Intelligent Systems for Industry, Supply Chain and Environment
(in short “IS4”)

LESSON 1

Introduction and course description




Lesson outline

- Organization of the course
- The exam
- What is an intelligent system?
- Results and limits
- Applications of Intelligent systems for
  - industry
  - environment
  - business and medical applications
- Strategic approaches to the exam
- **Main points**

The IS4 course

Intelligent Systems for Industry, Supply chain and Environment

(in short “IS4”)

Be an expert in neural networks is enough! (?)

No

- Properties and differences between current models used in AI
- How to manage the data needed to train the models
- Avoid typical errors about the application of AI models
- Peculiarities about industrial applications in the different sectors
- Creating your own “toolbox”
- Deep learning models are just a part of the business

In brief…

Machine Learning = Deep Neural Networks

NO!!

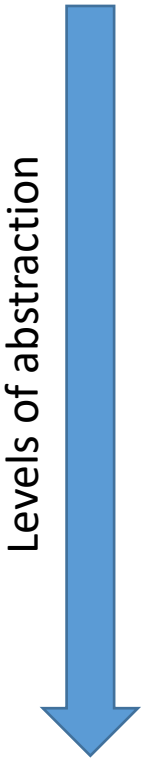
Not just about training NNs

- State of the art
  - Provide the background historical (previous methods..)
  - Methodologies/Best practices
  - Analyze research trends
  - Describe what is present today in the literature and in the market
- Aggregate-fuse data
  - Can I add any knowledge, data, or feature to improve the learning?
- Comparisons (Fair)
  - How to compare methods and performances?

Not just training neural networks (2)

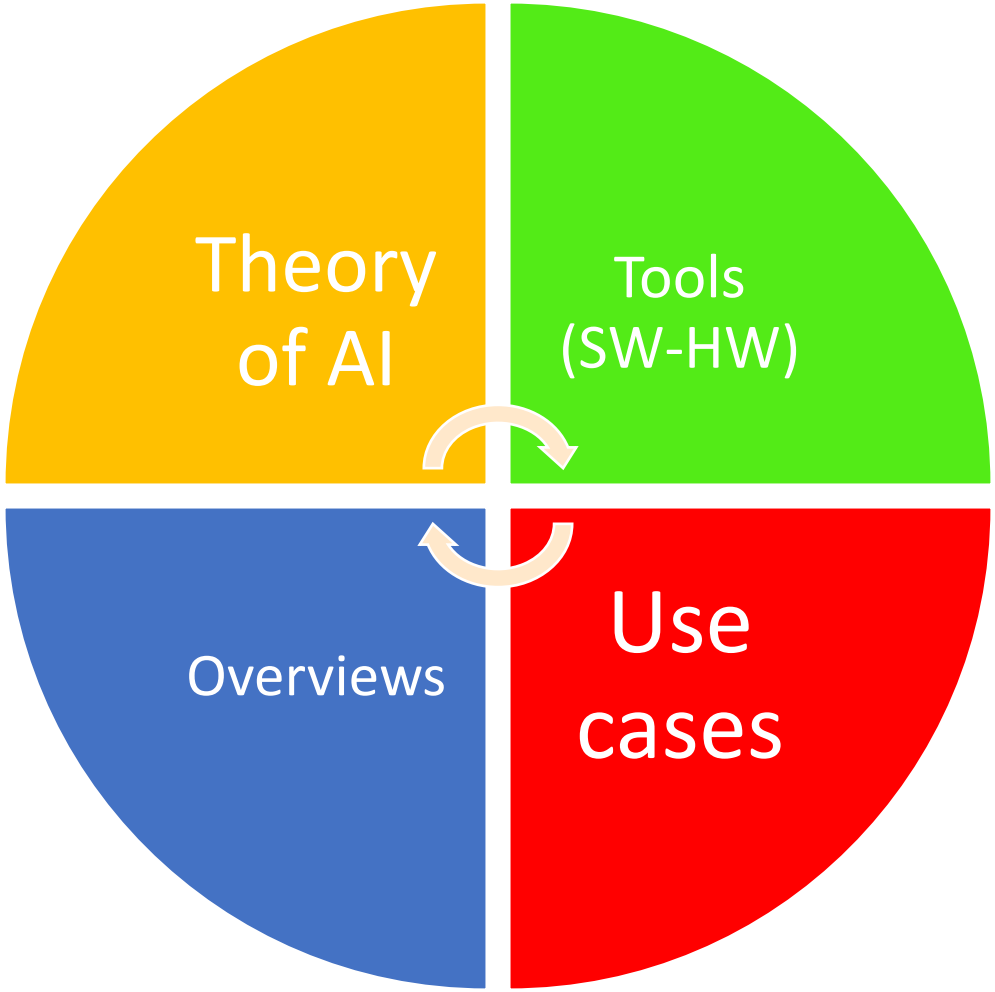
- Find features in common, find distinguishing features from similar/different domains/applications
- Create tables, charts, plots using the available data
- **ONLY AFTER THAT….**
  Start train, validate and deploy models

The structure of the course



- **Theory** about AI models and learning methods
- Classical Artificial Intelligence (pattern matching)
- Recent developments (deep learning)
- How to apply concepts to applications
  - Industrial
  - Enviromental
  - Supply
- **Use cases**

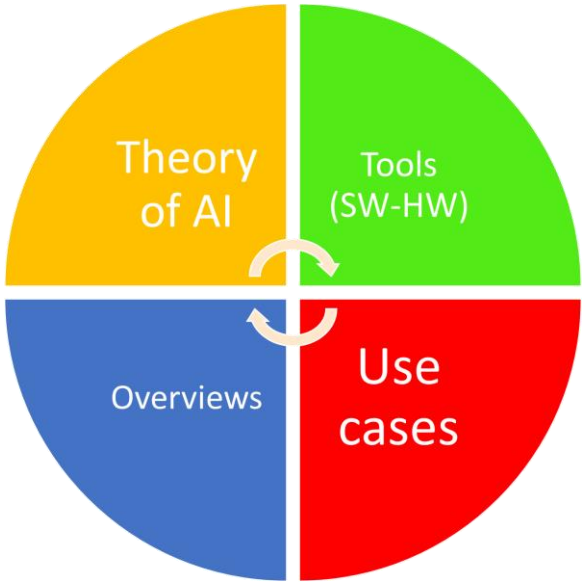
The course:
4 different type of contents



Some time the difference is «fuzzy»…

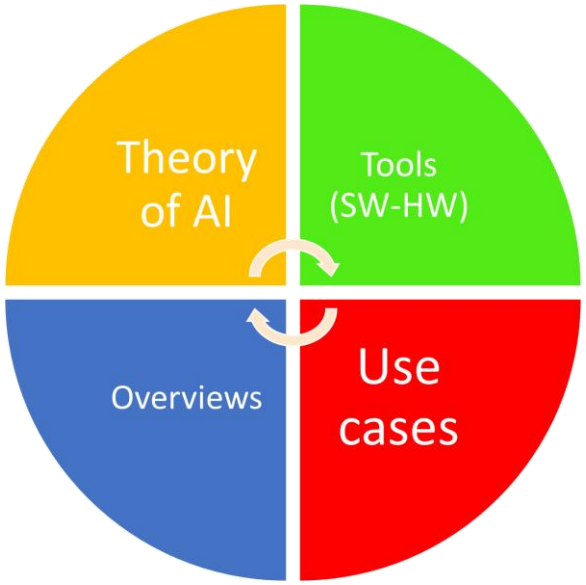
Theory of AI

- Not limited to AI and neural networks
- Learn what we need to understand what's «under the hood»
- We will consider many topics
  - Pattern matching
  - Learning
  - Data analysis
  - Data processing
  - Feature extraction and fusion



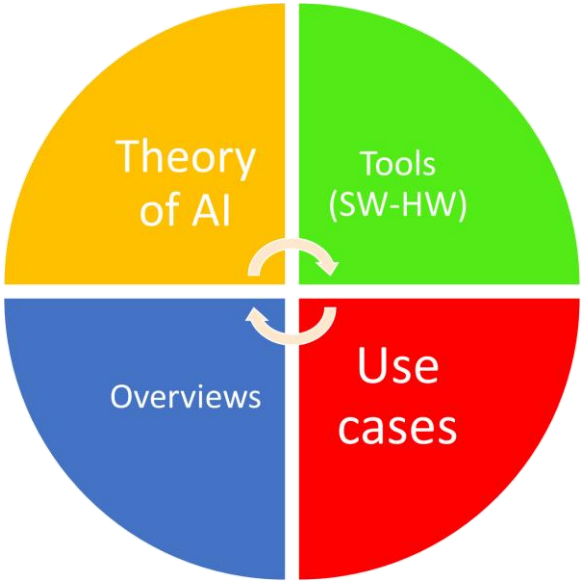
Tools (SW-HW)

- What we need in our «toolbox»
- SW
  - Data analysis
  - Data processing
  - Data visualization
  - Learning enviroments
    - Flexibility, do not fall in love with one!
    - Matlab, Tensorflow, GoogleColab,…
- HW
  - CUDA and dedicated boards
  - Edge and fog computing



Overviews

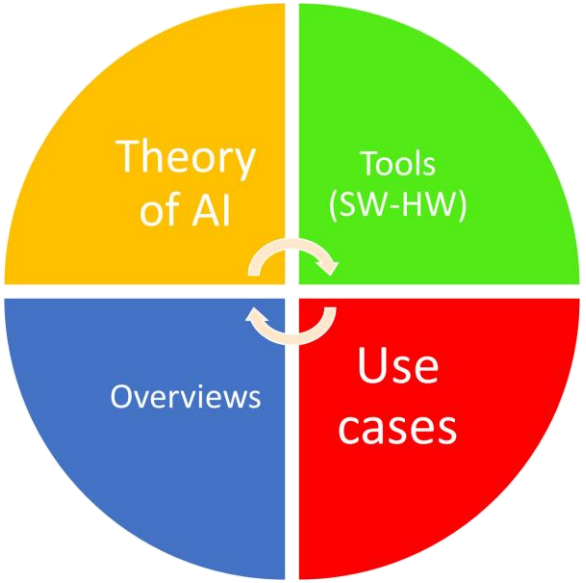
- Improving the knowledge about
  - State of the art
  - What can be done or not in different sectors and markets
  - What are the best tools
  - What kind of dataset we need
  - Limits of the techniques
  - General trends



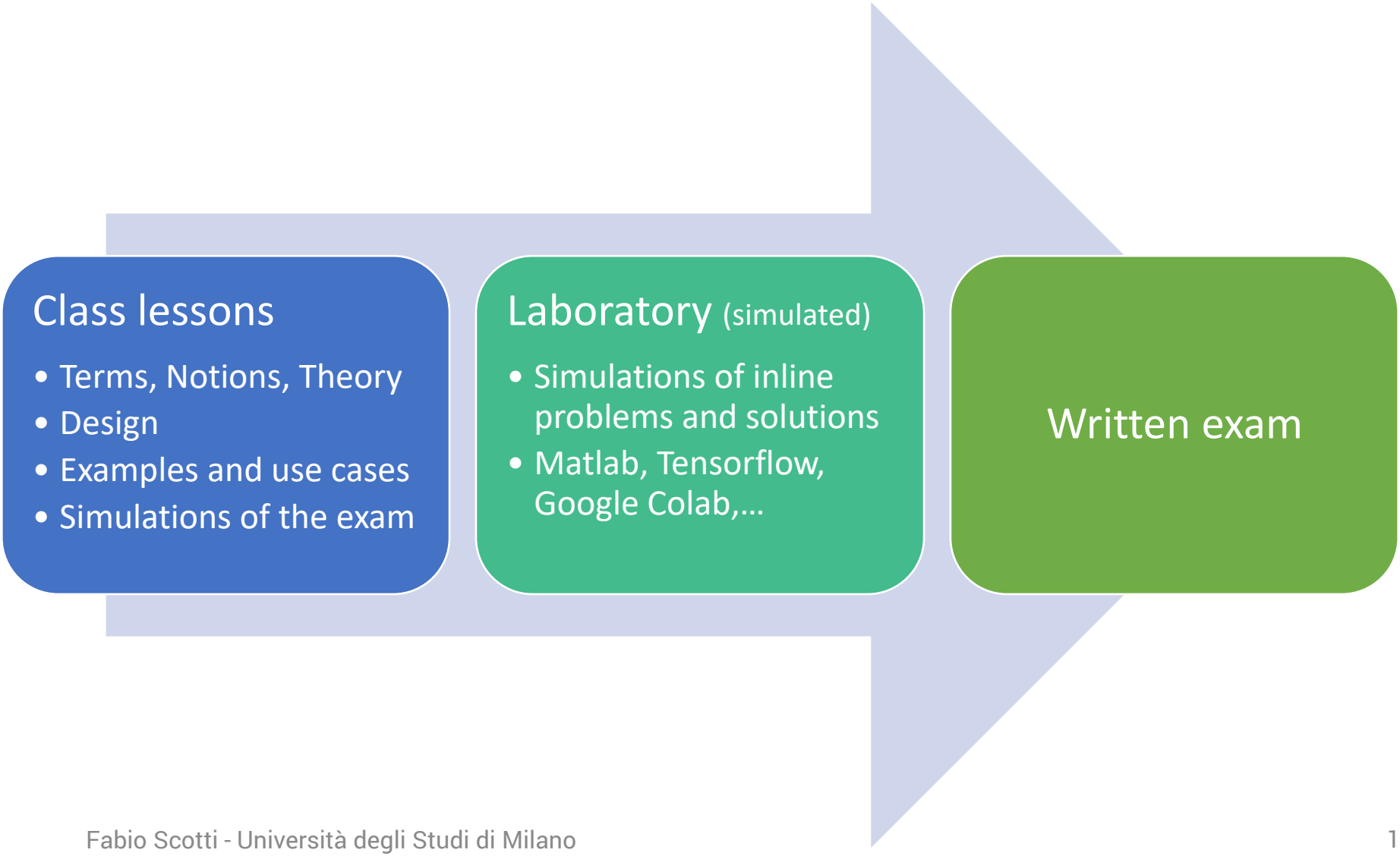
Overview's information are part of the course and present in the exam

Use cases

- Examples
- Data managment
- Inputs/Outputs
- Expected results
- `Codes and snippets`
- Usage of HW and SW tools



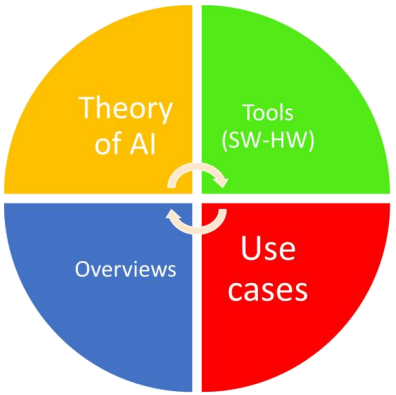
The course: different type of “work”






Artificial intelligence

State of the art and applications



Diffusion and relevance

- Applications that sounded like **science fiction** only a decade ago are now part of our daily lives
- On a far larger scale, in the coming years **AI** will radically transform the future of work, the way in which economies function
- Machine learning in particular allows us to process data at unprecedented scales. We can
  - see patterns,
  - detect problems earlier
  - and allocate resources more efficiently

Sectors where AI is applied (a short list)

- Aviation
- Computer science
- Education
- Finance:
  - Algorithmic trading,
  - Market analysis and data mining,
  - Personal finance,
  - Portfolio management,
  - Credit underwriting
- Heavy industry
- Hospitals and medicine
- Marketing
- Media
- Music
- News, publishing and writing
- Online and telephone customer service
- Telecommunications maintenance
- Toys and games
- Transportation

Applications of AI in Computer Science

- Web search
- Computational biology
- Finance
- E-commerce
- Space exploration (areas, cities, houses,…)
- Robotics
- Information extraction
- Social networks
- Debugging
- **Your application!**
  - **Be smart and clever, AI can be applied in every task and activity of your project and application providing benefits**

Examples of task solved with AI

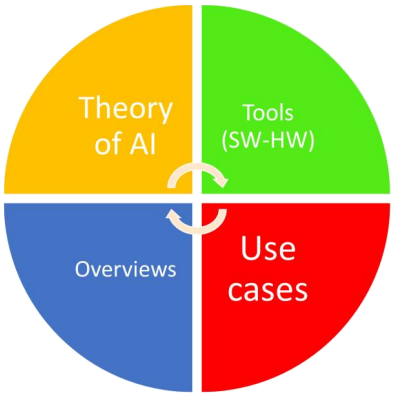
- Optical character recognition
- Handwriting recognition
- Speech recognition
- Face recognition
- Artificial creativity
- Computer vision, Virtual reality and Image processing

- Diagnosis (artificial intelligence)
- Game theory and Strategic planning
- Game artificial intelligence and Computer game bot
- Natural language processing, Translation and Chatterbots
- Nonlinear control and Robotics

THEORY

Natural interaction

One of the most relevant and limiting feature



Natural interaction

- Promises …
  - deep learning will permit to have a natural human machine interaction.
  - ..will be able to **understand language**, **reason**, and **interact** with humans in a more *natural way*.
- Given the advances in ***natural language processing*** and ***vision capability***, it seems only a question of time until machines will be smart enough to reach this level.

Natural interactions limits: discussion

Almost there …. improving

- Even though speech recognition software now has an **error rate <5%** compared to more than 10% just a few years ago,
- It means that 40 words of an 800-word article would be wrongly recognized….

- *Andrew Ng*, a machine learning world expert, has suggested that **naturally interacting** with a computer will not happen until we reach error rates of **<1%** (meaning in real applications)

Andrew Ng: VP & Chief Scientist of Baidu; Co-Chairman and Co-Founder of Coursera; Adjunct Professor at Stanford University.

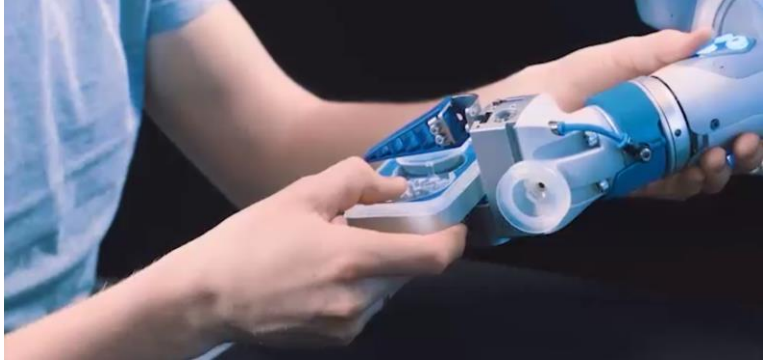
Natural interaction: example

Voice Recognition For Order Picking in Logistics

Voice picking systems for increased productivity, greater accuracy, and improved safety

https://www.realtimelogistics.com.au/technologies/voice-picking-systems/

Natural interaction
Advanced applications (not just voice…)



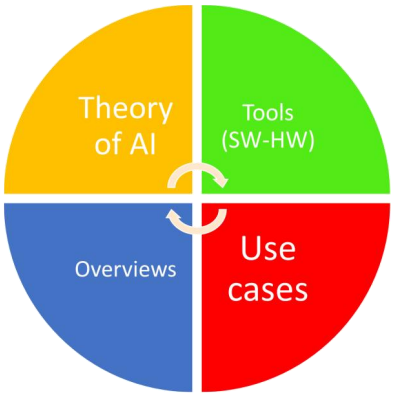
Cobots = Cooperative Robots

THEORY

Biases, improvements, limitations

Similarly to a kid which who growing up…

and improving…, but it depends who is teaching!



Some recent facts or improvements

- Neural networks are good at learning **human biases**
  - Cognitive biases are systematic patterns of deviation from norm or rationality in judgment

"You could mean bias in the sense of racial bias, gender bias. For example, you do a search for C.E.O. on Google Images, and up come 50 images of white males and one image of C.E.O. Barbie. That's one aspect of bias."
Daphne Koller

Harriet Lee-Merrion

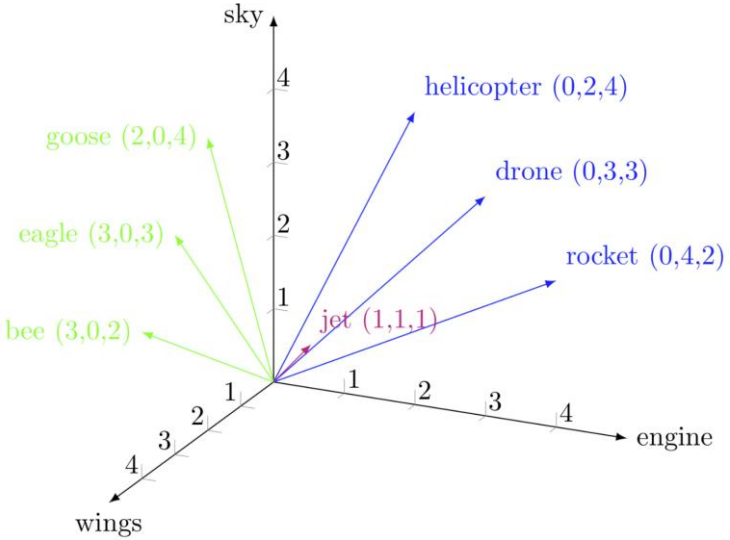
Example of a different AI bias

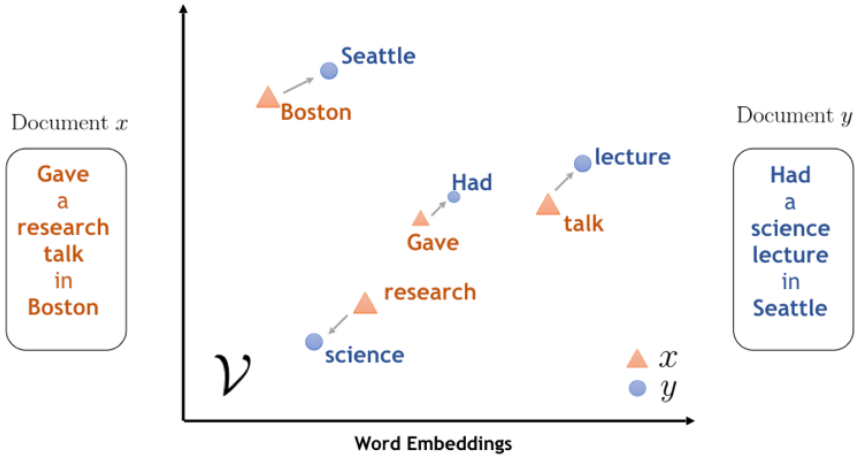
- An algorithm is latching onto something that is meaningless and could potentially give you very poor results.
- Example
  - Predict fractures from X-ray images in data from multiple hospitals.
  - If you're not careful, the algorithm will learn to recognize which hospital generated the image.
  - Some X-ray machines have different characteristics in the image they produce than other machines, and some hospitals have a much larger percentage of fractures than others (e.g., large traumatology units).
  - And so, you could actually learn to predict fractures pretty well on the data set that you were given simply by recognizing which hospital did the scan, without actually ever looking at the bone.

Example from Daphne Koller (Stanford and Coursera founder)

Some recent improvements

- So-called **word embeddings** that are often used as input for a neural network
  - A set of language modeling and feature learning techniques in natural language processing (NLP) where words or phrases from the vocabulary are mapped to **vectors** of **real** numbers



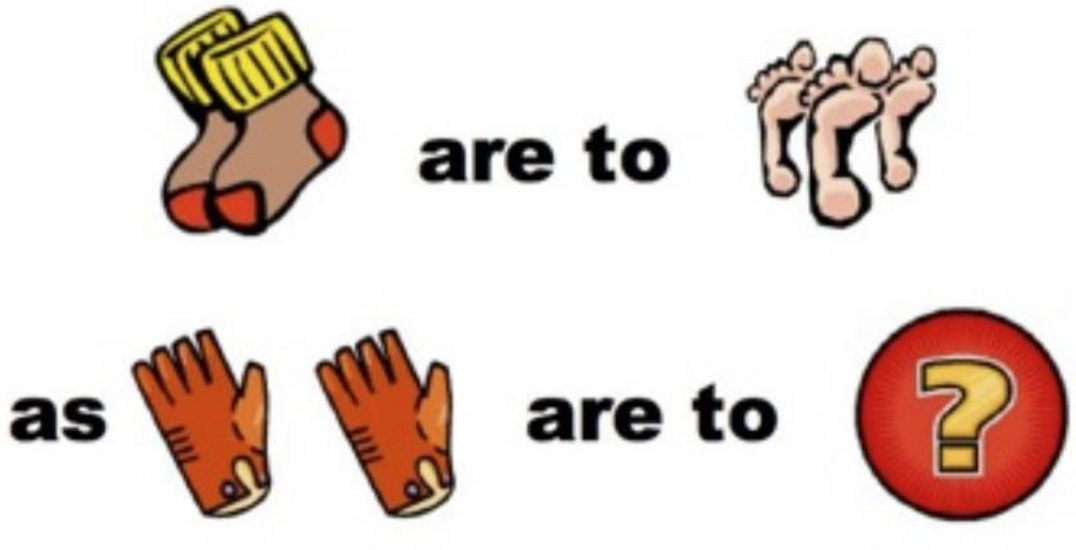


Some recent improvements (2)

- Solving **analogy puzzles**
  - “Paris is to France as Tokyo is to ?,”

  -> producing the correct answer, “Japan.”

(Frank Schilder, Armineh Nourbakhsh, Thomson Reuters)

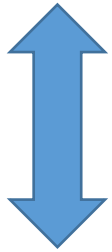


Caenorhabditis elegans

Artificial VS Natural brain

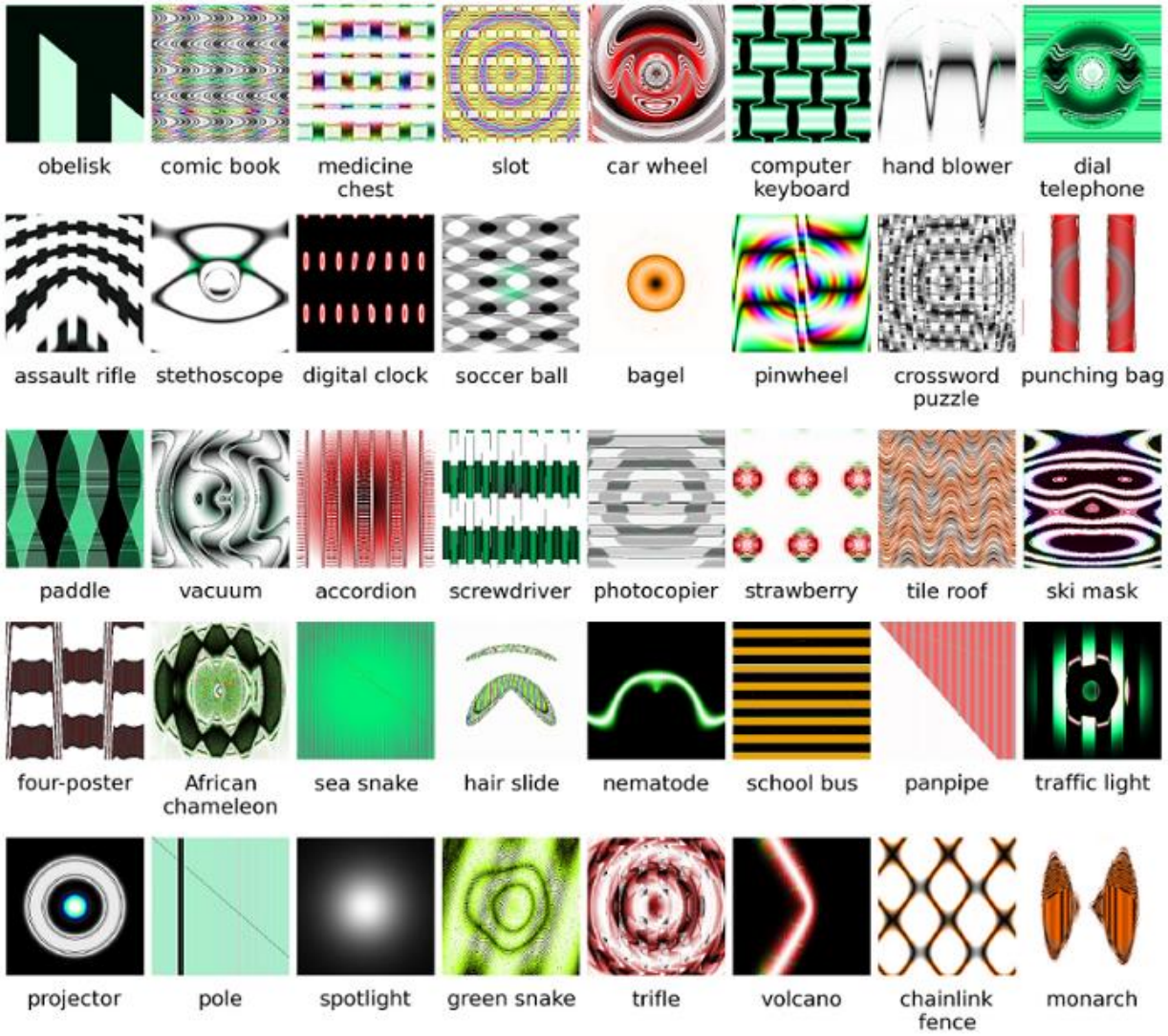
- Neural networks can already carry out complex cognitive tasks but…
- Current artificial networks are somewhere between the neural capacity of a bee's and a frog's brain.
  - The simple worm c. elegans, has 302 neurons and about 7000 synapses
- Human brains are at least **an order of magnitude larger** than current neural networks
  - But the human brain has about 10^11 neurons, and more than 10^3 synapses per neuron…. (Nature, 21 August 2019)
- Complex cognitive tasks are still far…

ML



Not (yet) perfect

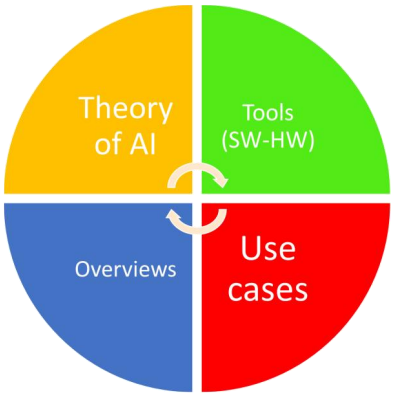
It is very easy to fool
a DL Neural Network
with artificially created images
(Anh Nugyen et al.)



THEORY

Data Knowledge Spectrum

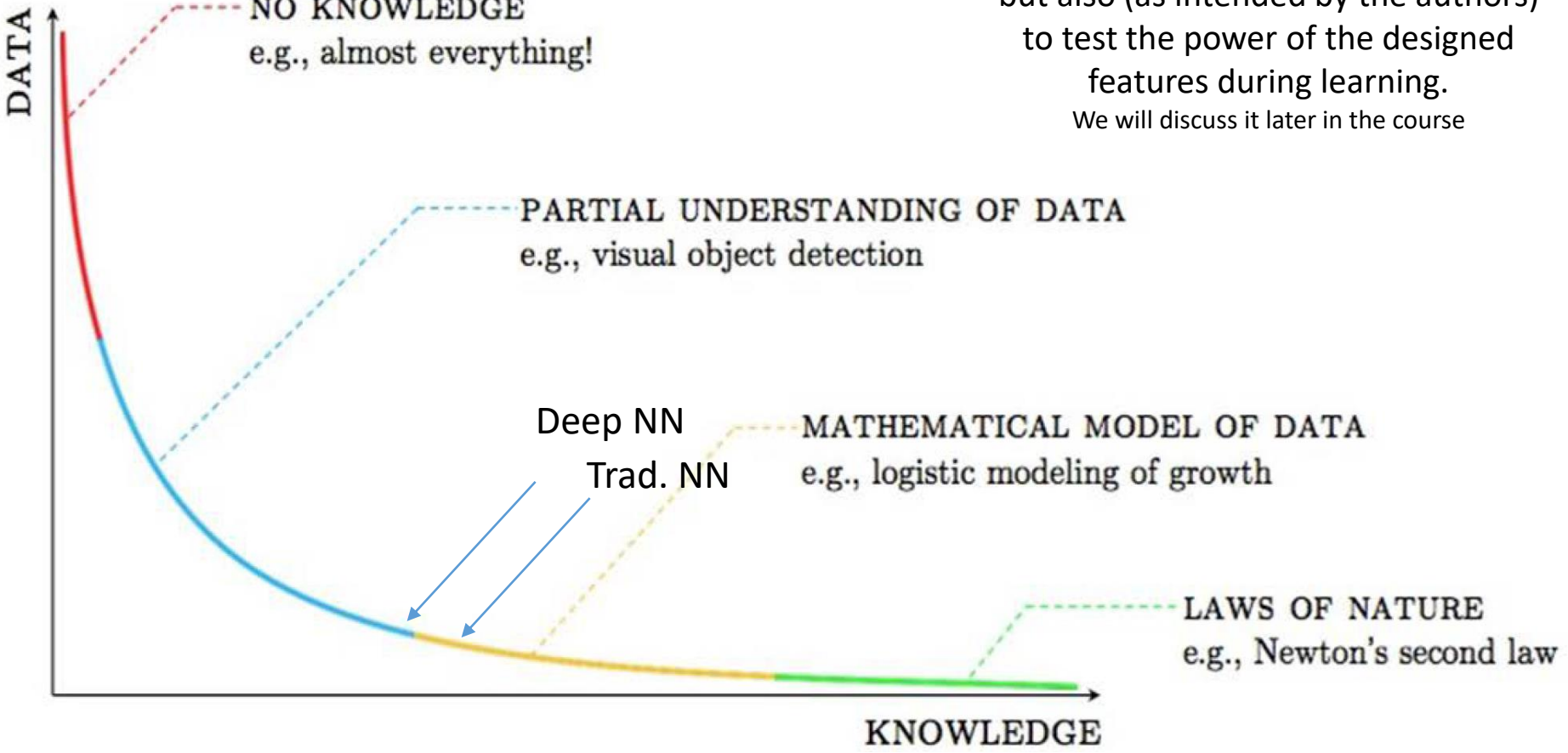
Where is the knowledge in the data?



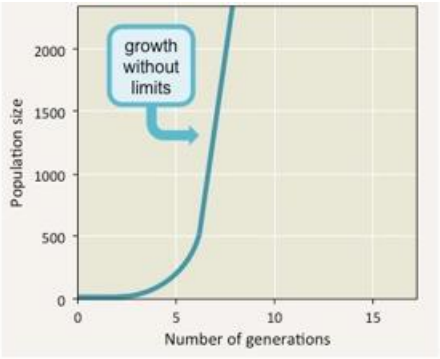
From latin speciō (“look at, view”)

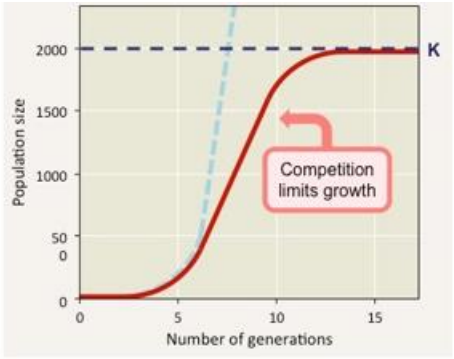
Data-Knowledge Spectrum

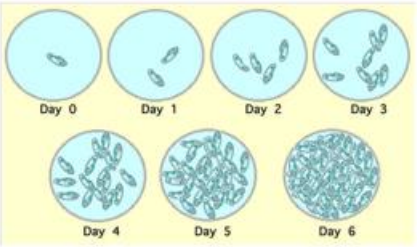
This plot can be considered as a general concept
but also (as intended by the authors) to test the power of the designed features during learning.
We will discuss it later in the course

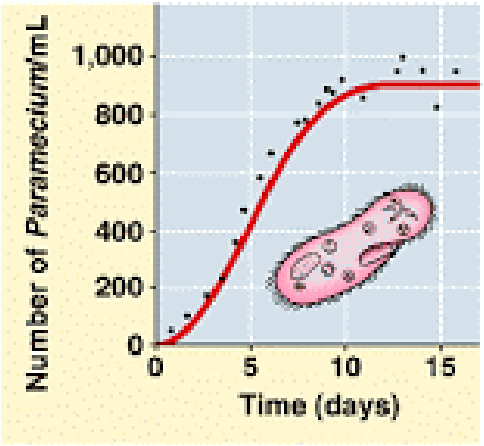


Data Knowledge Spectrum
Example #1: Fitting simple data

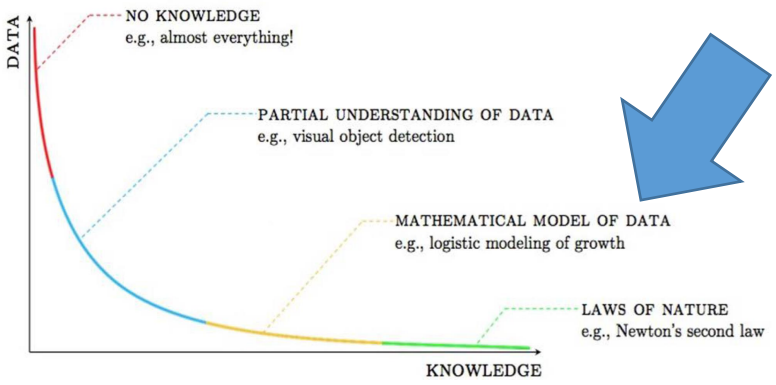








(a) A *Paramecium* population in the lab



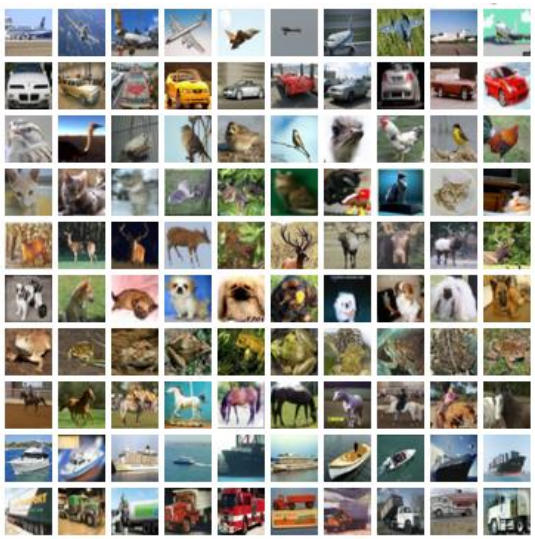
We have a very
specific and simple model
to be fitted with the data

It is not correct use a very large NN
to fit the data!

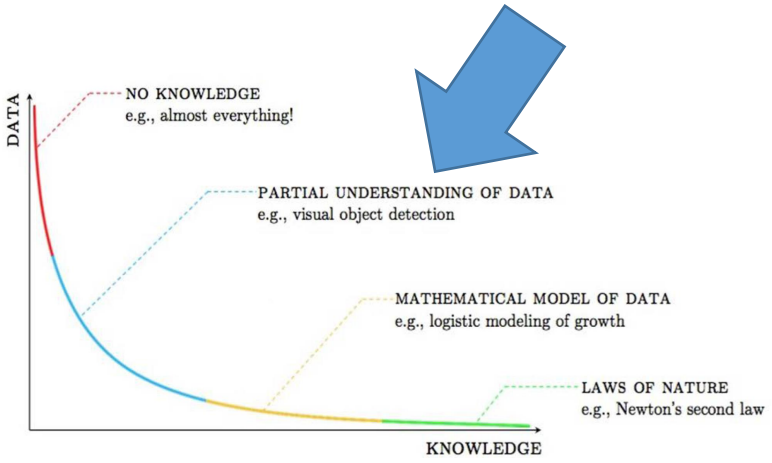
Data knowledge spectrum
Example #2: Visual object detection

Task

Data



Images with labels



We have not a specific model to be fitted with the data

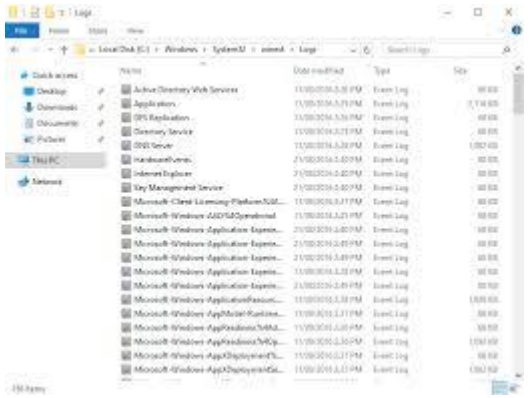
We must use a large e general model to fit the data (at least we have data labels)
→ needs a lot of data to ne fitted correctly

Data knowledge spectrum
Example #3: Security attacks

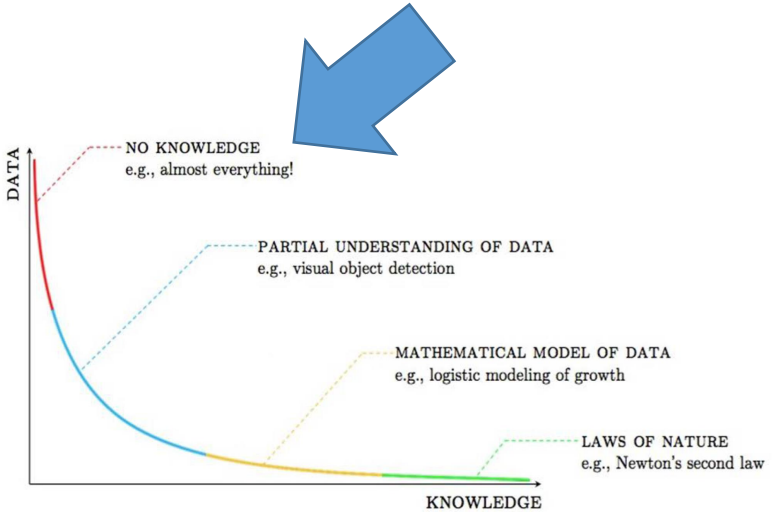
Task

What are the behaviors/features correct to identify attacks?

Data



Million of logs with no labels



We have not a specific model to be fitted with the data with no labels

We must use a large e general models capable to work in an unsupervised fashion (no labels in data)




EXAM

How to prepare yourself

Exam

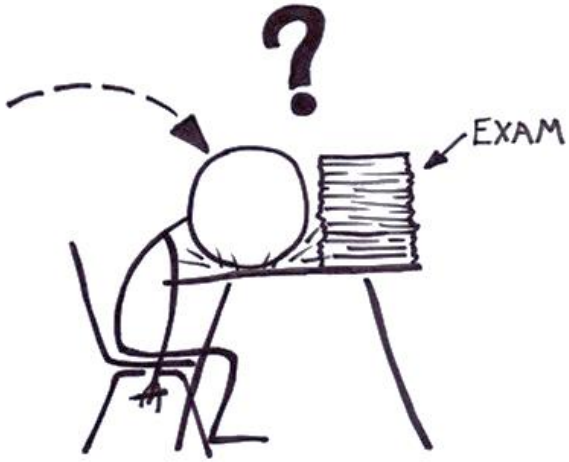
- It will focus on the main topics discussed during the course with respect to
  - Theory
  - Overviews
  - Use cases
  - Tools
  - Applications
  - Design of simple cases

- HINT: browse all slides of the course and ask yourself: what can be asked in this slide?

The final exam

- **Written exam only (no projects)**

- **During the course will be given**
  - **more details on how to face the exam**
  - **simulations of the exam**



Exam structure

- The exam will be given in the laboratory in front of the PC (or by remote with video surveillance)
- It can be considered as a written exam
- No oral, No projects
- Topics of the test
  - Theory
  - Design cases
  - Code interpretation (as seen in class)
  - Use cases
- All questions/answers are based on the printed material of the course.

Exam structure

- It’s a multiple-choice test
  - 1 single correct answer (weigth = 1)
  - N wrong answers (weigth = 0)
  - ~~1 (rarely 2) very bad answer (weigth = -1)~~ No more
  - Final normalization of the test score to marks
- Duration: about 1h
- Can I do the test every exam date? YES
- Can I bring books/PC/material/etc? NO

Strategic approach: Rule #0

- You are not registered to the exam
  → no exam *****no exceptions*****
- You must be registered.

- Do it now! Write on your calender

Strategic approach: Rule #1

- Is there a golden rule? YES, FIRST OF ALL

  DO NOT LOOK FOR THE RIGHT ANSWER

  EXCLUDE THE WRONG ONES

Ex. What is the best estimation of my age?

Searching for the right one	Excluding the wrong ones
A) 49 ←67% confident	A) Don't care ← I choose this one
B) 35	B) 35 NO 75% confident
C) 12	C) 12 NO 99.9% confident
D) 65	D) 65 NO 80% confident

- Rule #1b: "Do you have doubts?"
  → choose the answer that "looks less wrong" to you

Strategic approach: Rule #2

- How can improve my study on the material?

1) Browse all slides of the course and ask yourself: what can be asked in this slide?
2) BE SPECIFIC
3) Do not use the simulations of the exam to study
    1) That is not the purpose!
    2) Use the simulation to understand
        1) how to face the questions and reason to find the solution
        2) If you are study profitably (see Strategic approaches 1,2,3)

Main points

- Course structure
- Going from the theory to the application you need:
  - Knowledge about the theory of AI models and methods (strengths and weakness)
  - Applications experience, knowledge of the state of the art, methodology to deal with data and models
  - Good toolboxes
- AI is greatly improving but strong limitations are present
  - Biases
  - Natural Iteration
- The less we know about the process, more data is needed to develop automatically the neural model
  - Data Knowledge Spectrum
- Exam structure and golden rules