GRAPHICAL MODELS

Duration: 20h

Lecturer's name: GRACZYK Piotr

Lecturer's institution: LAREMA Université d'Angers, France

Syllabus of the course

Description:

Graphical models provide one of the most powerful methods of unsupervised learning and sparse modelization of modern Data Science and High Dimensional Statistics. It is an important tool for a contemporary data scientist.

The lectures will be accessible to all students of data sciences, mathematics and informatics, after a first course on applied probability and statistics of Licence L1 level.

The domain of Graphical models was initiated as a branch of modern mathematical statistics by Lauritzen and his collaborators in the 1990's; Lauritzen's book *Graphical Models*(1996) has since become one of classics of unsupervised learning literature. Very recently the *Handbook of Graphical Models(2018)* of numerous authors appeared. From the applied statistics point of view, Lasso type Graphical Model Selection methods have been worked out and are presented in a chapter of the celebrated book T. Hastie, R. Tibshirani, M. Wainwright, *Statistical Learning with Sparsity(2015).*

The lectures will contain simply presented theoretical basics of graphical Gaussian models as well as numerous examples, starting with the Simpson paradox of apparent sex discrimination at a public university and ending with Big Data examples. The exact computation of the MLE of the covariance matrix of a graphical model requires the graph to be decomposable, so we will learn basics on decomposable graphs. LASSO type graphical Model Selection will be presented and practiced. Students will be encouraged to carry out some programming tasks in R and/or Python. Among others, the 4-dimensional example of Frets' heads will be studied.

Tentative Programme:

1. Simpson paradox. Basics on conditional independence.
2. Multidimensional Gaussian laws, marginal and conditional laws.
3. Gaussian Graphical Models
4. Markov properties and factorization property of Graphical Models.
5. Maximum Likelihood Estimators of the Covariance Matrix on Gaussian Graphical Models
6. Decomposable graphs. MLE for decomposable Gaussian Graphical Models
7. Graphical Model Selection via LASSO.
8. Wishart matrices.
9. Bayesian graphical Model Selection.

References:

[1] S. Lauritzen, *Graphical Models,* Oxford Statistical Science Series, 1996.

[2] Maathuis, M., Drton, M. , Lauritzen, S. , Wainwright, M.(editors*), Handbook of Graphical Models*, Chapman and Hall – CRC Handbooks of Modern Statistical Methods, 2018.

[3] T. Hastie, R. Tibshirani, M. Wainwright, *Statistical Learning with Sparsity: The Lasso and Generalizations,* Chapman and Hall/CRC Monographs on Statistics and Applied Probability, 2015
https://web.stanford.edu/~hastie/StatLearnSparsity/