

MATH-412

**Statistical machine learning**

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Cursus	Sem.	Type
Electrical Engineering		Opt.
Financial engineering	MA1, MA3	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.
Robotics, Control and Intelligent Systems		Opt.
Statistics	MA1, MA3	Opt.

Language of teaching	English
Credits	5
Session	Winter, Summer
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Lecture	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

A course on statistical machine learning for supervised and unsupervised learning

**Content**

- Introduction: supervised and unsupervised learning, loss functions, train and test errors, bias-variance tradeoff, model complexity and overfitting, linear regression, k-nearest neighbors.
- Regression: linear regression, model selection, ridge and Lasso.
- Local averaging methods: k-nearest neighbor, Nadaraya-Waston estimators
- Simple validation, cross-validation and leave-one-out.
- Classification: linear discriminant analysis, logistic regression.
- Nonparametric regression: smoothing splines, reproducing kernel Hilbert spaces.
- Support vector machines (possibly) and kernelized linear regression.
- Tree-based methods: classification and regression trees, bagging, random forests.
- Boosting: AdaBoost, boosted trees.
- Deep learning: introduction to neural networks (architecture, backpropagation, CNNs)
- Unsupervised learning: principal component analysis, k-means, Gaussian mixtures and the EM algorithm.

**Learning Prerequisites****Important concepts to start the course**

This course introduces machine learning with a statistical and mathematical perspective. Prior to following this course, the student must have very good knowledge of basic probability and statistics (statistical modeling and inference, linear regression). Some of the concepts used in course: abstract conditional expectations, multivariate linear regression, convexity, strong convexity, vector space, Hilbert space.

**Learning Outcomes**

By the end of the course, the student must be able to:

- Assess / Evaluate underfitting / overfitting of ML algorithms

**Transversal skills**

- Write a scientific or technical report.
- Make an oral presentation.
- Demonstrate the capacity for critical thinking
- Take feedback (critique) and respond in an appropriate manner.
- Demonstrate a capacity for creativity.

### Teaching methods

Ex cathedra lectures, exercises and computer practicals in the classroom and at home, and a project in a group of 3 students.

### Assessment methods

Written final exam (70%) + Project of implementation or application on real data of a model/algorithm based on a classical research paper describing an important method from the literature. (30%)

### Resources

#### Moodle Link

- <https://go.epfl.ch/MATH-412>