Statistical Methods

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\textbf{Timetable:} 24 hrs. \textit{s}lectures on Wednesday and Friday, 14:30-16:30, starting from May 4th, 2022 (see on https://phd.dei.unipd.it/course-catalogues/)

\textbf{Enrollment:} Students must enroll in the course using the Enrollment Form on the PhD Program eLearning platform (requires SSO authentication).

\textbf{Course requirements:} familiarity with basic linear algebra and probability.

\textbf{Examination and grading:} Homework assignments

\textbf{SSD:} Information Engineering

\textbf{Aim:} The course will present a small selection of statistical techniques which are widespread in applications. The unifying power of the information theoretic point of view will be stressed.

\textbf{Course contents:}

- \textit{Background material.} The noiseless source coding theorem will be quickly reviewed in order to introduce the notions of entropy and informational divergence (relative entropy or Kullback-Leibler distance) between positive measures.

- \textit{Divergence minimization problems.} Three I-divergence minimization problems will be posed and, via examples, connected with basic methods of statistical inference: ML (maximum likelihood), ME (maximum entropy), and EM (expectation-maximization).

- \textit{Multivariate analysis methods.} The three standard multivariate methods, PCA (Principal Component Analysis), Factor Analysis, and CCA (Canonical Correlations Analysis) will be reviewed and their connection with divergence minimization discussed. Applications of PCA to least squares (PCR principal component regression, PLS Partial least squares). Approximate matrix factorization and PCA, with a brief detour on the approximate Non-negative Matrix Factorization (NMF) problem.

- \textit{EM methods.} The Expectation-Maximization method will be introduced in the context of Maximum Likelihood (ML) estimation with partial observations (incomplete data) and interpreted as an alternating divergence minimization algorithm à la Csizsár Tusnády.

- \textit{Applications to stochastic processes.} Introduction to HMM (Hidden Markov Models). Maximum likelihood estimation for HMM via the EM method. If time allows: derivation of the Burg spectral estimation method as solution of a Maximum Entropy problem.

\textbf{References:}
Lecture notes and a list of references will be posted on the course moodle site.