QANZIAM Conference 2022

Queensland University of Technology

Wednesday 15th June 2022

Location

The QANZIAM Conference 2022 will be held in-person and online via Zoom. The in-person component will be in the Room P-506, P Block, Gardens Point Campus, Queensland University of Technology (circled in red on the map).

Participants can also join online via the Zoom link: tinyurl.com/3hzxsf8w

Schedule

Time	Speaker	Title
8:00 – 8:30		Registration
8:30 – 8:40		Welcome
8:40 – 9:00	Jack McKinstry (UQ)	Optimal Harvest Size in Aquaculture
9:00 – 9:20	Jun Ju (UQ)	Model-based Offline Reinforcement Learning for Sustainable Fishery Management
9:20 – 9:40	Sarah Vollert (QUT)	Strategic model reduction by analysing model sloppiness: a case study in coral calcification
9:40 – 10:00	Manuela Mendiolar (UQ)	Capturing episodic impact of environmental signals
10:00 – 10:30		Morning Tea
10:30 – 10:50	James Hogg (QUT)	Searching for stability in Bayesian small area estimation of proportions
10:50 – 11:10	Abbish Kamalakkannan (Griffith)	Developing a Computationally Efficient Bayesian Inference Protocol
11:10 – 11:30	Riley Whebell (QUT)	Macro-scale wheat leaf reconstructions with micro-scale features using RBFPU surface reconstruction
11:30 – 11:50	Johnathan Adams (QUT)	Predicting Human Behaviour with Opinion Dynamics
11:50 – 12:10	Luke Filippini (QUT)	Simplified models of diffusive transport in radially-symmetric media
12:10 – 13:10		Lunch
13:10 – 14:00		**Panel Discussion - Careers after a PhD** Moderated by Dr Kate Saunders (QUT) Panelists: Ms Emma Lawrence (CSIRO), Dr Matthew Holden (UQ), Professor Scott McCue (QUT)
14:00 – 14:10		Short 10 minute break (no catering)
14:10 – 14:30	Dylan Oliver (QUT)	Coarse-to-fine grid mapping method for solving the advection-diffusion-reaction equation in a heterogeneous medium
14:30 – 14:50	Cailan Jeynes-Smith (QUT)	Improved Analytic Solutions to Complex Problems
14:50 – 15:20		Afternoon Tea
15:20 – 15:40	Isabela Conde (UQ)	Delay Differential Equations of El Niño Southern Oscillation
15:40 – 16:00	Imke Botha (QUT)	Iterative ensemble Kalman inversion for static Bayesian models with unknown measurement error covariance
16:00 – 16:20	Zhihao Qiao (UQ)	Risk critical threshold of a rational function of a random variable
16:20 – 16:40		Close of Conference

Panel Members

Dr Kate Saunders is a lecturer in the School of Mathematical Sciences whose research interests are in statistical climatology. Her primary focus is on modelling climate extremes; and understanding how the probability of extreme events might be influenced by climate change. Other interests include; statistical post-processing of meteorological forecasts, quality control of meteorological data and how to estimate the risk posed by compound weather events. Kate's research improves our understanding of the probability of extreme climate/weather events and helps us to make informed decisions about natural disaster risk

Ms Emma Lawrence is an Environmental Statistician with CSIRO Data61 in Brisbane, Australia. For many years the focus of her work has been on the application of statistical techniques in the marine domain. Emma has a particular interest in the design and analysis of marine monitoring projects and enjoys working in multi-discplinary teams to ensure that field work is well-designed to ensure the best possible project outcomes.

Emma is currently leading the Crown-of-thorns starfish (COTS) Control Innovation Program Detection Subprogram, who are working to deliver a step-change in monitoring and surveillance strategies, tools and technologies for efficient early detection of COTS outbreaks to inform effective outbreak response in the Great Barrier Reef.

Prior to joining CSIRO Emma worked at the then Bureau of Rural Sciences (Australian Government Department of Agriculture, Fisheries and Forestry) where she was involved in developing a national sampling strategy for monitoring invasive marine species at high-risk locations around Australia.

Dr. Matthew Holden is an applied mathematician using dynamic models and decision theory to improve conservation planning when conservation benefits depend on how humans modify their behaviour in response to policy. Some of his projects include saving the African elephant from poaching for ivory and developing novel quantitative methods for invasive and threatened species management. He earned his PhD in Applied mathematics at Cornell University, winning a National Science Foundation Graduate Research fellowship to work on optimization problems in fisheries management, invasive species control, and sustainable agriculture. He received his bachelor's degree from the University of California, Davis, where he won the University Medal, working on the effect of habitat fragmentation on species persistence.

Professsor Soctt McCue was awarded a PhD in Applied Mathematics from the University of Queensland in May 2000. His PhD supervisor was Professor Lawrence Forbes, who is now at the University of Tasmania. Scott was a Postdoctoral Research Fellow at the University of Nottingham from 1999-2001, under the supervision of Professors David Riley and John King. He was then a Postdoctoral Research Fellow at the University of Wollongong from 2002-2004 under the supervision of Professor James Hill, who is now at the University of South Australia. In 2004 Scott took up a position as Lecturer in Applied Mathematics at Griffith University. He moved to QUT in 2007 as Lecturer in Mathematics, was promoted to Senior Lecturer in 2009, Associate Professor in 2012, and Professor in 2016.

In 2019 Scott was awarded the EO Tuck Medal for research and service to ANZIAM. From Aug-Dec 2019 he was a Simons Visiting Fellow at the Isaac Newton Institute of Mathematical Sciences at the University of Cambridge. In 2013 he spent time on sabbatical leave in the School of Mathematics and Statistics at the University of Melbourne. In 2009 he was awarded the JH Michell Medal.

Talk Abstracts

Optimal Harvest Size in Aquaculture

Jack McKinstry

Supervisor(s): Matt Holden

The University of Queensland

Aquaculture is a rapidly growing industry with the capability to establish itself as a sustainable global food source in the near future. It is important to investigate the conditions that make aquaculture economically optimal, in order to ensure efficient allocation of resources and a healthy competitive environment. By investigating key influencing factors of a profitable aquaculture business, I arrive at a simple profit model utilising the von Bertalanffy Growth Function (VBGF) that can be used to determine the optimal harvest weight of fish farmed in an inland, open-pond aquaculture system. The results from simulating populations of barramundi with growth parameters based on the literature suggest that optimal harvest sizes actually fall below what is considered by most to be the most popular size that barramundi is sold at.

Model-based Offline Reinforcement Learning for Sustainable Fishery Management

Jun Ju

Supervisor(s): Nan Ye, Dirk Kroese

The University of Queensland

Reinforcement learning provides a simple and general computational approach for sequential decision making. Recent advances of reinforcement learning focus on fully observable environments. However, real-world problems are often partially observable, and it remains a challenge to develop sample-efficient and robust algorithms for such problems. In this talk, I will show how to address these challenges in an important partially observable domain, sustainable fishery management. Specifically, we propose MOOR, a robust and interpretable model-based offline reinforcement learning algorithm. MOOR achieves sample-efficiency by first learning fishery POMDP models, then learning a strategy from past fishery data without directly interacting with the environment. Our simulation study shows that MOOR can learn a fairly accurate model and is robust against model learning errors.

Strategic model reduction by analysing model sloppiness: a case study in coral calcification

Sarah Vollert

Supervisor(s): Christopher Drovandi, Gloria Monsalve-Bravo, Matthew Adams

Queensland University of Technology

It can be difficult to identify ways to reduce the complexity of large models whilst maintaining predictive power, particularly where there are hidden parameter interdependencies. Here, we demonstrate that the analysis of model sloppiness can be a new invaluable tool for strategically simplifying complex models. Such an analysis identifies parameter combinations which strongly and/or weakly inform

model behaviours, yet the approach has not previously been used to inform model reduction. Using a case study on a coral calcification model calibrated to experimental data, we show how the analysis of model sloppiness can strategically inform model simplifications that maintain predictive power.

Capturing episodic impact of environmental signals

Manuela Mendiolar

Supervisor(s): Jerzy Filar, Matthew Holden, Anthony Courtney, Leahy Susannah and Wen-Hsi Yang

The University of Queensland

In environmental applications, scientists typically rely on time series of important explanatory variables to try to explain their impact on a response variable of interest. There are many standard statistical methods to capture such impacts. However, it is quite common that rather than using raw observations of the explanatory variable, researchers are more interested in derived indices induced by episodes embedded in the time series. This complicates the analysis when we are interested in intermittent episodes, occurring within a specific memory window, persisting long enough, at sufficient intensity, and overlapping significant periods with respect to the response variable. The latter aspect will be referred to as timing. In this paper, we develop a generic, parametrised, family of weighted indices extracted from observations of a relevant environmental signal. These indices can be adequately calibrated to capture the importance of intermittency, memory, persistence, intensity and timing of the underlying episodes. To facilitate ease of construction and calibration of these indices we developed a user-friendly IMPIT-a application in Shiny R. We illustrate the effectiveness of the design and calibration of IMPIT indices for two widely used environmental signals; the Southern Oscillation Index and Marine Heatwaves and we study their impact on two Queensland species: snapper (Chrysophrys auratus) and saucer scallop (Ylistrum balloti). We expect this novel methodology can form another, useful, tool in exploratory data analysis.

Searching for stability in Bayesian small area estimation of proportions

James Hogg

Supervisor(s): Kerrie Mengersen, Susanna Cramb, Peter Baade, Jessica Cameron

Queensland University of Technology

With the rise in popularity of digital Atlases to communicate spatial variation in health to the public, there is an increasing need for robust small area proportion estimates. Useful predictors of health outcomes are generally not available for all individuals and thus it is important to develop small area estimation methods that can incorporate survey-only covariates at the individual level. We propose a new Bayesian hierarchical model that accounts for survey design and leverages both individual-level survey-only and area-level census covariates to simultaneously reduce the variance and bias of estimates and allow for the prediction of proportions for non-sampled areas. Initial testing of our model's performance using simulated survey data, compared with existing Bayesian SAE methods, showed that our novel model provides optimal performance when important individual-level survey-only covariates are utilized.

Developing a Computationally Efficient Bayesian Inference Protocol

Abbish Kamalakkannan

Supervisor(s): Barbara Johnston, Peter Johnston

Griffith University

Finding solutions to inverse problems is computationally expensive, if not infeasible, under specific scenarios. This presentation highlights the benefits and limitations of implementing a surrogate model, developed through polynomial chaos techniques, to approximate the solution of the cardiac bidomain equations on a multi-electrode array. The resulting cardiac potentials can be used to solve inverse problems using Bayesian inference techniques. This inference protocol has also been developed to be robust against outliers found in experimental data. The utility of this protocol is demonstrated by estimating the bidomain parameters from animal experimental data. Although we have used this inference protocol to infer the cardiac bidomain parameters, it can be tailored to suit many inverse problems.

Macro-scale wheat leaf reconstructions with micro-scale features using RBFPU surface reconstruction

Riley Whebell

Supervisor(s): Timothy Moroney, Ian Turner, Scott McCue, Ravindra Pethiyagoda

Queensland University of Technology

Realistic digital models of plant leaves are crucial to fluid dynamics simulations of droplets, towards the optimisation of agrochemical spray technologies. The presence and nature of microstructures on the surface have been shown to significantly affect the droplet evaporation, and thus the leaf's potential uptake of active ingredients. We show that implicit radial basis function partition of unity (RBFPU) surface reconstructions from micro-CT scan datasets can capture these microstructures. However, scanning a whole leaf ($20cm^2$) at micron resolutions is infeasible due to both storage and time constraints. Instead, we micro-CT scan only a small segment of a wheat leaf ($4mm^2$). We fit a RBFPU implicit surface to this segment, then replicate it many times across a larger, coarser wheat leaf model reconstructed from a range scanner. We use a locally orthogonal coordinate system to parameterise the leaf surface. The edge of one segment is blended into its neighbour naturally by the partition of unity method. The result is one implicit surface reconstruction that captures the wheat leaf's features at both the micro- and macro-scales.

Predicting Human Behaviour with Opinion Dynamics

Johnathan Adams

Supervisor(s): Gentry White and Robyn Araujo

Queensland University of Technology

In the field of opinion dynamics there are many models that predict human behaviour, none so precisely as the Martins model. As part of my research I had devised an experiment to test the Martins model and its ability to predict shifts in individuals opinion. The results suggest that the Martins model has some predictive power, but the experiment revealed that individuals switch between continuous and discrete forms of thinking which the Martins model cannot explain.

Simplified models of diffusive transport in radially-symmetric media

Luke Patrick Filippini

Supervisor(s): Elliot Carr, Matthew Simpson

Queensland University of Technology

Simple reduced-order mathematical models are commonly proposed in applications such as drug delivery and food drying to approximate PDE models describing the spatial and temporal dynamics of diffusive heat and mass transport. Such reduced-order models are appealing as they bypass solving the PDE model, while also allowing for a simplified analysis and interpretation of results. Recently, a moment-matching approach was proposed and used to develop a simple single-term exponential model for the temporal evolution of the spatial-average of the diffusion equation in homogeneous radially-symmetric geometries. In this talk, I show how this approach can be extended to a two-term exponential model that significantly improves on the accuracy of the single-term exponential model.

Coarse-to-fine grid mapping method for solving the advection-diffusion-reaction equation in a heterogeneous medium.

Dylan Oliver

Supervisor(s): Elliot Carr, Ian Turner

Queensland University of Technology

Substantial research conducted by the wider scientific community is focussed on the development of models describing heat and mass transport phenomena. Often, the associated PDE models are highly complex and not amenable to analytical solution methods. This is especially evident for models describing processes in heterogeneous media where the computational cost of numerical simulation is high due to the prohibitive number of elements/nodes required to capture the heterogeneous structure. In this talk, I will outline a new dual-grid mapping method for accurately computing solutions to the heterogeneous advection-diffusion-reaction equation on a coupled coarse and fine grid. Using a spatial discretisation of the governing equations on the fine grid, a novel dimension-reducing mapping is developed, allowing solutions to be accurately computed on the coarse grid and then accurately reconstructed on the fine grid. Computational experiments demonstrate that our approach is more accurate than either solving the problem directly on the coarse grid or using other more standard interpolation-based mappings.

Improved Analytic Solutions to Complex Problems

Cailan Jeynes-Smith

Supervisor(s): Robyn Araujo, Michael Bode

Queensland University of Technology

Recent studies determined a simple condition required for a network to achieve an important signalling response, robust perfect adaptation. However, this condition only holds true when the network can only demonstrate this one signalling response. In this presentation we extend this method to identify robust perfect adaptation capability in networks with more than one signalling response. We then extend this methodology to another key signalling response, unlimited ultrasensitivity.

Delay Differential Equations of El Ni no Southern Oscillation

Isabela Conde

Supervisor(s): Cecilia Gonzalez Tokman

The University of Queensland

The El Niño Southern Oscillation or ENSO, is a weather pattern defined by changes in the Pacific Ocean's mixing layer (thermocline), and sea surface temperatures. The principal drivers of ENSO are Rossby and Kelvin waves, where the progression of Kelvin waves heavily depends on the strength of trade winds flowing eastwards, whereas Rossby waves are a consequence of the Earth's rotation. These mechanisms act on different time scales which have been successfully modelled by delay differential equations, these are defined as a system with state variables dependent on the past. Delay differential equations or DDEs, lead to complicated dynamics that are characterised by transcendental equations. This project looks at two separate models, one describing the change in sea surface temperatures, and the other in terms of thermocline depth as ENSO progresses. Models with one and two delays are considered, representing the transit time of Kelvin and Rossby waves. The aim of this study is to understand long term behaviour arising in these models both analytically and numerically, in particular the stability of the solutions as the strength of feedbacks and the delay terms are modified.

Iterative ensemble Kalman inversion for static Bayesian models with unknown measurement error covariance

Imke Botha

Supervisor(s): Christopher Drovandi

Co-Author(s): Matthew P. Adams, Dang Khuong Tran, Frederick R. Bennett

Queensland University of Technology

The ensemble Kalman filter (EnKF) is a Monte Carlo approximation of the Kalman filter for high dimensional linear Gaussian state-space models. EnKF methods have also been developed for parameter inference of static Bayesian models with a Gaussian likelihood, in a way that is analogous to likelihood tempering sequential Monte Carlo (SMC). EnKF methods for static models are commonly referred to as ensemble Kalman inversion (EKI). Unlike SMC, the inference from EKI is only asymptotically unbiased if the likelihood is linear Gaussian and the priors are Gaussian, however it is significantly faster to run. Currently, a large limitation of EKI methods is that the covariance of the measurement error is assumed to be fully known. We develop a new method that allows elements of the covariance matrix to be inferred alongside the model parameters at negligible extra cost. We find that the novel method has relatively similar predictive performance to SMC, albeit with greater uncertainty, and it has a significantly faster run time.

Risk critical threshold of a rational function of a random variable

Zhihao Qiao

Supervisor(s): Jerzy Filar, Vladimir Ejov, Yoni Nazarathy

The University of Queensland

We consider the problem of parametric sensitivity of a characterization of threshold risk of a random variable $Y = f(X)$, where $f(X)$ is a rational function of an absolutely continuous random variable X. That risk is modelled as the probability of Y falling below the threshold δ. When δ_c is such that the risk is not Lipschitz continuous, we call this threshold a critical point. We demonstrate that for rational functions of that random variable there exist at most finitely many risk critical points. We illustrate this general theorem with a special case where $f(X)$ is ratio of two linear functions. In this case, there can be at most one critical threshold, depending on whether the distribution of the random variable X is sufficiently heavy tailed.

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Code of Conduct

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All participants have a responsibility to speak out against breaches of this code of conduct. Depending on the situation, this could mean raising it with the transgressor, or reporting the behaviour to a conference organiser. If a QANZIAM member engages in harassing behaviour, the Executive Committee may take any action they deem appropriate, including warning the offender or expulsion from the Society.

Acknowledgements

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A very big thank you to ANZIAM for funding the QANZIAM ECR conference. The funding from ANZIAM enabled us to run the conference with no registration fee.

We would also like to thank QUT for allowing the QANZIAM ECR conference to be held on the Gardens Point Campus and donating use of the room free of charge. QUT acknowledges the Turrbal and Yugara as the First Nations owners of the lands where QUT now stands. We pay respect to their Elders, lores, customs and creation spirits.