Bayesian Statistics III/IV (MATH3361/4071) Michaelmas term 2019

Description of the course

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The following details concern the module Bayesian Statistics III/IV (MATH3361/4071) in Michaelmas term 2019. The description below is informal and aims to help the student organize his/her study. The official description of the course can be found here for the Level III, and here for the Level IV.

1 Description of the course

Aim

This course provides an introduction to the Bayesian statistical theory and methods. We will gain the necessary background to (i.) justify why it is desirable to use Bayesian statistical analysis and what are the associated challenges, (ii.) specify a suitable Bayesian statistical model, and (iii.) perform inference in the Bayesian framework.

Intended learning outcomes

The students will be able to

[ILO1] Explain the foundations and theoretical basis of the Bayesian paradigm, as well as possible challenges and related paradoxes

[ILO2] Explain, and specify a Bayesian model (parametric, prior, posterior, and predictive model)

[ILO3] Specify a prior model for a given statistical model

[ILO4] Explain, and apply Bayesian parametric and predictive inference, as well as design the necessary appropriate inferential tools.

[ILO5] Explain, extend, and apply theoretical properties of Bayesian concepts

[ILO6] Explain, theorize, derive, apply Bayesian filtering and smoothing: The Kalman-Filter

Teaching and learning activities

[TLA1] Lectures

Students will be introduced to the theory, and be exposed to a small number of examples.

- Major focus [ILOs 1-4]

[TLA2] Problem Class

Students will learn how to implement the theory and methods introduced in Lectures. Examples will be given, and exercises will be solved in the blackboard.

- Major focus [ILOs 1-4]

[TLA4] Office hours

Students will ask further questions. Students should have itemize their questions to be discussed in a bullet list on a piece of paper.

- Major focus [ILO 1-4]

Assessment tasks / activities

Formative assessment

[FA1] Four homework assignments will be assigned regularly. The homework sheet will contain a number of problems, some of which will be assessed and returned, while the rest will be set for self-study. Homework problems and solutions will be available from DUO (Tab: Exercises & Solutions). Major focus [ILOs 1-4].

Sumative assessment

[SA1] ILOs 1-4 will be assessed in the end-of-year examination.

2 Syllabus

Foundations of Bayesian statistics:

- Subjective probability, Bayesian paradigm, sufficiency, stopping rules, likelihood principle, decision theory elements [ILO1]

Bayesian inference:

- prior model specification (conjugate, conditional-conjugate, hierarchical, mixture priors, Jeffrey, maximum entropy), [ILOs 1-3]
- Bayes point estimation, credible intervals, hypothesis tests [ILO 4]
- prior/posterior/predictive distribution, estimates, and intervals [ILO 4]
- inference under model uncertainty, [ILO 3-5]
- ~~asymptotic behavior of the posterior and predictive distributions; [ILO 5]~~
- ~~Hierarchical Bayes, and Empirical Bayes [ILOs 2-5]~~

Statistical Modeling:

- Exchangeable model [ILO 1]
- ~~Non-identifiability [ILO 3]~~
- The Normal linear regression model [ILOs 2-4]
- Kalman Filter (MATH4071 only) [ILOs 1-6]

3 Reading list

Primary:

- Robert, C. (2007). The Bayesian choice: from decision-theoretic foundations to computational implementation. Springer Science & Business Media.
  - Mainly for Bayesian methods
- Berger, J. O. (2013). Statistical decision theory and Bayesian analysis. Springer Science & Business Media.
  - Mainly for Bayesian methods, and decision theory

Secondary:

- DeGroot, M. H. (2005). Optimal statistical decisions (Vol. 82). John Wiley & Sons.
  - Mainly for foundations: Bayesian paradigm, subjective probability, decision theory (theory)
- Raiffa, H., & Schlaifer, R. (1961). Applied statistical decision theory.
  - Mainly for foundations: Conjugate priors, decision theory (theory & application)
- O'Hagan, A., & Forster, J. J. (2004). Kendall's advanced theory of statistics, volume 2B: Bayesian inference (Vol. 2). Arnold.
  - Mainly foundations and methods: Linear regression model, model uncertainty

Additional reading material for the MATH4071

- Sarkka, S. (2013). Bayesian filtering and smoothing (Vol. 3). Cambridge University Press.
  - Section 4: Bayesian filtering equations and exact solutions