

# MVE550 2023 Lecture 19

## Review. Where to go from here. Exam tips

Petter Mostad

Chalmers University

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# Stochastic processes: Dobrow

- ▶ Chapters 2, 3: Discrete time discrete state space Markov chains.
- ▶ Chapter 4: Branching processes.
- ▶ Chapter 5: MCMC.
- ▶ Chapter 6: Poisson processes.
- ▶ Chapter 7: Continuous time discrete state space Markov chains.
- ▶ Chapter 8: Brownian motion.

# Introduction to Bayesian inference: Compendium

- ▶ Basic ideas of Bayesian inference.
- ▶ The idea of conjugacy and how to use it in computations.
- ▶ Discretization and computation of integrals used in low dimensions.
- ▶ The idea and usage of Hidden Markov Models.
- ▶ Using MCMC for Bayesian inference. Gibbs sampling.
- ▶ Specifically we looked at Bayesian inference for:
  - ▶ Discrete time discrete state space Markov chains.
  - ▶ Hidden Markov models (HMM).
  - ▶ Branching processes.
  - ▶ Poisson processes (also spatial).

# Going forward: Stochastic processes

- ▶ Infinite collections of random variables. We have only looked at a few examples.
- ▶ For example "Brownian motion", "Martingales", and "Stochastic Processes" are names of PhD level courses at Chalmers.
- ▶ A number of proofs actually need measure theory, which is not covered in our course.
- ▶ For those with an interest, I recommend checking out Chapter 9 of Dobrow, introducing Stochastic Calculus!
- ▶ Some related courses of possible interest: "Basic Stochastic Processes", "Foundations of Probability Theory", "Stochastic Analysis", "Integration Theory". Courses in finance. "Computational methods for SDEs".
- ▶ A large number of application areas: Basically any system with uncertainty. Example: Climate.
- ▶ Stochastic Differential Equations (SDE) and Stochastic Partial Differential Equations (SPDE). Active area at Chalmers Mathematical Sciences. Also connections to Bayesian inference!

# Going forward: Bayesian inference

- ▶ Stochastic models to be used for real applications almost always need fitting (inference) of their parameters using data.
- ▶ In Bayesian inference, we specify an entire stochastic model, also for the parameters (using a prior). Then we use for prediction the conditional distribution given the observed data.
- ▶ In practice, the main difference in most cases to frequentist inference is that Bayesian inference averages over a posterior for the parameters instead of using a single parameter estimate.
- ▶ In this course, we have looked at Bayesian inference for
  - ▶ Small toy models
  - ▶ Discrete-time discrete state space Markov chains, and Hidden Markov Models (HMM).
  - ▶ Branching processes
  - ▶ In assignments: Poisson processes and Continuous-time discrete state space Markov chains.
- ▶ We have also looked at how to use Markov chains (MCMC) for Bayesian inference.

Examples from the contents:

- ▶ More on conjugacy and simple computations.
- ▶ Much more on MCMC. E.g., Hamiltonian MCMC.
- ▶ Information theory and the EM algorithm.
- ▶ State space models.
- ▶ Graphical models.
- ▶ Variational Bayes.

# Studying for the exam

- ▶ Make sure you have *some* general understanding of *all* parts of the course.
- ▶ Make sure you have tried out and played around with the small R codes on Canvas. For me, trying out actual computation of things is very helpful to make them more concrete.
- ▶ You don't have to memorise proofs but going through them can be a great way to increase understanding.
- ▶ DO OLD EXAM QUESTIONS! Note how some, during the pandemic, had “all aids allowed”, while you will be allowed a “Chalmers approved calculator”.

# How to formulate exam answers

- ▶ You may be asked for an answer specified as the result of a matrix computation: Specify as with numerical matrices, but don't compute (e.g., matrix inversions).
- ▶ For some results, you may write down how to compute the value with R. BUT: If you are not sure if you remember the R syntax correctly, write down the mathematical expression for what you want to compute.

# General exam tips

- ▶ Write clearly, and *precisely*, with full sentences. If I'm not sure what you mean, I will *not* necessarily make the interpretation that is most in your interest.
- ▶ As long as you are clear and cover everything you want to say, writing short is better than writing long.
- ▶ Make sure you answer all parts of a question, and answer exactly what is asked for!
- ▶ Make sure you attempt to answer all questions: I cannot give you any points for a question if you do not answer anything.
- ▶ If you have *any* doubts about the interpretation of a question, do not hesitate to ask me! I plan to visit the exam around 9:30 and 11:30. The exam personnel may also contact me by phone.
- ▶ Distribute your time wisely.