ST407-15 Monte Carlo Methods

21/22

Department
Statistics
Level
Undergraduate Level 4
Module leader
Ritabrata Dutta
Credit value
15
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module runs in Term 1 and will provide students with the tools for advanced statistical modelling and associated estimation procedures based on computer-intensive methods known as Monte Carlo techniques.

Pre-requisites:
Statistics Students: ST218 Mathematical Statistics A AND ST219 Mathematical Statistics B
Non-Statistics Students: ST220 Introduction to Mathematical Statistics

Module web page

Module aims

When modelling real world phenomena statisticians are often confronted with the following dilemma: should we choose a standard model that is easy to compute with or use a more realistic model that is not amenable to analytic computations such as determining means and p-values. We are faced with such choice in a vast variety of application areas, some of which we will encounter in this module. These include financial models, genetics, polymer simulation, target tracking, statistical image analysis and missing data problems. With the advent of modern computer technology we are no longer restricted to standard models as we can use simulation-based inference. Essentially we replace analytic computation with sampling of probability models and

statistical estimation. In this module we discuss a variety of such methods, their advantages, disadvantages, strengths and pitfalls.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Introduction and Examples: The need for Monte Carlo Techniques; history; example applications.
Basic Simulation Principles: Rejection method; variance reduction; importance sampling.
Markov chain theory: convergence of Markov chains; detailed balance; limit theorems.
Basic MCMC algorithms: Metropolis-Hastings algorithm; Gibbs sampling.
Implementational issues: Burn In; Convergence diagnostics, Monte Carlo error.
More advanced algorithms: Auxiliary variable methods; simulated and parallel tempering; simulated annealing; reversible jump MCMC; Metropolis-adjusted Langevin algorithms.

Learning outcomes

By the end of the module, students should be able to:

- Knowledge of a collection of simulation methods including Markov chain Monte Carlo (MCMC); understanding of Monte Carlo procedures.
- Ability to develop and implement an MCMC algorithm for a given probability distribution
- Ability to evaluate a stochastic simulation algorithm with respect to both its efficiency and the validity of the inference results produced by it.
- Ability to use Monte Carlo methods for scientific applications.

Indicative reading list

View reading list on Talis Aspire

Subject specific skills

TBC

Transferable skills

TBC

Study

Study time

Type	Required	Optional
Lectures	30 sessions of 1 hour (20%)	2 sessions of 1 hour
Practical classes	10 sessions of 1 hour (7%)	
Private study	110 hours (73%)	
Total	150 hours	

Private study description

Weekly revision of lecture notes and materials, wider reading, practice exercises and preparing for the examination.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group D4

	Weighting	Study time
Assignment 2	10%	

Due Term 1 Week 9.
The assignment will contain a number of questions for which solutions and / or written responses will be required.
The number of words noted refers to the amount of time in hours that a well-prepared student who has attended lectures and carried out an appropriate amount of independent study on the material could expect to spend on this assignment. 500 words is equivalent to one page of text, diagrams, formula or equations; your ST407 Assignment 2 should not exceed15 pages in length.

Assignment 1	10%	

Due Term 1 Week 5.
The assignment will contain a number of questions for which solutions and / or written responses will be required.
The number of words noted refers to the amount of time in hours that a well-prepared student who has attended lectures and carried out an appropriate amount of independent study on the material could expect to spend on this assignment. 500 words is equivalent to one page of text, diagrams, formula or equations; your ST407 Assignment 1 should not exceed15 pages in length.

On-campus Examination	80%	

The examination paper will contain four questions, of which the best marks of THREE questions

	Weighting	Study time

will be used to calculate your grade.

~Platforms - Moodle

- Answerbook Pink (12 page)
- Graph paper
- students may use a calculator

Assessment group R1

	Weighting	Study time
Online Examination	100%	

The examination paper will contain four questions, of which the best marks of THREE questions will be used to calculate your grade.

~Platforms - Moodle

- Online examination: No Answerbook required

Feedback on assessment

Marked assignments will be available for viewing at the support office within 20 working days of the submission deadline. Cohort level feedback and solutions will be provided.

Solutions and cohort level feedback will be provided for the examination.

Past exam papers for ST407

Availability

Courses

This module is Optional for:

- TCYA-G5P5 MSc in Scientific Computing
  - Year 1 of G5P5 Scientific Computing
  - Year 2 of G5P5 Scientific Computing
- Year 1 of TMAA-G1PE Master of Advanced Study in Mathematical Sciences
- Year 1 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)

- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 1 of TSTA-G4P1 Postgraduate Taught Statistics
- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
    - Year 3 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics

This module is Option list A for:

- Year 4 of UCSA-G4G3 Undergraduate Discrete Mathematics
- USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
    - Year 3 of G1G3 Mathematics and Statistics (BSc MMathStat)
    - Year 4 of G1G3 Mathematics and Statistics (BSc MMathStat)
- USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
    - Year 4 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
    - Year 5 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)

This module is Option list B for:

- Year 4 of USTA-G304 Undergraduate Data Science (MSci)
- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 3 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
    - Year 4 of G106 Mathematics (MMath) with Study in Europe
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list D for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated

This module is Option list E for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated