PhD Course in Statistical Sciences – cycle XXXVII, 2022

Statistical models

Instructors: Bruno Scarpa (coordinator), Carlo Gaetan, Stefano Mazzuco, Davide Risso, Mauro Bernardi

Syllabus

- [10h] Introduction. The "philosophy" of statistical modeling between machine learning and statistical learning, "surface plus noise" models and pure prediction algorithms, explanation and prediction
- Dependent observations
    - [25h] Random effects, multilevel models, hierarchical models:
      Frequentist and Bayesian approaches. Estimates and prediction, nonlinear models. Model checking and comparison.
      Complex experimental design. Factorial and fractional designs, nested and longitudinal designs (connection with random effect models), sequential tests and bandits (connection with multiple testing).
    - [20h] Space and Time dependence:
      Advanced methods and models for temporal and/or spatial processes: linear (review) and non linear models, hierarchical modelling of temporal and spatio-temporal processes, extensions to non-Gaussian processes, semiparametric and nonparametric models, signal extraction, filtering and prediction. Exact and approximate inference.
- [20h] Advanced nonparametric models (statistical and machine learning):
  Nonparametric estimation of distribution functions and quantiles; Jackknife and Bootstrap; Density estimation; Smoothing; Nonparametric regression techniques; Gaussian regression.
- [15h] Variable selection (Frequentist and Bayesian):
  Relaxed, generalized, fused, group Lasso.
  Bayes variable selection: spikes and slab and horseshoe priors

In each topic there will be a focus to analytical development of models and to computational methods (introduction to optimization theory, convex optimization and duality, MCMC algorithms, variational methods)

References

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Azzalini, A., Scarpa, B. (2012). *Data Analysis and Data Mining: An Introduction*, Oxford University Press. ISBN 13: 9780199767106. Chapter 3.

Cox, D.R., Donnelly, C.A., (2011). *Principles of Applied Statistics*. Cambridge: Cambridge University Press. ISBN: 9781107644458. Chap. 1.
Breiman, L., (2001) Statistical Modeling: The Two Cultures, *Statistical Science,* Vol. 16, No. 3, 199–231.
Shmueli, G., (2010) To Explain or to Predict?, *Statistical Science, Vol. 25, No. 3, 289–310.*
Wasserman, L. (2005) *All of Nonparametric Statistics*, New York, Springer.