

Description of the course

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The following details concern the module Bayesian Statistics III/IV (MATH3361/4071) in Michaelmas term 2021. 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] Use appropriate software to facilitate Bayesian statistical analysis
- [ILO7] Explain, theorize, derive, apply an additional concept that will be given as an additional reading material for Level IV and postgraduate students.

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]

[TLA3] Computer practicals

Students will learn how to use R and JAGS statistical software to facilitate Bayesian statistical analysis.

- Major focus [ILOs 4 & 6]

[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 1-7]

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 1-6].

Sumative assessment

[SA1] ILOs 1-5 will be assessed in the end-of-year examination. Level IV and postgraduate students will be assessed in ILO 7 as well.

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]

Additional reading material for Level IV and postgraduate:

- To be decided...

3 Reading list

Go to '<https://durham.rl.talis.com/index.html>' and search for 'Bayesian Statistics III/IV'

- Robert, C. (2007). The Bayesian choice: from decision-theoretic foundations to computational implementation. Springer Science & Business Media.
 - Mainly for Bayesian methods.
 - This is one of the two main textbooks of the course.
- Berger, J. O. (2013). Statistical decision theory and Bayesian analysis. Springer Science & Business Media.
 - Mainly for Bayesian methods, and decision theory
 - This is one of the two main textbooks of the course.
- Raiffa, H., & Schlaifer, R. (1961). Applied statistical decision theory.
 - Mainly for foundations: Conjugate priors, decision theory (theory & application)
- DeGroot, M. H. (2005). Optimal statistical decisions (Vol. 82). John Wiley & Sons.
 - Mainly for foundations: Bayesian paradigm, subjective probability, decision theory (theory)
- O'Hagan, A., & Forster, J. J. (2004). Kendall's advanced theory of statistics, volume 2B: Bayesian inference (Vol. 2). Arnold.
 - Mainly: Bayesian model selection/uncertainty, Linear regression model
- Reich, B. J., & Ghosh, S. K. (2019). Bayesian statistical methods. CRC Press.
 - Mainly for application of the above concepts: Bayesian statistical tools (brief description), examples in RJAGS, and WINBUGS

Additional reading material for for Level IV and postgraduate

- To be decided...