MA3K0-15 High-Dimensional Probability

23/24

Department
> Warwick Mathematics Institute

Level
> Undergraduate Level 3

Module leader
> Stefan Adams

Credit value
> 15

Assessment
> Multiple

Study location
> University of Warwick main campus, Coventry

Description

Introductory description

N/A

[Module web page](#)

Module aims

- Concentration of measure problem in high dimensions
- Three basic concentration inequalities
- Application of basic variational principles
- Concentration of the norm
- Dependency structures
- Introduction to random matrices

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.

- Preliminaries on Random Variables (limit theorems, classical inequalities, Gaussian models,

Monte Carlo)
- Basic Information theory (entropy; Kull-Back Leibler information divergence)
- Concentrations of Sums of Independent Random Variables
- Random Vectors in High Dimensions
- Random Matrices
- Concentration with Dependency structures
- Deviations of Random Matrices and Geometric Consequences
- Graphical models and deep learning

Learning outcomes

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

- Understand the concentration of measure problem in high dimensions
- Be able to distinguish three basic concentration inequalities
- Be able to distinguish between concentration for independent families as well as for various dependency structures
- Understanding of basic concentrations of the norm
- Familiar with random matrices (main properties)
- Be familiar with some application of graphical models
- Be able to understand basic variational problems

Indicative reading list

We won't follow a particular book and will provide lecture notes. The course is based on the following three books where the majority is taken from [1]:
[1] Roman Vershynin, High-Dimensional Probability: An Introduction with Applications in Data Science, Cambridge Series in Statistical and Probabilistic Mathematics, (2018).
[2] Kevin P. Murphy, Machine Learning - A Probabilistic Perspective, MIT Press (2012).
[3] Simon Rogers and Mark Girolami, A first course in Machine Learning, CRC Press (2017).
[4] Alex Kulesza and Ben Taskar, Determinantal point processes for machine learning, Lecture Notes (2013).

Subject specific skills

- Understanding that the concentration of measure problem
  requires analytical expertise as well as some basic probability
- Be able to distinguish three basic concentration inequalities
- Be able to distinguish between concentration for independent families as well as for various dependency structures
- Understanding of basic concentrations of the norm
- Familiar with random matrices (main properties)
- Be familiar with some application of graphical models

Transferable skills

Students will acquire key reasoning and problem solving skills which will empower them to

address new problems with confidence.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (77%)
Seminars	9 sessions of 1 hour (23%)
Total	39 hours

Private study description

No private study requirements defined for this module.

Costs

No further costs have been identified for this module.

Assessment

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

Assessment group D1

	Weighting	Study time
Written homework	15%	
Written homework (4 example sheets)		
In-person Examination	85%	

- Answerbook Gold (24 page)

Assessment group R

	Weighting	Study time
In-person Examination - Resit	100%	

- Answerbook Gold (24 page)

Feedback on assessment

Marked homework and exam feedback.

[Past exam papers for MA3K0](#)

Availability

Courses

This module is Optional for:

- 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)
- UCSA-G4G1 Undergraduate Discrete Mathematics
  - Year 3 of G4G1 Discrete Mathematics
  - Year 3 of G4G1 Discrete Mathematics
- Year 3 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 4 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 4 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year
- 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 Core option list B for:

- UMAA-GV17 Undergraduate Mathematics and Philosophy
  - Year 3 of GV17 Mathematics and Philosophy
  - Year 3 of GV17 Mathematics and Philosophy
  - Year 3 of GV17 Mathematics and Philosophy
- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list D for:

- UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year
  - Year 4 of GV18 Mathematics and Philosophy with Intercalated Year
  - Year 4 of GV18 Mathematics and Philosophy with Intercalated Year
- Year 4 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Option list A for:

- TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
  - Year 1 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
  - Year 2 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
  - Year 1 of G1PC Mathematics (Diploma plus MSc)
  - Year 2 of G1PC Mathematics (Diploma plus MSc)
- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
  - Year 3 of G105 Mathematics (MMath) with Intercalated Year
  - Year 4 of G105 Mathematics (MMath) with Intercalated Year
  - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 3 of G100 Mathematics
  - Year 3 of G103 Mathematics (MMath)
  - Year 3 of G103 Mathematics (MMath)
  - Year 4 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 USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 3 of GG14 Mathematics and Statistics
  - Year 3 of GG14 Mathematics and Statistics
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year
- USTA-Y602 Undergraduate Mathematics,Operational Research,Statistics and Economics
  - Year 3 of Y602 Mathematics,Operational Research,Stats,Economics
  - Year 3 of Y602 Mathematics,Operational Research,Stats,Economics
- Year 4 of USTA-Y603 Undergraduate Mathematics,Operational Research,Statistics,Economics (with Intercalated Year)

This module is Option list B for:

- Year 1 of TMAA-G1PE Master of Advanced Study in Mathematical Sciences
- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 4 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)

This module is Option list E for:

- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
  - Year 3 of G30D Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
  - Year 4 of G30D Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
- USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated
  - Year 3 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
  - Year 5 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)