Abstracts

Thursday 11 June,
9am-5pm
Colombo Theatres, UNSW
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| 13:30-14:00   | Ashish Goyal  
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| 14:00-14:30   | Houying Zhu  
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| 14:55-15:15   | Yuehua Li  
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| 15:15-15:35   | Yoshihito Kazashi  
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| 15:35-15:55   | Afternoon tea                                |
| 15:55-16:20   | Catheryn Gray  
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| 16:20-16:50   | Bryce Kerr  
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Welcome!

Welcome to the second annual School Postgraduate Conference!

As last year we have organised talks in a mixture of plenary and parallel sessions – the plenary talks in Colombo A, the parallel sessions in LG01/02 (but note the move to LG01/02 for the final plenary session at 3:55). Plenary talks are reserved for students who recently published their research in a top international journal, and for students preparing to present their research overseas.

We have made two changes to the structure this year. Firstly, there will be a poster session over lunch, where students will give a practice run ahead of the Science Postgraduate Competition. At 1pm these students will present a 60-second lightning talk on their research in Colombo A, then they will answer questions at their posters over the remainder of the lunch break. The second addition to the program is prizes for especially outstanding talks and posters, which will be announced at the close of proceedings. If you have any thoughts on your favourite talks feel free to put in a good word to Anna Cai or Trevor McDougall (regarding Applied students), Thomas Britz or Denis Potapov (Pure students), Jake Olivier or David Warton (Stats students). Poster judges are John Roberts, Zdravko Botev and Kim Ngan Le.

We hope you have a rewarding day!

The organising committee.

Organising committee, left-to-right: Yuehua Li, Houying Zhu, David Warton, Xin Lei, Eric Kwok
Recent achievements

The conference is a chance to celebrate the achievements of our postgraduate research students, who have a significant role in progressing research and indeed many of the core functions of the school. Please make the most of this opportunity to meet our postgrad students and find out more about them and their research, whether you are a staff member, a student considering a postgraduate research degree, or just lost and looking for the pharmacy.

Some summary statistics – the school currently has 44 enrolled postgraduate students who come from 14 countries across four continents. Seven are enrolled part-time, and 15 (34%) are female. Our postgraduate cohort are an intelligent and highly motivated group of students with a lot to contribute, expect to be impressed.

The most notable achievement over the last year has been the award of a Fulbright scholarship to Isaac Donnelly, who is heading off several weeks from now for a ten month stint at Northeastern in Boston. Fulbright scholarships are highly prestigious awards, with only 11 awarded to postgraduate students this year across Australia, and Isaac was the only UNSW recipient. Isaac has also been an active contributor to the school over the last couple of years, co-organising the postgraduate seminar series (with Austen Erickson) and getting involved in school outreach activities, giving talks to Honours students and whatnot. So by all means shout him a drink at the White House.

Another recent achievement was the J B Douglas Award, for best talk by a NSW postgraduate statistics student, awarded to Boris Beranger, one of our plenary speakers this year. The awards are named in honour of a long-serving member of staff here, the first statistician at UNSW. Students from our school have won three of the last four awards, so it is safe to say we are on a roll.

Finally, below is a list of thesis-related papers (co-)authored by our currently enrolled postgraduate research students, which appeared in print or were accepted for publication over the last year. Getting a paper accepted for publication while still enrolled should be a goal of every student, but it is a goal that can be very difficult to achieve, so a big congrats to the students below.


Acknowledgements

The conference organising committee is: Eric Kwok, Xin Lei, Yuehua Li, Houying Zhu and myself, of whom the students did pretty much everything with little input! Including this book. So a special thanks to them.

Thanks to Susannah Waters who helped with advertising, helped students prepare their posters, and helped out on the day, with Margreta Morello-Janssen and Kaye Sedgers, who helped organise catering.

Thanks to our poster judging panel: John Roberts, Zdravko Botev and Kim Ngan Le.

I’m assisted on the Postgraduate Annual Review panel by Thomas Britz, Anna Cai, Trevor McDougall, Jake Olivier, and Denis Potapov. They will spend the day judging talks and the next couple meeting students to discuss their plans over the coming year. Many thanks for the time and energy they put into this important role.

Prof David Warton
Director of Postgraduate Studies (Research)
School of Mathematics and Statistics, UNSW
Conference program

• Plenary sessions
  1. *The spectral shift function and the Witten index*
     Galina Levitina (09:10–09:40 Colombo Theatre A)
  2. *Exploratory data analysis of extreme values using non-parametric kernel methods*
     Boris Beranger (11:05–11:25 Colombo Theatre A)
  3. *Impact of delta hepatitis on hepatitis B epidemiology and optimal intervention policies*
     Ashish Goyal (13:30–14:00 Colombo Theatre A)
  4. *Discrepancy bound for deterministic acceptance-rejection sampler beyond $N^{-1/3}$ in dimension 1*
     Houying Zhu (14:00–14:30 Colombo Theatre A)
  5. *From Insulin to the Akt switch*
     Catheryn Gray (15:55–16:20 Colombo Seminar Room LG01)
  6. *Bounding certain exponential sums in finite fields via sum-product theorems*
     Bryce Denis Kerr (16:20–16:50 Colombo Seminar Room LG01)

• Contributed session A I (09:45–10:45 Colombo Seminar Room LG01)
  (A I–1) *On the Arazy conjecture concerning Schur multipliers on Schatten ideals*
     Anna Tomskova
  (A I–2) *On the Beurling-Hedenmalm uncertainty principle*
     Xin Gao
  (A I–3) *Estimating the error of an $H^1$-mixed finite element solution for the Benjamin-Bona-Mahony equation*
     Sabrina Binti Shafie

• Contributed session B I (09:45–10:45 Colombo Seminar Room LG02)
  (B I–1) *Use of a stochastic model to study the cyclic motion in nanowires under focused gaussian beams*
     Juan Ignacio Ortega Piwonka
  (B I–2) *Tracking moving clusters with Bayesian non-parametric models*
     Xin Lei
  (B I–3) *Simulating the likelihood of the COGARCH model with sequential Monte Carlo*
     Damien Wee

• Contributed session A II (11:30–12:30 Colombo Seminar Room LG01)
  (A II–1) *Mean-standard-deviation time consistent portfolio selection: a discrete time model*
     Wei Wu
  (A II–2) *Bayesian semiparametric quantile regression*
     Thais Carvalho Valadares Rodrigues
  (A II–3) *A possible alternative to the method of characteristics for the reconstruction of scalar potentials from scaled gradient fields*
     Stefan Riha
• Contributed session B II (11:30-12:10 Colombo Seminar Room LG02)

(B II-1) Universal period distributions for piecewise Cat maps over rational lattices
Timothy Siu

(B II-2) An efficient inverse model of the ocean’s coupled nutrient cycles
Benoit Pasquier

• Contributed session A III (14:35-15:35 Colombo Seminar Room LG01)

(A III-1) A variant of the component-by-component algorithm for Quasi-Monte Carlo integration in weighted spaces
Alexander Gilbert

(A III-2) Horizontal residual mean theory
Yuehua Li

(A III-3) Polynomial approximations on spherical shells
Yoshihito Kazashi

• Contributed session B III (14:35-15:35 Colombo Seminar Room LG02)

(B III-1) Approximate Bayesian Computation for multi-drug-resistant tuberculosis modelling
Guilherme Souza Rodrigues

(B III-2) On likelihood functions of interval-valued random variables
Xin Zhang

(B III-3) Euler lines and Schiffler points
Nguyen Hong Le

Poster session (1-minute poster presentation starts from 13:00 in Colombo Theatre A)

1. Control theory for real world networks
   Isaac Donnelly

2. An anomalous compartment model for early stage HIV infection
   Austen Mendel Erickson

3. Effective dimension for weighted ANOVA and anchored spaces
   Chenxi Fan

4. Dynamic Isoperimetry on weighted manifolds
   Eric Kwok

5. Covariance modelling and inference for discrete ecological data
   Gordana Popovic

6. Impact of eddy encroachment on the NSW shelf circulation
   Nina Ribbat

7. A saddlepoint approximation to option price in a regime-switching model
   Mengzhen Zhang

8. A novel approach for Markov random field with intractable normalizing constant on large lattice
   Wanchuang Zhu
Plenary talks

The spectral shift function and the Witten index

Galina Levitina (09:10–09:40 Colombo Theatre A)

The Witten index of an operator $T$ can be considered as a substitution for the Fredholm index of $T$, whenever the operator $T$ ceases to be Fredholm. The Witten index is closely related to the notion of the value of the spectral shift function. In particular, if $A$ is a self-adjoint operator on a Hilbert space $H$, $B$ is a self-adjoint bounded operator on $H$ and $\theta$ is a parameter function on $R$, then the Witten index of the operator $D_A = d/dt + A + M_\theta B$ can be computed as the value of the spectral shift function for the pair $(A + B, A)$ at zero, where $M_\theta$ is the operator given by multiplication by the function $\theta$. However, the assumptions on the operators $A$ and $B$ rules out the classical differential operators even in low dimensions. We generalize the earlier results and compute the actual value of the Witten index of the operator $d/dt - id/dx + M_\theta M_f$.

Exploratory data analysis of extreme values using non-parametric kernel methods

Boris Beranger (11:05–11:25 Colombo Theatre A)

In environmental fields such as climatology or hydrology the study of extreme events (e.g. heat waves, storms, floods) is of high importance. These extreme events are those whose observed values exceed a threshold and lie in the tails of the distribution function. We investigate some non-parametric methods to analyse these tail distributions by introducing a modification of classical kernel estimators which focuses directly on the tail density. Given the mild distributional assumptions required to compute these kernel estimators, we can consider them to be the closest smooth representation of the discretised data sample. This allows us to visualise the tail behavior without the gaps in the observed data and without having to impose the stronger assumptions of a parametric model. In more quantitative terms, computing the divergences of a suite of parametric models to the kernel tail density estimator serves as a proxy for selecting which of these parametric models most closely fits the data sample. Moreover our proposed approach, being kernel-based, is straightforward to extend to the exploratory analysis of multivariate extremes. We illustrate the applicability of our non-parametric analysis on a range of simulated and experimental environmental extreme values data.

Authors: Boris Beranger, Tarn Duong, Michel Broniatowski and Scott Sisson

Keywords: Tail density, smoothing, multivariate extreme, model selection
Impact of delta hepatitis on hepatitis B epidemiology and optimal intervention policies

Ashish Goyal (13:30–14:00 Colombo Theatre A)

The major cause of liver cancer around the globe is hepatitis B virus (HBV) which also contributes to a large number of deaths due to liver failure. Hepatitis delta virus (HDV) is as potentially alarming as HBV since life threatening cases are 10 times more likely with HBV-HDV dual infection as compared to HBV mono-infection.

Quantitative modelling can lead to a better understanding of HDV epidemiology and health policies to reduce its impact. Numerous studies have captured the transmission dynamics of HBV in a population, including determining optimal controls to curb HBV. However the impact of HDV has not been considered. Therefore, we construct a mathematical model to represent the transmission of HBV and HDV, and compare both the health benefit and cost outcomes of four interventions: testing with HBV adult vaccination (diagnosis), diagnosis with antiviral treatment for HBV mono-infected individuals, diagnosis with antiviral treatment for dually infected individuals and awareness programs.

We find that the presence of HDV makes little difference to the structure of optimal control policies. However, HBV prevalence, HDV prevalence, the cost per capita at 50 years and the death toll all increase significantly in moderate and high HDV endemic regions compared to HBV mono-infected regions. Modelling also showed that in highly HDV endemic countries with poor infrastructure, high efficacy awareness programs can be used as a substitute for high cost antiviral treatment. These results can assist policymakers.

Discrepancy bound for deterministic acceptance-rejection sampler

beyond $N^{-1/2}$ in dimension 1

Houying Zhu (14:00–14:30 Colombo Theatre A)

In this talk, we consider an acceptance-rejection sampler based on a deterministic driver sequence. The deterministic sequence is chosen such that the discrepancy between the empirical target distribution and the target distribution is small. We prove that the discrepancy of samples generated by this way is bounded by $N^{-2/3} \log N$ in dimension 1. Moreover, another possible construction of low-discrepancy points according to an unnormalized density is proposed based on optimization approach. Numerically it works well for low-dimensional problems, in particular, we observe an empirical convergence rate of order $N^{-1}$ in dimension 1 for the $L_2$-discrepancy.
Akt/PKB is a key biochemical regulator within mammalian cells. It is a switch-point for numerous signalling pathways that display distinct signalling modalities. One of these key pathways is the regulation of glucose transport by insulin. The phosphorylation (activation) of only a small percentage of the Akt pool in insulin-sensitive cells results in maximal activation of downstream components: it is a very low threshold switch.

Akt activation can be thought of as the culmination of two distinct processes: translocation and phosphorylation. Unactivated Akt is synthesized in the cytosol but under the influence of insulin translocates to the PM, where it is phosphorylated to form pAkt. Although phosphorylation occurs only at the PM, pAkt is found both at the PM and in the cytosol, and its physical location appears to be an important determinant of downstream regulation. Here we present an experimentally validated four compartment model of Akt activation that embodies both these processes. Furthermore, using data from a number of independent data sets, we directly link the upstream insulin signal to the activation process.

Bounding certain exponential sums in finite fields via sum-product theorems

Bryce Denis Kerr (16:20-16:50 Colombo Seminar Room LG01)

Let \( q \) be prime and \( e_q(x) \) be an additive character of the finite field \( F_q \) with \( q \) elements. Many problems in number theory may be translated into giving upper bounds for sums of the form

\[
\left| \sum_{a \in A} e_q(a) \right|,
\]

over certain sets \( A \). In many cases these sums may be bounded by showing that either the sum set

\[
A + A = \{a_1 + a_2 : a_1, a_2 \in A\},
\]

or the product set

\[
AA = \{a_1a_2 : a_1, a_2 \in A\},
\]

has large cardinality, which we refer to as a sum-product theorem. In this talk we discuss applications of such theorems to exponential sums, focusing on the case when our set \( A \) is defined by

\[
A = \{g^n : 1 \leq n \leq N\},
\]

for some nonzero element \( g \).
Contributed talks

Session A I: Colombo Seminar Room LG01

On the Arazy conjecture concerning Schur multipliers on Schatten ideals

Anna Tomskova (09:45-10:05)

In this talk I consider the problem of describing the class of operators $A$ and $B$ on a Hilbert space $H$ and the class of functions $f$ which guarantee that the difference $f(A) - f(B)$ belongs to the Schatten von Neumann ideal $S^p$. In particular I will discuss some known results concerning the problem above and present our new achievement in this topic, which consists of the affirmative resolution of the Arazy conjecture made in 1982.

On the Beurling-Hedenmalm uncertainty principle

Xin Gao (10:05-10:25)

We show that if $f \in L_1(\mathbb{R})$, $\hat{f} \in L_1(\mathbb{R})$, and

$$\int_{\mathbb{R}} \int_{\mathbb{R}} |f(x)\hat{f}(y)|e^{\lambda |xy|}dxdy \leq \frac{C}{(1 - \lambda)^N}$$

when $0 \leq \lambda < 1$, then $f(x) = P(x)e^{-\gamma x^2}$ for some $\gamma \geq 0$, and a polynomial $P(x)$ of degree at most $2N - 2$.

Estimating the error of an $H^1$-mixed finite element solution for the Benjamin-Bona-Mahony equation

Sabrina Binti Shafie (10:25-10:45)

Computation of error estimations of an $H^1$-mixed finite element method for Benjamin-Bona-Mahony equation is considered. By using an $H^1$-mixed finite element method, the problem is reformulated into a system of first order partial differential equations, which allows the approximation for $u$ and its derivative $u_x$. Methods to approximate the true errors by using the computed solutions, the so-called a posteriori error estimates, are proposed. Numerical experiments show that the error estimations converge to the true errors.
Use of a stochastic model to study the cyclic motion in nanowires under focused gaussian beams

Juan Ignacio Ortega Pisonka (09:45-10:05)

A simple two-dimensional model to study cyclic motion in nanowires exposed to linearly polarized, gaussian optical beams is proposed. A parameter reduction is rendered in order to simplify this study and provide a full description of the system response in terms of its power spectral density and calculate the expected value for the angular velocity, which turns out to be zero only if the optical force is conservative.

This model is in good agreement with simulations of nanowires modeled as arrays of particles, and it is in partially good agreement with results from experiments conducted with indium phosphide nanowires. Further corrections are being incorporated into the model in order to amend this.

Tracking moving clusters with Bayesian non-parametric models

Xin Lei (10:05-10:25)

We will introduce a new method to create a dynamic Bayesian non-parametric model. We will illustrate how it can be used in video tracking and storm tracking.

Simulating the likelihood of the COGARCH model with sequential Monte Carlo

Damien Wee (10:25-10:45)

The COGARCH model of Kluppelberg [2004] is a Levy driven continuous time stochastic volatility model. In practice, one usually deals with a discretely observed set of observations, and as the underlying process is continuously evolving, to calculate the likelihood of the observations one has to integrate out all the possible paths the process could have taken between observations. The resultant likelihood is then a high dimensional integral which is intractable to calculate. Being able to calculate the likelihood is useful when one wishes to calibrate the model to a real world data set. We employ the use of Sequential Monte Carlo techniques to evaluate the likelihood through simulation.
Mean-standard-deviation time consistent portfolio selection: a discrete time model

Wei Wu (11:30-11:50)

We study a multiperiod portfolio selection problem in which a mean-standard-deviation utility is considered as a selection criteria. This utility not only defines a confidence level through investor’s risk aversion, but also provides a link with the translation-invariant and positive-homogeneous risk measures class. We formulate the problem into a discrete time stochastic optimal control problem in which the accumulated rate of return in the log scale is taken to be the state process. We first work in a market of risky assets only, and found a closed form optimal strategy for investors whose risk aversion is larger than a pre-specified bound. Then, we consider two extensions. The first extension considers the market in which returns of risky assets are affected by market transitions, and the second extension considers the market in which a risk free asset is available, and restrict borrowing and investing in risk free asset is allowed.

Bayesian semiparametric quantile regression

Thais Carvalho Valadares Rodrigues (11:50-12:10)

Quantile regression is challenging when interest lies in estimating many quantiles of the response distribution or when extreme quantiles are needed. In general, little information is known about these conditional distributions and estimates are very sensitive to the model restrictions imposed. Therefore, non-parametric statistical methods are appealing since no parametric assumptions are made about the underlying distribution of the data. In this talk, we will introduce a new approach to simultaneous linear quantile regression using Bayesian non-parametric techniques. More specifically, we will use quantile pyramids to construct random probability measures for the conditional distributions. Quantile regression using more general quantile processes with non-pyramidal schemes will also be considered. Simulation results show that the new approach outperforms existing methods, particularly for extreme quantiles. This is a joint work with Jean-Luc Dortet-Bernadet and Yanan Fan.
A possible alternative to the method of characteristics for the reconstruction of scalar potentials from scaled gradient fields

Stefan Riha (12:10-12:30)

We develop algorithms which automate the construction of Neutral Density in ocean models. In an idealized ocean, iso-surfaces of Neutral Density are characteristic surfaces of a simple linear first-order PDE. While the method of characteristics is a straightforward solution method for this type of problem, its practical application and automation is hampered by the need to determine multiple free integration functions arising in the spatial domain of interest. We suggest a possible alternative solution method based on previous work by Eden and Willebrand (1999), who treat the input vector field as an unscaled gradient field and accordingly solve a Poisson equation with Neumann boundary conditions to reconstruct the scalar potential. We simply modify their approach by iterative re-scaling of the input vector field with the previous solution, and present numerical experiments in which iso-surfaces of the obtained scalar potential indeed approach characteristic surfaces after several iterations.
Universal period distributions for piecewise Cat maps over rational lattices

Timothy Siu (11:30-11:50)

We look at specific reversible piecewise linear maps of the 2-torus on their in-variant rational lattices and consider the distribution of their periodic orbits. It has been conjectured by Roberts and Vivaldi (2005, 2009) that the distribution follows the Gamma distribution.

An efficient inverse model of the ocean’s coupled nutrient cycles

Benoit Pasquier (11:50-12:10)

We construct a data-constrained model of the ocean’s coupled macronutrient and micronutrient cycles. The model focuses initially on phosphate and dissolved iron. The nutrient cycling is embedded in a data-assimilated steady ocean circulation. Biological nutrient uptake is parameterized in terms of nutrient and physical limitations on plankton growth, without the need of tracers for the concentration of phytoplankton. The uptake parameterization is formulated using a novel, versatile functional form that is able to capture different plankton classes, both in terms of size and species. A matrix formulation of the discretized partial differential equations allows for very efficient solutions and facilitates the objective optimization of key model parameters by minimizing the mismatch with the observed global nutrient climatology. This approach matches observed phosphate and iron concentration with RMS errors of less than 10%. In the near future, the model will allow us to quantify the timescales and pathways through which perturbations in the iron supply are communicated throughout the world ocean’s ecosystem. Including the ocean’s silicon cycle will elucidate the role of diatoms in the biological pump and the sensitivity of elemental ratios to iron perturbations.
Session A III: Colombo Seminar Room LG01

A variant of the component-by-component algorithm for Quasi-Monte Carlo integration in weighted spaces

Alexander Gilbert (14:35-14:55)

The component-by-component (CBC) algorithm is a method for constructing good generating vectors for lattice rules to efficiently compute high-dimensional numerical integrals in the “weighted” function space setting introduced by Sloan and Woźniakowski. The “weights” that define such spaces are taken as inputs into the CBC algorithm and so a natural question is, for a given problem how does one choose appropriate weight parameters?

In this talk I will introduce a new algorithm as a variant of the CBC algorithm which chooses not only the components of a lattice rule generating vector but also the weight parameters, by heuristically minimising a bound on the integration error.

Horizontal residual mean theory

Yuehua Li (14:55-15:15)

The residual mean theory provides a better interpretation of the relation between advection and properties of fluid by the form of residual mean velocities. Based on that, temporal residual mean theory has been developed and implemented on ocean models. It provides the link between different views from averaging flow fields in height coordinates and in density coordinates. Also, it incorporated the influence of time into the streamfunction. Addition to that, horizontal residual mean theory aims at implementing the spatial correlation on streamfunction of fluid. The research project is currently at the early stage because it started in this April. But we have done some evaluations by analysing the snapshot dataset from UvicESCM model.

Polynomial approximations on spherical shells

Yoshihito Kazashi(15:15-15:35)

In this work, we consider two polynomial approximation methods on spherical shells, namely the $L_2$ projection and hyperinterpolation methods. In hyperinterpolation, continuous integrals are discretised using quadrature rules. Error estimates in $L_2$ norm are provided. Numerical examples are also presented to support our theoretical results.
Approximate Bayesian Computation for multi-drug-resistant tuberculosis modelling

Guilherme Souza Rodrigues (14:35-14:55)

According to the World Health Organization, anti-tuberculosis (TB) drug resistance is a major public health problem that threatens progress made in TB care and control worldwide. Understanding the mechanisms by which resistance is acquired is therefore paramount to efficiently tackle this global issue. In this research project, we address some crucial biological hypotheses by developing an epidemiological model to describe the data generating process of a real data set. Due to the complex intrinsic conditioning structure of this class of stochastic processes, the likelihood is intractable, making estimation a challenging statistical problem. Throughout this talk we explore the use of Approximate Bayesian Computation (ABC) to make inference possible in this context. In particular, we discuss several techniques to boost the algorithm’s computational efficiency. This is joint work with Mark Tanaka, Scott Sisson and Andrew Francis.

On likelihood functions of interval-valued random variables

Xin Zhang (14:55-15:15)

Interval-valued data are different from conventional data in that they have inherit internal structures. This paper aims to develop the mathematical theory for the likelihood-based modeling of interval-valued random variables. The resulting likelihood functions are flexible to capture both intra- and inter-interval structures. We first study the topological property and the measurability of the space of intervals, which lead to the distribution functions and density functions. Then, we propose two types of models, the descriptive model and the generative model. In particular, we focus on the generative model, of which the sequence of latent variables are exchangeable. It results in the mixture model, which can account for both intra- and inter-interval variations. The asymptotic properties of mixture models have been studied and their connections to descriptive models are emphasized. We illustrate the proposed models through simulated studies and one real world application of modeling the aggregated interval-valued data from the credit card customers.

Euler lines and Schiffler points

Nguyen Hong Le (15:15-15:35)

We investigate the concurrency of triples of Euler lines and the concurrency of two Euler lines and a bline and show the pleasant result that these concurrencies lie on the Circumcircle. We also extend the classical Schiffler point S to four-fold Schiffler points in the language of standard coordinates.
Poster Session

1-minute poster presentations (starts from 13:00 in Colombo Theatre A)

Control theory for real world networks

Isaac Donnelly

With the advent of the Internet and global airline networks, the world is becoming increasingly interconnected. The scientific community is also realizing the importance of considering systems as a whole, i.e., the gene regulatory network, not as a set of single components. Network science provides a language in which to understand these complex systems. True understanding requires analytic capability, predictability and controllability. I will present recent results on control theory on networks as well as discuss some exciting applications.

An anomalous compartment model for early stage HIV infection

Austen Mendel Erickson

During sexual transmission of HIV, invading virions must cross an epithelial layer in order to reach and potentially infect cells below. Particle tracking experiments suggest that virions undergo anomalous subdiffusion through mucous and tissues, which cannot be modeled accurately using classical models of diffusion. We propose a multi-compartment model of early stage HIV infection including infected semen, mucus, epithelium, and goal layers and allowing for anomalous virion transitions between compartments, and infection of target cells within the latter two layers.

Effective dimension for weighted ANOVA and anchored spaces

Chenxi Fan

Effective dimension, an indicator for the difficulty of high dimensional integration, describes whether a function can be well approximated by low dimensional terms or a sum of low order terms. This talk considers weighted ANOVA and anchored spaces of functions. The main focus is on how to measure the effective dimension for these two kinds of spaces using the embedding between them and the relation between the corresponding multivariate decomposition.
Dynamic Isoperimetry on Weighted Manifolds

Eric Kwok

Transport and mixing in dynamical systems are important mechanisms for many physical processes. We consider the detection of transport barriers using a recently developed geometric technique [1]: the dynamic isoperimetric problem. Solutions to the dynamic isoperimetric problem are sets with persistently small boundary size relative to interior volume, as the sets are evolved by the dynamics. In the presence of small diffusion these sets have very low dispersion over finite-times because of their lasting small boundary size, and thus are natural candidates for coherent sets, bounded by transport barriers.

We construct a weighted dynamic Laplacian operator, and show corresponding results for a dynamic Cheeger inequality and dynamic Federer-Fleming theorem. We can handle general nonlinear dynamics, and weighted versions of area and volume. Finally, we formulate the connection between the present geometrical approach to recent probabilistic approaches to determining coherent sets using transfer operators.


Covariance modelling and inference for discrete ecological data

Gordana Popovic

We propose an algorithm that generalises to discrete data any given covariance modelling algorithm originally intended for Gaussian responses, via a Gaussian copula approach. Combining copulas with covariance modelling allows us to build parsimonious multivariate models for a range of data types when the number of observations is not large compared to the number of variables. This problem often arises in ecology when modelling a community of species, where there are a large number of potential species interactions relative to the number of locations where species abundances have been observed. Modelling these covariances not only gives insight into how species interact with one another, but also allows us to build models which take these interactions into account when making inferences about associations between a community and the environment, or potential environmental impacts. Simulations demonstrate we can use this method to accurately model covariance patterns and carry out more powerful inference.
Impact of eddy encroachment on the NSW shelf circulation

Nina Ribbat

The shelf seas are highly dynamic transition zones connecting the open ocean and the coast. Along the east coast of Australia, submeso and mesoscale eddies are dominant features of the shelf circulation downstream of the EAC separation point. Offshore waters have been found to intrude onto the continental shelf and into the coastal zone mainly through cyclonic and anti-cyclonic eddy encroachment. However we do not know the impact of these intrusions on nearshore circulation and productivity.

The purpose of this study is to investigate eddy encroachment along South East Australia and its impact on shelf circulation. In order to achieve this goal, we use a combination of observations from an intensive field campaign and outputs from a 3-D regional ocean model (ROMS). Particularly, we develop a one-way nested configuration to downscale from a coarse eddy-resolving grid (2.5 -6 km in the horizontal, 30 levels in the vertical direction) to a finer coastal grid (750 m in the horizontal and 25 levels in the vertical direction) to sufficiently resolve the complex interaction of the mesoscale eddy field with barotropic tides and topography.

Simulations are validated against observations in the region. Temperature/salinity and velocity outputs from the simulations are compared with regards to eddy characteristics and implications on along-shelf and across shelf water transports. Findings of this study will provide insight into drivers of productivity in coastal waters and provide guidance for the location of purpose built artificial reefs. An output of the study is a high resolution ROMS configuration for the productive Stockton Bight/Sydney Shelf region that will aid future assimilation and forecasting efforts.

Keywords: shelf dynamics, tides, eddies, ROMS

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A saddlepoint approximation to option price in a regime-switching model

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This paper is considered the saddlepoint approximation for the valuation of a European-style call option in a Markovian, regime-switching, Black-Scholes-Merton economy, where the price process of an underlying risky asset is assumed to follow a Markov-modulated geometric Brownian motion. Standard option pricing procedure under this model becomes problematic as the occupation time for a given state can not be evaluated easily. In the case of the underlying Markov process has two states, we present an explicit analytic formula of the cumulant generating functions (CGFs). When the process has more then two states, an approximate formula of the CGF is provided. We adopt a splitting method to reduce the complexity of computing the exponential matrix function. Then we use these CGFs to apply the saddlepoint approximations and our numerical results show that our method is an efficient and reliable approach in option pricing under a multi-state regime-switching model.

A novel approach for Markov random field with intractable normalizing constant

on large lattice

Wanchuang Zhu

We introduce a novel method to solve issue of normalizing constant in hidden Markov random field. The method takes advantage of conditional independence in Markov random field to split large field into tractable size. In addition, our method is generalized to manage second order neighbourhood structure problem. The method is studied in both simulated data and real data. It outperforms other methods in several aspects. Firstly, our method estimates variance more precisely than others. Secondly, good estimation is obtained in many cases. While other methods may results in biased estimator in high dependence case. Especially, our method is applicable for large lattice.