# Pre-requisites

- (**PRE1**, Applied Stats): **M**aximum **L**ikelihood **E**stimate and related notions

- (**PRE2**, Maths for DS): **Basic Linear Algebra**

  → **Note that PRE1 and PRE2 are mandatory,** i.e. you **must attend them to be allowed to follow TC0/FPML,** except if you can argue that you are already very fluent in statistics (PRE1) and linear algebra (PRE2).

- (PRE4, Scientific prog.): it was advised to follow it: we'll use **numpy** heavily

- (TC2, Optimization): **Gradient Descent** mostly (we'll discuss it) – it's advised to take it as well. More advanced notions are very useful to understand SVMs

- (OPT9, Hands On ML): it's a good complement to this class, very good to master sklearn. Here we'll look inside the algos of sklearn.

# FPML – Fundamental Principles of ML
# **François Landes** & Manon Verbockhaven

In 3 words: **inside** the **black boxes** – let's do the maths !

- This course **is the theoretical counterpart of HoML** (Hands-on ML, applying ML to concrete projects, which is more hands-on than this course).
FPML is **algorithms-oriented, i.e. we will sketch the great principles of ML, but focus on how algorithms work in practice, including all necessary mathematical aspects**.

- Assuming a knowledge of fundamental maths notions (Bayesian inference, Algebra, Analysis, some optimization), we will cover the **inner workings of ML algorithms in detail.**
Beyond their technical implementation, we will also **explain their theoretical foundations (mathematical definitions, limits, when and why they fail or work, etc).**

- The course will be **supported by pen-and-paper sessions and lab sessions** in groups of ~20, where we will re-code and play with algorithms, using Python.

- Note !  An **important part of the course material will be dispensed through the black/white/digital-board.** You are supposed to be **taking notes**, either **individually or in groups**.
To adjust for covid-related constraints, motivated **students are encouraged to self-organize to type a set of notes**, which we may proofread, to then share with the class.
(although the class will be recorded, **I recommend taking notes**: a video does not replace good notes).

# Goals

## What you should know *by the end of the term*

Know the basics of **ML vocabulary**

Make good **habits**, understand the standard **pipeline**

1. **Know** a couple of standard algorithms (be able to write their pseudo-code, explain their functioning)

2. Be able to code an algo (implement it) by **reading its doc** (documentation $\simeq$ book chapter)

3. Be able to **analyze critically** typical (classic) **experimental phenomena**, be able to make the good decisions

4. Given a problem (task), guess the relevant class of methods
*(this is the slightly Hands-on part)*

# Goals
In the *long term*

- Learn **life-long fundamentals** that will not be outdated (obsolescent) in a couple of years

- Know the fundamentals enough so that you may **go beyond them** (with other classes) – to understand **newer paradigms**, you need to know about the previous one !

# Grades / Evaluation

MCC (grades):

- **Session 1**: 0.3 CC + 0.7 EE *(Controle Continu, Examen Écrit)*

  – EE 70% **Limited time written exam.**
  (Limitless) documents will be allowed.

  – CC 30% **5 min quizzes at the beginning of each class + [probably] a small homework coding exercise**

- **Session 2:** 1.0 EE (2nd chance exam)

  – EE 100% New written exam
  (replaces previous grades)

Advice: Quizz is easy → more easy points in 1st session → try to get it the 1st time.

# How to get ready ?

- Written exam (70%) - *December 16th, 3h-long, pen-and-paper*
  - what you need to know: **points 1, 2 (a bit of 3) in slide #3**
  - prepare: work at constant pace on tutorials (+read corrections)
  - /!\ **: documents allowed: <span style="color:red">6 pages of notes</span>** (If typed, typed by yourself, not stupid copy-paste from anywhere)

- Quizz : *Fridays, 5 to 10 min quizzes online (MCQ & the like)*
  - *https://ecampus.paris-saclay.fr/course/view.php?id=28064#section-5*
  - be in class on time (easy !)
  - review last week material (lectures, tutorials, tutorials corrections), making sure you understood everything
  - easy points to score !

# Python

IMPORTANT – make sure you have un **updated version of python3 and jupyter-notebook**, with at least **numpy, scipy, matplotlib** installed. Shortly we will also need **sklearn** (**scikit-learn**), possibly **pandas**. **Seaborn** is always nice to have (I am not an expert of it).

- Alternative Solution 1: **Use https://jupyterhub.ijclab.in2p3.fr/ . Use your institutional (Paris-Saclay, typically) account to connect for the first time.** This will open a work session of jupyter-notebook, that runs on the cloud, or more precisely, on the servers of the LAL (Linear Accelerator Laboratoire). You can click on the blue button on the top right corner, « upload », to import a notebook file onto the cloud, and then edit and run it online. Your files are saved over time there.

- Alternative Solution 2 (worse): same thing but using instead https://colab.research.google.com/notebooks/intro.ipynb (bad point: it's google, you need an account + data privacy is bad)

# Outline of contents

**Approximate and Tentative program** of the semester (or term, really)
(1 subject ≠ 1 session, some are longer, some shorter)

If you get bored with the basic subjects, please ask questions, interact, and we can do more ! Also it's good to really master the basics in deep (no pun intended).

- **Linear Regression** and related models: coding from scratch, basic notions + Gradient Descent
- **Perceptron**, Single Layer Neural Network : coding from scratch
  *Toy examples / MNIST*
- *[Generic]:* ***train/validation/test*** *(extremely important !), Cross Validation*
- **PCA**, from scratch (knowing algebra and np.linalg.eig )
  *Image compression*
- *[Generic]* **Feature maps, Kernels** *(not from scratch, probably)*
- *[Generic]* **Regularization**
- **SVM**, ~from scratch (knowing Lagrange multipliers)
  *Classification*
- **Naive Bayes,** from scratch (knowing Bayesian Inference)
  + also **using a Prior** (i.e. real bayesian computation)
  *Image classification*
- *[probably no time for this]* **EM**, from scratch *(knowing Bayesian Inference)*
  *image clustering*
- [optionnal] **Decision trees**, ~from scratch, (knowing Entropy, Mutual Information)
  *Categorical data clustering*
- *[Generic, Optionnal]* **Metrics** *(MSE, MAE, ROC AUC)*

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# Bibliography
## *books*

**GO SEE:** *http://lptms.u-psud.fr/francois-landes/machine-learning-resources/*

### [BEST] Classics:

- *Pattern Recognition and Machine Learning*, Christopher **Bishop**, 2006 (more advanced, rather general)

- *Information Theory, Inference, and Learning Algorithms*, David J.C. **MacKay** (more theoretical, excellent if you enjoy probabilities)

- Your friends: **sci-hub** (papers) and **lib-gen** (books) or **book-zz** (books) *(sometimes blocked from outside the university)*


### Simple + exists in French:

- *Hands On Machine Learning with Scikit Learn and TensorFlow,* **Aurélien Géron** (not too hard, simulatneously rather practical yet complete) https://github.com/yanshengjia/ml-road/blob/master/resources/

Version **en Francais**:

- *Introduction au Machine Learning*, **Aurélien Géron**

# Course Material
## (see gitlab)

- **Slides** like this

- Writings on the blackboard (take notes)

- There will be **no official lecture notes** !
  But, you can ***make your own*** (collective) notes.
  (I can take the time to proofread them if you give me clean notes)

- **Jupyter** notebooks (subjects)

- Jupyter notebooks (corrections)

- **Pen-and-paper** subjects

- Pen-and-paper corrections (Some)

- **Past exams** : only 1, from last year.

- Quizz solutions (ecampus) -
  https://ecampus.paris-saclay.fr/course/view.php?id=28064#section-5

# FPML – Fundamental Principles of ML
# **François Landes** & Manon Verbockhaven

- francois.landes@u-psud.fr; manon.verbockhaven@inria.fr

- https://gitlab.inria.fr/flandes/fpml

- Fridays, 13:30 – 17:15

- Typically, 1h30 Lecture, 15 min break, 2h TD/TP

- MCC: 0.3CC+0.7EE

- Needed: **install** *python3, jupyter, scipy, numpy, matplotlib, scikit-learn* (+ *seaborn, pandas*, if possible)

# Where is the class ?

- Lecture: **always in E212, always at 13:30**

- 4 november: **Salle E212 (TD) E204/E205 (TP)**
  **1 CM** 13h30-15h     **Salle E212 (TD)**
  **1 TP** 15h15-17h15  **E204/E205 (TP)**

- The rest: to be announced