2024 QANZIAM Conference

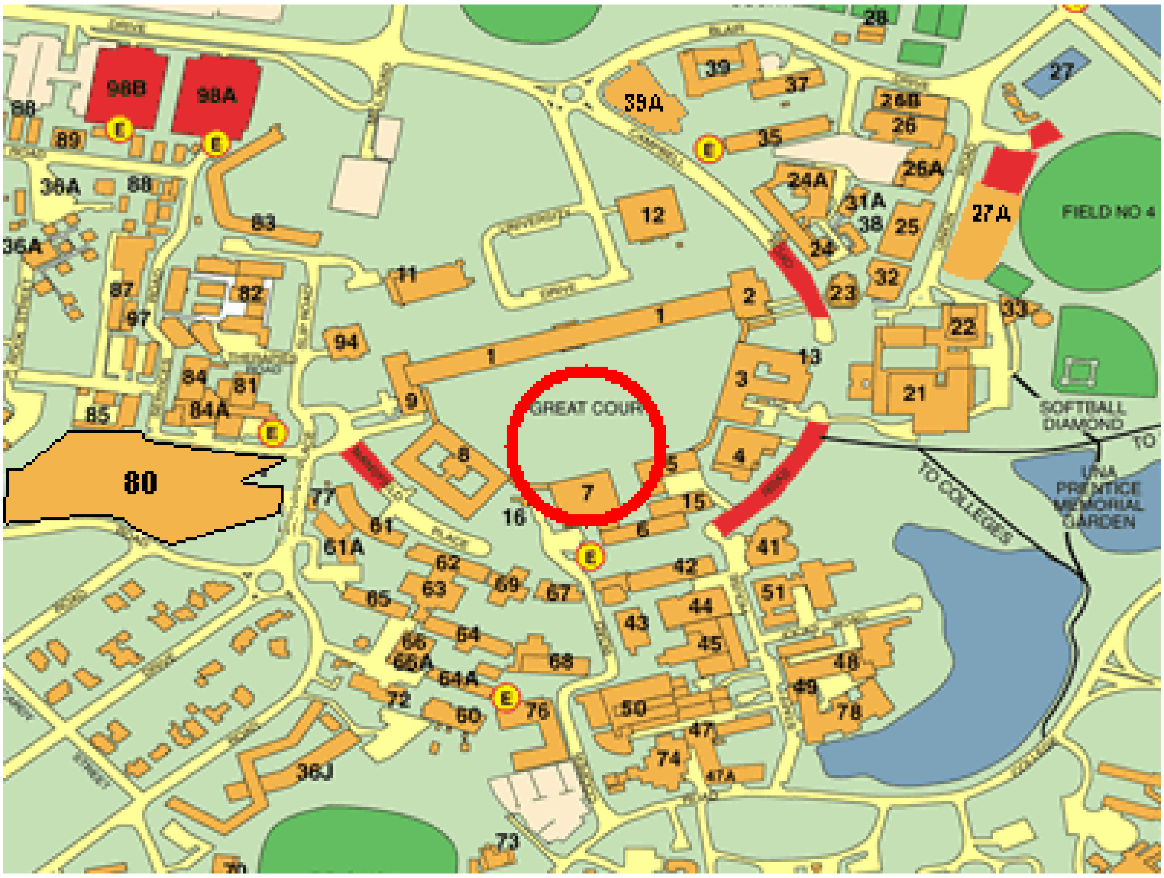
University of Queensland, St Lucia Campus

Thursday, June 6, 2024

Location

The 2024 QANZIAM Conference will be held at the University of Queensland, St Lucia campus.

To start the conference, please join us in room 07-234 (Building 7 - Parnell Building, Room 234) at 9am for the official welcome. The QANZIAM conference will have two parallel sessions. These will be held in rooms 07-234 and 07-222. The schedules for each of the rooms is included in this booklet.



Schedule: 07-234 (Building 7 - Parnell Building, Room 234)

Time	Speaker	Title
08:30 – 09:00		Registration
09:00 – 09:20	Welcome	Conference officially opened by Professor Virginia Slaughter, Dean of the Graduate School, University of Queensland
09:20 – 09:30		10 minute break to move to parallel sessions
09:30 – 09:50	Georgia Weatherley	*Session Chair: Scott McCue* Tackling the erosion of neurological function: can we restore functionality to multiple sclerosis patients?
09:50 – 10:10	Irio M Coutinho	Fingering stabilization and adhesion force in the lifting flow with a fluid annulus
10:10 – 10:30	Mason Lacy	Impact of Resistance on Therapeutic Design: a Moran Model of Cancer Growth
10:30 – 11:00		Morning Tea
11:00 – 11:20	Joshua Peters	*Session Chair: Vivien Challis* Averaging for random metastable systems
11:20 – 11:40	Qingyuan Zhang	Consistent information criteria for regularized regression and loss-based learning problems
11:40 – 12:00	Jordan Holdorf	Time Matters: Optimising Finance for Nature Investments
12:00 – 12:20	Zachary J Wegert	GridapTopOpt.jl: A scalable Julia toolbox for level set-based topology optimisation
12:20 – 12:40	Stephen Sanderson	Local temperature measurement in dynamical systems with rigid constraints
12:40 – 13:40		Lunch
13:40 – 14:30	**Invited Speaker** Dr David Howard	*Session Chair: Zachary J Wegert* Representations and learning for real-world optimisation
14:30 – 14:40		10 minute break to move to parallel sessions
14:40 – 15:00	Junji Zhang	Machine learning coarse grained simulation for aqueous NaCl
15:00 – 15:20	Sarika Karanth	Using k-means clustering to define ecosystems of Macquarie Island and their collapses
15:20 – 15:50		Afternoon Tea
15:50 – 16:10	Chang Chen	*Session Chair: David Warne* Mean-CVaR portfolio optimisation
16:10 – 16:30	Duy-Minh Dang	Fourier Neural Network Approximation of Transition Densities in Finance
16:30 – 16:50		Close of conference

Schedule: 07-222 (Building 7 - Parnell Building, Room 222)

Time	Speaker	Title
08:30 – 09:00		Registration
09:00 – 09:20	Welcome	Please join room 07-234
09:20 – 09:30		10 minute break to move to parallel sessions
09:30 – 09:50	Patrick Grant	*Session Chair: Zoltan Neufeld* Wet Wood Woes
09:50 – 10:10	Hasitha Weerasinghe	Ordinary Differential Equation Modelling for the Tumour Microenvironment
10:10 – 10:30	Llewyn Randall	The nuances of amphitheatre gully erosion: a three-state approach
10:30 – 11:00		Morning Tea
11:00 – 11:20	Hamish Murray	*Session Chair: Maria Kleshnina* Optimisation of List Management in the Australian Football League using Deterministic Methods
11:20 – 11:40	Scott Forrest	Predicting animal movement with a deep learning step selection framework
11:40 – 12:00	Renee Oldfield	Measure theoretic entropy for Blaschke products
12:00 – 12:20	Hao Zhou	Numerical analysis for American options under the two-asset jump-diffusion model
12:20 – 12:40	Yuxin Huang	Bayesian spatial relative survival model to estimate the loss in life expectancy for cancer patients in Queensland
12:40 – 13:40		Lunch
13:40 – 14:30	**Invited Speaker** Dr David Howard	Please join room 07-234
14:30 – 14:40		10 minute break to move to parallel sessions
14:40 – 15:00	Jenney-Yuhui Chen	*Chair: Melanie Roberts* A New Numerical Approach to Fractional Pharmacokinetics Model using Sibuya Distribution
15:00 – 15:20	Sanchita Malla	Physics Informed Neural Network for Free Boundary Problems in Science and Engineering
15:20 – 15:50		Afternoon Tea
15:50 – 16:10	Yash Vats	*Session Chair: Alistair Falconer* A new perspective for scientific modelling: Sparse reconstruction based approach for learning time-space fractional differential equations
16:10 – 16:30	Maria Kleshnina	Optimal sharing in social dilemmas
16:30 – 16:50		Close of conference - Please join room 07-234

Invited Speaker

Representations and learning for real-world optimisation

Dr David Howard

CSIRO

Abstract: Machine learning has the potential to revolutionise the broad field of industrial design – providing new high-performance equipment for a range of high-value target domains including robotics, flow chemistry, and direct air capture, amongst others. But how do we decide on the fundamental mathematics behind these computational search processes? From closing the reality gap to describing and searching huge multi-dimensional spaces, this presentation covers the what, the why, and the how, of using computational design and artificial intelligence for real world optimisation problems. David will describe the above in the context of the AI4Design portfolio, which combines genetic algorithms, topology optimisation, physics simulation, and 3D printing, to revolutionise Australian industry.

Bio: David leads the Robotic Design and Interaction Group and is a Principal Research Scientist in the Cyber Physical Systems program at CSIRO, Australia's national science body. He received his BSc in Computing from the University of Leeds in 2005, and the MSc in Cognitive Systems at the same institution in 2006. In 2011 he received his PhD from the University of the West of England. He is a member of the IEEE and ACM, and an avid proponent of education, STEM, and outreach activities. His work has been published in IEEE and Nature journals.

Talk Abstracts

All abstracts are in alphabetical order (by first name).

Mean-CVaR portfolio optimisation

Chang Chen

Supervisors/Collaborators: Duy-Minh Dang

University of Queensland

Retirement saving and wealth management are critical financial topics globally. In Australia, superannuation assets exceed 2.77 trillion USD, with 87% being Defined Contribution (DC) plans. Under DC plans, holders self-manage their retirement funds and bear all associated risks. In this talk, we introduce a Mean-CVaR framework for long-term wealth management, focusing on one-side tail risk rather than variance, making it more suitable for retirees. In a multi-period setting, we examine the advantages and disadvantages of pre-commitment and time-consistent approaches. Numerical results show that pre-commitment yields higher expected terminal wealth and CVaR, while time-consistent strategies are more robust against model misspecification errors. Our findings suggest that the choice between these approaches depends on specific objectives and investment philosophies.

Fourier Neural Network Approximation of Transition Densities in Finance

Duy-Minh Dang

Collaborators: Rong Du

University of Queensland

This paper introduces FourNet, a novel single-layer feed-forward neural network (FFNN) method designed to approximate transition densities for which closed-form expressions of their Fourier transforms, i.e. characteristic functions, are available. A unique feature of FourNet lies in its use of a Gaussian activation function, enabling exact Fourier and inverse Fourier transformations and drawing analogies with the Gaussian mixture model. We mathematically establish FourNet's capacity to approximate transition densities in the L_2-sense arbitrarily well with finite number of neurons. The parameters of FourNet are learned by minimizing a loss function derived from the known characteristic function and the Fourier transform of the FFNN, complemented by a strategic sampling approach to enhance training. We derive practical bounds for the L_2 estimation error and the potential pointwise loss of nonnegativity in FourNet, highlighting its robustness and applicability in practical settings. FourNet's accuracy and versatility are demonstrated through a wide range of dynamics common in quantitative finance, including Lévy processes and the Heston stochastic volatility models-including those augmented with the self-exciting Queue-Hawkes jump process.

Tackling the erosion of neurological function: can we restore functionality to multiple sclerosis patients?

Georgia Weatherley

Supervisors/Collaborators: Dr Adrianne Jenner, Assoc. Prof Robyn Araujo

Queensland University of Technology

People with multiple sclerosis (MS) experience diverse neurological symptoms arising from their immune system's mistaken attack on the protective myelin sheaths of nerve fibres. Myelin is a membrane extension of oligodendrocytes, and bouts of heightened immune dysfunction result in the loss of these vital cells and their myelin, leading to functional deficits. Current therapeutics are designed to suppress the levels of harmful immune activity but do little to address the wellbeing of patients with large accumulations of existing myelin and oligodendrocyte loss, motivating recent interest in remyelination therapies. I will discuss our development of an agent-based model of the key disease dynamics for use in understanding the thresholds of immune stress beyond which oligodendrocytes stop myelinating and undergo apoptosis. Our implementation of remyelination therapies targeting oligodendrocyte reintroduction and preservation suggests the capacity to restore functionality to patients. This is an exciting result, given that current clinical interventions are limited to slowing the disease course in a preventative approach, and are only effective for select MS subtypes.

Optimisation of List Management in the Australian Football League using Deterministic Methods

Hamish Murray

Supervisors/Collaborators: A/Prof Paul Corry, Dr Elliot Carr, Prof Chris Drovandi

Queensland University of Technology

List management plays an important role in developing a successful sporting team. Choosing and investing in the right players and drafting well is the important off-field work that teams must succeed in before their team even reaches the field. This talk examines the list management decision making process applied to the Australian Football League (AFL) to determine optimal team construction given an initial list and customised team objectives over a long-term time horizon. The proposed tool can be used in scenario analysis and to assist decision makers in planning their team for the longer term.

Numerical analysis for American options under the two-asset jump-diffusion model

Hao Zhou

Supervisors/Collaborators: Duy-Minh Dang

University of Queensland

This paper introduces an efficient, easy-to-implement, and strictly monotone numerical integration method for valuing two-asset American options under the jump-diffusion model, which results in Variational Inequalities (VIs). Each timestep involves identifying the continuation value, which solves two-dimensional partial integro-differential equations (PIDEs) framed as two-dimensional convolution integrals. Using a known closed-form expression for the Fourier transform of the Green's functions associated with the PIDEs, we present an infinite series representation of the Green's function, with each term being strictly positive and computable. This allows the two-dimensional convolution integrals to be conveniently approximated by a monotone integration method, such as the composite quadrature rule, commonly available in popular programming languages. The proposed monotone numerical integration scheme is shown to be both ℓ_∞-stable and consistent in the viscosity sense, ensuring its convergence to the viscosity solution of the VIs. Numerical experiments indicate a strong agreement with benchmark solutions available in the literature, highlighting the robustness and effectiveness of our method.

Ordinary Differential Equation Modelling for the Tumour Microenvironment

Hasitha Weerasinghe

Supervisors/Collaborators: Pamela M Burrage

Queensland University of Technology

Cancer is a disease involving abnormal (tumour) cell growth. Continuum mathematical models can be used to study tumour behaviour under the effect of cellular stress at the tissue level. This research derives a system of ordinary differential equations (ODEs) to analyse tumour and healthy cell dynamics at the tissue level, considering eight reactions between two cell populations. To derive this system of ODEs, we consider cell division, cell death, mutation, competition and restricted growth of tumour and healthy cells. We apply simulated results of an agent-based model to estimate the parameters of the system using Picard parameter estimation method. Results of the study show the system has a stable coexistence equilibrium which represents a commensalism relation between healthy and tumour cells.

Fingering stabilization and adhesion force in the lifting flow with a fluid annulus

Irio M Coutinho

Supervisors/Collaborators:

Federal University Of Pernambuco

The lifting Hele-Shaw cell flow commonly involves the stretching of a viscous oil droplet surrounded by air, in the confined space between two parallel plates. As the upper plate is lifted, viscous fingering instabilities emerge at the air-oil interface. Such an interfacial instability phenomenon is widely observed in numerous technological and industrial applications, being quite difficult to control. Motivated by the recent interest in controlling and stabilizing the Saffman-Taylor instability in lifting Hele-Shaw flows, we propose an alternative way to restrain the development of interfacial disturbances in this gap-variable system. Our method modifies the traditional plate-lifting flow arrangement by introducing a finite fluid annulus layer encircling the central oil droplet, and separating it from the air. A second-order, perturbative mode-coupling approach is employed to analyze morphological and stability behaviors in this three-fluid, two-interface, doubly connected system. Our findings indicate that the intermediate fluid ring can significantly stabilize the interface of the central oil droplet. We show that the effectiveness of this stabilization protocol relies on the appropriate choice of the ring's viscosity and thickness. Furthermore, we calculate the adhesion force required to detach the plates, and find that it does not change significantly with the addition of the fluid envelope as long as it is sufficiently thin. Finally, we detect no distinction in the adhesion force computed for stable or unstable annular interfaces, indicating that the presence of fingering at the ring's boundaries has a negligible effect on the adhesion force.

A New Numerical Approach to Fractional Pharmacokinetics Model using Sibuya Distribution

Jenney-Yuhui Chen

Supervisors/Collaborators: Dr James Nichols

Queensland University of Technology

Fractional compartment models are widely used to simulate pharmacokinetics with power-law behavior. However, the conventional approach using Mittag-Leffler functions is computationally demanding. This study presents an efficient alternative using the Sibuya distribution, a discrete-time, non-Markov probability distribution, to effectively emulate Mittag-Leffler functions. We extend this method to interpret master equations in discrete time, providing a solution for fractional derivatives. Practicality is demonstrated by applying this novel approach to fractional pharmacokinetics data from various studies. Additionally, we propose a Gillespie-like stochastic numerical simulation technique for optimized computational resources.

Time Matters: Optimising Finance for Nature Investments

Jordan Holdorf

Supervisors/Collaborators: Melanie Roberts, Ivan Diaz-Rainey, Chris Brown

Griffith University

When integrating private investment into nature-based solutions, it is imperative to consider the sunk costs, potential returns from nature markets, and the inherent risks associated with climate variability. Focusing on mangrove restoration, this talk explores how to prioritise resilience in investment strategies. Climatic events like cyclones pose significant threats to project viability and returns. We have utilised Stochastic Dynamic Programming, to develop an optimised investment framework under climate uncertainty. Aiming to develop strategies that foster both environmental conservation and financial sustainability.

We explore the significance of prioritising resilience to climate events in investment decisions, with a specific focus on the potential trade-offs between pursuing numerous smaller-scale projects versus fewer larger-scale initiatives. This research highlights the critical role of climate risk in shaping successful investment outcomes in nature markets and emphasizes the impact of an optimised investment strategy.

Averaging for random metastable systems

Joshua Peters

Supervisors/Collaborators: Associate Professor Cecilia Gonzalez-Tokman

University of Queensland

Random metastability occurs when an externally forced or noisy system possesses more than one state of apparent equilibrium. This work investigates a class of random dynamical systems, arising from perturbing a one-dimensional piecewise smooth expanding map of the interval with two invariant subintervals, each supporting a unique ergodic absolutely continuous invariant measure. Upon perturbation, this invariance is destroyed, allowing trajectories to randomly switch between subintervals. We show that the invariant density of the randomly perturbed system may be approximated by an explicit convex combination of the two initially invariant densities, obtained by averaging. Further, we also identify the limit of the second Oseledets space, or coherent structure, as the perturbation shrinks to zero. Finally, our results are applied to random paired tent maps over ergodic, measure-preserving, and invertible driving systems.

Machine learning coarse grained simulation for aqueous NaCl

Junji Zhang

Supervisors/Collaborators: Tim Duignan

University of Queensland

Understanding molecular behaviour is critically important in accurately predicting the properties and chemical process involved in electrolyte solutions. Such predictions require simulations in large systems over extended long-time scales, where traditional coarse grained models are preferred approach. However, these models generally employ an implicit treatment of the solvent, which likely overlooks the critical interactions between the solvent and ions. Machine learning, as an advance technique, has been introduced to address the limitations of coarse grained models, particularly in enhancing the prediction of interactions within explicit solvents. In this study, we incorporate the E(3)-equivariant graph neutral networks (NequIP) into classical molecular dynamics (MD) simulations of aqueous NaCl to develop a force field for the solution at high concentrations. This force field was directly applied to coarse grained models to predict the structural properties for various aqueous NaCl solutions. Our findings demonstrate that the force field derived from NequIP, trained on a high-concentration system within a small box, can predict the dynamics properties of electrolyte solutions in large systems and over long timescales. The radial distribution functions predicted by the coarse-grained models align closely with the original training systems at comparable concentrations. Furthermore, the force field enables the direct calculation of interactions between two ions without many-body ion-ion effects. A novel observation from our study is the transient nucleation and subsequent crystallization process accuring at high solute concentration, which were not sustained over time. Hence, our application of machine learning to coarse grained simulations offers a promising methodology to efficiently and accurately determine the structural properties for aqueous solutions and compute the osmotic coefficients within environmental accuracy, based on these structural predictions.

The nuances of amphitheatre gully erosion: a three-state approach

Llewyn Randall

Supervisors/Collaborators: Dr Melanie Roberts and Dr Nathan Garland

Griffith University

Gully erosion is a significant contributor to the sediment discharged to the Great Barrier Reef. Recent developments have lead to the improved modelling of linear gullies using process-based techniques. However, the non-linear and geometrically-complex, amphitheatre counterparts require a different approach. I propose the use of a combined: hydrology, sediment transport and gully morphology model to track the the physical processes these larger, complex landforms.

Optimal sharing in social dilemmas

Maria Kleshnina

Collaborators: Manuel Staab, Valentin Huebner, Christian Hilbe, Krishnendu Chatterjee

Queensland University of Technology

Public goods games are frequently used to model strategic aspects of social dilemmas and to understand the evolution of cooperative behaviour among members of a group. While providing a baseline case, a (local) public goods model implies an equal sharing of returns. This appears an unsatisfying modelling choice in contexts where contributors are heterogeneous and returns can be divided freely. Furthermore, it is intrinsically linked to the negative effect of inequality on cooperation, which is observed both theoretically and experimentally. To better understand the link between inequality and cooperation when returns can be shared flexibly, we characterise sharing behaviour that maximises contributions in an infinitely repeated voluntary contribution game, where players differ in both their endowments as well as the productivities of their contributions. In sharp contrast to egalitarian sharing, we find that endowment inequality makes cooperation easier to sustain when returns can be shared unequally. Maybe surprisingly, this qualitative relation between endowment inequality and cooperation is independent of players' productivities. We derive a unique sharing rule as a function of productivities and endowments that is weakly superior to all other sharing rules. This rule generically departs from both equal as well as proportional sharing. If inequality is high, for example, individuals with the highest endowment need to be compensated more in absolute terms, but their relative share may be significantly less than their proportional contribution. Our analytical findings are qualitatively supported by numerical simulations of simple evolutionary learning dynamics.

Impact of Resistance on Therapeutic Design: a Moran Model of Cancer Growth

Mason Lacy

Supervisors/Collaborators: Adrianne Jenner

Queensland University of Technology

Resistance of cancers to treatments, such as chemotherapy, largely arise due to cell mutations. These mutations allow cells to resist apoptosis and inevitably lead to recurrence and often progression to more aggressive cancer forms. Sustained-low dose therapies are being considered as an alternative to maximum tolerated dose treatments, whereby a smaller drug dosage is given over a longer period of time. However, understanding the impact that the presence of treatment-resistant clones may have on these new treatment modalities is crucial to validating them as a therapeutic avenue. In this study, a Moran process is used to capture stochastic mutations arising in cancer cells, inferring treatment resistance. The model is used to predict the probability of cancer recurrence given varying treatment modalities. The simulations predict that sustained-low dose therapies would be virtually ineffective for a cancer with a non-negligible probability of developing a sub-clone with resistance tendencies. Furthermore, calibrating the model to in vivo measurements for breast cancer treatment with Herceptin, the model suggests that standard treatment regimens are ineffective in this mouse model. Using a simple Moran model, it is possible to explore the likelihood of treatment success given a non-negligible probability of treatment resistant mutations and suggest more robust therapeutic schedules.

Wet Wood Woes

Patrick Grant

Supervisors/Collaborators: Prof Ian Turner (QUT), Dr. Steven Psaltis (QUT), Dr. Maryam Shirmohammadi (QDAF)

Queensland University of Technology

This talk is designed to take you on a journey through the complex modelling considerations required to model one of the most common construction materials used in Australia, wood. Specifically, modelling moisture migration and swelling in engineered wood products. We will start with a brief introduction of the well-established TransPore model and the form we will be using throughout the project. Next, we begin our modelling journey for a single timber board with a homogenous framework and why that's a bad idea. Then, we gradually improve upon the model until we arrive at a heterogenous transverse isotropic model that accurately describes the flow through timber boards. Next, a two-layered cross laminated timber panel section is considered which now makes the problem fully anisotropic with dense material property tensors. The model will be solved using the Jacobian free exponential Euler method whilst taking full advantage of Krylov subspace methods for approximating matrix-vector products.

Consistent information criteria for regularized regression and loss-based learning problems

Qingyuan Zhang

Supervisors/Collaborators: Dr. Hien Duy Nguyen

University of Queensland

Many problems in statistics and machine learning can be formulated as model selection problems, where the goal is to choose an optimal parsimonious model among a set of candidate models. It is typical to conduct model selection by penalizing the objective function via information criteria (IC), as with the pioneering work by Akaike and Schwarz. Via recent work, we propose a generalized IC framework to consistently estimate general loss-based learning problems. In this work, we propose a consistent estimation method for Generalized Linear Model (GLM) regressions by utilizing the recent IC developments. We advance the generalized IC framework by proposing model selection problems, where the model set consists of a potentially uncountable set of models. In addition to theoretical expositions, our proposal introduces a computational procedure for the implementation of our methods in the finite sample setting, which we demonstrate via a simulation study.

Measure theoretic entropy for Blaschke products

Renee Oldfield

Supervisors/Collaborators: Associate Professor Cecilia González-Tokman

University of Queensland

Measure theoretic entropy, a measure-theoretic invariant of a dynamical system, measures the rate of increase in dynamical complexity over time. We consider the measure theoretic entropy

of Blaschke products, inner functions formed by taking products of Möbius transforms. A Blaschke product can be divided into one of three mutually exclusive classes according to the nature of its fixed points. The measure theoretic entropy of a Blaschke product acting on the complex unit circle can be explicitly described by its derivative and nature of its fixed points. We present current developments extending such results to a class of random Blaschke product cocycles.

Physics Informed Neural Network for Free Boundary Problems in Science and Engineering

Sanchita Malla

Supervisors/Collaborators: Dr. Dietmar Oelz (UQ), Dr. Sitikantha Roy (IITD)

University of Queensland

In the study of moving free boundary problems, determining the moving boundary's position, evolution and its interplay with system variables is essential. The evolution of this moving interface is unknown beforehand, significantly affecting the problem's physics under consideration. Addressing these moving boundary problems is challenging due to multiple de-formed boundaries, broken surfaces, varied length and time scales, and nonlinear dynamics associated with them. Traditional methods, like moving grid and fixed grid approaches (e.g., level set, finite element, and finite volume methods), are commonly used to solve them but have limitations. Recent advances in deep learning and mathematics have led to new methods and improvements in existing algorithms for these complex problems. Physics-Informed Neural Networks (PINNs) represent a significant advancement, offering a mesh-free method to solve partial differential equations(PDEs) by converting the problem into an optimization problem of the cost function defined based on governing equations. PINNs provide several advantages over traditional methods, such as simplifying grid generation, handling high-dimensional problems, incorporating noisy data, and addressing inverse problems. Our developed PINN effectively solves various one-dimensional moving boundary problems, demonstrating its potential as a robust simulation platform for deformable domain free boundary problems in science and technology. PINNs promise greater ease and feasibility in contexts where application of traditional methods to handle complex moving boundary dynamics efficiently is challenging.

Physics Informed Neural Network for Free Boundary Problems in Science and Engineering

Sarika Karanth

Supervisors/Collaborators: Prof. Michael Bode and Dr. Matthew Adams

Queensland University of Technology

The choice of definition of an ecosystem has huge consequences for our environment. A definitionn of an ecosystem implies the definition of its collapse, which indicates which ecosystems need to be prioritized in terms of conservation efforts. Here, we aim to classify Macquarie Island's vegetation into ecosystems and analyze the impact of mathematical choices on the collapse of these ecosystems.

Predicting animal movement with a deep learning step selection framework

Scott Forrest

Supervisors/Collaborators: Dan Pagendam (CSIRO), Conor Hassan (QUT), Michael Bode (QUT), Chris Drovandi (QUT), Andrew Hoskins (CSIRO)

Queensland University of Technology

Predicting animal movement is difficult due to the fine-scale and complex decisions made by animals as they move. A common approach to infer the relationships between animals and their external environment is a step selection analysis (SSA). SSA approaches have recently been used to generate animal trajectories for prediction, although the SSA model fitting framework is limited in several ways, namely that regression is performed on point locations that ignore the structure and composition of habitat features, and it is prohibitively difficult to fit and interpret models that include interacting components such as multi-scale temporal dynamics. Fortunately, the goal of SSA model fitting is simply to determine the next step probability given the surrounding environment, and deep learning is aptly suited to this task.

This study will train and compare between neural network architectures that receive scalar values and multiple habitat layers as inputs, and output a single layer representing the next-step probability. This is equivalent to SSA model fitting, but benefits offered by deep learning include the ability to learn features that are present in the habitat covariate layers, such as linear features (rivers, forest edges), and the composition or size of certain habitat areas. It can also represent the complex and seemingly abstract interactions between habitat covariates, time of day or year, and memory and social dynamic processes. Additionally, there is promising potential for integrating non-spatial data sources such as accelerometers and physiological sensors. We expect that the deep learning approach will lead to generating more accurate animal movement trajectories.

Our research is motivated by the need to accurately predict invasive water buffalo and cattle locations in Northern Australia, both of which cause significant environmental damage and represent economic opportunities for traditional landowners. The data collection consists of 916 GPS devices that have recently been deployed by CSIRO.

Local temperature measurement in dynamical systems with rigid constraints

Stephen Sanderson

Supervisors/Collaborators: Shern R. Tee; Debra J. Searles

University of Queensland

Temperature measurements in particle simulations must account for the reduction in degrees of freedom (DoF) due to constraints. However, when local temperature is measured, e.g. from a set of particles in a subvolume or from velocities projected onto one Cartesian direction, the result can appear to unphysically violate equipartition if the local DoF are not correctly calculated. This work introduces a self-consistent method to calculate the DoF for an arbitrary local kinetic temperature measurement.

A new perspective for scientific modelling: Sparse reconstruction based approach for learning time-space fractional differential equations

Yash Vats

Supervisors/Collaborators: Prof. Dietmar Oelz and Prof. Mani Mehra

University of Queensland

This paper studies a sparse reconstruction based approach to learn time-space fractional differential equations, i.e. to identify parameter values and particularly the order of the fractional derivatives. The approach uses a generalized Taylor series expansion to generate, in every iteration, a feature matrix which is used to learn the fractional orders of both, temporal and spatial derivatives by minimizing the LASSO operator using Differential Evolution algorithm. To verify the robustness of the method, numerical results for time-space fractional diffusion equation, wave equation, and Burgers' equation at different noise levels in the data are presented. Finally, the methodology is applied to a realistic example where underlying fractional differential equation associated to published experimental data obtained from an in-vitro cell culture assay is learned.

Bayesian spatial relative survival model to estimate the loss in life expectancy for cancer patients in Queensland

Yuxin Huang

Supervisors/Collaborators: Helen Thompson

Queensland University of Technology

To date, there have not been any population-based cancer studies quantifying geographical patterns of the loss in life expectancy (LLE) of people diagnosis with cancer. This absolute measurement of survival provides a fuller understanding of geographical disparities in survival outcomes for cancer patients. We propose using a spatial flexible parametric relative survival model in the Bayesian framework, which allows for the inclusion of spatial effects in hazard-level model components. This approach does not require information on the cause of death and allows complex and robust small-area estimation. The model was applied to breast, prostate, colorectal, and lung cancer data from the Queensland Cancer Registry across 528 geographical areas. The associated computer program scripts are available to support the understanding and implementation of our methodology to other spatial cancer modelling applications.

GridapTopOpt.jl: A scalable Julia toolbox for level set-based topology optimisation

Zachary J Wegert

Supervisors/Collaborators: Vivien J Challis, Jordi Manyer, Connor Mallon, Santiago Badia

Queensland University of Technology

Topology optimisation is a class of PDE-constrained optimisation that seeks to minimise functionals that depend on the underlying domain and the solutions to weakly-posed PDEs. Owing to a rich theoretical foundation and wide array of ever-evolving industrial applications, topology optimisation has become an increasingly popular topic in both industry and academia. As a result, there is a need for general, extendable, and scalable high performance open-source algorithms that handle general optimisation problems with complicated underlying PDEs.

In this talk we will discuss on-going research and development of high-performance Julia-based level-set algorithms that are readily distributed across a HPC cluster via MPI. We use automatic differentiation to enable handling of complex problems without the need to calculate shape derivatives. We demonstrate the generality of the API and underlying algorithms by formulating and solving several optimisation problems of increasing complexity.

List of Participants

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Code of Conduct

QANZIAM is dedicated to providing a harassment-free conference experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion (or lack thereof), or technology choices. Conference participants are to abide by the ANZIAM Conference Code of Conduct, which is as follows:

Harassment in any form will not be tolerated. This includes, but is not limited to, speech or behaviour (whether in person, in presentations, or in online discussions) that intimidates, creates discomfort, prevents or interferes with a person's participation or opportunity for participation in ANZIAM's vision and mission. We aim for ANZIAM to be an organisation where harassment in any form does not happen, including but not limited to harassment based on race, gender, religion, age, colour, national or ethnic origin, ancestry, disability, parental status, caring responsibilities, marital status, sexual orientation, or gender identity. Harassment includes but is not limited to verbal comments that reinforce social structures of domination; sexual images in public spaces; deliberate intimidation, stalking, or following; unwelcome photography or recording; sustained disruption of talks or other events; inappropriate physical contact; unwelcome sexual attention; and advocating for or encouraging any of the above behaviour.

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.

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