Welcome!

Welcome to the 7th annual School Postgraduate Conference!

2020 has of course been a very unusual year for all of us. Undertaking the apprenticeship that a research degree entails is very challenging while everyone is exiled from the campus, their fellow students, and the academic staff. I know that some of you have found it a great opportunity (à la Newton during the Great Plague of the 1660s) to settle down quietly and work away at some hard problems, but I also know that it has been a hard time for some of you.

As we cannot come together for this year’s conference, we have had to join the trend of having an on-line meeting. I am aware that not all of our students have wonderful internet connections. And indeed they are not all currently in Sydney.

Rather than having live presentations, I decided to set all the students the task of making a video of their talk. This is a slightly different challenge to giving a live talk. On the one hand you have to opportunity to edit out any blunders and perhaps use some different visualizations. But one also has to deal with the rather strange experience of talking to yourself. Anyway, I am impressed at the way that the students have dived in and met the challenge and I am sure that you will all find much to enjoy during the day.

Enjoy the conference!

Thanks

The conference is an opportunity not just for our students to present their research, but also to get some experience at the important professional skills of running such a meeting. Many of the usual jobs, such as getting all the participants fed and supplied with coffee, disappeared this year.

Instead there was a lot more checking on how we might run things in the time of COVID-19. I’d like to thank Haya Aldosari, Kris Wu and Kevin Limanta who stepped up and gave me great help in getting this all working. And as usual, Susannah Waters, provided a good deal of help with promotion and wise advice.

Finally, thanks to my colleagues, Alina Ostafe, Feng Chan, Zdravko Botev, Chris Angstmann, Anna Cai and Denis Potapov who serve on the Postgraduate Review Committees. They will have a busy few days this week, providing guidance and advice to students throughout their studies, and importantly, helping us choose the prize winning talks:

Ian Doust
Director of Postgraduate Studies (Research)
School of Mathematics and Statistics, UNSW
Our postgraduate research students and their recent achievements

The conference is a chance to celebrate the achievements of our postgraduate students. It is particularly nice to acknowledge those students who have successfully completed their degrees in the last 12 months, and those who have managed to get their work published. As you can see from the lists below, their research covers an incredibly broad range of topics.

Recent completions:

- Timothy Siu PhD, “Order, randomness and orbit distributions for dynamics of birational maps over finite fields”, (supervisor Professor John Roberts)
- Adam Mammoliti PhD, “On matching sequenceability, the Erdős-Ko-Rado Theorem and other unrelated stuff”, (supervisor Dr Thomas Britz)
- Wai Hong Tan PhD, “Predicting the popularity of tweets using the theory of point processes”, (supervisor Dr Feng Chen)
- Dominic Vella PhD, “The Dixmier trace and zeta residue: a double operator integral approach”, (supervisor: Professor Fedor Sukochev)
- Ed McDonald PhD, “Double Operator Integration with applications to quantised calculus”, (supervisor: Professor Fedor Sukochev)
- Thomas Stindl PhD, “Statistical inference for renewal Hawkes self-exciting point processes”, (supervisor: Dr Feng Chen)
- Carlos Vieira Rocha PhD, “Biogeochemical modelling of the East Australian Current system”, (supervisors: Professor Moninya Roughan and Dr Paulina Cetina Heredia)
- Eve Slavich PhD, Sources of uncertainty in ecological modelling: modelling species and multiple species distributions (supervisor: Professor David Warton)
- Manzoor Khan PhD, “Quantification and estimation of regression to the mean for bivariate distributions”, (supervisor: Professor Jake Olivier)
- Sin Keong Tong MSc, Generalised inversion frequency distribution (supervisor: Dr Thomas Britz)
- Thomas Whitaker PhD, “Innovative methods for the analysis of complex and non-standard data”, (Professor Scott Sissons)
- Nina Ribbat PhD, “High resolution circulation of the Hawkesbury Shelf Region, SE Australia: mean, variability and transport pathways”, (supervisor: Professor Moninya Roughan)
- Simon Macourt PhD, “Exponential sums and additive combinatorics”, (supervisor Professor Igor Shparlinski)
- Fadi Antown PhD, “Linear response theory and dynamical systems”, (supervisor Professor Gary Froyland)
- Kam Hung Yau PhD, “Distribution of integers with prescribed arithmetic structure and applications”, (supervisor Professor Igor Shparlinski)
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Abstracts

The Trotter-Kato product formula in symmetric quasi-Banach ideals

Meiram Akhymbek

Let $A$ and $B$ be non-negative self-adjoint operators on a separable Hilbert space, then one can define their well-defined form sum $C = A \uparrow B$ on the subspace $H_0 = \text{dom}(A^{1/2}) \cap \text{dom}(B^{1/2})$. In 1978, Kato proved the following formula:

$$\lim_{n \to \infty} \left( e^{-tA/n} e^{-tB/n} \right)^n = e^{-tC} P_0,$$

where limit is in sense of strong operator topology and $P_0$ is an orthogonal projection onto $H_0$. The latter is known as Trotter-Kato product formula.

In this talk, I will briefly outline the history of this formula, existing results in different topologies and further extensions to the case of symmetric quasi-Banach ideals.

Supervisor/s: Prof. Fedor Sukochev, Dr. Galina Levitina & Dr. Dmitriy Zanin.

About the speaker: I completed my BSc and MSc at Kazakh National University of Almaty, Kazakhstan. Currently I am finishing my second year of PhD at UNSW.
Sharper existence and uniqueness results for solutions to third-order boundary value problems

Saleh Almuthaybiri

The purpose of this note is to sharpen Smirnov’s recent work on existence and uniqueness of solutions to third-order ordinary differential equations that are subjected to two- and three-point boundary conditions. The advancement is achieved in the following ways. Firstly, we provide sharp and sharpened estimates for integrals regarding various Green’s functions. Secondly, we apply these sharper estimates to problems in conjunction with Banach’s fixed point theorem. Thirdly, we apply Rus’s contraction mapping theorem in a metric space, where two metrics are employed. Our new results improve those of Smirnov by showing that a larger class of boundary value problems admit a unique solution.

Supervisor/s: Prof. Chris Tisdell.

About the speaker: Saleh completed his Bachelor degree in mathematics in 2012, from the College of Science at Al Jouf University, Saudi Arabia. In 2017, he completed his Master of Science degree in applied mathematics at University of Dayton, U.S.A. He is now in the 3rd year of his PhD degree. Currently I am at the stage of writing my thesis, and once I pursue my degree at UNSW, I will be returning to my university (Qassim University, Saudi Arabia) where It is my hope to use my educational experiences at UNSW to benefit not only myself and the mathematical field, but also Qassim University and the people of Saudi Arabia.
The oceanic branch of the water cycle: diahaline and meridional contributions to ocean salt and freshwater transport

Chris Bladwell

Previous approaches to quantify the relationship between the atmospheric and oceanic branches of the water cycle have focused on diahaline and meridional processes in isolation. Here we introduce a precise budget for ocean salt transport in latitude-salinity coordinates which relates meridional and diahaline processes to surface freshwater forcing. We demonstrate that the salinity distribution is maintained by the circulation of saline water from the evaporation dominated mid-latitudes to the adjacent precipitation dominated regions, and the downgradient transfer for salt from high-salinity to low-salinity water within these fresher regions of the ocean. We establish a relationship between the ocean salt and freshwater budgets, which allows either tracer to be used to study changes to ocean salinity. Applying this framework to a 1° global ocean model, we are able to quantify the regional contribution to ocean salinity made by parameterised mixing processes and numerical diffusion associated with truncation errors in the model’s advection scheme. We find that boundary layer mixing is largest in the tropics, transferring $3.5 \times 10^7$ kg sec$^{-1}$ of salt across the global mean salinity of 34.4$S_A$, which is equivalent to 1$Sv$ of freshwater transport from low salinity to high salinity water. We analyse the internal freshwater budgets of the Indo-Pacific and Atlantic Ocean basins and identify the transport pathways between them which redistribute freshwater added through precipitation, balancing asymmetries in freshwater forcing between the basins. We also introduce a new weighted time-averaging method for tracer budgets. This method minimises the effect of transient features such as eddies and avoids cancellation between processes which occur with standard time-averaging methods. We discuss how this the weighted time-averaged budget can be used to study the response of oceanic processes to water cycle change.

 Supervisor/s: Dr. Jan Zika.

 About the speaker: I am a PhD candidate from Sydney. I like rock climbing and cycling, and am looking forward to travelling again after the pandemic.
Accurate prediction of the onset and strength of breaking surface gravity waves is a long-standing problem of significant theoretical and applied interest. Recently, one author examined the energetics of focusing wave groups in deep and intermediate depth water and found that breaking and non-breaking regimes were clearly separated by the normalised energy flux, $B$, near the crest tip. Furthermore, the transition of $B$ through a generic breaking threshold value $B_{th} \approx 0.85$ was found to precede visible breaking onset by up to one fifth of a wave period. This remarkable generic threshold for breaking inception has since been validated numerically for 2D and 3D domains and for shallow and shoaling water waves; however, there is presently no theoretical explanation for its efficacy as a predictor for breaking. This study investigates the correspondence between the parameter $B$ and the crest energy growth rate following the evolving crest for breaking and non-breaking waves in a numerical wave tank using a range of wave packet configurations. Our results indicate that the time rate of change of the $B$ is strongly correlated with the energy density convergence rate at the evolving wave crest. These findings further advance present understanding of the elusive process of wave breaking.

*Supervisor/s:* Dr. Shane Keating.

*About the speaker:* Studying part-time.
Constructing group divisible designs of block size 4 on at most 30 points

Yudhistira Andersen Bunjamin

A $k$-GDD, or group divisible design with block size $k$, is a triple $(X, \mathcal{G}, \mathcal{B})$ where $X$ is a set of points, $\mathcal{G}$ is a partition of $X$ into subsets (called groups) and $\mathcal{B}$ is a collection of $k$-element subsets of $X$ (called blocks) such that any two points from distinct groups appear together in exactly one block and no two distinct points from any group appear together in any block. The group type (or type) of a $k$-GDD is the multiset $\{|G| : G \in \mathcal{G}\}$ which denotes the group sizes.

There are a number of known necessary conditions for the existence of a GDD with a particular group type which come from simple counting arguments. However, these conditions are not sufficient. A group type for a $k$-GDD is said to be feasible if it satisfies all of the currently known necessary conditions for its existence.

Although 3-GDDs are relatively well-studied, extremely little is known about 4-GDDs. The existence of all except three feasible types of 4-GDDs on at most 30 points was determined by Kreher and Stinson in 1997. This talk will introduce the two most common techniques for constructing GDDs and discuss how 4-GDDs for two of the three remaining types were found using a different method.

Joint work with R. Julian R. Abel and Diana Combe.

Supervisor/s: Prof. Catherine Greenhill & Dr. Diana Combe.

About the speaker: I grew up in Jakarta, Indonesia before coming to UNSW Sydney for my undergraduate studies, completing a Bachelor of Science (Adv. Math.) majoring in Statistics in 2017. Prior to starting my PhD candidature in 2019 Term 3, I worked as a STEM Learning Designer in industry.
The reject regenerate MCMC sampler via exponentially tilted sequential proposal

Yi-Lung Chen

Some seemingly intractable Bayesian posterior densities such as the Bayesian Lasso, Bayesian Tobit and the Bayesian smoothing spline actually exhibit perfect sampling schemes that remain efficient even for problems with hundreds of dimensions. The idea is to construct exponentially tilted sequential proposal densities and employ rejection schemes. However, these rejection schemes are bound to fail as the dimensions of the problems grow. In such cases, one ultimately has to resort to approximate Markov chain Monte Carlo (MCMC) schemes.

On the other hand, the error in MCMC schemes can be notoriously difficult to quantify. Nevertheless, quantifying the errors in a Markov chain can be a lot easier if we can identify the regeneration times for the Markov chain.

In this talk we revisit the notion of exponentially tilted sequential proposal densities. We then consider it as a proposal density for an independent Markov chain sampler. From there, we shall introduce the the reject regenerate sampler, in which the simulated Markov chain is regenerative. Moreover, in the event of a regeneration, the Markov chain has some probability of achieving a perfect draw.

Supervisor/s: Dr. Zdravko Botev & Prof. Josef Dick.

About the speaker: -
On the Ramsey numbers for the tree graphs versus wheel graph

Zhi Yee Chng

Let $G$ and $H$ be two simple graphs, the Ramsey number, $R(G, H)$ is the smallest integer $n$, such that for any graph of order $n$, either it contains $G$ or its complement contains $H$. Let $T_n$ be a tree graph of order $n$ and let $W_m$ be the wheel graph $K_1 + C_m$, which is, the graph of order $m + 1$ obtained by connecting a single universal vertex to all vertices of a cycle $C_m$. In this talk, we will focus on the Ramsey numbers for the tree graphs with $\Delta(T_n) \geq n - 4$ versus the wheel graph $W_8$.

Supervisor/s: Dr. Thomas Britz.

About the speaker: Currently in my first year of PhD studies at UNSW, under the supervision of Dr. Thomas Britz. I had completed my master studies in 2018, also at UNSW.
Ocean flows are dominated by coherent structures, like eddies, with lifetimes longer than typical dynamical timescales. These features are embedded within and transported by the surrounding fluid flow, and are frequently referred to as Lagrangian Coherent Structures (LCSs). Due to their capacity to transport water and material over large distances, LCSs play an important role in climate, biogeochemistry, and small-scale mixing. A range of powerful techniques have been adopted from the dynamical systems theory literature to identify coherent features in fluid flows. The most widely used of these methods require Eulerian observations of ocean currents, that is, on a fixed grid. However, due to the paucity of available observations of oceanic velocity fields with sufficient spatio-temporal resolution, it is often difficult to identify and track LCSs in the real ocean. Typically real ocean data come from Lagrangian observations, such as those from drifters, gliders, and ARGO floats. Therefore, an outstanding challenge in Mathematical Oceanography is the development and validation of new methods for identifying LCSs in real ocean data.

One recent method uses the transfer (or dynamic Laplace) operator to identify regions of phase space that form finite-time coherent sets. Finite-time coherent sets are sets or regions of fluid flow that for a finite period of time minimally mix with the remainder of the flow. In this talk I will provide an overview of Finite-Time Coherent Sets and the dynamic Laplacian approach using finite element methods to compute them, and discuss problems faced when implementing this method in real world applications. I will provide an application on eddies, specifically Agulhas rings, where we try to understand how they form, travel, and ultimately decay.

Supervisor/s: Dr. Shane Keating & Prof. Gary Froyland.

About the speaker: I completed my undergraduate degree at the University of Sydney in 2016 in applied mathematics and computer science, with an honours thesis in mathematical finance. I've spent a couple of years working in a data and predictive analytics team in industry, before beginning my PhD in mid 2018. After a 10 year hiatus, I've started to play ice hockey again, and I'm dealing with the pandemic by walking my dog even more often!
Fast approximations for fitting log-Gaussian Cox Processes to presence-only data

Elliot Dovers

Presence-only data are a potential source of important information about species’ distributions, although difficult to model because of uncontrolled sources of variation and biased sampling due to opportunistic collection. Log-Gaussian Cox processes (LGCP) offer a framework to handle such records. The latent Gaussian random field has the capacity to deal with unmodelled sources of clustering, and account for correlation across different species (in a multi-species model) or across different data sources (when combining data across species). Such a hierarchical structure lends itself to inference via Monte Carlo sampling methods where lengthy computation times abound. We have developed a fast approximation method that considers the LGCP as a type of extension of generalised linear mixed models (GLMM). Three aspects comprise our novel approach. First, Laplace or variational approximations permit a closed-form solution to the marginalised log-likelihood. Second, a rank reduced approximation to the large, spatial variance-covariance matrices enables computation where these would be otherwise restrictive. Finally, automatic differentiation is used to quickly obtain gradient information for efficient optimisation and inference. This talk will further describe the methodology, illustrated and assessed via application to both simulated and real data.

Supervisor/s: Prof. David Warton & Dr. Gordana Popovic.

About the speaker: Trying to complete my studies.
Stochastic Landau-Lifshitz equation on real line

Farah El Rafei

In this talk, I present my research on the Stochastic Landau-Lifshitz equation. First, I introduce how the equation is derived. Then I present a proof of existence and uniqueness of solution to this equation on the whole real line. In fact, I use a semi discrete finite difference method to find approximate solutions and to prove that the approximate solutions converge and that the limit is the solution. Then, I present a fully discrete finite difference method to solve the equation on the whole real line. Partial results have been done to prove convergence of approximate solutions. Finally, I show a numerical experiment which validates the numerical method.

Supervisor/s: Prof. Thanh Tran & Prof. Beniamin Goldys.

About the speaker: I completed my Master’s studies back in my home country Lebanon. I got married and came to Australia 5 years ago. I am a mother of a 2 years old boy which could be challenging at times especially with the current pandemic. With both my husband and I currently working from home, we’re sharing the burden of these stressful times and providing much needed support to one another.
Depth structure and drivers of Marine Heatwaves in the Tasman Sea

Youstina Elzahaby

Marine heatwaves (MHWs) have the potential for extreme impacts (from mass mortality of marine organisms to irreversible redistribution of species within the ecosystem) and they pose a growing threat as they become more intense and frequent.

To date MHWs have mostly been analysed as surface events despite evidence that they can extend well below the mixed layer. Our aim is to understand the subsurface ocean dynamics preceding the onset and decay of MHW events. We focus on the Tasman Sea, as it is a known global warming hot-spot, and identify 4 sub-regions along the south east coast of Australia and the west coast of New Zealand. We use a mixed layer heat budget analysis to diagnose subsurface factors contributing warming to the temperature balance and identify the drivers and depth extent of anomalous warming in the temporal evolution of MHWs in the regions.

*Supervisor/s:* Dr. Amandine Schaeffer & Prof. Moninya Roughan.

*About the speaker:* I completed my master’s research project on marine heatwaves (also at UNSW) and learning about the topic only served to pique my interest which is what leads me here today.
Modelling the elimination of cervical cancer in a country with active HIV control

Michaela Hall

WHO have set draft targets for cervical cancer elimination involving scale-up of HPV vaccination (90% coverage in females), twice-lifetime HPV screening (70% participation) and treatment of precancer/cancer (90% coverage) by 2030. Cervical cancer is more difficult to control in countries with a high prevalence of HIV, such as Tanzania (HIV prevalence 5.5%; cervical cancer incidence 59.1 cases/100,000), as HIV-positive women are at elevated risk of HPV infection, persistence and progression. Previous analysis, not explicitly accounting for HIV, predicts that adopting WHO recommendations will reduce age-standardised cervical cancer incidence rates in Tanzania to 8.4 cases/100,000 women in 2099. The aim of this analysis was to estimate outcomes via explicit modelling of HIV and HPV, using Tanzania as an example.

A dynamic model of HIV and HPV was used to simulate the impact of meeting the WHO targets for vaccination, screening and precancer treatment, in the context of sustained HIV control measures (80% male circumcision prevalence; 47% viral suppression due to anti-retroviral treatment in people with HIV) in Tanzania, from 2020-2120.

Without scaled-up HPV vaccination or HPV testing, cervical cancer incidence rates are predicted to decrease by 37% over 100 years (58.1/100,000 in 2020, 36.3/100,000 in 2120) due to existing HIV control measures. Compared to 2020 rates, scaled-up HPV9 vaccination is predicted to decrease cervical cancer incidence rates by 82% by 2120 (10.7/100,000); twice-lifetime HPV testing at 35 and 45 years will increase the relative reduction to 86% (8.3/100,000).

Scaling-up vaccination and HPV testing to meet WHO targets will substantially reduce cervical cancer incidence in Tanzania over 100 years. The findings from this analysis accord with predictions from prior analysis not explicitly accounting for HIV. Countries with high HIV and HPV prevalence, particularly types not included in the vaccine, may require more frequent screening to eliminate cervical cancer.

Supervisor/s: Prof. John Murray.

About the speaker: My favorite thing to do on a Friday night is watch Harry Potter with a glass of wine.
Apollonian Circles in Triangles

Joshua Ho

Although Apollonian circles in triangles have been studied for more than 2000 years, when we cast the topic in the setting of chromogeometry, interesting results start to surface. Adopting Rational Trigonometry allows us to better understand the interaction between geometry and the underlying number field. The combination of algebra, dynamic mathematics software and computation also provide an interesting approach for investigation.

**Supervisor/s:** Prof. Norman Wildberger.

**About the speaker:** I’m in my second year of PhD studying chromogeometry in general and finite fields. I did my undergraduate studies here at UNSW and spent a few years working in the IT industry. Coming back to university after 20+ years has been both challenging and exciting.
Bayesian sparse learning with exponential power prior

Xiongwen Ke

We propose a simple and exact Laplace mixture decomposition for the Bayesian $L_{\frac{1}{\alpha}}$ prior in regression and classification problem. The decomposition also appeals to a more border class, the global-local scale mixtures of Gaussian distribution. Two computation strategies are developed for Bayesian $L_{\frac{1}{\alpha}}$ estimator. One is partially collapsed Gibbs sampling scheme, which outperforms other known MCMC strategies for Bayesian bridge regression, both in ease of coding and in computational efficiency. The other we call it variational LLA algorithm, which approximates the posterior of Bayesian sparse regression as Bayesian adaptive Lasso. In this case, finding the sparse solution is equivalent to finding the mode of the approximate posterior. We further extend our approach to sparse generalized additive models by introducing the spike-and-slab group $L_{\frac{1}{2}}$ prior. The posterior concentration rates with be derived for both linear regression and sparse GAM. Finally, we illustrate our methodology by simulated data and real data.

Supervisor/s: A/Prof. Yanan Fan & Prof. Josef Dick.

About the speaker: I am a year 2 PhD student in statistics. My study area is Bayesian sparse learning.
Evaluating bias in student evaluations using natural language processing techniques

Fiona Kim

This research aims to understand the prevalence of gender bias in student evaluations of teaching (SET), using natural language processing techniques, to identify drivers behind the discrepancies amongst lecturer ratings. This study utilises longitudinal data across several years of SET data at a leading Australian University. To the best of our knowledge, previous studies exploring gender bias in the higher education setting have not incorporated student comments into the models, though the richness of this qualitative data can prove to provide compelling insights in this area. This study aims to fill that gap by conducting Aspect-Based Sentiment Analysis (ABSA) on students' comments and using the results as features in a cumulative logit-link model to predict the ordinal SET scores students assign their lecturers. The results indicate there to be an unexplained negative difference in ratings when the lecturer is female and the students are discussing aspects of Staff Quality in the Science Faculty. The sentiments derived were also modelled as the response using a linear mixed-effects model to further understand drivers of these sentiments. The implications of this study suggest there to be a possible bias against female staff members when attributes discussed directly relate to the individual. This adds more doubt into the practicality of the SET surveys to assess teaching performance and the need to address the framing behind the questions to ensure the focus is on the teaching and not influenced by unconscious bias.

Supervisor/s: A/Prof. Yanan Fan & Prof. Emma Johnston.

About the speaker: Prior to commencing her PhD, Fiona Kim spent years working as an Analytics and AI Consultant with Deloitte Consulting. She graduated with First Class Honours in Economics from UWA.
A Markov chain method for weighting climate model ensembles

Max Kulinich

Climate change is typically modelled using sophisticated mathematical models (Climate Models) of physical processes taking place over long periods of time. Multi-model ensembles of climate models show better correlation with the observations than any of the models separately. Currently, an open research question is how climate models can be combined to create an ensemble in an optimal way. We present a novel approach based on Markov chains to estimate model weights in order to obtain ensemble means. The method was compared to existing alternatives by measuring its performance on training and validation data. The Markov chain method showed improved performance over those methods when measured by the root mean squared error and the R-squared metrics. The results of this comparative analysis should serve to motivate further studies in Markov chain and other nonlinear methods application, that address the issues of finding optimal model weight for constructing ensemble means.

Supervisor/s: A/Prof. Yanan Fan, Prof. Spiridon Penev & Prof. Jason P. Evans.

About the speaker: I obtained my masters at Gothenburg University (Sweden) and worked as a Data Scientist at AB Volvo for 12 years before joining UNSW. After finishing my PhD I would like to work with applied mathematics/statistics. Loving Coogee beach and have a tradition of going there for sunrises. Not too troubled by pandemic as it means more time of the day next to my fiancee. Big fan of travels and meeting new cultures, but not much happened on this front since January 2020.
The Hawkes process is a class of Self-Exciting Point Processes (SEPP) that is commonly used to describe sequences of events at random times that display a temporal clustering behaviour. By allowing the background intensity of the Hawkes process to vary, it presents a much more flexible class of Hawkes processes. Our focus on this work is to explore asymptotic theory for maximum likelihood estimation based statistical inference through a sequence of parametric SEPP models with time-varying background intensities with an exponential kernel. Ogata (1978) established consistency and asymptotic normality of Maximum Likelihood Estimators (MLE) under stationarity and ergodicity. Due to the time-varying background intensity component, the models that we consider are generally non-stationary, therefore the typical scenario is not appropriate in this setting. Through dividing the process into $\sqrt{n}$ blocks and approximate each block using a SEPP with a constant baseline intensity, we are able to derive consistency and prove the asymptotic normality of the MLE. We also derived the asymptotic distribution of the score test statistic under the null hypothesis that the baseline intensity is constant. Furthermore, we invested what happens to the distribution of the score test statistic when the null hypothesis fails through the local power approach.

*Supervisor/s:* Dr. Feng Chen & Prof. William Dunsmuir.

*About the speaker:* Second year PhD with Feng and William, currently looking into parametric inference for a SEPP with time-varying background intensity. Enjoys the occasional suffer fest that is falling off cliff faces while rock climbing.
In this project, we introduce a new method to form the neutral surface, which aims to minimize the diapycnal advection through continuous density surfaces. Neutral surfaces are essential for describing the isopycnal directions for the ocean flow. Generating more accurate neutral surfaces is though work for the oceanographers. Since McDougall (1987) came up with neutral surface theory, there are several software to construct neutral surfaces, such as neutral density surfaces (Jackett and McDougall, 1997), Othobaric density surfaces... However, due to the slope of these approximate neutral surfaces will not perfectly align with neutral tangent plane (NTP) (McDougall, 1987), there are cross surface flow through the surfaces. Even if the most accurate approximate neutral surface still can not be perfectly aligned with the NTP because of the neutral helicity (McDougall and Jackett, 1988). So the cross surface flux can be as a result of neutral helicity and the definition of the continuous "density" surface used. A good approximate isopycnal surface should make such diapycnal flows as small as possible. Thus, it is meaningful to create an approximate neutral surface which aims to minimize the diapycnal flux across itself. We call this new surface as $\omega_2$ surface.

Supervisor/s: Sci. Prof. Trevor McDougall, Dr. Geoff Stanley & Dr. Jan Zika.

On minimal Ramsey graphs

Thomas Lesgourgues

Ramsey theory studies the emergence of order in any large enough structure. The diner party problem and Happy Ending theorem are classical examples of Ramsey-type problems. In graph theory, this is often studied through Ramsey graphs: Graphs for which any red/blue colouring of their edges must have some regular substructures. My research covers several topics in this branch of mathematics, trying to understand the inherent structure of Ramsey graphs through parameters such as the Ramsey number or other related ones. I will present 3 original results we found recently with different teams in Europe and Australia (UNSW and UWA).

Supervisor/s: Dr. Anita Liebenau.

About the speaker: I’m French. I initially got a MSc in Statistics and mathematical finance in France. I worked for about 10 years, before going back to pursue a MSc in discrete mathematics in Spain, leading to the actual PhD here in Sydney. I’m a member of UNSW Wind symphony orchestra (although on pause right now).
Random L-Systems on Graphs with Fractality

Ziyu Li

L-systems are systems of word generation from initial words and given substitution rules. They can be used to represent trees and other combinatorial objects to generate self-similar fractals. We intend to extend L-systems to graphs by introducing rules to replace arcs by given subgraphs. This models particular complex real-world networks. We have studied deterministic arc substitution networks and proven that they are fractal and scale-free in nature by giving its dimension, and we recently extended these models to allow random substitutions and thereby more realistic modelling. However, many significant problems remain open.

Supervisor/s: Dr. Thomas Britz.

About the speaker: I am from China and expert at Chinese accent. Pandemic allows me to focus on some big problems by getting rid of social activities and review what I have learned before given enough time. Thanks to it I am now so good at cooking.
A Multivariate Equivalence Testing Approach for Ecological Restoration

Shi Jie Michelle Lim

Ecological restoration aims to initiate, accelerate or recreate the recovery of an ecosystem that has been disturbed. Assessment of restoration efforts generally involves comparing the restored site with a reference site, usually represented by nearby undisturbed sites, to find evidence of similarity. Multivariate abundance data are often collected by simultaneously recording abundances of different taxa in an assemblage and used as the basis for comparing sites. A classical hypothesis testing approach is not well suited to this problem, as the technique looks for evidence that the restored and reference sites are different rather than similar. We propose using equivalence testing instead, an idea commonly used in manufacturing and pharmaceutical development, but challenging to extend to a multivariate context. Equivalence testing requires a well-defined notion of effect size, for which we propose an original approach suited to multivariate abundances in ecology, combined with simulation from a Gaussian copula model. We use simulation to verify the performance of the technique and illustrate how it can be used to assess the effects of crayweed restoration on the fish assemblages along the coastline of Sydney, Australia.

Supervisor/s: Prof. David Warton.

About the speaker: I completed my Master’s Degree in Singapore, where I worked as a research associate prior to moving to Sydney. I was (and sort of still am) a chartered accountant before defecting to research. Due to the pandemic, time for leisure reading has been mostly consumed by reading the news.
In this talk, I will give a brief introduction of the super Catalan numbers

\[ S(m, n) = \frac{(2m)!(2n)!}{m!n!(m+n)!} \]

and their curious connection to the polynomial integration over the unit circle. The analysis will be done in a purely algebraic way, using finite fields as our underlying field. This lets us see Fourier analysis in a different perspective.

Supervisor/s: Prof. Norman Wildbeger.

About the speaker: Born and raised in Indonesia, I started my MSc by research at UNSW in 2015 before commencing my PhD in 2018. I like harmonising songs, if that is considered odd enough. Picking up a new language to learn during pandemic, no more excuses to avoid learning this time, and it turns out to be so rewarding.
The first part of my PhD focuses on strong approximations of stochastic processes driven by Lévy processes. Initially being studies as continuous branching processes with immigrations (see e.g. Fu and Li (2010)), a model in this class was introduced to mathematical finance to feature sovereign interest rates, and it has been named the $\alpha$-CIR model (Jiao, Ma, and Scotti (2017)). Then, Li and Taguchi designed a positivity-preserving approximation scheme for the $\alpha$-CIR process, and proved strong convergence (2019), which opens up an interesting area for my research. My last project considers a positivity-preserving implicit Euler-Maruyama scheme for an $\alpha$-CEV (constant elasticity of variance) process, where the jumps are governed by a compensated spectrally positive $\alpha$-stable process for $\alpha \in (1, 2)$. We proved a strong convergence rate for the numerical scheme. Moreover, compared with previous studies such as Li and Taguchi (2019) or Li and Taguchi (2019), we removed the boundedness requirement on the jump coefficient. We also improved convergence rate for the $\alpha$-CIR case in Li and Taguchi (2019) from a logarithmic rate to a polynomial rate. The next step of our study is to consider different designs of numerical schemes and different stochastic processes.

Supervisor/s: Dr. Libo Li.

About the speaker: Only a few seminar talks.
Erich Kähler, a leading 20th century geometer, introduced zeta functions to the study of geometric objects. In the 1-dimensional case, these zeta functions were already fairly well-understood. Ernst Witt, a leading 20th century algebraist, showed (1960) that Kähler’s zeta functions don’t converge in the 3-dimensional case and higher. This makes the 2-dimensional case particularly significant. Gerhard Lustig (1955) and Rolf Berndt (1969) worked on this case in their PhD theses. Unfortunately, Kähler’s zeta functions fell by the wayside for some time. However, they were independently reignited in the 1-dimensional noncommutative case by the likes of Louis Solomon (1977), Collin Bushnell and Irving Reiner (1980’s). We will discuss the 2-dimensional noncommutative case, focusing on generalising Lustig’s results.

*Supervisor/s:* A/Prof. Daniel Chan & Dr. Lee Zhao.

*About the speaker:* A product of Australasia, I have been at UNSW since the start of my bachelor’s degree in 2014. If things return to some degree of normalcy by the time I finish my PhD, I hope to get kicked around between Postdoc positions for several years. If that doesn’t work out, I intend on changing my last name to Moreau and moving to an isolated island in the southern Pacific Ocean, on which I will engineer human-animal chimeras.
Adding latent variables to glmmTMB for parsimonious high dimensional modelling

Maeve McGillycuddy

Generalised linear mixed models provide a flexible approach to model data, including multivariate data, with clustered or correlated outcomes via random effects. The variance-covariance matrix of the random effects may require estimating many parameters which is problematic with high dimensional random effects and few observations. This often happens when modelling multivariate abundance data in ecology. Another way to model correlation is to use a factor analytical approach, sometimes called a generalised latent variable model (GLVM). A latent variable can be understood as a reduced rank covariance structure for the random effects, with potentially many fewer parameters. While there are several software packages available that can fit a multivariate GLVM, they are not very flexible when it comes to adding additional random effects. We have extended the flexible package, glmmTMB, to include latent variables to create a reduced rank covariance structure to account for correlation across observations.

We apply this model to a study investigating the effect of an offshore wind farm on fish abundance with 10 fish taxa. Instead of accounting for correlation across taxa using an observation-level multivariate random effect, which would have 55 parameters, to be estimated from a sparse dataset with only 179 observations, we have 2 latent variables which only requires 20 parameters. Additionally, we make inferences about the treatment effects via inference on the variance of the relevant random effect terms.

**Supervisor/s:** Prof. David Warton & Dr. Gordana Popovic.

**About the speaker:** Irish fueled by coffee and beer!
Almost there, lessons learnt and next steps

Robert Nguyen

In my presentation I will talk about my journey through being a PhD student, some lessons learnt, and what I am planning for the next few months as I get to the end of my PhD studies.

Supervisor/s: Prof. David Warton.

About the speaker: –
Semidegenerate Superintegrable Systems in 3D

Jeremy Nugent

Superintegrable systems are physical systems with the maximum amount of symmetry. The most well studied case is the nondegenerate systems, where a potential function satisfies a particular set of PDE’s. If some of these conditions are relaxed, we find the next ‘highest’ level of symmetry allowed leads to a semi degenerate system, of which there has been no classification. This talk will discuss efforts to classify these in 3 dimensions using recent techniques.

Supervisor/s: A/Prof. Jonathan Kress.

About the speaker: I have studied at UNSW since 2011 and unfortunately did not beat the light rail to completion. I hope to end up doing something interesting and hopefully mathematical. I enjoy music a lot and have coped fairly well with the pandemic as most of my life was spent inside anyway.
Likelihood-based inference for interval-valued symbols of renewal processes

Prosha Rahman

In typical statistical analysis, it is desirable to collect as many data points as possible in order to obtain a more precise estimation. However, the analysis of particularly large volumes of data is often computationally infeasible. To address this concern, the data is frequently summarised into objects which we call symbols. These symbols contain explicit internal variation, rendering classical statistical procedures invalid.

Beranger et al. (2019) provide a framework to assess the generative model of the underlying data from a set of symbols by naturally accommodating the aggregation function. Essentially, it is now possible to make valid inference for generating distribution when the only available information are the data summaries.

In this talk, we apply the principles of Beranger et al. (2019) to interval-valued symbols within the context of renewal processes. We establish some desirable properties, including consistency, relative efficiency bounds, and an optimal family of models. This particular problem is motivated by an application to internet network traffic and will be illustrated by an analysis of real data.

Supervisor/s: Prof. Scott Sisson & Dr. Boris Beranger.

About the speaker: I’ve been at UNSW for about 8 years now. The only benefit I’ve got to being stuck at home is spending more time training.
Roundness and generalised roundness are two numerical invariants of metric spaces that are intimately related to problems in embedding theory. For example, a metric space has generalised roundness 2 if and only if it embeds isometrically into a Hilbert space, and a Banach space has generalised roundness $p$ if and only if it is linearly isometric to a subset of an $L^p$ space. In this talk, we introduce a new related numerical invariant in the linear setting of Banach spaces, called coroundness, and study its relation to embedding properties. This new numerical invariant highlights the importance of studying best constants in roundness inequalities. We then talk about what can be done with best constants in the analogous setting of generalised roundness, focusing in particular on $L^p$ spaces.

Supervisor/s: A/Prof. Ian Doust.

About the speaker: I have lived in Sydney, Australia all my life. For my undergraduate studies I completed a Bachelor of Science (Advanced Mathematics) with Honours in Pure Mathematics at UNSW. I hope to one day work in mathematical research at a university. My way of coping with the pandemic is to stay inside and do maths, and more or less pretend that the rest of the world doesn't exist.
Dynamic Laplacian techniques for identifying coherent sets

Christopher Rock

Finite-time coherent sets in time-varying fluid flows are parcels of fluid which remain maximally separated from the rest of the flow. Identifying coherent sets is an active area of research. The $k$th dynamic Cheeger constant measures the coherence of the $k$th-best coherent set, in an optimal collection of $k$ disjoint sets. This is hard to calculate explicitly, but it can be approximated using the eigenvalues of a dynamic Laplace operator. We describe this method and give some error bounds, both in the dynamic setting, and in the related problem of finding ‘open spaces’ in a static region using the static Laplace operator. We also show that the dynamic Laplace operator’s eigenfunctions approximate the coherent sets. Our proofs require a novel result in plane geometry: the area within a bounded, simply connected plane set, at distance less than $r$ from the boundary, cannot exceed the corresponding area for a disc with equal perimeter.

Supervisor/s: Prof. Gary Froyland.

About the speaker: Higher-order Cheeger and Buser isoperimetric inequalities
Reinventing the Well-Bounded Operator

Alan Stoneham

Generalising the spectral theorem for normal operators to Banach spaces has been a long active area of research. A version of this theorem states that an operator $T$ is normal if and only if it has a continuous functional calculus (i.e., $f(T)$ makes sense for all continuous functions $f$ on the spectrum of $T$). One generalisation of normal operators is the concept of a well-bounded operator, which is an operator that has an absolutely continuous functional calculus. It has been long known that well-bounded operators on reflexive spaces can be represented as a Riemann-Stieltjes type integral over a family of projections, and that the functional calculus can be extended to functions of bounded variation. However, the very 'left-to-right' tendencies of the theory, as well as defining absolute continuity in the complex plane $\mathbb{C}$, have prevented generalisation to subsets of $\mathbb{C}$. In this talk, we will present a different integral that is consistent with the existing theory which can also be generalised to some subsets of the complex plane.

Supervisor/s: A/Prof. Ian Doust.

About the speaker: I studied pure maths, mainly functional analysis, and physics for my undergrad at UNSW. Enjoy teaching university level mathematics and will get through the pandemic as long as I have quality whisky.
This talk is an overview of a method for solving the linear system that arises in the discontinuous Galerkin method, which an implicit time-stepping procedure for classical and fractional diffusion problems. After a description of the procedure, we will describe the matrix using the Kronecker product, and show how the generalised Schur decomposition leads to a quasi upper triangular system that can be solved efficiently.

_Supervisor/s: A/Prof. William McLean._

_About the speaker:_ I have done B.Sc.(Honors) from UTS, Sydney in 2019 after 12 years of gap from 2007 when I completed M.Phil from University of Punjab in Pakistan. I am originally from Pakistan and migrated to Australia in 2015 with family. I have been involved in teaching at secondary level and want to continue it. Teaching is a heritage of my mother and grand father. Sewing is my odd hobby and trying to stay at home most of the time during pandemic.
Penalized regression is a popular method due to its simplicity and bias-variance tradeoff. In many applications, a sparsity-induced penalty is used to perform variable selection and to obtain a simpler model. Some well-known examples of sparsity-induced penalties are the $\ell_0$ penalty and its convex relaxation, the $\ell_1$-norm. However, penalized regression with $\ell_0$ penalty can be unstable due to its intrinsic discontinuity while $\ell_1$-norm regularization performs worse in high-dimensional problems. Thus, non-convex and non-smooth penalties such as the $\ell_q$ penalty, with $q \in (0, 1)$, have been investigated and numerical experiments show positive results in high-dimensional setting.

In this talk, we will introduce a new non-convex, non-smooth penalty and compare the numerical results with the $\ell_q$ penalty. The algorithm to solve the problem and the convergence analysis will be described briefly. Finally, we will provide some possible future directions for the topic in this presentation.

Supervisor/s: Prof. Josef Dick & A/Prof. Guoyin Li.

About the speaker: I completed honor at UNSW and currently in second year of PhD. My main hobby is avoiding giving talk at the conference and my second hobby is watching funny pictures from 'Virtual Afternoon Tea' emails.
Health research often collect different types of outcomes on each subject, including longitudinally measured responses and survival time of some event of interest. Analyzing these data separately is inefficient in some cases, for example, in the presence of outcome related dropouts in the longitudinal data, or there are time-dependent covariates measured intermittently and/or measured with error in the survival data. In these cases, jointly modelling the longitudinal and survival outcomes will reduce the bias of parameter estimates and improve the efficiency of statistical inference. Each of the longitudinal and survival models is considered as a submodel in the joint models and linked together through a certain association structure, for instance shared parameters. Recently, these models have been extensively developed, including the extension from a single event to a multistate process, such as onset and progression of diseases. Moreover, with the increasing usage of functional data, such as heart rate monitor data or magnetic resonance imaging (MRI), the joint models have also been developed to account for a functional predictor. However, to the best of our knowledge, there has been no research in joint modelling of longitudinal and multistate processes with a functional predictor. Therefore, I will study this research topic to improve the knowledge of the association of longitudinal measurements and functional predictor with disease progressions.

**Supervisor/s:** Prof. Jake Olivier & A/Prof. Pierre Lafaye de Micheaux.

**About the speaker:** I am from Indonesia. I took my undergraduate and master degrees in Universitas Gadjah Mada, Indonesia. I live with my husband and my child. Taking PhD in other country with different language, bringing family with a little child, and in the situation of covid-19 pandemic is very challenging for me. But I will always be grateful, because I am sure whatever happened to me is the best for me.
Characterising internal tides in a region of dynamic meso and sub-mesoscale circulation: East Australian Current at 27° S

Eduardo Vitarelli de Queiroz

Internal tides can generate ocean mixing, surface convergences and near-bottom currents, so their predictability is of interest. The interaction between internal tides and meso and sub-mesoscale ocean features makes their prediction challenging. Using in situ observations of temperature, salinity and velocities from an array of deep ocean moorings, this study characterises the strength and variability of the internal tides, in both time and space, off eastern Australia (−27° S). The internal tide energy in the diurnal frequency band is, generally, greater than in the semidiurnal band. Internal tide variability is compared to local barotropic tidal forcing, stratification, sea surface density and eddy kinetic energy to determine the influence and interaction with mesoscale ocean circulation. The results reveal that the diurnal internal tide is locally generated above the continental slope and the strength is modulated by the passing of cyclonic frontal eddies (30 km diameter) that alter the local stratification and velocity field. Moreover, depending on resonant conditions (scales of wavenumber and velocity), mesoscale eddies (100 km) can interact with the barotropic tide and intensify the internal tides in the study area. Peaks in semidiurnal internal tide energy are sporadic and may result from a combination of remote and local generation. The results provide insight into the origin of the internal tides above the continental slope off eastern Australia and the mechanisms of variability. Studying the characteristics of internal tides and their interaction with ocean features helps us quantify their variability and improve their predictability, which is non-trivial in contrast to the deterministic barotropic tides that generate them.

Supervisor/s: Prof. Moninya Roughan.

About the speaker: Ocean Science Meeting Feb 2020.
Optimal Stopping Problem and Cancellable American Look-back Option

Zhuoshu Wu

Inspired by the game options, which allows both their buyer and seller to stop them at any time and then the buyer can exercise the right to buy (call option) or to sell (put option) a specified security for certain agreed price, we are investigating the fair price of the cancellable American look-back options.

In this talk, the classic optimal stopping problem will also be discussed.

Supervisor/s: Dr. Libo Li & Prof. Ben Goldys.

About the speaker: 2nd-year PhD student, check. Book hoarder, check. Chess obsessor, check.
Call option price approximation

jiefei Yu

This talk will presents an analytic approximation for the price of VIX options under a new stochastic model, namely 4/2 Regime switching model and adopts an alternative saddle point method to calculate the price of VIX call options. The work of Grasselli (2018) shows that the 4/2 model can be utilised to fit the general market situation and capture the effects of both short and long term price dynamics. Furthermore, we will show the Regime switching factor into consideration while designing the 4/2 model.

Supervisor/s: Dr. Chan Leung.

About the speaker: I did not joint any Conference in 2019 and this will be my first presentation.
Pricing European Exchange Options under a Double Regime-Switching Jump-Diffusion model

Ashwaq Zarban

Although the Black-Scholes (BS) (1973) model is a popular option pricing method in the finance world, it suffers several oversimplifications. The obvious simplification is that stock price dynamics should evolve as a stochastic process with a continuous sample path only. There have been many extensions to the BS model, for instance, the jump-diffusion models as in Cheang and Chiarella 2011, stochastic volatility models as in Heston 1993, mixed method between these as in Cheang and Garces 2020 and regime-switching models. In this current research, we propose to price an European exchange option under jump-diffusion double regime-switching model, which is an extension of Cheang and Chiarella 2011 and Shen, Fan and Siu 2014 papers.

Supervisor/s: Dr. Donna Salopek & Dr. David Colwell.

About the speaker: I am from Saudi Arabia. I got my master degree from Queensland university in Brisbane.
The CR structures on stratified Lie groups and flag manifolds

Junze Zhang

A CR manifold $M$ of CR-dimension $n$ and CR-codimension $k$ is essentially defined to abstract the structure of a smooth, real, codimension-$k$ submanifold of a complex manifold with real dimension $2n + k$. In this talk, we give an overview of the CR structure on a stratified Lie group $N$ and provide an example of the globally CR equivalence on the Heisenberg group $H_n$, the boundary of Seigel domain $\partial \Omega_{n+1}$ and $2n + 1$-sphere.

Supervisor/s: Dr. Alessandro Ottazzi & Prof. Michael Cowling.

About the speaker: I am a Manchurian and come from China. I started my research work from term 3 of 2019. And before that, I also did my undergraduate and postgraduate in UNSW.
Nonconvex optimization: a review of developments

Leyang Zhao

We will present the developments of optimization techniques in solving non-convex optimization in a variety of settings, from the traditional methods such as simulated annealing, interior point methods and proximal gradient methods, as well as the more recent smoothing projected gradients and the modified conjugate gradient method, etc. We will also discuss the optimization problems when there is presence of perturbation to the parameters, the modelling of which leads to distributionally robust type problems. Their respective numerical methods will be discussed and compared.

Supervisor/s: Prof. Spiridon Penev & A/Prof. Guoyin Li.

About the speaker: I am from China, but I have spent several years in Australia already. I did my undergraduate in Melbourne University and Masters here in UNSW. I hope I could be a mathematician one day and be able to share my ideas about maths.