2023 AUT Mathematical Modelling and Analytics Summer Symposium

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Contents

Welcome **4**

AUT Campus Map **5**

Symposium Information **6**

Symposium Schedule **7**

List of Authors and Titles **8**

Abstracts **11**

Index of Authors **24**

Welcome to the 2023 AUT Mathematical Modelling and Analytics Summer Symposium

On behalf of the Department of Mathematical Sciences, and the Mathematical Modelling and Analytics Research Centre (MMARC) within the School of Engineering, Computer and Mathematical Sciences at Auckland University of Technology, I have much pleasure in welcoming you to the 2023 Mathematical Modelling and Analytics Summer Symposium.

This year's Symposium is a continuation of our efforts to develop and promote the research being undertaken in Mathematical Sciences at AUT. I am delighted to welcome a number of keynote speakers to the Symposium with the aim of exploring collaborative opportunities and potential new areas of research that can be established with our research active staff.

The concept of this Symposium was a joint effort of Professor Emeritus Jeffrey Hunter and me, starting in 2014. With interruptions in the past three years due to covid, I am glad that we are able to resume this important series in this year. I appreciate the assistance of staff of the Department and the Centre, in particular Dr Sarah Marshall, Dr Victor Miranda, Dr Catherine Hansell Sweatman, Dr Nuttanan Wichitaksorn, Dr Wenjun Zhang and others, who have each been involved in a variety of activities to ensure the continued success of this series.

As New Zealands newest university and the only university of technology, we have recently had the opportunity to refresh our undergraduate program in Mathematical Sciences with the offer of two majors: "Analytics" and "Mathematical Modelling and Computation", together with three relevant minors in BSc. We are currently continuing to promote and expand this new program. For this purpose, we are putting in place a number of opportunities that will support and assist our academic staff to extend and enhance their activities, with this meeting being one such effort.

Our growing postgraduate programme in the Mathematical Sciences at Honours, Masters and Doctoral levels has been enhanced with our Master of Analytics (MAnalytics) degree, now in its ninth year. The success of this programme, with close on sixty students at various stages of completion of the degree, is leading to increased project supervision demands on our staff as well as leading to growing links with business and industry. We have an established arrangement with the SAS Institute that sees students in our MAnalytics degree gaining SAS Certification on graduation.

The Mathematical Modelling and Analytics Research Centre focuses on four main themes Financial modelling and computation, Industrial optimisation and operations research, Modelling in health, biology and the environment, Statistical data analytics. We are very much focused on "research lead teaching" and we have developed a small number of research clusters to strengthen and support those academic staff working in these themes. Ideally we would like to foster collaborative activities and we thank those of you who have joined us at this meeting and we hope that we can facilitate some future joint research efforts.

We have kept the focus narrow so as to make the meeting meaningful and rewarding for those who participate. I hope that you enjoy your time with us and that you find the exercise a useful adjunct to the mathematical and statistical scene within New Zealand.

On behalf of the Mathematical Sciences Department, and the Mathematical Modelling and Analytics Research Centre.

Jiling Cao
Professor of Mathematics
Chair of the 2023 Mathematical Modelling and Analytics Summer Symposium

AUT CITY CAMPUS

55 Wellesley Street East, Auckland

SCHOOLS

Art & Design – Level 3, WE building
Business – Level 1, WF building
Communication Studies – Level 12, WG building
Engineering, Computer & Mathematical Sciences – Level 3, WZ building
Future Environments – Level 11, WG building & level 3, WZ building
Hospitality & Tourism Reception – Level 4, WQ building
Language & Culture Reception – Level 4, WQ building
Law – Level 6, WY building
Science – Level 1, WS building
Social Sciences & Public Policy – Level 5, WQ building
Te Ara Poutama Reception– Level 4, WQ building

STUDENT HUB

Level 2, WA building

SERVICES AND FACILITIES

AUT International – Level 16, WO building
AUT Security – Corner St Paul & Wakefield St, WO building
AUT Shop – WH102, WH building
AUT Student Association (AUTSA) – Level 2, WC building
Learning Lab – Level 3, WA building
Library – Level 4, WA building
PinkLime (print services) – Level 3, WA building
Student Accommodation – WR building
Student Accommodation & Recreation Centre – WQ building
Student Counselling & Mental Health – WB204, WB building
Student Medical Centre – WB219, WB building
Tech Central – Level 4, WA building

- Student Hub
- Student lounge & study space
- Café
- Library
- Gym
- Conference facility
- City Campus-South Campus shuttle bus stop
- Breast feeding and baby change room
- Mobility parks
- Defibrillator

WA4 Hikuwai Plaza, outside library
WB222 Health & Counselling Centre
WF01 Lift lobby
WG1 Help desk in the atrium
WH209 Piko restaurant
WO2 Security reception
WS01 Lift lobby
WY1 Mayoral Drive – lift lobby
WQ3 Reception area

Symposium Information

Location

The AUT Mathematical Sciences Symposium will be held in **WZ Building**, 6 St Pauls Street, Auckland Central, rooms WZ416, WZ501, WZ502.

Registration

Registration will take place on level 4 of the WZ building.

Presentations

Invited talks will be 40 minutes with 5 minutes for questions and contributed talks will be 20 minutes with 5 minutes for questions. There is a 5 minute break after each invited talk to allow delegates to move between rooms.

Refreshments

Morning tea and afternoon tea will be served on level 4 of the WZ Building, outside WZ416. There are a large number of choices for lunch within a short walking distance of the campus.

Dinner

The symposium dinner will begin at 6pm on Thursday 16th February 2023. The venue for the dinner is Level 1 WZ Building, 6 St Pauls Street, Auckland.

Further Queries

If you have any queries please do not hesitate to contact a member of the organising committee: Jiling Cao, Catherine Hassell Sweatman, Sarah Marshall, Victor Miranda and Nuttanan Wichitaksorn.

MATHEMATICAL MODELLING
& ANALYTICS RESEARCH CENTRE

mmarc.aut.ac.nz

Symposium Schedule

	Thursday 16th February	
8:45- 9:00	**Registration** WZ416	
9:00 - 9:10	**Welcome** WZ416	
9:15-10:00	**Alona Ben-Tal** WZ416	
10:05-10:30	**Sarah Marshall** WZ501	**Graeme Wake** WZ502
10:30-11:00	Morning Tea	
11:00-11:45	**Angelos Dassios** WZ416	
11:50-12:15	**Sahar Barmomanesh** WZ501	**Rewat Khanthaporn** WZ502
12:15-12:40	**Victor Miranda-Soberanis** WZ501	**Nuttanan Wichitaksorn** WZ502
12:40-13:40	Lunch	
13:40-14:05	**Nurul Sarkar** WZ502	**Yunjie Shi** WZ502
14:05-14:30	**Siyang Li** WZ501	**Xinyan Zhang** WZ502
14:30-14:55	**Robin Hankin** WZ501	**Simona Fabrizi** WZ502
14:55-15:25	Afternoon Tea	
15:25-15:50	**Winston Sweatman** WZ501	**Tanvi Chandel** WZ502
15:50-16:15	**Alna van der Merwe** WZ501	**Patricio Maturana-Russel** WZ502
16:20-17:05	**Melanie Reuter-Oppermann** WZ416	

	Friday 17th February	
9:30-10:15	**Renate Meyer** WZ416	
10:15-10:45	Morning Tea	
10:45-11:10	**Xi Li** WZ416	**Kai Zhou** WZ502
11:10-11:35	**Jiling Cao** WZ416	**Yipan Chen** WZ502
11:35-12:00	**Wenjun Zhang** WZ416	**Candice Lao** WZ502
12:00-13:00	Lunch	
13:00-13:25	**Gray Manicom** WZ501	**Steven Pan** WZ502
13:25-13:50	**Joshua Looker** WZ501	**Vicky Liu** WZ501
13:50-14:15	**Catherine Hassell Sweatman** WZ501	**Lizbeth Naranjo Albarran** WZ502
14:25-15:10	**Patrick Beissner** WZ416	
15:10-15:20	**Farewell**	

18:00	**Dinner** WZ1

List of Authors and Titles

Sahar Barmomanesh, Victor Miranda-Soberains, Jiling Cao
Potential Discrimination or Unfairness Associated with the Process of Developing Predictive Risk Models in the Child Welfare 11

Patrick Beissner, Ali Khan
Endogenous Ambiguity under Commodification of Probabilistic Information 11

Alona Ben-Tal
When all you have is a hammer everything looks like a nail: mathematical modelling of real-world phenomena using a variety of approaches 11

Jiling Cao, Jeong-Hoon Kim, Wenqiang Liu, Wenjun Zhang
The 4/2 stochastic volatility model for pricing options 12

Tanvi Chandel, Victor Miranda-Soberains, Andrew Lowe, Tet Chuan Lee
Blood Pressure Device Accuracy Evaluation: Statistical Considerations with an Implementation in R 12

Yipan Chen, Sarah Marshall
Analysis of Mixed integer linear programming (MILP) in fleet allocation and re-timing . 13

Angelos Dassios
Exact Simulation for Finance and Insurance Mathematics 13

Simona Fabrizi, Steffen Lippert, Addison Pan, Matthew Ryan
Voting Behaviour with an Asymmetric Loss Function 13

Robin Hankin
A generalization of the Bradley-Terry model 14

Catherine Hassell Sweatman
Modelling remission from overweight type 2 diabetes reveals how altering advice may counter relapse 14

Rewat Khanthaporn, Nuttanan Wichitaksorn
Modelling and Forecasting COVID-19 Stock Returns using Asymmetric GARCH-ICAPM with Mixture and Heavy-Tailed Distributions 14

Candice Lao, Sarah Marshall, Mahsa Mohaghegh
Development of an optimisation model for matching mentors and mentees: Improving mentoring relationships for Women in STEM 15

Siyang Li, Renate Meyer, Patricio Maturana-Russel
The Inflated Density Ratio Approach for Marginal Likelihood Computation 15

Xi Li, Jiling Cao, Jeong-Hoon Kim, Wenjun Zhang
Valuation of Barrier and Lookback Options under Hybrid CEV and Stochastic Volatility 15

Vicky Liu, Victor Miranda-Soberanis, Thomas Yee
Implementation of the truncated lognormal distribution using vector generalized linear models . . . 16

Joshua Looker, Emily Harvey, Gray Manicom, Samik Datta
Consequences of different household contagion spread algorithm choices and equity implications . . . 16

Gray Manicom
Waning immunity in epidemic models . . . 16

Sarah Marshall, Richard Arnold, Stefanka Chukova, Yu Hayakawa
Modelling Warranty Claims for Ageing Repairable Systems with Non-Zero Repair Times 17

Patricio Maturana-Russel, Renate Meyer
Bayesian log-PSD estimation using P-splines with applications to Gravitational Wave data. . . . 17

Renate Meyer
Bayesian Nonparametric Spectral Analysis of Multivariate and Locally Stationary Time Series . . . 18

Victor Miranda-Soberanis, Thomas Yee
Quantile Regression using Vector Generalized Linear Models . . . 18

Lizbeth Naranjo Albarran, Carlos J. Perez, Ruth Fuentes Garcia
A hidden Markov model to address monotonic and measurement errors . . . 18

Steven Pan, David Wilson, Martin Stommel
Automating the inspection of power lines using domain-specific machine learning . . . 19

Melanie Reuter-Oppermann
Recent topics in EMS logistics . . . 19

Nurul Sarkar
Simulation/Analysis/Testbed: The Impact of Analytical Modelling on High-Impact Journal Publications . . . 20

Yunjie Shi, Steffen Lippert, Simona Fabrizi
Voluntary contributions to an incomplete information public good game under an endogenous move structure . . . 20

Winston Sweatman
Periodic families in the symmetrical four-body problem . . . 20

Alna van der Merwe
A local linear Timoshenko beam with axial compression . . . 21

Graeme Wake, Bruce van Brunt, Steve Taylor
The important role of nonlocal calculus . . . 21

Nuttanan Wichitaksorn, Yingyue Kang, Faqiang Zhang
Random feature selection using random subspace logistic regression . . . 21

Xinyan Zhang, Simona Fabrizi, Steffen Lippert
Two-stage Contest and Labour Contracts under the New Normal . . . 22

Wenjun Zhang, Jiling Cao, Xi Li
Pricing Geometric Asian Options under Fractional Stochastic Volatility via Mellin Transform 22

Kai Zhou, Sarah Marshall
Mixed Integer Linear Programming Model for Tail Allocation and Disruption Mitigation Analysis 23

Potential Discrimination or Unfairness Associated with the Process of Developing Predictive Risk Models in the Child Welfare

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Growing evidence suggest that clinical judgement and predictive risk models can assist social workers to segregate children at risk of maltreatment and rule out when authorities should intervene. One crucial concern from governments and research communities worldwide is that misinterpretations or poor modelling techniques will often result in biased outcomes for people with certain characteristics (e.g., race). In the New Zealand care and protection system, the over-representation of Maori may be intensified by predictive risk models, consequently, its use in decision-making would potentially pose a cycle of bias leading Maori groups to being disadvantaged or discriminated against. Ensuring these models can identify the risk as accurately as possible and do not unintentionally drive over-representation of Maori becomes a crucial matter. This work discusses this concern with the application of predictive risk modelling in the New Zealand care and protection system. We highlight the factors that might impact the accuracy and fairness of such statistical models along with initial approaches taken toward improvement.

Endogenous Ambiguity under Commodification of Probabilistic Information

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In this paper we consider decision problems involving partial information, and present a conception of commodification of information under which a buyer with limited probabilistic sophistication can reduce any resulting ambiguity through purchases of new probabilistic information. We show how, in the specific formulation articulated herein, a lottery of information batches helps overcome the induced holdup during the contracting process. Under the proposed formulation, additional noise in the lottery leads to a randomness in the buyer's ambiguity that is reduced by the introduction of an expectation operator for random sets. We show that the buyer's utility function for information, formalized as Hurwicz expected utility, is monotone,continuous and linear in information, and also consider alternative settings emphasized by variational preferences and the smooth ambiguity model.

When all you have is a hammer everything looks like a nail: mathematical modelling of real-world phenomena using a variety of approaches

Alona Ben-Tal
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This talk will highlight three distinct approaches to modelling real-world phenomena, illustrating the importance of finding the right tool for the problem in hand. The first example involves a Boolean representation of the respiratory neural network. The outputs of the Boolean network are sequences of "1 " and "0 " where the "1 " represents an action potential and the "0 " no action potential. Among other things, the new Boolean representation provides a possible explanation of how inspiration and expiration times can be regulated selectively and can be easily scaled to represent breathing rates of different species. The second example illustrates the use of optimal control theory in formulating a new hypothesis about the physiological significance of heart rate variation with breathing. This modelling work was instrumental in predicting mechanisms that have led to trials of a new pacemaker in animals and humans. The third example involves a nonsmooth dynamical system which consists of two piecewise linear ordinary differential equations with discontinuous, flow-dependent resistances. The model successfully mimics the one-directional airflow in the lungs of birds and provides a possible explanation to the observations that the airflow can peak at different times during the breathing cycle.

The 4/2 stochastic volatility model for pricing options

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The 4/2 stochastic volatility model, unifying the Heston and 3/2 models, exhibits important features on volatility so that instantaneous volatility can be uniformly bounded away from zero and the model is tractable enough to enable an efficient pricing procedure. Despite the successful results, a closed form formula for option prices is still lacking. In this paper, using an asymptotic approach, we obtain a closed form solution for the approximate option prices. Moreover, we conduct three types of numerical experiments. First, we compare the results given by our closed form formulas with those generated by the Monte-Carlo simulation. Second, we use S&P 500 market data from 3 May 2008 to 3 May 2010 to test our formula. Third, we compare the 4/2 model with the Heston and 3/2 models, respectively. We also apply the same approach to study the double-mean reverting 4/2 stochastic volatility model, which is a natural extension of the 4/2 stochastic volatility model.

Blood Pressure Device Accuracy Evaluation: Statistical Considerations with an Implementation in R

Tanvi Chandel, Victor Miranda-Soberains, Andrew Lowe, Tet Chuan Lee
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Blood Pressure (BP) device inaccuracy unknowingly introduced during non-invasive measurement of blood pressure (BP) can have significant clinical consequences. International standards such as the current ISO 81060-2 and AAMI/ANSI SP10 provide acceptance criteria for BP measurement device accuracy based on prescribed sample sizes and fixed underlying assumptions. While this criteria is frequently applied as there are no frameworks readily available to develop more suitable acceptance standards, evidence shows that it may not be appropriate for some research and clinical purposes. In this talk we present a framework for formal statistical analysis of the accuracy of blood pressure devices that generalizes the method first developed by the AAMI Sphygmomanometer Committee. This work provides an opportunity to study changes in the acceptance region for a range of different sample sizes via the sampling distribution for proportions. We also introduce methodology to estimate the exact probability for BP devices meeting international standards and its companion, newly developed, "bpAcc " package for R that can calculate and simulate acceptance statistics for arbitrary sample sizes and limits of allowable error. This work will enable a more appropriate evaluation of the accuracy of sphygmomanometers.

Analysis of Mixed integer linear programming (MILP) in fleet allocation and re-timing

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Airlines are subject to a variety of logistical challenge issues, with tail allocation for different types of fleets being one of the main issues in airline operational management. This study is concentrated on the subject of fleet allocation. Fleet Allocation Problem (FAP) involves assigning an aircraft type to each scheduled flight according to the expected number of passengers, running cost, planned revenue of each fleet and other operational requirements. This is an important challenging problem because FAP results not only affect airlines' costs and resilience to disruptions, but different airports have different requirements for different types of fleets. For example, some specific airports only allow a single fleet type of aircraft to operate otherwise penalties will be charged. In addition, airlines may be interested in knowing if slight variations to flight times in an existing schedule can have a beneficial impact on costs and resiliency. The FAP can be formulated as a mixed integer linear programming problem and with the development of computer technology, we can handle more complex flight schedule data. Previous literature has typically considered how fleet allocation should be carried out with the objective of maximising income. In this paper, we have developed a model that can be applied to the FAP and takes into account the requirements for different airports. The model can be used to determine if a slight re-timing of the flights can provide a more robust schedule. The model is applied to real data from Air New Zealand.

Exact Simulation for Finance and Insurance Mathematics

Angelos Dassios
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Machine learning algorithms often need to be trained on simulated data. Traditional Monte Carlo simulation algorithms that generate simulated samples may rely on results involving approximations. These generate small biases that while in the past did not matter, they demonstrate themselves in the very large samples needed today. This creates the need for exact (or perfect) simulation algorithms. In this seminar, we will present the mathematics needed for such algorithms and we will apply them to simulate samples involving Levy processes with truncated measure (jumps have a ceiling). Examples from financial and insurance mathematics will be presented.

Voting Behaviour with an Asymmetric Loss Function

Simona Fabrizi, Steffen Lippert, Addison Pan, Matthew Ryan
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There is a small literature that tests binary voting behaviour in the laboratory – think of voting in a jury trial (but without discussion between jurors). Most of these experiments use symmetric loss functions – both types of error (convicting the innocent and acquitting the guilty) receive the same penalty – even when the unanimity rule is used to determine the outcome (i.e., the defendant is acquitted unless all jurors vote guilty). There is one extant study (Anderson et al., 2015) that employs a loss function with a higher penalty for convicting the innocent, and its results show by far the largest difference between the data and the theoretical prediction. We have conducted two more voting experiments involving an asymmetric loss function. This study discusses our results, as well as those of Anderson et al. (2015), and assesses the prospects of reconciling the data with theory.

A generalization of the Bradley-Terry model

Robin Hankin
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The Bradley-Terry model (BT) for datasets involving comparisons or competition has wide uptake in the R community. Here I present software and analysis for a new generalization of BT in which individuals may have additional strength conferred by a new lambda term. The method allows one to quantify difficult aspects of competition such as team cohesion and non-transitive sport tactics using standard likelihood-based techniques. I apply it to situations including professional surfing,basketball, and gastronomic analysis of puddings and salads.

Modelling remission from overweight type 2 diabetes reveals how altering advice may counter relapse

Catherine Hassell Sweatman
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Remission from type 2 diabetes, defined by HbA1c $< 6.5\%$, or fasting plasma glucose concentration less than 126 mg/dl, may be achieved rapidly by following weight loss guidelines. However, remission is often short term, followed by relapse. Mathematical modelling with ordinary differential equations provides a way of investigating a typical situation, in which patients are advised to first lose and then maintain fat mass. Modelling predicts that a trajectory which maintains fat mass will be a relapse trajectory, if the fat mass chosen is too high, the threshold being dependent on the lipid to carbohydrate ratio of the diet. This prediction is more specific than a hypothesis made recently by clinicians, concerning a personal fat threshold.Results suggest alterations to traditional advice to help counter relapse.

Modelling and Forecasting COVID-19 Stock Returns using Asymmetric GARCH-ICAPM with Mixture and Heavy-Tailed Distributions

Rewat Khanthaporn, Nuttanan Wichitaksorn
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COVID-19 pandemic is an extreme event that created turmoil in stock markets around the world. This unexpected circumstance poses a critical question of whether the prevailing models can help predict the plummets of indices, hence the returns. In this study, we aim to analyze and forecast the daily stock returns using various generalized autoregressive conditional heteroscedastic (GARCH) models with intertemporal capital asset pricing structure and innovation following (1) a mixture of generalized Pareto and Gaussian distributions and (2) generalized error distribution that can capture extreme events. We also employ the parallel griddy Gibbs (GG) sampling, which is a Markov chain Monte Carlo method, to facilitate parameter estimation. Our simulation study shows that the GG estimation method outperforms the benchmark quasi-maximum likelihood estimation method. We then proceed to the empirical study of seven stock markets where the results from the in-sample period before the COVID-19 pandemic justify the use of the proposed GARCH models. The out-of-sample forecasts during the early COVID-19 period also show satisfactory results.

Development of an optimisation model for matching mentors and mentees: Improving mentoring relationships for Women in STEM

Candice Lao, Sarah Marshall, Mahsa Mohaghegh
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Good mentoring relationships can positively influence STEM students' attitudes towards their majors and encourage them to continue this career path after graduation. Current studies about mentoring have demonstrated that some characteristics, such as gender, age, race, and schedule, are closely related to the degree and quality of a mentoring relationship. This study uses some of these characteristics to develop a method for assigning mentors and mentees. The project includes three phases. The first phase is the scoring algorithm, which involves assigning each mentor/mentee pair a score for each characteristic, and then combining these using a weighted sum to obtain an overall score for each pair. The second phase uses a mixed integer linear programming model that identifies an assignment of mentors and mentees which maximises the weighted sum of the scores across all mentor/mentee pairs. In the third phase, the performance of the model is assessed for different weights, using criteria such as the number of mentees who were assigned a mentor of their preferred gender. The three-phase model is applied to data from the 2021 AUT Women in Tech Mentoring Programme, and results are compared with those from the actual assignment of mentors and mentees. Limitations and suggestions for future work are discussed.

The Inflated Density Ratio Approach for Marginal Likelihood Computation

Siyang Li, Renate Meyer, Patricio Maturana-Russel
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Bayesian model selection is based on calculating the Bayes factor, the ratio of the marginal likelihoods for two competing models. However, the computation of the marginal likelihood poses a difficult numerical task as it requires integrating the posterior kernel over the entire parameter space, which is challenging when the dimension of the parameter space is large.As demonstrated in (Wang et al., 2018) and (Wang et al., 2020), the inflated density ratio approach, a new importance sampling technique, is promising because it only requires a posterior sample and the posterior kernel function. It is also more stable than other importance sampling techniques such as the harmonic mean. Here, we investigate its performance in various simulation studies. We compare the results from the inflated density ratio method with other popular marginal likelihood computation methods, including thermodynamic integration, the stepping stone and the Fourier integral method, in particular for high-dimensional parameter spaces and in the presence of correlations in the posterior distribution.

Valuation of Barrier and Lookback Options under Hybrid CEV and Stochastic Volatility

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In this paper, we evaluate down-and-out put option and floating strike lookback option prices when the underlying asset is driven by a hybrid model with constant elasticity of variance and stochastic volatility (SVCEV). Usually, it is difficult to get closed-form solutions for those exotic options under stochastic volatility models. Here, we use an asymptotic expansion approach and the Mellin transform method to obtain explicit closed-form formulae for the zero-order and first-order correction terms. In addition, we perform a sensitivity analysis numerically on the asymptotic terms and compare the option prices corresponding to the Black-Scholes, CEV and SVCEV models with those calculated by Monte-Carlo simulations and the binomial tree method to illustrate the accuracy of our pricing formulae.

Implementation of the truncated lognormal distribution using vector generalized linear models

Vicky Liu, Victor Miranda-Soberanis, Thomas Yee
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Truncated values appear quite often on ecology and survival studies. Particularly, the truncated lognormal distribution is commonly used to model, e.g., species-abundance data. Indeed, the practice of fitting this distribution to various types of ecological data has become (increasingly) important as one means of describing what ecologists know as "community structure'. Currently, only a handful of software implementations of the truncated lognormal distribution are available which, however, have shown numerical instability with estimates wandering around the solution. One option is available in the VGAM package for R (statistical software) via the family function trunclognormal() developed under the vector generalized linear models (VGLMs, Yee, 2015) computational and statistical framework. In this talk we introduce the newly implemented trunclognormal() family function under the VGAM framework. This work marks the initial steps in my PhD with the aim of augmenting the VGLM class of models with random effects. Some examples with real data are discussed.

Consequences of different household contagion spread algorithm choices and equity implications

Joshua Looker, Emily Harvey, Gray Manicom, Samik Datta
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In light of the COVID-19 pandemic and the rise of other infectious diseases (such as an avian flu outbreak in the UK), many have turned to epidemic modellers to inform their disease management and responses. In order to inform the New Zealand government's response to COVID-19, we developed a network contagion model for understanding and predicting the different dynamics of contagion spread in different interaction contexts and between individuals of different demographics.As with all mathematical models, modelling assumptions had to be made that both limit and severely influence results. One such assumption is to assume frequency dependent spread, where one infectious individual spends the same total interaction time between their contacts, regardless of the number of contacts. One drawback of this realistic assumption is that it may lead to demographic groups who are over-represented in larger households being under-represented in predicted infection counts.In this talk we investigate the spread of the contagion within dwellings of various sizes. By comparing our simulation results with real case data we are able to determine where, and how, our modelling assumptions could lead to lead to inequitable modelling outcomes and inequitable pandemic responses.

Waning immunity in epidemic models

Gray Manicom
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One of Contagion Modelling Aotearoa's tools which has been used to inform COVID-19 related policy decisions is a network contagion model. This model has two primary components: a network approximation of Aotearoa and an expanded SEIR contagion model to run on the network. The most important long-term measure to prevent the negative effects of COVID-19 is vaccination. Unfortunately, both vaccinated individuals and those who have been previously infected may still get infected. Additionally, the immunity from vaccines and prior infection against being infected or severe disease wanes over time. In this talk I will discuss two aspects of how we implement vaccinations and prior infections in our

network contagion model. Firstly, I discuss how construct a target dataset of the waning immunity we want represented in our model. These are based on model results and fit to real-world data. Secondly, I discuss how we fit functions to this target dataset and parameterise these functions in a parsimonious way so that they are useful in our model. This is complicated by the fact that real-world measurements of vaccine protection against infection depend on the probabilities that susceptible individuals are infected over many possible interactions with infectious individuals. However, in our model we require the protection against infection per interaction.

Modelling Warranty Claims for Ageing Repairable Systems with Non-Zero Repair Times

Sarah Marshall, Richard Arnold, Stefanka Chukova, Yu Hayakawa
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Accurate estimation of warranty costs is an important, yet challenging, task for manufacturers. In this work we focus estimating the number of warranty claims for ageing repairable systems with nonzero repair times. The motivating example for this work is a vehicle manufacturer. Whilst under warranty coverage, vehicles are typically repaired, at the cost of the manufacturer, and then returned to their owners. Repairs may have varying degrees of severity, and some may have lengthy repair times. The lifetime of this type of system can be modelled as an alternating sequence of operational times and repair times, and the warranty claims correspond to the failures which occur within the warranty period. If each repair returned the system to an "as good as new " condition, then an alternating renewal process could be an appropriate model for the alternating sequence of operational and repair times. However, here we are interested in ageing systems, in which "ageing " means that operational times are stochastically decreasing and repair times are stochastically increasing. In this scenario, the assumptions of the alternating renewal process no longer hold. This talk will present an alternative model, the alternating alpha-series process, which accounts for system ageing. The alternating alpha-series process will be introduced and its application in warranty cost analysis will be discussed. Examples from the automotive industry will be provided.

Bayesian log-PSD estimation using P-splines with applications to Gravitational Wave data.

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Recently, we proposed a Bayesian approach to estimating the power spectral density (PSD) of a stationary time series using a prior based on a mixture of P-splines distributions. The method achieves a very good performance to accurately estimate complex PSDs due to the proposed novel data-driven knot allocation scheme, but significantly reduces the computational costs in comparison to previous Bayesian methods. In this talk, we discuss a method to estimate the log-PSD based on the P-spline algorithm using a parametric auxiliary model to gain efficiency. We show its performance in the analysis of gravitational wave data, where the PSD plays a key role in understanding the sources that originate them. In addition, we will discuss potential improvements for the algorithm.

Bayesian Nonparametric Spectral Analysis of Multivariate and Locally Stationary Time Series

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Various Bayesian nonparametric approaches to time series analysis have been developed over the last two decades. These are usually based on Whittle's likelihood, an approximation of the true likelihood for a large class of distributions. It depends directly on the spectral density as the main characteristic of the dependence structure of a stationary time series. While nonparametric methods are less sensitive to deviations from model assumptions, parametric approaches are more powerful if the model is correctly specified. To exploit both the efficiency of parametric and the robustness of nonparametric approaches, we proposed a nonparametric correction to a parametric likelihood for univariate stationary time series (Kirch et al, 2019). The Whittle likelihood is a special case, the nonparametric correction of a Gaussian white noise likelihood. In many applications, however, one wants to explain the interactions and co-movements among variables observed over time, e.g. interest rates, money growth, income, inflation. Furthermore, in many applications the assumption of stationarity is questionable and the dependence structure might change slowly over time. Therefore, we developed extensions of the nonparametrically corrected likelihood to multivariate time series as well as to locally stationary time series. It will be shown that these are asymptotically robust in the sense of posterior consistency and have favourable small sample properties. We illustrate these approaches through applications in physiology, ecology, and astrophysics.(This is joint work with Yixuan Liu, Yifu Tang, Claudia Kirch, Kate Lee, Patricio Maturana-Russel)

Quantile Regression using Vector Generalized Linear Models

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We present the general theory for two-parameter link functions in the large class of vector generalized linear models. The solution involves total derivatives applied to a composite log-likelihood within the Fisher scoring/iteratively reweighted least squares algorithm. Our primary example focuses on a proper statistical approach to quantile regression using the gaussian distribution. Our work also solves a four-decade old problem as second example: the canonical link for the negative binomial distribution. The methods described in this talk are implemented by the VGAM and VGAMextra R packages.

A hidden Markov model to address monotonic and measurement errors

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Motivated by a longitudinal health study, a hidden Markov model is proposed. The disease under study is assumed a continuous monotone non-decreasing process, which is associated to a set of exogenous covariates. These monotonic patterns are not observed, in its stead, the observed responses are subject to measurement error. Under Bayesian methods, the parameters are identified and estimated from data without external information about the measurement errors.

Automating the inspection of power lines using domain-specific machine learning

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Knowing where and when to repair, or replace a span, of powerlines is crucial to prevent unexpected power failure for an electrical lines company. The research investigated ways to classify the health of the conductor, some of which may be 70 years old. The current industry practice uses human experts to characterize the copper conductor by assigning a visual score ranging from 1 to 5, that also serves as a predictor for predicting a conductor's remaining life. We are interested to automate this time-consuming and expensive process by both exploiting domain-specific knowledge to first isolate the line in the drone-capture image, and then use deep convolutional neural networks to establish the health condition, and hence estimate the remaining life, something that is vital for the asset management process. Our sponsoring company, Unison Networks has been actively gathering and processing new image data for this study. Results to date show that we can accurately identify the conductor in the image and human comparable condition classification performance can be reached. We'd like to acknowledge Alex Castellanos and Ben van Vliet from the Unison project team for their contribution and technical leadership.

Recent topics in EMS logistics

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Almost all emergency medical service (EMS) systems worldwide face an increasing cost pressure often accompanied with a shortage of staff and other necessary resources as well as issue of long distances to sparsely populated areas. This means that adequate response times for all patients, 24 / 7, and throughout all regions are difficult or even impossible to ensure. An efficient use of resources is crucial, including those available as pre-EMS services, e.g. first responders. Operations research (OR) approaches can support that.

Unfortunately, the German EMS system falls short in terms of digitalisation in general and the use of well-grounded methods for managing and planning their logistics and processes. Based on interviews performed with German EMS experts, we compare the decision problems and desired support with existing research and identify gaps between academia and practice. The problem of planning patient transports that experts referred to the most relates to the vehicle routing problem, a well-known and well-studied OR problem. Therefore, we have asked experts about barriers preventing the implementation of existing research in practice.

The research project SPELL funded by the German Ministry for Economic Affairs and Energy aims at developing a platform that provides decision support to coordination centres on a daily bases, but also in case of a crisis or (natural) disaster. The platform will offer various AI-based services including intelligent dashboards, chatbots as well as forecasting, optimisation and simulation approaches for addressing strategical, tactical and operational problems. With this platform, we hope to overcome some of the determined barriers for improvements of the EMS systems.

In this talk, we address recent topics in EMS logistics from a practical and a research perspective and discuss different planning problems including the location of ambulances and the scheduling of patient transports.

Simulation/Analysis/Testbed: The Impact of Analytical Modelling on High-Impact Journal Publications

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In this speech, Professor Sarkar will reflect upon his experience to discuss the importance of selecting appropriate research methods (e.g., Simulation/Analysis/Testbed), especially analytical modelling in formulating research papers for high-impact journal publications. It draws information from peer-reviewed research articles in network and communications. By serving as an editorial review board member of several prestigious journals, Prof Sarkar has a wealth of experience to share with colleagues and emerging researchers.

Voluntary contributions to an incomplete information public good game under an endogenous move structure

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We model voluntary contributions to a public good under an endogenous move structure, where contributors have incomplete information about others' valuations. We assume there to be two agents of two potential types (high and low valuation types for the public good), and two stages for the decision whether, when, and how much to contribute to the public good as a one-off contribution only, eventually. A conventional framework with quasi-linear utility is adopted to isolate wealth effects. We analyse the existence of separating and pooling equilibria in pure strategies and show that there are no pooling equilibria, but that under some conditions a unique separating equilibrium exists in which the low valuation type agent moves first, and the high valuation agent moves second. In this unique pure strategy equilibrium, the high-type agent endogenously moves last, making up the free riding behaviour of the agent who contributes first. We also show that the expected total contribution generated in a sequential move game (i.e., where a separating equilibrium of that sort may emerge) is weakly higher than in a simultaneous move voluntary contribution to a public good game. In other words, even if a fundraiser was unaware of the valuations of potential contributors, introducing a sequential mechanism for such contributions would be conducive to an improvement of the expected total contribution to a public good over a simultaneous mechanism.

Periodic families in the symmetrical four-body problem

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Consider systems of four masses moving under their mutual gravity for there is a symmetry about the centre of mass. The Schubart orbit is a special kind of collinear orbit that exists for each mass ratio. Each of these generates a family of periodic orbits within the plane.

A local linear Timoshenko beam with axial compression

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The Timoshenko beam model consists of two linear partial differential equations formulated in terms of the deflection of the beam and the angle due to rotation of a cross section. The Local Linear Timoshenko (LLT) model for the planar motion of a rod or beam that undergoes flexure, shear and extension extends this model to cases where large displacements are allowed, and a system of nonlinear partial differential equations is obtained. A numerical algorithm based on the mixed finite element method may be used to investigate elastic waves propagated in the LLT beam. In this talk, I discuss the case of a LLT beam with axial compression and the appearance of buckled states or equilibrium solutions.

The important role of nonlocal calculus

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The role of nonlocal calculus appears to be undervalued in both the curriculum and as a tool in both constructing and auditing underpinning modelling scenarios. Why is this? This expository talk seeks to examine this, seek answers, give some examples where it has been crucial to obtain useful results, and extend the relevant theory. More needs to be done.Often nonlocal equations are called “functional differential equations ”, where cause and effect occur explicitly by action occurring some distance away, earlier in time; or more generally by effect from different values of the domain, for example: size, temperature, etc. The most interesting example given is a first order nonlocal singular eigenvalue problem on a semi-infinite region with a nonlocal multiplicative advancement. This leads to a new kind of asymptotic steady behaviour: called a “Steady-Size Distributions SSDs ”. This has proved to be very useful in cell growth models and has helped the development of cancer treatments. The nonlocal eigenvalue problem has a countable infinity of eigenvalues, with eigenfunctions which are Dirichlet series. The completeness of the set of eigenfunctions, we believe, is still an open question.Thanks are due to current colleagues in this work: Associate Professor Bruce van-Brunt (MU), Dr Steve Taylor (UA), Professor Bruce Baguley (UA),; Professor Marie Doumic and Dr Pierre Gabriel (both of Ecole Polytechnic, France); Dr Ali Zaidi (LUMS, Pakistan) for continued input; and the organisational support of AUT and Massey University.

Random feature selection using random subspace logistic regression

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Feature selection becomes a prominent method in the big data era. The logistic regression model is a wrapper method that provides better classification or prediction accuracy but it is computationally expensive. In this study, we propose the random subspace logistic regression where features are randomly selected through bootstrap cycles. The random subspace regression method is applied to both standard and lasso logistic regression models. Using the simulated and empirical data, our proposed random subspace logistic regression shows favorable results and can be a promising alternative for flat feature selection.

Two-stage Contest and Labour Contracts under the New Normal

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This paper proposes a two-stage contest model between pairs of employers and employees that assumes ambiguity about the disadvantages of working in an unknown environment. We assume that there are two possible states of nature, the familiar state and the unfamiliar state or New Normal, the latter is such that the unfamiliar work environment needs extra costly efforts, potentially compounded by the agents' respective adaptation ability to the new environment. Stage one is related to the familiar state, where the pair of the employee and employer can be matched if the employee obtains a nominal wage better than the reservation wage and the employer gains a non-negative profit. Then the pair of the employee and employer move to Stage two which has two possible states: the familiar state and the unfamiliar state or New Normal. If they move to the same state as in Stage one, the conditions for them to be matched keep as before. If they move to the New Normal, and the match still holds at that stage, they share the value of this particular match which is exogenous, and the share of the match depends on their adaptation effort relative to their partner. We analyse the model considering alternative wage contracts with complete and incomplete information, and under two alternative scenarios: (1) with costly adaptation effort by both the employer and the employee but no adaptation disutility for either of them, and (2) costly adaptation effort and adaptation disutility for both. Our results suggest that the effort level(s) of the employee and employer increase(s) with the value of the match, and they will not be matched if one of them has the lowest adaptation ability. Furthermore, we find that in the complete information scenarios, the cross-point of the employee and employer's best response functions, which shows their effort level(s), is unique, and the result is symmetric; whereas multiple cross-points and both symmetric and asymmetric results could be found in the incomplete information scenarios. Our results also suggest that when the adaptability of the employee and employer is the same, the employee puts less effort into the job than the employer, who has less information about their opponent.

Pricing Geometric Asian Options under Fractional Stochastic Volatility via Mellin Transform

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In this study, we use asymptotic expansion and Mellin transform methods to derive explicit formulae of first-order approximate values for Geometric Asian options under a fractional stochastic volatility model. The closed-form formulas for zero-order term and first-order correction term are obtained. We perform numerical integration to verify the accuracy of the closed-form formulas by comparing the option price formulae with Monte-Carlo simulation.

Mixed Integer Linear Programming Model for Tail Allocation and Disruption Mitigation Analysis

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Tail allocation is known as the process of assigning scheduled flights to a particular aircraft (a tail). A sufficient "turn-time " must also exist between the flights to enable a connection to occur. Other criteria may also be required to ensure that a schedule is "feasible ". The tail allocation problem can be formulated as a mixed integer linear programming problem. The development of computer technology and software upgrades enable the airline industry to have more capability to process larger and more complex flight schedules. Previous work was mainly focused on connecting flights that satisfied minimum "turn-time " requirements. The new mathematical model has included several new features and restrictions, in order to address a real problem facing Air New Zealand. For example, maintenance requirements can be included so that the model can allocate a certain aircraft to return to its home base to undertake maintenance at the end of the flight sequence. We have also achieved a balance in each airport, where the number of planes departing is equal to the number of planes arriving on the same day. Penalties are also introduced in the objective function for flight cancellations and unbalanced schedules. The model is used to investigate the impact of different types of disruptions (e.g., bad weather or crew sickness) on performance measures such as the number of cancellations and the number of passengers flown, and how the effect of disruptions can be minimized.

Index of Authors

Arnold, Richard, 17

Barmomanesh, Sahar, 11
Beissner, Patrick, 11
Ben-Tal, Alona, 11

Cao, Jiling, 11, 15, 22
Chandel, Tanvi, 12
Chen, Yipan, 13
Chukova, Stefanka, 17

Dassios, Angelos, 13
Datta, Samik, 16

Fabrizi, Simona, 13, 20, 22
Fuentes Garcia, Ruth, 18

Hankin, Robin, 13
Harvey, Emily, 16
Hassell Sweatman, Catherine, 14
Hayakawa, Yu, 17

Kang, Yingyue, 21
Khan, Ali, 11
Khanthaporn, Rewat, 14
Kim, Jeong-Hoon, 11, 15

Lao, Candice, 15
Lee, Tet Chuan, 12
Li, Siyang, 15
Li, Xi, 15, 22
Lippert, Steffen, 13, 20, 22
Liu, Vicky, 15
Liu, Wenqiang, 11
Looker, Joshua, 16
Lowe, Andrew, 12

Manicom, Gray, 16
Marshall, Sarah, 13, 15, 17, 23
Maturana-Russel, Patricio, 15, 17
Meyer, Renate, 15, 17
Miranda-Soberains, Victor, 11, 12, 15, 18
Mohaghegh, Mahsa, 15

Naranjo Albarran, Lizbeth, 18

Pan, Addison, 13
Pan, Steven, 18
Perez, Carlos J., 18

Reuter-Oppermann, Melanie, 19
Ryan, Matthew, 13

Sarkar, Nurul, 19
Shi, Yunjie, 20
Stommel, Martin, 18
Sweatman, Winston, 20

Taylor, Steve, 21

van Brunt, Bruce, 21
van der Merwe, Alna, 21

Wake, Graeme, 21
Wichitaksorn, Nuttanan, 14, 21
Wilson, David, 18

Yee, Thomas, 15, 18

Zhang, Faqiang, 21
Zhang, Wenjun, 11, 15, 22
Zhang, Xinyan, 22
Zhou, Kai, 23