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Bayesian Statistics and Data Analysis
Course information

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Section 1

Course information

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Course information

The aims of this course are that, after this course you should:

1. have knowledge in basic concepts, philosophy, and perspectives in Bayesian Statistics,
2. derive posterior distributions in simple situations,
3. derive and use predictive distributions,
4. identify and formulate Bayesian probabilistic models for analysis and predictions,
5. estimate models using contemporary computer-based methods for posterior approximations,
6. understand and use basic principles for decisions under uncertainty,
7. have knowledge about and be able to use Bayesian methods for model comparisons,
8. be able to critically evaluate Bayesian methods,
9. report, orally and in writing, a Bayesian statistical analysis

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Pre-requisites

- Basic probability theory
  - probability, probability density, distribution
  - sum, product rule, and Bayes' rule
  - expectation, mean, variance, median
- Basic linear algebra and calculus
- Basic visualisation techniques (R or Python)
  - histogram, density plot, scatter plot

First assignment is a recap.

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Course Outline

Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)
- Mini-project: do your own Bayesian data analysis (2-3 students)

Exact dates and details; see the course page.

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Core Content

- Every week: lectures/and assignments (approx. 2-4h)
  - Online video material and reading assignments (approx. 2-4h, 50-90 pages a week)
  - Lecture(s): present overall theory and content (overview)
  - Assignment(s): Computational and theoretical individual work. *Start monday morning every week!*
- An individual assignment (approx. 12-16h). Deadline Sundays 23.59.
- Recommended workflow for each week
  - Do the reading assignments
  - Watch the videos (although, optional)
  - Do self-study exercises
  - Start with the assignment
  - Attend lecture (bring questions!)
  - Attend datalabs (bring questions!)
  - Submit the assignment

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Section 2

Assignments

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Assignments

1. Core components and concepts and state-of-the-art methods
2. *Warning!* There might be bugs in the assignments!
3. All labs can be turned in a three times (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere
6. *Important!* Do the assignment evaluation!
7. Three one hour zoom seminars per week with individual help on assignments.

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R vs Python and Colab

- We strongly recommend using R in the course as there are more packages for Stan and statistical analysis in general in R
- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be more useful to learn also R
- We supply a Google Colab template with everything pre-installed.

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Stan

- Stan is a probabilistic programming framework (PPF) and ecosystem
- 40+ developers, 100+ contributors, 100K+ users
- R, Python, Julia, Scala, Stata, Matlab, command line interfaces
- More than 120 R packages using Stan
- Many packages to support diagnostics and workflow
- Can be used for frequentist inference as well
- Alternative PPF exists, Turing (Julia), Pyro (PyTorch), etc.

mc-stan.org

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Section 3

Mini-project

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Mini-project

- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.
- Ideally, use a model not presented in this course.
- Project will last two weeks (half time) - but start earlier.
- The project should use Stan.
- Approximate 40 hours of work *per student*.
- The project should result in a 4 page report (PDF) using the ICML LaTeX template (see course page).
- Project oral presentation (10-15 minutes)

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Section 4

Practicalities

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Practicalities

- Course page/content: Github – please do a PR if something is wrong!
- Communication: Studium
- Schedule: Time Edit/Studium
- Assignments submissions: Studium
- Acknowledgements: Aki Vehtari
- Teaching assistant: Väinö Yrjänäinen

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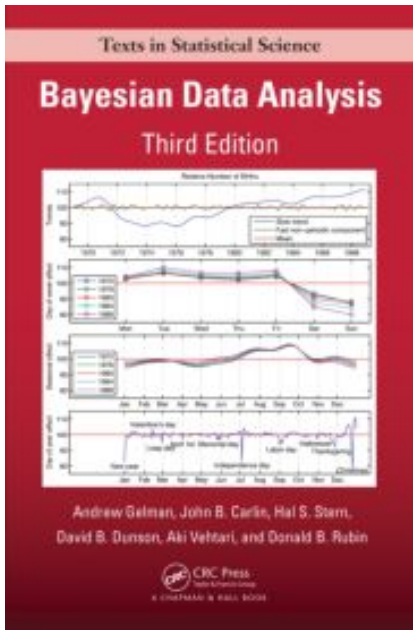
Literature

- Book: Gelman, Carlin, Stern, Dunson, Vehtari & Rubin: Bayesian Data Analysis, Third Edition. (online pdf available)



- Additional articles and blog posts

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Section 5

Examination

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Examination

1. To pass (G): All labs, mini-project, and project review need to be passed
2. To pass with distinction (VG): 7/10 VG points
3. If everything is correct in an assignment (¿90%), 1 VG point is awarded *on the first submission deadline*.
4. The mini-project is worth 2 VG-points (if it is passed with distinction).
5. Ph.D. students: I suggest you get VG to pass the course. Make the project a potential paper.

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Section 6

Course improvements

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Course improvements since last time

- Multiple short TA sessions over zoom