MATH5835M Statistical Computing

Matthew Aldridge

2027-06-10

Table of contents

Schedule **5**

About MATH5835 **6**

1 Introduction to Statistical Computing **7**
1.1 What is statistical computing? 7
1.2 Probability and statistics background 7
1.3 R programming 7

I Monte Carlo estimation **8**

2 Introduction to Monte Carlo **9**
2.1 Example: estimating the expection 9
2.2 Example: Estimating with a tin-can and a box 9
2.3 Monte Carlo estimator 9

3 Monte Carlo examples **10**
3.1 Example of Monte Carlo estimation 10
3.2 Monte Carlo estimation of probabilities 10
3.3 Monte Carlo estimation of integrals 10

4 Monte Carlo error **11**
4.1 Reminder: bias and error 11
4.2 Reminder: limit theorems 11
4.3 Bias and error of the Monte Carlo estimator 11

5 Importance sampling I **12**
5.1 Variance reduction 12
5.2 Rejection 12
5.3 Importance sampling: definition 12

6 Importance sampling II **13**
6.1 Error of importance sampling 13
6.2 Importance sampling: example 13
6.3 Picking a good distribution 13

Problem Sheet 1 14

7 Antithetic variables I 15
7.1 Estimation with correlation 15
7.2 Estimation with antithetic variables 15
7.3 Estimating again 15

8 Antithetic variables II 16
8.1 Error with antithetic variables 16
8.2 Antithetic variables: example 16
8.3 Finding antithetic variables 16

9 Control variates 17

II Random number generation 18

10 Generating random numbers 19

11 LCGs 20

Problem Sheet 2 21

12 Uniform and discrete generation 22

13 Inverse transform method 23

14 Rejection sampling 24

15 Envelope rejection sampling I 25

16 Envelope rejection sampling II 26

Problem Sheet 3 27

III MCMC 28

17 Introduction to Markov chains 29

18 Long-run behaviour of Markov chains 30

19 Markov chains in continuous space 31

20 Metropolis–Hastings algorithm I 32

21 Metropolis–Hastings algorithm I 33

22 Convergence and mixing 34

23 MCMC and Bayesian statistics 35

Problem Sheet 4 36

IV Bootstrap 37

24 Empirical distribution 38

25 Bootstrap estimation 39

26 Bootstrap error 40

27 Bootstrap confidence intervals 41

Problem Sheet 5 42

V Appendix 43

28 FAQ 44

29 Coursework 45

Schedule

This is a Quarto book.

To learn more about Quarto books visit https://quarto.org/docs/books.

```
1 + 1
```

```
[1] 2
```

About MATH5835

1 Introduction to Statistical Computing

1.1 What is statistical computing?

1.2 Probability and statistics background

1.3 R programming

Part I

Monte Carlo estimation

2 Introduction to Monte Carlo

2.1 Example: estimating the expection

2.2 Example: Estimating with a tin-can and a box

2.3 Monte Carlo estimator

3 Monte Carlo examples

3.1 Example of Monte Carlo estimation

3.2 Monte Carlo estimation of probabilities

3.3 Monte Carlo estimation of integrals

4 Monte Carlo error

4.1 Reminder: bias and error

4.2 Reminder: limit theorems

4.3 Bias and error of the Monte Carlo estimator

5 Importance sampling I

5.1 Variance reduction

5.2 Rejection

5.3 Importance sampling: definition

6 Importance sampling II

6.1 Error of importance sampling

6.2 Importance sampling: example

6.3 Picking a good distribution

Problem Sheet 1

7 Antithetic variables I

7.1 Estimation with correlation

7.2 Estimation with antithetic variables

7.3 Estimating again

8 Antithetic variables II

8.1 Error with antithetic variables

8.2 Antithetic variables: example

8.3 Finding antithetic variables

9 Control variates

Part II

Random number generation

10 Generating random numbers

11 LCGs

Problem Sheet 2

12 Uniform and discrete generation

13 Inverse transform method

14 Rejection sampling

15 Envelope rejection sampling I

16 Envelope rejection sampling II

Problem Sheet 3

Part III

MCMC

17 Introduction to Markov chains

18 Long-run behaviour of Markov chains

19 Markov chains in continuous space

20 Metropolis–Hastings algorithm I

21 Metropolis–Hastings algorithm I

22 Convergence and mixing

23 MCMC and Bayesian statistics

Problem Sheet 4

Part IV

Bootstrap

24 Empirical distribution

25 Bootstrap estimation

26 Bootstrap error

27 Bootstrap confidence intervals

Problem Sheet 5

Part V

Appendix

28 FAQ

29 Coursework