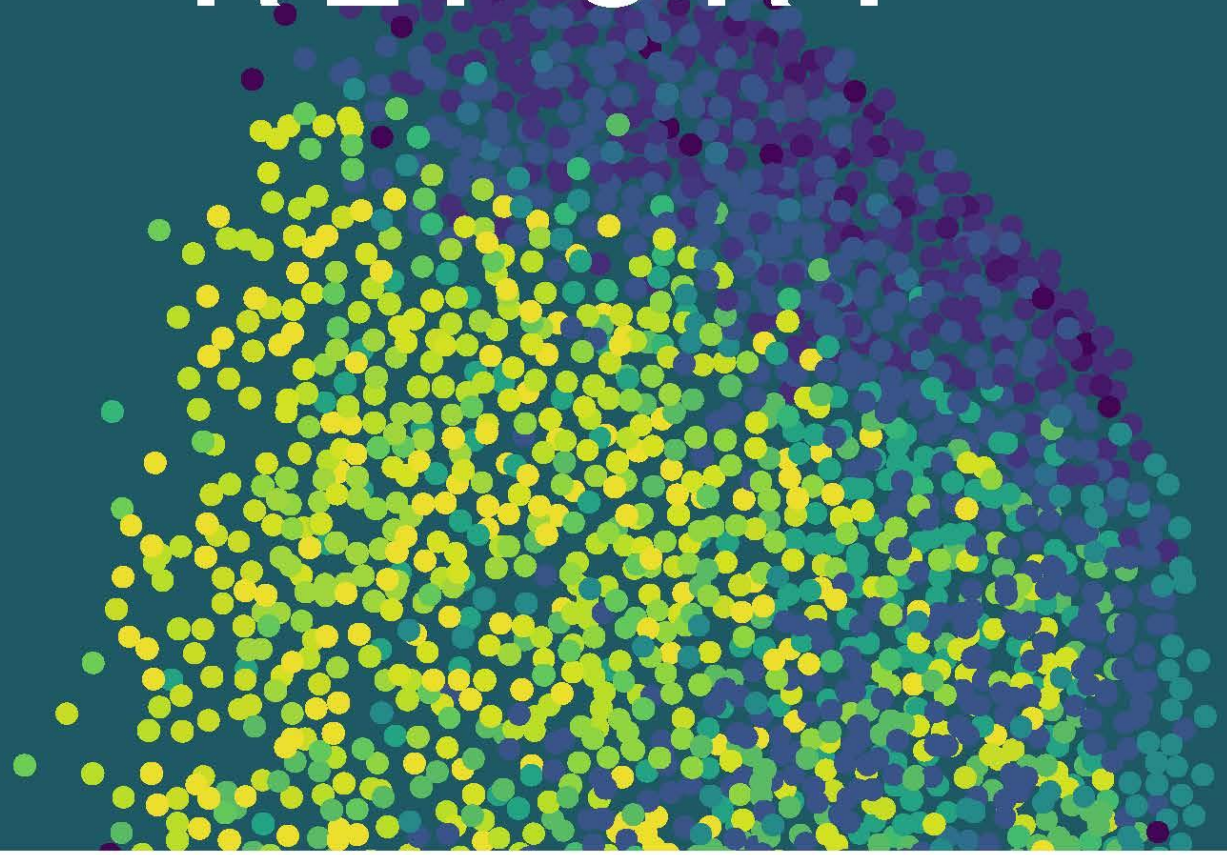
AMSI WINTERSCHOOL 21

STATISTICAL DATA SCIENCE

12 – 23 JUL 2021 VIRTUAL EVENT HOSTED BY **QUT**

EVENT REPORT



AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Australian Government
Department of Education, Skills and Employment

QUT Centre for Data Science

QUT

Thank you to the following AMSI Winter School 2021 sponsors

AMSI Winter School 2021

on Statistical Data Science

Queensland University of Technology
12–23 July 2021

FOREWORD

AMSI Winter School is one of five premier flagship events hosted each year around Australia. It forms part of the Securing Australia's Mathematical Workforce: 2016-2021 agreement between AMSI and the Department of Education, Skills and Employment. Now in its fifteenth year, AMSI Winter School is a key annual event for PhD and postgraduate students, as well as early-career researchers in the mathematical sciences and cognate disciplines.

Hosted over two weeks, the program offers a range of specialist topics with an overarching theme. The aim of the AMSI Winter School is to develop the next generation of mathematical scientists who can thrive in tomorrow's information age. This program draws upon the knowledge of national and international lecturers at the forefront of their fields, and attracts students from all around Australia.

The complete program, comprising course content and extra activities, is designed to align with the project objectives of the agreement to:

- Strengthen research training and the work-readiness of advanced mathematical sciences graduates
- Promote university-industry collaborations that will encourage the private-sector employment of mathematical sciences graduates
- Attract and improve the retention of senior undergraduate students in the mathematical sciences, with particular attention to women and Aboriginal and Torres Strait Islander students

AMSI Winter School 2021 was jointly funded by the Australian Mathematical Sciences Institute (AMSI) and the Australian Government's Department of Education, Skills and Employment, with support from Queensland University of Technology, the QUT Centre for Data Science, the Australian Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS), the Queensland Cyber Infrastructure Foundation (QCIF), and the Statistical Society of Australia (SSA).

"The exposure to cutting-edge methodologies at AMSI Winter School, and the exchange of knowledge among peers and experts in the field is invaluable. The program's positive impacts both immediate and ongoing serve to further mathematics as well as strengthen innovation in Australia."

Professor Tim Marchant, AMSI Director

DIRECTOR'S REPORT

Professor Christopher Drovandi
Queensland University of Technology

The 2021 AMSI Winter School on Statistical Data Science was hosted by the School of Mathematical Sciences and the Centre for Data Science at the Queensland University of Technology (QUT) from Monday 12 July to Friday 23 July. Motivated by the COVID pandemic, this was the first time that the Winter School proceeded in virtual mode, which was facilitated by Zoom for lectures and Gathertown for workshops and social activities. Participants also interacted in local physical hubs in Brisbane, Melbourne and Perth for intervals when COVID restrictions were relaxed. There were 109 participants, the largest of any Winter School to date. Participants were predominantly PhD students from universities across Australia, including some undergraduate and Masters students, early career researchers and established academics. We enjoyed hosting one student from a Chinese university. It was also a pleasure to host seven participants from outside the university sector including Geoscience Australia, Australian Bureau of Statistics, Boeing Research and Technology, CSIRO Data 61 and Department of Defence.

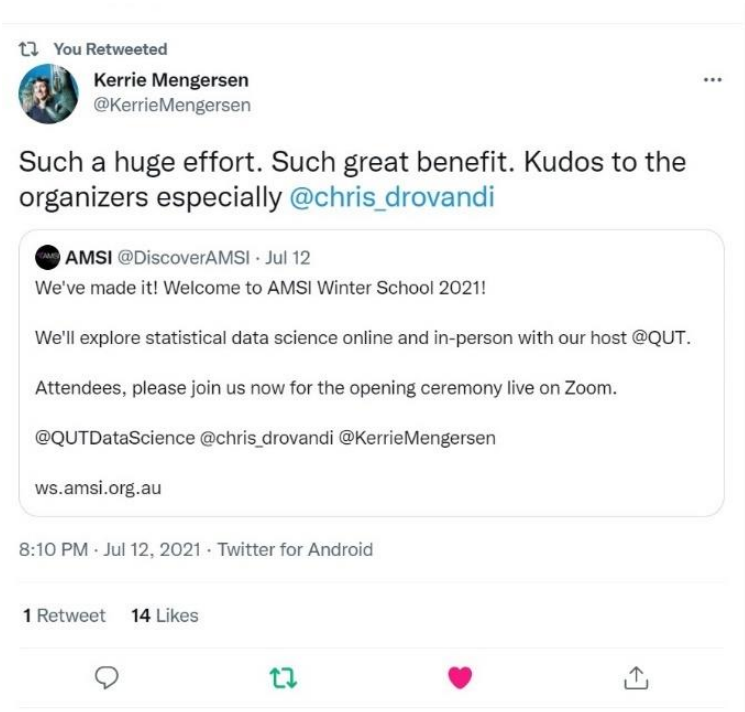
The AMSI Winter School lecturers did a brilliant job of covering many important cutting-edge methods and tools in statistical data science. Advanced Bayesian methods, deep neural networks and dimension reduction, what's not to like? I was really impressed how the Lecturers went out of their way to ensure that material covered was connected and coherent, which participants greatly appreciated. The lecturers genuinely cared about fostering a positive learning environment for the participants. Professor Gael Martin set the scene by covering the foundations of Bayesian statistics. The material of Dr Leah South, Dr Matias Quiroz and Associate Professor David Frazier directly built on these foundations. Dr South showed us how we can assess the quality of the output produced by advanced Bayesian methods, Dr Quiroz explained how to scale Bayesian methods to big data utilising subsampling and Associate Professor Frazier enlightened us on how to conduct Bayesian inference for complex models where standard Bayesian methods don't work. Dr Susan Wei shed light on what deep neural networks are and how to implement them in a Bayesian framework. Dr Robert Salomone used the foundations of Susan's lectures to take us on a probabilistic machine learning journey into methods such as normalising flows and generative adversarial networks. Associate Professor Anastasios Panagiotelis revealed how to discover manifolds in high dimensional data to reduce dimension through methods such as Isomap and multidimensional scaling, which connected well with some of Robert's material where we also tried to find manifolds!

The Program Extras were the icing (and cherry!) on the cake; Professor Renate Meyer blew us away by new discoveries made in astronomy facilitated with Bayesian methods, the

Celebration of Maths event illuminated diverse pathways in mathematical careers and the participant talks were of the highest quality. Much needed down time was facilitated through mindfulness sessions, and I apologise for being a liability to my trivia team!

I will always treasure the opportunity to experience life as an event director of the 2021 AMSI Winter School. It was hard work, but easily worth it. I could not have pulled it off without the huge support network around me. I sincerely thank AMSI staff Anna Muscara and Angela Coughlin, who worked alongside us to ensure there was no stone left unturned in the planning and running of the Winter School. I would also like to thank Andree McFarlane who was there to address any issues as soon as they came up. I thoroughly enjoyed working closely with Anna, Angela and Andree for several months, and thank them for their positive encouragement and support, and for overcoming the challenges of running the event virtually.

I also wish to thank and acknowledge the important contributions of QUT professional staff in the School of Mathematical Sciences and the Australian Centre of Excellence for Mathematical and Statistical Frontiers. Thank you to the scientific advisory committee Professors Kerrie Mengersen, Scott Sisson, Chris Oates and Associate Professor Tamara Broderick for helping to shape the program. I also acknowledge the strong support offered by the Head of School of Mathematical Sciences, Professor Tony Roberts, and the Director of the QUT Centre for Data Science, Distinguished Professor Kerrie Mengersen, in hosting the event at QUT. Finally, thank you to the lecturers and participants for making this a truly special and successful Winter School. It was a pleasure to host you all at QUT (physically or virtually!) and I look forward to interacting with you again in the future.



"One of the most valuable aspects of the Winter School is the exposure to new ideas. Being relatively new to the data science field I gained a really deep insight into the area. It provided new branches that I could explore either immediately as part of my PhD or expose me to new areas that someday I can come back to."

Mathew Berry University of Wollongong

PARTICIPANT PROFILE

Lucy Conran
University of Western Australia

Lucy Conran studied mathematics as an undergraduate, before embarking on a 15-year career in banking. With a nagging need to go back and expand on what she'd learnt, she later returned to university to complete a Master's, and now a PhD, in statistics.

For Lucy, AMSI Winter School was an opportunity to engage in mathematics subjects outside of her course offering, experience fresh perspectives and network.

"The quality of the Winter School speakers was extremely impressive. There was one unit, in particular, that I was looking forward to, but I also learnt a lot from the other units, which was an unexpected bonus," said Lucy.

Lucy's PhD topic focusses on methods of estimating and measuring variability in data, which she says has advanced tremendously since her undergraduate years.

"Statistics and data science have come such a long way, due to growth in computing power. It's opened up many new opportunities for research, which is really exciting," Lucy said.

Her advice to students considering applying for Winter School 2022?

"Do it without hesitation! Participating in AMSI Winter School was a great experience. I am at the start of my PhD, so it was the first time presenting my work and I was grateful for the encouragement. I also enjoyed listening to others – it was interesting to hear how other PhD projects progress through various stages of development," Lucy added.

Whether students pursue research straight after their undergraduate degrees, or circle back to postgraduate studies, like Lucy, AMSI Winter School provides an opportunity to advance mathematical skill sets in new areas.

PARTICIPANT PROFILE

Trevor Matthews
The University of Adelaide

From software engineer to paramedic, Trevor Matthews has had an interesting career path. Recently returning to university to pursue a Master's degree, nearly 30 years after completing his honours in Computer Systems Engineering, Trevor is now focused on utilising big data to develop support tools for ambulance dispatch.

"I'm interested in operational research – using data to provide decision support tools for my clinical and communications room colleagues," said Trevor.

"The concept of taking big data, which my Ambulance Service has, and levering the insights to provide better services to the community is something I'm passionate about," Trevor added.

To broaden his knowledge in data science techniques, Trevor successfully applied to attend AMSI Winter School 2021, which was centred around statistical data science.

"This year's Winter School theme aligned perfectly with my research focus, which was great. I'd highly recommend the experience to others whose research aligns with the event theme," said Trevor.

"The subjects gave me a good primer on several statistical techniques, which I'd heard of, but hadn't had much exposure to previously. The lecturers were knowledgeable and approachable. I also found it interesting to hear from other participants on the depth and variation of similar research using big data techniques – it showed me the breadth of the field and the opportunities available to explore," Trevor said.

Winter School 2021 was held as a virtual event for the first time, due to COVID-19 restrictions, which Trevor found both beneficial and challenging.

"I missed the ability to interact face-to-face with others, but there were still opportunities to network through online social events – the AMSI team did a great job. On the plus side, I saved a lot of time that would have been required to travel to and from the event," he said.

Where does Trevor see himself in 10 years' time?

"I'm hoping my Master's research will be useful to better leverage our Ambulance Service data and provide useful insights for my colleagues. Our Service doesn't have a large research arm, like other states, so I hope to be uniquely qualified to fill this niche."

AMSI wishes Trevor the best of luck in his inspiring healthcare endeavours!

COURSE PROGRAM

PROGRAM THEMES

Bayesian Statistics

Advanced Markov Chain Monte Carlo Methods

Likelihood-Free Inference

Modern Neural Networks

Dimension Reduction for High Dimensional Data

COURSES

An Introduction to Bayesian Statistics
Professor Gael Martin, Monash University

Dimension Reduction: A plane and simple primer on linear and nonlinear algorithms with applications
Associate Professor Anastasios Panagiotelis, The University of Sydney

Neural Networks and Related Models (Part I)
Dr Susan Wei, The University of Melbourne

Post-Processing of MCMC
Dr Leah South, Queensland University of Technology

Approximate Bayesian Computation: The Likelihood is dead, Long Live Simulation!
Associate Professor David Frazier, Monash University

Neural Networks and Related Models (Part II)
Dr Robert Salomone, Queensland University of Technology

Subsampling MCMC – An approach to speed up MCMC by data subsampling
Dr Matias Quiroz, University of Technology Sydney

"The choice of topics and the way they were structured made it easy to see the connections between the various fields, which really helped with my understanding."

Imke Botha, Queensland University of Technology

An Introduction into Bayesian Statistics

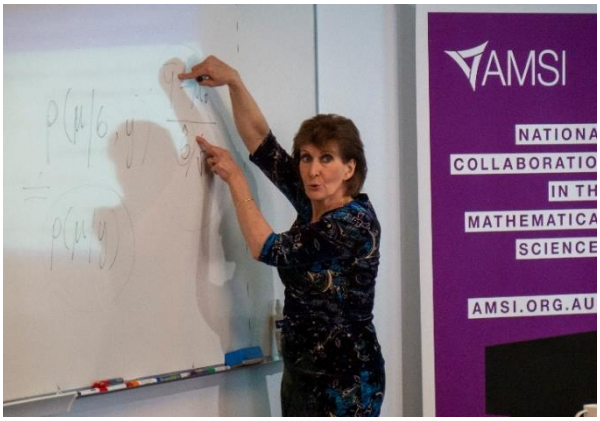
Professor Gael Martin
Monash University

These two lectures introduced students to the key foundational, methodological and computational principles underlying the Bayesian statistical paradigm. We began with a brief history of Bayesian statistics, and outlined the contrast between the Bayesian and frequentist (or classical) paradigms. We then looked at all three aspects of Bayesian inference: inference about unknown parameters, inference about unknown models and prediction of unknown future (or out-of-sample) values. The core computational challenge associated with the implementation of 'Bayes' – the evaluation of posterior expectations – was highlighted, and the three main categories of computational method briefly described: 1) deterministic integration methods; 2) (exact) simulation methods (e.g. Markov chain Monte Carlo (MCMC)); and 3) approximate methods (e.g. approximate Bayesian computation; variational Bayes). This set the scene for the later lectures, in which more detailed expositions of modern computational techniques were provided.

An additional 'tutorial' was conducted in which we ran a couple of R programs that implemented (and 'diagnosed') various simple MCMC algorithms.

"My favourite speaker was Gael. She delivered the fundamentals of Bayesian statistics very neatly and enthusiastically. Her teaching style was elegant, sophisticated, and to the point."

Doran Huh, The University of Melbourne



"Prof Gael Martin's lectures helped me clearly understand many concepts that I was confused about. She also provided a great introduction to the problems handled by different Bayesian computation methods."

Dan Li, Queensland University of Technology

Dimension Reduction: A plane and simple primer on linear and nonlinear algorithms with applications

Associate Professor Anastasios Panagiotelis
The University of Sydney

Many modern datasets contain a large number of variables, that is they are high-dimensional. Such high-dimensional datasets are often however characterised by an underlying low dimensional structure. Recovering this low dimensional structure can enable exploratory analysis, visualisation and feature construction.

This short course took a journey through the development of dimensionality reduction techniques. They ranged from linear methods such as Principal Components Analysis and Classical Multidimensional Scaling through to modern Manifold Learning techniques including Isomap, Laplacian Eigenmaps and Local Linear Embedding. Also covered was the evaluation of different dimension reduction techniques compared to one another, both with respect to computational considerations and with respect to the fidelity with which they capture the structure of high dimensional data. Applications of dimensionality data to real data problems was also covered.

"I found the dimension reduction lectures really thought-provoking. I didn't think they'd be relevant for my research but given some of Anastasios' examples I might be able to use dimension reduction after all."
Ben Harrap, The University of Melbourne

"Anastasios Panagiotelis was outstanding because he really engaged me in a subject that is not relevant to my research. And left me wanting to learn more."

Jennifer Dunne, Curtin University of Technology

Neural Networks and Related Models (Part I)

Dr Susan Wei
The University of Melbourne

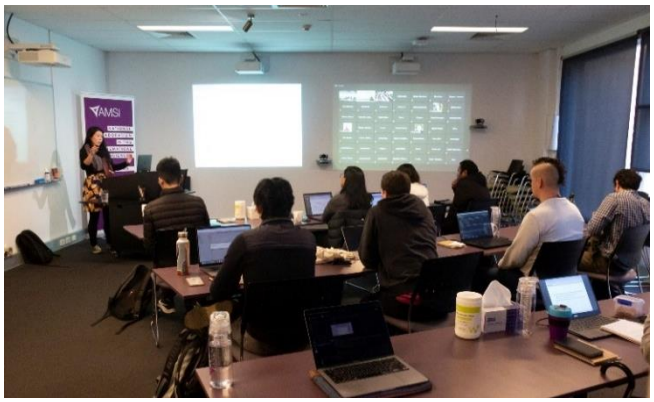
This course is an introduction to deep learning as well as some probabilistic models involving neural networks (flow-based models and deep generative models).

Part I: Deep Learning Basics and Models

- An Introduction to Neural Networks: key components of DL pipeline, multilayer perception, forward/backward propagation, computational graphs
- Stochastic Optimization and Extensions
- The Art of Model Training and Regularization: Model selection, weight decay, dropout, initialization
- Convolutional Neural Networks and Recurrent Neural Networks

(Part II: Variational Inference, Normalizing Flows, and Deep Generative Models was taught by Dr Robert Salamone in Week 2 of the program)

Computational Demonstrations used the Python package PyTorch. The latter part of the course involved demonstrations using the probabilistic programming language Pyro, which was based on PyTorch and had additional features.



"Attending the Melbourne hub and having the lecturer in the same room was a magnificent opportunity, given the circumstances. This motivated conversations/networking with the community of our cities and related universities."

Luis Torres, Monash University

Post-Processing of MCMC

Dr Leah South
Queensland University of Technology

This lecture series took a deeper dive into the Markov chain Monte Carlo (MCMC) methods introduced in Professor Gael Martin's course. The output from MCMC is a sequence of N samples from a Markov chain that we hope will asymptotically target the posterior, but how do we use this chain to estimate quantities of interest in practice? The course covered three key aspects of this post-processing: diagnosing convergence, assessing sample quality and using the chain to estimate quantities of interest. The first lecture covered popular methods and their limitations under modern challenges in Bayesian statistics. The second lecture introduced modern alternatives which have recently been developed for scalable MCMC.

1. Standard methods for post-processing MCMC

This lecture introduced popular methods for post-processing of MCMC. Diagnostics such as the Gelman and Rubin convergence diagnostic were introduced as tools to assess convergence and control bias via removal of an initial burn-in period. Approaches to using the chain for estimation, ranging from vanilla averaging of samples to control variates, were described. The lecture finished by describing a popular MCMC method for big data where standard post-processing methods break down.

2. Modern methods for post-processing MCMC

This lecture introduced a series of post-processing tools based on Stein's method. This included Stein goodness of fit tests, Stein thinning and a general-purpose gradient-based control variate. These methods can be used in standard MCMC, in MCMC for big data and in the context of challenging applications where practitioners wish to trade-off bias and variance in their estimates.

Tutorial:

The tutorial demonstrated how to implement these methods with the support of R packages for applications in standard MCMC and "biased" MCMC for big data. This gave students practical tools for their own implementation of MCMC methods.

"The lectures and content of the courses were world class. Very well organised, very good way to connect and learn related fields."

Thomas Goodwin, University of Technology Sydney

Approximate Bayesian Computation: The Likelihood is dead, Long Live Simulation!

Associate Professor David Frazier
Monash University

Knowingly or unknowingly, a web of complex models underpins modern life. Models are used to predict traffic patterns (via mechanistic network models or interconnected dynamic queues), help environmental agencies control pest populations (such as invasive species), and underpin policy decisions regarding epidemiological restrictions for disease prevention (such as restrictions aimed at reducing the spread of COVID-19). To use such models, we must first perform inference on the unknown quantities that drive these models. However, in many interesting cases the cornerstone upon which inference is based, the exact Bayesian posterior, is intractable and cannot be readily accessed using standard techniques.

Approximate Bayesian methods provide a solution to conducting inference in challenging settings where the exact posterior is intractable. Using simulation from the model, and by replacing the unknown likelihood with a version estimated using simulated data, these methods circumvent the intractability of the original inference problem. However, this simplification is not without cost, and ultimately results in a posterior distribution that only approximately expresses our uncertainty about the true process assumed to have generated the data.

This course introduced the ideas behind simulation-based approximate Bayesian methods, the practical application of these methods, their theoretical behavior, and discussed fields of application where these methods are commonly applied. A general outline of the course was as follows.

Lecture 1: Intractable Likelihoods, standard solutions, and the method of Approximate Bayesian Computation (ABC)

Lecture 2: The statistical behavior of basic ABC

Lecture 3: Alternatives to basic ABC

Lecture 4: Limitations of approximate Bayesian inference, and (some) potential solutions

Labs: Application of ABC methods in R

Neural Networks and Related Models

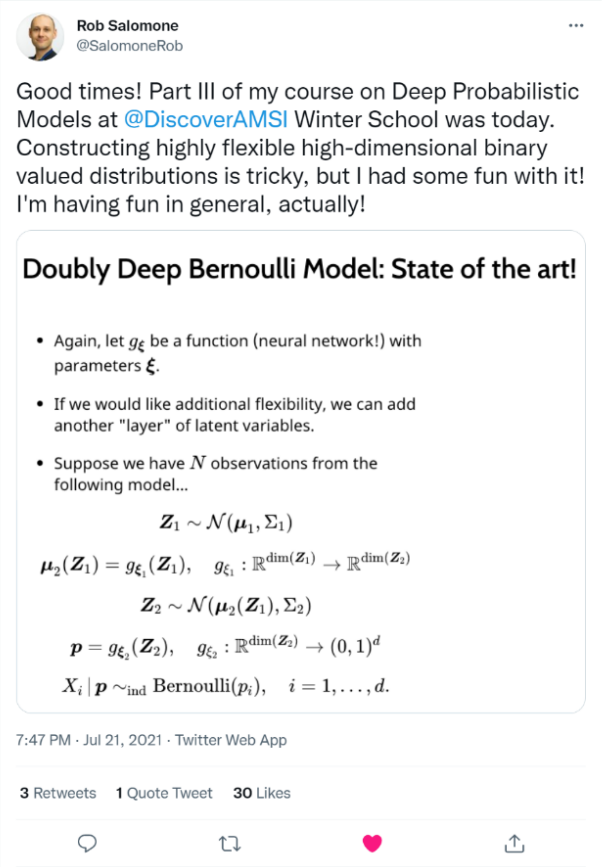
Dr Robert Salomone
QUT Centre for Data Science

Part II: Variational Inference, Normalizing Flows, and Deep Generative Models

- An Introduction to Variational Inference
- Normalizing Flows (for both Variational Inference and Density Estimation)
- Deep Generative Models: Variational Autoencoders & Generative Adversarial Networks.

Computational Demonstrations used the Python package PyTorch. The latter part of the course involved demonstrations using the probabilistic programming language Pyro, which was based on PyTorch and had additional features.

(Part I: Deep Learning Basics and Models was taught by Dr Susan Wei in Week 1 of the program)



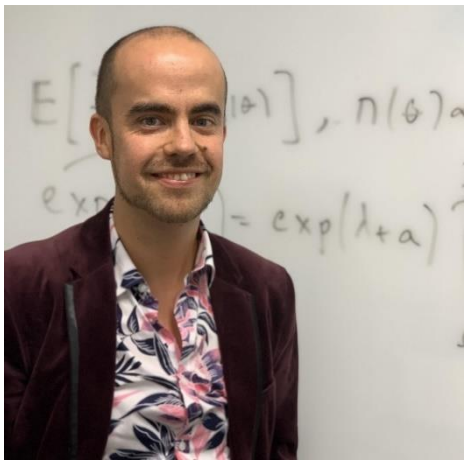
"It was interesting to see the cutting edge of math and stats techniques in the field. [It] highlighted that good quantitative skills are useful across the board-industry and academia-and worth investing time in to learn."

Catherine Kim, The University of Queensland

"The courses were well designed and delivered, taking me through the basics as well as the latest development of those topics."

Roy Yang, Queensland University of Technology

Subsampling MCMC – An approach to speed up MCMC by data subsampling

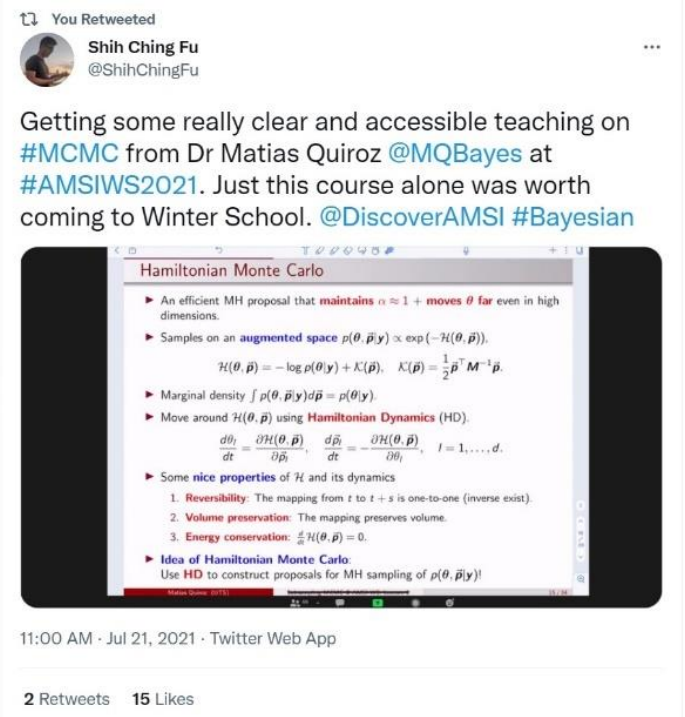


Dr Matias Quiroz
University of Technology Sydney

This course gave an introductory overview of subsampling Markov chain Monte Carlo (MCMC), a so-called pseudo-marginal MCMC approach to speeding up MCMC through data subsampling. The course started with a brief introduction to Bayesian Statistics, followed by an introduction to Bayesian computations with an emphasis on simulation algorithms. The latter part of the course introduced state of the art pseudo-marginal MCMC methods and showed how these can be used to speed up MCMC inference through data subsampling.

"The most valuable part of the program was learning from the experts. They provided very nice "road maps" of their topics. This overview is a perfect springboard to further investigate these topics. I can envision using many of the methods taught in the program during my future research."

Matthew Sainsbury-Dale, University of Wollongong



PARTICIPATION BREAKDOWN

UNIVERSITY/INSTITUTION	
Australian Bureau of Statistics	2
Australian National University	1
Beihang University (China)	1
Boeing Research and Technology	1
Bureau of Meteorology	1
CSIRO's Data 61	1
Curtin University of Technology	9
Department of Defence: Defence Aviation Safety Authority	1
Geoscience Australia	1
Macquarie University	1
Monash University	6
Queensland University of Technology	30
RMIT University	1
Swinburne University of Technology	1
The University of Adelaide	3
The University of Melbourne	6
The University of New South Wales	6
The University of Queensland	13
The University of Sydney	8
The University of Western Australia	3
University of Southern Queensland	1
University of Tasmania	1
University of Technology, Sydney	5
The University of Wollongong	6

109 attendees

from **24** universities

GENDER		
Female	31	28%
Male	78	72%
Other	0	0%
Prefer not to disclose	0	0%

RESIDENCY STATUS		
Australian Citizen	55	50%
Permanent Resident	9	8%
Student Visa	40	37%
Other	5	5%
Prefer not to disclose	0	0%

ABORIGINAL AND TORRES STRAIT ISLANDER		
No	109	100%
Yes	0	0%
Prefer not to disclose	0	0%

STATE/TERRITORY		
ACT	4	4%
NSW	22	20%
QLD	47	43%
SA	3	3%
TAS	1	1%
VIC	17	15%
WA	12	11%
International (includes students from Australian universities studying offshore)	3	3%

PARTICIPANT TYPE		
Undergraduate	3	3%
Honours	4	4%
Masters (by Coursework)	8	7%
Masters (by Research)	5	5%
PhD	71	65%
Early-Career Researcher	9	8%
Academic	4	4%
Other	5	4%

"A lot of scientists never receive any formal training in statistics. In astronomy, it's expected that we teach ourselves. This school helped me solidify and connect a lot of concepts that I had only half grasped, presenting them in a single, cohesive framework."

Benjamin Metha, The University of Melbourne

SCHOLARSHIPS

This year, AMSI Winter School scholarships were funded by AMSI, the Department of Education, Skills and Employment, Queensland University of Technology's Centre for Data Science and Queensland Cyber Infrastructure Foundation (QCIF). Awarded on a competitive basis, these scholarships cover the cost of student program fees providing access to a greater number of students to attend and fully participate in program activities by removing financial barriers.

In 2021, AMSI Scholarships were awarded to 59 participants from 11 AMSI Member Universities, 18 of which were women:

- Turgut Acikara, Queensland University of Technology
- Chintan Advani, Queensland University of Technology
- Abdul Hadi Asfarangga, The University of Adelaide
- Hassan Bahrami, University of Technology Sydney
- Samuel Barton, The University of Queensland
- Prithvi Bhat Beeramoole, Queensland University of Technology
- Matthew Berry, University of Wollongong
- Imke Botha, Queensland University of Technology
- Adam Burke, Queensland University of Technology
- Justin Case, Queensland University of Technology
- Zac Chen, Queensland University of Technology
- Adam Clements, Queensland University of Technology
- Lucy Conran, The University of Western Australia
- Laurence Davies, Queensland University of Technology
- Jennifer Dunne, Curtin University of Technology
- Jiaxuan E, Queensland University of Technology
- Owen Forbes, Queensland University of Technology
- Gabriel Gonzalez, Curtin University of Technology
- Thomas Goodwin, University of Technology Sydney
- Ben Harrap, The University of Melbourne
- Conor Hassan, Queensland University of Technology
- Alesha Hatton, The University of Queensland
- Paula Hatum, Queensland University of Technology
- Zhipeng He, Queensland University of Technology
- Grace Heron, Queensland University of Technology
- Angus Horner, Queensland University of Technology
- Doran Huh, The University of Melbourne
- Josh Jacobson, University of Wollongong
- Jun Ju, The University of Queensland
- Ahmad Hakiim Jamaluddin, The University of New South Wales
- Ryan Kelly, Queensland University of Technology

- Catherine Kim, The University of Queensland
- Hani Jieun Kim, The University of Sydney
- Kevin Ho Fai Lam, The University of New South Wales
- Yeming Lei, The University of Queensland
- Dan Li, Queensland University of Technology
- Nicolas Mandel, Queensland University of Technology
- Trevor Matthews, The University of Adelaide
- Benjamin Metha, The University of Melbourne
- Hamish Murray, Queensland University of Technology
- Nikhil Nair, Queensland University of Technology
- Vibhor Pandey, Queensland University of Technology
- Alan Pearse, University of Wollongong
- Jacob Priddle, Queensland University of Technology
- Matthew Sainsbury-Dale, University of Wollongong
- Joshua Stevenson, University of Tasmania
- Chenjunyan Sun, Queensland University of Technology
- Smit Bharat Thakkar, Queensland University of Technology
- Farha Usman, The University of Sydney
- Daniel VandenHeuvel, Queensland University of Technology
- Mythreyi Velmurugan, Queensland University of Technology
- Sarah Vollert, Queensland University of Technology
- Bao Anh Vu, University of Wollongong
- Quan Vu, University of Wollongong
- Xiaoyu Wang, Queensland University of Technology
- Yue Xie, The University of Adelaide
- Hanwen Xuan, The University of New South Wales
- Roy Yang, Queensland University of Technology
- Yunpeng Zhang, The University of Queensland

"The scholarship was instrumental to my attendance to the Winter School. Without it, I would have been hard pressed to find a justification for spending money on a data science Winter School in front of my superiors, despite the deeply ingrained relevance of the underlying mathematical models."

Nicolas Mandel, Queensland University of Technology

PROGRAM EXTRAS

OPENING CEREMONY

In 2021, AMSI Winter School was conducted in a virtual format for the first time. The program kicked off on Monday 12 July with the traditional Opening Ceremony prior to participants starting their first class. With 54 participants attending online and 49 attendees present in Event Hubs in Brisbane, Melbourne and Perth, this was a great opportunity for students to meet and orientate themselves for the upcoming two-week program.

Resident QUT Elder, Uncle Cheg performed a Welcome to Country, noting the importance of science and mathematics in Australian First Nations culture. Professor Tony Roberts and Professor Tim Marchant offered their own welcomes from QUT and AMSI respectively, wishing participants well in their academic journeys and encouraging them to participate fully in the program. The keynote address was delivered by QUT Provost, Professor Nic Smith. He reflected on the importance of data science throughout history, deciphering high volumes of information to help us discover underlying patterns of behaviours in our world amid an ever-increasing set of complex variables.

Distinguished guests at the event included Professor Troy Farrell (QUT Executive Dean of Science), Distinguished Professor Kerrie Mengersen (Director of QUT Centre for Data Science), and Professor Joseph Grotowski (Head of Physics and Mathematical Sciences at The University of Queensland).

"I loved how all the experts were cordial and keen to make us feel included."

Smit Bharat Thakkar, Queensland University of Technology

CELEBRATION OF THE MATHEMATICAL SCIENCES

Hosted after classes in the first week, the Celebration of the Mathematical Sciences panel event gave Winter School attendees the opportunity to get a richer perspective on life in the mathematical sciences. The evening included discussions about unconventional career journeys, current issues around diversity and inclusion, and ways to make the transition from student to professional, getting a foothold in either industry or academia despite the looming pandemic.

Eighty-nine guests, included Winter School participants, academics and members of industry, attended the event, either online or in-person at the Brisbane and Melbourne hubs. Thank you to our six industry and academic panel members:

- Professor Benjamin Burton, The University of Queensland
- Dr Susan Wei, The University of Melbourne
- Associate Professor Anastasios Panagiotelis, The University of Sydney
- Associate Professor Roslyn Hickson, CSIRO and James Cook University
- Professor Mat Simpson, Queensland University of Technology
- Brooke Jamieson, Blackbook.ai

"Attending AMSI Winter School has inspired me to do my PhD. It also highlighted that mathematics can take you into any discipline you want because of how different everyone's research interests were."

Sarah Vollert, Queensland University of Technology

PARTICIPANT TALKS

The participant talks provide an opportunity for students to share their research with their peers and see the broad scope of study for mathematics in their general field. Participants were separated into 13 groups of eight and delivered 10-minute talks in fields including astrophysics, traffic management, eco-conservation, social policy, healthcare, geology and economics, just to name a few. Given the hybrid nature of the program, the first round of talks was hosted via the virtual platform GatherTown. This gave everyone the opportunity to interact with others from different states and with those outside their specialised areas.

After Round One, participants voted on the best presentations in their respective groups. Winners from each group were then invited to present their talks to the entire Winter School cohort for Round Two with a final vote determining two best participant talks winners:

- *Geostatistics of Galaxies*
  Benjamin Metha, The University of Melbourne
- *Manifold Learning with Approximate Nearest Neighbours*
  Fan Chen, Monash University

"It was genuinely interesting to hear the presentations from other participants. To hear about the depth and variation of environments and research questions which were using big data showed me the breadth of the field and the opportunities available out there. As it happens, I struck an issue in my next research step which I know someone else has, or is in the process of dealing with, in another field. As a result of participant seminars, I'm planning to contact that participant for some background information about possible approaches to the issue."

Trevor Matthews, The University of Adelaide

TRIVIA NIGHT AND BINGO

As a way for the Winter School cohort to get to know each other better and connect amid the socially distanced conditions, various online social activities were arranged. Participants were invited to complete the social bingo card across the two-week program. The card asked questions to encourage conversation and served as an icebreaker during group activities such as tutorials and the Participant Talks. These icebreaker activities assisted in creating a more relaxed and friendly atmosphere, alleviating any nerves associated with networking and giving a presentation. This in turn helped to foster a more collegial and community-focused approach to program participation.

A trivia night was also conducted in the second week of the program. This was an opportunity for attendees to take some time out from the intense program and socialise with each other in a relaxed environment. Attendees were invited to create trivia teams over the virtual GatherTown platform and test their general knowledge. While many still felt face-to-face networking is irreplaceable, there was very positive feedback from those participating in these activities and a general consensus that there was a good attempt at providing social networking opportunities despite the lockdowns.

"The biggest positive was that it gave opportunity for researchers from many different locations to participate which created a bigger community atmosphere. Although communicating online is not the same as in-person, the program was run in an effective and efficient way which made the virtual experience a real positive."

Samuel Barton, The University of Queensland

MINDFULNESS SESSIONS

To combat the intense class schedule, two mindfulness sessions were offered to attendees. Programmed during lunch breaks, students were encouraged to take some time out between classes to focus on their breath and practice some useful techniques to help mitigate stress in their everyday lives. Acknowledging that the current life and times of students and professionals can at times be overwhelming with competing pressures, the techniques learned during the session are transferrable and could easily be used at any time. These sessions were well received with positive feedback from those who attended this activity.

SLACK

Slack was employed as the official communications system, where participants could access class materials, ask lecturers questions regarding concepts learnt throughout the day, and engage in both academic and social discussions with their fellow classmates. Dedicated channels were created for each subject as well as one for more general program announcements and notifications. These channels helped to create a unified learning community, promoting collaboration to solve problems as a group and made lecturers accessible in what may have otherwise been an isolating virtual environment. Lecturers were also involved in some of the more social discussions further enhancing the comradery among the cohort. The importance of the Slack platform became obvious as over the course of the program, students began to use the channels to promote other activities within their industries such as upcoming jobs and other conferences. Feedback from participants regarding the platform as both a resource and communication channel was overwhelmingly positive.

TWITTER

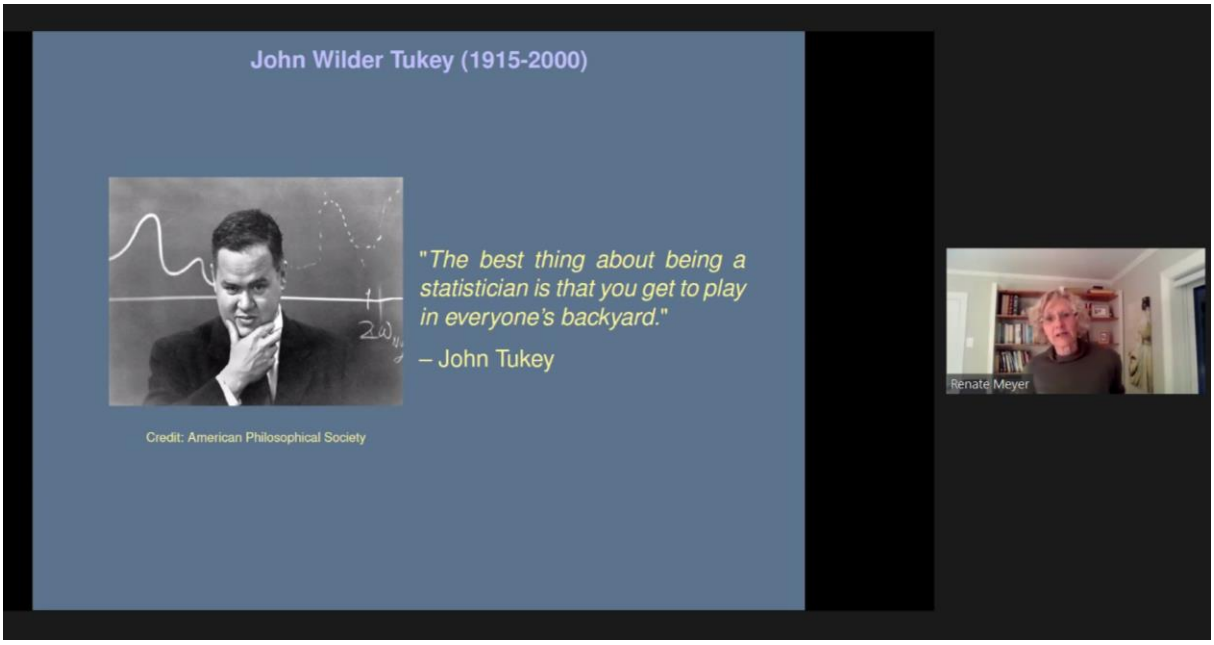
Throughout the two-week program AMSI continued to commentate on program activities using the #AMSIWS21 hashtag. Here, the AMSI team, lecturers and students added to the discussions, publicly promoting their positive experiences, and showcasing new skills learnt in classes. This was another element which assisted in keeping the Winter School cohort connected and feel included in a community.

The combination of platforms - Zoom, Slack, and GatherTown - meant there were "spaces" for discussion outside the lecture that had more in common with the spontaneous conversations in traditional conferences."

Adam Burke, Queensland University of Technology

PUBLIC LECTURE

AMSI partnered with the Statistical Society of Australia to deliver the biennial AMSI-SSA public lecture as part of the Winter School 2021 program. This event was an occasion for members of the public to interact with the mathematical sciences community and be exposed to the broad range of applications and positive impacts that mathematics has on the community. On 22 July, over 100 people tuned into Zoom to watch Professor Renate Meyer from the University of Auckland present her fascinating talk *Data Detectives on the Trail of Black Hole Mergers*. Professor Meyer discussed the role data science (in particular, Bayesian statistics) had to play in helping astrophysicists to uncover the mysteries and history of the universe as we know it. At the end of the talk, audience members were given an opportunity to ask questions and delve deeper into some of the concepts that were covered. Watch parties hosted at the QUT and Curtin University event hubs continued the festivities after the lecture, giving guests an opportunity to network over a light supper.



"The most valuable part for me was the exposure I got to the possibilities and open questions in statistics and data science. I was introduced to new concepts and got to explore ideas I was only vaguely aware of in more detail. I also absolutely enjoyed meeting other participants and got to see how they applied data science in other fields, and data-related challenges in government and industry. The Winter School expanded my view of how statistics and data science are used."

Mythreyi Velmurugan, Queensland University of Technology

FEEDBACK ANALYSIS

A staggering 78 participants completed the 2021 Winter School post-event feedback survey, accounting for 71.6 per cent of the total cohort. Data remains strong indicating a high appetite for the Winter School program (whether in hybrid mode or face-to-face) among postgraduate students, researchers and industry professionals. In rating their overall experience, with 1 being poor and 10 being excellent, respondents rated the event an average of 9.04. This rating is in step with previous Winter School programs held in a face-to-face format.

Survey respondents reported that their main motivator for attending Winter School was because the theme was closely connected to their research interests (49 per cent), to broaden their knowledge (42 per cent), to assist their career prospects (4 per cent) and to learn from a specific lecturer (4 per cent). This data suggests that participants are future-focused and keen to pursue the mathematical sciences long term. It also suggests that there is an appetite to grow their already expert knowledge and learn from the most eminent minds leading the world on their chosen topics. This trend follows those of recent years, with data almost mirroring that of past cohorts.

This year's data makes it clear that the AMSI Winter School continues to sharpen skills and be a launchpad for future studies. Ninety-one per cent of the survey respondents reported that newfound knowledge and skills learnt during the program was useful and would be applied in their everyday research and studies (54 per cent strongly agreed; 37 per cent agreed). Additionally, 76 per cent felt that being part of the program strengthened their ability to conduct individual research outside the program (40 per cent strongly agreed; 36 per cent agreed). Building on these findings, the large majority of respondents felt that AMSI Winter School had exposed them to other research fields they may not have otherwise known about (58 per cent strongly agreed; 33 per cent agreed).

Even when hosted in a hybrid format, it remains clear that Winter School provides opportunities for students, researchers and professionals to widen their networks and connect with others in their field. Seventy-seven per cent of survey respondents attested to making useful contacts with whom they would potentially collaborate with in future (38.5 percent strongly agreed; 38.5 per cent agreed).

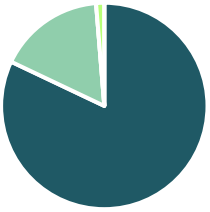
Overall, this data continues to build on trends of previous years, solidifying AMSI Winter School as a program indispensable to strengthening the mathematical sciences pipeline. Its immediate effects of deepening and reinforcing skills are significantly apparent, as is its strong potential to act as a germinating seed for future collaborations, innovations and career development.

"AMSI Winter School was a remarkable experience not only for the educational and networking opportunities but also for the fantastic atmosphere created by the team of organisers."

Paula Hatum, Queensland University of Technology

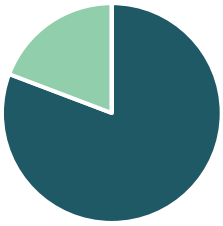
THE SCHOOL WAS OF A HIGH STANDARD

Strongly Agree	82%
Agree	17%
Neutral	0%
Disagree	1%
Strongly Disagree	0%



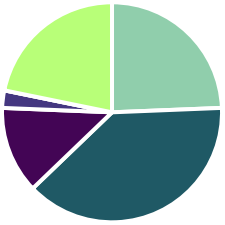
THE SCHOOL WAS WELL-ORGANISED

Strongly Agree	81%
Agree	19%
Neutral	0%
Disagree	0%
Strongly Disagree	0%



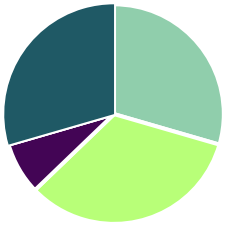
THE CELEBRATION OF THE MATHEMATICAL SCIENCES EVENT WAS INSIGHTFUL AND INSPIRING

Strongly Agree	24%
Agree	38%
Neutral	13%
Disagree	3%
Strongly Disagree	0%
Did Not Attend	22%



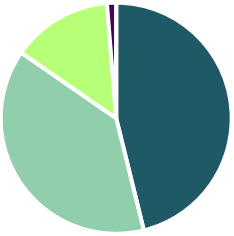
THE PUBLIC LECTURE WAS INTERESTING AND INFORMATIVE

Strongly Agree	29.5%
Agree	33%
Neutral	8%
Disagree	0%
Strongly Disagree	0%
Did Not Attend	29.5%



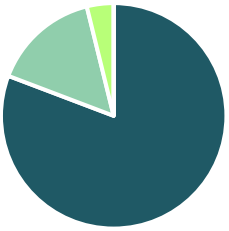
WINTER SCHOOL STRENGTHENED MY MATHEMATICAL CREDENTIALS

Strongly Agree	46%
Agree	39%
Neutral	14%
Disagree	1%
Strongly Disagree	0%



I WOULD RECOMMEND WINTER SCHOOL TO OTHERS

Strongly Agree	81%
Agree	15%
Neutral	4%
Disagree	0%
Strongly Disagree	0%



"The most valuable part of the program for me was the opportunity to meet both people working on similar research to mine, and people working in areas I have never heard about (e.g. visual ecology or geostatistics for cosmology). It further expands my understanding of the capabilities of data science and makes me very excited to see where it could take me in the future."

Bao Anh Vu, University of Wollongong

COMMITTEES

AMSI wishes to acknowledge and thank the following committees who contributed their time and expertise to making Winter School 2021 a success:

STANDING COMMITTEE

Joseph Grotowski (Chair), The University of Queensland

Christopher Drovandi (Event Director), Queensland University of Technology

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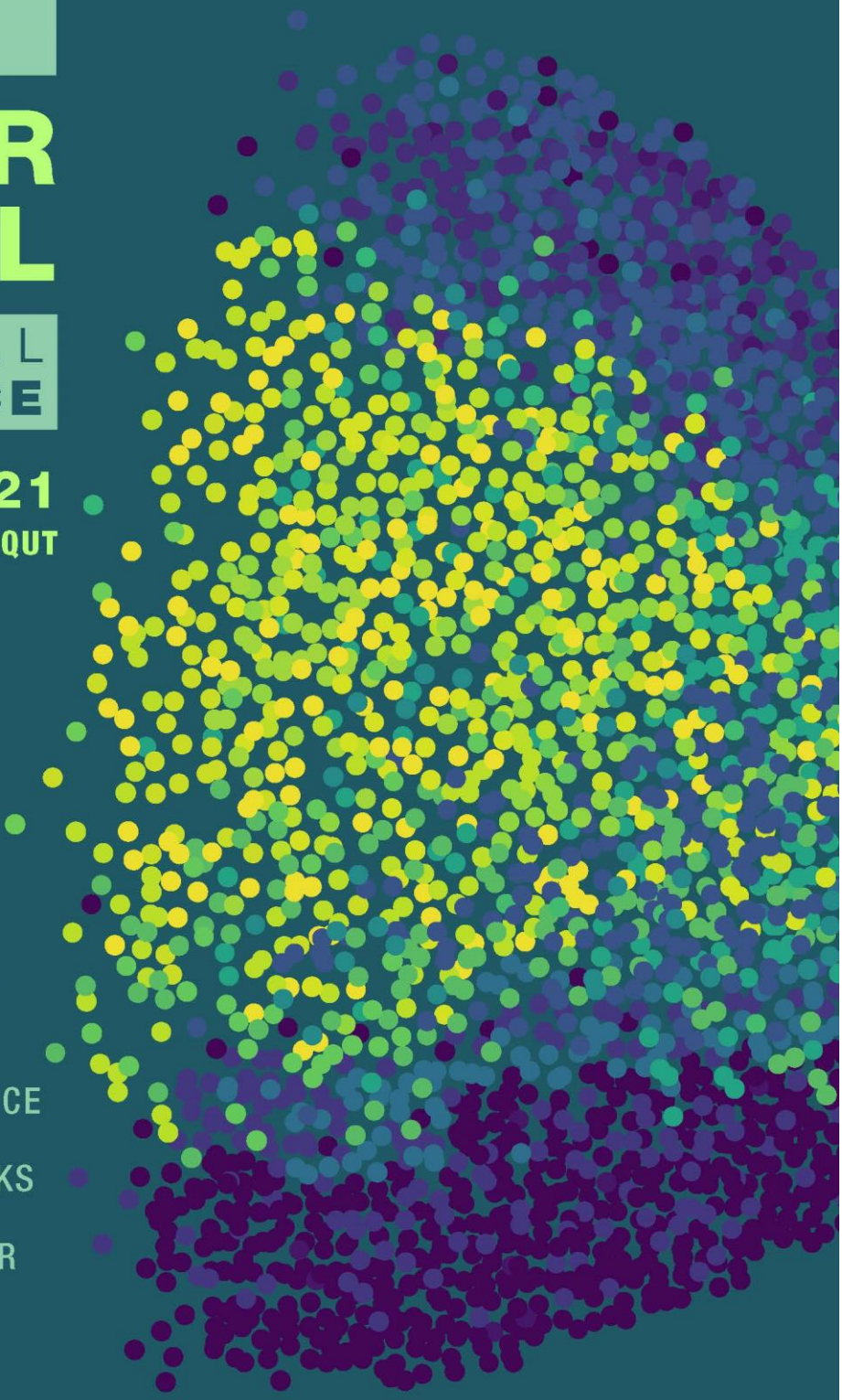
AMSI 21 WINTER SCHOOL

STATISTICAL DATA SCIENCE

12–23 JULY 2021

VIRTUAL EVENT HOSTED BY **QUT**



TOPICS

BAYESIAN STATISTICS

ADVANCED MARKOV CHAIN MONTE CARLO METHODS

LIKELIHOOD-FREE INFERENCE

MODERN NEURAL NETWORKS

DIMENSION REDUCTION FOR HIGH DIMENSIONAL DATA

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