COURSE SYLLABUS

Bayesian Statistical Modeling

2526-2-F8204B042-F8204B042M

Learning objectives

The module aims to explore the main concepts and methodologies of Bayesian statistical models, providing the tools to solve classical statistical problems such as regression, classification and clustering, obtaining a proper uncertainty quantification with complex data. The methods presented in the module can be used in many applied problems through the specification and estimation of advanced bayesian models. By the end of the module, the student will have acquired: 1) the knowledge needed to specify a Bayesian model for a specific problem which is studying; 2) the techniques to estimate these models with open-source software, such as R and Stan; 3) perform model assessment with suitable theoretical, graphical and quantitative tools. The module, while introducing advanced moels in a Bayesian framework, contributes to the learning objectives of the CdS: "Statistics".

Contents

Review of Bayesian methods and computational strategies; regression models and methods; classification and clustering in the Bayesian framework; model validation and selection; prior distributions for model regularization; models for high-complexity data.

Detailed program

Review of foundational topics for Bayesian inference and the main MCMC computational approaches. Linear regression models in the Bayesian framework. From linear regression models to generalized linear regression models with a Bayesian approach. Assessing the goodness-of-fit and model selection in the Bayesian framework. Hierarchical models and random effect models. Clustering in the Bayesian framework through mixture models. Prior distributions for sparse problems and high-dimensional data. Models for high-complexity data: time-series and spatial data models in the Bayesian framework.

Prerequisites

The module required a general knowledge of Statistics at a bachelor's level and knowledge of foundational topics of Bayesian inference (module "Bayesian Statistics M" of Clamses). The module is not suggested for undergraduate students on international exchanges (Erasmus program), who should contact the instructor before the module starts.

Teaching methods

The 42 hours module will be entirely taught with lectures. Case studies, examples and implementations will be discussed in specific lectures in the same classroom.

Assessment methods

The final exam consists of two parts, a project to be carried out in groups and an oral exam. The project focuses on the evaluation of the analysis and use of model skills acquired by the students, where they will be asked to produce a paper discussing the analysis of an applied problem using Bayesian techniques. The project aim to improve the student judgment and communication skills, regarding bayesian statistical methodologies. The oral exam aims to verify the methodological skills acquired by the student.

Textbooks and Reading Materials

Main textbooks:
Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). Bayesian Data Analysis, Third Edition. CRC Press.

Gelman, A., & Hill, J. (2007). Data analysis using regression and multilevel/hierarchical models. Cambridge University Press.

Further readings:

Hoff, P. D. (2009). A First Course in Bayesian Statistical Methods. Springer.

Neal, P., Dellaportas, P., Polson, N. G., & Stephens, D. A. (2013). Bayesian theory and applications. Oxford University Press.

Congdon P. (2007). Bayesian Statistical Modelling, 2nd Edition. Wiley.

Robert, C.P., Casella, G. (2004). Monte Carlo Statistical Methods, 2nd Edition. Springer.

Other learning materials:

Lecture notes, R scripts, datasets and futher examples will be available to the student on the eLearning web page

of the module.

Semester

First term of the second semester.

Teaching language

English.

Sustainable Development Goals

QUALITY EDUCATION