2014 AUT Mathematical Sciences Symposium

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Auckland University of Technology
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AUT UNIVERSITY | COMPUTER + MATHEMATICAL SCIENCES

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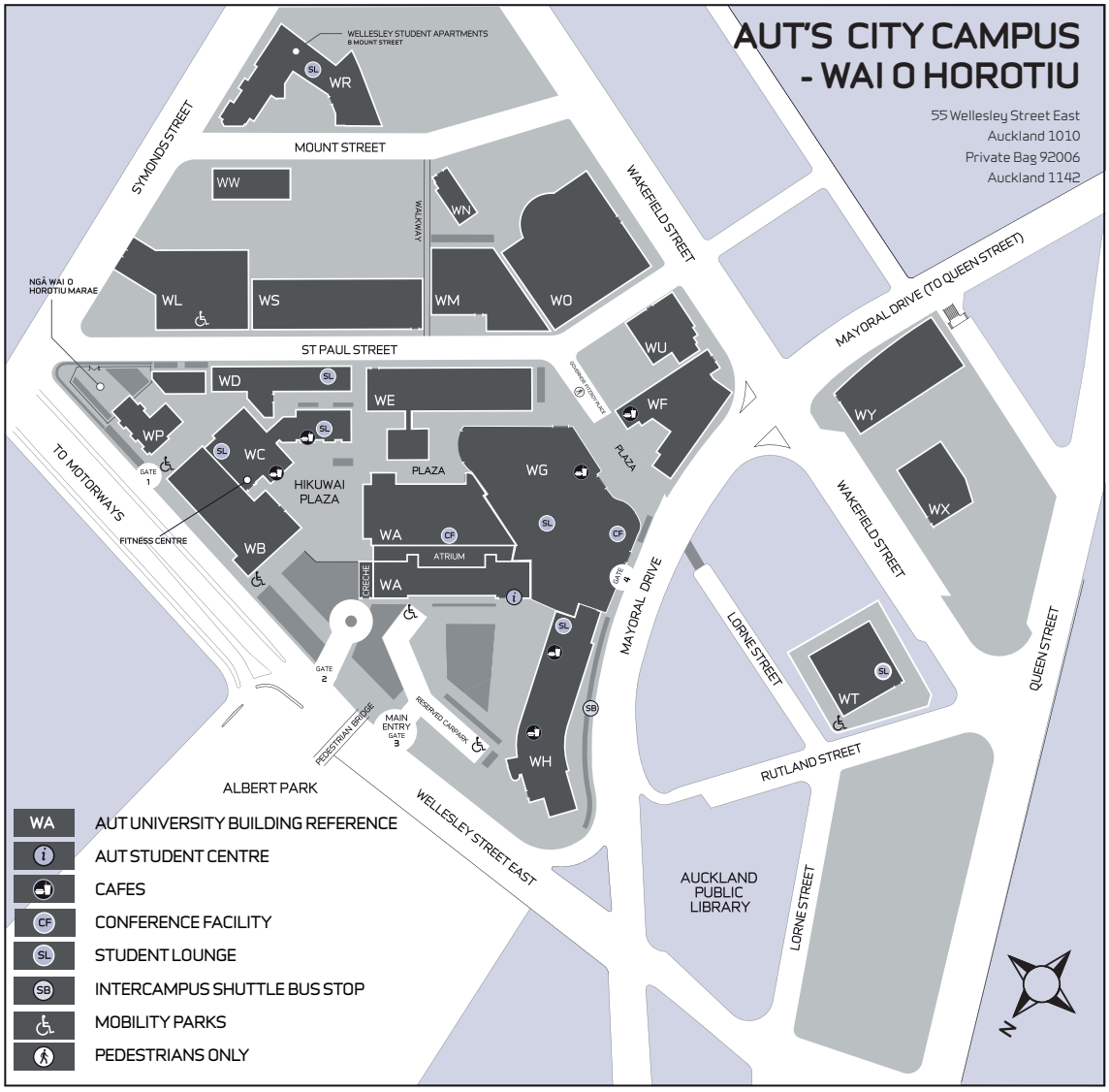
The AUT Mathematical Sciences Symposium will be held in AUT Tower (WT Building), corner of Wakefield and Rutland Streets, Auckland Central.



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AUT UNIVERSITY

Welcome to the 2014 AUT Mathematical Sciences Symposium

On behalf of the Mathematical Sciences Research Group within the School of Computer and Mathematical Sciences at Auckland University of Technology, I have much pleasure in welcoming you to our Inaugural Mathematical Sciences Symposium.

Following support from the School to develop and promote opportunities for our academic staff, the concept of this Symposium was a joint effort of myself and Prof Jiling Cao, the Professor of Mathematics, with the assistance of Drs Kate Lee, Sarah Marshall and Katharina Parry. The School has undergone significant changes in the past few years. As New Zealand's newest university we have had the opportunity to employ a number of recent graduates, all of whom who have developing research records. The School is putting in place a number of opportunities that will support and assist them in extending and enhancing their activities, with this meeting being one such effort.

We have a growing postgraduate programme in the Mathematical Sciences at Honours, Masters and Doctoral levels. In particular we will be introducing a new degree, the Master of Analytics, from 2015. As a consequence, research supervision is very much a developing activity for the academic staff in this area.

The Mathematical Sciences Research Group focusses on our two main programmes – Analytics and Applied Mathematics. Since we are very much focussed on "research lead teaching" we have developed a small number of research clusters within these two broad areas to strengthen and support those academic staff working in these areas. Ideally we would like to foster collaborative activity 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.

Subject to continuing support from the School, we hope that this Symposium will continue in the future, hopefully on an annual basis. We have kept the focus narrow so as to make the meeting meaningful and rewarding for those who participate. We 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.

Jeffrey Hunter
Professor of Mathematical Sciences
Co-chair of the 2014 AUT Mathematical Sciences Symposium

Symposium Schedule

	Thursday 27th November		Friday 28th November	
8:15-8:45	Registration WT604			
8:45-9:00	Welcome WT604			
9:00-9:45	Schlögl A Consistent Framework for Modelling Basis Spreads in Tenor Swaps. WT604		Ziedins Accumulating Priority Queues and Healthcare Applications. WT604	
9:45-10:10	Lee WT604	Van der Merwe WT802	Hunter WT604	Da Fonseca WT805
10:10-10:35	Roslan WT604	Denier WT802	Wake WT604	Zhang, W. WT805
10:35-11:00	Morning tea WT604		Morning tea WT604	
11:00-11:45	Chukova Why study warranties? WT604		Olsen Queueing Models for Leadtime Dependent Pricing. WT604	
11:45-12:10	Anchugina WT604	Kachapova WT802	Ryan WT604	Bačić WT805
12:10-13:30	Lunch		Lunch	
13:30-14:15	Sisson Functional Regression Approximate Bayesian Computation for Gaussian Process Density Estimation. WT604		Emms Sound and Vibration Research at Scion. WT604	
14:15-14:40	Marshall WT604	Butcher WT802	Chung WT604	Hankin WT805
14:40-15:05	Parry WT604	Millar WT802	Afternoon tea WT604	
15:05-15:30	Afternoon tea WT604 Announcements NZIMI (G. Wake)		Mosig WT604	Edwards WT805
15:30-16:15	Laing Fronts and Bumps in Spatially Extended Kuramoto Networks. WT604		Montiel Modelling Waves in Ice: A New Approach to Scattering by Large Random Arrays. WT604	
16:15-16:40	Cao WT604	Shymanska WT802	Farewell WT604	
16:40-17:05	Dimitrov WT604	Hassell Sweatman WT802		

All sessions will be held in AUT Tower (WT Building), cnr of Wakefield and Rutland Streets, Auckland Central.

Morning tea and afternoon tea will be served outside WT604. There are a large number of choices for lunch within a short walking distance of the campus.

List of Authors and Titles

A new (and simpler) axiomatization of exponential and quasi-hyperbolic discounting

Nina Anchugina

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How can we compare costs and benefits which occur in different periods of time? The standard approach is to convert future values into their present values by attaching some weight to each period. The procedure is known as discounting and a number of possible functional forms of discounting have appeared in the literature so far. Understanding which rules a decision-maker follows when he uses a particular form of discounting is one of the central issues of intertemporal choice. In order to evaluate whether it is rational to apply a certain discounting function it is important to reveal which normative requirements, or axioms, lead to it.

Exponential discounting remains the most widely used, partially due to its well-established axiomatic foundation, originally developed by Koopmans (1960) with subsequent contributions by several other authors. However, an alternative axiomatic characterization of exponential discounting is possible. In particular, Anscombe and Aumann's result (1963) from Subjective Expected Utility theory can be extended to axiomatize exponential discounting.

In this talk I will firstly consider Koopmans' axiomatization for infinite consumption streams and show how it can be adjusted for the case of a finite time-horizon. Secondly, I will analyze Anscombe and Aumann's representation theorem in the framework of Subjective Expected Utility theory. Finally, based on Anscombe and Aumann's theorem results I will demonstrate how it is possible to obtain representations with discount functions in exponential, quasi-hyperbolic and semi-hyperbolic forms.

The hypergeometric distribution can help reduce cross-validation incidents: Two case studies

Boris Bačić

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Choosing a validation method for the evaluation of a model performance on limited data sets is not clear-cut. In order to mitigate the validation error component, this paper presents adjustments based on quantifying the probability of validation incidents of test/training sets.

The contexts and captured limited data sets, collectively covered by the two case studies, include: small data set, unbalanced data set and subspace modelling, where tacit expert's insight extends beyond the number of output labels.

The application of the hypergeometric formula to predict validation incidents on internalised cognitive distance based clustering was initially tested with simulations, where the difference between the formula and simulation results converged towards zero with a large number of trials ($n=10^6$). To inform selection of validation method and data splits in the experiments, a presence of minority class samples in the test portion was chosen as independent variable. The resulting hypergeometric distribution produced Gaussian bell-shaped curves (with different mean and variance) indicating a better option for avoiding validation accidents. The analytical results suggesting favourable vs. less-favourable data split parameters on the available data set, have been proven by comparisons. The obtained classification results included overall classification performance ($89.45\pm2.56\%$ vs. $87.93\pm4.65\%$), class performance variance (0.65 vs. 0.71) and confusion tables results showing identified validation incidents.

The achieved application and results can aid the selection of a validation method, and adjustments of test/train data portions. The application of the hypergeometric formula will be further investigated in semi-supervised learning, data mining, machine learning and computational intelligence in general.

Conservative Computations

J. C. Butcher

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Differential equation systems are central to the modelling of mechanical and other phenomena. A simple example known as the Harmonic Oscillator describes the motion of a point moving in a circle:

$$\begin{aligned} \frac{dy}{dx} &= -z, \qquad & y(0) &= r, \\ \frac{dz}{dx} &= y, & z(0) &= 0. \end{aligned}$$

For this problem, the solution is easy and well known:

$$\begin{aligned} y &= r\cos(x), \\ z &= r\sin(x), \end{aligned}$$

but this is an exception! For most of the important problems in physics and other sciences, there is no formula known for the solution. Hence, to make progress understanding the phenomenon, numerical methods have to be used.

Looking back at the solution to the harmonic oscillator problem, we observe that, for all time, y^2+z^2 is invariant.

The simplest numerical method, known as the Euler method, is based on taking small steps in the x variable (often referred to as time) and, in each step, updating the solution using the elementary rule for the area of a rectangle ("base" times "height"). For example in the case of the harmonic oscillator, if the approximate solution after $n-1$ steps is

$$\begin{aligned} y_{n-1} &\approx y(x_{n-1}), \\ z_{n-1} &\approx z(x_{n-1}), \end{aligned}$$

then, after one further step, the approximation is

$$\begin{aligned} y_n &= y_{n-1} - (x_n - x_{n-1})z_{n-1}, \\ z_n &= z_{n-1} + (x_n - x_{n-1})y_{n-1}. \end{aligned}$$

Unfortunately, the invariant y^2+z^2 is not respected by the Euler method and other methods must be sought, not only for this easy problem, but for difficult problems arising in astronomy and other branches of physical science, where invariants such as energy and momentum need to be conserved.

This talk will focus on the accuracy of numerical methods for this sort of problem as well as their ability to obey conservation laws. There will be some pictures and some numbers. There will also be a glimpse, but only a glimpse, at some of the underlying mathematics.

The unsteady flow due to a spinning sphere

Sophie Calabretto[1], Jim Denier[1] and Trent Mattner[2]

[1]Department of Engineering Science, The University of Auckland
[2]School of Mathematical Sciences, The University of Adelaide

The flow due to a rotating sphere provides a paradigm for the study of many phenomena that arise in unsteady fluid flows. This talk will present some new results demonstrating that this flow evolves through a series of well defined stages, starting from a collision of viscous boundary layers which result in the development of a radial jet. This radial jet is preceded by a starting vortex which subsequently detaches forming an isolated toroidal vortex. The radial jet then develops an absolute instability which leads to a turbulent flow in the vicinity of the sphere's equator. The talk will present a mix of theory (a little), some computations (through a movie or two), and comparison with some experiments done a little over 50 years ago (not by us).

Equilibria under Ambiguity: Existence and Characterizations

Jiling Cao

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Modeling the market with uncertainty is of important academic significance and realistic value in economics as most decision making is made under uncertainty. Towards this direction, the Arrow-Debreu 'state contingent model' allows the state of nature of the world to be involved in the initial endowments and payoff functions, which is an enhancement of the deterministic general equilibrium model of Arrow-Debreu-McKenzie. Radner (1968, 1982) further extended the analysis of Arrow and Debreu by introducing asymmetric (differential) information. Along this line, Yannelis (1991) proposed a core concept, which is called *private core*.

A crucial assumption in the frameworks of Radner and Yannelis is that agents maximize Bayesian expected utilities. However, there is a huge literature which criticizes the Bayesian paradigm and explores the non-expected utility theory. The maximin expected utility (MEU) of Gilboa and Schmeidler (1989) is one of the successful alternatives. Recently, de Castro et al. formulated a notion of rational expected equilibrium in the framework of (MEU) and proved the existence of such an equilibrium when the economy has finitely many agents, finitely many states of nature and finitely many commodities. They asked whether the result still holds for economies in more general cases. Moreover, it is also an open question how to characterize those equilibrium allocations

In this talk, I will present some recent work with Anuj Bhowmik and Nicholas C. Yannelis which addresses the afore-mentioned and related questions.

A Consistent Framework for Modelling Basis Spreads in Tenor Swaps

Yang Chang[1] and Erik Schlögl[2]

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[2] Quantitative Finance Research Centre, University of Technology, Sydney, Erik.Schlogl@uts.edu.au

The phenomenon of the frequency basis (i.e. a spread applied to one leg of a swap to exchange one floating interest rate for another of a different tenor in the same currency) contradicts textbook no–arbitrage conditions and has become an important feature of interest rate markets since the beginning of the Global Financial Crisis (GFC) in 2008. Empirically, the basis spread cannot be explained by transaction costs alone, and therefore must be due to a new perception by the market of risks involved in the execution of textbook "arbitrage" strategies. This has led practitioners to adopt a pragmatic "multi–curve" approach to interest rate modelling, which leads to a proliferation of term structures, one for each tenor. We take a more fundamental approach and explicitly model liquidity risk as the driver of basis spreads, reducing the dimensionality of the market for the frequency basis from observed spread term structures for every frequency pair down to term structures of two factors characterising liquidity risk. To this end, we use an intensity model to describe the arrival time of (possibly stochastic) liquidity shocks with a Cox Process. The model parameters are calibrated to quoted market data on basis spreads, and the improving stability of the calibration suggests that the basis swap market has matured since the turmoil of the GFC.

National Brand and Store Brand Advertising and Pricing Strategies: An Analytical Modeling Perspective

Jen-Yi Chen [1] and Stanko Dimitrov [2]

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As more store brands come out with premium brands that are at times more expensive than national brands, they must compete with national brands on more than just price. In fact, there may be times when the store brand would like to advertise its brand and compete with the national brand in terms of brand awareness. In this presentation we present results from a recently accepted paper in the Journal of the Operational Research Society in which we consider a national brand and a store brand setting their advertising and pricing decisions in a Stackelberg setting. We present an analytical model in which a National Brand (NB) is the first mover and the Store Brand (SB) is the follower. In our model, we consider both pricing and advertising spillover effects, for example, some customers may arrive to a store interested on purchasing the NB product after seeing an advertisement, but leaving the store with a SB product. We show that if either of two decisions, pricing and advertising, are exogenously determined, then both the NB and SB may exert either advertising effort or compete on price. However, when both decisions are set in unison, then the NB has an incentive to compete with the SB solely on price. We conclude by discussing future research directions.

Why study Warranties?

Stefanka Chukova

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We introduce warranty analysis and outline the taxonomy of the mathematical models in warranty for malfunctioning. We follow with brief illustrations of possible research directions in warranty, focusing on data mining in warranty, modelling related to warranty of malfunctioning, and modelling related to warranty of misinforming.

In the illustration of the data mining in warranty, we consider automotive warranties and study truncation that typically occurs in the auto warranty data. Warranty coverage and the resulting claims data are limited by mileage as well as age. Age is known for all sold vehicles all the time, but mileage is only observed for a vehicle with a claim and only at the time of the claim. We concentrate on univariate solutions taking either age or mileage as usage measure. We take a nonparametric approach, so the methods are extensions of the usual calculations for the mean cumulative number of claims or cost of claims and its standard error. Under linear and piecewise linear models for the vehicles trajectories, we illustrate our approach with real data on several cases based on whether the usage measure is age or mileage and whether the results are adjusted for withdrawals from warranty coverage.

In the illustration of the warranty of misinforming we discuss a possible approach for quantifying the risk of misinforming.

We conclude this presentation with some open questions in warranty/maintenance research area.

Vibration reduction in lightweight floor/ceiling systems with a sand-sawdust damping layer

Hyuck Chung

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This paper shows how to use a mathematical model to predict the vibration of lightweight timber-framed floor/ceiling systems (LTFSs) caused by mechanical excitation. The LTFS considered here is made up of an upper floor layer, a cavity space with timber joists and a ceiling. These components are joined by timber battens, ceiling furring channels and ceiling clips. The vibration in the structure is caused by a localized excitation on the top surface and the resulting vibration level of the ceiling surface will be analysed. The cavity space is filled with fibre infill for damping the sound transmitting through the cavity. A unique feature of the design and the model is the sand-sawdust mixture in the upper layer. The theoretical model and the experimental measurements show that the sand-sawdust dampens the vibration in the frequency range between 10 and 200 Hz. The damping by the sand-sawdust and the fibre infill are found by comparing the numerical simulations against the experimental measurements. We show that the simple linear frequency dependent loss factors can be used to predict the low-frequency vibrations of LTFSs.

The α-Hypergeometric Stochastic Volatility Model

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The aim of this work is to introduce a new stochastic volatility model for equity derivatives. To overcome some of the well-known problems of the Heston model, and more generally of the affine models, we define a new specification for the dynamics of the stock and its volatility. Within this framework we develop all the key elements to perform the pricing of vanilla European options as well as of volatility derivatives. We clarify the conditions under which the stock price is a martingale and illustrate how the model can be implemented.

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p-values: Panacea or Plague?

Howard Edwards

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p-values are used to report the results of a test of hypothesis and have been widely adopted to the point where experimental results in virtually all disciplines are accompanied by the ubiquitous p-value (for example, the recent Higgs boson discovery was accompanied by a p-value). Despite this massive popularity, p-values have some shortcomings and many statisticians advise relying on them solely, although for differing reasons. I will discuss some of the criticisms of p-values and explore some alternative approaches to measuring the level of evidence against a hypothesis.

Sound and Vibration Research at Scion

Grant Emms

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Scion is a Crown Research Institute which supports the New Zealand Forestry and Biomaterial sectors. Sound and vibration research has an important role to play all the way along the value chain in the forestry sector, from measuring wood quality in seedlings to the prediction of the acoustic performance of timber-framed housing.

The first half of this presentation will cover the use of sound and vibration to measure the stiffness of trees, logs and timber. We will look at the practical side of measurement; including various systems employed, as well as the use of signal processing techniques. We will also delve into some applied inverse problems, looking at what techniques are employed in order to determine the stiffness of wood within trees and boards.

The second half of this presentation will examine the prediction and measurement of sound insulation of timber-framed multi-storey houses. The light-weight nature of timber-framed housing structures gives rise to poor insulation of low-frequency impact sound. Therefore, we will focus on the problem of low-frequency sound insulation in timber floors.

Complex Gaussian Processes

Robin K. S. Hankin

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Many computer models require weeks or, in some cases, months, of computer time to run. Examples include high-resolution climate models, simulation of nuclear events, and modelling of molecular processes such as crack propagation and sublimation. In this talk I will consider such computationally intensive models to be random functions, specifically Gaussian processes, and as such the methods of statistical analysis can be brought to bear on them. I will present a computational technique, known as the "emulator", which allows one to estimate the output of a computer model without actually running it. The emulator is an established technique in many fields but in this talk I will discuss several extensions and generalizations of the emulator which are the subjects of ongoing research.

Mathematical model of diabetes, fat mass and hepatic and peripheral insulin sensitivity reveals biological adaptations

Catherine Z. W. Hassell Sweatman

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Diabetes is a major health issue in many countries. A mathematical model of glucose, insulin, glucagon, β-cell, leptin and fat dynamics is presented and the steady state behaviour is investigated. Of interest are the effects on steady state behaviour of the way in which hepatic and peripheral insulin sensitivity depend on, or are associated with, fat mass. For systems with healthy parameter values, the model predicts one healthy physiological stable steady state and one set of pathological stable steady states, representing Type I diabetes. However, the steady state behaviour changes as two insulin-dependent negative feedback loops, one involving hepatic glucose production, and the other involving peripheral fat accumulation, become less effective. Extra bifurcations and physiological systems with higher fat Type II diabetic and lower fat non-diabetic stable stationary steady states are seen as a consequence of a greater proportional loss of hepatic insulin sensitivity, compared with peripheral loss. Biological adaptations are revealed.

The accurate computation of key properties of Markov and semi-Markov Processes

Jeffrey J. Hunter

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Based upon the Grassman, Taksar and Heyman algorithm [1] and the equivalent Sheskin State Reduction algorithm [2] for finding the stationary distribution of a finite irreducible Markov chain, Kohlas [3] developed a procedure for finding the mean first passage times (MFPTs) (or absorption probabilities) in semi-Markov processes. The method is numerically stable as it doesn't involve subtraction. It works well for focussing on the MFPTs from any state to a fixed state but it is not ideally suited for a global expression for the MFPT matrix. We present a refinement of the Kohlas algorithm which we specialise to the case of Markov chains to find expressions for the MFPT matrix. A consequence of our procedure is that the stationary distribution does not need to be derived in advance but is found from the MFPTs. This also leads to an expression for the group inverse of I - P where P is the transition matrix of the embedded Markov chain. A comparison, using some test problems from the literature, with other techniques using generalised matrix inverses is also presented.

References:

[1] Grassman W.K., Taksar M.I., and Heyman D.P., Regenerative analysis and steady state distributions for Markov chains, Oper. Res. 33, (1985), 1107-1116.

[2] Sheskin T.J., A Markov partitioning algorithm for computing steady state probabilities, Oper. Res. 33 (1985), 228-235.

[3] Kohlas J. Numerical computation of mean first passage times and absorption probabilities in Markov and semi-Markov models, Zeit fur Oper Res, 30, (1986), 197-207.

Convergence of random field transformed by renormalization group

Farida Kachapova [1] and Ilias Kachapov [2]

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Ising model is a mathematical model that describes interaction in a physical system with many particles, such as gas, fluid, crystal, ferromagnetic and anti-ferromagnetic systems. For example, the Ising model for a ferromagnetic metal cube assigns a random variable to each atom of the cube. These random variables make a random field and interaction between adjacent regions of the cube is represented by a function of this field.

Renormalization group is a transformation of the random field in Ising model, which allows to study the physical system at different distance scales, such as atomic and molecular levels.

Here we are interested in the Ising model with weak particle interactions and the probability distribution of its random field at a large scale. Using the mathematical apparatus of the renormalization group, we prove that the limit distribution is the independent multivariate normal distribution.

Fronts and bumps in spatially extended Kuramoto networks

Carlo Laing

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We consider moving fronts and stationary "bumps" in networks of non-locally coupled phase oscillators. Fronts connect regions of high local synchrony with regions of complete asynchrony, while bumps consist of spatially-localised regions of partially-synchronous oscillators surrounded by complete asynchrony. Using the Ott-Antonsen ansatz we derive non-local differential equations which describe the network dynamics in the continuum limit. Front and bump solutions of these equations are studied by either "freezing" them in a travelling coordinate frame or analysing them as homoclinic or heteroclinic orbits. Numerical continuation is used to determine parameter regions in which such solutions exist and are stable.

Bayesian threshold selection for extremal models using measures of surprise

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Statistical extreme value theory is concerned with the use of asymptotically motivated models to describe the extreme values of a process. A number of commonly used models are valid for observed data that exceed some high threshold. We propose the use of Bayesian measures of surprise to determine suitable thresholds for extreme value models. Such measures quantify the level of support for the proposed extremal model and threshold, without the need to specify any model alternatives. This approach is easily implemented for both univariate and multivariate extremes.

Modelling Rainfall in New Zealand Under Future Climate Scenarios

Sarah E. Marshall

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Rainfall data are essential in hydrological studies, such as flood prevention and the design of urban drainage systems. However, observed rainfall data are limited and, hence, stochastic models (e.g. point processes) are required in order to gain insight into the nature of the underlying climatic process. These stochastic models can then be used to inform hydrological studies and to make predictions about extreme rainfall events. To ensure that hydrological studies are suitable for future climates, the stochastic models need to take into account potential changes in the climate, due to factors such as global warming. Results from the literature about the impact of climate change in New Zealand are presented and used to obtain parameter estimates for a point process model of rainfall under future climate scenarios. These parameter estimates are used within a Neyman-Scott rectangular pulse to simulate rainfall scenarios for the future climate. The simulation results allow comparisons to be drawn between rainfall expected under current and future climates. The analysis of the annual rainfall maxima – the extreme values – is of particular interest. Preliminary results from this simulation study will be presented.

Beyond DIC: New developments in Bayesian model comparison

Russell B. Millar

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A recent development showing great promise for better model comparison is the widely applicable information criterion (WAIC), presented in a series of works by Sumio Watanabe. The nomenclature "widely applicable" reflects its applicability to singular and non-realizable models. However, WAIC does have a practical restriction due to its requirement that observations are independent. The theoretical derivation of WAIC and its properties are deeply rooted in complex algebraic geometry and the terminology of machine learning. This work presents a statistically oriented perspective to WAIC, with particular focus on the unconditional expected loss functions underlying the Gibbs-WAIC (WAIC_G) and Bayes-WAIC (WAIC_B), and their connection with the deviance information criterion (DIC) and bias-corrected DIC. A simplified proof of the asymptotic equivalence between WAIC_B and Bayesian leave-one-out cross-validation is provided, and this more direct approach suggests strategies for extension of WAIC to data that are not independent, including a more widely applicable information criterion (MWAIC).

Modelling waves in ice: a new approach to scattering by large random arrays

Fabien Montiel

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In a warming climate, ocean waves increasingly impact the morphology of the ice-covered Arctic and Southern Oceans, as intensified wave spectra have the ability to break sea ice deeper in the pack ice. This process is currently not modelled properly (or at all) in large scale climate models, however, so a significant effort is needed to provided these models with realistic parametrisations of wave/sea ice interactions. As waves travel through a sea ice cover, they experience scattering, which redistributes conservatively the energy across all directions, and dissipation, due to many non-linear processes e.g. collisions between floes, floe breaking, turbulences, viscous damping... Most existing scattering models are two dimensional (1 horizontal and 1 vertical dimension) or assume infinite periodic distributions of identical scatterers (i.e. floes), and therefore cannot properly describe the evolution of realistic directional wave spectra through large random distributions of ice floes. After briefly discussing these models and their limitations, I propose a new approach to remedy these shortcomings. The so-called slab-clustering method is devised to solve deterministically the scattering of multi-directional waves by arbitrary arrays of $O(10^4–10^5)$ scatterers. The method is first described in the simpler context of 2D planar acoustic waves scattered by sound-hard inclusions and then applied to the wave-ice interaction problem. I will show preliminary results suggesting the model is appropriate to characterise the attenuation of ocean wave energy and the widening of its directional spread, as observed in the field.

Rheological models of flexural-gravity waves in an ice covered ocean on large scales

Johannes E. M. Mosig[1] Fabien Montiel[2] and Vernon A. Squire[3]

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Modelling interactions between ocean waves and sea-ice is important to improve the forecasting of waves and climate in the polar regions. Nonetheless, large scale operational wave models, such as Wavewatch III, do not currently parametrise realistically the processes affecting the dispersion and attenuation of waves in ice-covered seas, e.g. conservative wave scattering effects and non-linear dissipative processes. To overcome the challenge of modelling all these processes, a continuum rheological model has recently been proposed in which the ice cover is modelled as a viscoelastic fluid layer with homogeneous properties. While this model gives rise to a large number of wave modes, some appear to be unphysical. Moreover, the predicted modes are difficult to compute and interpret due to the inherent complexity of the dispersion relation. As a remedy, we propose a simpler approach where the ice cover is modelled as a viscoelastic thin plate. In this case it is straight forward to extract and interpret the wave modes from the dispersion relation.

In this talk, I will conduct a comparative analysis of the two modelling approaches and present results showing that the thin plate model makes predictions very similar to those of the viscoelastic fluid layer model for a wide range of parameters. Therefore, we argue that the thin plate model is more appropriate to parametrise ocean wave / sea-ice interactions in operational wave models.

Queueing Models for Leadtime Dependent Pricing

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We consider queueing models for make-to-order systems where customers are quoted both leadtimes and prices. Customers have a general (non-linear) disutility for delay and are heterogeneous in their preferences. We survey the key modelling decisions for such stochastic systems and how they translate into queueing models.

We then study a queueing model where there are two customer classes and each customer is dynamically quoted a menu of price and leadtime pairs upon arrival. Customers select their preferred pairs from the menu and the server is obligated to meet the quoted leadtime. The firm does not have information on a given customer's type, so the offered menus must be incentive compatible. A menu quotation policy is given and proven to be asymptotically optimal under traditional large-capacity heavy-traffic scaling.

Finally, we present a queueing model where expediting is allowed and identify efficient expediting policies, explicitly quantifying the cost reduction ensuing from the use of expediting. We also investigate the relationship between expediting and the ability to offer express orders, shedding new light on how expediting policies could be strategic for companies. Finally, we consider the interaction of such policies with the offering of super-saver discounts and how this interaction affects a company's revenues and costs.

Bayesian fitting procedures for hydrological point processes

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Model fitting and selection typically requires the use of likelihoods. Applying standard methods to hydrological point processes, however, is problematic as their likelihoods are often analytically intractable and the data sets used for analysis are very large.

We consider the use of Approximate Bayesian Computation (ABC) to fit these models without the need to calculate the likelihood, in conjunction with the Deviance Information Criterion (DIC) for model selection. ABC works by simulating artificial data for different parameter values, and comparing the summary statistics of the simulated data to the summary statistics of the observed data.

A critical problem is that ABC only works well in lower dimensions, that is, no more than three or four summary statistics should be used. In addition, the choice of the set of statistics is relevant for the accuracy of the parameter estimation. In this presentation, we discuss the process of finding a suitable subset of summary statistics. This work has important applications for the use of ABC in hydrological modelling.

Evaluation of variance swaps prices with stochastic volatility and stochastic interest rates under full correlation structure

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This paper considers the pricing of discretely-sampled variance swaps under the class of equity-interest rate hybridization. Our modeling framework extends the Heston stochastic volatility model by including the Cox-Ingersoll-Ross stochastic interest rates and imposes correlation between the stochastic interest rate and volatility. It is known that one limitation of the hybrid models is that the analytical pricing formula is often unavailable due to the non-affinity property of hybrid models. An efficient semi-closed form pricing formula is derived for an approximation of the fully correlated hybrid model. Our pricing formula which involves solving two phases of three-dimensional partial differential equations is evaluated through numerical implementations to ensure its accuracy. Furthermore, the impact of correlations between the underlying, volatility and interest rate are also discussed in details.

Binary Choice Probabilities on Mixture Sets

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Experimental evidence suggests that choice behaviour has a stochastic element. Much of this evidence is based on studying choices between lotteries – choice under risk. Binary choice probabilities admit a strong utility representation (SUR) if there is a utility function such that the probability of choosing option A over option B is a strictly increasing function of the utility difference between A and B. Debreu (1958) obtained a simple set of sufficient conditions on binary choice probabilities for the existence of a SUR. More recently, Dagsvik (2008) considered binary choices between lotteries and provided axiomatic foundations for a SUR in which the underlying utility function is linear (i.e., conforms with expected utility). Our paper strengthens and generalises Dagsvik's result. We show that one of Dagsvik's axioms can be weakened, and we extend his analysis to encompass choices between uncertain prospects, as well as various non-linear specifications of utility.

Mathematical and computational modelling of noise transformation in imaging devices

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Although the human eye is a good and adaptable photon detector it has some physical limitations, such as wavelength, sensitivity, resolving power and contrast perceptibility. These limitations can be improved using imaging devices which give access to a larger spectral domain of electromagnetic radiation than the human eye, amplify low light images and increase the eye sensitivity. Distinction of small details of an object, and therefore, the range of vision of any image detector, are limited by optical properties of the detector, particularly, by the value of noise produced by the device. Poor noise characteristics are the main drawback of electron-optical devices with microchannel amplification widely used in many areas due to many remarkable properties. Loss of information, caused by statistical fluctuations in the gain of channels, increases a noise factor which is a measure of the loss of available information. Investigations dealing with reducing of the noise factor are of considerable practical interest. A computational method for simulation of stochastic processes of the electron multiplication, developed by the author, is used for calculations of the noise factor in image converters and intensifiers which incorporate an inverting electron optical system and a microchannel plate as an amplifier. The method is based on 3D Monte Carlo simulations and the theorems of serial and parallel amplification stages, proposed by the author. A contribution of each stage to the entire process can be easily investigated by splitting a stochastic process into a number of different stages. The method provides high calculation accuracy with minimal cost of computations. The computational model easily implements new experimental data without any changes in the algorithm. The computational model is used to investigate the effect on the noise factor of parameters of the channel amplifier.

Functional regression approximate Bayesian computation for Gaussian process density estimation

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We propose a novel Bayesian nonparametric method for hierarchical modelling on a set of related density functions, where grouped data in the form of samples from each density function are available. Borrowing strength across the groups is a major challenge in this context. To address this problem, we introduce a hierarchically structured prior, defined over a set of univariate density functions, using convenient transformations of Gaussian processes. Inference is performed through approximate Bayesian computation (ABC), via a novel functional regression adjustment. The performance of the proposed method is illustrated via a simulation study and an analysis of rural high school exam performance in Brazil.

Elastic waves in a Timoshenko beam with boundary damping

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The Timoshenko beam model consists of two partial differential equations formulated in terms of the deflection of the beam, and the angle due to rotation of a cross section. Shear and rotary inertia are taken into account in this model and in many practical applications this model compares well with higher dimensional beam models.

Using boundary damping to diminish the effect of unwanted vibrations in beams is an established practice. The effect of boundary damping on the vibration of a Timoshenko beam has been studied in some detail by solving the associated quadratic eigenvalue problem, and it is well known that the spectrum has a two-banded structure.

In this talk, I consider a Timoshenko beam with a damping moment applied to one of the endpoints. The elastic waves that develop from two sets of localised initial disturbances in the beam are simulated. The boundary moment is significantly more effective in reducing vibrations in the beam in one of the cases under consideration, as is shown by tracking the total energy in the beam. The so-called second spectrum of the Timoshenko beam plays a prominent part in explaining this phenomenon and in finding an optimal value for the damping parameter.

Modelling Growth Variability in Cell Populations

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The study of cell population dynamics has become increasingly significant - in part because of the importance of understanding phenomena such as tumour growth driven by epigenetic effects. These models will lead to a better understanding of the progression of the disease. The resulting dynamical models provide a relatively simple method for determining parameters that both regulate and enhance growth, which can help quantify the effectiveness of cancer therapy drugs. Populations of cells that are simultaneously undergoing growth and division are considered when the growth is random and cells are dividing symmetrically into two or more daughter cells. Following earlier work by Wake, van-Brunt, Kim and Cooper (Comm. Appl. Anal. 4, 2000, pp 561-574), use is made of the Fokker-Planck formulation to incorporate the stochastic effects in the growth. These models have separation of variables solutions which suggest there is an asymptotically attracting steady-size distribution. In this work a constructive existence theorem is obtained for the linear non-local dispersion-growth equation now with an arbitrary initial size-distribution and with a no-flux boundary condition. This solution is unique. It is still an open question as to whether or not the solutions obtained by separation of variables form a complete spanning set.

The Impact of Global and Domestic Volatility of Monetary Policy

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In the past six decades a lot of research has been carried out to find the effect of monetary policy on real economy. But in the most of these articles, the effect of the volatility of monetary policy has been ignored. This paper investigates the impact of the international and domestic volatility of monetary policy shocks using the GARCH-SVAR model. We enrich the SVAR model by adding time-varying volatility as endogenous variables. We consider three different types of shocks: internal (domestic), regional and global. For our empirical evidence we use quarterly data of Australia and New Zealand from 1988:1 to 2014:1. The data are collected from datastream. We employ the correlation of supply shocks between New Zealand/Australia and the USA, UK and the Euro area to find the main source of the global shocks. Results show that the supply shock correlation between New Zealand and UK is positive and of course bigger than the others. But for Australia the correlation of supply shocks by the United States are positive and bigger. This study assumes that the source of regional shocks is from Australian economy. We find a large amount of the volatility of monetary policy in New Zealand during period of 1988 to 2000 (Donald Brash's period). Since then and in the Allain Bolard's period, except in the current financial crisis (2008-2010)), New Zealand has experienced a period of tranquility. Australia shows more tranquility in the volatility of monetary policy in the period of study. The results also show that although monetary policy shocks have transient effect on real economy (neutrality of money), the impact of the volatility of monetary policy shocks on real part of the economy is permanent and significant.

Accumulating priority queues and healthcare applications

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Patients needing treatment are often assigned a priority, for instance, in Accident and Emergency departments, or when being placed on a waitlist for an operation. The timescales in these two situations are very different, yet in both situations patients who are assigned a low initial priority may have to wait for very long periods of time before being seen, as all the higher priority patients are cleared from the queue first. This talk will discuss a priority scheme where patient priorities increase with the time spent in the queue. This is joint work with Peter Taylor and David Stanford.

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