Intelligent systems for industry, supply chain and environment

LESSON 4

What is intelligent? Machine learning basics, Digital ages, Simulation of the exam




Outline

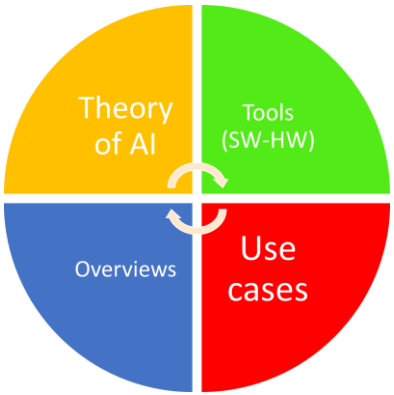
- Theory
  - What is intelligent?
  - Representation
  - Evaluation
  - Optimization
- Current and future scenarios where the intelligent systems play a relevant role
- Digital Ages
  - Collaborative age
  - Autonomous age
- Simulation #1of the exam with comments
- **Main points**




THEORY

What is intelligent?

What are the feature to call intelligent a system?



Artificial Intelligence (AI) vs Machine learning (ML)

- AI:
  is the broader concept of machines being able to carry out tasks in a way that we would consider “**smart**”.
- ML:
  a current application of AI based around the idea that we should really just be able to give machines access to data and let **them learn for themselves**.

Artificial Intelligent Systems

- SW programs or SW/HW systems designed to perform **complex tasks** employing strategies that mimic some **aspect of human thought**
- One can debate endlessly about whether a certain system is intelligent or not
- The key is **evolution**: it is intelligent if it can **learn** (even if only a limited sense) and/or get better in time

ML is NOT for all applications..

- IF
  - the nature of computation required in the task is not well understood

  OR
  - there are too many exceptions to the rules

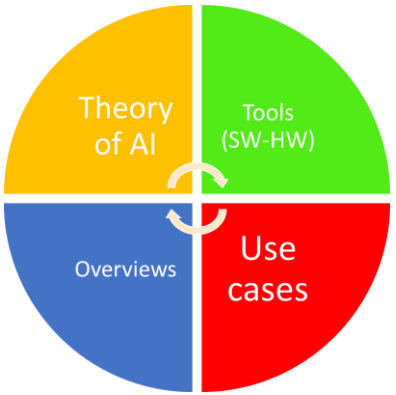
  OR
  - known algorithms are too complex or inefficient
- THEN
  - AI can be considered as a possible solution



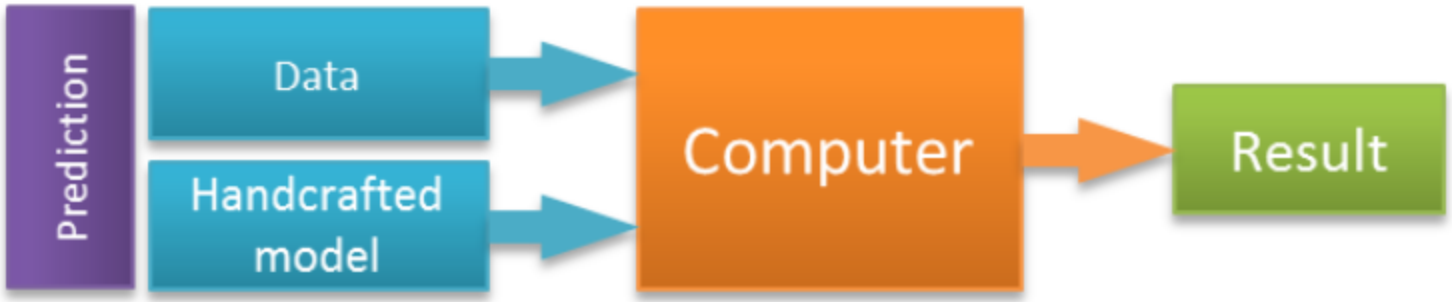

THEORY

Machine learning basics

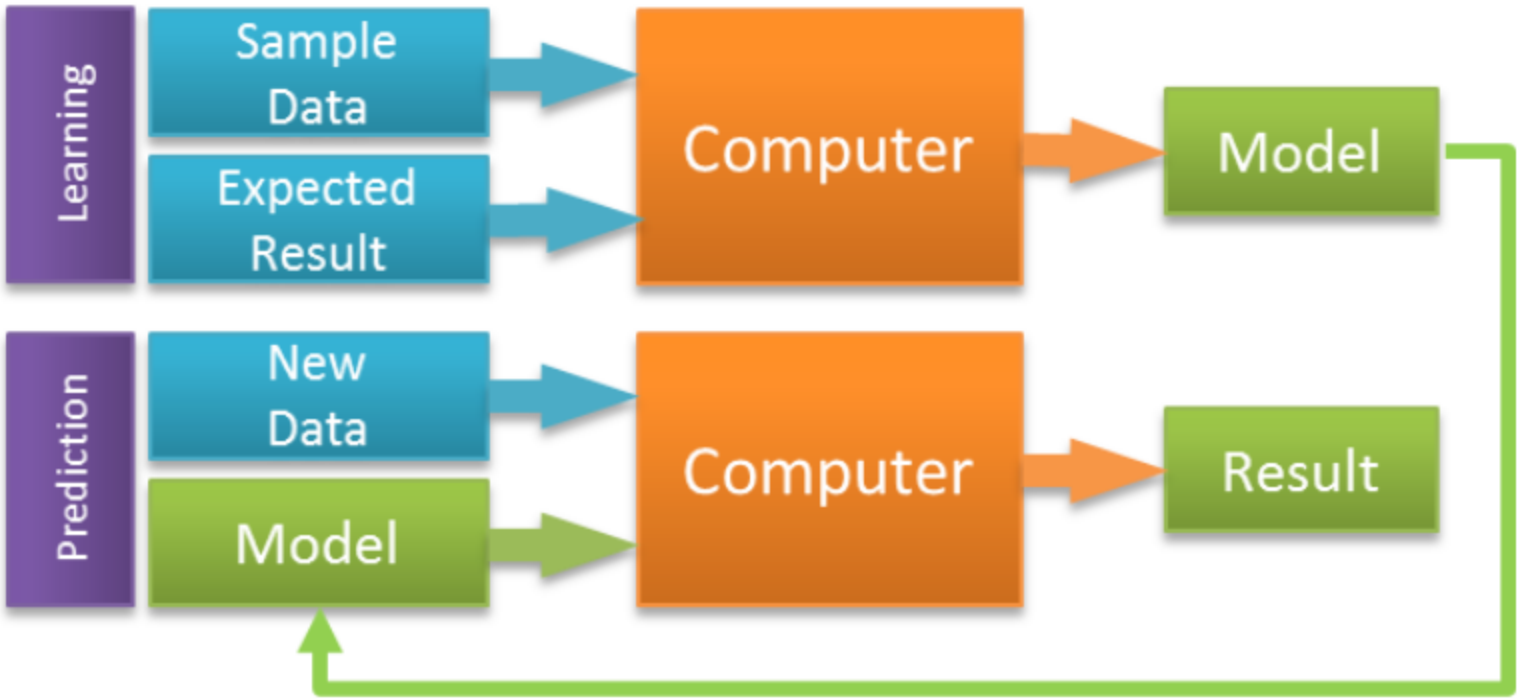
Model, Training, Evaluation



Traditional modeling:

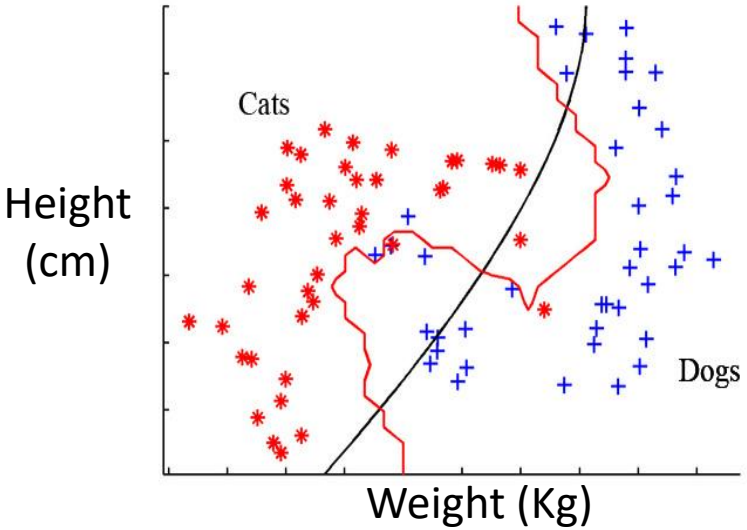


Machine Learning:

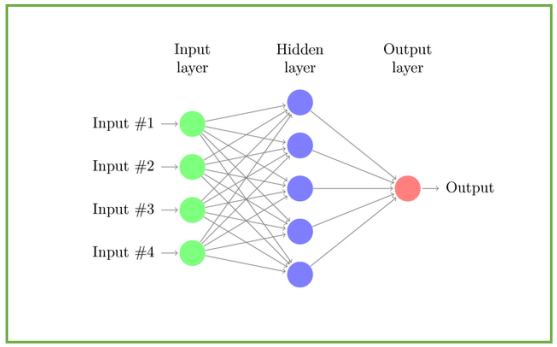


Example: Dog/Cat classifier

- Classical programming
  - IF ((W>A) AND (H<B)) → dog
  - IF ((A*W+B*H+C)>Z) →dog
- ML
  - Table of classified data
  - Train a model Y=F(X)
  - Dog = IF (F(X)>0)



F() ≡



Model

ML in a metaphor

It’s like gardening

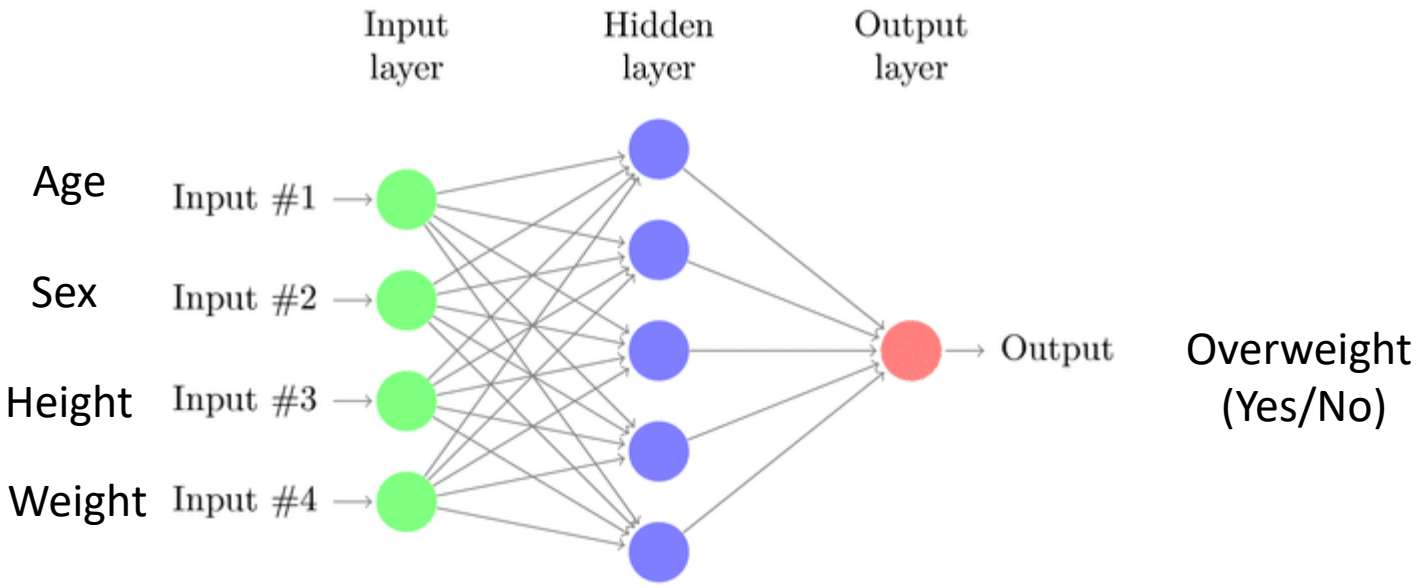
- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs

So… What Is Machine Learning?

- Automating automation
- Getting computers to program themselves
- Writing software is the bottleneck
- Let the data do the work instead

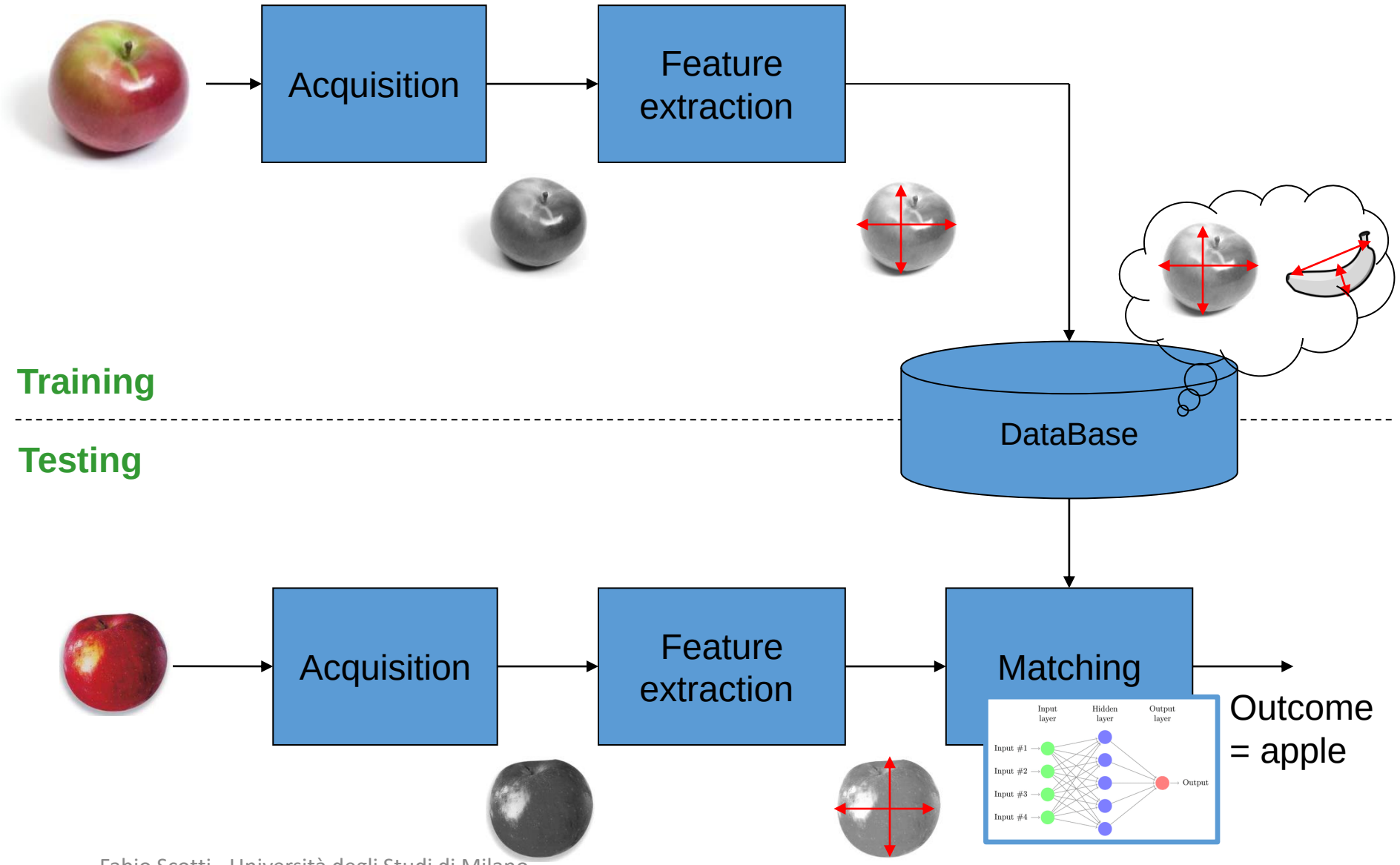
Example: Neural Network

- Without lack of generality in the following we will refer to the feed-forward NNs



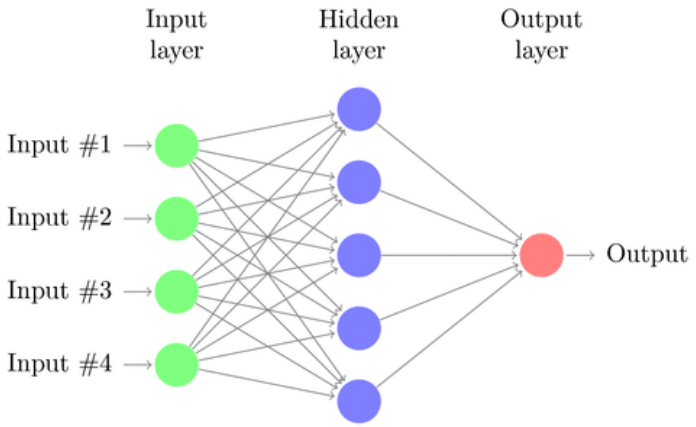
Aggiungiamo una feature: Sport?

Pattern Recognition Systems

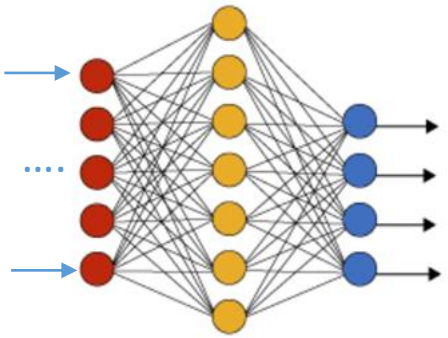


ML: the 3 main components

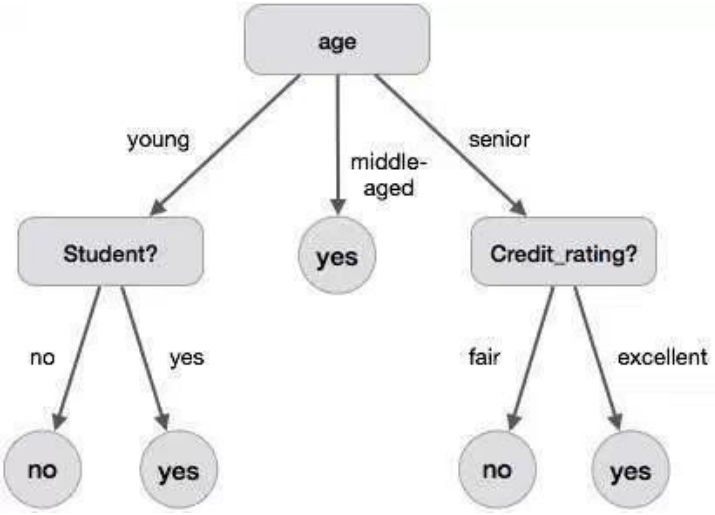
- Tens of thousands of machine learning algorithms. Hundreds new, every year
- Every machine learning algorithm has **3 components**:
  - Representation
  - Evaluation
  - Optimization



Representation



- Decision trees
- Sets of rules / Logic programs
- Instances
- Graphical models (Bayes/Markov nets)
- Neural networks
- Support vector machines
- Model ensembles
- Etc.



About Representation: we have different features

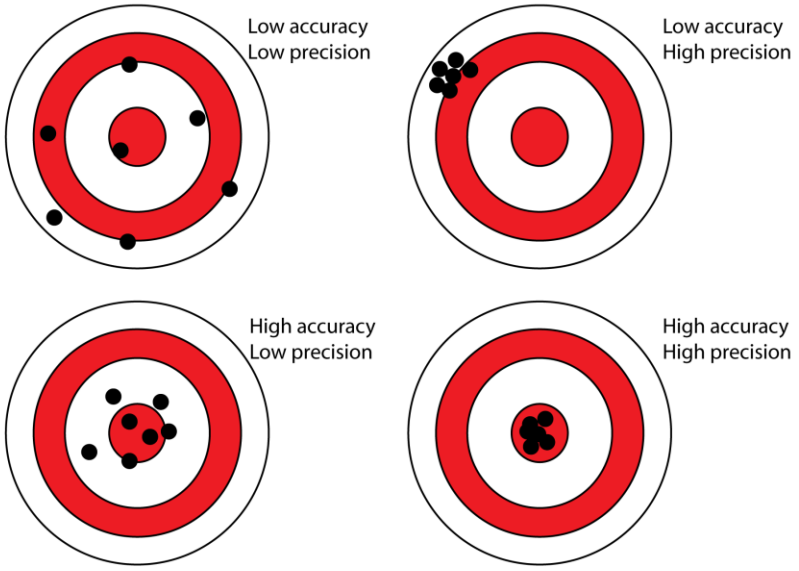
Which features is relevant for your application?
(This is not the complete list)

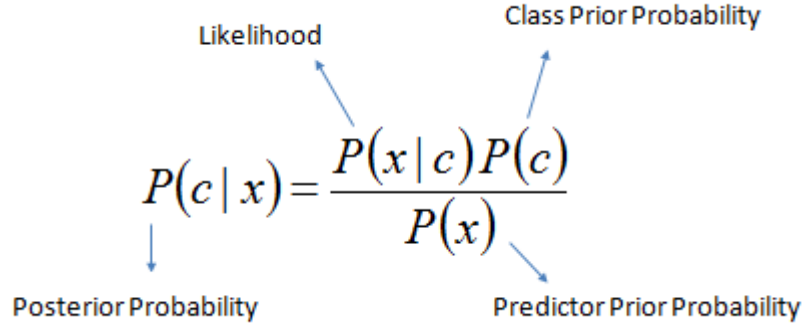
AI Method	Distributed	Real-Time	Embedded	Robust	Autodidactic	...
Artificial Neural Network	✓	✓	✓	✓	✗	
Bayesian Network (dynamic structure)	✓	✗	✓	✗	✗	
Bayesian Network (static structure)	✓	✓	✓	✗	✓	
Expert System	✓	✗	✗	✗	✓	
Reinforcement Learning	✓	✗	✓	✗	✗	
Random Forest	✓	✓	✓	✓	✗	
Support Vector Machine	✓	✓	✓	✓	✗	

Autodidactic:
should support being updated with
new information as it becomes available.

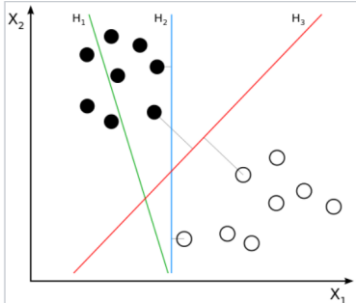
Evaluation

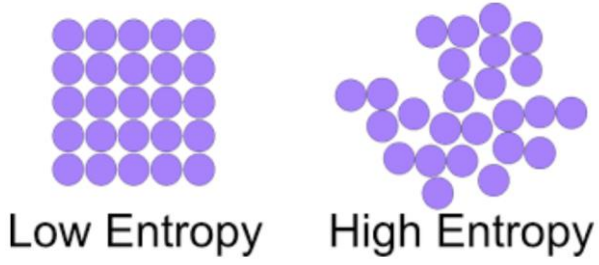
- Accuracy
- Precision and recall
- Squared error
- Likelihood
- Posterior probability
- Cost / Utility
- Margin
- Entropy
- K-L divergence
- Etc.



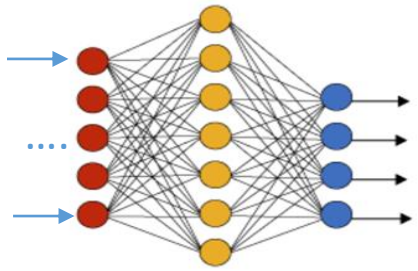


Having in input *x*, which is the probability that is a dog (Hypot. *c*)?

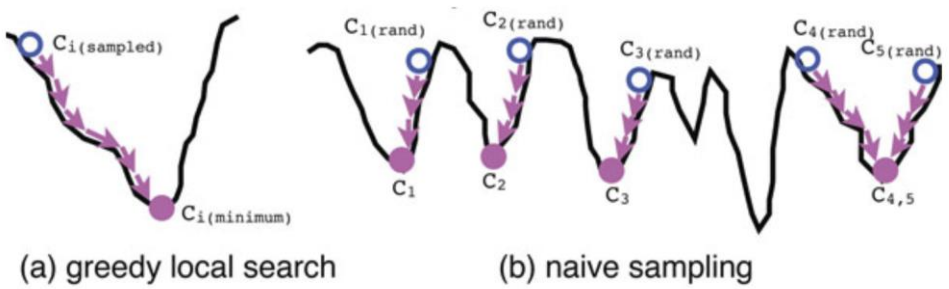




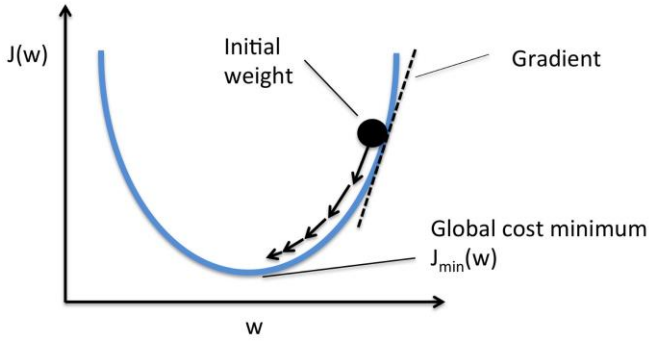
Optimization



- Combinatorial optimization
  E.g.: Greedy search



- Convex optimization
  E.g.: Gradient descent

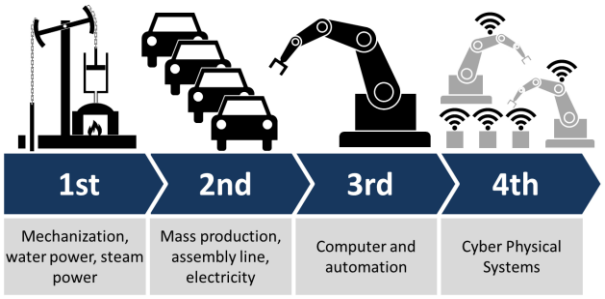


- Constrained optimization
  E.g.: Linear programming

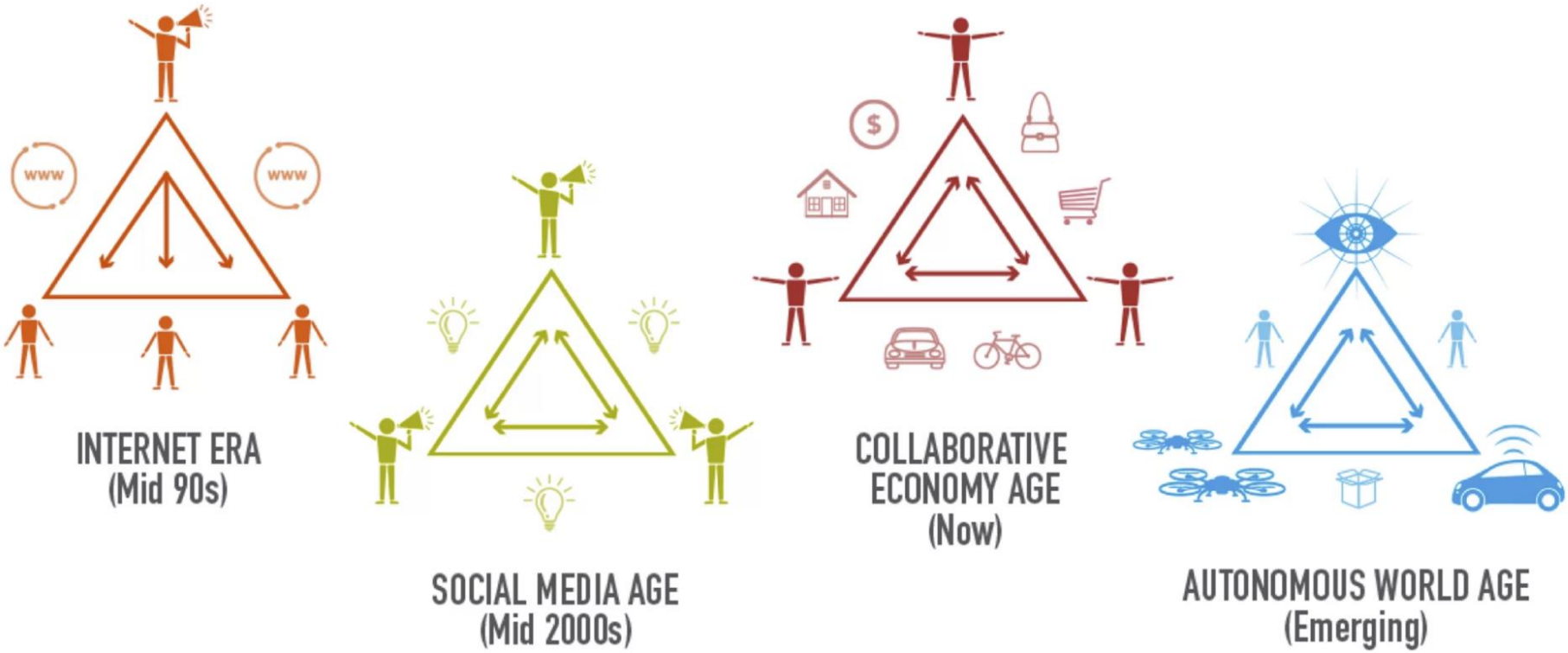



Overview

Digital ages and recent challenges

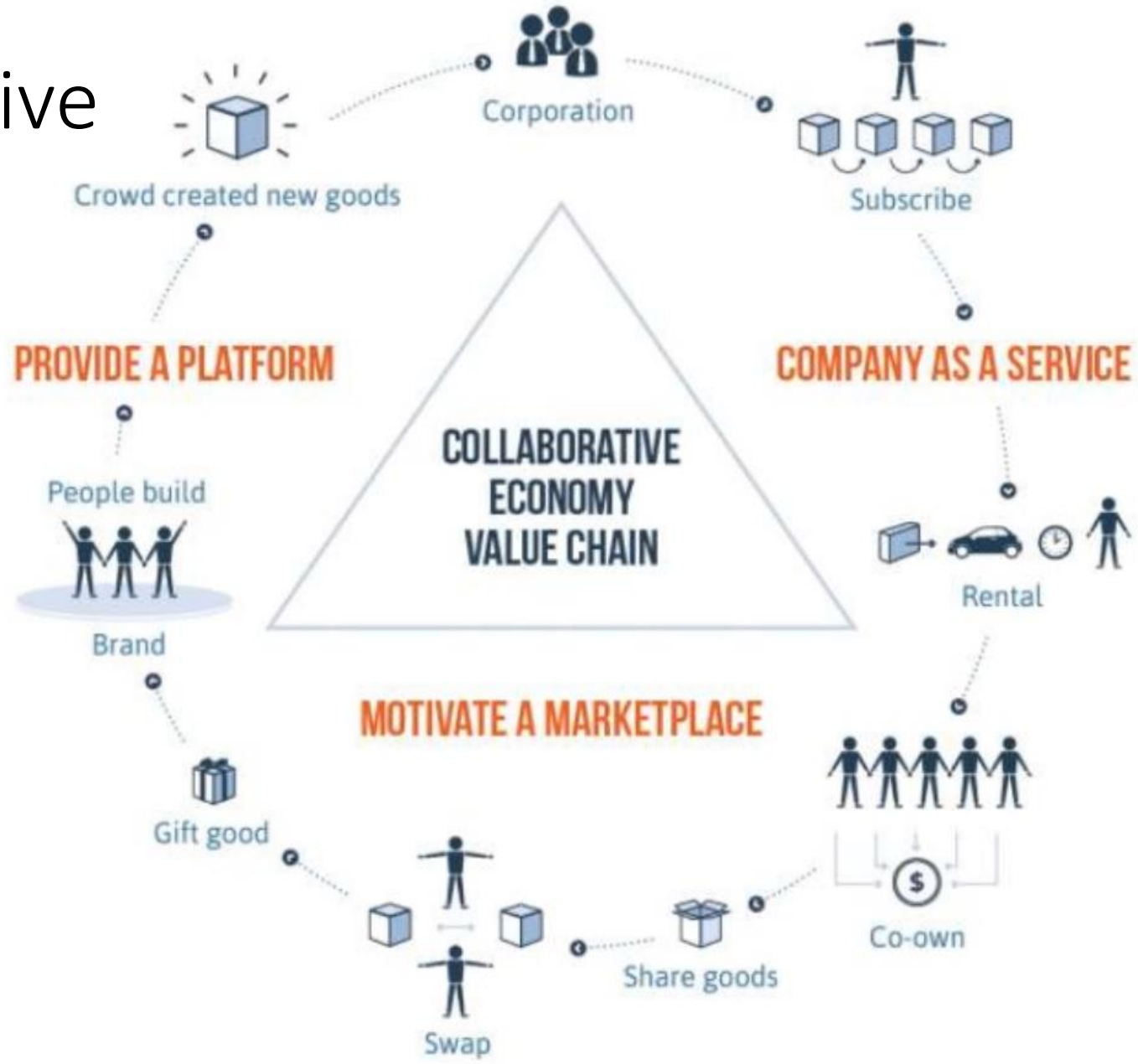


The 4 phases of the digital ages

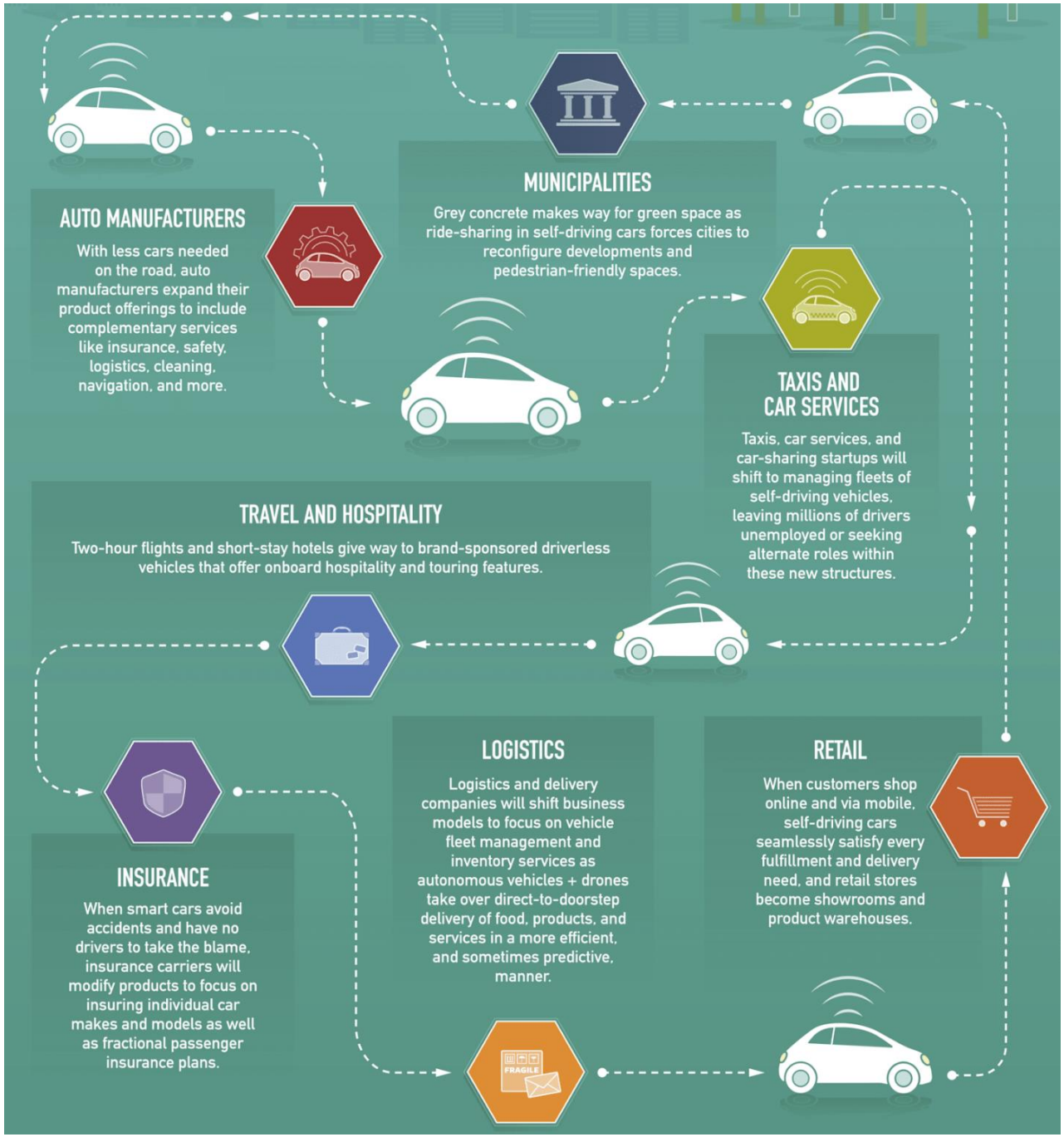


Autonomous world:
intelligent technology systems (operating without human participation) enable new business models in a more efficient society.

(3) Collaborative economy

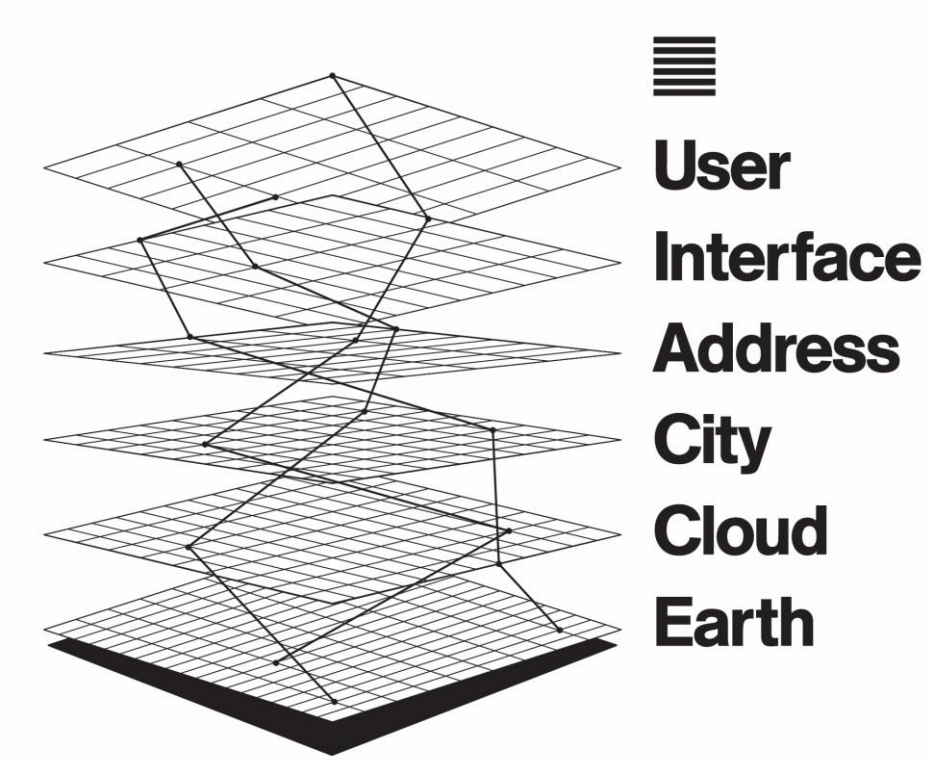


(4)
Robots
+
Autonoum.
+
Int. Sys



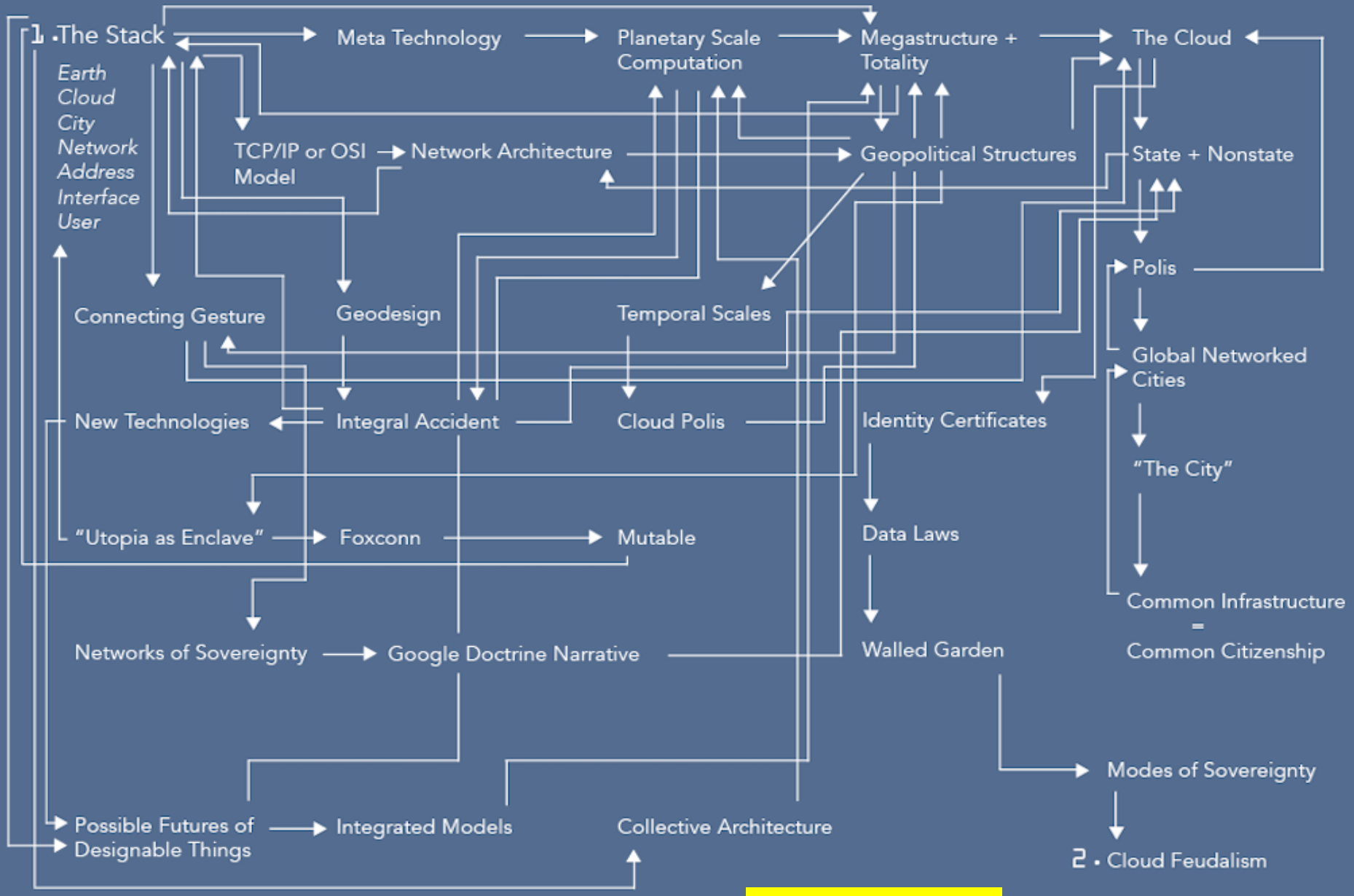
The Bratton's stack

Benjamin H. Bratton
Sociologist



These different genres of computation —smart grids, cloud platforms, mobile apps, smart cities, the Internet of Things, automation— can be seen not as so many species evolving on their own, but as forming a coherent whole: an **accidental megastructure** called "The Stack" that is both a computational apparatus and a **new governing architecture**. We are inside "The Stack" and it is inside of us.

THE CLOUD, THE STATE, AND THE STACK: METAHAVEN IN CONVERSATION WITH BENJAMIN BRATTON



(not in the exam!)

VSOON 031515

A digital word:
challenges for environment and industries

- Players are facing huge challenges but across the globe relevant initiatives are present for example:
  - Industry 4.0
  - Internet of Things (IoT)
  - Internet of Everything (IoE) - Cisco def.

- Artificial intelligence

  →increasing relevance in every application!




EXAM SIMULATION

To TEST your preparation

(do not use the simulation to study)

Please remember

Multiple-choice test:

- 1 single correct answer → *weigth = 1*
- N wrong answers → *weigth = 0*
- ~~1 (rarely 2) very bad answer → *weigth = -1*~~ (No more)

1. No penalties for not answering
   →OK BUT IT'S BETTER TO TRY TO ASWER
2. DO NOT LOOK FOR THE RIGHT ANSWER, EXCLUDE THE WRONG ONES
3. DOUBTS? → Choose the answer that "looks less wrong" to you

.Q1

Nowadays, the usage of *classical feature extraction* and *data analysis methods* is outdated since the capability of the recent deep learning models and methods made them obsolete and not more present in the common practice.

1. True
2. False

.Q1

Nowadays, the usage of *classical feature extraction* and *data analysis methods* is outdated since the capability of the recent deep learning models and methods made them obsolete and not more present in the common practice.

1. True
2. False ←correct

Comment: most part of the job is about prepare, study and validate the data to create efficient datasets, also with classical tools!

..Q2

Artificial Intelligence can be applied to the following sectors

1. Robotics
2. Information extraction
3. All the above

..Q2

Artificial Intelligence can be applied to the following sectors:

1. Robotics
2. Information extraction
3. All the above ← correct

Comment: the range of applications is really exploding including 1) and 2)

...Q3

Artificial neural networks are capable to learn human biases.

1. False: the achievable complexity of the artificial neural networks is so far from the complexity of the human brain to make impossible to mimic this characteristic
2. False: human biases are not reproducible nor measurable
3. True.

...Q3

Artificial neural networks are capable to learn human biases.

1. False: the achievable complexity of the artificial neural networks is so far from the complexity of the human brain to make impossible to mimic this characteristic
2. False: human biases are not reproducible nor measurable
3. True ← correct

Comment: it's true because the humans prepare the datasets, and the statistical distribution of the samples among different labels and classes can strongly influence the learning of the artificial intelligent models.

....Q4

Recent artificial intelligence models can solve analogy puzzles like
“Paris is to France as Tokyo is to ?”
producing the correct answer “Japan.”

1. True
2. False

....Q4

Recent artificial intelligence models can solve analogy puzzles like
“Paris is to France as Tokyo is to ?”
producing the correct answer “Japan.”

1. True ← correct
2. False

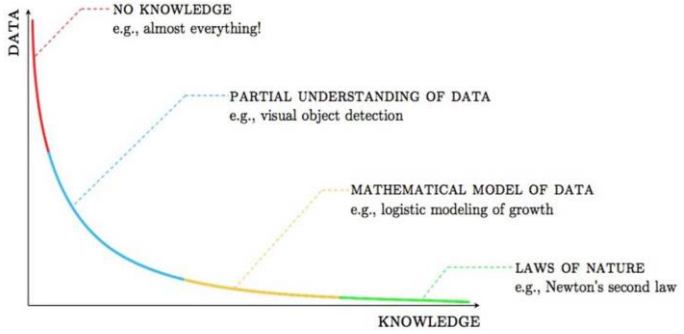
Comment: yes. So-called “word embeddings” that are often used as input for a neural network are learned from large text collections and are able to solve analogy puzzles.

.....Q5

Considering the “Data knowledge spectrum plot” discussed in class, the **minimum** amount of data required is in the following case.

1. No knowledge about the model generating the data is available
2. A statistical model of the process is available
3. A mathematical model of the process is available

.....Q5



Considering the "Data knowledge spectrum plot" discussed in class, the **minimum** amount of data required is in the following case.

1. No knowledge about the model generating the data is available
2. A statistical even is limited model of the process is available
3. A mathematical model of the process is available ← correct

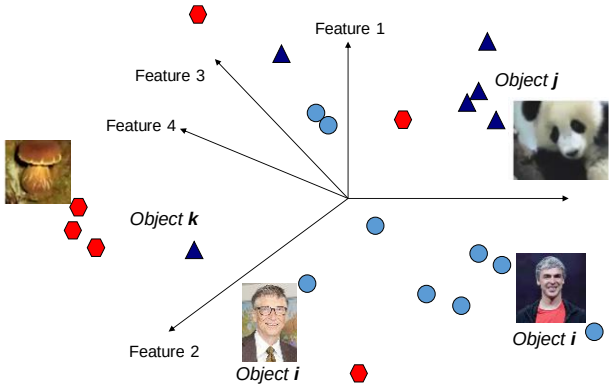
Comment: since just some parameters of the mathematical model must be tuned/fitted, the number of needed data is less than the amount needed to train the complete model with no a-priori information.

……Q6

It is possible to think to the single datum in input to the neural network as a point in the “input space” of the model, even if the input is a single value, a N dimensional vector, or an image

1. True
2. False

.....Q6



It is possible to think to the single datum in input to the neural network as a point in the "input space" of the model, even if the input is a single value, a N dimensional vector, or an image

1. True ← correct
2. False

Comment: yes, that is exactly the correct representation that will allow to understating under a common framework the artificial intelligence models

.....Q7

It is correct to say the one of the key feature of an intelligent artificial system is the capability to learn (even if only a limited sense) and/or get better in time

1. True
2. False

.....Q7

It is correct to say the one of the key feature of an intelligent artificial system is the capability to learn (even if only a limited sense) and/or get better in time

1. True ← correct
2. False

Comment: One can debate endlessly about whether a certain system is intelligent or not, but the capability to learn is one of the most important

.....Q8

According to the Andries Engelbrecht definition of Computational intelligence what of the following is not included?

1. Artificial Neural Networks
2. Evolutionary Computing
3. Swarm Intelligence
4. Artificial immune system
5. Fuzzy Systems
6. All the above are included

.....Q8

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3. Swarm Intelligence
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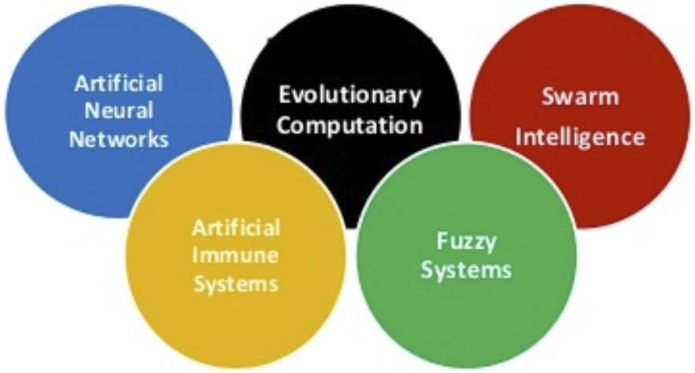
6. All the above are included ← correct



.....Q9

According to the class discussion of the Gestalt capability, what of the following sentences is more correct?

1. The Gestalt capability is a typical feature present by-design in the model of classical neural networks
2. The Gestalt capability is a typical feature present by-design in the model of deep learning neural networks
3. The Gestalt capability is a typical human feature not well (yet) mimicked in current artificial networks

.....Q9

According to the class discussion of the Gestalt capability, what of the following sentences is more correct?

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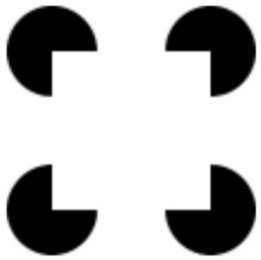
2. The Gestalt capability is a typical feature present by-design in the model of deep learning neural networks
3. The Gestalt capability is a typical human feature not well (yet) mimicked in current artificial networks ← correct

Comment: just let's think to this example…



.....Q10

The following activity:
a) Data Selection;
b) Data Filtering;
c) Data Enhancing…

1. Are part of the job of the artificial intelligent specialist in normal activities
2. Contribute to keep lower the complexity of the learning task
3. All the above (1. and 2.)
4. Are part of the classical machine learining approaches and they are (correctly) no longer used in deep learning applications

.....Q10

The following activity:
a) Data Selection;
b) Data Filtering;
c) Data Enhancing…

1. Are part of the job of the artificial intelligent specialist in normal activities
2. Contribute to keep lower the complexity of the learning task
3. All the above (1. and 2.) ← correct
4. Are part of the classical machine learning approaches and they are (correctly) no longer used in deep learning applications

Comment: a), b) and c) are extremely important in the final behavior of the trained model and the complexity of the training task.

.....Q11

The Mean Squared Error is typically present in what step of the design?

1. Representation
2. Evaluation

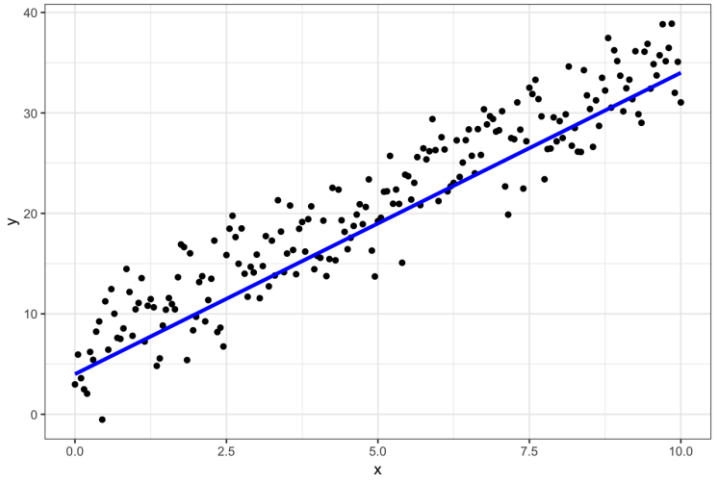
.....Q11

The Mean Squared Error is typically present in what step of the design?

1. Representation
2. Evaluation

$$MSE = \frac{1}{n}\Sigma\underbrace{\left(y - \hat{y}\right)}^{2}$$

The square of the difference between actual and predicted



What about topics not present in the simulation?

- They are equally important
  - The absence in the simulation does not mean they are not relevant
- You can find them in the exam
- Do not study the simulation, but use it to understand if you are profitably attending the course and, in case, to change the study method
- THE CORRECT METHOD:
  Try to create your own simulation by browsing all slides of the course and ask yourself:
  what can be asked in this slide?

Main points

- Theory of intelligent systems: *Representation*, *Evaluation* and *Optimization*
- The design is like gardening: *Seeds* = Algorithms, *Nutrients* = Data, *Gardener* = You, *Plants* = Programs
- Digital Ages
  - Collaborative age
  - Autonomous age
- Exam simulation