University of Geneva

Geneva School of Economics and Management
Research Center for Statistics

ADVANCED STATISTICAL INFERENCE

Master in Statistics and PhD program in Statistics

Fall term 2021-2022

Davide LA VECCHIA

ADVANCED STATISTICAL INFERENCE

Master in Statistics

Lecturer: Davide La Vecchia

Lectures : Tuesday 8h15 - 10h00

Exercises : Wednesday 14h15 - 16h00

Exam: A written exam of 2 hours. The exam is “closed book” and no electronic calculators are needed.

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Synopsis: Statistical inference is presented by covering the fundamental theory and method at an advanced level. The course has two parts. In the first part (the main one), we start from a review of some fundamental results in probability and measure theory. Then, we move to the key notions related to data reduction techniques (sufficiency, completeness and ancillarity) and to the general theory of estimation (unbiasedness and optimality). Asymptotic (large sample) theory, a crucial part of statistical inference, is studied throughout the course, rather than in a separate/specific lecture. In the second part, we give an overview of some recent developments in the inference for dependent data (spatial processes and network data).

Learning Outcomes: By the end of the course, the student must have the technical skills to understand complex inferential problems. In particular, they must be able to:

- Formulate the various elements of a statistical problem in a rigorous way.
- Assess the performance of estimators.
- Construct efficient statistical procedures for estimation.
- Understand advanced statistical techniques to extract efficiently the information content of complex datasets.
- Specify suitable tools for data analysis in several scientific areas.
- Identify new challenges related to data analysis.

The course at a glance (13 weeks, 2h lectures + 2h exercises)

Part I: Theoretical Statistic

1. Introduction

1.1. Review of some probability concepts (key notions from measure theory, conditional probability, conditional expectation)

1.2. Statistical models

1.3. Exponential family and location-scale family

2. Principles of data reduction

2.1. Intuition

2.2. Sufficiency

2.3. Completeness and ancillarity

2.4. The likelihood principle

3. Optimal estimators

3.1. Intuition

3.2. Estimation

3.3. Unbiased and minimum variance estimator (UMVUE)

3.4. Rao-Blackwell theorem

3.5. Cramér-Rao lower bound

3.6. Asymptotic considerations: Best Asymptotically Normal (BAN) estimators

4. M-estimation and Maximum likelihood method

4.1. Intuition

4.2. M-estimators: definition, asymptotics, and construction

4.3. Maximum Likelihood estimation

4.4. Concentrated likelihood

4.5. Misspecification

Part II: Some recents developments

5. Spatial processes (random fields): SARAR models

5.1.1. Intuition

5.1.2. Definition of the process and its basic properties

5.1.3. Maximum Likelihood estimation

5.1.4. Exponential random graph models

References (main ones)

Part I

Casella, G.
Berger, R. L. *Statistical inference*, 2nd ed., Duxbury Press, Belomont (2002)

Cox, D.R.
Hinkley, D.V. *Theoretical statistics,* Chapman and Hall, New York, (1986)

Mood, A.
Graybill, F.
Boes, D. *Introduction to the theory of statistics*, McGraw-Hill, (1974)

Silvey. S.D *Statistical Inference*, Chapman and Hall, New York, (1991)

Shao, J. *Mathematical statistic*, 2nd ed., Springer, Berlin, (2003)

Welsh, A.H. *Aspects of statistical inference,* Wiley, New York, (1996)

Part II

Brockwell, P.J.
Davis, R. A. *Introduction to Time Series and Forecasting*, 2nd ed., Springer, New York, (2002)

Gaetan C.,
Guyot, X. *Spatial Statistics and Modeling,* Springer, New York, (2010)

Kolaczyk, E. D. *Statistical Analysis of Network Data,* Springer, New York. (2009)

Kolaczyk, E. D.
Csardi, G *Statistical Analysis of Network Data with R,* Springer, New York. (2014)