STAT8178

Modern Computational Statistical Methods

Session 1, In person-scheduled-weekday, North Ryde 2022

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff
Convener / Lecturer
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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
This unit is co-badged 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 bootstrappping 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

General Faculty Policy on assessment submission deadlines and late submissions:

- Online quizzes, in-class activities, or scheduled tests and exam must be undertaken at the time indicated in the unit guide. Should these activities be missed due to illness or misadventure, students may apply for Special Consideration.
- All other assessments must be submitted by 5:00 pm on their due date.
- Should these assessments be missed due to illness or misadventure, students should apply for Special Consideration.
- Assessments not submitted by the due date will receive a mark of zero.

Assessment Tasks

Name	Weighting	Hurdle	Due
Assignment 1	30%	No	Week 4
Assignment 2	30%	No	Week 9
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 bootstrappping methods.

Assignment 2

Assessment Type [1]: Quantitative analysis task
Indicative Time on Task [2]: 10 hours
Due: **Week 9**
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 bootstrappping 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.

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[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.

Unit Schedule

Week Topic

Weeek	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	

Weeek	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			
9	Histogram & density estimation			Assignment 2 due
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). 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). 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) 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 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.