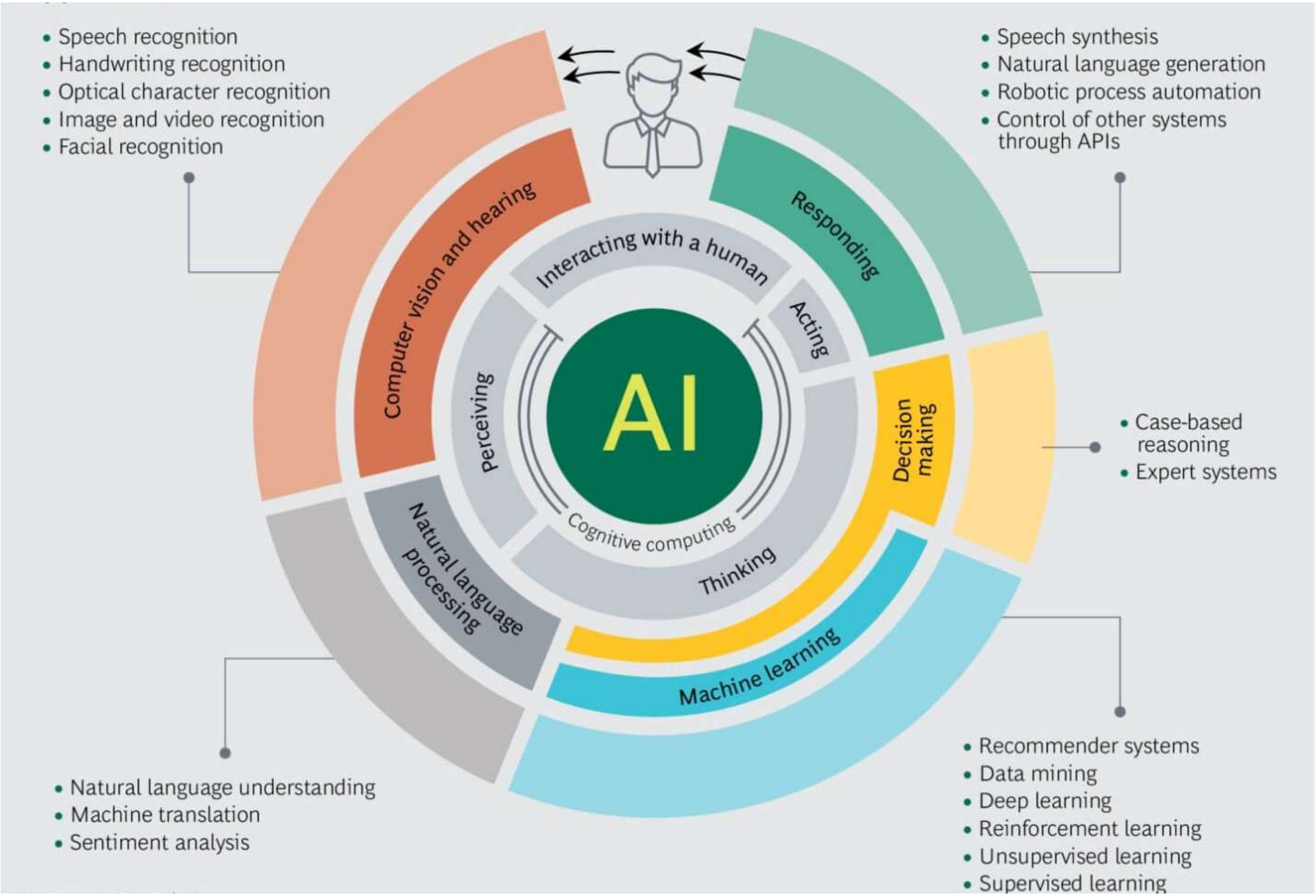
- *deduces or infers new knowledge*
- *creating new relationships about facts and concepts*
    - *from existing knowledge*
- *using representation and manipulation methods to solve complex problems that are often non-quantitative in nature*

Project

What an AI project requires

The main issues to be addressed by the designer of an AI system are:

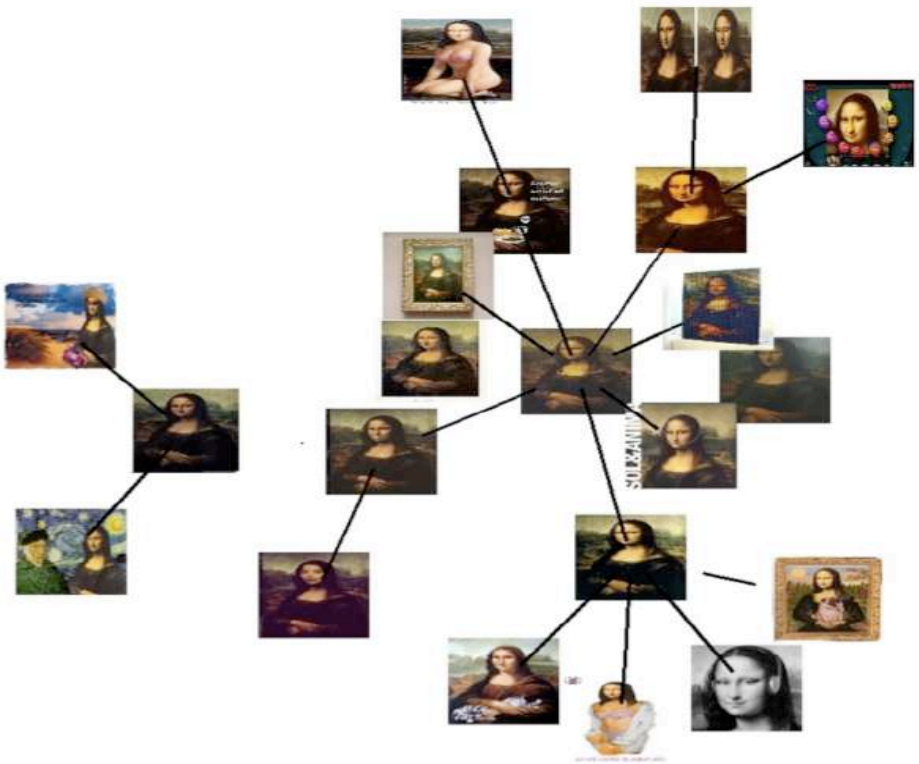
1. *Knowledge acquisition*
2. *Knowledge representation*
3. *Knowledge manipulation*
4. *Control strategy or inference machine that determines*
    1. *The knowledge items to be accessed*
    2. *Deductions to be made*
    3. *The order of steps to be used*

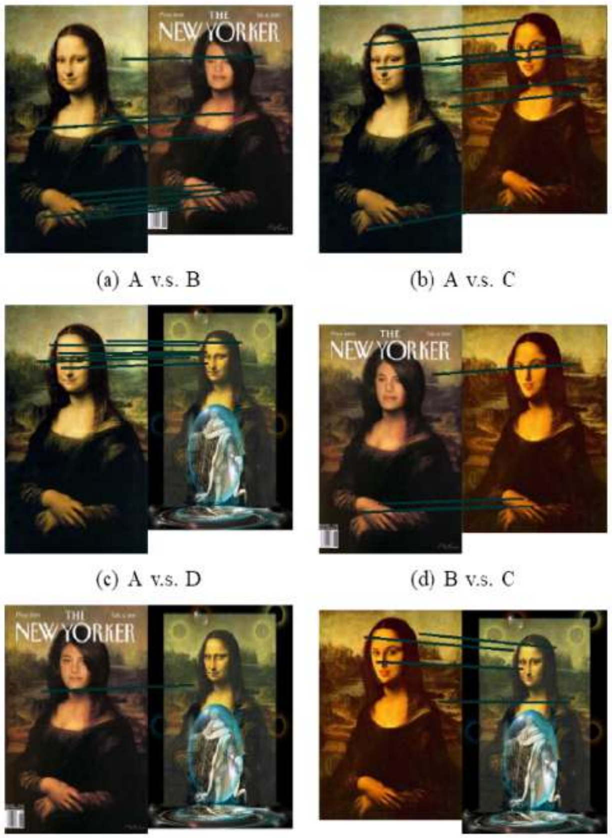


Fonte: The Boston Consulting Group, Time to Double Down on AI and Robotics (2017)

Applications

Google - Search for similar images





(a) A v.s. B (b) A v.s. C

(c) A v.s. D (d) B v.s. C

(e) B v.s. D (f) C v.s. D

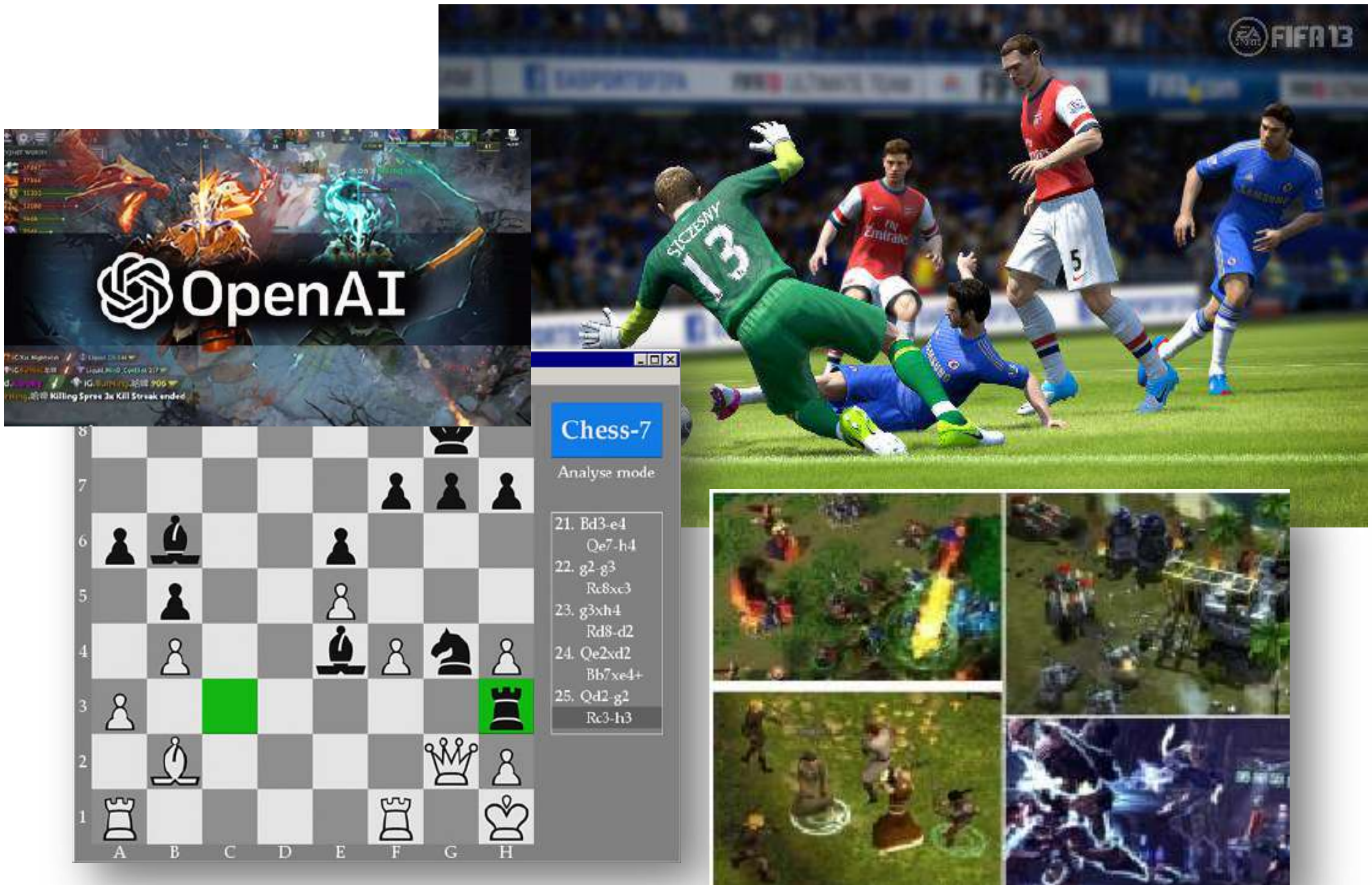
Since all the variations (B, C, D) are based on the original painting (A), A contains more matched local features than others.

Applications

Google Sets – provides related terms

Applications

Games



Applications

Autonomous Vehicles

Applications

Intelligent Robotics

What AI paradigms do you believe were implemented in previous applications?

Applications

- Aviation
  - The Air Operations Division (AOD) uses AI through expert rule-based systems to assist with mission management, support systems for tactical decision making and post-processing of simulator data in symbolic summaries.
- Education
  - Smart tutors
- Finance
  - Algorithmic trading
  - Market analysis and data mining
  - Personal finances
  - Portfolio management
- Industry
  - Industry 4.0
  - Failure prediction
  - Logistics

Applications

- Health
  - Clinical decision support systems
  - Diagnostic systems
  - Computer aided interpretation of medical images.
  - Companion robots for the care of the elderly
  - Mining medical mining records to provide more useful information
  - Design treatment plans
  - Assist in repetitive work, including medication management
  - Provide queries
  - Drug creation
  - Use of avatars in place of patients for clinical training
  - Predict the likelihood of death from surgical procedures
  - Predict disease progression
- HR and recruitment
- Job search

Applications

- Marketing
- Media and e-commerce
- Arts (music, painting, etc.)
  - Initiatives like Google Magenta, led by the Google Brain team, want to find out if an artificial intelligence might be able to create
  - IBM Watson edits movie trailer
- Power electronics
- Sensors
- Transportation
- Other relevant points:
  - AI for Good is a United Nations platform, centered around annual Global Summits, which promotes dialogue on the beneficial use of Artificial Intelligence, developing concrete projects.

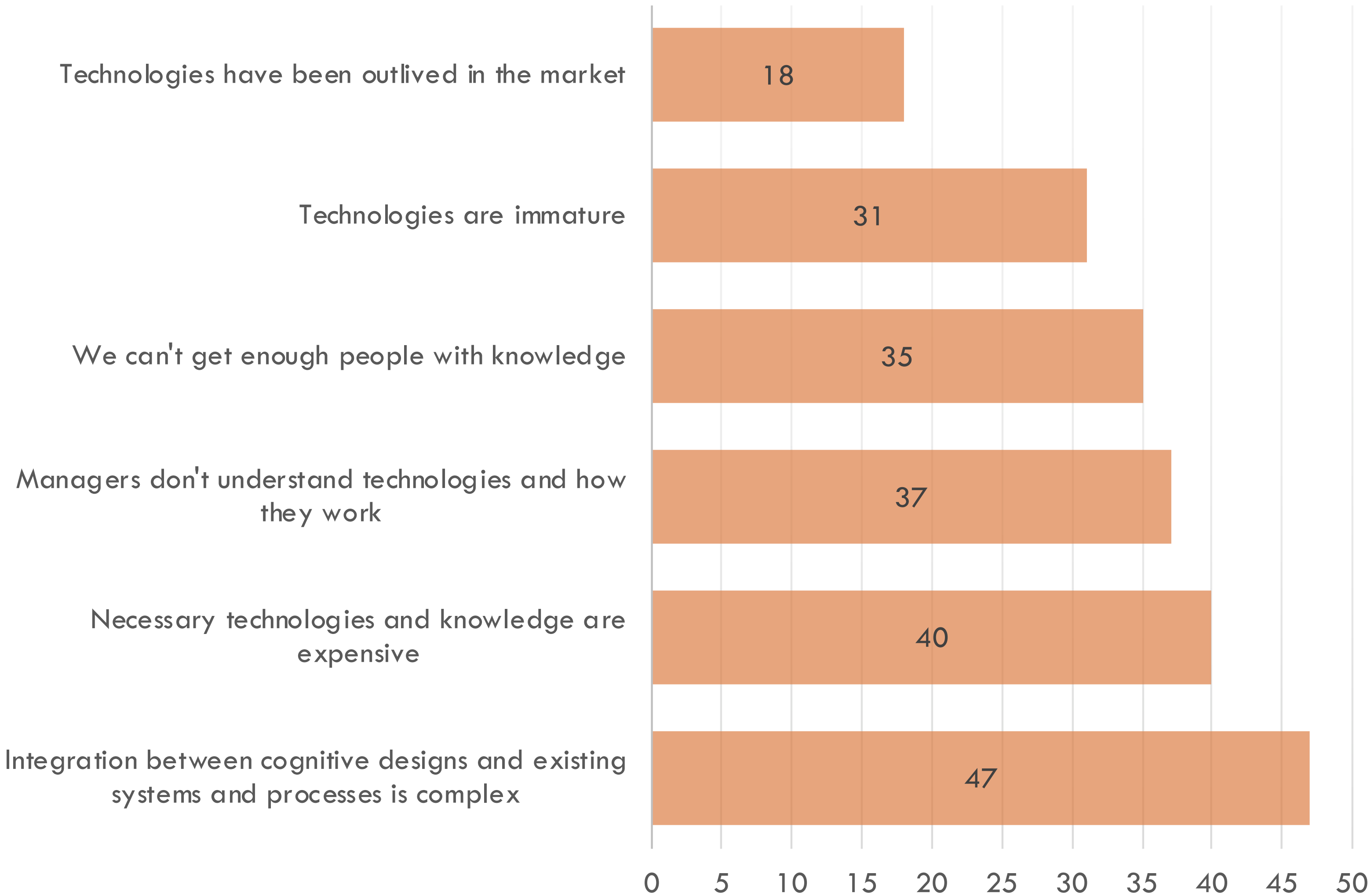
AI in the corporate world

- Overall, AI can support three important business needs:
  - Process automation
  - Cognitive insight
  - Cognitive Engagement

Source: https://hbr.org/2018/01/artificial-intelligence-for-the-real-world

AI in the corporate world

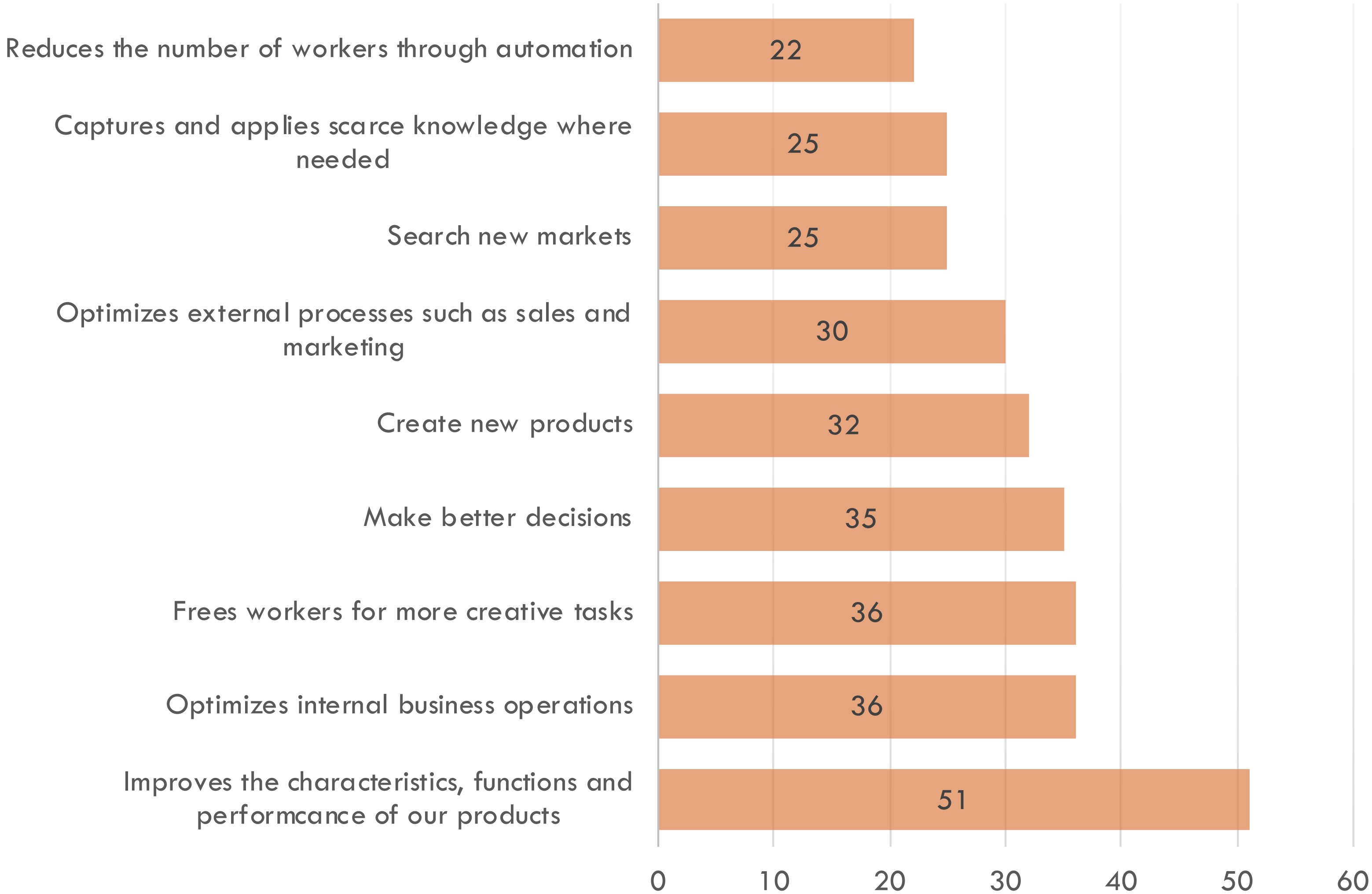
The challenges of AI according to executives



Source: Deloitte 2017: Artificial Intelligence for the real world

AI in the corporate world

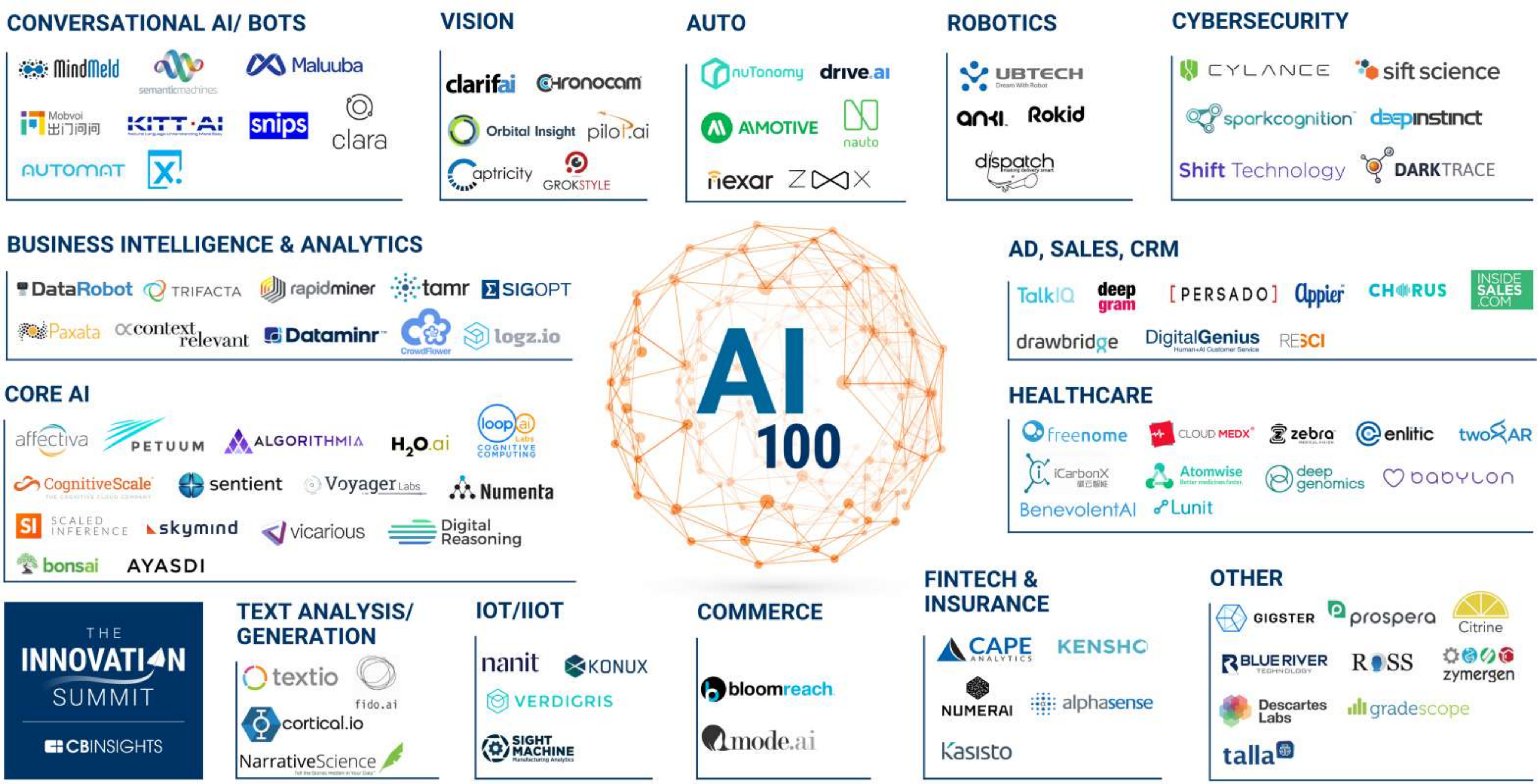
The benefits of AI according to executives



Source: Deloitte 2017: Artificial Intelligence for the real world

AI and Startups

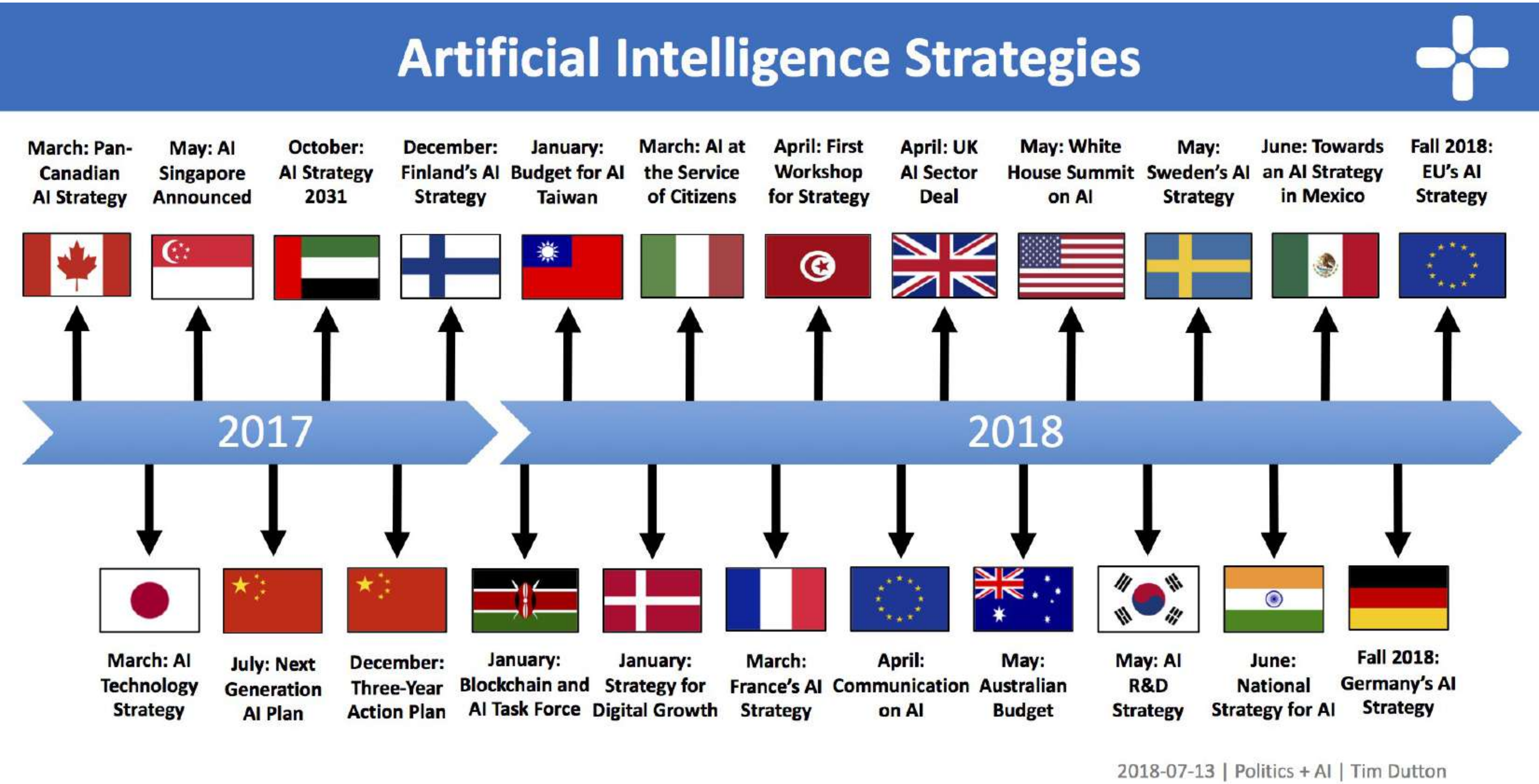
100 Startups that use AI to transform industry



https://medium.com/qtma-insights/ai-in-practice-61be3c16bfb8

AI in the world

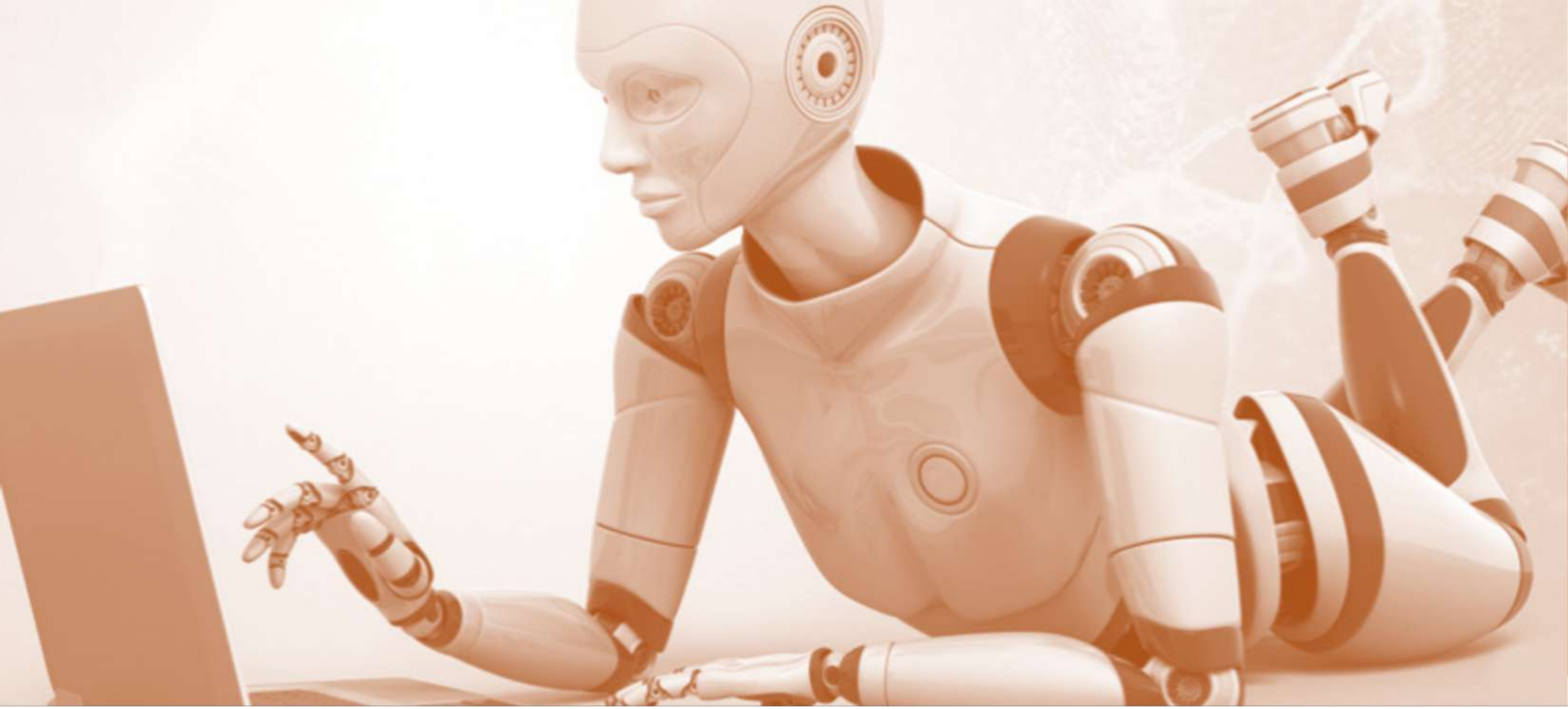
AI investment strategies worldwide



Source: Deloitte 2017: Artificial Intelligence for the real world

AI as public policy

- EU Commission:
  - Investment in AI from €500 million in 2017 to €1.5 billion in 2020;
- China:
  - three-step plan:
  - making China's AI industry on par with competitors by 2020;
  - achieve world leadership in some AI fields by 2025; and
  - become the primary center of AI innovation by 2030
- US:
  - The Pentagon spent approximately $7.4 billion on AI and related fields;



Machine Learning

Why so much fame?

Machine Learning

Definition

… Programming computers to optimize a performance criterion using sample data or past experience

Alpaydin, 2014

… make computers modify or adapt their actions to make those actions more accurate, where accuracy is measured by how well the chosen actions reflect the correct ones

Marsland, 2015

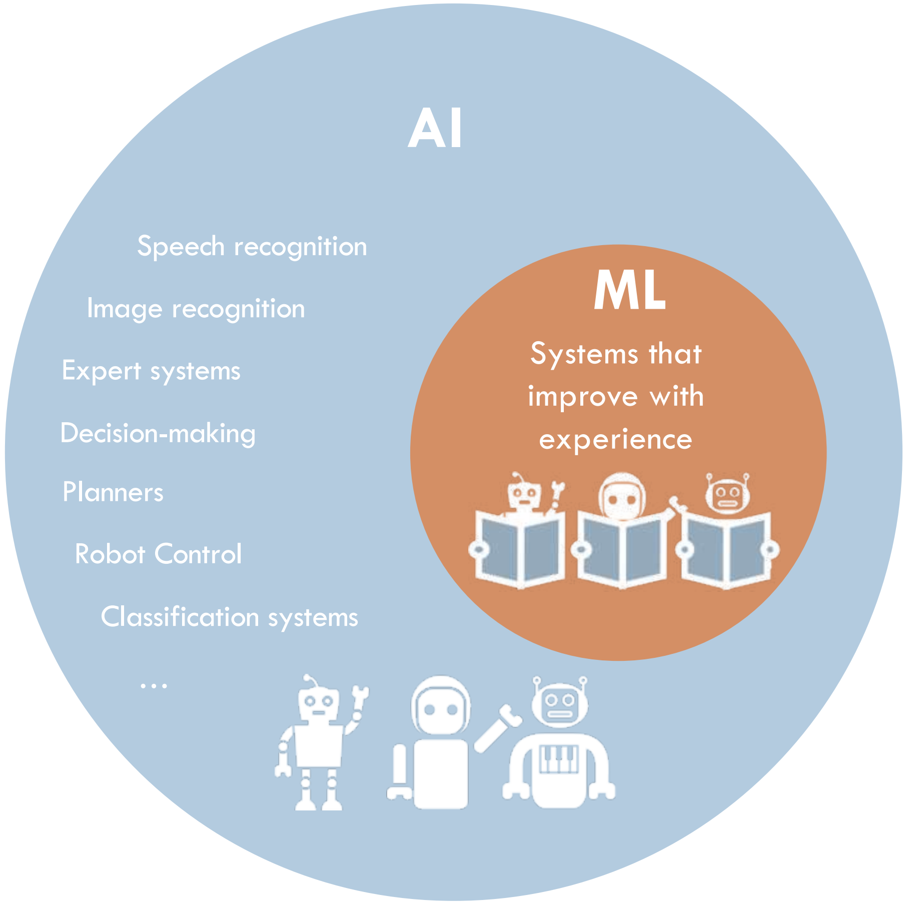
… the science (and art) of programming computers so they can learn from the data

Géron, 2017

… The field concerned with the question of how to build computer programs that automatically improve with the experience

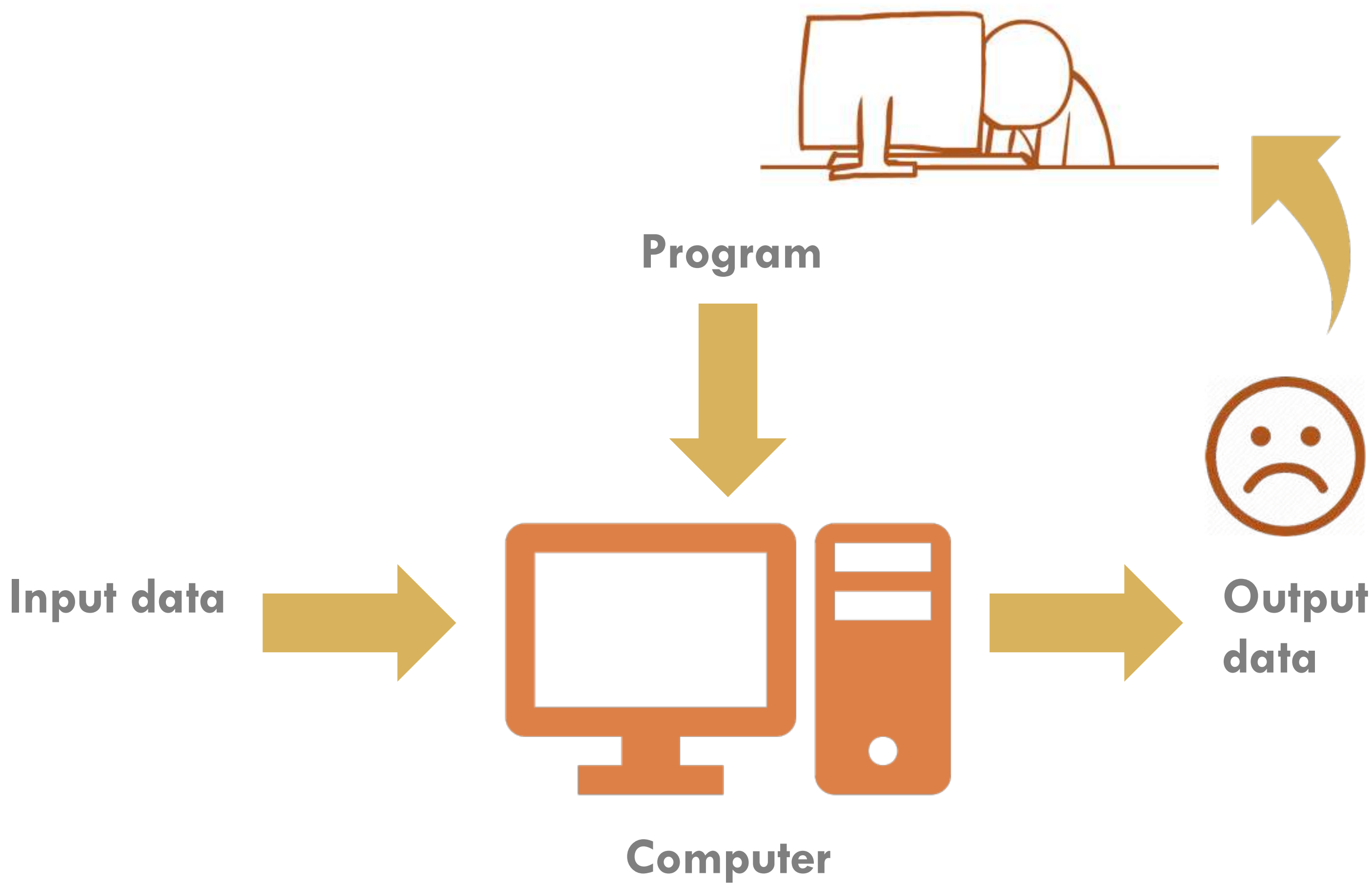
Mitchell, 1987

Machine Learning



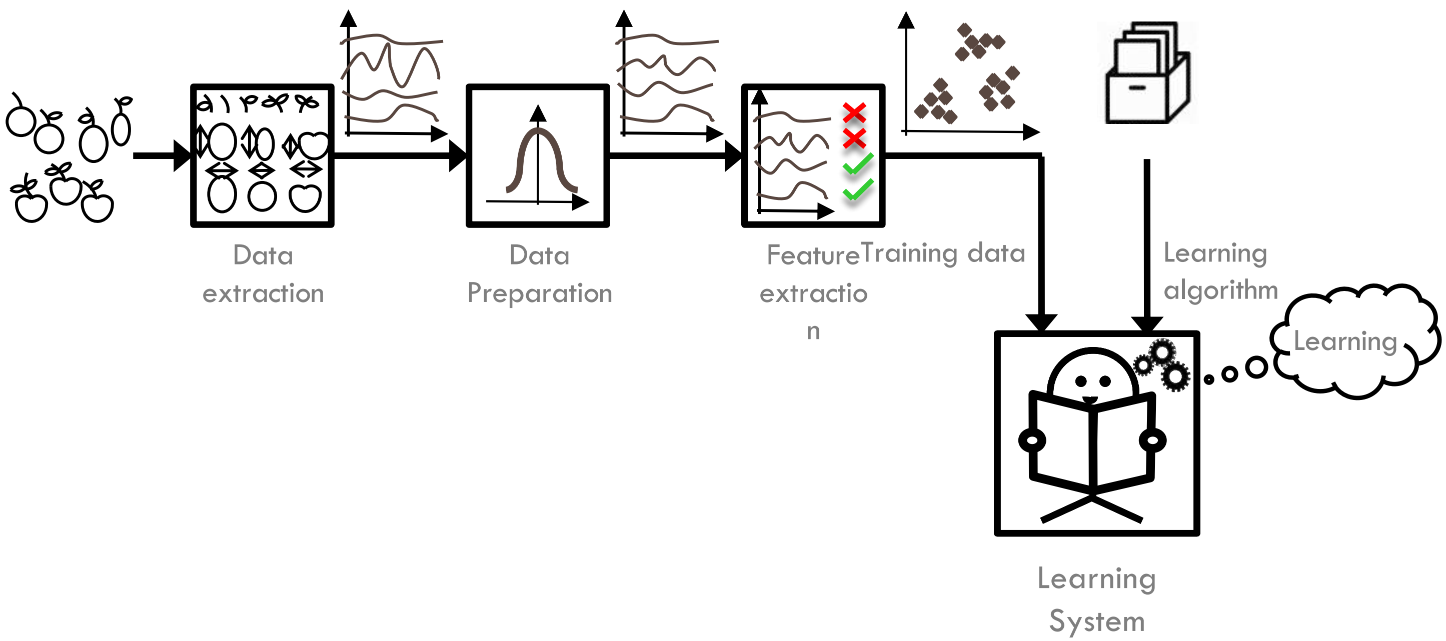
Machine Learning

Traditionally



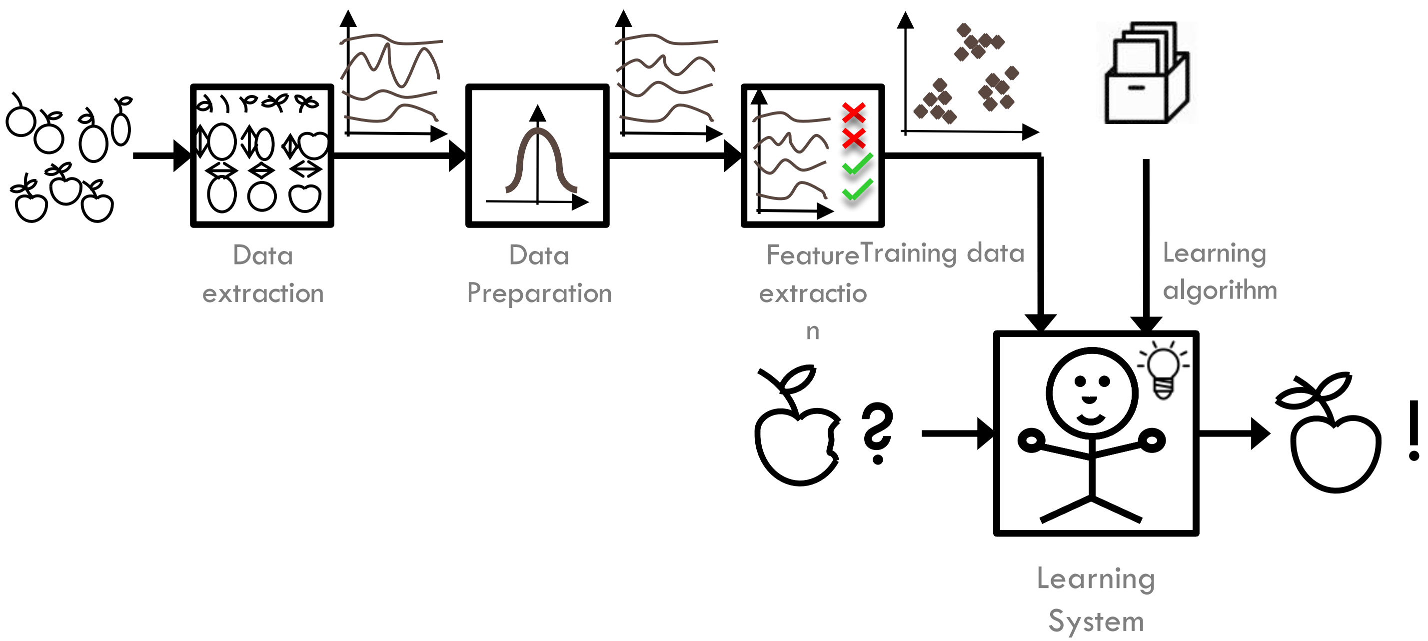
Machine Learning

With ML



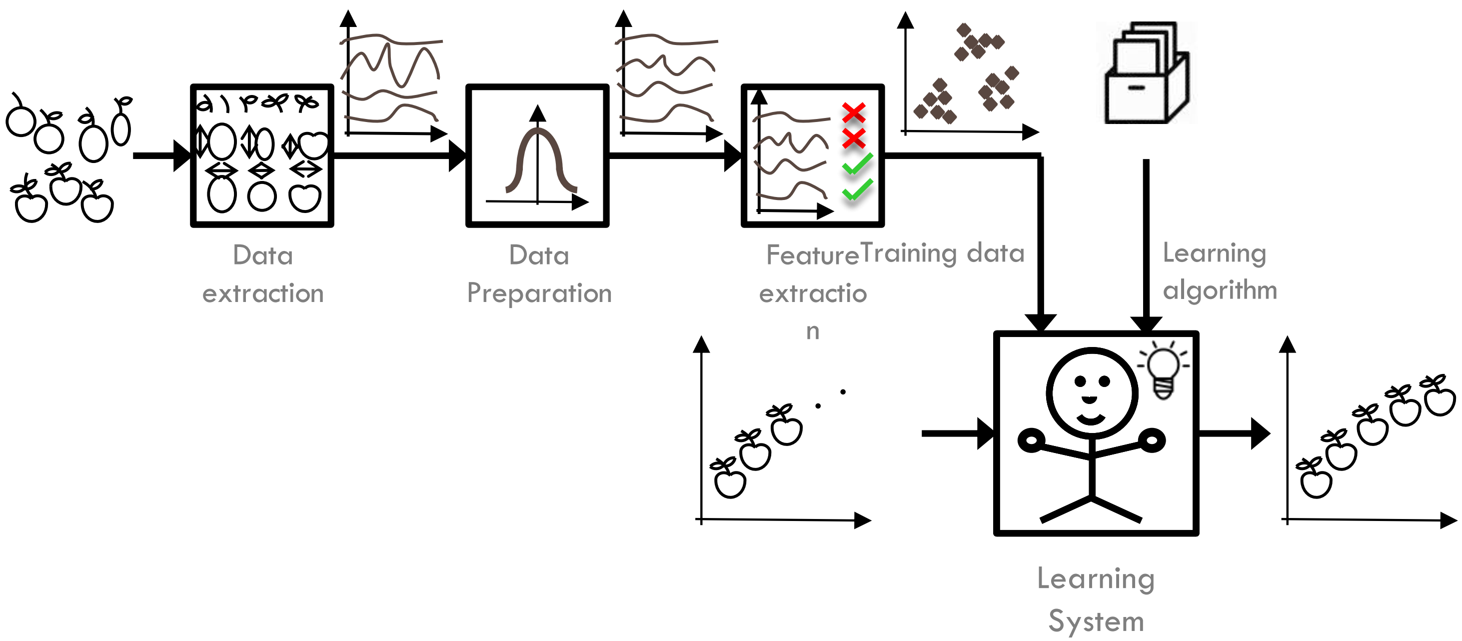
Machine Learning

With ML



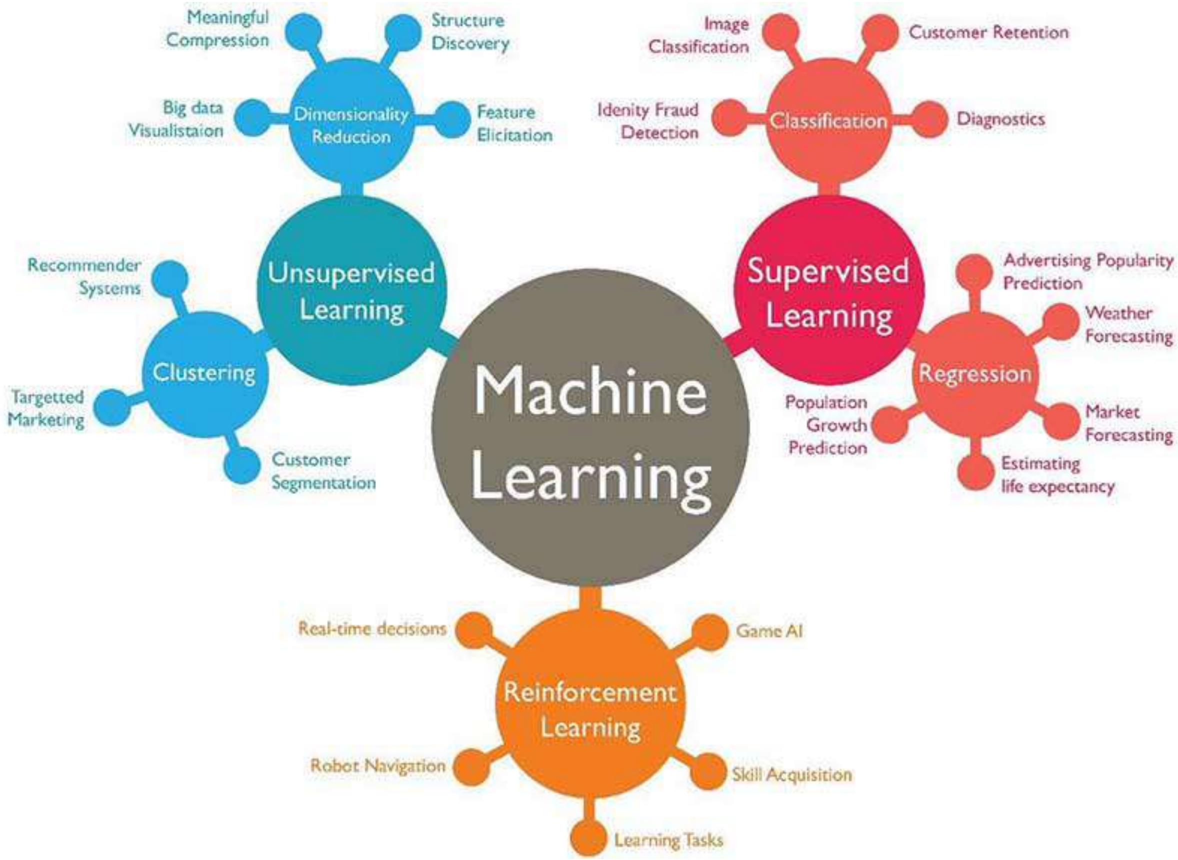
Machine Learning

With ML



Machine Learning

Paradigms



Applications

Detection of highways, faces, pedestrians

Applications

Detection of highways, faces, pedestrians

Applications

Dreaming, painting with the artist's style

A Neural Algorithm of Artistic Style by Leon A. Gatys, Alexander S. Ecker, and Matthias Bethge.

Robotics

What is it, why, why and since when?

Robotics

What is it?

Multidiscplinar

Because it gets involved and is spread over several disciplines

Interdisciplinar

Because it establishes relationships between two or more disciplines

Transdiciplinar

Well, there may be an organizing thought that goes beyond the disciplines themselves

Definition

Industrial Robots (ISO 8373)

An automatically controlled multifunctional manipulator, reprogrammable in three or more axes, which can be fixed or mobile for use in industrial automation applications.

Service Robots (ISO 8373-2012)

A service robot is a robot that performs useful tasks for humans or equipment, excluding the application of industrial automation. The classification of a robot into an industrial robot or a service robot is made according to the intended application.

Robotics

Why?

Robotics is on track to become one of the top 10 research areas by 2020[1]

Until 2014, it was already one of the areas that hired the most in American universities in the context of CC

Manufacturing robotics: 11.5% growth a.a. up to 2021[1]

Service robotics will grow 20% a.a. until 2021
semi or fully autonomous robots perform services, for professional or personal use, useful for the well-being of human beings, excluding manufacturing operations

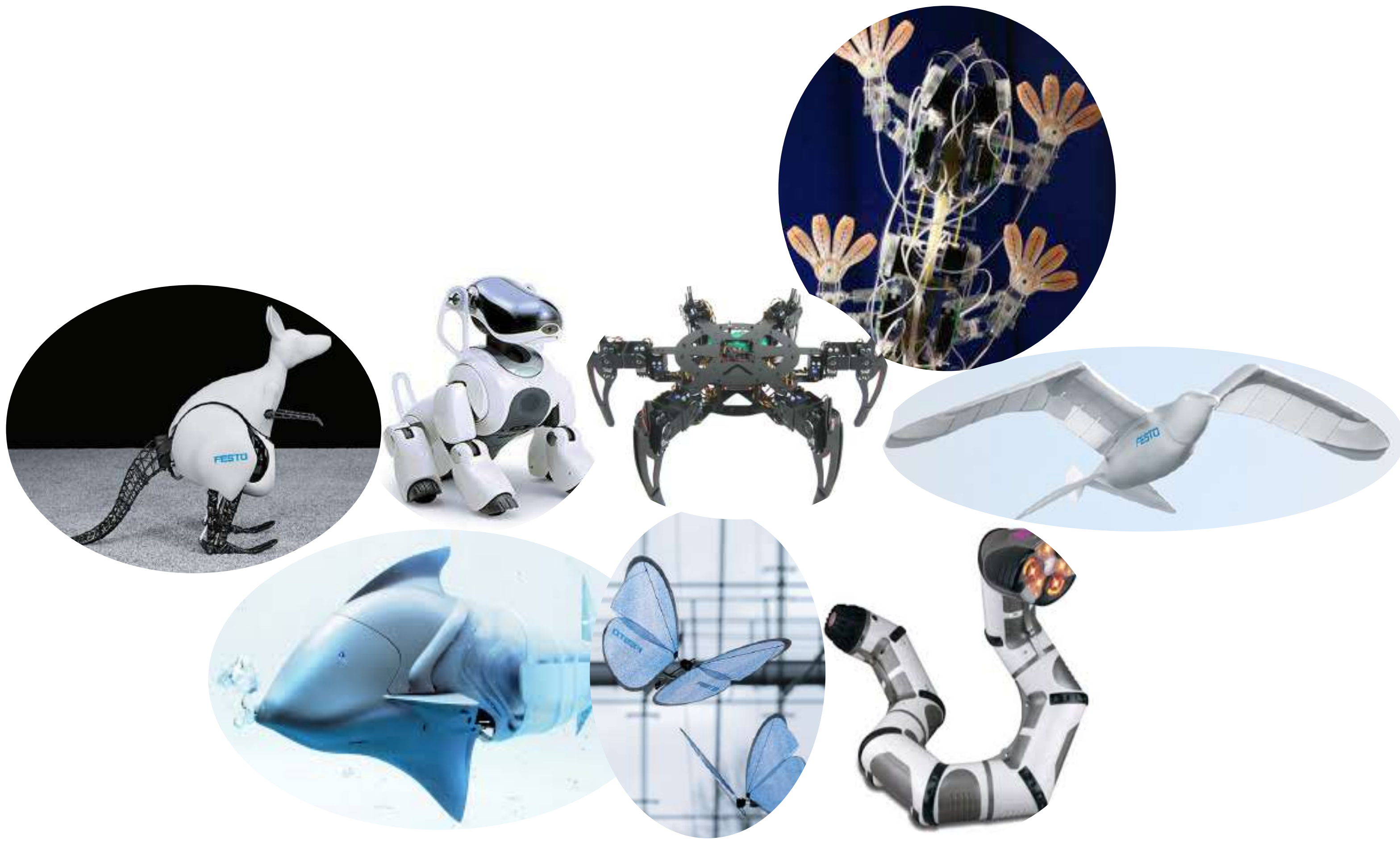
[1] Source: Wintergreen Research report. Disponível em: http://www.researchmoz.us/industrial-robot-market-shares-strategy-and- forecasts-worldwide-2015-to-2021-report.html

What is a robot

Micro, Nano and Soft Robotics

What is a robot

Nature-inspired



What is a robot

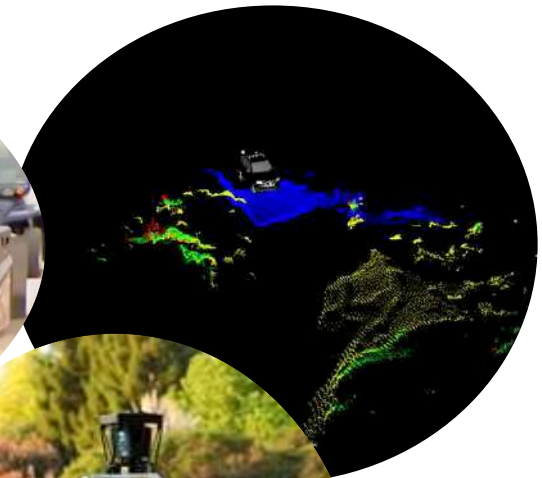
Commercial… space…

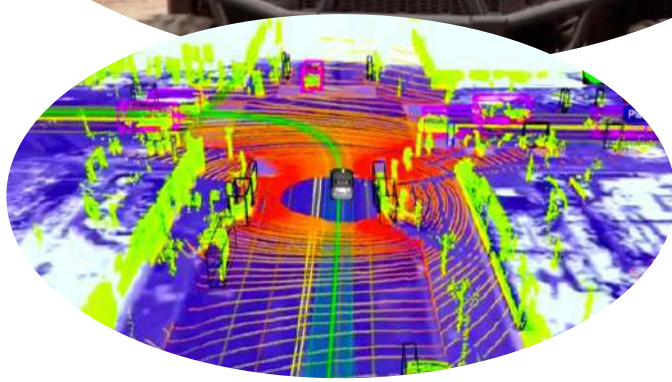
What is a robot

Educational

What is a robot

Auntonomous vehicles





What is a robot

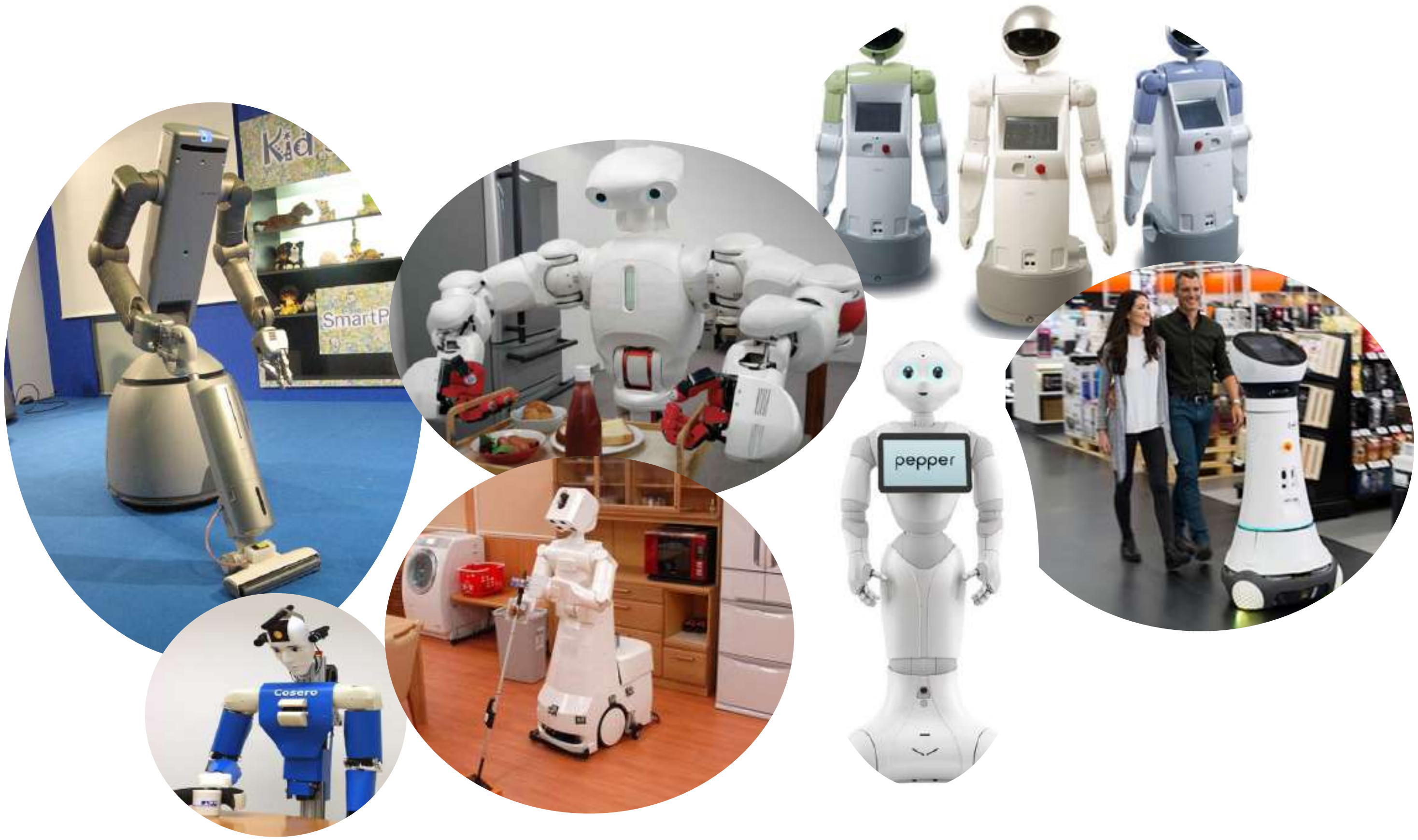
Skillful

What is a robot

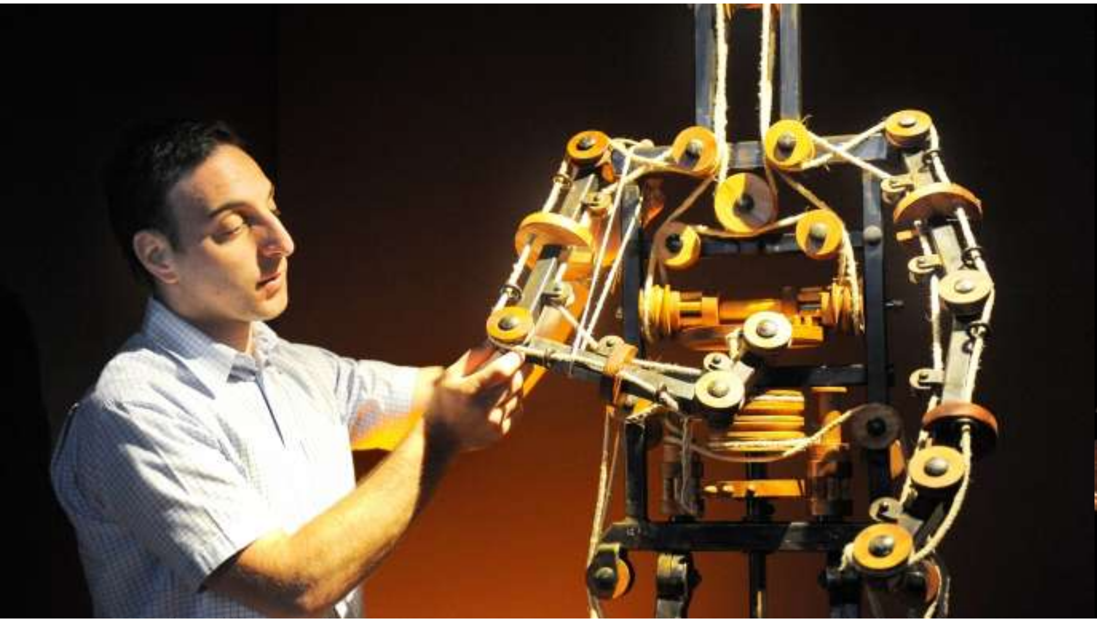
Humanoid

What is a robot

Helper



- Robotics gestation: rudimentary technical works and great influence of literature



Da Vinci's Night

Jaquet-Droz's Three Automatons

Sec. XVIII	**Sec. XIX**	**1920**	**1945**	**1950**
Mechanical robots	Jacquard loom	R.U.R Karel Capek	First Computers	"I, robot" Isaac Asimov

- Asimov's stories presented in the book “I, Robot”, introduced:
  - The positronic brain: the “precursor” of the microprocessor
  - The three laws of Robotics
- The three laws of Robotics (1942)
  - 1st law: a robot cannot harm a human being or allow any harm to happen to it.
  - 2nd law: a robot must obey the orders of human beings, except when they contradict the first law.
  - 3rd law: a robot must protect its physical integrity, provided that it does not contradict the first two laws.

- 1st generation of robots: embryonic AI work, industrial presence of proprioceptive manipulator robots

1951	1952	1959	1969	1971	1971
Teleoperated machines	CNC Machines (MIT)	AI is born, first languagens (LISP, GPS)	Fisrt intelligennte mobile robot: Shakey (Stanford)	First robotics arms (Stanford)	Robotics and AI restricted to micro-worlds

Evolution of robotics

- 2nd generation of robots: robots with proprioceptive and exteroceptive sensors (partially structured environments), strong presence of control

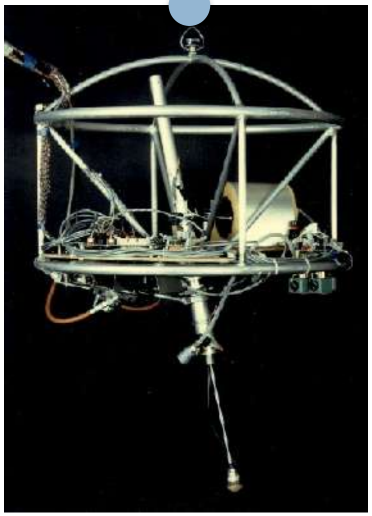
1980
Reborn of AI

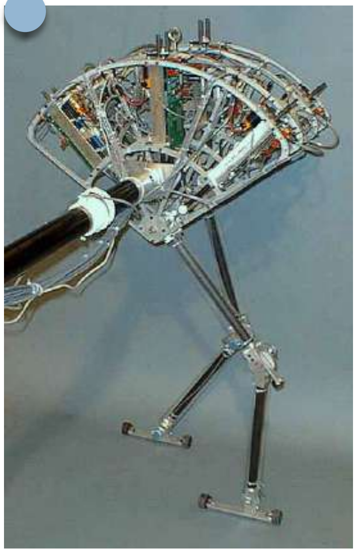
1983
Rilbertt Hopper robot (MIT)

1986
Begin of Asimo Project (Honda)

1989
Fisrt hexapod robot (MIT)

1996
Bipedal robot Flamingo (MIT)





Evolution of robotics

- 3rd generation of robots: robots make intensive use of sensors, perception, control and communication algorithms; growth in autonomy; able to operate in an unstructured environment

1995
Extensive use of the reactive paradigma (MIT)

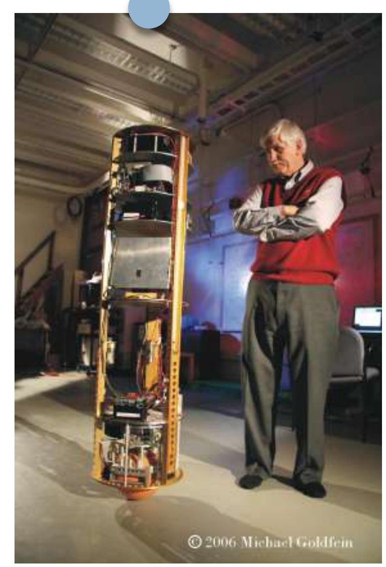
1997
IBM deep Blue wins against Garry Kasparov

1997
RoboCup Federation is born

1997
Asimo developments (Honda)

2000
Robots start arriving at homes

1971
Ballbot (CMU)



Why Robotics?

- Typical tasks where robots are employed:
  - Repetitive tasks;
  - Potentially dangerous tasks when performed by humans;
  - Tasks where it is necessary to reduce costs;
  - Imitation of living beings (entertainment).
- Social implications: jobs vs. robots
  - The evolution of technology is an irreversible trend
  - Robots extinguish low-skilled jobs;
  - Robots require more qualified professionals;
  - Ethics in robotics.

- Robotics today
  - Segments with commercial products:
  - aid for the disabled
  - military
  - industrial automation
  - office automation
  - entertainment
  - home automation
- But still… very fragmented

- A mobile robot is an automatic device that is able to move and interact in a defined environment (Wikipedia)
- Problems and challenges of mobile robotics:
  - How to build robots?
    - Sensors, actuators, processing, physical structure, etc .;
  - How to control robots?
    - Low-level, high-level control (programming, A.I., etc.)
- Challenges inherent in mobile robotics:
  - Mapping and location;
  - Pattern Recognition;

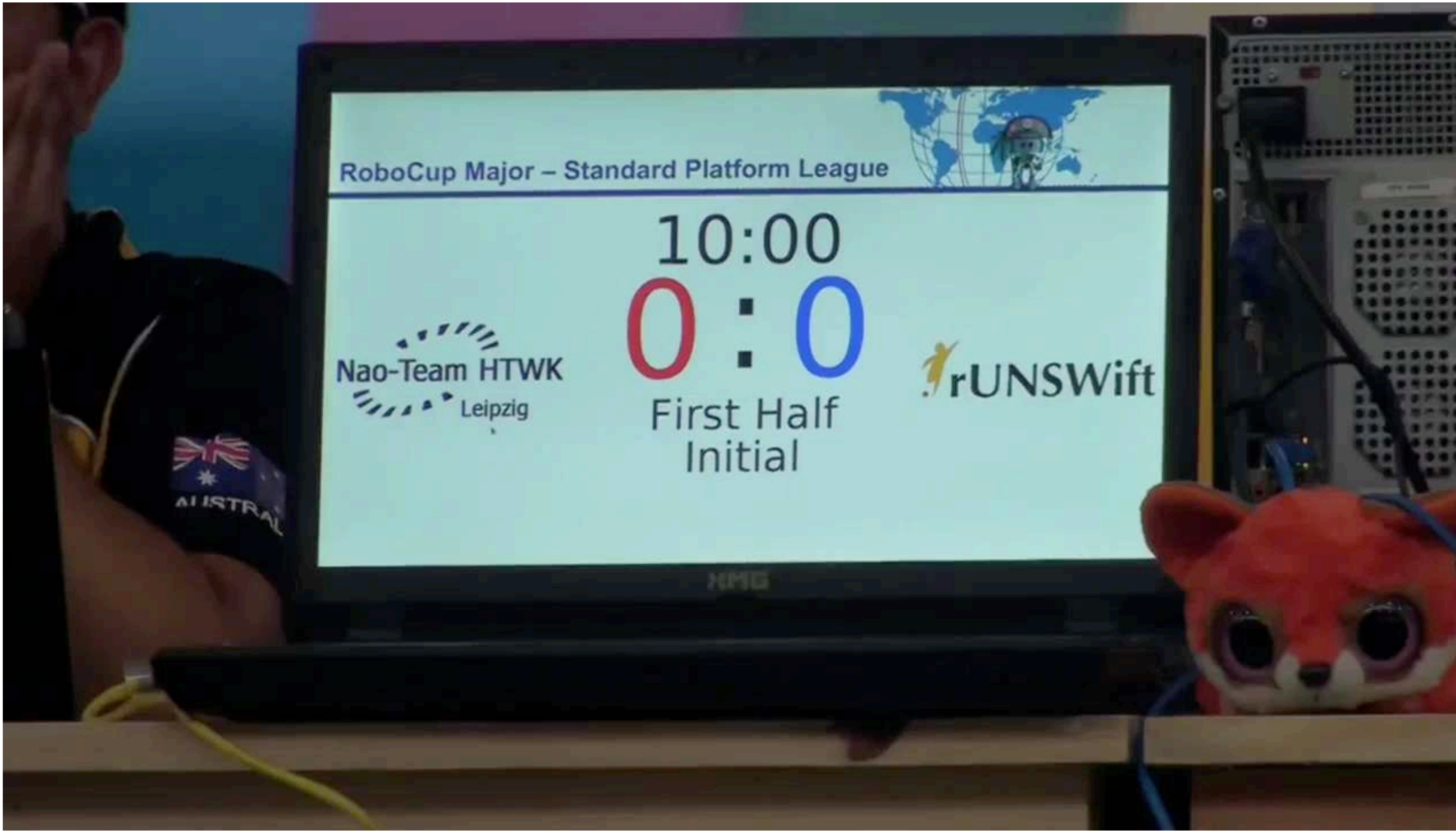
- The relationship between the primitive feel, plan and act
  - Sense
    - how, when and what to observe?
  - Plan
    - how to determine the right actions?
  - Act
    - how to activate the actuators properly?

What can a robot do?

Play soccer

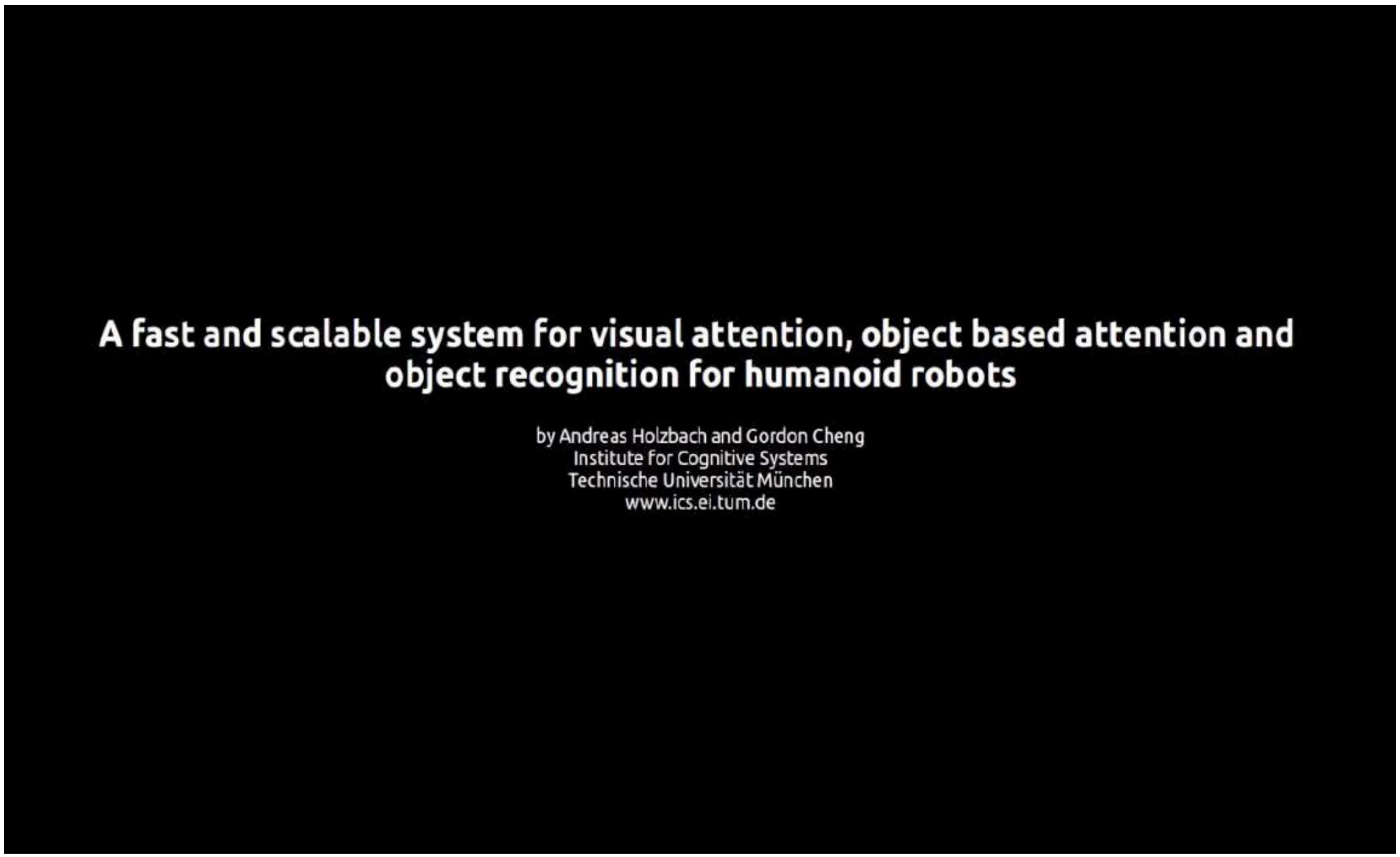
What can a robot do?

Play Soccer



What can a robot do?

Recognize the world ...



What can a robot do?

Fly

What can a robot do?

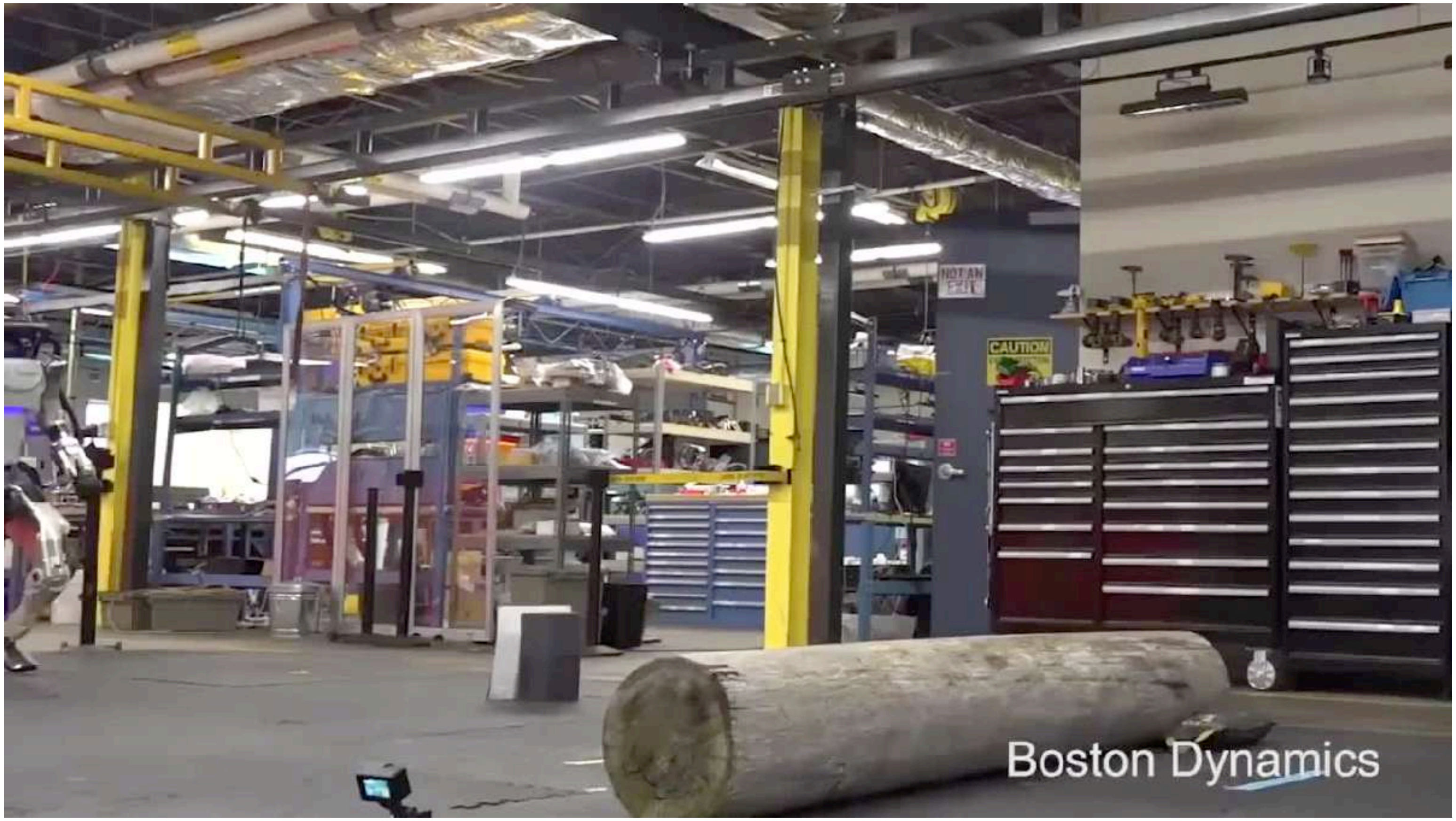
Fly

What can a robot do?

Fall

What can a robot do?

Not fall



Challenges

Why do we need AI and Machine Learning in Service Robotics?

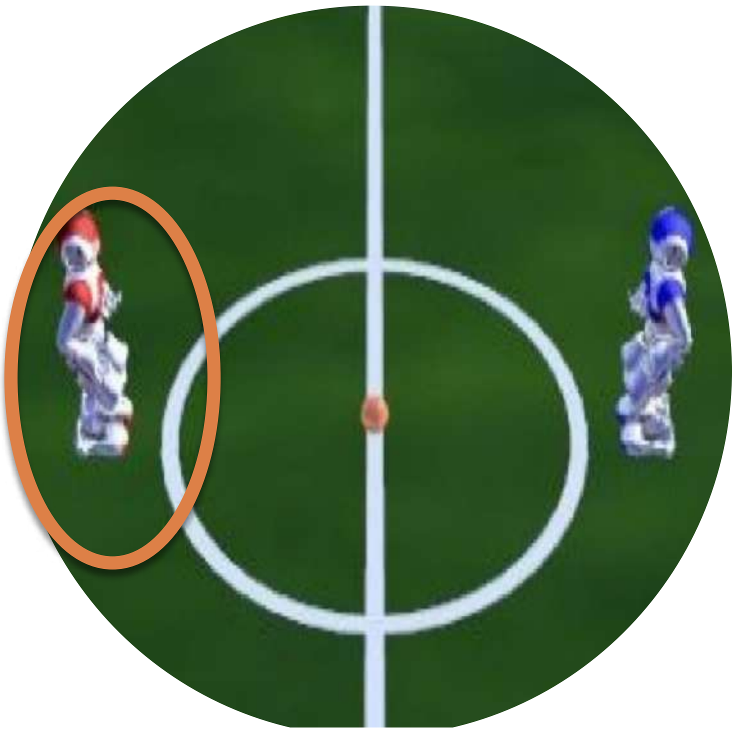
1. Autonomous robots
2. Mobile robots
3. Environment partially unknown, Unpredictable and unstructured
4. Almost impossible pre-programming
5. It is not possible to determine the universe of sensory and motor transformations required
6. Interaction with unknown environment

Robotics & AI

And now? Where are we going?

An autonomous soccer match

Challenges



Football challenges

- Who am I?
- How do I move?
- Where am I?
- Where's the ball?
- What are the limits of the field?
- Who is on my team?
- Who is the opponent?
- What to do?
- How to exchange information?

An autonomous soccer match

Features

Not fully observable environment

Agent sensors do not allow access to the total state of the environment

Continuous environment

The environment does not have a finite number of states
Sensors do not have a finite number of states
Time does not have a finite number of states

Non-deterministic environment

Next state is not entirely determined by the current state and the action taken by the agent

Multiagent

Several agents who simultaneously cooperate and compete

Dynamic environment

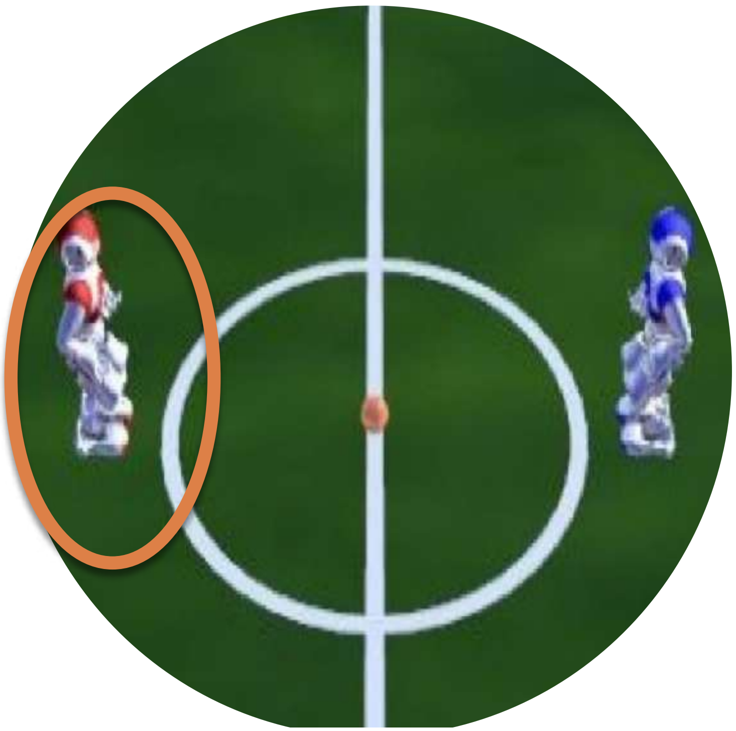
The environment changes while the agent is deliberating

Sequential environment

The following episodes depend on the actions taken in the previous episodes

An autonomous soccer match

Challenges

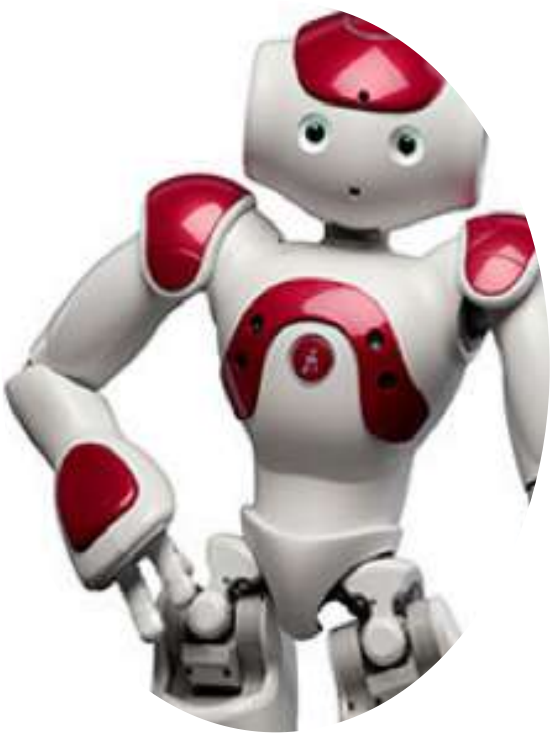


Football challenges

- How to perform the proc. in real time (~ 60 times / sec)?
- How to extract useful information from the sensors?
- How to perform image processing?
- How to do sensory fusion?
- How to recognize objects?
- How to act on objects?
- How to recognize sounds / proc. natural language?
- How to communicate with other agents?
- How to carry out the processing of strategies?
- How to model the behavior of robots?
- How to live with uncertainty?
- How to locate yourself in the world?
- How to map the world?
- How to build representations of the world?
- How to write code independent of hardware or mechanical / electronic technology?

Who am i?

Challenge

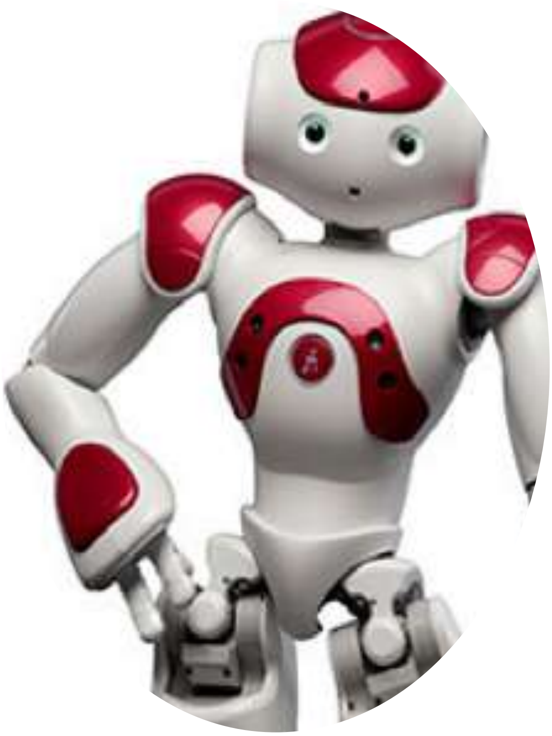


The robot needs to recognize its

- Sensors (camera, sonar, laser, accelerometer, gyroscope, compass, gps, microphone, torque sensor, etc.)
- Actuators (motors, speaker, screens, leds, etc.)
- Know how to receive information from them
- Sensors of different nature provide data of different nature and with different precision
- Know how to filter and merge this information
- Know how to modify them
- Actuators have different limitations and, depending on how they are connected, will behave differently

How to move?

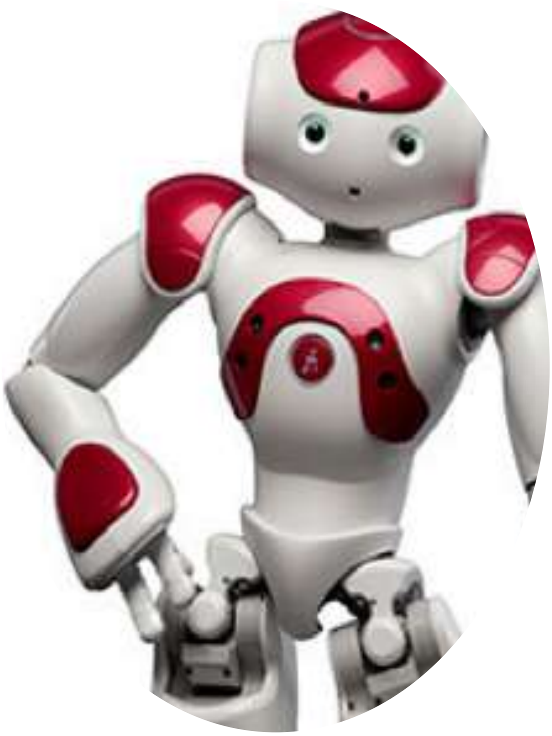
Challenge



- Knowing its actuators and how they connect, the robot needs
  - Have a model of your body
  - Calculate the performance of each engine to achieve the desired position
  - With the best possible performance
- Imagine the structure of the robot:
  - 25 DOF (degrees of freedom)
  - Each engine with + -180o range of motion
  - If we discretize each engine 1 in 1 degree
  - 180 ^ 25 = 2.4*e+56 ☹
  - Overall, it uses models based on ZMP or Truncated Fourier, with optimized or learned parameters
  - Or learn model-free

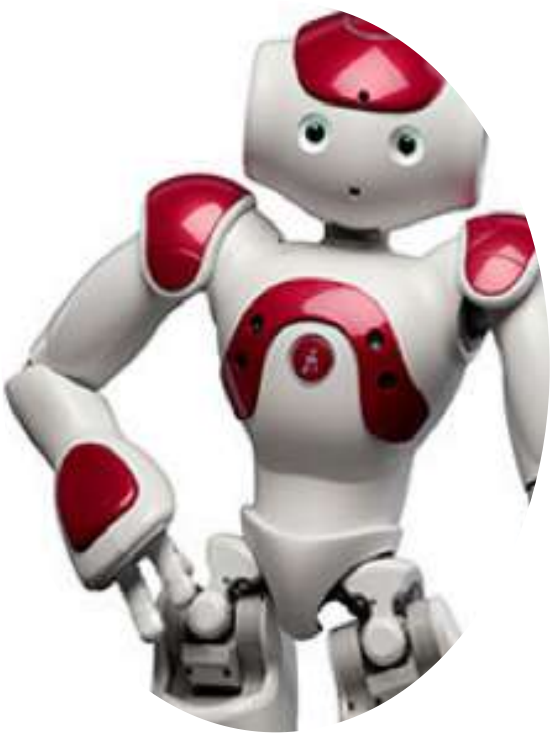
How to move?

Challenge



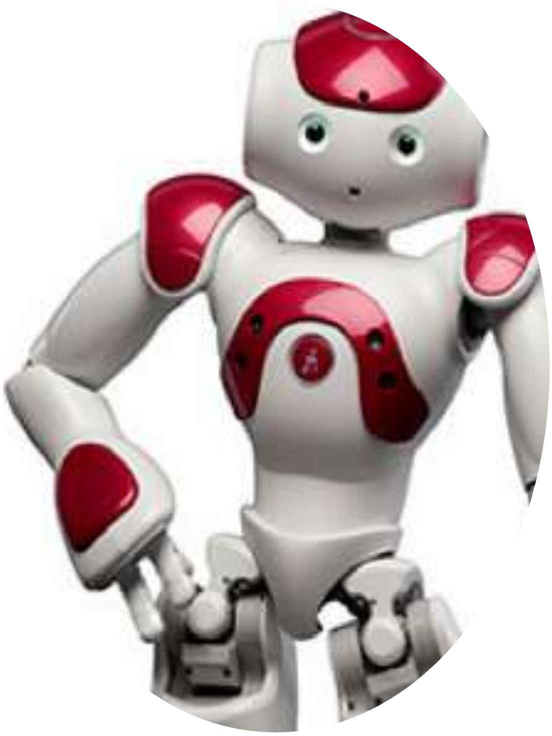
How to move?

Challenge



Where am I?

Challenge

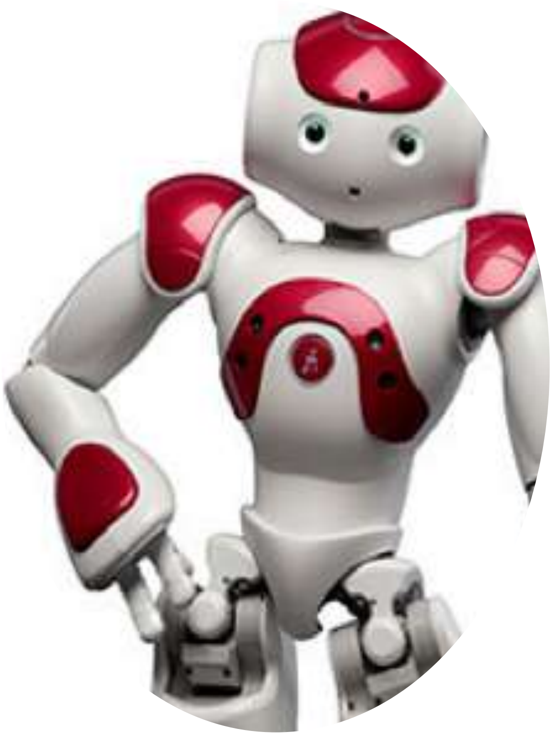


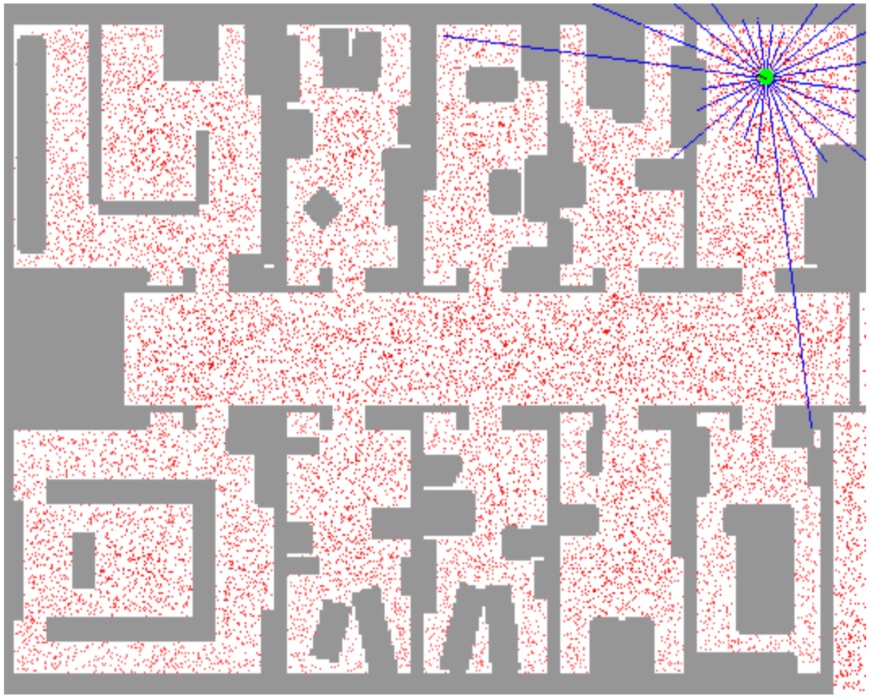
With the sensor data, the robot needs to be located in the environment

- Use GPS!
  - Very inaccurate for indoor environments with such small robots
- The problem of robot location is a key aspect of intelligent robotics
  - Extended Kalman Filter
  - Particle filter
  - Monte Carlo
  - Symmetry and kidnapping problems

Where am I?

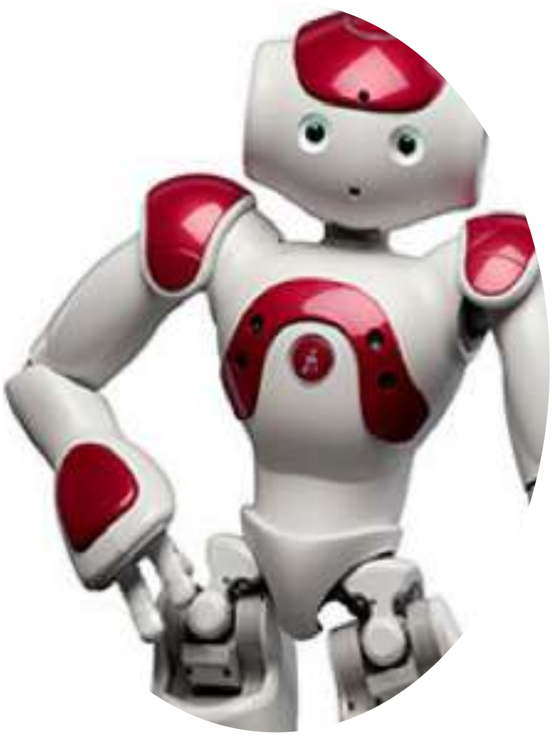
Challenge





Where am I?

Challenge

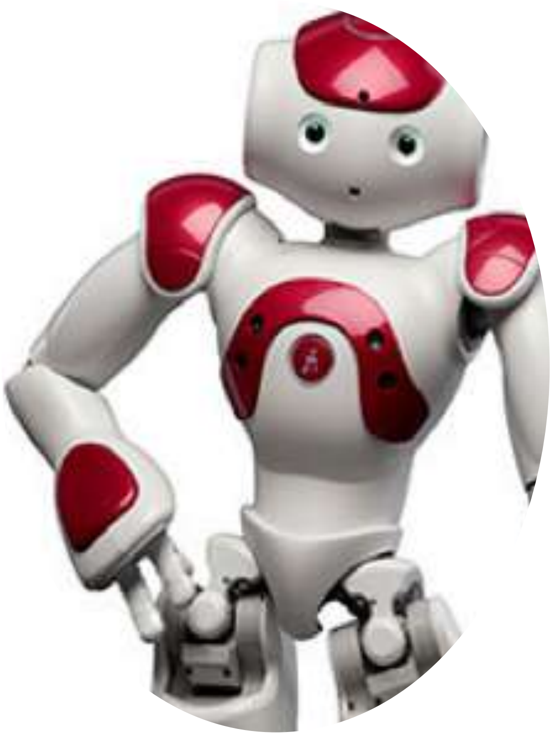


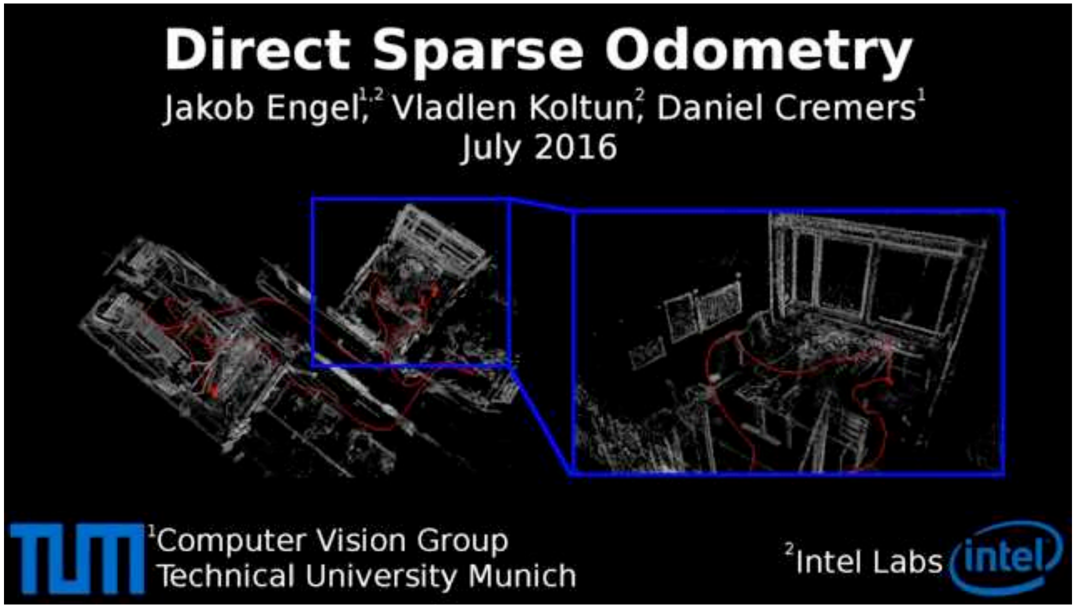
In addition, we may need the environment map to make a decision. If this is unknown, it requires MAPPING (2D or 3D)

- Mapping is another extremely relevant element in robotics
  - Depends on the robot's motion model (noise)
  - From (noisy) sensor readings
  - It can be done through maps:
    - Metrics
    - Occupancy grids
    - Topological
    - Characteristics
    - Probabilistic

Where am I?

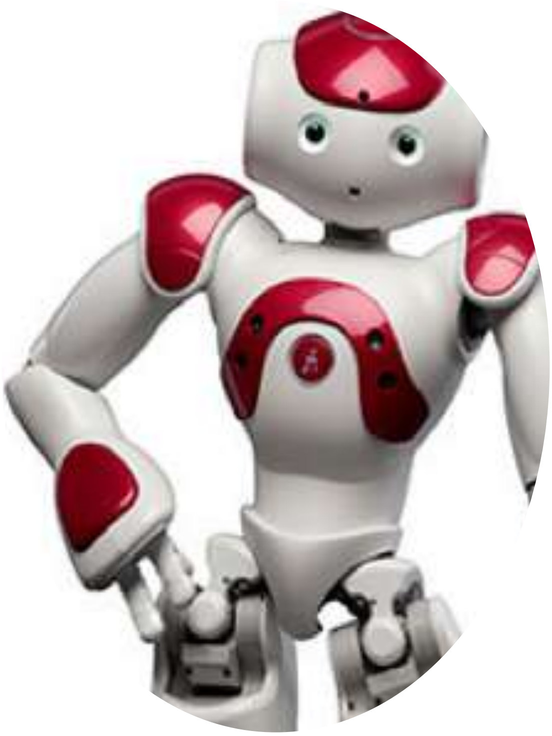
Challenge





A few more questions...

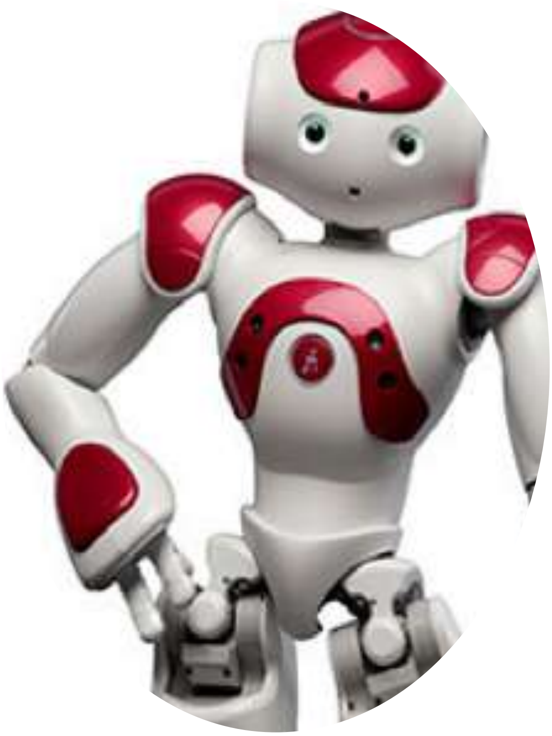
Challenge



- Where's the ball?
- What are the limits of the field?
- Who is on my team?
- Who is the opponent?
    - Let's consider that the robot uses SVM, RN, Deep Learning, LDA, GIST, etc.
    - Does it need to be trained for everything she will contact?
    - It needs to handle all this online and in real time. How?

How to tackle the problem

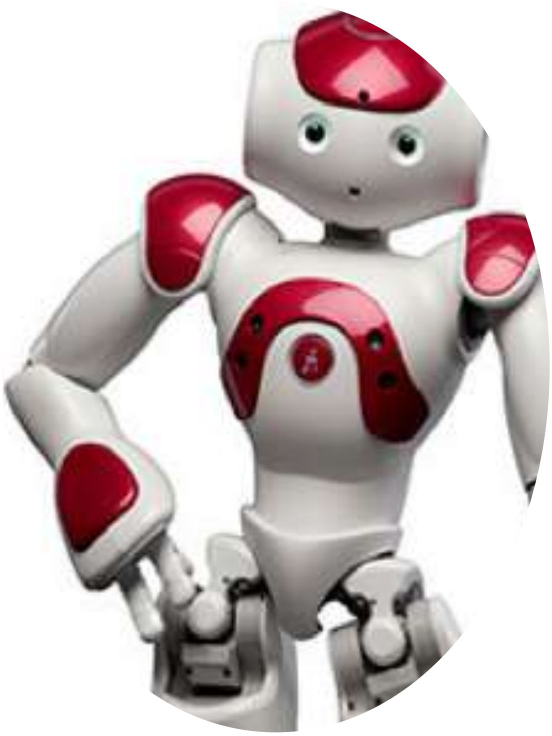
Challenge

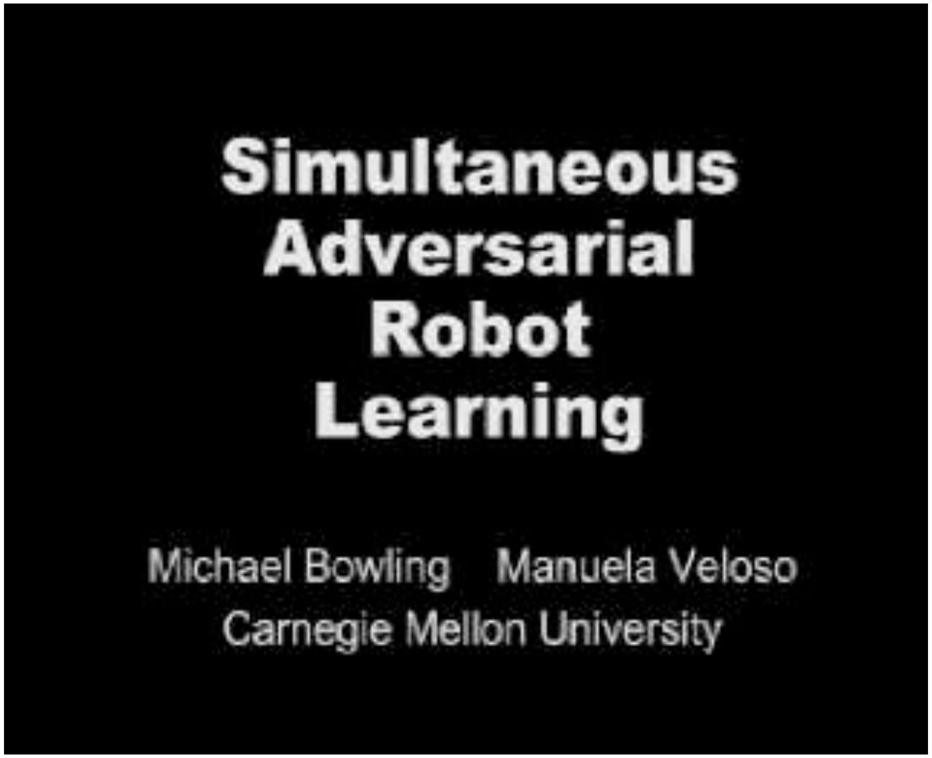


- Given that the robot knows where it is, how to get around, who is where in the countryside…
  - What action should it take?
  - Based on what does it make that decision?
  - What software architecture connects these elements?

Learning...

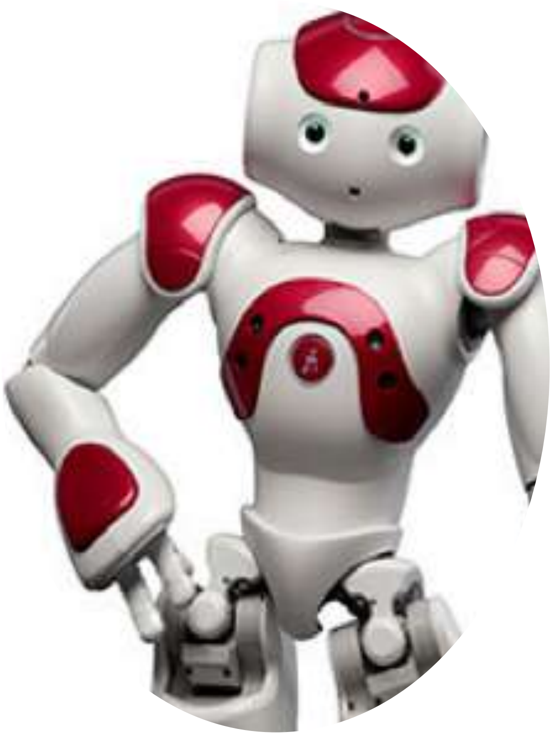
Challenge





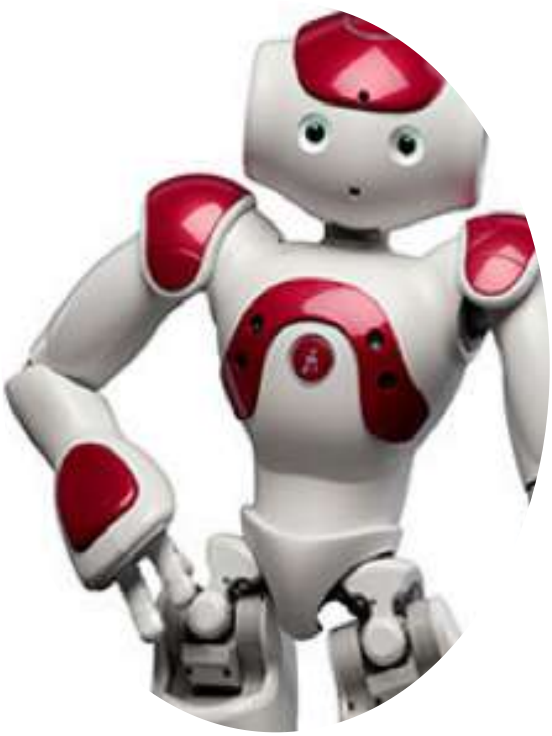
Learning...

Challenge



Key concept in autonomous robotics ...

Learning



By 2050, win against FIFA's champion team

Challenge

- Subfields previously isolated from I.A. need to be rearranged
- Example:
  - Sensory systems cannot provide perfectly reliable information about the environment
  - Reasoning and planning systems must deal with uncertainty
  - Approach trend within A.I .:
    - Examine the “agent as a whole” problem
  - How to represent such agents?
  - What is involved in the agent model?
- Next class

Extra-class activities

Lecture 2

- Activities
  - Reading:
    - RUSSELL, S. NORVIG, P. Inteligência Artificial. 3ª edição. Capítulo 1.
  - Exercises:
    - 1.1, 1.3, 1.4, 1.5, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14

References

Lecture 2

- RUSSELL, S. NORVIG, P. Inteligência Artificial. 3ª edição.
- Simões, A. S. Slides de aula: IA para Controle e Automação.