Machine Learning for Geosciences

By Francisco Mendoza

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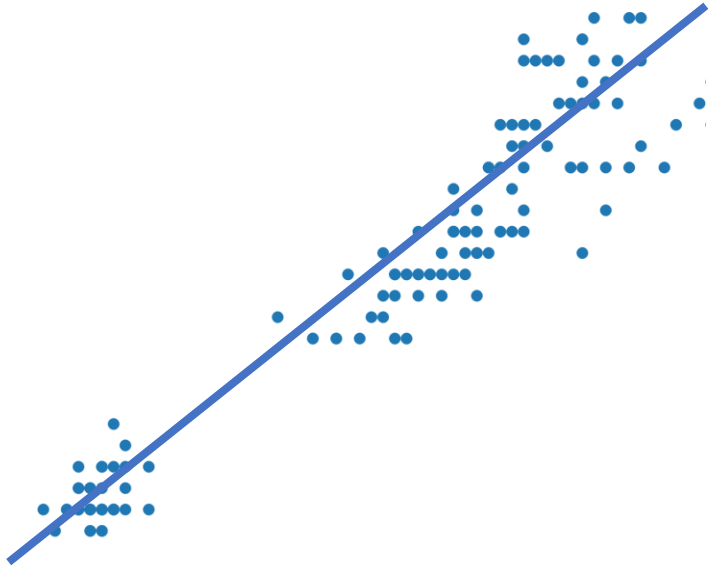
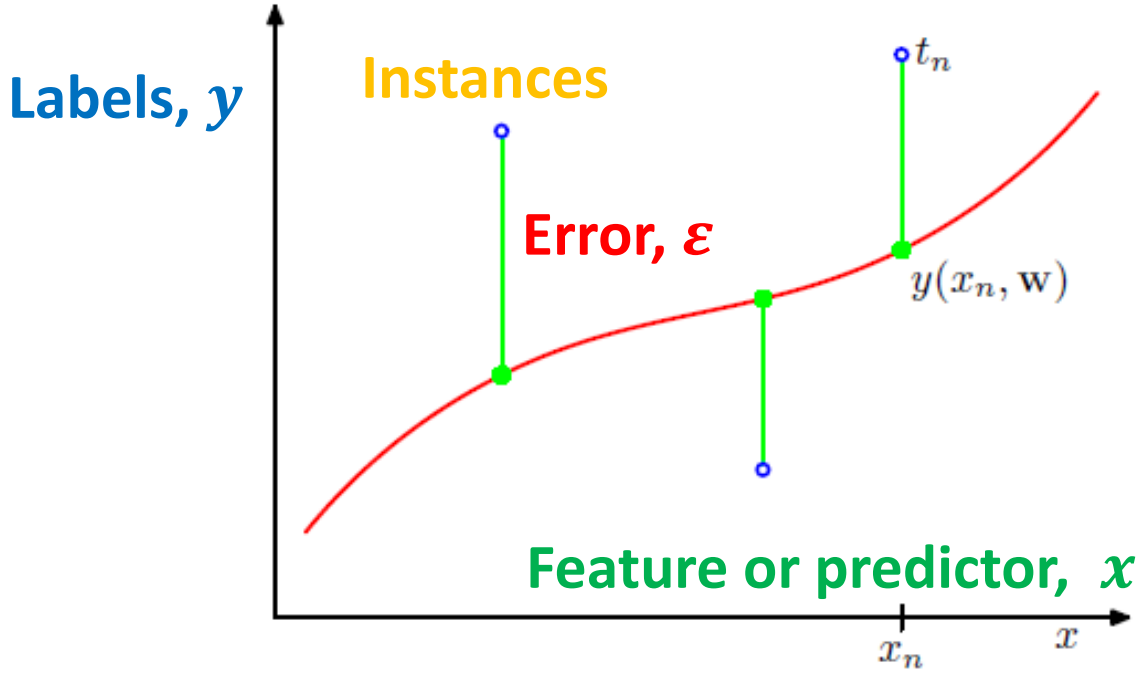
Course material:
https://github.com/**mathphysmx/teaching-ml**

Basic concepts

All previous concepts used in statistics such as (in)?dependent variable, input/output variables, etc plus the following,

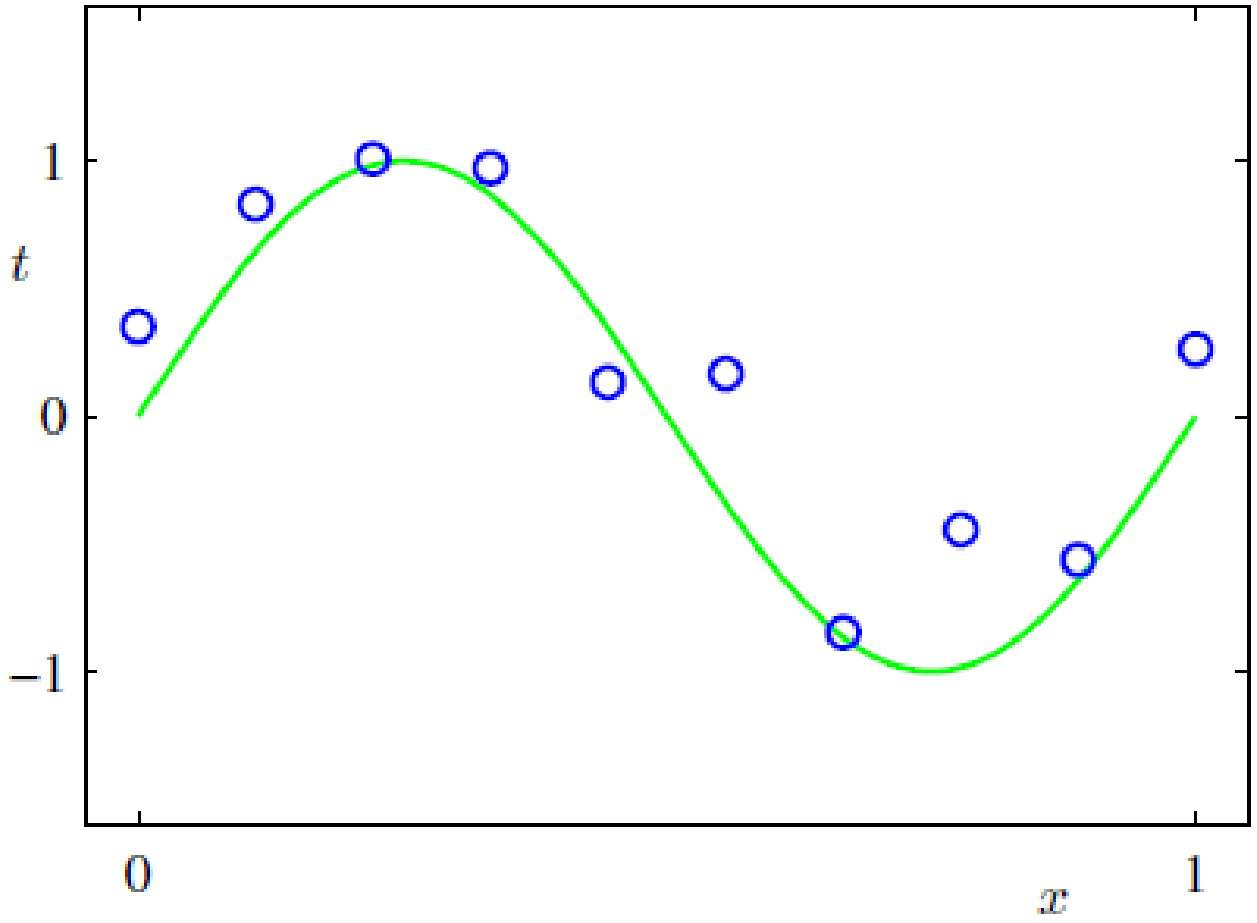




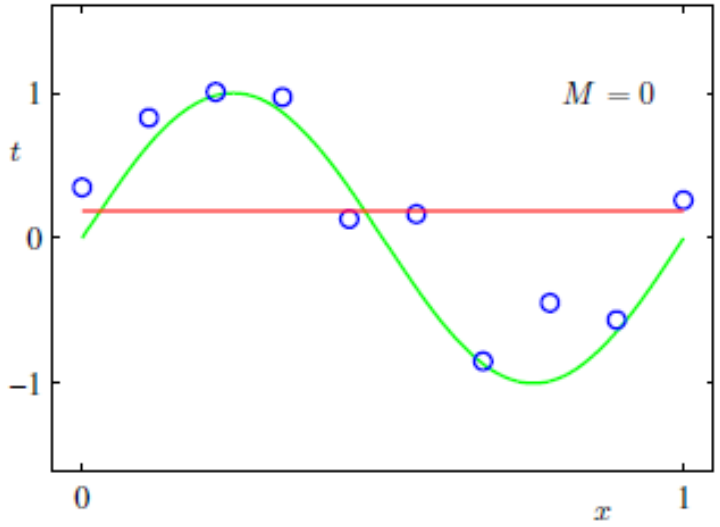
Training set

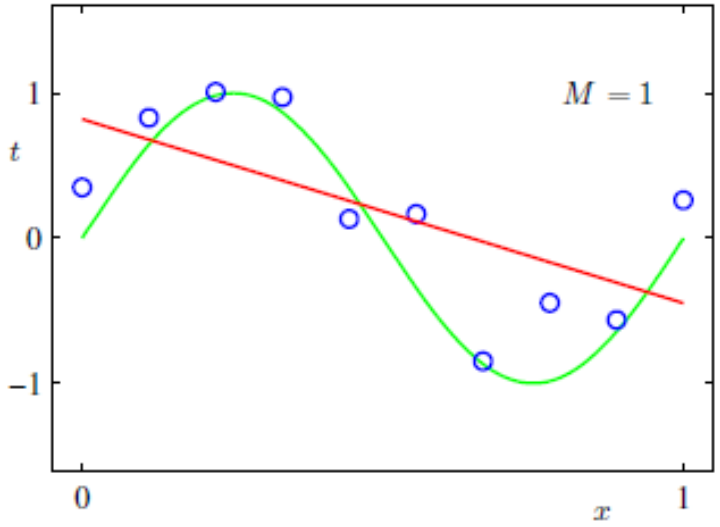
	Features x	Labels y	Error ε
Instance 1			
Instance 2			

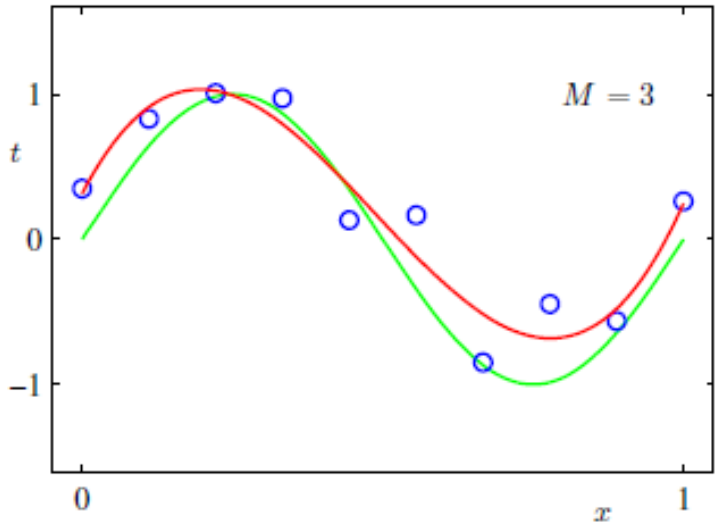
Machine learning. Introduction

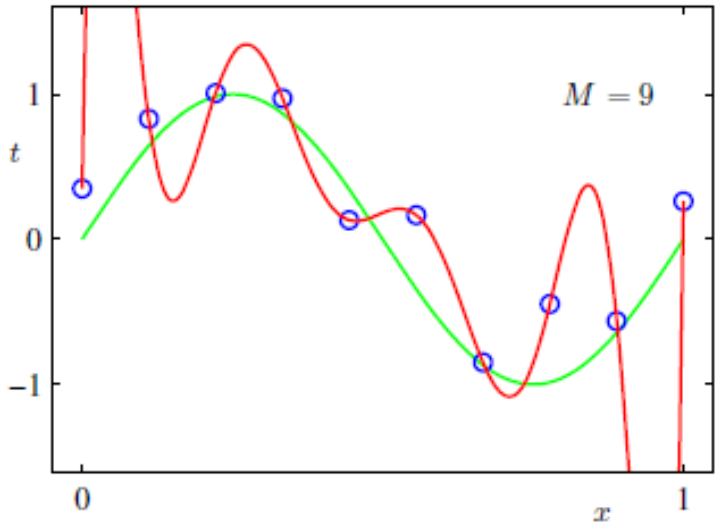


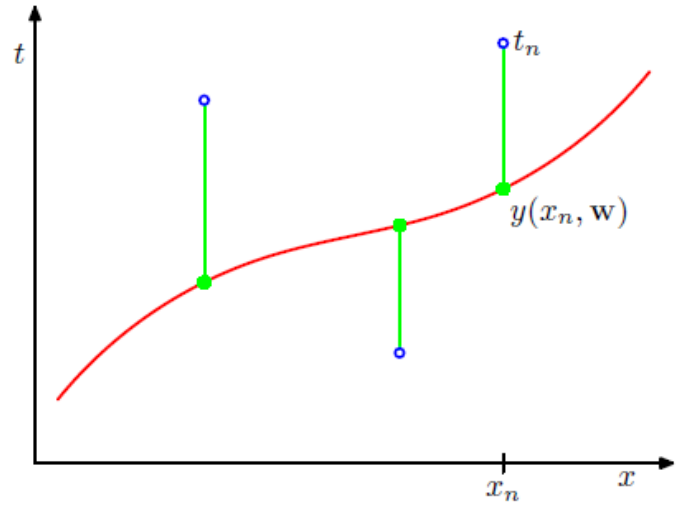
Model selection

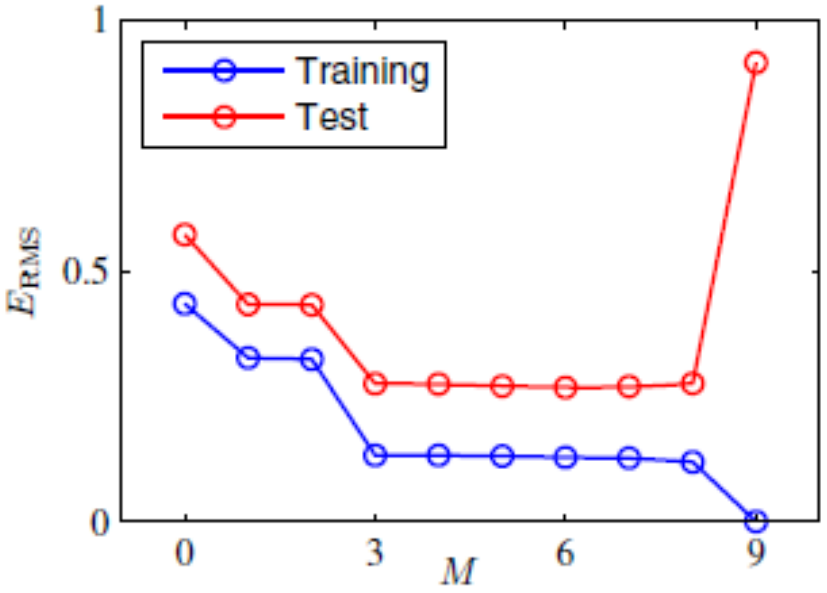




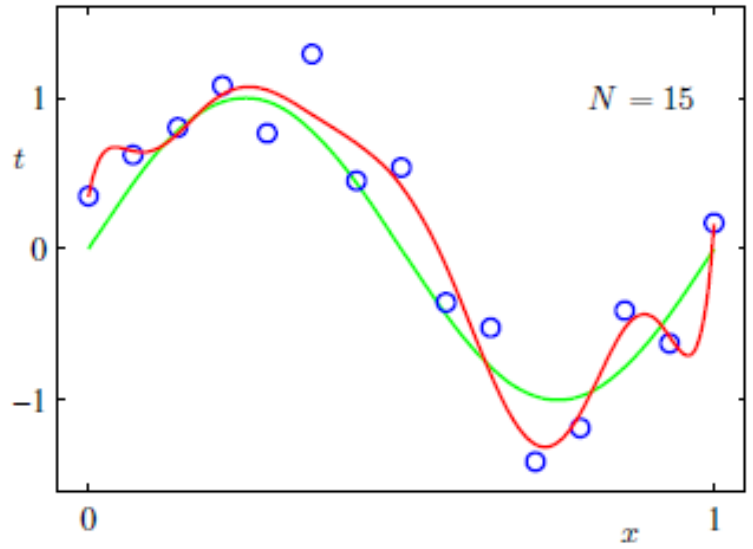


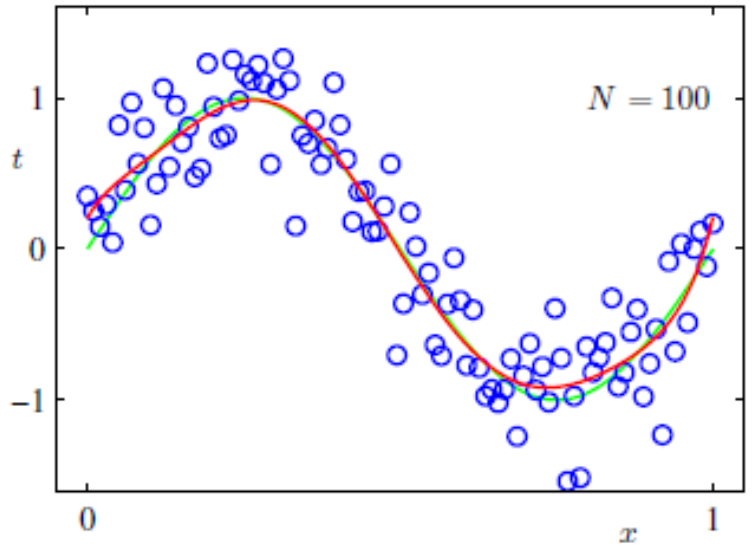


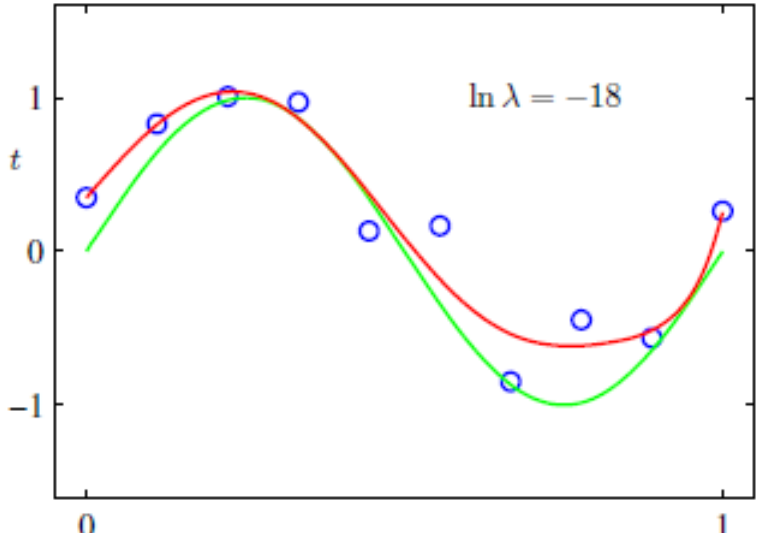


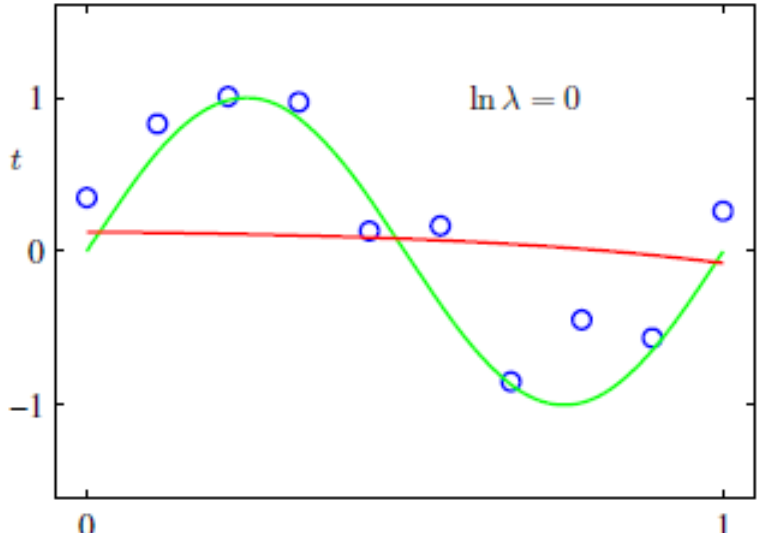


Over-fitting?



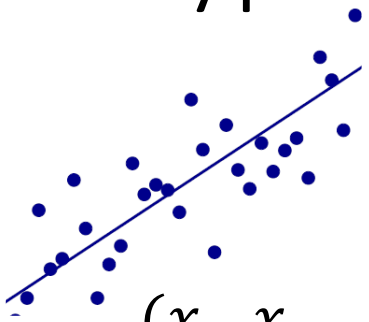






Concepts review

Type of problems, data types

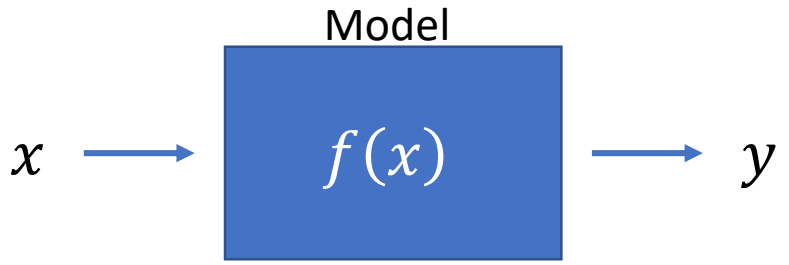


$x \to y$

$(x_1, x_2, \dots, x_n) \to y$

$(x_1, x_2, \dots, x_n) \to (y_1, y_2, \dots, y_k)$

Supervised



$f: X \to Y$

Unsupervised

ID	x_1	…	x_n	Category
1	3.532		A	Catx
2	7.234		H	Caty
⋮	⋮		⋮	⋮

ID	Cat y
1	aaa
2	hhh
⋮	⋮

What is ML

Machine Learning is the science (and art) of programming computers so they can *learn from data*.

Here is a slightly more general definition:

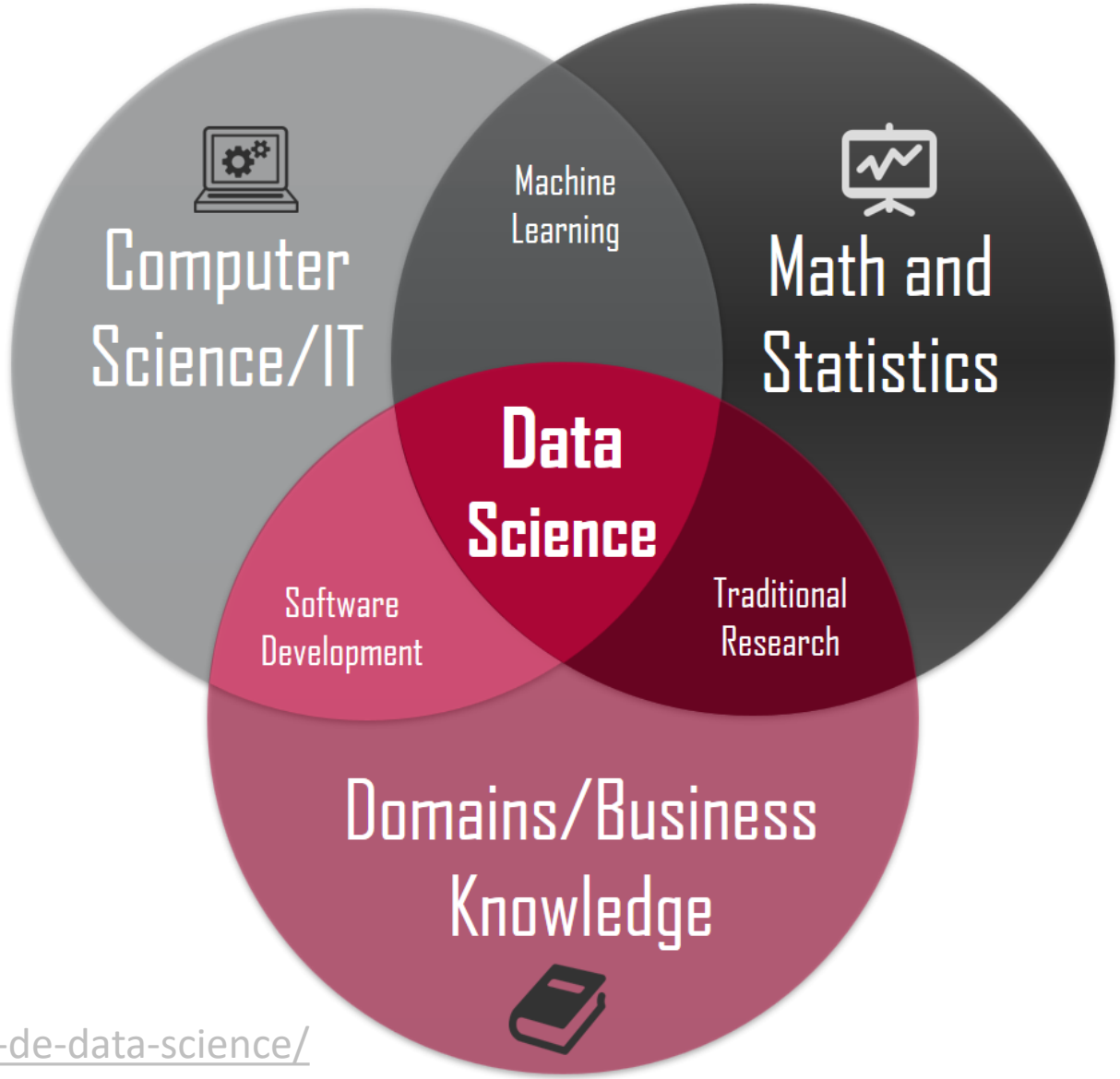
> [Machine Learning is the] field of study that gives computers the ability to learn without being explicitly programmed.
>
> —Arthur Samuel, *1959*

And a more engineering-oriented one:

> A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.
>
> —Tom Mitchell, *1997*

Related areas. Data Science

- Data manipulation (50 – 80 %)
- Machine Learning
- Deep learning



http://sitiobigdata.com/2018/08/27/los-tres-nucleos-de-data-science/

Applications in this course

Hydrology, geothermal, radioactive waste disposal, oil and gas, CO2 sequestration, mining

- Fluid volume production from a well
- Porosity from depth (Pyrcz)
- …

Mostly based on

- https://github.com/GeostatsGuy
- Guangren Shi, 2014. Data Mining and Knowledge Discovery for Geoscientists

Types of Machine learning algorithms

- Supervised
  - k-Nearest Neighbors
  - Linear Regression
  - Logistic Regression
  - Support Vector Machines (SVMs)
  - Decision Trees, Ensemble methods
  - Neural networks
- Unsupervised
  - Clustering: K-means, Hierarchical Cluster Analysis (HCA)
  - Visualization and dimensionality reduction (Kernel)? PCA, t-distributed Stochastic Neighbor Embedding (t-SNE)
- Reinforcement learning

- Batch and Online learning

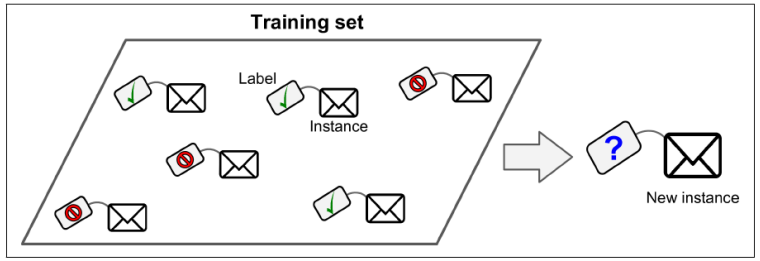


Figure 1-5. A labeled training set for supervised learning (e.g., spam classification)

Figure 1-6. Regression

Grading

- 20% Theoretical
- 20% Computational exercises
- 20% Exams
- 20% Oral presentation of application of ML in Geosciences
- 20% MOOC (Coursera, Udemy, …)

Current research (Journals)

- Mathematical Geosciences
  - Neural Networks
  - Machine learning
- Computer and Geosciences
  - Neural networks
  - TensorFlow
  - Machine learning
- Computational Geosciences
  - Neural Networks
  - TensorFlow
  - Machine learning

Table of Content (TOC)

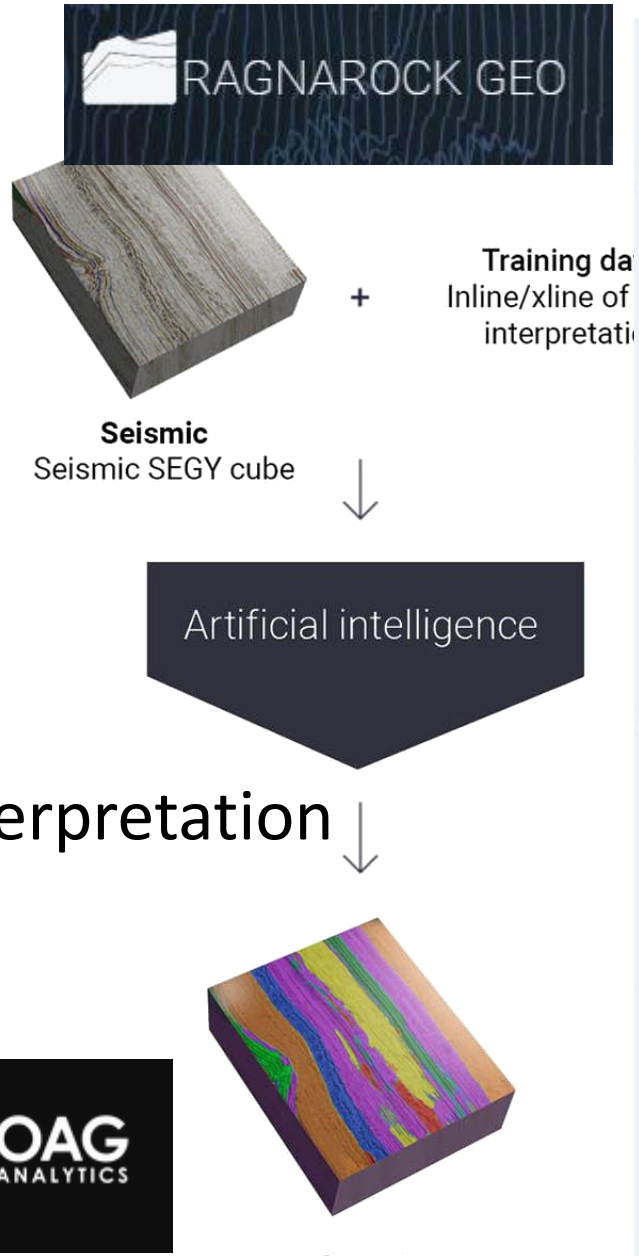
Índice Temático			
Unidad	Tema	Horas	
		Teóricas	Prácticas
1	Panorama general sobre machine learning	2	0
2	Proyecto aplicado de machine learning	4	4
3	Modelos lineales y regresión logística	3	3
4	Máquinas de soporte vectorial (Support Vector Machines)	3	3
5	Métodos basados en árboles de decisión	6	6
6	Modelos basados en teoría de gráficas	3	3
7	Aprendizaje no supervisado	3	3
8	Reducción de la dimensionalidad	3	3
9	Redes neuronales y aprendizaje profundo	6	6
	Total de horas:		
	Suma total de horas:	64	

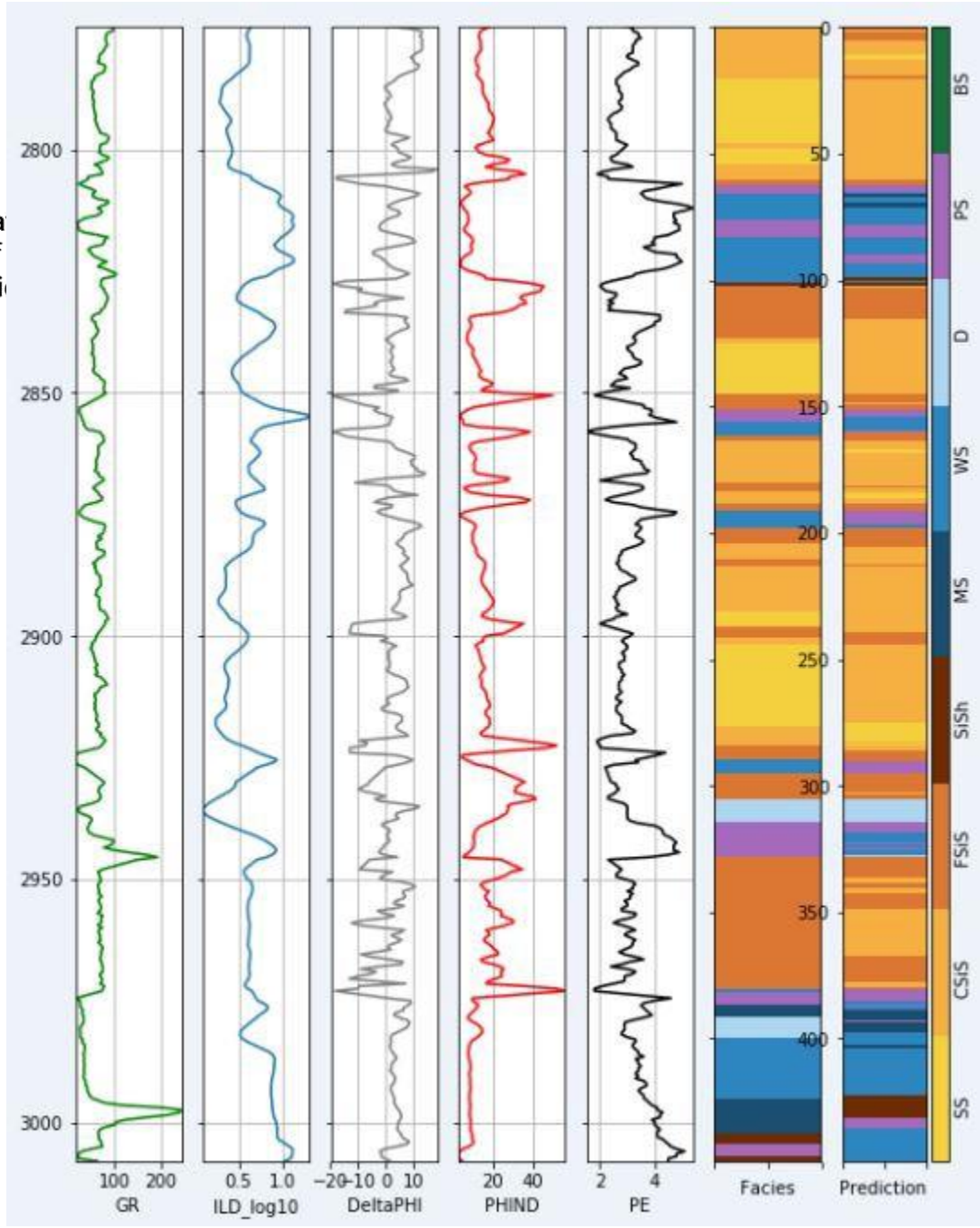
Bibliography

Companies

- All big companies +

- Well spacing
- Earth models
- Seismic horizons interpretation





Concepts review

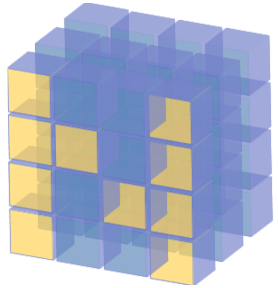
Software stack

python™

Visual Studio Code

pandas

matplotlib



NumPy

See also

- YouTube Michael Pyrcz 00 Machine Learning: Introduction
- YouTube Michael Pyrcz 06 Machine Learning: Intro to Machine Learning

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