



STAT8178

Modern Computational Statistical Methods

Session 1, In person-scheduled-weekday, North Ryde 2023

School of Mathematical and Physical Sciences

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General Information

Unit convenor and teaching staff

Convenor

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Credit points

10

Prerequisites

(STAT806 or STAT810 or STAT8310 or STAT6110) or (Admission to MBusAnalytics and BUSA8000 and ECON8040)

Corequisites

Co-badged status

STAT7178

Unit description

This unit offers students the opportunity to study some modern computational methods in statistics. The first half of the unit covers maximum likelihood computations, penalised likelihood, missing data and the EM algorithm. The second half considers Kernel density estimation, Kernel regression, quantile regression and inferences using Monte-Carlo and bootstrapping methods. State-of-the-art computing softwares are used.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at <https://www.mq.edu.au/study/calendar-of-dates>

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: Derive and explore Maximum Likelihood and Penalised Maximum Likelihood estimators.

ULO2: Apply EM algorithm to deal with missing data.

ULO3: Produce estimates of bias and variance along with confidence interval by applying Monte-Carlo and bootstrapping methods.

ULO4: Apply nonparametric function estimation approaches to estimate density function, regression function and quantile regression function.

ULO5: Evaluate the performance of nonparametric curve estimators by applying Monte-Carlo and bootstrapping methods.

General Assessment Information

Requirements to Pass this Unit

- Achieve a total mark equal to or greater than 50%

General Faculty Policy on assessment submission deadlines and late submissions: .

- For any late submission of time-sensitive tasks, such as scheduled tests/exams, performance assessments/presentations, and/or scheduled practical assessments/labs, students need to submit an application for Special Consideration.
- Should these assessments be missed due to illness or misadventure, students should apply for Special Consideration.
- Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark) will be applied each day a written assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of 0 will be awarded even if the assessment is submitted. Submission time for all written assessments is set at 11:55 pm. A 1-hour grace period is provided to students who experience a technical concern.

Assessments where Late Submissions will be accepted

- Assignment 1 - Yes, Standard Late Penalty applies
- Assignment 2 - Yes, Standard Late Penalty applies
- Assignment 3 - Yes, Standard Late Penalty applies

Special Consideration Policy:

The Special Consideration Policy aims to support students who have been impacted by short-term circumstances or events that are serious, unavoidable and significantly disruptive, and which may affect their performance in assessment. If you experience circumstances or events that affect your ability to complete the written assessments in this unit on time, please inform the convenor and submit a Special Consideration request through ask.mq.edu.au.

Assessment Tasks

| Name | Weighting | Hurdle | Due |
|------------------------------|-----------|--------|---------|
| Assignment 1 | 30% | No | Week 4 |
| Assignment 2 | 30% | No | Week 8 |
| Assignment 3 | 40% | No | Week 13 |

Assignment 1

Assessment Type ¹: Quantitative analysis task

Indicative Time on Task ²: 10 hours

Due: **Week 4**

Weighting: **30%**

Students will write code and interpret output in order to answer statistical questions. Students may work on the assignment on their own computers or using University resources.

On successful completion you will be able to:

- Derive and explore Maximum Likelihood and Penalised Maximum Likelihood estimators.
- Apply EM algorithm to deal with missing data.
- Produce estimates of bias and variance along with confidence interval by applying Monte-Carlo and bootstrapping methods.

Assignment 2

Assessment Type ¹: Quantitative analysis task

Indicative Time on Task ²: 10 hours

Due: **Week 8**

Weighting: **30%**

Students will write code and interpret output in order to answer statistical questions. Students may work on the assignment on their own computers or using University resources.

On successful completion you will be able to:

- Apply nonparametric function estimation approaches to estimate density function, regression function and quantile regression function.
- Evaluate the performance of nonparametric curve estimators by applying Monte-Carlo and bootstrapping methods.

Assignment 3

Assessment Type ¹: Quantitative analysis task

Indicative Time on Task ²: 10 hours

Due: **Week 13**

Weighting: **40%**

Students will write code and interpret output in order to answer statistical questions. Students may work on the assignment on their own computers or using University resources.

On successful completion you will be able to:

- Derive and explore Maximum Likelihood and Penalised Maximum Likelihood estimators.
- Apply EM algorithm to deal with missing data.
- Produce estimates of bias and variance along with confidence interval by applying Monte-Carlo and bootstrapping methods.
- Apply nonparametric function estimation approaches to estimate density function, regression function and quantile regression function.
- Evaluate the performance of nonparametric curve estimators by applying Monte-Carlo and bootstrapping methods.

¹ If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the [Writing Centre](#) for academic skills support.

² Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

You should attend the following classes each week:

- one 2 hour lecture
- one 1 hour SGTA class

Check timetables.mq.edu.au or the unit iLearn page for class details.

Lectures begin in Week 1. Lecture notes are available on iLearn prior to the lecture.

SGTA classes begin in week 1 and are based on work from the current week's lecture.

Prescribed texts

Students should obtain the lecture overheads from iLearn prior to the lecture. The lecture overheads are available module by module.

The following are recommended reading books for this unit:

- *Pattern Recognition and Machine Learning*, Bishop, Christopher M. 2006.
- [*Machine Learning: A Probabilistic Perspective*](#), Kevin Murphy, MIT Press, 2012.
- *Computational Statistics Handbook with MATLAB®*, W. L. Martinez and A. R. Martinez, Chapman & Hall. (QA276.4.M272)
- *Local regression and likelihood*, C. Loader, Springer-Verlag, 1999. QA276.8 .L6/1999.
- *Quantile Regression*, Roger Koenker, Cambridge University Press 2005,

Unit webpage

Unit webpage is located on iLearn at <https://ilearn.mq.edu.au>.

You can only access the material on iLearn if you are formally enrolled in the unit. All lecturing materials are available at this webpage.

Teaching and Learning Strategy

The unit is taught in both traditional mode and external mode. In traditional mode, students are on campus in standard semesters with weekly lectures. In external mode, students access all teaching material from iLearn and do not attend lectures on campus.

Students are expected to

- attend all the lectures if enrolled internally;
- have read through the material to be covered using the lecture notes provided on iLearn;
- submit assignments on time via iLearn;
- contact the unit convenors in advance if for any reason, you cannot hand in your assessment tasks on time;

Refer to the next section for a week-by-week list of topics to be covered in this unit.

Software used in teaching

We are using R through Rstudio in teaching this unit. R and Rstudio are free software and are widely used nowadays by statisticians.

Communication

We will communicate with you via your university email or through announcements on iLearn. Queries to convenors can either be placed on the iLearn discussion board or sent to your lecturers from your university email address.

COVID Information

For the latest information on the University's response to COVID-19, please refer to the Coronavirus infection page on the Macquarie website: <https://www.mq.edu.au/about/coronavirus-faqs>. Remember to check this page regularly in case the information and requirements change during semester. If there are any changes to this unit in relation to COVID, these will be communicated via iLearn.

Unit Schedule

Week Topic

| Week | Lectures | Topics | SGTA | Task Due |
|------|--|--|--|------------------|
| 1 | Statistics and Machine Learning: Estimation Methods (Part 1) | - Linear Model - Loss function - Maximum Likelihood - Shallow Neural network | | |
| 2 | Statistics and Machine Learning: Estimation Methods (Part 2) | - Logistic Model - Cross entropy - Shallow Neural network - Multi-classification | Maximum Likelihood optimization Gradient Descent | |
| 3 | Optimisation procedures | - Convexity - Gradient Descent - Stochastic Gradient Descent | "One versus all" MNIST Data set | |
| 4 | Beyond Linearity and overfitting | - polynomial model - one-layer NN - Train/validation/Test - Cross validation | Implementation: GD, SGD, Mini-Batch | Assignment 1 due |
| 5 | Penalized Regression | - Colinearity -Ridge regression -Lasso model | Investigation overfitting - polynomial regression - Non linear boundary classification | |
| 6 | EM Algorithm | - missing data - Mixture Model | Implementation: ridge regression use software R package for Lasso | |

| Week | Lectures | Topics | SGTA | Task Due |
|------|--|--------|---|------------------|
| 7 | Monte-Carlo method for hypothesis testing | | Implementation EM for Mixture model: - Gaussian case | |
| | Session Break | | | |
| 8 | Bootstrapping method for Confidence Interval | | | Assignment 2 due |
| 9 | Histogram & density estimation | | | |
| 10 | Kernel density estimation | | | |
| 11 | Kernel regression | | | |
| 12 | Quantile regression | | | |
| 13 | Revision | | | Assignment 3 due |

Students should read the lecture notes, which will be available at the unit web page, before the lecture.

Policies and Procedures

Macquarie University policies and procedures are accessible from [Policy Central \(https://policies.mq.edu.au\)](https://policies.mq.edu.au). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- [Academic Appeals Policy](#)
- [Academic Integrity Policy](#)
- [Academic Progression Policy](#)
- [Assessment Policy](#)
- [Fitness to Practice Procedure](#)
- [Assessment Procedure](#)
- [Complaints Resolution Procedure for Students and Members of the Public](#)
- [Special Consideration Policy](#)

Students seeking more policy resources can visit [Student Policies \(https://students.mq.edu.au/support/study/policies\)](https://students.mq.edu.au/support/study/policies). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

To find other policies relating to Teaching and Learning, visit [Policy Central \(https://policies.mq.edu.au\)](https://policies.mq.edu.au) and use the [search tool](#).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of

Conduct: <https://students.mq.edu.au/admin/other-resources/student-conduct>

Results

Results published on platform other than [eStudent](#), (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in [eStudent](#). For more information visit ask.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Academic Integrity

At Macquarie, we believe [academic integrity](#) – honesty, respect, trust, responsibility, fairness and courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free [online writing and maths support](#), [academic skills development](#) and [wellbeing consultations](#).

Student Support

Macquarie University provides a range of support services for students. For details, visit <http://students.mq.edu.au/support/>

The Writing Centre

[The Writing Centre](#) provides resources to develop your English language proficiency, academic writing, and communication skills.

- [Workshops](#)
- [Chat with a WriteWISE peer writing leader](#)
- [Access StudyWISE](#)
- [Upload an assignment to Studiosity](#)
- [Complete the Academic Integrity Module](#)

The Library provides online and face to face support to help you find and use relevant information resources.

- [Subject and Research Guides](#)
- [Ask a Librarian](#)

Student Services and Support

Macquarie University offers a range of [Student Support Services](#) including:

- [IT Support](#)
- [Accessibility and disability support](#) with study
- Mental health [support](#)
- [Safety support](#) to respond to bullying, harassment, sexual harassment and sexual

assault

- [Social support including information about finances, tenancy and legal issues](#)
- [Student Advocacy](#) provides independent advice on MQ policies, procedures, and processes

Student Enquiries

Got a question? Ask us via [AskMQ](#), or contact [Service Connect](#).

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the [Acceptable Use of IT Resources Policy](#). The policy applies to all who connect to the MQ network including students.