Project III 2025/26

Fast and efficient Bayesian inference for epidemic models

Statistical epidemiology is a large and ever-growing field that combines statistical models with state-of-the-art inference techniques to analyse complex data arising from observational studies. The COVID-19 pandemic underlines the importance of fast and reliable inference techniques to allow real-time decision making. A compartment model classifies individuals into states such as “susceptible”, “infected” and “recovered”. A dynamic model describing the evolution of individuals in these states is then specified; this can be deterministic (e.g. a set of ordinary differential equations) or stochastic (e.g. a Markov jump process). Given temporal data e.g. the times at which individuals become infected, practitioners typically wish to learn about the model parameters. These are key in determining the properties of the epidemic and to make future predictions.

This project will allow students to explore one or more of several epidemic models, with the overarching goal of performing Bayesian inference for the model parameters and any unobserved quantities of interest. This will necessarily involve techniques such as Markov chain Monte Carlo, sequential Monte Carlo and approximate Bayesian computation. It is anticipated that R will be used to implement one (or more) of these techniques. The application of these techniques to several different data sets (e.g. prevalence data on influenza, Ebola or COVID-19) will also be possible.

Essential companion modules: Bayesian Computation and Modelling III

Resources (indicative)

- Allen, L. S. (2003). Stochastic Processes with applications to Biology. Pearson Prentice Hall.
- Challenges in pandemic modelling
- A tutorial introduction to ABC for epidemic models

Anticipated outcomes

- A literature review, outlining existing approaches to epidemic modelling, starting with compartment models.
- A discussion of existing approaches to Bayesian inference for epidemic models.
- Focus on one or more inference techniques with application to real or synthetic data.
- A suite of bespoke R functions for simulating, fitting, analysing and forecasting epidemics.

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