TP “Python for AI”:
a crash course focused on linear regression models

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Page: https://auranic.github.io/teaching/2021-python_for_ai

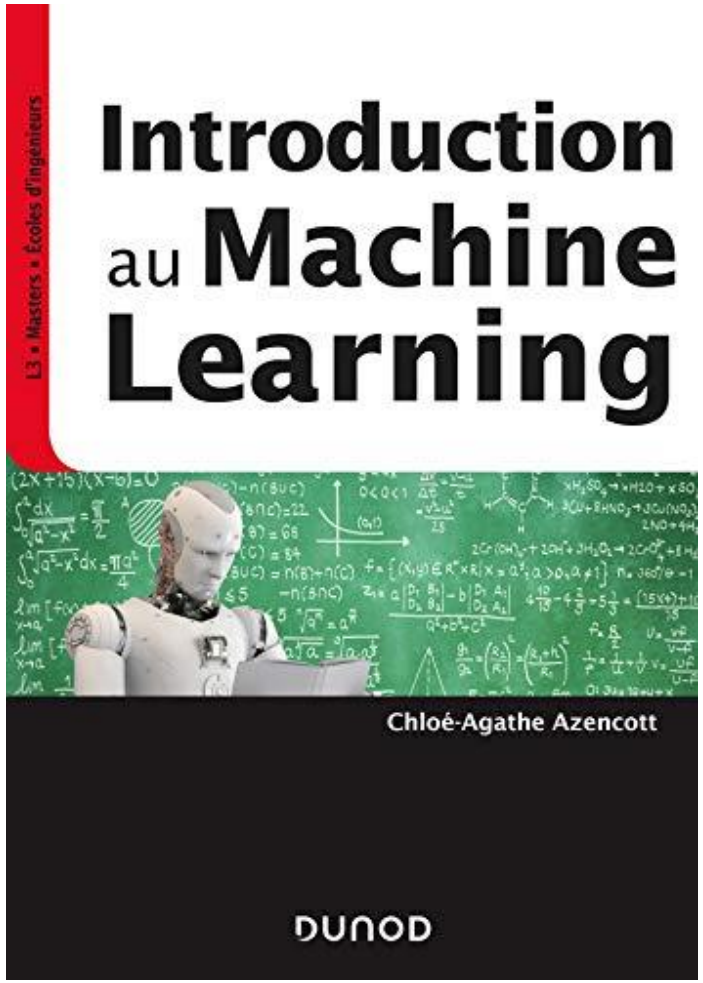
Python language

- *Franca lingua* for data science community today
- General purpose programming language (not specialized for a field like R)
- Rich set of standard libraries for data manipulation
- Rich set of standard libraries for numerical computations
- Rich set of standard libraries for machine learning
- Rich set of standard libraries for deep learning

- We will use Python 3!

What to read?


O'REILLY
Le Machine learning avec Python
LA BIBLE DES DATA SCIENTISTS
jupyter
Andreas C. Müller et Sarah Guido


L3 • Masters • Écoles d'ingénieurs
Introduction au Machine Learning
Chloé-Agathe Azencott
DUNOD

Jupyter Python notebook

- To learn Python
- To write simple Python programs
- To develop complex Python program prototypes
- To exploit powerful computers remotely
- To do cloud computing
- To do data analysis and machine learning!
- To do data analysis without installing Python!

Colab: using Google computers and their GPUs, for your own projects

- Only a gmail account is needed
- Based on Jupyter notebooks
- Integrated with Google Drive
- Has Google machine learning products installed (such as TensorFlow)
- Free Cloud service with free GPU

Kaggle: open data scientist environment

- An online Community (3 million users) of Data Scientists and Machine Learners
- Enter competitions to solve data science challenges
- Data science online education
- Allows finding and publishing data sets

Other available services for online machine learning using Jupyter notebooks

Microsoft Azure

Few Python libraries we will use in this TP

- pandas – for manipulating data frames (‘tables with headers’ similar to Excel sheets)
- numpy – for manipulating 1d and 2d arrays
- scipy – for statistical calculations
- matplotlib – for standard data plotting
- seaborn – for easy data graphics with pandas
- scikit-learn – for machine learning
- tensorflow – for computing regression as a neural network

- lifelines – for survival analysis

scikit-learn: the most popular library machine learning

- Almost any machine learning method, using the same code pattern

```
model = SomeModel(parameters)
model.fit(X,Y)
Y_predicted = model.predict(X)
model.score(X,Y)
```

- Excellent documentation: https://scikit-learn.org/
- Started and implemented in France by INRIA in 2010

tensorflow: Google open source library oriented to deep learning

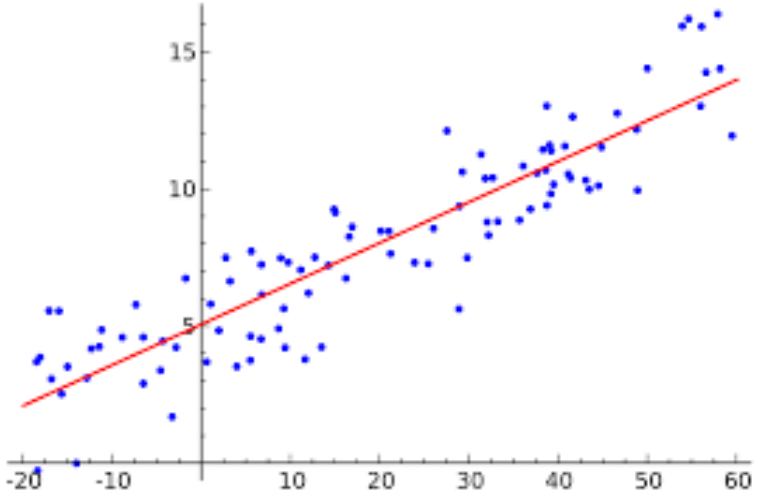
- a free and open-source software library for machine learning
- Developed by Google Brain in 2017
- Based on dataflow and computational graph
- Based on differentiable programming

- Easiest way to use TensorFlow is by using Keras : a wrapper on top of tensorflow which allows one to construct deep learning models and fit them to data

Linear regression

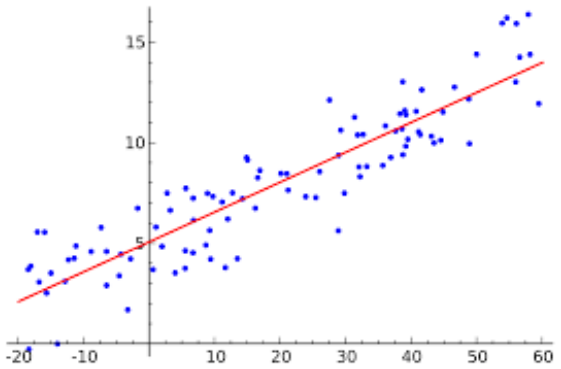
$$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i = \mathbf{x}_i^{\mathsf{T}} \boldsymbol{\beta} + \varepsilon_i, \qquad i = 1, \ldots, n,$$

- Connects many independent and one dependent variable via linear function
- Linear regression: the father of all supervised machine learning methods
- Linear regression: the most used machine learning method today
- Linear regression: the first machine learning method to apply, and see what it gives
- Linear regression: common problems and ways to deal with them (regularization)
- Linear regression can be used to produce non-linear data models

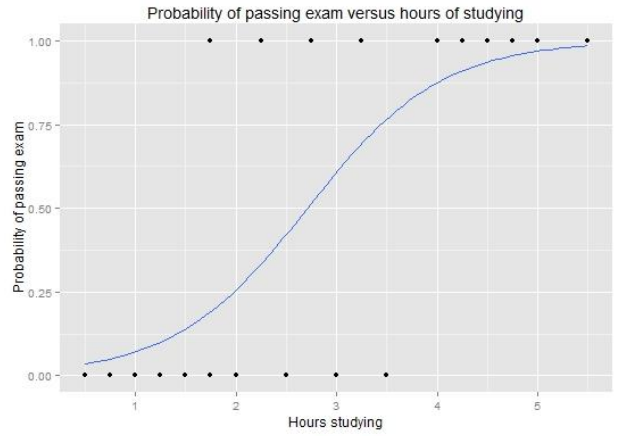


Three major flavors of linear regression in healthcare-related data science

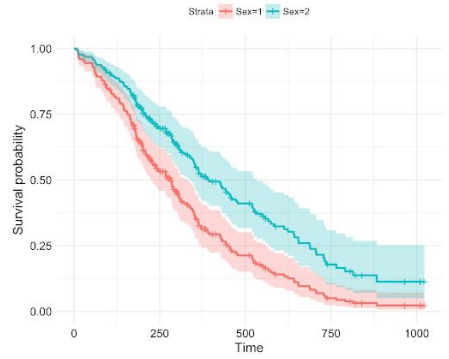
- Simple Ordinary Least Square : when the target variable is continuous



- Logistic linear regression (logit): when the target variable is discrete (for example, binary)

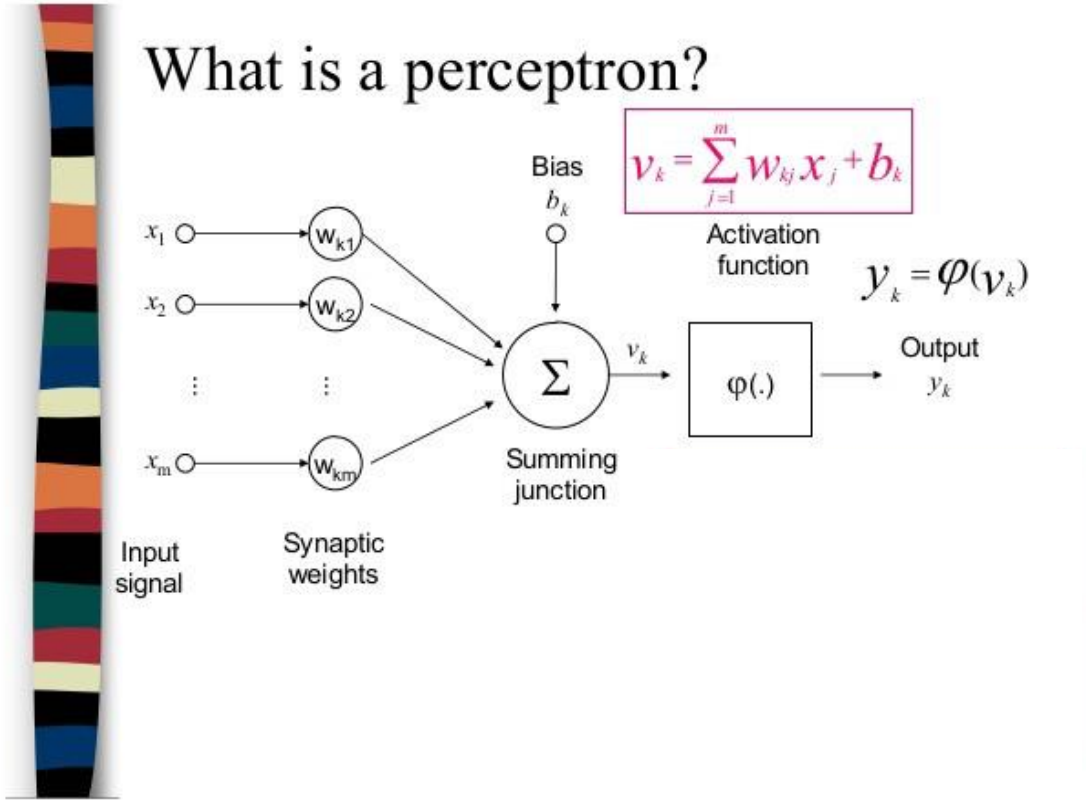


- Survival Cox linear regression : when the target variable is a pair (follow up time + event)



Linear regression and a simple perceptron (formal neuron)

- Invented by Frank Rosenblatt in 1950s
- Elementary unit of any complex and deep neural network today



If $\varphi(x) = x$, then it is simple linear regression model

If $\varphi(x)$ is a step-wise or sigmoidal function then it is a binary classifier just as logistic regression (even though they are trained with different algorithms!)

Linear regression is explainable ML model!

$$y_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i = \mathbf{x}_i^{\mathsf{T}} \boldsymbol{\beta} + \varepsilon_i, \qquad i = 1, \ldots, n,$$

Coefficients β_1, β_2, … , β_p are comparable if independent variables are standardized (to z-scores) and have straingforward interpretation

It is possible to estimate statistical significance of β_i coefficients and provide p-value on the hypothesis that the coefficient is non-zero

This can help to simplify the regression

Other methods (such as regularization by lasso) for selecting important variables are readily avaialable

Objective of the TP: learn how to build simple regression models in Python

- Univariate and multi-variate regressions
- Validating the regression models in Python
- Building regression models using scikit-learn
- Building regression models using scipy
- Building regression models using tensorflow and train them using gradient-descent (similarly to building neural networks)

Plan of the TP

- Lesson I (~2.5 hours)
  - Connecting to Colab
  - Creating first Jupyter notebook
  - Working with a toy dataset
  - Visualizing simplest linear regression
  - Linear regression: using scikit-learn
  - Linear regression: using scipy statmodels
  - Loading a real-life dataset and exploring it
  - Simplifying the regression model

Plan of the TP

- Lesson II (~2.5 hours)
  - Testing and validating the linear regression

  Implementing linear regression in tensorflow
  - Basic things in tensorflow
  - First computational graph
  - Linear regression: using tensorflow and gradient descent

Ways to work on TP: all depends on your Python level/motivation!

- Some initial level of Python is assumed:
  - If not then a good start is at:
    https://wiki.python.org/moin/BeginnersGuide/NonProgrammers
    https://wiki.python.org/moin/BeginnersGuide/Programmers
    https://www.w3resource.com/python-exercises/python-basic-exercises.php
- We will start with a simple warming up exercise
- We will have a basic code example on a tiny imaginary example
- *Five real-life datasets from healthcare have been prepared (preprocessed) for this TP : try applying and validating linear regression on some of them*
- In some tasks you will need to insert missing code indicated by '…'
- Do not hesitate to copy-paste (from anywhere, e.g. Stack Overflow)
- Do not hesitate to read Wikipedia