

Applied Machine Learning Course

Introduction to Key Concepts in Machine Learning

What is Machine Learning?

Machine Learning encompasses a large set of algorithms that aim at inferring information from what is hidden.



Independent Component Analysis (ICA) can decompose mixture of signals

What is Machine Learning?

Algorithms that can compute automatically information that would take days to do by hand.



Learn a mapping across images, here through support vector regression

Machine Learning: Definition

Output: mathematical expression

Computational methods

*“Machine Learning is the study of **computer algorithms** that **improve automatically** through **experience**.” “Machine learning algorithms build a **mathematical model** based on sample data”* Wikipedia (2020)

*“Machine Learning is the process by which a computer is able to **improve its own performance** (as in analyzing image files) by **continuously** incorporating new **data** into an existing **statistical model**.”* Webster Dictionary

Input: measurements - data

Statistical analysis of the data

Machine Learning ~ Data Mining



Pattern recognition with
very large amount of **high-dimensional** data

(Tens of thousands to billions)

(Several hundreds and more)

Machine Learning ~ Data Mining

Mining webpages



- Cluster groups of webpage by topics
- Cluster links across webpages



Other algorithms required:

- Fast methods for crawling the web
- Text processing (Natural Language Processing)
- Understanding semantics

Issues:

- Domain-specific language / terminology
- Foreign languages
- Dynamics of web (pages disappear / get created)

Types of Learning

- ***Supervised learning*** – where the algorithm learns a function or model that maps a set of inputs to a set of desired outputs.
- ***Unsupervised learning*** – where the algorithm learns a model that represents a set of inputs without any feedback (no desired output, no external reinforcement).
- ***Reinforcement learning*** – where the algorithm learns a mechanism that generates a set of outputs from one input in order to maximize a reward value (external and delayed feedback).

We will not cover RL in this course, see

[EE-618 Theory and Methods for Reinforcement Learning](#)

Supervised Learning

Supervised learning relates to a vast group of methods by which one estimates a model from a set of examples,
→ The system is given the *desired output*.

Types of supervised algorithms:

- Classification methods
- Regression methods

Supervised Learning - Regression: example



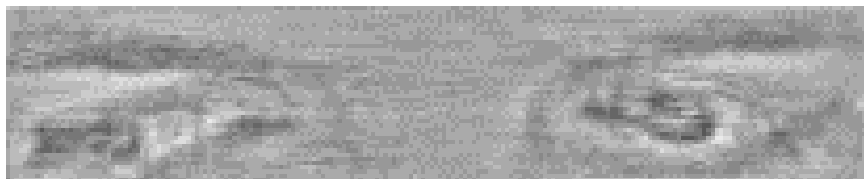
Where do the eyes look?

→ Map image of the eyes to point in the camera image

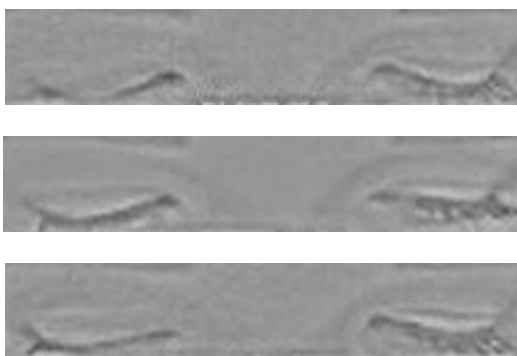


Supervised Learning - Regression: example

What is sometimes impossible to see for humans is easy for ML to pick.



Exploit information not only on the pupil, cornea, but also on wrinkles, eyelids and eyelashed pattern to infer gaze direction.



Wrinkles, Eyelids and Eyelashes



Support Vector Regression can be used to learn this mapping

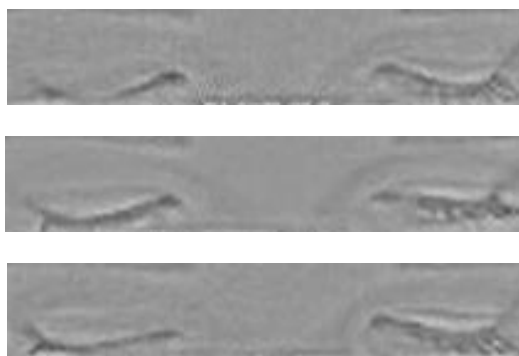
Supervised Learning - Regression: example

Learn a function f :

$$y = f(x)$$

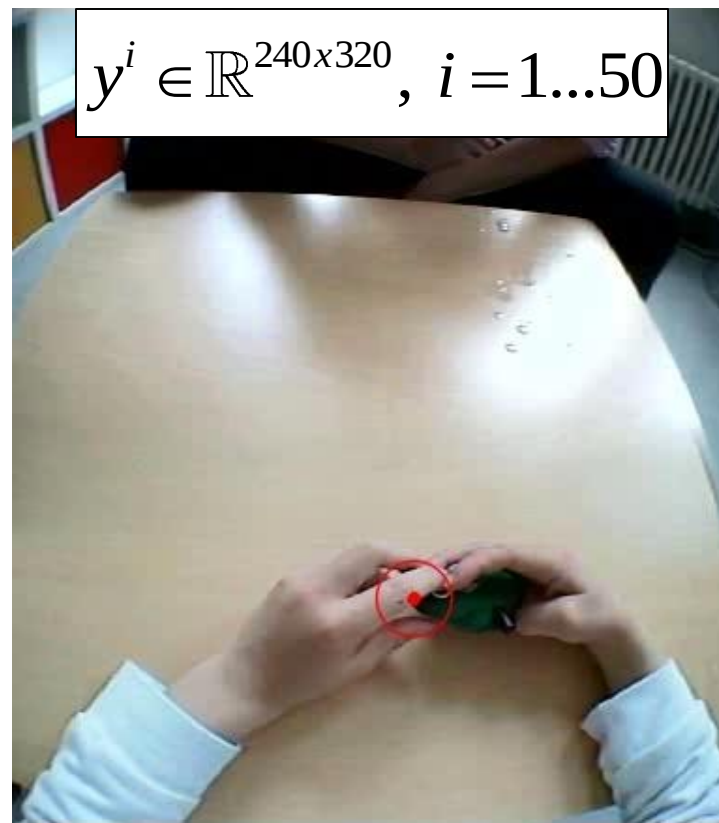
Input: 50 images of the eyes,
In grey color 20x20 pixels

$$x^i \in \mathbb{R}^{20 \times 20}, i = 1 \dots 50$$



Output: 50 images of the scene,
In grey color 240x320 pixels

$$y^i \in \mathbb{R}^{240 \times 320}, i = 1 \dots 50$$



**Support Vector
Regression can be used
to learn this mapping**

Summary & Outlook

Supervised learning relates to a vast group of methods that learn a mapping given an input to a *desired output*.

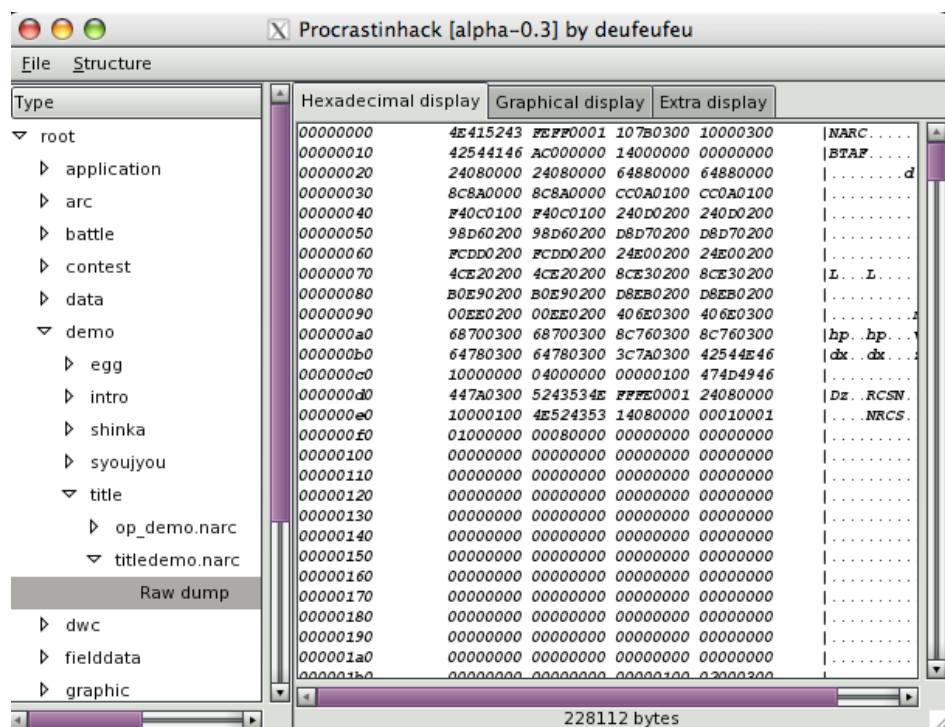
In this course, we will see the following supervised learning techniques:

- ❑ **Classification:** Support Vector Machine, Bayes classification, Neural networks
- ❑ **Regression:** Gaussian Mixture Regression, Support Vector Regression
Regression with Neural Networks

More techniques are covered in the Advanced Machine Learning course – MICRO 570

- ❑ **Classification:** Relevant Vector Machine, Gaussian Process Classification
- ❑ **Regression:** Probabilistic and Gaussian Process Regression,
Incremental non-linear regression

Unsupervised learning ~ Structure discovery

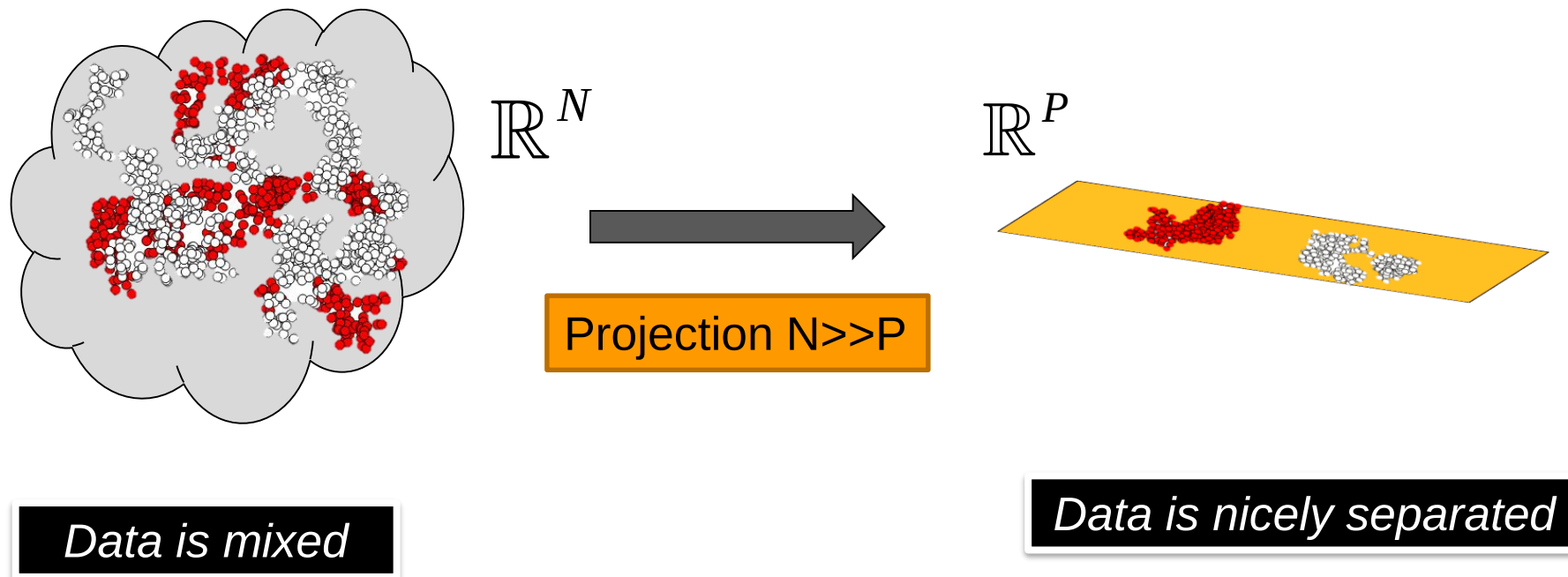


Raw Data



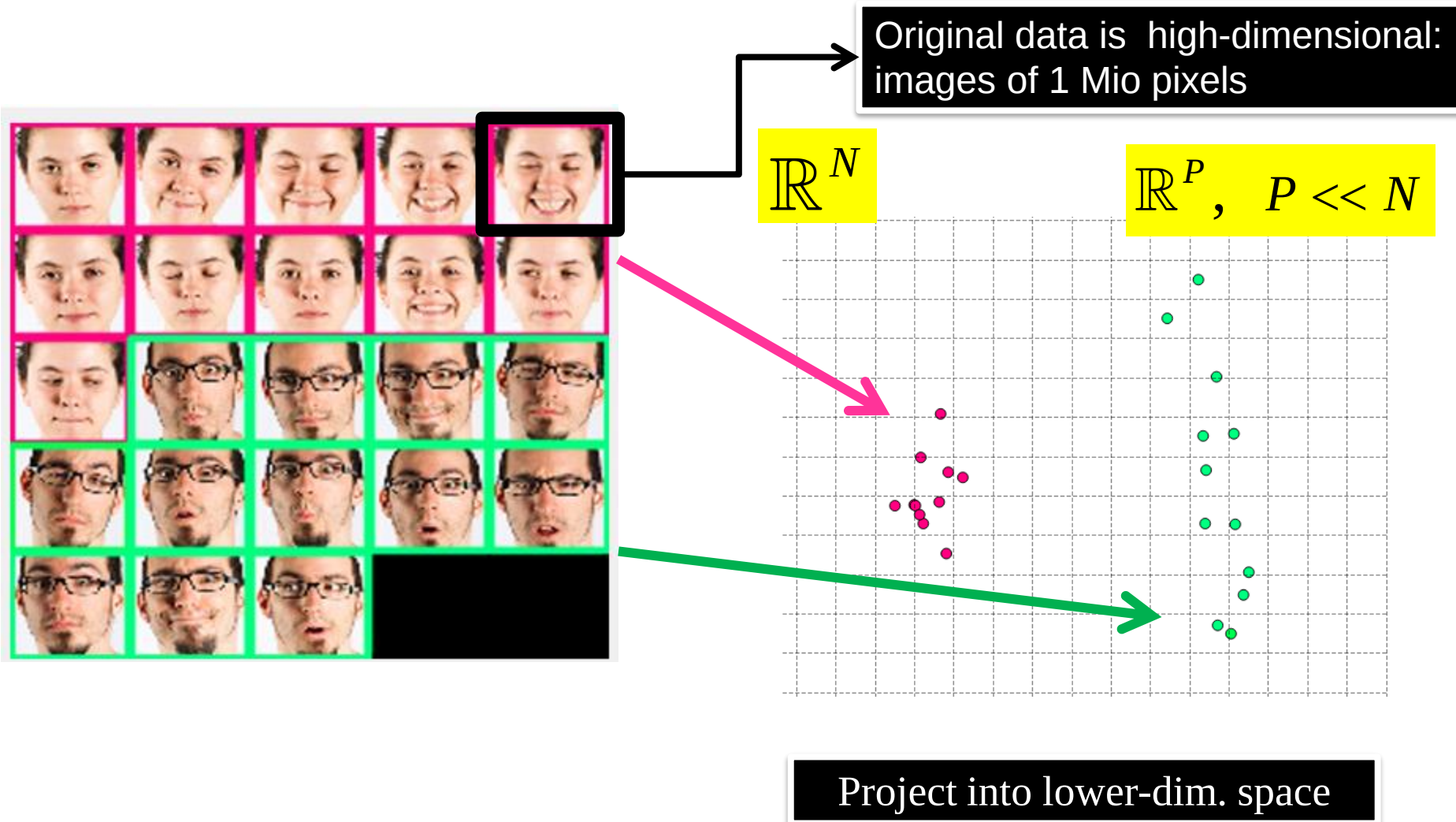
Trying to find some structure in the data.....

Structure discovery

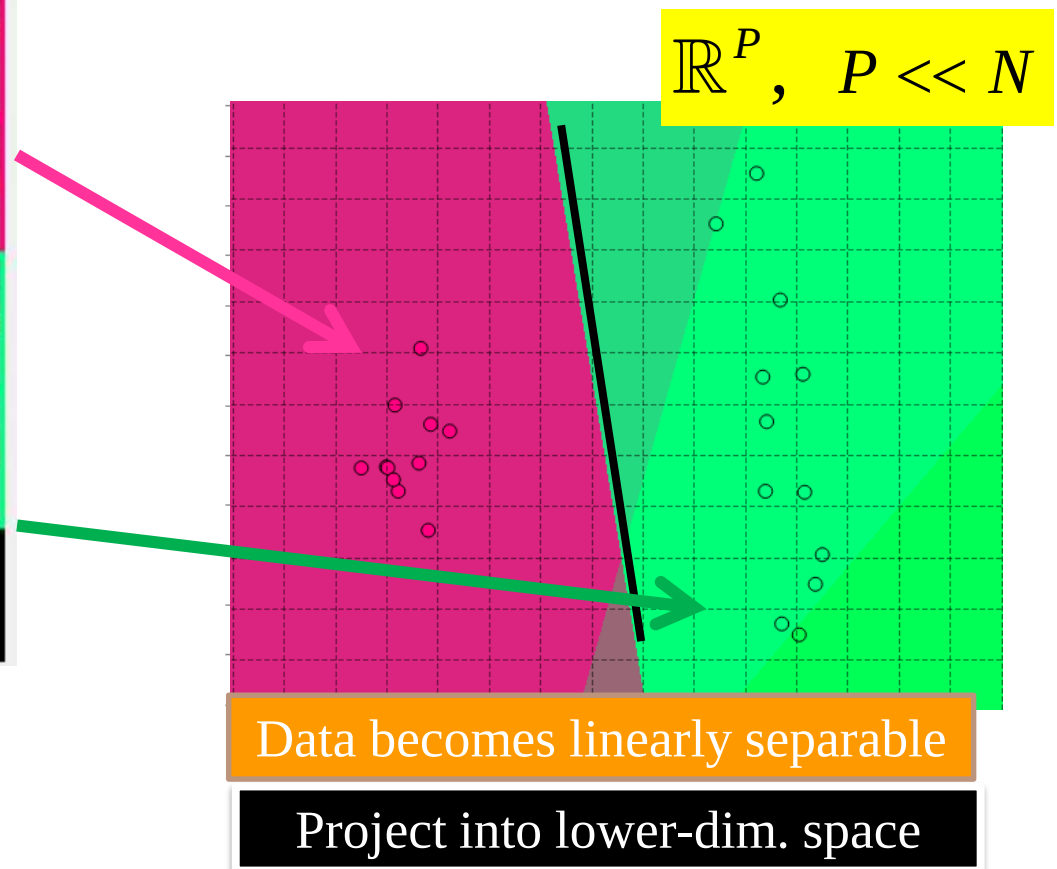


Find a latent space in which data features can be nicely extracted

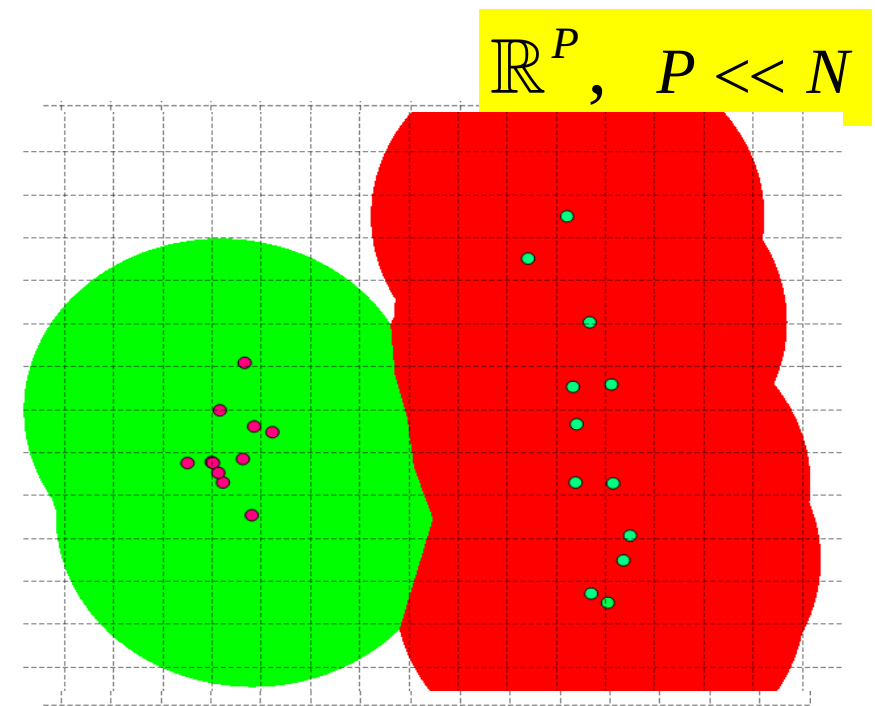
Structure discovery: PCA



From structure discovery to classification



Structure discovery: Clustering



Clustering techniques can also extract the underlying distribution

Summary & Outlook

Unsupervised learning refers to a variety of methods by which a pair of signals are associated to one another automatically, but there is no explicit labeling to determine how the signals should be paired.

In this course, we will see the following unsupervised learning techniques:

- ❑ **Structure discovery:** Principal Component Analysis
- ❑ **Clustering:** K-means, K-nearest neighbor, Gaussian Mixture Models

In Advanced Machine Learning course – MICRO 570

- ❑ **Structure discovery:** Kernel PCA, kernel CCA, Manifold learning
- ❑ **Clustering:** kernel K-means, Spectral Clustering, Support Vector Clustering)

Scope of this class

- Machine Learning encompasses a very large number of algorithms, which cannot all be covered here.
- We will focus on a subset of algorithms that form the foundation of most current advances in machine learning.
- Topics omitted here are covered in other courses on machine learning at EPFL.