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.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

A course on statistical methods 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.
- Classification: linear discriminant analysis, logistic regression.
- Resampling methods: cross-validation, bootstrap.
- Nonparametric regression: smoothing splines, reproducing kernel Hilbert spaces.
- Support vector machines and kernel logistic regression.
- Tree-based methods: classification and regression trees, bagging, random forests.
- Boosting: AdaBoost, gradient boosting machines.
- Deep learning: introduction to convolutional neural networks.
- Unsupervised learning: principal component analysis, k-means, Gaussian mixtures and the EM algorithm.

Learning Prerequisites

Required courses

Analysis, Linear Algebra, Probability and Statistics, Linear Models

Important concepts to start the course

This is a statistics/mathematics course. Prior to following this course, the student must have very good knowledge of basic probabilty and statistics (statistical modeling and inference, linear regression).

Learning Outcomes

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

- Formulate appropriate models for empirical data
- Estimate the parameters of a statistical model
- Interpret the fit of a model to data
- Justify the choice of a model/technique to analyze empirical data
- Implement statistical learning algorithms

• Explain the mathematical/statistical mechanisms of most common machine learning algorithms

Teaching methods

Ex cathedra lectures, exercises and computer practicals in the classroom and at home.

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%)
Seconde tentative : Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

Resources

Bibliography

• James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013) An Introduction to Statistical Learning, with Applications in R. Springer.
• Hastie, T., Tibshirani, R. and Friedman, J. (2009) The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Second edition. Springer.
• Efron, B. and Hastie, T. (2016) Computer Age Statistical Inference: Algorithms, Evidence and Data Science. Cambridge University Press.
• Bishop, C. M. (2006) Pattern Recognition and Machine Learning. Springer.
• Kuhn, M. and Johnson, K. (2013) Applied Predictive Modeling. Springer.
• Shalev-Shwartz, S. and Ben-David, S. (2014) Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press.

Ressources en bibliothèque

- Applied Predictive Modeling / Kuhn & Johnson
- Pattern Recognition and Machine Learning / Bishop
- Understanding machine learning
- (electronic version)
- Elements of Statistical Learning
- (electronic version)
- Introduction to Statistical Learning, with Applications
- (electronic version)
- Computer Age Statistical Inference / Efron & Hastie

Notes/Handbook

A polycopié will be available on Moodle.