Collegio Carlo Alberto

UNIVERSITÀ DEGLI STUDI DI TORINO

Bayesian Statistics

Instructor: **Raffaele Argiento**

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Objective of the course

The aim of this course is to give an overview of Bayesian parametric modelling, by the end of the course students will know how to set a Bayesian parametric model and how analytically compute posterior distributions. They will be able to perform inference (point and interval estimation and test) in a Bayesian framework.

A successful completion of the course should also make students able to independently formulate Bayesian models for analyzing a simple datasets arising from standard statistical regression designs, including model choice in this setting. They will also be able to implement these models using statistical software (R and OpenBugs), and write reports for their analysis.

Prerequisites

The minimal prerequisites for this course are the familiarity with basic Probability theory for discrete and continuous random variables and the knowledge of frequentist parametric Statistics: point estimation, hypothesis testing, interval estimation and linear regression. A minimal knowledge of the R software (www.r-project.org) is not mandatory but welcomed.

Contents

- The Bayesian approach to statistics: the likelihood principle, the prior and posterior distribution. The Bayes Theorem for dominated models. Interpretation of the scientific inference via the Bayesian approach.
- The three fundamental problems of inference: point estimation, hypothesis testing and interval estimation; comparison between the Bayesian and frequentist methods.

- Priors distribution. The choice of the prior distribution: not informative distributions; conjugates and mixtures distributions.
- Some examples with the most common univariate models: Bernoulli beta model, Poisson gamma model, normal normal-inverse-gamma model.
- Introduction to computational methods for non conjugate Bayesian models. An outline of the Markov chain Monte Carlo methods. Sketch of the Metropolis-Hastings and the Gibbs sampler algorithms. The use of the OpenBUGS software to implement a Gibbs sampler in a Bayesian framework. How to check the convergence of a Markov Chain Monte Carlo simulation algorithm.
- Introduction to multivariate linear model (generalized linear models) in Bayesian setting: parameter estimation and variable selection via spike-and-slab priors.

Textbooks

The main text for the course is:

- Hoff P. (2009), A First Course in Bayesian Statistical Methods, Springer Texts in Statistics
  http://www.stat.washington.edu/~hoff/book.php

In particular we will touch the material presented in Chapters 1, 2, 3, 4, 5, 6, 9 (with different levels of detail) of the book.

Software

We will use two software:

- R (www.r-project.org),
- OpenBUGS (http://www.openbugs.net/w/FrontPage).

Evaluation and Grading

The final grade for this course will be assigned by the evaluation of two works:

1. At the end of the course I will assign an homework requiring a simple and guided analysis of a dataset. The students should provide (in approximately two weeks) a pdf document describing the analysis they performed (the mark for this part will count 25% of the final grade, but a minimum grade of 60/100 will be necessary to pass the exam).
2. There will be a single final exam consisting of a written test in which students will be asked to provide solutions to a set of exercises (this will count 75% of the final grade, but a minimum grade of 60/100 will be necessary to pass the exam).

1 Reading List

Alternative references are:

- Albert J. (2007). Bayesian computation with R. Springer.
- Christensen R., Johnson, W., Branscum, A. Hanson, T.E (2011). Bayesian ideas and data analysis. CRC Press, Boca Raton (USA).
- Lunn D., Jackson C., Best N., Thomas A., Spiegelhalter D. (2013). The BUGS book. CRC Press.
- Jackman S. (2009). Bayesian analysis for the social sciences. Wiley, New York.
- Ntzoufras, I. (2009). Bayesian modeling using WinBUGS. Wiley, New York.
- Robert C. (2007). The Bayesian Choice, Second Edition. Springer.

Remark

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