Probability and Statistical Inference (61101)

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Core Course, 1st semester, 7.5 ECTS units
Course level: Graduate (MSc)
Language: English

Course Description

The aim of the course is to present key topics of probability and distribution theory and to place particular emphasis on statistical inference. Initially, the axiomatic definition of probability is given by using measure theory and its interpretation in the classical/Bayes approach. Then the conditional probability is given, the concept of random variable, conditional expectation and its role as estimator, transformations, moments, moment generating function and characteristic functions. It follows the distribution theory, location/scale families, exponential family and goodness of fit measures. The topics defined in the one-dimensional case are presented for multivariate distributions and furthermore are defined the hierarchical models, the idea of independence, correlation and prediction, while some basic inequalities are given. Next, is the theory of order statistics, convergence (in probably, almost sure and by law), law of large numbers, central limit theorem and delta method. The principle of sufficiency and likelihood and completeness are also given. Finding point estimators (method of moments, maximum probability, Bayes rule) and their evaluation (mean square error, uniformly minimum variance unbiased estimator, Cramer-Rao, Rao-Blackwell, decision theory). Hypothesis testing (likelihood ratio test, Bayesian testing, union-intersection tests) and their evaluation (size and level, p-value, type I and II errors, even more powerful test, Neyman-Pearson lemma, monotone probability ratio, Karlin-Rubin), hypothesis testing and large data, multiple comparisons and corrections. Finally, confidence interval material is covered by finding methods (inverting a test statistic, pivots and Bayes methods), their evaluation (coverage probability) and interpretation.

Prerequisites

Undergraduate probability and calculus of functions of multiple variables.

Target Learning Outcomes

Upon successful completion of the course, students will be able to handle issues related to: probability and distribution theory, principles of sufficiency and likellihood, and statistical inference with emphasis on the presentation of analytical methods of finding and evaluating: point estimators, interval estimators and hypothesis tests (using the Frequentist and the Bayesian approachs).

Recommended Bibliography

- G. Casella and R.L. Berger "Statistical Inference", 2nd edition, Duxbury Advanced Series
- Jacod and Protter Probability essentials 2nd edition Springer

Teaching and Learning Activities
In vivo and online teaching.

Assessment and Grading Methods
Exercises during the semester, essays and written or oral exam.