ADVANCED STATISTICAL METHODS FOR ASTRONOMY AND ASTROPHYSICS

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Teaching staff
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Program of the course:

1) Probability and Statistical Distributions. Uncertainties; Axioms of probability; Conditional probabilities; Bayes' theorem; Independent events; Random variables; Density and distribution functions; Quantile function.
2) Classical Statistical inference. Concepts of statistical inference; Classical vs. Bayesian Statistical Inference. Maximum Likelihood Estimation (MLE). Goodness of fit and Model Selection; Confidence Estimates; Hypothesis Testing; Comparison of distributions; Non-parametric Modeling. Selection effects and luminosity function estimation; Survival analysis.
3) Bayesian Statistical inference. Bayesian priors and posteriors; Uncertainty quantification; Model selections; The Montecarlo Marcov Chain (MCMC) method.
4) Reduction of dimensionality. Principal component analysis (PCA)
5) Regression and model fitting. Formulation of the regression problem; Linear and nonlinear regression; Regression robust to outliers; Gaussian process regression; Overfitting and underfitting;
6) Classification. Principles; K-nearest-neighbor classifier; Decision trees;
7) Autoencoders: Inference via conditional variational autoencoders (cVAE).

Bibliography:

1) Statistics, Data Mining, and Machine Learning in Astronomy, by Z. Ivencić et al. Princeton, NJ: Princeton University Press, 2014
2) Modern Statistical Methods for Astronomy, by Eric D. Feigelson , G. Jogesh Babu, Cambridge, UK: Cambridge University Press, 2012
3) Practical Bayesian Inference: A Primer for Physical Scientists by C. Bailer-Jones, Cambridge UK: Cambridge University Press, 2017
4) Gabbard, H. et al., 2022, Nature Physics, Volume 18, Issue 1, p.112-117