



University of Minho
School of Engineering



CENTROALGORITMI



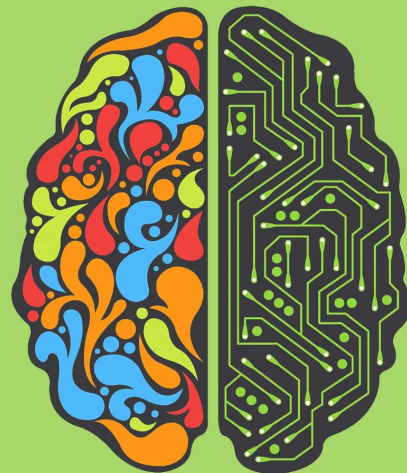
ISLab

Applied Artificial Intelligence

PAMWater's Case Study

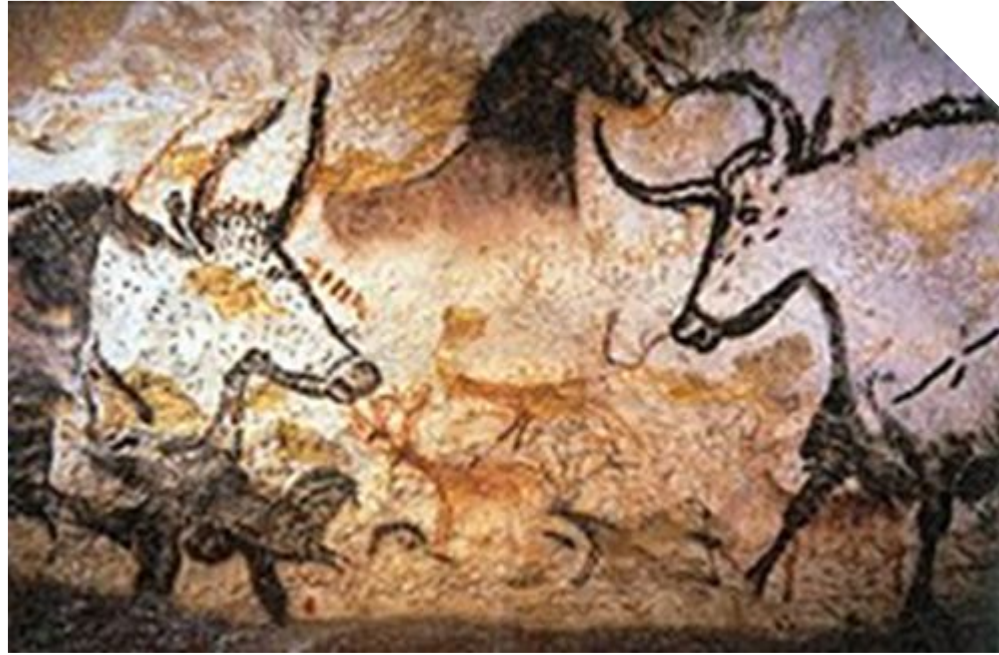
Paulo Novais, Bruno Fernandes, and Pedro Oliveira
@ISLab.ALGORITMI, Departamento de Informática, Universidade do Minho

July 27, 2021



@Beginning of times

Most of our actions
generate **data**!



Source: Lascaux Cave
https://pt.wikipedia.org/wiki/Arte_rupestre

Data

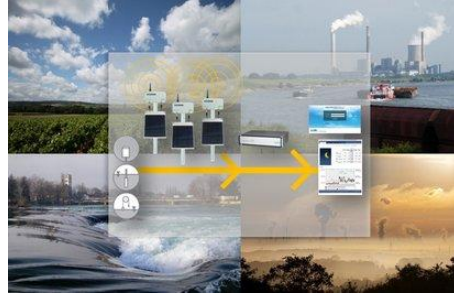
Most of our actions
generate **data**!



Source:
Crowdsignals.io

Data

Most of our actions
generate **data**!



Source: <https://www.adcon.com/>

Big Data

Things one can do at a large scale that cannot be done at a smaller one



Decisions!!!

- The action or process of deciding something or of resolving a question (quickly and decisively).
- To make (good) decisions, we must be able to predict the future, accurately perceive the present, have insight into the will of others, and the capacity to deal with uncertainty.
- The problem of (to much) intuition!
- Although intuition can be a helpful tool, it would be a mistake to make all decisions based on a feeling.
- Intuition can provide a spark that starts something new, it's through data (knowledge) that you verify, understand, and quantify...



Image source: <https://www.advantageperformance.com/framing-a-decision/>

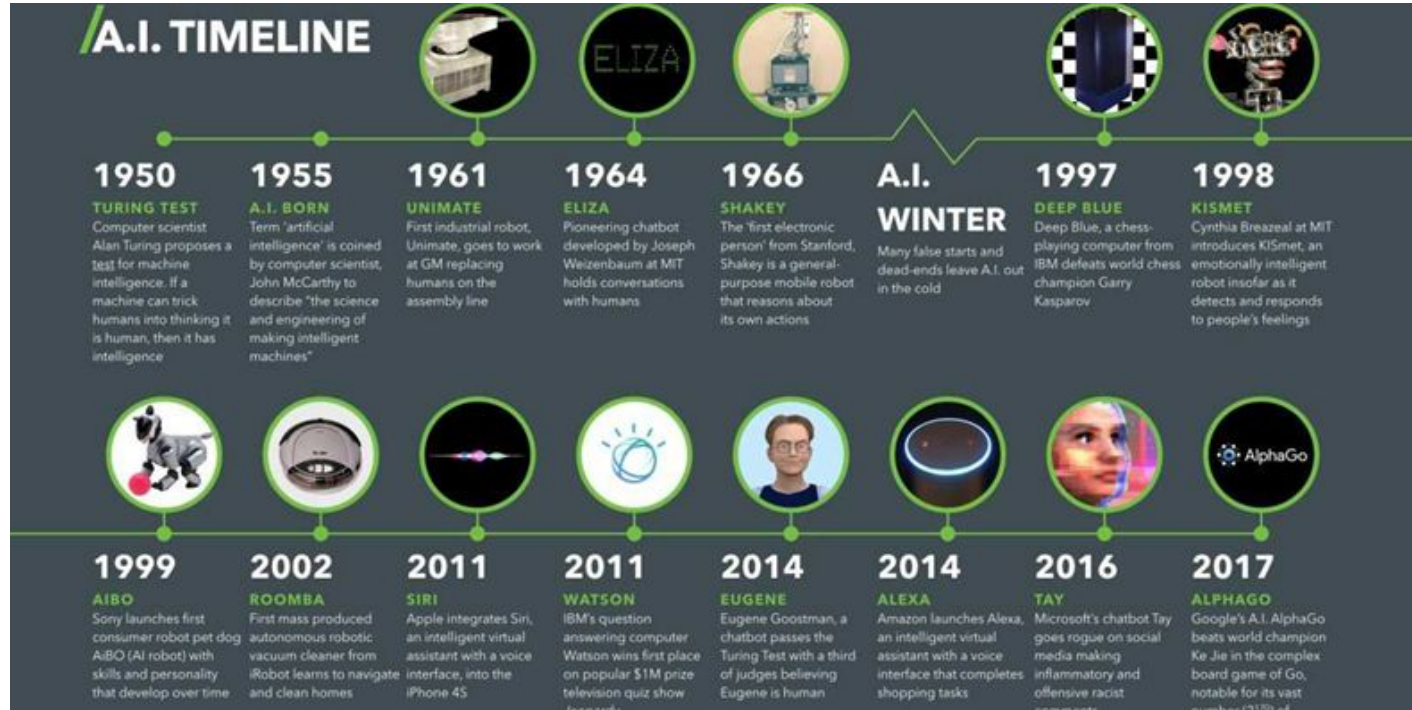
Learning

“Learning is any process by which a system improves performance from experience.”

“Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task (or tasks drawn from a population of similar tasks) more effectively the next time.”

Herbert Simon (Nobel Prize in Economics (1978))

AI Timeline

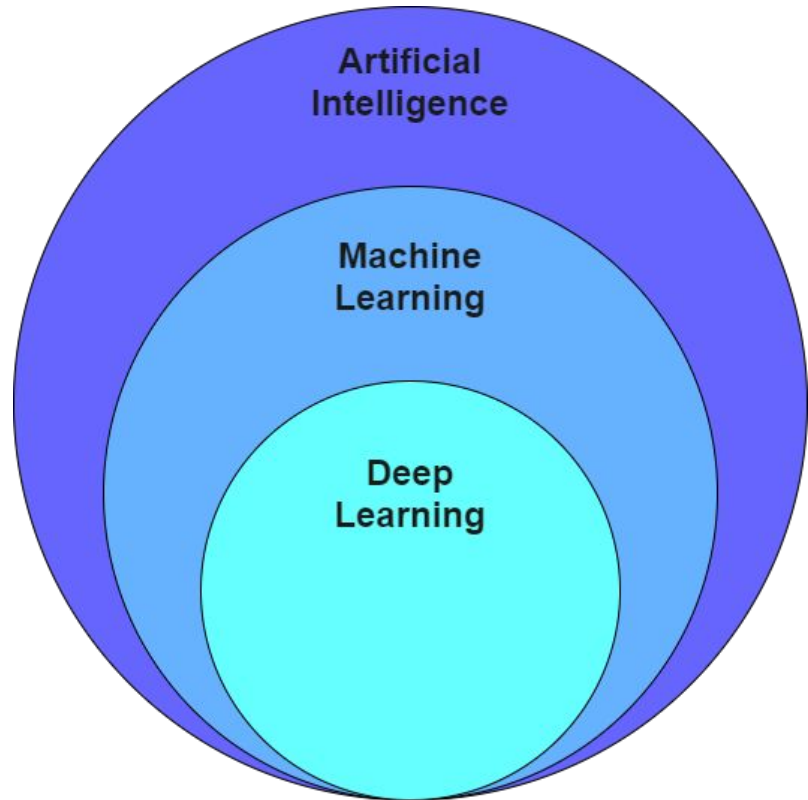


(<https://digitalwellbeing.org/artificial-intelligence-timeline-infographic-from-eliza-to-tay-and-beyond/>)

Machine Learning

“The field of *machine learning* is concerned with the question of *how to construct computer programs that automatically improve with experience.*”

Tom Mitchell, Machine Learning (1997)

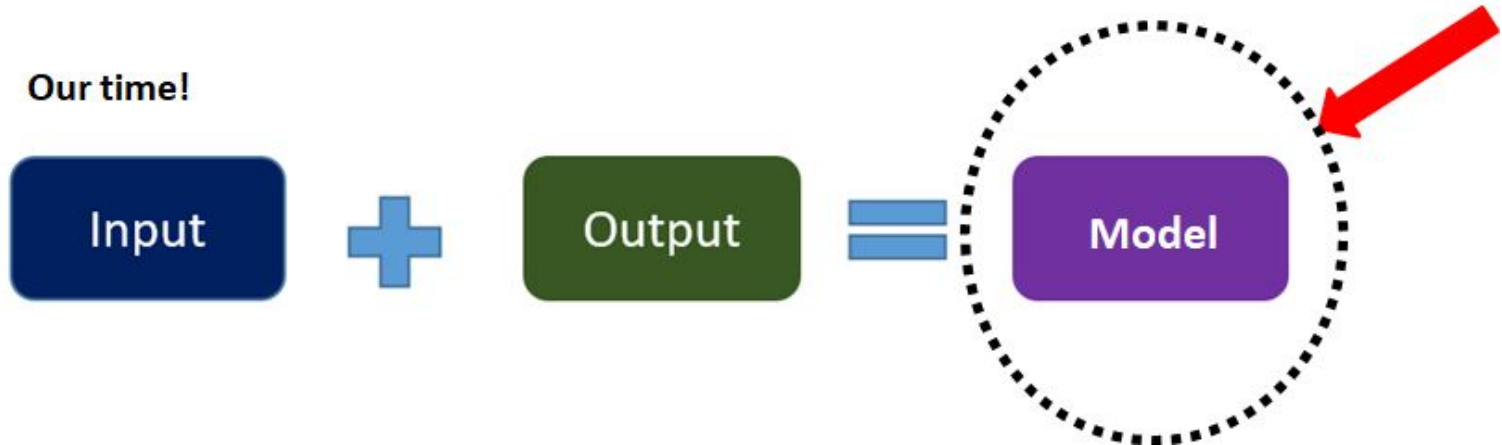


New times!

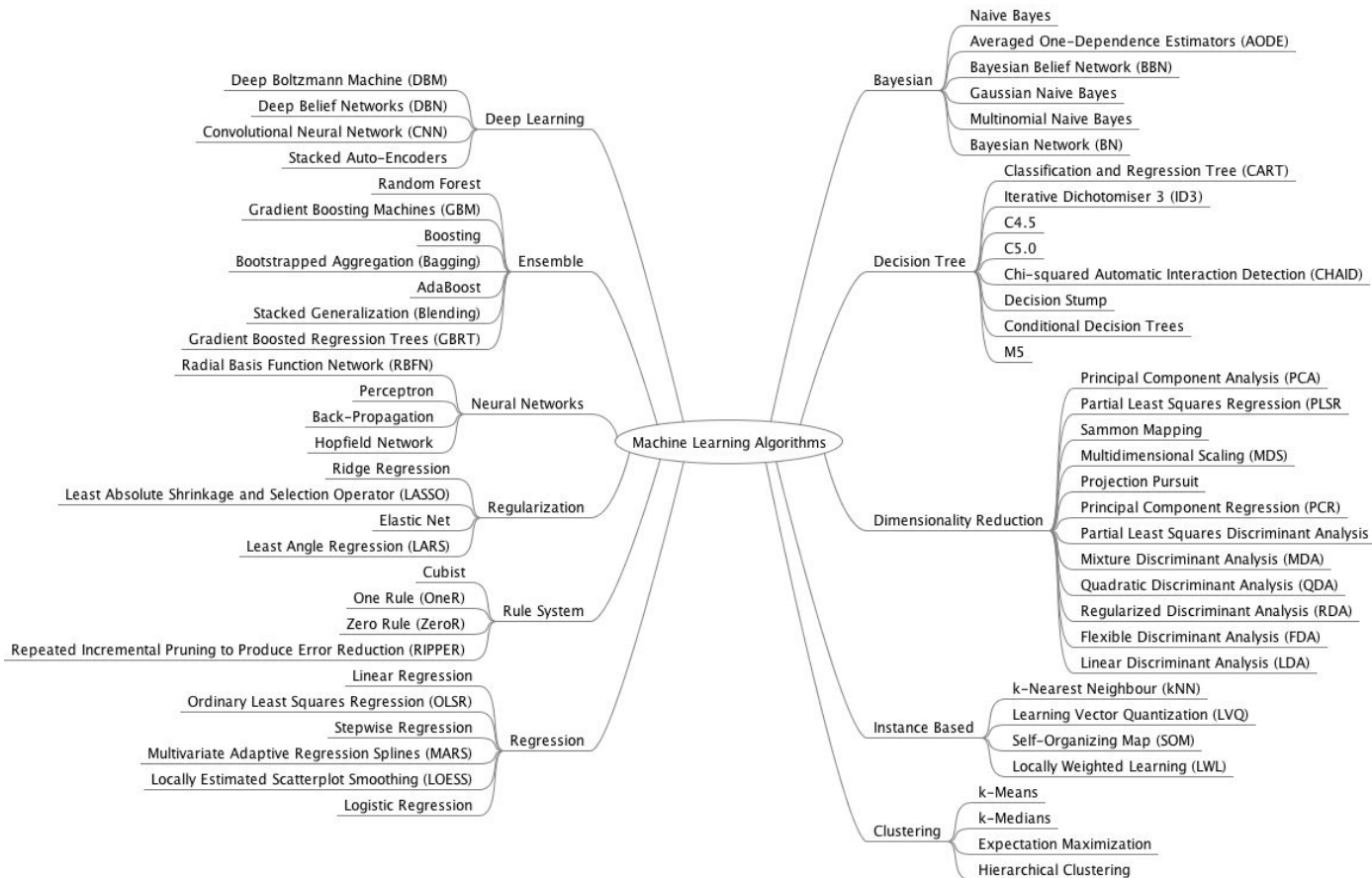
"Old times"



Our time!



New times!





Las Laboratório
Associado
Sistemas
Inteligentes


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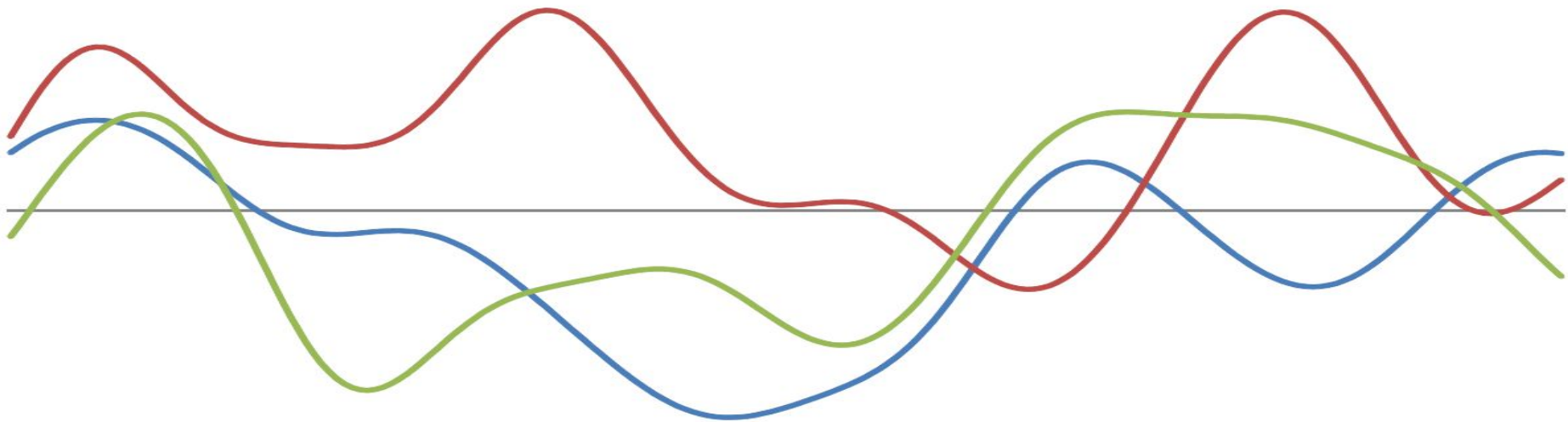
 **ISLab**

PAMWater

Behind the Scenes



Time series



Statistical-based models

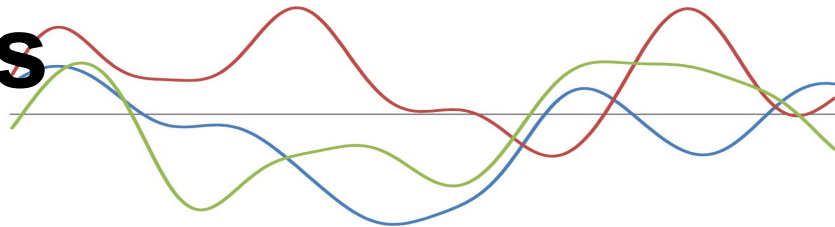


Deep Learning models



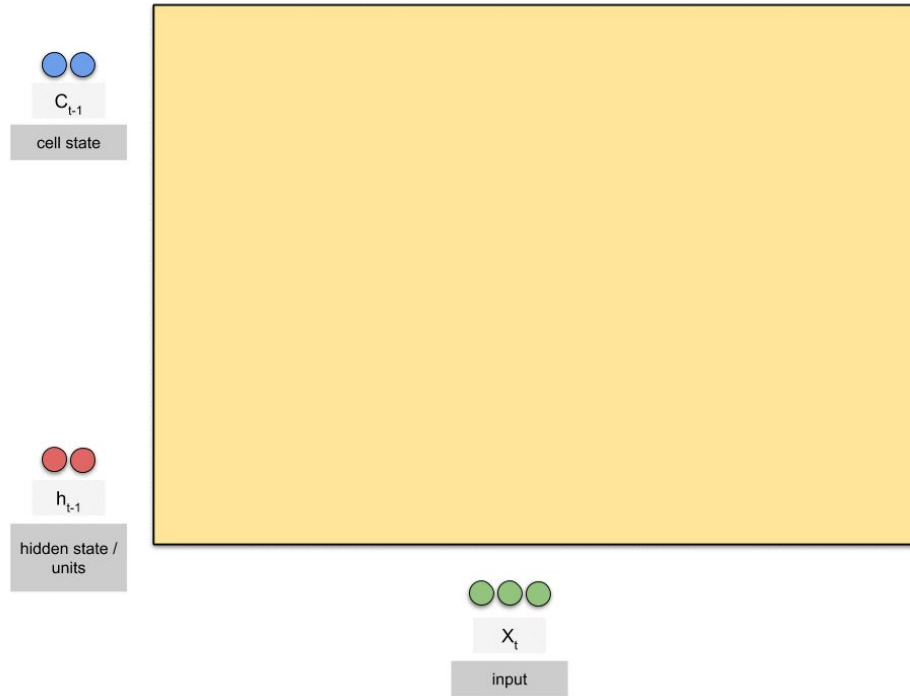
Handling Time series

(The not so obvious)



- Handling missing timesteps;
- Set the supervised problem;
- Time series cross-validator;
- Tuning the time frames and multi-step approaches.

Long Short-Term Memory Nets



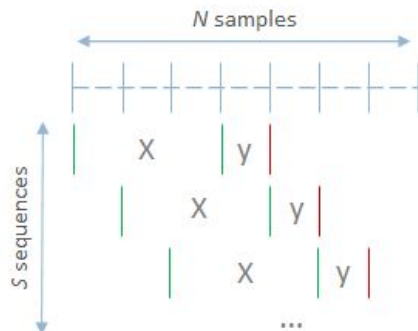
Gated Recurrent Units



1d-Convolutional Neural Net

Input Layer

N: 1609
Timesteps: 7
Features: 4



$$S = N - (\text{size}(X) + \text{size}(y))$$

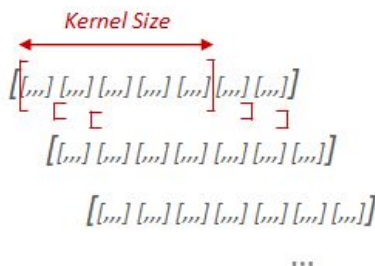
$$S = 1609 - (7 + 1)$$

$$S = 1601$$

Input Shape: (1601, 7, 4)
Output Shape: (1601, 7, 4)

Conv1D (Multi-Variate)

Kernel Size: 5
Stride: 1
Nr of Filters: 16



$$\text{output}_{\text{timesteps}} = (it - ks) + 1$$

$$\text{output}_{\text{timesteps}} = (7 - 5) + 1$$

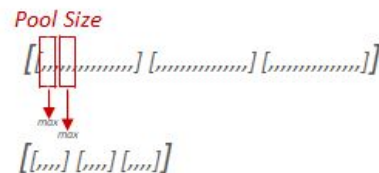
$$\text{output}_{\text{timesteps}} = 3$$

Input Shape: (1601, 7, 4)
Output Shape: (1601, 3, 16)

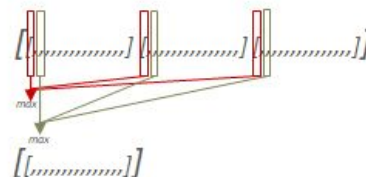
Max Pool1D

Pool Size: 3
Stride: Defaults to Pool Size

Channels' First (feature reduction):
Input Shape: (1601, 3, 16)
Output Shape: (1601, 3, 5)

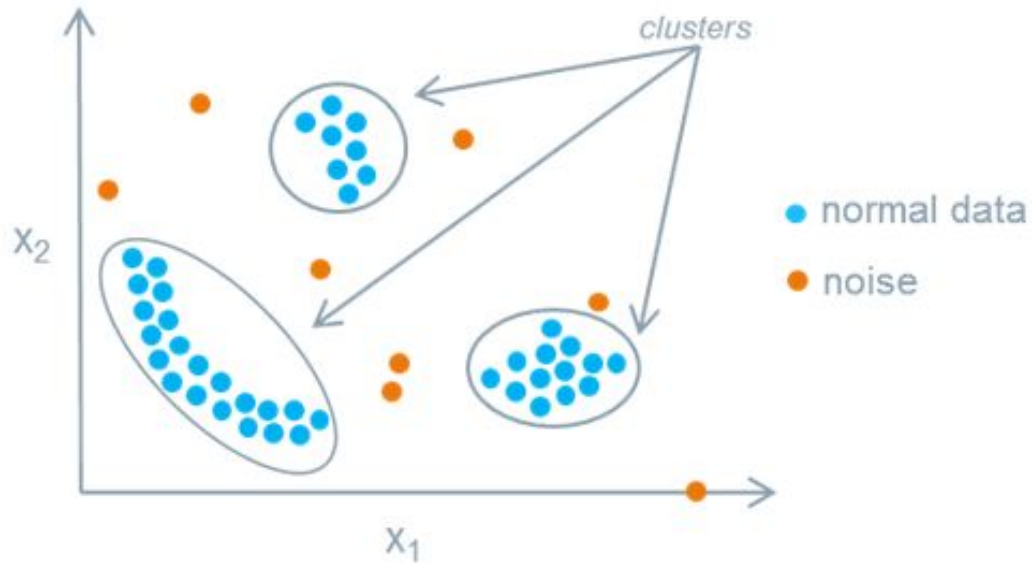


Channels' Last (timesteps reduction):
Input Shape: (1601, 3, 16)
Output Shape: (1601, 1, 16)



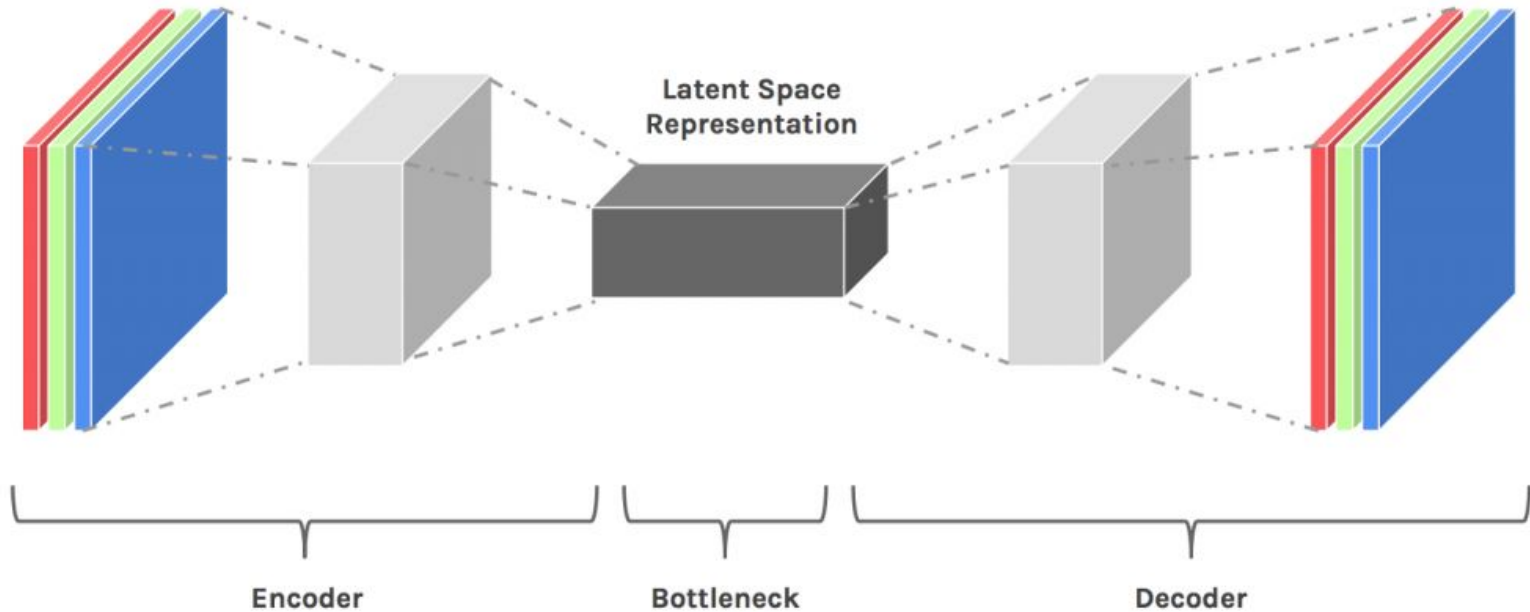
Anomaly Detection

Clustering-based



Anomaly Detection

Autoencoders



PAMWater

... So far!



Why?

- Pollution increases over the years;
- Environmental crisis;
- Impacts in environmental quality.



PAMWater Project

- Multi-municipal water companies challenges:
 - Optimization of energy efficiency;
 - Water characteristics analysis;
 - Effect of climatological events on flows.



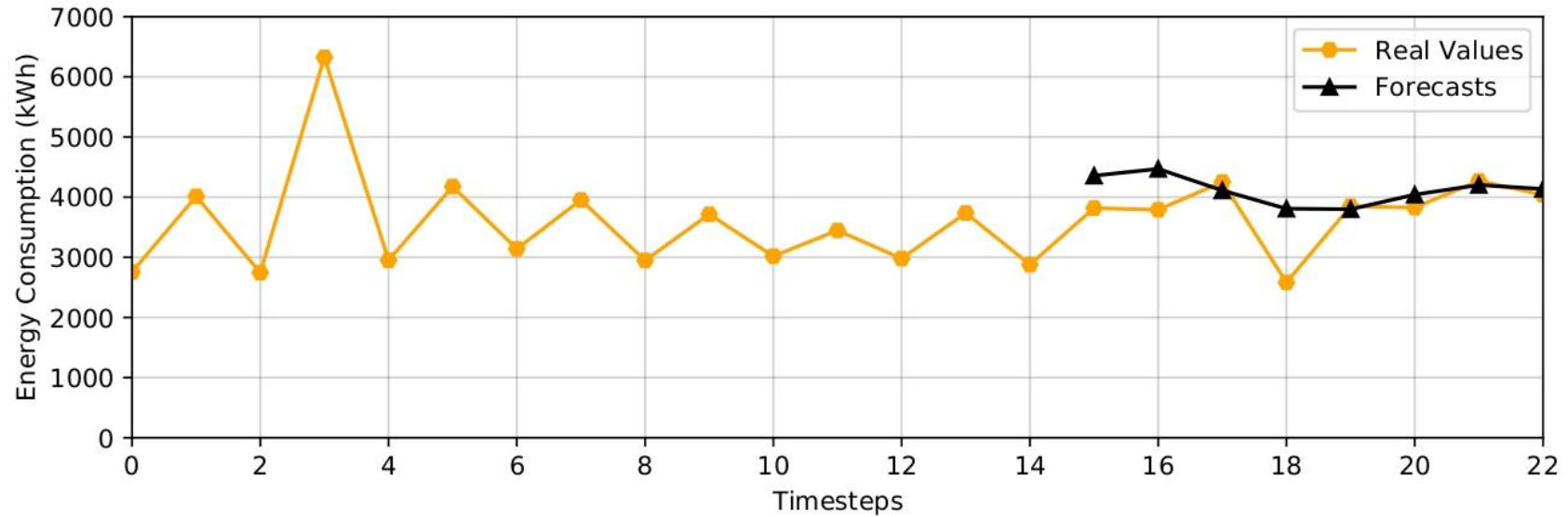
Source: <https://poseur.portugal2020.pt/pt/#>

Goals

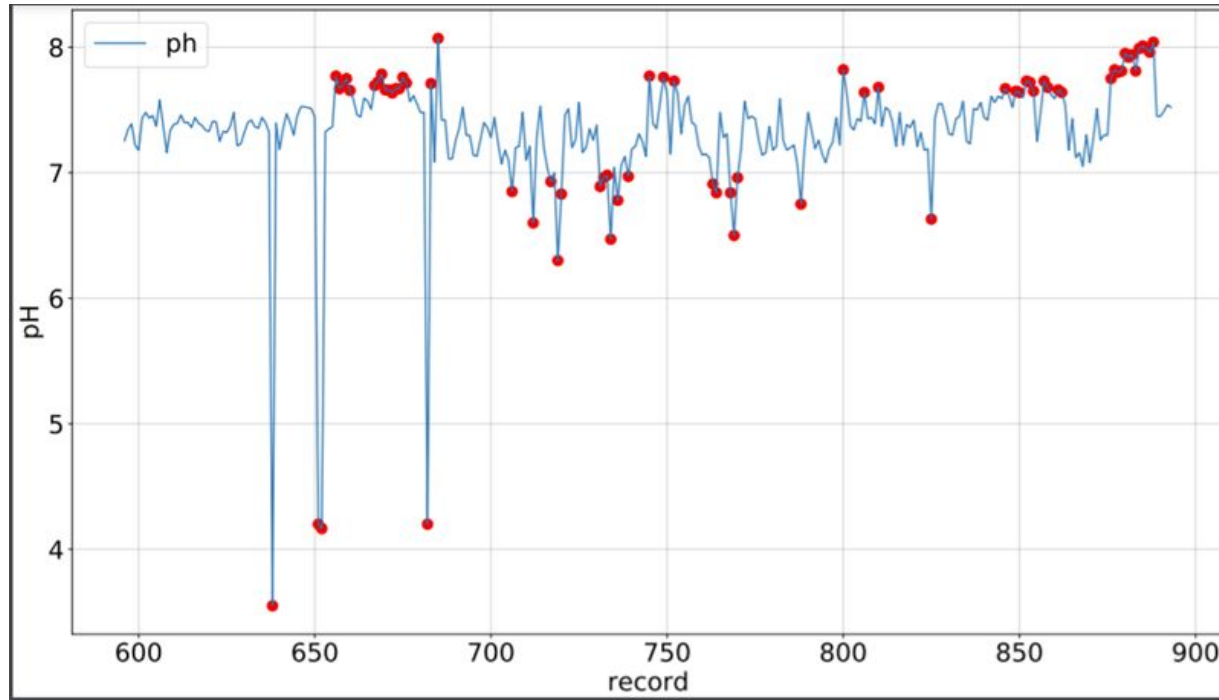
- Model the impact of the weather;
- Model and forecast the flows;
- Model and forecast water substances;
- Improve energetic efficiency.



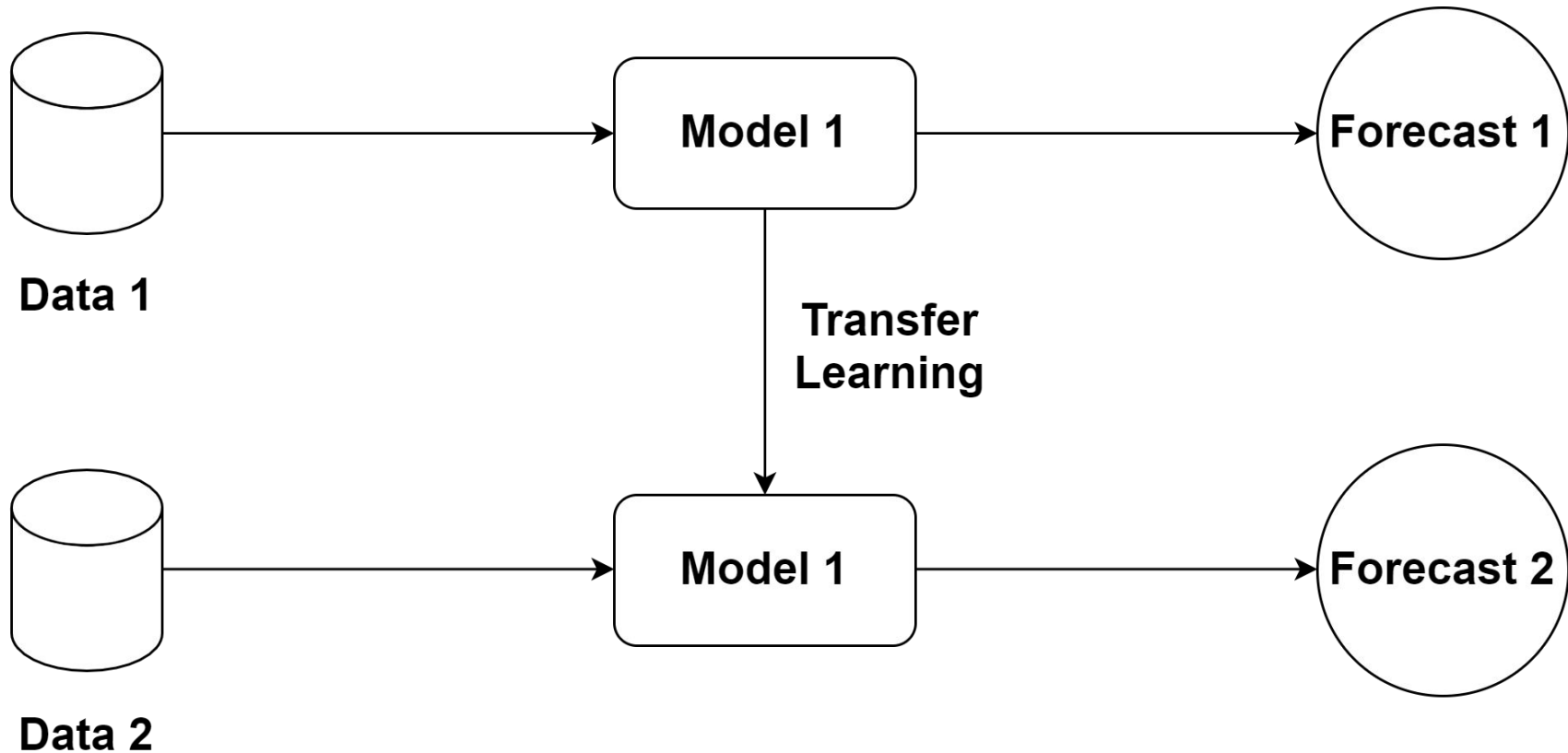
PAMWater - Modelling



PAMWater - Modelling

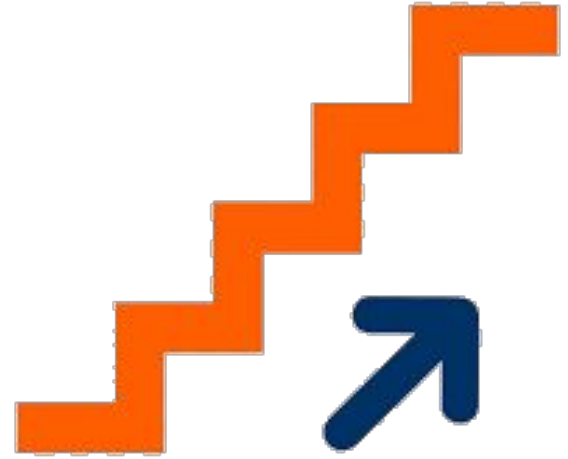


Transfer Learning Process



PAMWater - Next Steps

- Continue the development of the PAMWater platform;
- Implement Automated ML Software;
- Deployment of ML and DL models.





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