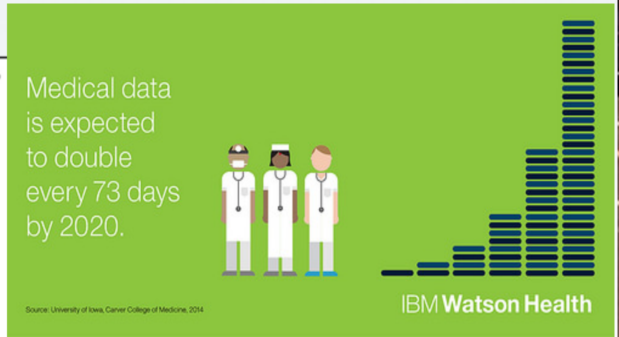
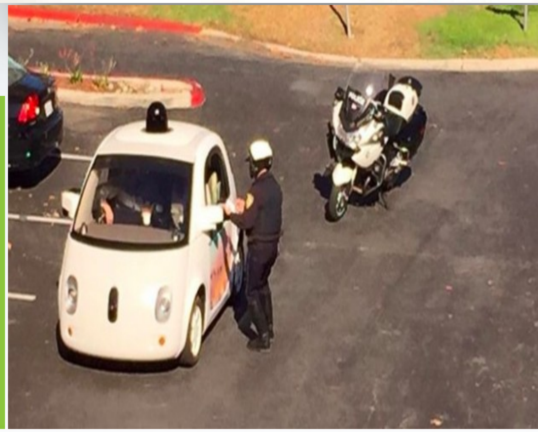
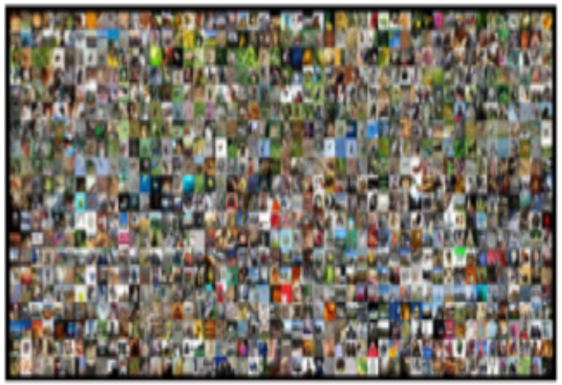
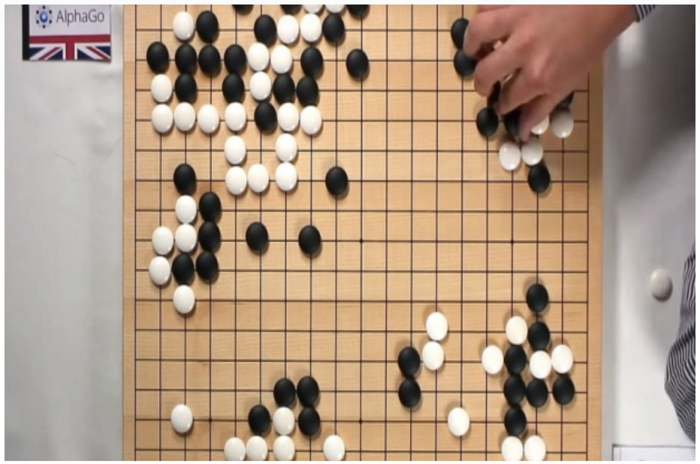
Artificial Intelligence applications







[Figure from vision.stanford.edu]

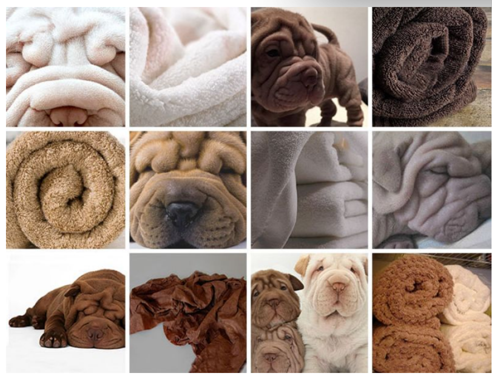


Artificial Intelligence applications

- **Decision support systems**
  - Very specialized on a given domain
  - Knowledge based and control

- **Formal systems and games (Chess/GO)**
  - Limited number of moves and space
  - Based on explicit, non-ambiguous rules

- **Natural language – question answering (Watson)**
  - Ambiguous, implicit, context dependent
  - Based on cognitive states



- **Vision (ImageNet)**
  - Object recognition/classification
  - Uncertanty and noise (simbolic/sub-simbolic)
- **Robotics and Autonomous systems (Robot)**
  - Agents working in an environment
  - Dynamic and real-time decisions

Knowledge based systems

"*The power of an intelligent system primarily derives by the quantity and quality of the knowledge it has on the problem*". *(Feigenbaum)*

Various applications: Planning, Prediction, Diagnosys.

Knowledge acquisition: bottleneck of KBS

Problems

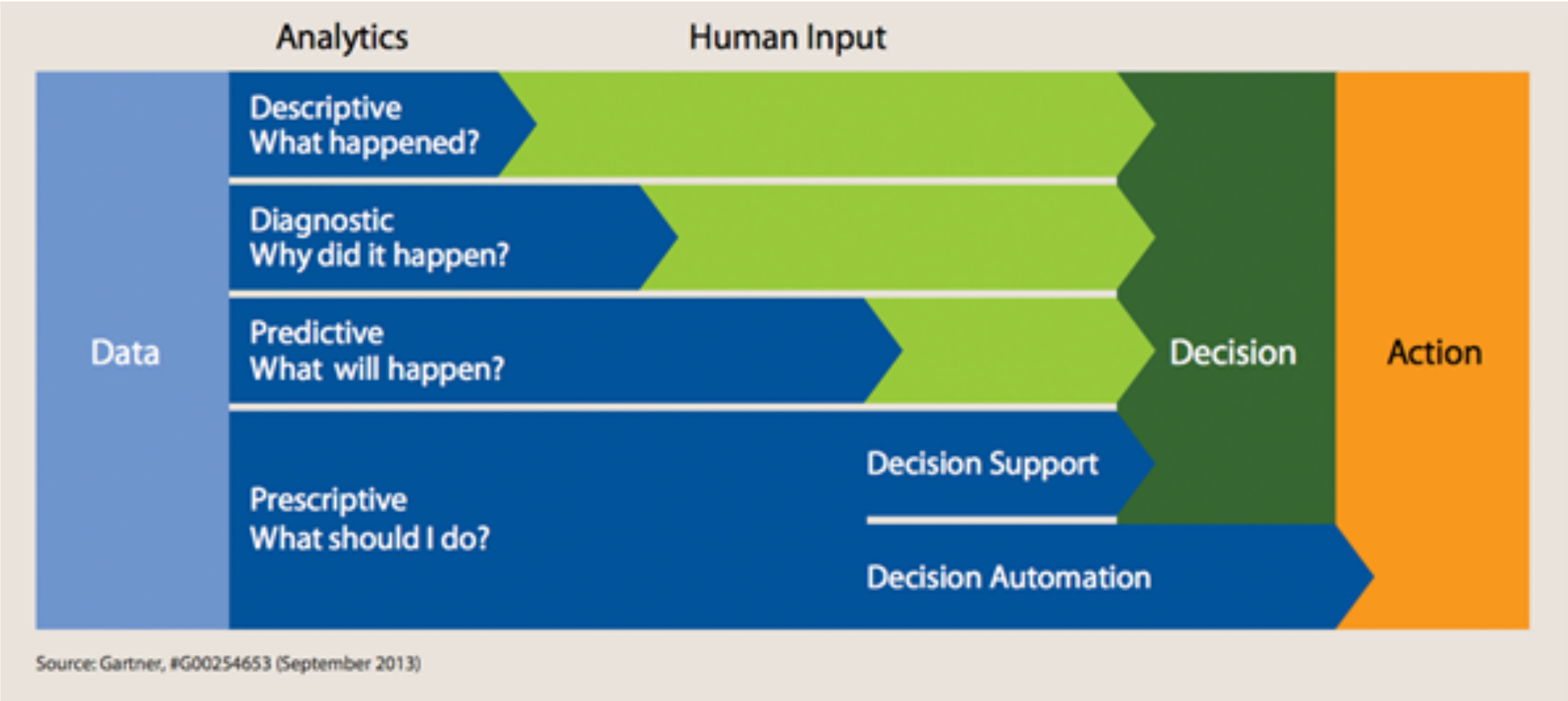
- The human expert cannot be substituted, but supported in long and repetitive tasks
- Different knowledge sources (often in contrast and incomplete)
- Knowledge changes in time
- Knolwedge is not always explicit (discovery)

→ **Learning and data-mining techniques**

Decision support systems

- Systems that support and do not replace human experts in their decision making process through:
  - Scenario generation, evaluation, visualiations, predictions
- Various degrees of decision support:
  - Data analysis for description
  - Diagnosys
  - Prediction
  - Optimiation
- Decision automation is one step forward as it excludes the human intervention

Human intervention in decisions



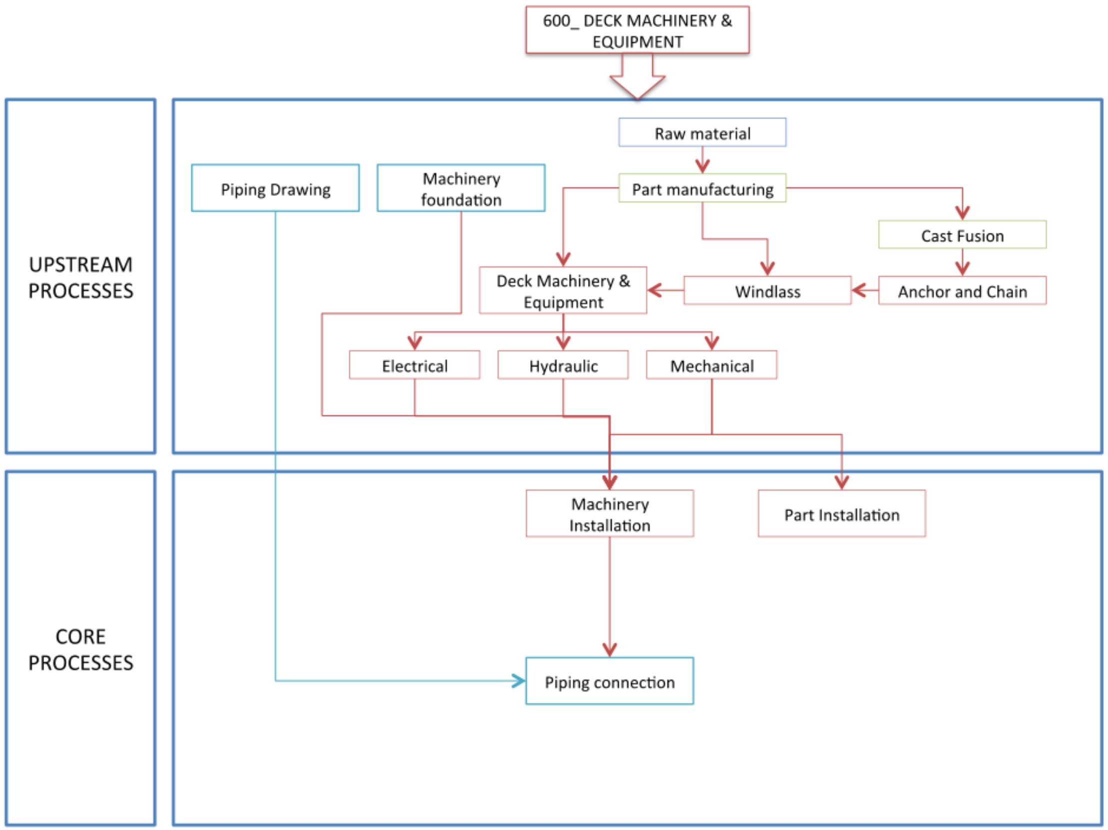
Descriptive analytics

- Data are used to describe the system
  - Visualization dashboards
  - Business intelligence
  - Statistical reports
  - Geo-referenced data

- Human intervention is largely needed

Example of descriptive analytics

- Configuration of a productive system/process with environmental constraints



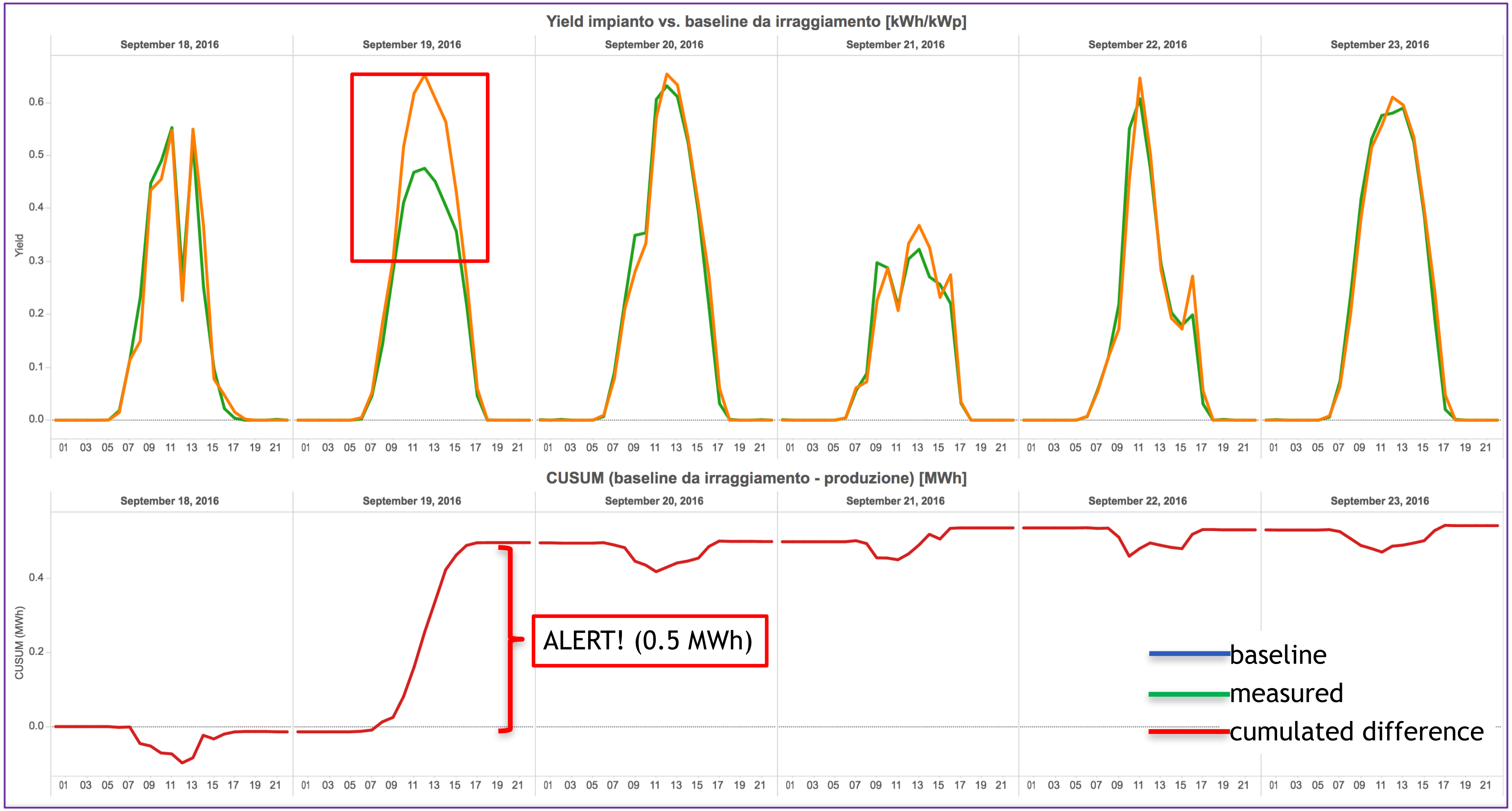
Static data: system characterization

For each process component we have to characterize data on:

- Energy consumption
- Water consumption
- Emissions in the air
- Emissions in the water
- Time of work
- Cost

Example of descriptive analytics

- **Energy baseline**



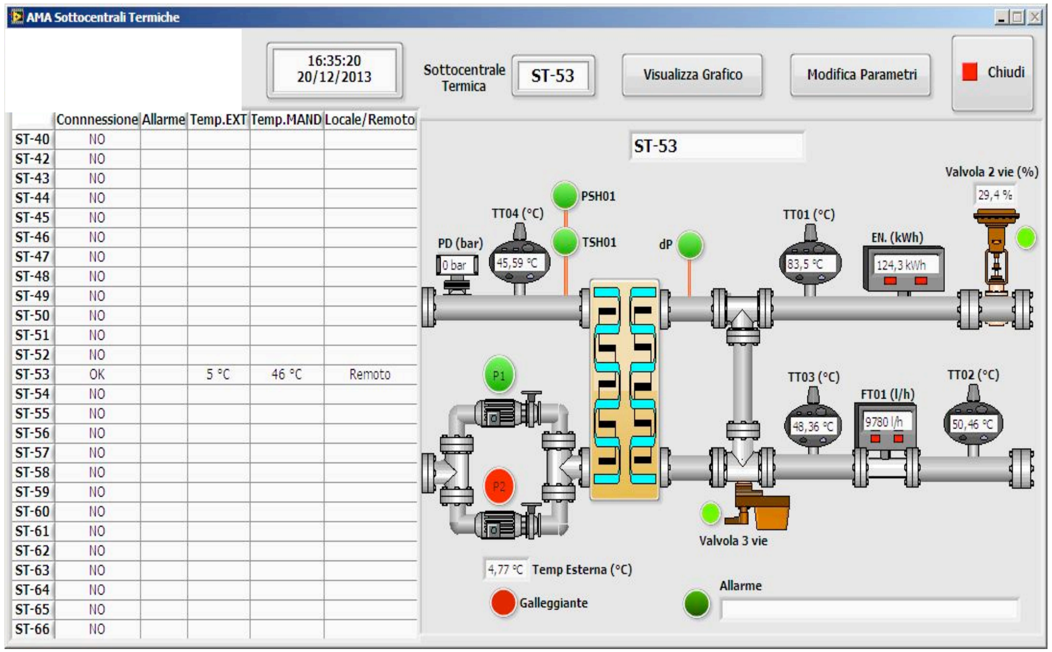
Diagnostic analytics

- Uses data to understand causes
- Fault diagnosis
- Root cause analysis

- To reach decisions human intervention is still largely needed

Example of diagnostic analytics

- **System for analyse data from a plant and to realize a diagnostic system**



© 2016 National Instruments Corporation

From plant data coming from sensors
+ fault data:

- Identify temporal series that precede a fault
- Classify the temporal series before the fault to identify the type of fault
- Identify the most informative sensors
- Create models to identify causes.

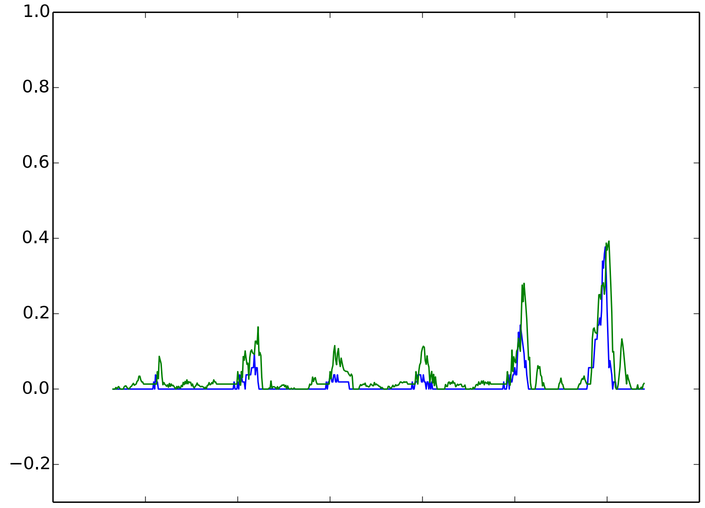
Predictive analytics

- Uses data to predict future system evolutions
  - Simulation systems
  - Temporal series prediction
  - Machine learning classification and regression

- To reach decisions we need **what if analysis**

Example of predictive analytics

- **System to predict the consumption of a photovoltaic system**
  - Input
    - Historical temporal series of past production
    - Meteo forecast
    - Day/month/year
  - Output
    - Future production



Example of predictive analytics

- **System to predict the photovoltaic adoption depending on diverse incentive schema**
  - Model
    - Agents divided by type
    - Agents characterised by social and economic aspects
    - Past data (incentives/adoption)
  - Output
    - Simulative model

Decision support – prescriptive analytics

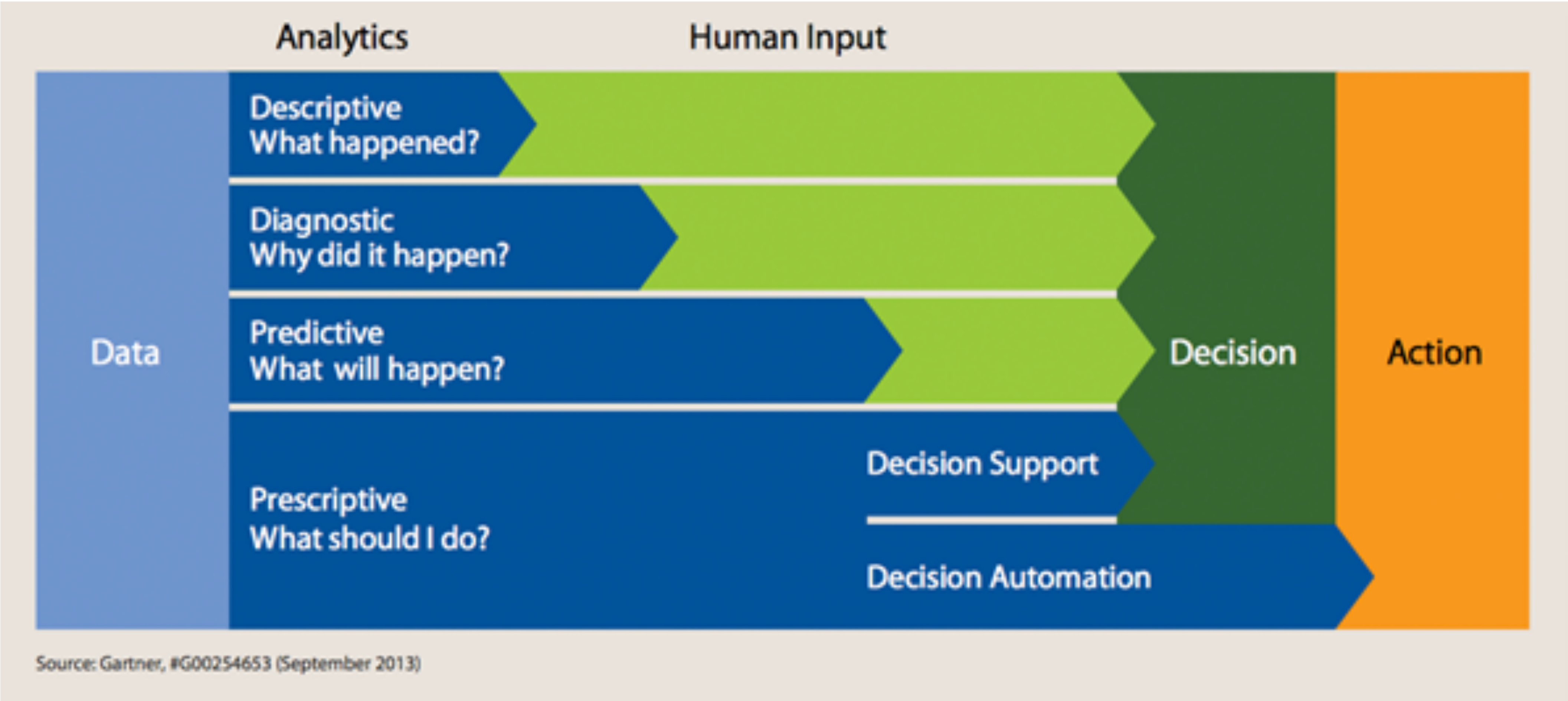
- **Prescriptive analytics**
  - Optimization systems (mono and multi objective)
  - Combinatorial problem solvers
  - Logic based solvers

  - To reach decisions we need to select the preferred scenario.

Example of prescriptive analytics

- **Decision support systems for proposing incentives to foster a given PV adoption**
  - Optimization system that takes as input
    - Simulator model
    - Economic/financial/territorial
    - Objective functions
  - Output
    - Alternative scenarios
    - Impacts

Human intervention in decisions



Human intervention in decisions

Value & Complexity

Act

Analyze

Inform

Descriptive Analytics What happened?	**Diagnostic** Analytics Why did it happen?	**Predictive** Analytics What will happen?	**Prescriptive** Analytics What shall we do?

Examples

• Plant operation report • Fault report • Sales reports • Service statistics	• Alarm management • Root cause identification • Fault analysis	• Load forecasting • Fault prediction • Price forecasts • Demand forecasts	• Self-learning systems • Control optimization • Load balancing • Production re-planning

Current penetration across all industries (according to Gartner 2013)

99% Adopt by vast majority but not all data	30% Adopted by minorities	13% Still few adopters	3% Very few early adopters

Application domains of DSS

- Decision support systems apply to a large variety of domains:
  - Industry (manufacturing, automotive, avionics, food, energy ….)
  - Public sector (health, mobility, public administration)
  - Global challenges (climate change, poverty, conflict reduction, enviornmental health, natural disaster mitigation)

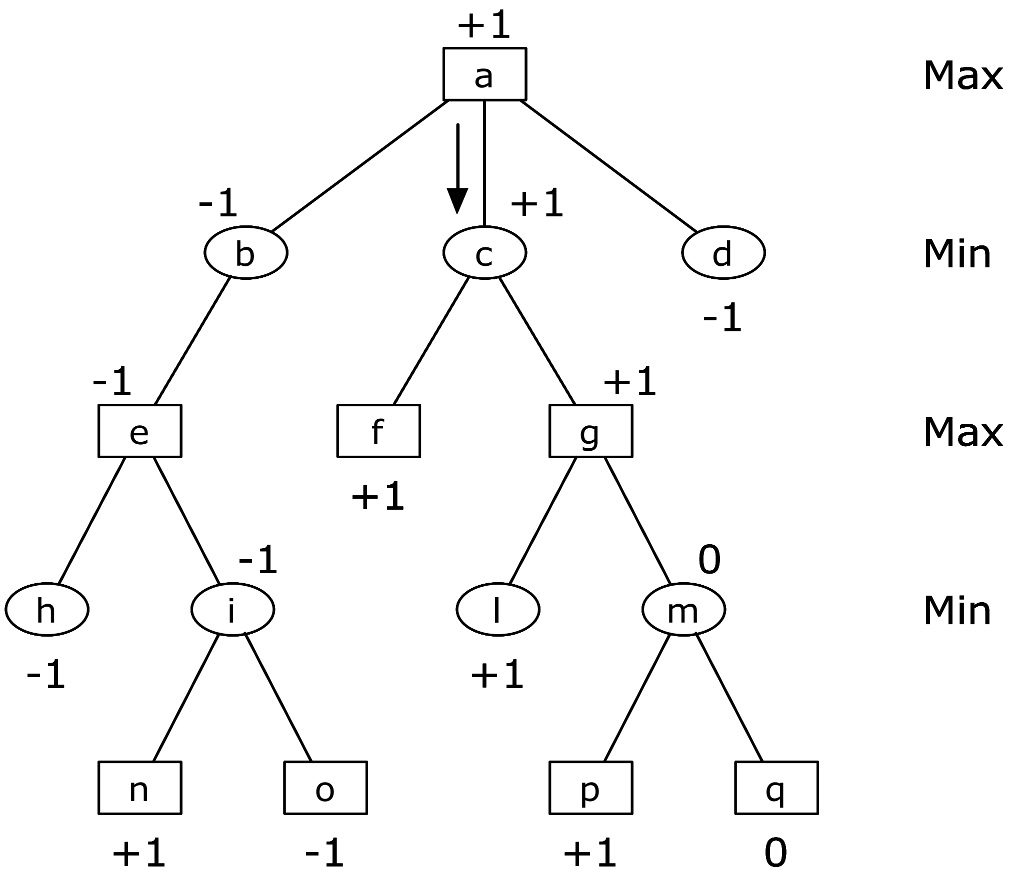
Games: Chess challenge

Deep Blue, IBM Risk 2000 …
- Evaluates 200 millions of moves per second
- knows 600.000 chess opening

- In 1997 Deep Blue beats Kasparov: is this intelligence?
- Chomski about Deep Blue, *“a computer program's beating a grandmaster at chess is about as interesting as a bulldozer's "winning" an Olympic weight-lifting competition”*

Algoritmo minmax → the brute force

- The min max algorithm is designed to define the optimal strategy for one player (max) and for suggesting the best move: for doing that the has makes the hypothesis that Min plays at his best.
- Huge problem space dimension. First move: 400 alternatives. Second move 144.000 ….. Combinatorial explosion
- We need an evaluation function that evaluates the position of each piece and the overall position on the chessboard.

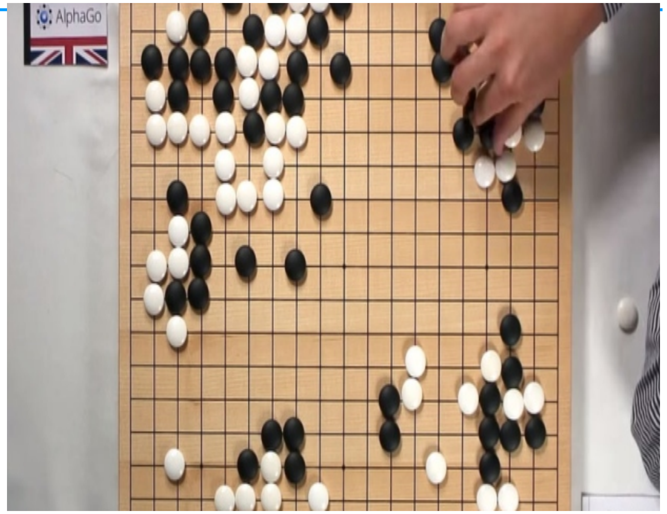


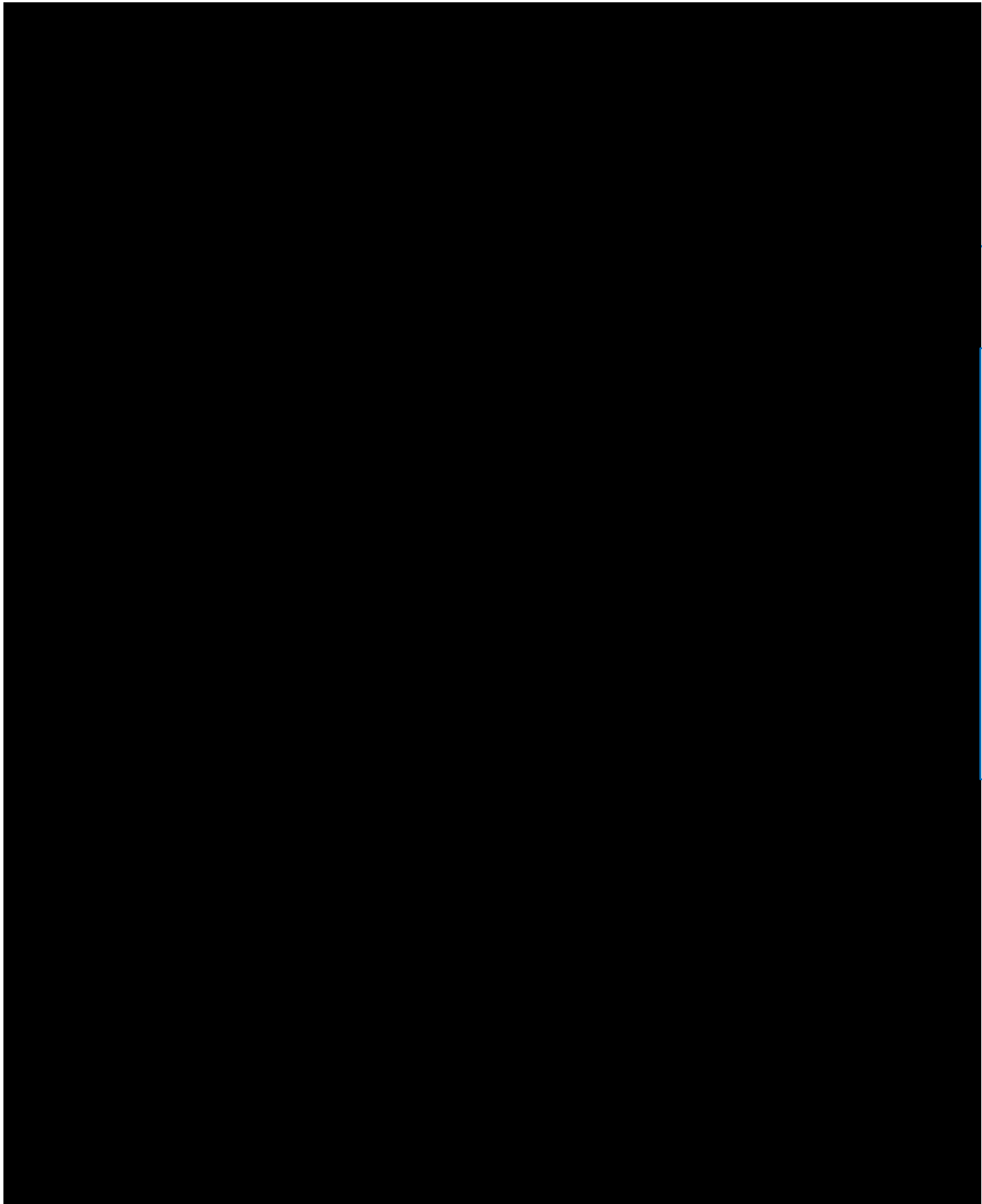
Games


Google DeepMind
Challenge Match
8 - 15 March 2016
AlphaGo
AlphaGo
Lee Sedol

Games AlphaGO

- AlphaGo has been developed from DeepMnd (acquired by Google in 2014). It learns to play videogames (49 games for Atari 2600) better than humans.
- Deep learning and simbolic techniques.
- **March 2016:** *AlphaGo beated Lee Sedol, world champion of Go*
- Way more complex than chess: 10^{170} possible positions (10^{50} for chess).
- IJCAI Marvin Minsky Medal for Outstanding Achievements in AI in 2017. Michael Wooldridge, Chair of the IJCAI Award: *“What particularly impressed IJCAI was that AlphaGo achieves what it does through a brilliant combination of classic AI techniques as well as the state-of-the-art machine learning techniques that DeepMind is so closely associated with. It’s a breathtaking demonstration of contemporary AI…”.*





DNN
Learning but not Deep Reasoning!

"After 240 minutes of training, [the system] realizes that digging a tunnel through the wall was the most effective technique…".

BUT...

The system does not know neither what is a tunnel nor what is a wall. It has learnt contingencies in specific scenarios.

Question answering and NLP Watson (IBM)

- Jeopardy is one of the most popular quiz in US since 1964
- You have possible answers (clue) and participants have to decide which is the most appropriate question for that answer. Es. The President of the United States in the sixties Proper question: Who is Kennedy?
- Watson, the supercomputer developed by IBM, won against Ken Jennings, famous for the record of 74 consecutive victories and Brad Rutter, in Feb 2011: 2 won and one tie for Watson.
- The knowledge in Watson has been built from texts, encyclopedia and the web.
- Watson is large like 10 fridges, it performs 80 trillion operators per second and reads 200 million pages in 3 seconds

John Searle: *"Watson Doesn't Know It Won on 'Jeopardy!' IBM invented an ingenious program—not a computer that can think."*

Noam Chomsky: *"Watson understands nothing. It's a bigger steamroller. Actually, I work in AI, and a lot of what is done impresses me, but not these devices to sell computers."*

Watson tells us that intelligence is a mixture between algorithms, knowledge and the way this is stored, used, organized.
Due tasks: text generation (humans better than computer) and answer generation (computer better than humans).

Element	Number of cores	Time to answer one Jeopardy! question
Single core	1	2 hours
Single IBM Power 750 server	32	<4 min
Single rack (10 servers)	320	<30 seconds
IBM Watson (90 servers)	2 880	<3 seconds

~1 000 000 million
lines of code
5 years development
(20 men)

Memory:
20 TB
200 million pages
(~1 000 000 books)

Internet and the Semantic Web

The Web contains everything an intelligent agent should "know". Search Engines always allow to retrieve the required information. The Web is a "distributed", "emergent", "autonomous" and "complete" repository of human knowledge.

Internet is full of information and knowledge and it can be used by humans and computers. It should be structured and made easier to retrieve.

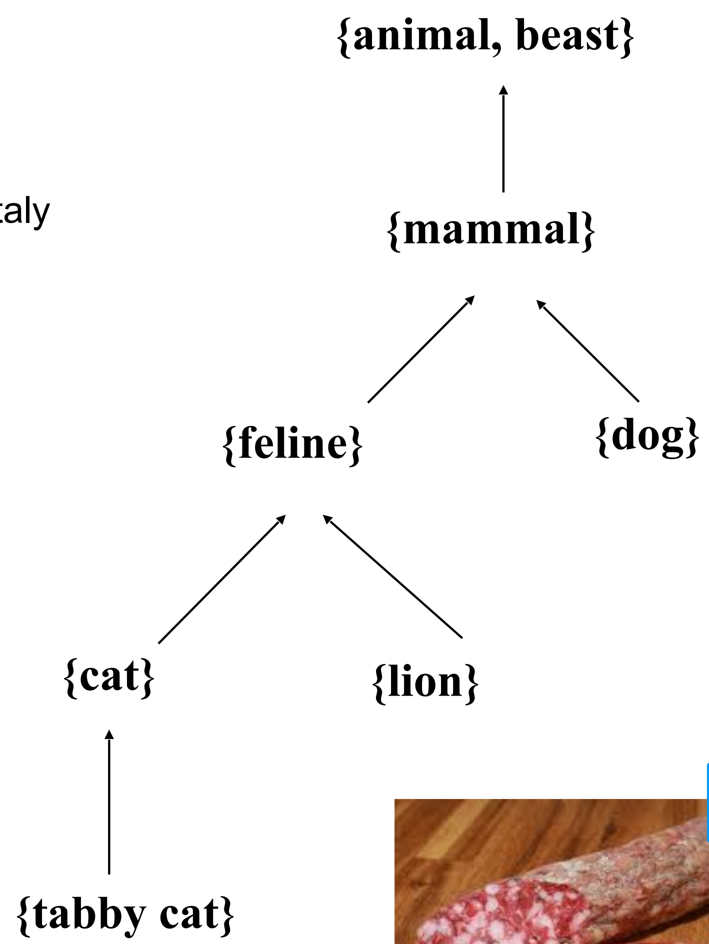
- ➔ Semantic web….. "*uses*" e "*reasons on*" Web data
- ➔ WWW development, memory cost reduction and mthe presence of unstructured big data, the augmented computing power, has changed the nature of AI applications.
- ➔ Storing all human knowledge and storing common sense in a usable way is possible. Can it be achieved now?
- ➔ Knowledge should be organized and structured: Ontologies

Simple example

- Through ontologies, we can add semantis. The cat and lion are both feline so are subclasses of this concept
- Each time I search for «feline» both cats and lions images will be found even if none of them has been tagged as feline.

- Ontologies are also used to solve natural language ambiguity. In italy for examklpe Feline is a salami type.

- WordNet: https://wordnet.princeton.edu/
- BabelnNet https://babelnet.org/



Text-to-speech

Google: Tacotron 2, is a text-to-speech system based on neural networks.

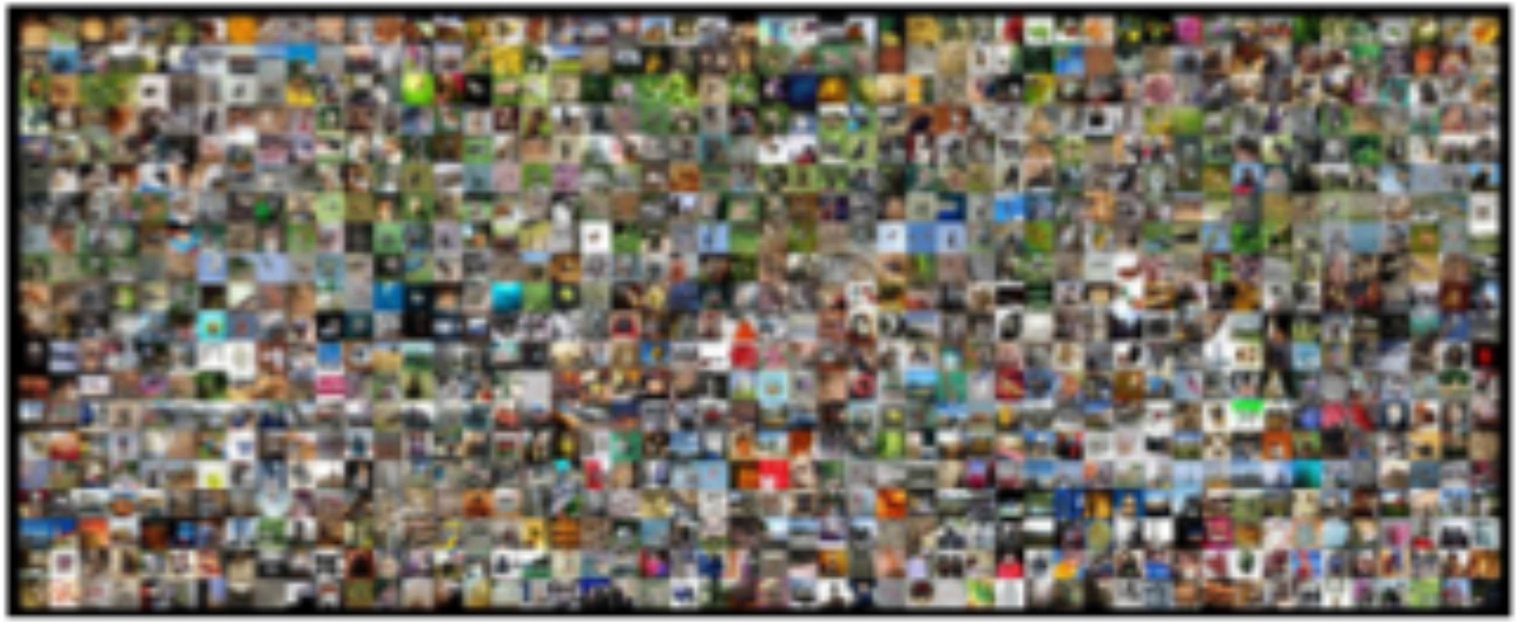
https://google.github.io/tacotron/publications/tacotron2/index.html

“George Washington was the first President of the United States.”

One of the audio is human while the other is synthetic voice
They are indistinguishable.

Computer Vision

- **ImageNet Challenge**: Universal image classifier
  - 14M images
  - 20k categories
  - Tagged via crowdsourcing
  - Labelled with the WordNet hierarchy
- In 2011 classification error 26%, today 3% (humans are less efficient: error 5%).



[Figure from vision.stanford.edu]

Russakovsky, O., Deng, J., Su, H., Krause, J., Satheesh, S., Ma, S., ... & Fei-Fei, L. (2015). Imagenet large scale visual recognition challenge. arXiv preprint arXiv:1409.0575.

Computer Vision

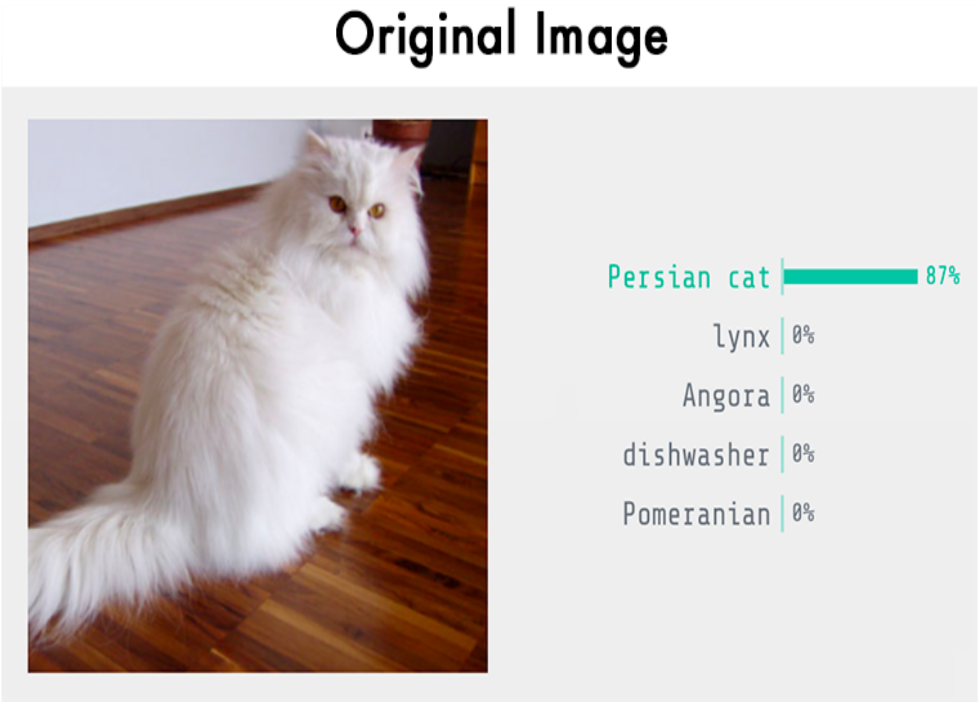
[Figure from Krizhevsky et al., 2012]

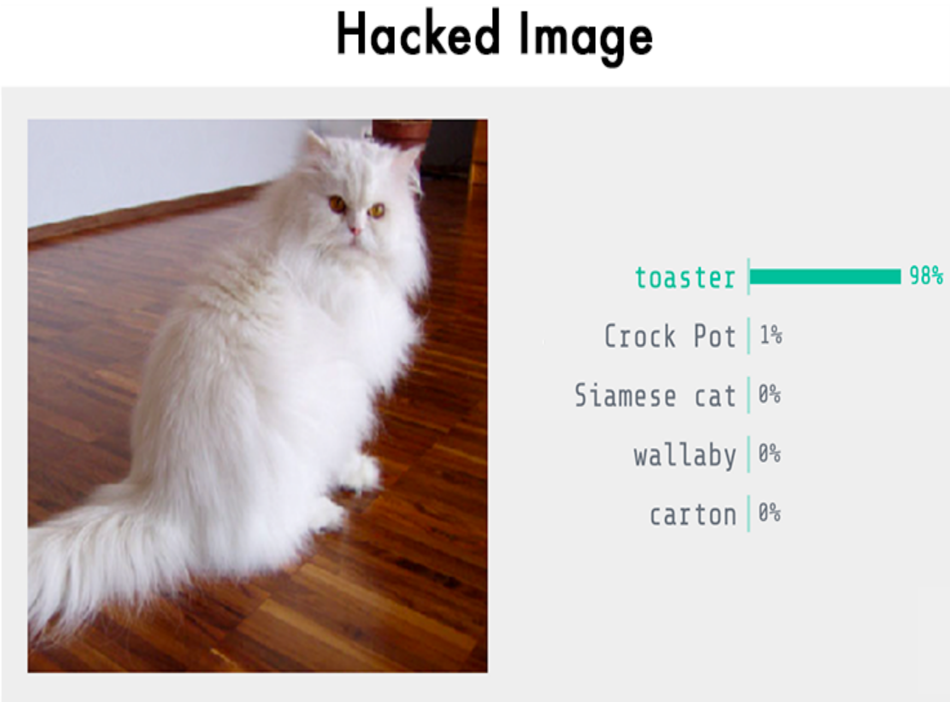
Captioning

- Describe the content of an image (from Google).

DNN: sometimes they make big mistakes!

DNN can be unstable: by applying some perturbations to inputs we can arbitrarily change the output.





"Only modification of some pixels not evident to the human eye".
https://medium.com/@ageitgey/machine-learning-is-fun-part-8-how-to-intentionally-trick-neural-networks-b55da32b7196

Can we trust DNN

DNN are extremely effective in perception tasks but….

“Are data and computational power eager and work in a known and stable world.”

We coud have problems is we work on new data that are far from the training data (overfitting)

Data might be biased (more on this later)

“Hardly explainable”

Millions of parametrs that are hard to understand not onlyby users but also by developers. Noe easy to explain the reason of a decision.

“Do not distinguish between causality and correlation”

DNN are statistical techniques that can discover complex and non linear correlations between input and output but these are not necessarily cause-effect relations. Just curve-fitting.

“Not trustworthy”

They can make big mistakes that are “different” from mistaked made by humans.

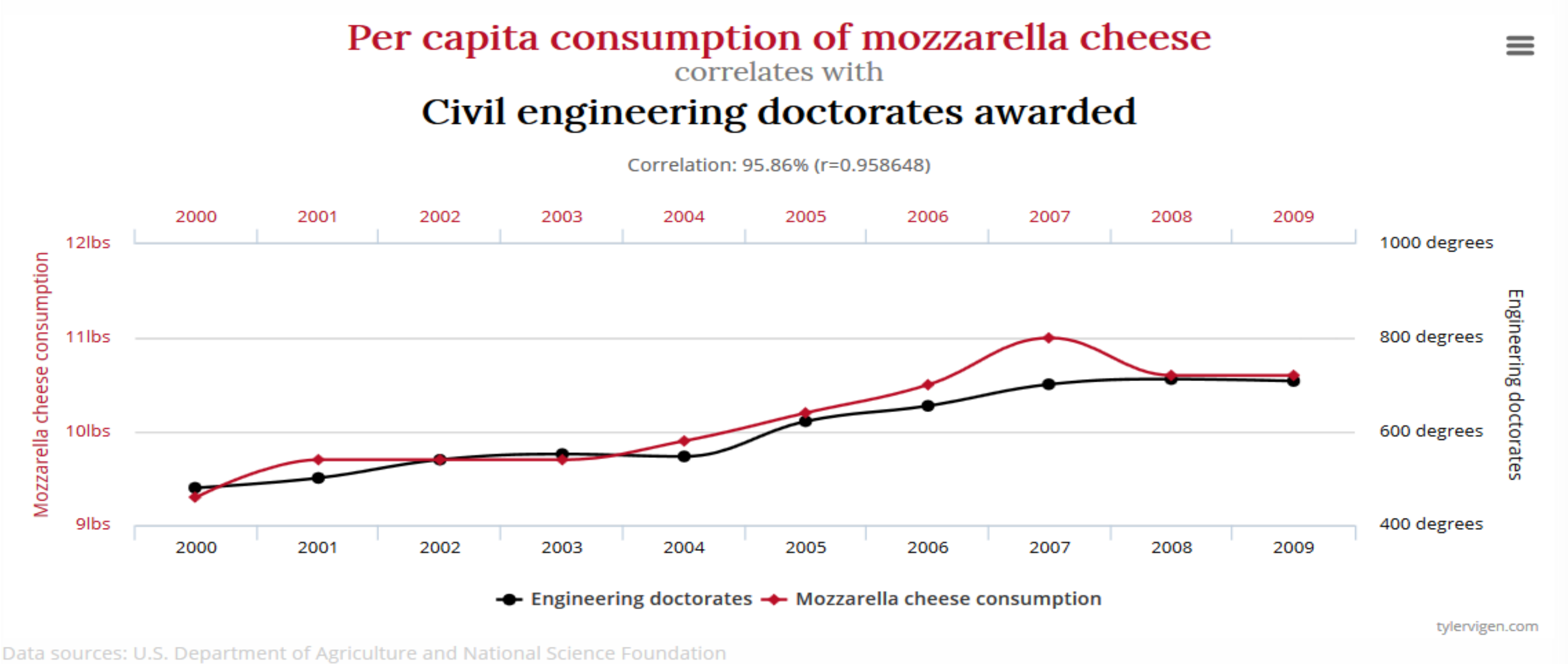
THE BOOK OF WHY: The New Science of Cause and Effect
Judea Pearl , Dana Mackenzie, 15 May 2018.

Gary Marcus, “Deep Learning: A Critical Appraisal”. CoRR abs/1801.00631 (2018).

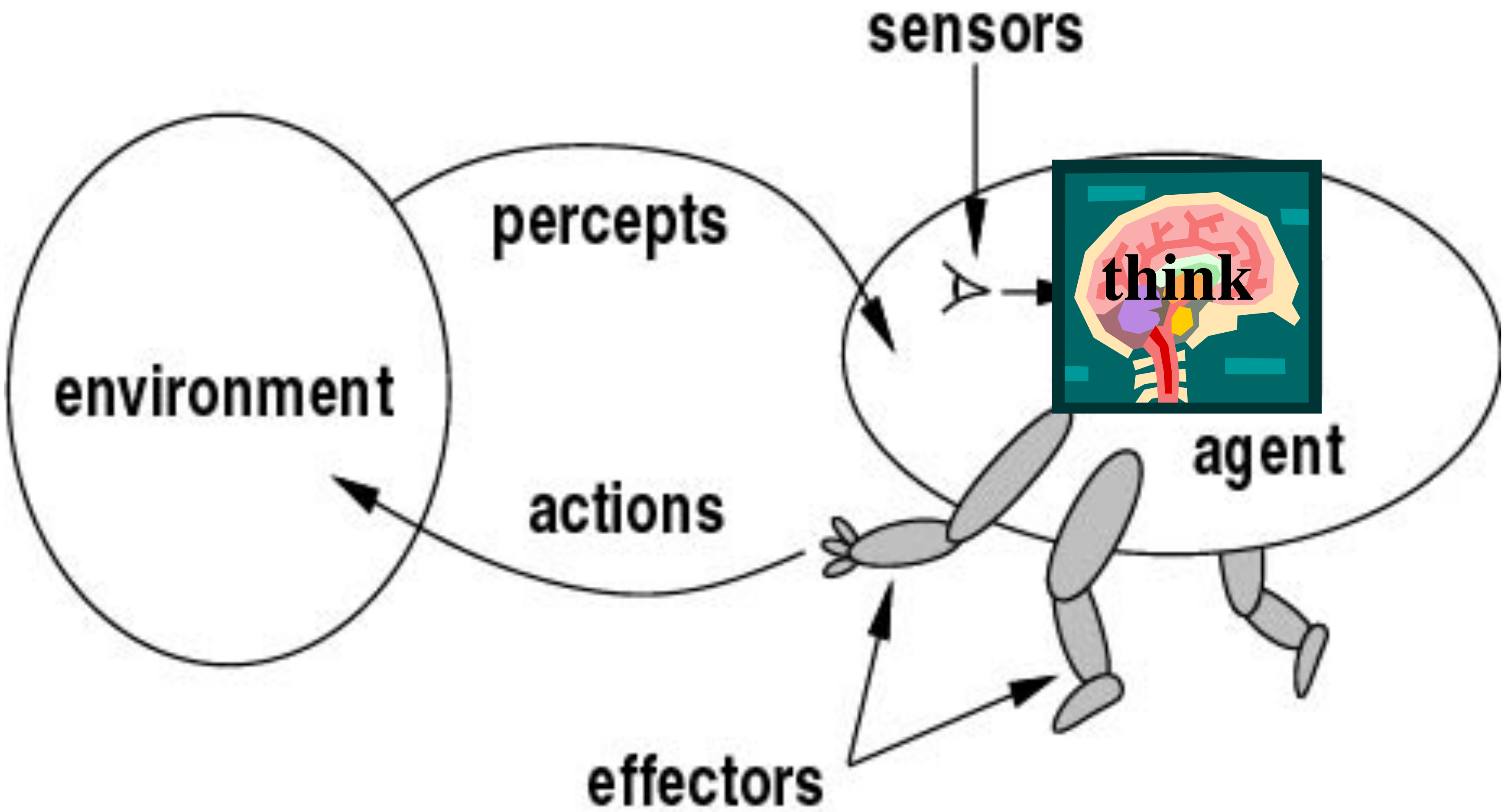
“Explainable Artificial Intelligence: Understanding, Visualizing and Interpreting Deep Learning Models”, W. Samek, T. Wiegand, K. Müller (August 2017).

Far from causality

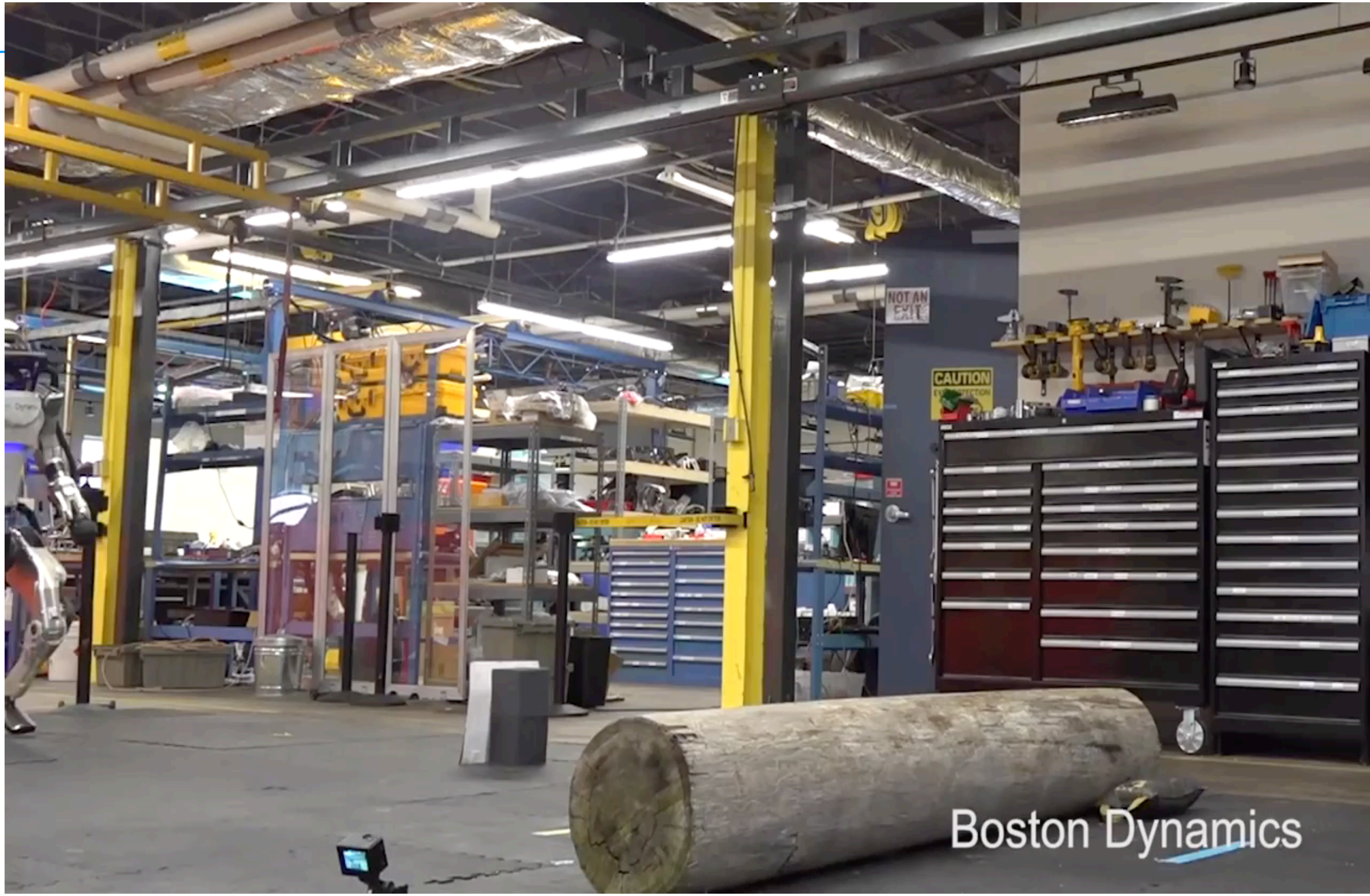
Funny example: http://tylervigen.com/spurious-correlations



Mind needs a body



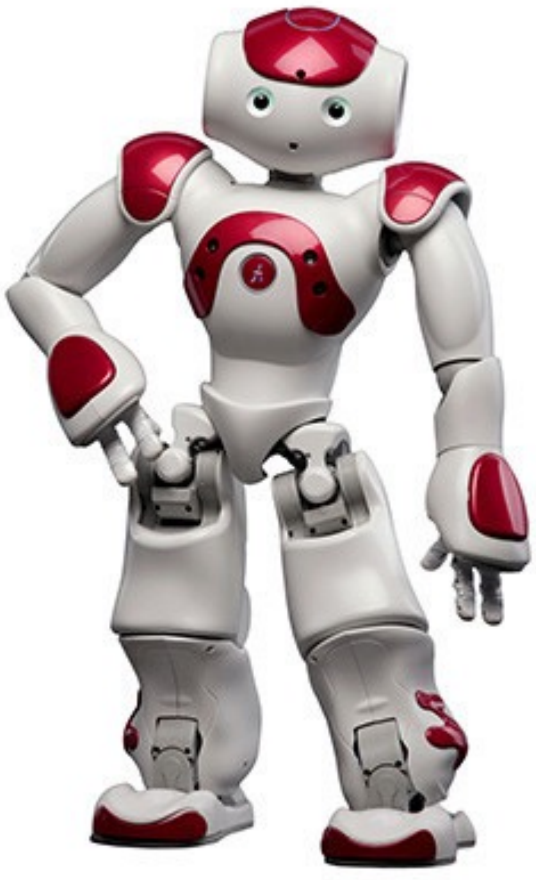
Atlas doing Parkour (Boston Dynamics)

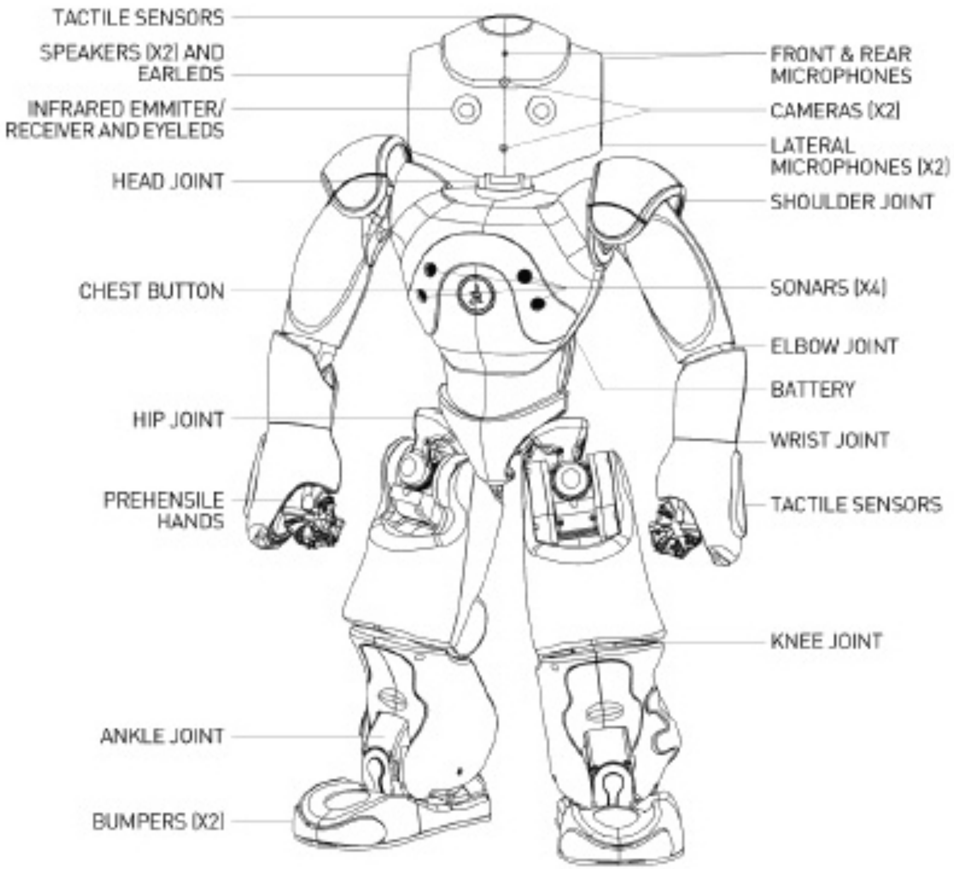


Robocup

- Contest started in Japan in 1997 with the goal of creating a soccer team within 2050 able to play against (and possibly beat) the world champion team
- Too ambitious? Deep Blue has been created 50 years after the first computer was invented, Moon landing (1969) 50 years after the first airplane.
- New challenge very different from games: immersed in an environment
- Autonomous Robots, with real-time sensing, reaction, communication, vision, perception, movement, coordination, planning learning cababilities.
- Full Turing Test

Nao: structure





ALDEBARAN Robotics

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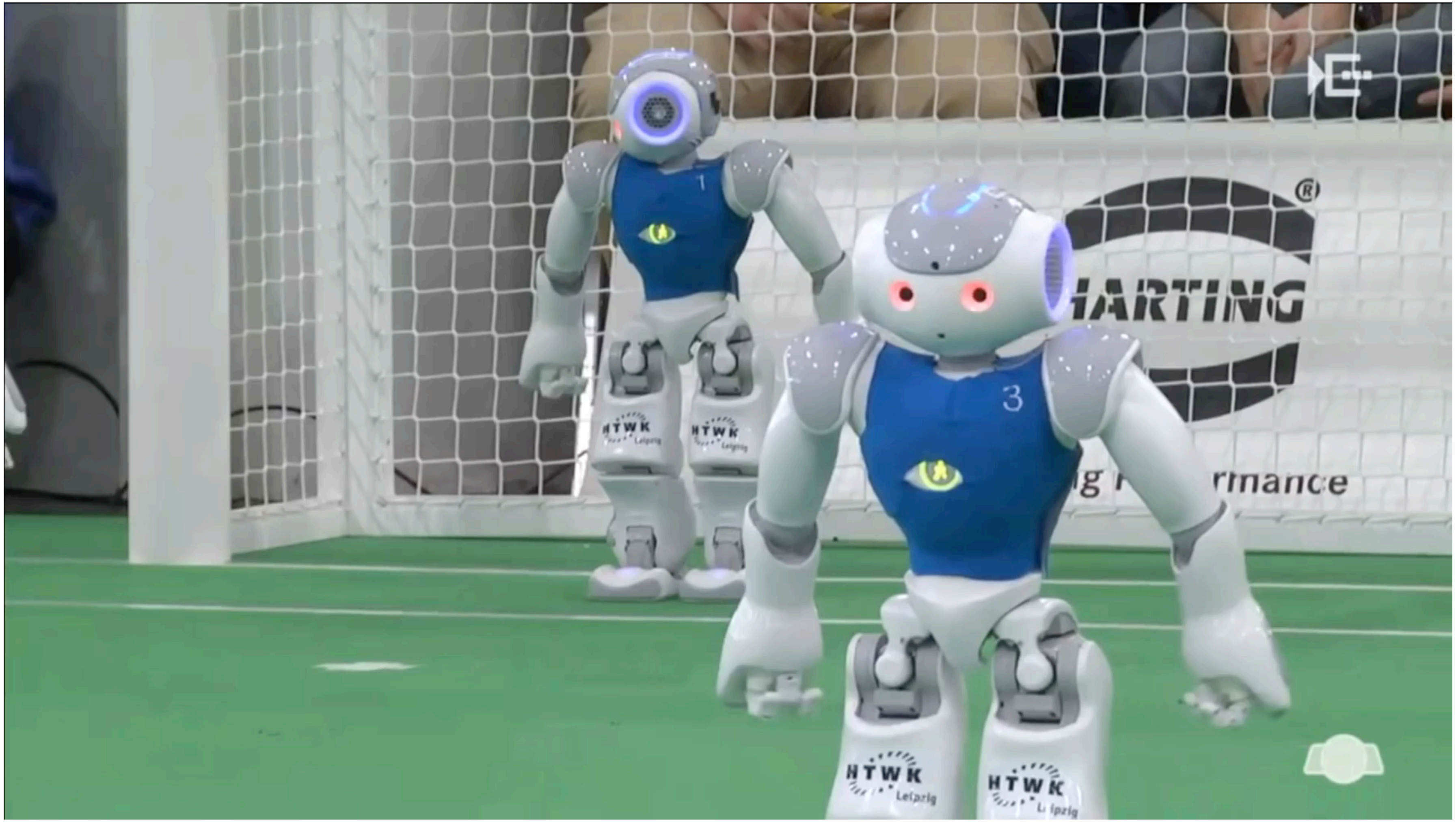
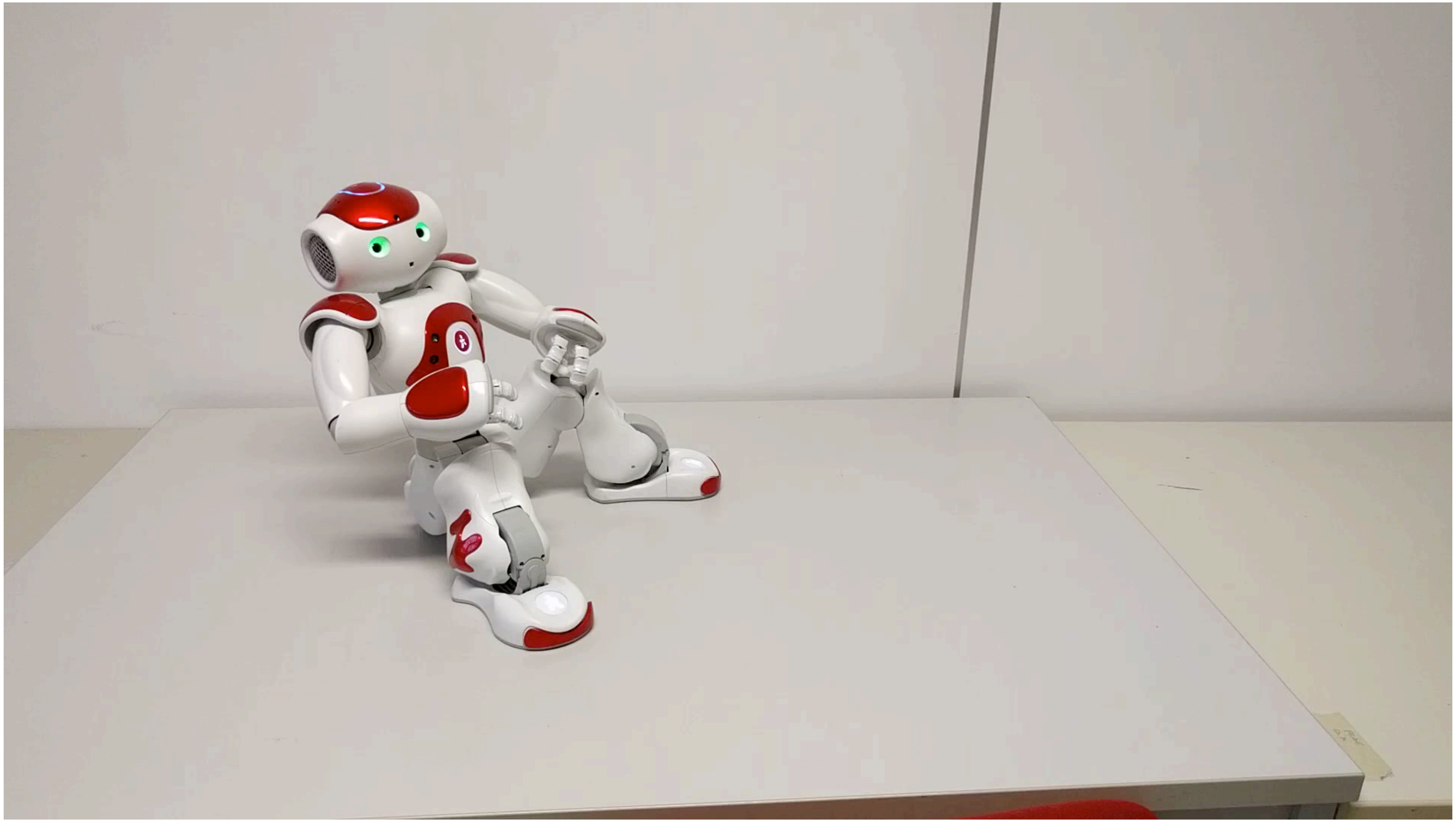
NAO and Robocup

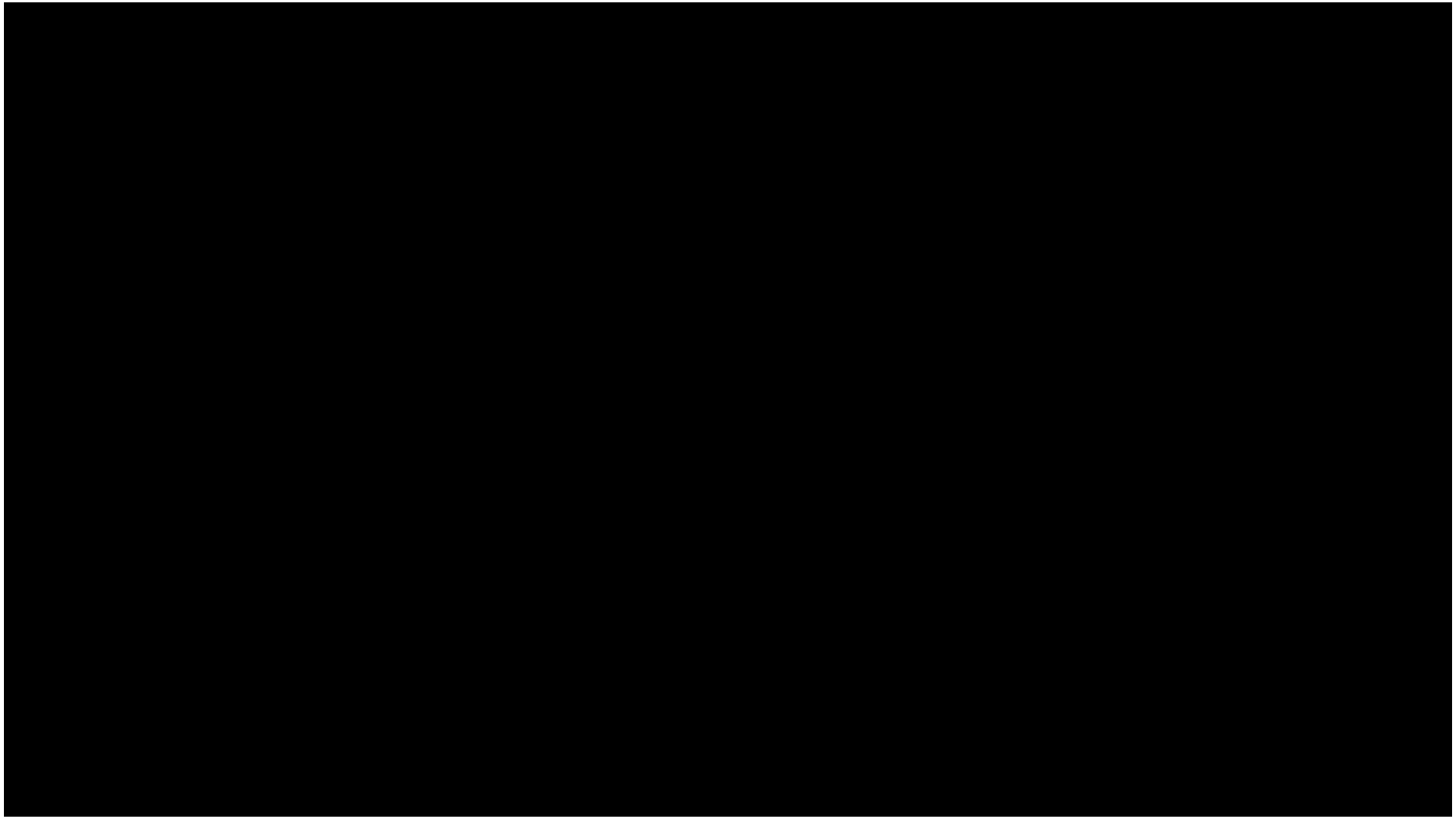


By Nao-Team HTWK, Università di Lipsia

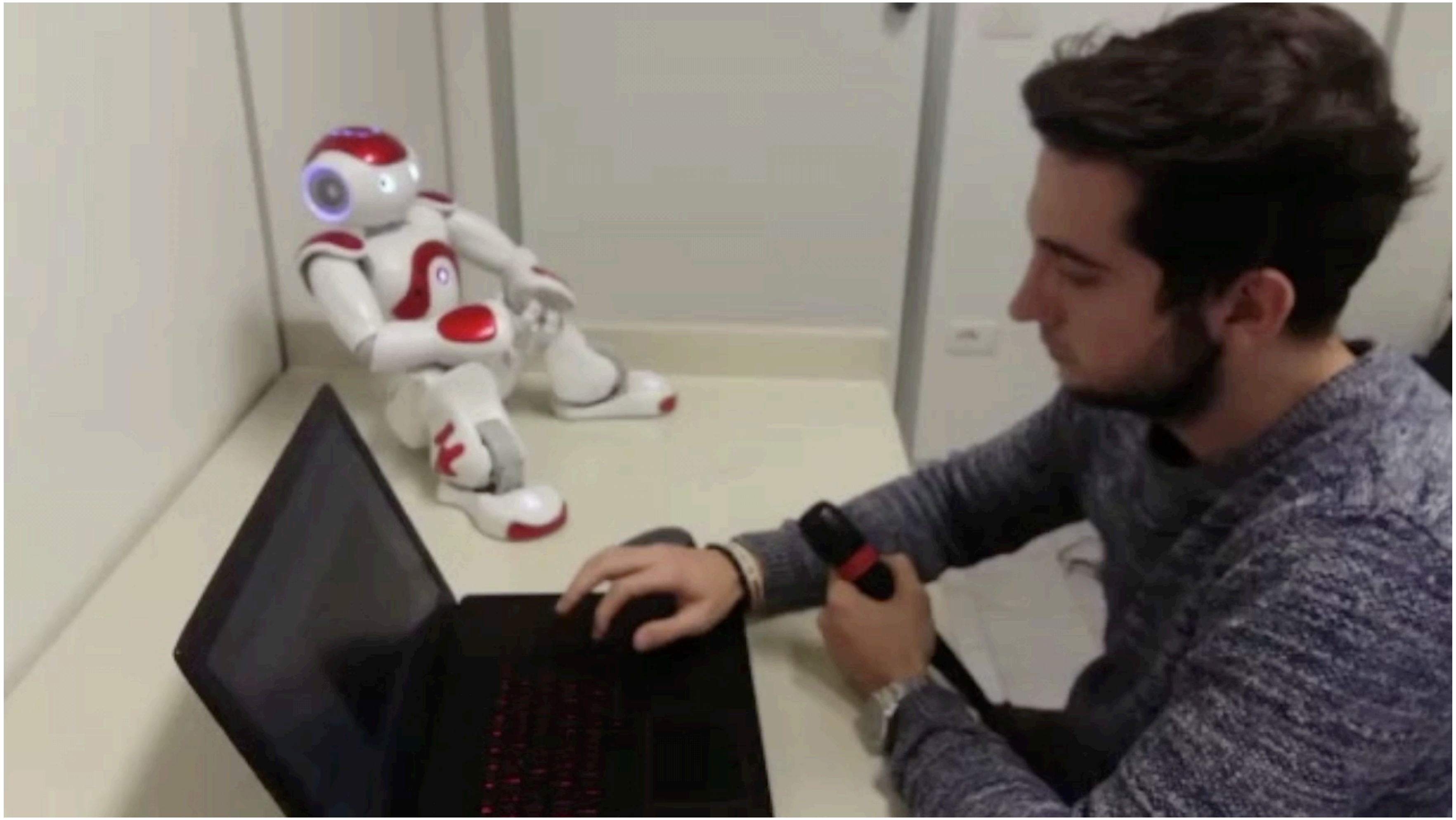
Nao reads a text (in italian)



Nao plays with natural language



Nao solves math expressions



Thesys of Paolo Magnani – Università di Bologna