Satellite Workshop Applied^2 Probability
"Uncertainty Quantification Applications"

2nd July, 2019
Centre for Applications in Natural Resource Mathematics (CARM)
The School of Mathematics and Physics,
The University of Queensland

Program, Book of Abstracts and List of Participants

[Venue: room 273 and 275 in the Global Change Institute, building 20]

Organising Committee

Ivo Adan, Eindhoven University of Technology
Konstantin Avratchenkov, INRIA Sophia Antipolis, France
John Boland, University of South Australia (UniSA)
Mark Fackrell, The University of Melbourne
Jerzy Filar, Director of CARM, The University of Queensland
David Golberg, Cornell University
Matthew Holden, The University of Queensland
Roxanne Jemison, The University of Queensland
Ross McVinnish, The University of Queensland
Joshua Ross, The University of Adelaide

Welcome to the Satellite Workshop Applied^2 Probability 2019

Raison D'être: One of the unsolved mysteries of mathematical sciences is that branches which have their roots in applications and natural phenomena, over time, become progressively more theoretical. For instance, typically, there are very few numbers in papers nowadays published in Number Theory journals. It is not surprising that Applied Probability is also susceptible to this theorization trend which, arguably, merely points to the maturity and success of the subject. However, in recognition of the above, there is an emerging need for a forum where researchers encountering applied probability problems in the context of specific applications can discuss their experiences and challenges. A fascinating aspect of modelling random phenomena in applications is that different groups of end users may have very different attitudes towards uncertainty and risk. For instance, medical practitioners, fishermen and fire fighters all deal with stochasticity on regular basis but have very different needs and expectations of the quantitative tools designed to assist them.

On behalf the entire organising committee we would like to thank our sponsors and welcome you to Brisbane, St Lucia and The University of Queensland.

Workshop Co-Chairs
Jerzy Filar, The University of Queensland
Joshua Ross, The University of Adelaide

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Catering for the workshop is ecotarian which supports food produced or prepared in a way that does not harm the environment.

Program - Parallel Sessions Tuesday, July 2nd – Global Change Institute #20 Rooms 273 and 275		
08:00 - 08:30	Registration	
08:30 - 08:45	**Welcome to Country Professor Jenny Seddon** Room: 273 **Professor's Jenny Seddon and Jerzy Filar to open the Workshop**	
	Parallel Session One Room 273	Parallel Session Two Room 275
8:45 – 10:15	Chairs: Mark Fackrell and Joshua Ross **Health and Epidemics Models 1** Mark Fackrell, University of Melbourne Laura Boyle, Queen's University Belfast Shaowen Qin, Flinders University	Chair: Jerzy Filar **Decision Making Under Uncertainty** Shane Henderson, Cornell University Matt Holden, The University of Queensland Kate Helmstedt, QUT Kerrie Mengersen, QUT
10:15 – 10:40	Tea Break	
10:40 – 12:10	Chairs: Mark Fackrell and Joshua Ross **Health and Epidemics Models 2** Robert Cope, The University of Adelaide Peter Taylor, University of Melbourne Belinda Spratt, QUT	Chairs: Konstantin Avrachenkov and Dmitry Krass **Stochastic Operations Research** Floske Spieksma, Univerrsiteit Leiden Michael McCourt, SigOpt Dmitry Krass, University of Toronto Konstantin Avrachenkov, INRIA Sophia Antipolis, France
12:10 – 13:00	Lunch	
13:00 – 14:30	Chair: John Boland **Energy Modelling and Forecasting** Phillip Wild, The University of Queensland Lui Cirocco, UniSA Adrian Grantham, Australian Energy Market Operator John Boland, UniSA	Chairs: Ross McVinish and Brenda Vo **Mathematical Biology** Sophie Hautphenne, Melbourne University Andrew Black, The University of Adelaide Dietmar Oelz, The University of Queensland Brenda Vo, University of New England
14:30 – 15:00	Tea Break	
15:00 - 16:30	Chairs: Wen-Hsi Yang and George Leigh **Sustainable Fisheries** Wen-Hsi Yang, The University of Queensland Trevor Hutton, CSIRO George Leigh, Agri-Science, Queensland Jerzy Filar, The University of Queensland	Chair: Ivo Adan **Networks, Queues and Control** Rik Timmerman, Eindhoven University of Technology Stella Kapodistria, Eindhoven University of Technology Daniel Silva, Auburn University Ivo Adan, Eindhoven University of Technology
16:30 – 17:30	Chair: Matthew Holden **Ecology and Conservation** Matthew Adams, The University of Queensland Katie Lee, The University of Queensland Ali Chauvenet, The University of Queensland Christopher Baker, QUT	Chair: Yoni Nazarathy **Simulation and Computation Tools** Anna Foeglein, Heisenberg Analytics Matthew Roughan, The University of Adelaide Yoni Nazarathy, The University of Queensland
17:30 – 18:00	Closing Room: 273	

Tuesday, July 2nd – Global Change Institute #20 Parallel Session One Room 273	
08:00 - 08:30	Registration
08:30 - 08:45	**Welcome to Country Professor Jenny Seddon** **Professor's Jenny Seddon and Jerzy Filar to open the Workshop**
08:45 – 10:15	**Chairs:** Mark Fackrell and Joshua Ross **Health and Epidemics Models 1** **Mark Fackrell:** Analysing and Modelling Donor Flow in an Australian Red Cross Blood Service Donation Centre **Laura Boyle:** Validation of the Coxian phase-type distribution approach to clustering in healthcare applications **Shaowen Qin:** Evidence based decision support - testing the effectiveness of patient flow decongestion solutions in a virtual hospital
10:15 – 10:40	Tea Break
10:40 – 12:10	**Chairs:** Mark Fackrell and Joshua Ross **Health and Epidemics Models 2** **Robert Cope:** Identifying the relative timing of infectiousness and symptom onset in a novel pathogen **Peter Taylor:** How do we choose the rates in an Accumulating Priority Queue? **Belinda Spratt:** Reducing post-surgery recovery occupancy
12:10 – 13:00	Lunch
13:00 – 14:30	Chair: John Boland **Energy Modelling and Forecasting** **Phillip Wild:** An assessment of options and implications for achieving State based 50% Variable Renewable Penetration in the NEM **Lui Cirocco:** Energy cost minimisation at a university campus fitted with thermal storage, a case study **Adrian Grantham:** Generating synthetic sequences of global horizontal irradiation **John Boland:** Probabilistic forecasting of solar farm output
14:30 – 15:00	Tea Break
15:00 - 16:30	**Chairs:** Wen-Hsi Yang and George Leigh **Sustainable Fisheries** **Wen-Hsi Yang:** Spatially and environmentally based quantitative assessment of the Queensland Saucer Scallop Fishery **Trevor Hutton:** Northern Prawn Fishery: Common Banana Prawn fishery dynamics – the probability of getting it right **George Leigh:** How do we know whether a fishery is sustainable when the main action took place before records began? **Jerzy Filar:** Uncertainties in an age-structured population model for Barramundi
16:30 – 17:30	**Chair:** Matthew Holden **Ecology and Conservation** **Matthew Adams**: Maximising the benefit of ecological data using Bayesian inference for ODEs **Katie Lee:** Where's the beef? Optimising for biodiversity in a global livestock model **Ali Chauvenet:** Cultivating informed management: deciding between ex situ and in situ conservation for threatened plants **Christopher Baker:** Optimising invasive species removal rates in highly uncertain systems
17:30 – 18:00	**Closing**

Tuesday, July 2nd – Global Change Institute #20 Parallel Session Two Room 275	
08:45 – 10:15	**Chair:** Jerzy Filar **Decision Making Under Uncertainty** **Shane Henderson:** Under the hood of bike sharing **Matt Holden:** Predicting the outcomes and cost-efficacy of anti-poaching interventions under extreme uncertainty **Kate Helmstedt:** Impacts of management hierarchies when making environmental decisions **Kerrie Mengersen:** Which way should I cycle? A case study in Bayesian modelling for decision-making under uncertainty study
10:15 – 10:40	Tea Break
10:40 – 12:10	**Chairs:** Konstantin Avrachenkov and Dmitry Krass **Stochastic Operations Research** **Floske Spieksma:** Area allocation for Picnic delivery **Michael McCourt:** Practical Aspects of Sample Efficient Optimization/Search using Probabilistic Models **Dmitry Krass:** Pricing, Location and Capacity Planning of Service Facilities under Congestion **Konstantin Avrachenkov:** Distributed optimization of caching devices with geographic constraints
12:10 – 13:00	Lunch
13:00 – 14:30	**Chair:** Ross McVinish and Brenda Vo **Mathematical Biology** **Sophie Hautphenne:** Parameter estimation of branching processes with applications to the endangered black robin population **Andrew Black:** Stochastic models of evolution by ecological scaffolding **Dietmar Oelz :** Tug-of-war between molecular motors **Brenda Vo:** Statistical inference for agent based models in cell biology
14:30 – 15:00	Tea Break
15:00 - 16:30	**Chair:** Ivo Adan **Networks, Queues and Control** **Rik Timmerman:** Platoon Forming Algorithms for Intelligent Street Intersections **Stella Kapodistria:** Integrated learning and decision making **Daniel Silva:** Last-mile on-demand public transportation service **Ivo Adan:** Online batching in high throughput poultry processing lines
16:30 – 17:30	**Chair:** Yoni Nazarathy **Simulation and Computation Tools** **Anna Foeglein:** Modern paradigms, techniques and tools in Discrete Event Simulation **Matthew Roughan:** Who is the mightiest Avenger? **Yoni Nazarathy:** Simulation with the Julia language

Contributed Paper Presentations

Session: Health and Epidemics Models 1

Mark Fackrell

Title: Analysing and Modelling Donor Flow in an Australian Red Cross Blood Service Donation Centre

Abstract

Mark Fackrell, Meirian Lovelace-Tozer, Stephen Wright, and Lele (Joyce Zhang)

Sufficient and quality blood supply is vital to meet demand for blood transfusions. The Australian Red Cross is the primary blood service provider Australia-wide, and depends on voluntary, non-remunerated donors. To maximise donor retention rates, it is paramount that donors have a satisfactory donation experience. Wait times have been shown to play a significant role in donors' return behaviour. In this talk, the process by which donors progress through a blood service centre is analysed to gain a better understanding of the system. We then established a model which represents the flow of donors through an Australian Red Cross Blood Service donation centre as accurately as possible. This model will assist decision makers at the strategic, tactical, and operational levels. Specifically, our model is a planning tool, enabling predictions to be made regarding new donation centres, which will focus on collecting plasma. Through simulations, we were able to emulate the running of a donation centre, and identify methods of reducing donor wait times.

Laura Boyle

Title: Validation of the Coxian phase-type distribution approach to clustering in healthcare applications

Abstract

Boyle, L., Johns, H., Marshall, A., Churilov

The Coxian sub-class of phase-type distributions represent the time to absorption of a finite-state Markov chain in continuous time through an ordered series of latent stages. Coxian distributions are frequently used to model patient length of stay (LoS) in healthcare facilities, as they capture skewed LoS distributions to a high level of accuracy and provide an improved fit over other commonly used survival distributions. An additional benefit of the Coxian distribution lies in its structure, where the latent phases of the model relate to stages of the underlying Markov process, such as short- and long-stays in hospital. Entities in the data can therefore be clustered by their exit phase of the model, providing an opportunity to identify characteristics of the individuals within each group. This research presents an investigation of the Coxian phase-type clustering approach, to determine when the method is both (i) valid, and (ii) robust. In part (i), the results from Coxian clustering are compared with actual exit phase in a range of different parameter settings. Part (ii) is concerned with robustness of the method under different fitting methods. Results will be presented using simulated data, in addition to a number of examples of Coxian parameters reported in the healthcare literature. In particular, an application of the method to emergency department data will be demonstrated, to discuss the potential for improved understanding of patient flow related issues, and communication with healthcare management.

Shaowen Qin

Title: Evidence based decision support - testing the effectiveness of patient flow decongestion solutions in a virtual hospital

Abstract

Hospitals worldwide are facing challenges of increased demand on their services, which results in frequent patient flow congestions. What can we do to alleviate the problem? Proposed solutions are available, based on either the know-how of seasoned health care professionals or theoretical research output. However, it is expensive and risky to evaluate the effectiveness of such proposed solutions in the real world. A virtual environment based on simulation modelling provides an ideal platform for testing these strategic or pragmatic solutions, providing evidence for discussion and decision support. We have developed HESMAD, a virtual hospital based on a typical Australian hospital that can be used for this purpose. We present a couple of examples of its application to test patient flow decongestion solutions and discuss the advantages and limitations of this approach.

Session: Health and Epidemics Models 2

Robert Cope

Title: Identifying the relative timing of infectiousness and symptom onset in a novel pathogen

Abstract

In an outbreak of an emerging disease the epidemiological characteristics of the pathogen may be largely unknown. A key determinant of ability to control the outbreak is the relative timing of infectiousness and symptom onset. The explanation is intuitive: If symptoms appear before infectiousness, then contact tracing and isolation strategies will be effective, whereas for post-infectiousness symptom presentation, broader, non-symptom based strategies must be adopted. Here we introduce, and demonstrate through a simulation study, a method for identifying with high accuracy the timing of infectiousness relative to symptom onset from household-stratified symptom surveillance data. Further, this can be achieved with observations taken on only a few specific days, chosen optimally, within each household. This constitutes an important tool for outbreak response. An accurate and computationally-efficient heuristic for determining the optimal surveillance scheme is introduced. This heuristic provides a novel approach to optimal design for Bayesian model discrimination.

Peter Taylor *email: taylorpg@unimelb.edu.au*

Title: How do we choose the rates in an Accumulating Priority Queue?

Abstract

Authors: Azaz Bin Sharif, David A. Stanford, Peter Taylor and lze Ziedins

In 1964, Kleinrock proposed the {\it time-dependent priority discipline} as a way of allocating customers from different classes to a server in such a way that key performance indicators based on the mean waiting time for each class are simultaneously met. More recently, Stanford, Taylor and Ziedins showed how to derive the waiting time distributions in such a queue, which they termed a Accumulating Priority Queue (APQ). This led to the possibility of using the APQ discipline to ensure that key performance indicators based on the tails of waiting time distributions, rather than mean waiting times, are satisfied. In this talk I shall present some ideas about how this can be done. Specifically I shall discuss how we can tune the accumulation rates of an APQ so that it operates `optimally'.

Belinda Spratt

Title: Reducing post-surgery recovery occupancy

Abstract

Operations Research approaches to surgical scheduling are becoming increasingly popular in both theory and practice. Often these models neglect stochasticity in order to reduce the computational complexity of the problem. In this talk, historical data is used to examine the occupancy of post-surgery recovery spaces as a function of the initial surgical case sequence. We show that the number of patients in the recovery space is well modelled by a Poisson binomial random variable. A mixed integer nonlinear programming model for the surgical case sequencing problem is presented that reduces the maximum expected occupancy in post-surgery recovery spaces. Given the complexity of the problem, Simulated Annealing is used to produce good solutions in short amounts of computational time. Computational experiments are performed to compare the methodology here to a full year of historical data. The solution techniques presented are able to reduce maximum expected recovery occupancy by 18% on average. This reduction alleviates a large amount of stress on staff in the post-surgery recovery spaces and improves the quality of care provided to patients.

Session: Energy Modelling and Forecasting

Phillip Wild

Title: An assessment of options and implications for achieving State based 50% Variable Renewable Penetration in the NEM

Abstract

There has been a lot of interest in the possibility of implementing State based 50% Variable Renewable Energy (VRE) targets applied to electricity generation in the NEM. These proposals constitute an important part of a more general policy suite aimed at decarbonising the electricity generation sector in Australia. On both a cost and technological maturity basis, such a proposal is likely to encompass significant investment in utility scale wind and solar PV plant. To investigate this aspect further, the ANEM wholesale market model of the NEM is used to investigate this transition pathway. Emphasis is given to a time-frame out to 2030 and to the current investment pipeline of VRE projects existing in each State in the NEM. Statistical based yield estimates of both solar PV and wind farm output are directly utilised in modelling, together with assessment of implications for VRE spillage effects and storage requirements.

Lui Cirocco

Title: Energy cost minimisation at a university campus fitted with thermal storage, a case study

Abstract

How can we operate a university campus's cooling plant and chilled water thermal storage elements to minimise the cost of grid supplied energy? This presentation outlines the salient features of an optimal control strategy for real time control of a campus chiller plant fitted with thermal energy storage. Forecasting, is used for estimating the various system inputs: the energy supply of onsite photovoltaic energy, the time varying price for grid purchased energy and the seasonally variable campus cooling loads. Energy prices in the Australian National Energy Market (NEM) are set every 30 minutes, and PV output is based on a fixed 1.8 MW installation distributed throughout the campus that is supplied by a 4.5 MW connection to the grid. The system controls the chiller power to meet the thermal load and interact with the chilled water storage tank.

Adrian Grantham

Title: Generating synthetic sequences of global horizontal irradiation

Abstract

When designing renewable energy systems it is common practice to use a short period of historical weather data or Typical Meteorological Year (TMY) data to evaluate the performance of a renewable energy system for a particular location. However, short periods of historical data or TMY data do not capture enough of the variation required to design a reliable renewable energy system. Longer data sequences are necessary to include a greater variety of sequences; synthetic sequences are useful because they can include sequences that have not occurred in the recorded data but are nonetheless as likely to occur as the observed data. We propose a method to generate synthetic sequences of daily and hourly global horizontal irradiation (GHI) by developing a model to deal with the deterministic component of GHI, and then adding a stochastic component using a nonparametric bootstrapping technique. We use our synthetic daily and hourly models separately and reconcile them to match afterwards, unlike other studies that generate synthetic GHI data downscaled / interpolated from \emph{observed} data. This is a fundamental difference to the literature. The synthetic daily and hourly GHI sequences can be used, for example, as input for testing the performance and operation of a solar energy system for a wider range of scenarios than previously observed data. Further, one could incorporate synthetic GHI with other synthetic renewable energy data, such as synthetic wind farm electricity output. Both of these approaches would be useful when designing a reliable renewable energy system. The synthetic sequences of daily and hourly GHI exhibit the same statistical properties as the real data. The two-sample Kolmogorov-Smirnov (KS) test shows that the distribution of the synthetic sequences of daily and hourly GHI match the distribution of the observed daily and hourly GHI respectively. The synthetic sequences of daily GHI have the same serial correlation structure as the observed data, an autoregressive model of order 1, AR(1), with similar AR(1) coefficients. Also, the synthetic sequences of hourly GHI have the same serial correlation structure as the observed data, an autoregressive model of order 3, AR(3), with similar AR(3) coefficients.

John Boland
Title: Probabilistic forecasting of solar farm output

Abstract
When supplying energy into the electricity grid, it is important to know the expected output from solar energy systems. While a point forecast of the expected output is valuable, it is only the expected value, whereas a probabilistic forecast gives a range of the most likely values of the output. A probabilistic forecast provides information about all expected outputs and allows one to asses a wide range of uncertainties and then can in turn improve decision making. A probabilistic forecast can be thought of as the *error bounds* of the forecast. These error bounds are also known as *prediction intervals*. Probabilistic forecasting is becoming more prevalent in the renewable energy forecasting literature. Note also that one of the priorities of the International Energy Agency Task 16 on "Solar resource for high penetration and large scale applications" is developing the best methods for probabilistic forecasting of solar radiation.
Previous work by Boland, Grantham *et al.* has developed procedures for conditional probabilistic forecasting of solar radiation, incorporating bootstrapping. There are subtle but significant differences between forecasting solar radiation and output from solar farms. The latter, at least in the Australian milieu, tends to reach the maximum capacity of the farm for significant periods. Thus, alteration of the methods previously developed need to be undertaken. Additionally, there is the ability to enhance the forecast skill by blending the statistical tools used in these previous works with sky camera and satellite based forecast methods.
Keywords solar radiation, forecasting, probabilistic forecasting, nonparametric, ARCH and GARCH, conditional heteroscedastic.

Session: Sustainable Fisheries

Wen-Hsi Yang *email: w.yang@uq.edu.au*
Title: Spatially and environmentally based quantitative assessment of the Queensland Saucer Scallop Fishery

Abstract
This is a joint work with Drs Michael F. O'Neill, Anthony J. Courtney, Joanne Wortmann, George M. Leigh and Matthew J. Campbell (the Department of Agriculture and Fisheries, Queensland), and Prof Jerzy A. Filar (CARM, University of Queensland).
The Queensland saucer scallop (*Ylistrum balloti*, formerly *Amusium balloti*) otter-trawl fishery used to be the most valuable commercially-fished species in Queensland ocean waters. Over the last few years, there has been growing concern among fishers, fishery managers and scientists over the decline in catch rates and annual harvest. A quantitative assessment conducted in 2016 showed that scallop abundance was at a historical low level. Based on the findings, the Queensland scallop stock was concluded to be recruitment overfished, and significant management changes to the fishery were announced accordingly. Since then, a continuation research project is focused on improving the performance of the stock assessment for better predictions for stock management. The new stock model is expected to cope with environmental influences and provide accurate predictions for the areas of interest such as SRAs (scallop replenishment areas). In this talk, the stock model accounting for spatial variations and environmental influences will be outlined along with its results about biomass prediction and reference points for fisheries management.

Trevor Hutton

Title: Northern Prawn Fishery: Common Banana Prawn fishery dynamics – the probability of getting it right!

Abstract

Trevor Hutton, Roy Deng, Rob Kenyon and Sean Pascoe

CSIRO, Brisbane, Australia

The Northern Prawn Fishery targeting Tiger and Banana prawns in northern Australia has been operating since the 1960s with extensive investment in assessment techniques. While a link between stock size and recruitment has been established for the tiger prawn species, such a relationship has remained elusive for banana prawns, and it is one of the few commercially valuable Australian species not assessed by any formal stock assessment methodology. Field studies, modelling and statistical analyses have only partly been able to un-fathom the tangled complex ecological and environmental factors that impact on this species' productivity. Advanced statistical analyses previously undertaken suggest significant annual environmental drivers in each watershed (rainfall) contribute directly to annual productivity. However, such functional relationships cannot be included in stock abundance predictions with any degree of confidence, with estimated coefficients of variation in the range of 30%. More recent research has indicated that offshore primary productivity is also important but its potential impact is highly regionalised. In this paper, a time series of fisheries independent data, which provides estimates of recruits and spawning stock, was re-analysed alongside the long time series of logbook data (on catch and effort spatially) and the previous statistical models of rainfall versus catch in order to attempt to unravel what future assessments are viable.

George Leigh

Title: How do we know whether a fishery is sustainable when the main action took place before records began?

Abstract

The early part of a fishery's history is often the most scientifically desirable period for gathering informative data. This is, however, commonly a period during which fishery data are not collected. In Queensland, for example, the commercial fishery logbook database began in 1988 but many fish stocks had been heavily fished before then, when commercial catch rates were not available. This problem is especially pertinent to yellowfin bream (*Acanthopagrus australis*), sand whiting (*Sillago ciliata*) and dusky flathead (*Platycephalus fuscus*) in south east Queensland: these species are popular targets for both commercial and recreational fishers, easily accessible to fishers from major human population centres, and the stocks have been fished down since the 1950s. Data for these three species are presented and possible solutions are described using secondary data sources that go back further in time than the commercial logbook database.

Jerzy Filar *email: j.filar@uq.edu.au*

Title: Uncertainties in an age-structured population model for Barramundi

Abstract

Sabrina Streipert, Jerzy Filar, Julie Robins, Michael O'Neill, Olivia Whybird

Lates Calcarifer (Barramundi) forms the basis of important commercial, recreational and Indigenous fisheries in Queensland. The development of quantitative models for this iconic Australian fish has been challenged by the complex nature of its life-cycle, the influence of environmental factors, as well as stocked Barramundi fingerlings. In this presentation, an age-structured population model describing Barramundi's unique characteristics is outlined. While acknowledging many desirable features of that model we focus on uncertainties that arise at various stages of both the modelling process and the context in which this process is applied.

Despite these uncertainties the model provides the best available information on recent biomass and egg production trends of that iconic Queensland species.

Session: Ecology and Conservation

Matthew Adams
Title: Maximising the benefit of ecological data using Bayesian inference for ODEs.

Abstract
Traditional deterministic models of ecological processes are limited because they provide only one prediction of future ecosystem state. This prediction may be imprecise if model parameter values have large uncertainty and/or if the model output is highly sensitive to these parameter values. One solution is to estimate probability distributions for model parameters, and propagate these distributions through to model output as a quantification of uncertainty in the predictions. The question then becomes, what are these probability distributions and how can we estimate them? And how much and/or what data do we need to collect to reduce the uncertainty in model predictions? And what can we do with these predictions? In this talk I show an applied ecological example of how Bayesian inference is used to estimate probability distributions of deterministic model parameters, using the posterior-simulation method of Sequential Monte Carlo sampling. I then show how the model outputs can provide new and easily interpretable information to ecologists and decision-makers about the ecosystem they are interested in.

Katie Lee *email: katie.lee@uq.edu.au*
Title: Where's the beef? Optimising for biodiversity in a global livestock model

Abstract
Global demand for beef is growing rapidly, which is economically profitable for beef producing nations. Unfortunately, cattle production is one of the leading drivers of land-use change contributing to the current biodiversity crisis. Biodiversity is rapidly declining worldwide, with rates of extinction approximately a thousand times higher than expected background rates. The question addressed in this study is **how do we meet future beef demand while minimising the impact on biodiversity?** Owing to the complex nature of biodiversity, the effects of beef cattle and feed crops are examined from two points of view i) land-use change and ii) the sensitivity of individual species distributions to threats. This will maintain a base level of biodiversity, while also limiting extinctions of vulnerable species. The beef distribution model is an integrated global systems model of beef production, using Pareto optimisation to balance the trade-offs of environmental and economic outcomes. A measure of mean species abundance linked to land-use is used to optimise the beef distribution model and a probability of extinction measure is used to minimise global species extinctions. The preliminary outcomes of this study will be discussed and a comparison of results from different objectives will be explored to highlight the importance of a multi-objective approach to complex environmental problems.

Ali Chauvenet
Title: Cultivating informed management: deciding between ex situ and in situ conservation for threatened plants.

Abstract
Managing threatened plant species often requires making conservation decisions under limited information. A common decision that managers face is whether to manage a plant species where it is (*in situ)* or remove the remaining individuals for *ex situ* management. We created a decision tree to help managers compare *ex situ* versus *in situ* conservation management actions in terms of the expected utility, benefit, and cost-effectiveness of potential actions.
Using this decision tree, we show thresholds at which each management action outperforms the others and describe these thresholds in management-relevant terms. We illustrate the approach with a case study of an Australian species threatened by urban development (*Croton mamillatus,* Bahr's scrub cotton), and show that for this species, the optimal course of action is to create an *ex situ* population, which can be used for reintroduction if the population decreases in the wild. Our decision tree provides managers with a customizable tool to that enables transparent consideration of the best course of conservation action for these commonly data-limited decisions.

Christopher Baker
Title: Optimising invasive species removal rates in highly uncertain systems

Abstract
Careful allocation of resources through time is critical for successful and cost-effective invasive species removal projects. The optimal management strategy depends strongly on the population dynamics of the target species, making a good understanding of system dynamics a prerequisite for good management. One particularly challenging aspect is system variation through time (for example, rainy periods will affect the population). This is both hard to predict and affects invasive species control methods. However, in the face of this uncertainty, it is currently unclear what type of variation is critical to understand and how best to deal with time-varying environments. In this talk I will discuss a mathematical formulation of invasive species control in changing environments its optimal management. This will provide guidance of how to manage a variable system, along with increasing our understanding of what aspects of systems are important to measure.

Session: Decision Making Under Uncertainty

Shane Henderson
Title: Under the hood of bike sharing

Abstract
Joint work with Daniel Freund, Nanjing Jian, Eoin O'Mahony, David Shmoys
Cornell's work on bike sharing with Citi Bike and its parent company Motivate relies on a combination of data analysis, stochastic modeling and optimization to help inform both the design and operation of the largest bike-sharing operations in North America. I'll present some of the inner workings of the stochastic modeling in this effort. I'll emphasize the use of (one of) the Poisson equation(s) in the computation of a central performance measure, a proof that the resulting objective function has important structural properties, and a heuristic underlying a simulation-optimization principle that is likely useful in many other contexts.

Matt Holden email: *m.holden1@uq.edu.au*
Title: Predicting the outcomes and cost-efficacy of anti-poaching interventions under extreme uncertainty

Abstract
NGOs and governments increasingly invest in campaigns to reduce consumer demand for wildlife products in an attempt to prevent the decline of overexploited and poached species. In this talk we analyse dynamic models of poaching given almost no data. Some of the simplest models suggest that the relative effectiveness of demand reduction compared to increased law-enforcement depends entirely on social and economic uncertainties rather than ecological ones. Illustrative case studies on wild meat and ivory reveal that campaigning to reduce demand may be more cost-effective than antipoaching enforcement if demand reduction campaigns drive modest price reductions (1 - 40%). We discuss key uncertainties in these results based on new dynamic models of poacher behavior and further extend the results to a range of anti-poaching interventions beyond law enforcement and demand reduction. The outputs from this framework can link targeted monitoring of wildlife product prices to management decisions that protect species threatened by harvest and trade.

Kate Helmstedt
Title: Impacts of management hierarchies when making environmental decisions

Abstract
Conservation decisions are rarely planned, funded, and performed by a single decision-maker. Often, high-level funders have little control over the actions that are performed on the ground, and may have poor information of the real system. This creates inefficiencies in the environmental management system, in which decision makers at the top of hierarchical systems think they can achieve more than is possible given the decisions of other actors. We model this bi-level control problem as two coupled integer programming problems, and solve using computational approaches. We show the inefficiencies that can arise in protected area planning in the US as a result of these decision-making hierarchies.

Kerrie Mengersen

Title: Which way should I cycle? A case study in Bayesian modelling for decision-making under uncertainty study

Abstract

Exposure to air pollution in the form of small particulate matter (PM2.5) is known to cause respiratory diseases and cancers. Consequently, the public are increasingly seeking health warnings associated with levels of PM2.5 using mobile phone applications and websites. Often, these existing platforms provide one-size-fits-all guidance, not incorporating any user specific preferences. Here we present a novel methodology for providing personalised air quality guidance, in the form of an optimal cycle route from A to B. This is achieved using a Bayesian decision framework in which a user's journey preferences, regarding the health impact of exposure to PM2.5, journey time and journey enjoyment, are elicited through an R shiny web application and used to create a user specific multiattribute utility function. The personalised optimal route is then identified as the one that maximises the expectation of this function. To ensure realistic predictions of PM2.5 exposure along potential routes within the decision framework, a novel Bayesian spatio-temporal model for PM2.5 is developed based on detailed, high resolution data from a single mobile air quality sensor. To facilitate computation at operational timescales, R-INLA, the computationally efficient alternative to MCMC, is used to fit and predict from the spatio-temporal model. As a proof-of-concept, the methodology is demonstrated using a set of journeys and air quality data collected in Brisbane city centre, Australia.

Session: Stochastic Operations Research

Floske Spieksma

Title: Area allocation for Picnic delivery

Abstract

The online supermarket Picnic guarantees the lowest price and free delivery of groceries to all customers. Picnic responded in 2015 to the growing trend of selling groceries online by opening as the first 100% online supermarket in the Netherlands. In contrast to the competitive Dutch market leaders Albert Heijn and Jumbo, Picnic has no physical retail stores. Customers can order their groceries through the Picnic application. In the supply chain of traditional supermarkets, groceries are transported from the warehouse to the supermarkets. Customers have to go to there and take their purchases home again. The concept of Picnic is based on making this supply chain more efficient; without physical stores, products are brought quickly and without delivery cost from the warehouse to the customers' homes.

Simultaneously, efficient movement of traffic is stimulated. Keeping durability in mind, Picnic makes use of electronic vehicles for delivery. These electronic vehicles are specially designed for delivery in urban areas. They are small and high, so they can park next to houses and they do not block streets, while having a lot of capacity. To be able to deliver without delivery cost and still have a profitable business, the routes driven by the vehicle drivers should be planned efficiently. In order to plan efficient routes, Picnic offers customers that live close to each other very similar time windows, with the aim of serving customers that live next to each other in the same trip. To do this, within the area served by a hub, three different subareas are defined with fixed time windows for delivery. Every one of these subareas is offered a different shift, which is a time window in which groceries can be delivered. When dividing a (future) delivery area of Picnic into three subareas, Picnic would like the expected amount of time needed to deliver within these subareas to be maximally equal. Therefore, in general we would like the subgraphs representing the subareas to be maximally homogeneous. Mathematically, the aim is to partition a weighted connected graph into three connected subgraphs with the sums of the vertex weights in all subgraphs maximally equal. In this talk I will discuss different approaches how we tackled this problem.

Michael McCourt

Title: Practical Aspects of Sample Efficient Optimization/Search using Probabilistic Models

Abstract

Many applications benefit from efficient search: drug discovery problems require searching the space of medical molecules; materials science requires searching the space of fabrication processes. Our motivating application is the search for optimal hyperparameters of a machine learning model in the space of possible configurations. We review the topic of Bayesian optimization using Gaussian process models of the relationship between model configurations and resulting performance. Then, we discuss complications which arise when applying the standard algorithm to practical circumstances; these complications include mixed continuous-discrete configuration domains, uncertainty in performance values, incorporating failed configurations, allowing for parallel model evaluations, etc. We survey literature and explain how we have developed strategies to address these issues at SigOpt, a company that provides a black-box hyperparameter optimization solution.

Dmitry Krass

Title: Pricing, Location and Capacity Planning of Service Facilities under Congestion

Abstract

Joint with O. Berman.

We focus on several of the most important strategic decisions for service facilities facing uncertain customer demand. These decisions include finding the locations of the facilities, determining the service capacity, and choosing the price to charge for service. Utility-maximizing customers are assumed to reside at the nodes of the network, generating stochastic demand streams. Customer utility is influenced by the price, travel distance and waiting times at the facility. Note that most service-improving decisions generate positive first-order effects and negative second-order effects. For example, a decrease in price leads to an increase in demand (a positive first-order effect), which in turn leads to a higher congestion at the facility, longer wait times and a resulting decrease in demand (a negative second-order effect). These negative feedback loops complicate the determination of optimal price, location and capacity. Other complicating factors include different time frames for pricing, capacity, and location decisions (the former a typically tactical and short-term while the latter are strategic and long-term). While theoretical considerations require joint optimization of all three variables simultaneously, practical implementation is greatly simplifies when the decisions can be separated. One of key questions we investigate is under what conditions is this separation justified. In particular, we are interested in conditions under which optimal locations are nodal (initially the possible location set is continuous). We derive a number of managerial insights and structural results. In particular, we show that first-order effects dominate the second-order ones, show that nodal optimality holds when the sensitivity of demand to distance is convex, and derive the conditions for separability of location, price and capacity decisions. We also show that using uniform prices that are not affected by locations and waiting times is optimal or asymptotically optimal under mild conditions. We show how our results can be used to develop optimal solutions for both single-facility and multiple-facility cases.

Konstantin Avratchenkov *email: konstantin.avratchenkov@inria.fr*

Title: Distributed optimization of caching devices with geographic constraints

Abstract

We consider caching in cellular networks in which each base station is equipped with a cache that can store a limited number of files. The popularity of the files is known and the goal is to place files in the caches such that the probability that a user at an arbitrary location in the plane will find the file that she requires in one of the covering caches is maximized. We develop distributed asynchronous algorithms for deciding which contents to store in which cache. Such cooperative algorithms require communication only between caches with overlapping coverage areas and can operate in asynchronous manner. The development of the algorithms is principally based on an observation that the problem can be viewed as a potential game. We confirm the efficiency of the algorithm by theoretical analysis as well as by experiments with synthetic and real network topologies.

Session: Mathematical Biology

Sophie Hautphenne

Title: Parameter estimation of branching processes with applications to the endangered black robin population

Abstract

We consider a class of continuous-time branching processes called Markovian binary trees (MBTs), in which the individuals lifetime and reproduction epochs are modeled using a transient Markovian arrival process (TMAP). We develop methods for estimating the parameters of the TMAP by using either age-specific averages of reproduction and mortality rates, or age-specific individual demographic data. Depending on the degree of detail of the available information, we follow a weighted non-linear regression or a maximum likelihood approach. We discuss several criteria to determine the optimal number of phases in the TMAP. Our results improve upon a previous MBT model for human demography, and provide insights for the future conservation management of the threatened Chatham Island black robin population.

Andrew Black

Title: Stochastic models of evolution by ecological scaffolding

Abstract

Evolutionary transitions are central to the emergence of biological complexity; for example, multicellular organisms evolved from unicellular ancestors. The question of why these transitions would occur is generally understood, but an explanation of how is still lacking mechanistic detail. The fundamental problem is to understand the emergence of properties at the collective level that would allow the collectives to participate in the process of evolution by natural selection. One solution is to recognise the importance of ecology in this process and how Darwinian properties can be scaffolded by the environment on collectives of cells. I will talk about how we are using multi-scale stochastic models to investigate this phenomenon and discuss some of the modelling challenges this work has raised.

Dietmar Oelz *email: d.oelz@uq.edu.au*

Title: Tug-of-war between molecular motors

Abstract

Intracellular transport is driven by molecular motors which pull cargo vesicles along cytoskeletal filaments. I will present a mathematical study of tug-of-war between antagonistic molecular motors. It relies on the formulation of a Markov process to describe the fluctuations of motor proteins as a random walk in what appears to be a double-well-potential. The mathematical analysis of expected hitting times allows us to derive a closed form expression for the mean run-length and run-time of cargo between random switches of direction and to predict how the effective diffusion rate in intra-cellular transport depends on key model parameters.

Brenda Vo

Title: Statistical inference for agent based models in cell biology

Abstract

Agent-based models are increasingly used to capture the real-world phenomena for many important systems in biology, ecology and medical sciences. These models have several advantages: first, they are able to incorporate important characteristics such as heterogeneity and stochasticity; second, they produce image-based and movie-based information which is ideally suited to collaborative investigations involving statisticians and applied scientists. However, the likelihoods, the functions that describe the probability of the observed data given parameter values, for these models are not analytically or computationally tractable. This makes statistical inference for these models challenging. To overcome these limitations, several new Bayesian “likelihood-free” techniques have emerged. In this talk, I will discuss about the principles as well as advantages and disadvantages of these methods with applications in cell biology.

Session: Networks, Queues and Control

Rik Timmerman *email: r.w.timmerman@tue.nl*
Title: Platoon forming algorithms for intelligent street intersections

Abstract
We study intersection access control for autonomous vehicles. Platoon forming algorithms, which aim to organize individual vehicles in platoons, are very promising. To create those platoons, we slow down vehicles before the actual arrival at the intersection in such a way that each vehicle can traverse the intersection at high speed. This increases the capacity of the intersection significantly, offering huge potential savings with respect to travel time in nowadays traffic. We propose several new platoon forming algorithms and provide an approximate mean delay analysis for our algorithms. A comparison between the current day practice at intersections (through a case study in SUMO) and our proposed algorithms is provided. Simulation results for fairness are obtained as well, showing that platoon forming algorithms with a low mean delay sometimes are relatively unfair, indicating a potential need for balancing mean delay and fairness.

Stella Kapodistria
Title: Integrated learning and decision making

Abstract
This is joint work with Collin Drent.

Inspired by the practice of Philips and the literature in the field, we considered an illustrative case (maintenance of screens) for which a machine learning approach is used to predict imminent failures. For this case: 1. We tested different approaches to gain trust and interpretability in the model and to simplify the underlying machine learning mechanism. 2. We built a surrogate simple stochastic model, reducing the dimension of the problem. 3. From the intuition built from the surrogate model, we showed how to enhance the machine learning approach accounting for the maintenance decision and its underlying costs.

Daniel Silva
Title: Last-mile on-demand public transportation service

Abstract
We consider modeling approaches for the analysis of last-mile, on-demand, public transit services. Specifically, we are interested in enabling evaluation of whether specific demand profiles and other system parameters allow for efficient implementation of such a service. We develop a series of Markov-chain models employing spatially and temporally distributed queuing systems. We will present some analytical conclusions as well as simulation results. Additionally, we briefly discuss the probability distribution of TSP-tour lengths for very few randomly distributed customers, which we use in our analytical models.

Ivo Adan
Title: Online batching in high throughput poultry processing lines

Abstract
We consider batching processes in high throughput poultry processing lines. The key objective is to form batches of arriving items that minimize the difference between the actual and target batch weight. Items are allocated first-come-first-served discipline to available bins in the batching machine and the exact weight of items is known over a given horizon of arriving items. We develop a hybrid algorithm combining a genetic algorithm and local search methods to assign items to the available bins. Simulations based on real-world data suggest that the proposed algorithm produces high quality solutions within a feasible time limit.

Session: Simulation and Computation Tools

Anna Foeglein
Title: Modern paradigms, techniques and tools in Discrete Event Simulation

Abstract
In theory, simulation is just the straightforward numerical implementation of a mathematical model. In practice, questions arise at every turn, from the selection of what modelling paradigms to use and the level of detail to incorporate, through to the choice of modelling package and the handling of randomness in model and data. This talk gives an overview of some current techniques in Discrete Event Simulation, and presents some ways of deriving insight from uncertainty from a commercial simulation practitioner's point of view.

Matthew Roughan
Title: Who is the mightiest Avenger?

Abstract
The Marvel Cinematic Universe is the most successful movie franchise ever. Its revenue is measured in the billions, and its fans numbered in the hundreds of millions. Understanding its success quantitatively is therefore of considerable interest. One aspect of that success is the large cast of colourful superheroes that populate its universe. And a perennial question about these characters is "who is mightiest?" We can tackle this question using ideas that have for many years provided ratings for contestants in sports (e.g., Soccer) or games (e.g., Chess). But there are many rating systems (Elo, Colley, Massey,...), often founded on appealing and intuitive, but contrasting ideas from linear algebra or stochastic modelling. The goal here is not simply to dump a new dataset into an existing ratings system as has often been done, but rather to use this data as a way to better understand ratings systems in general. In this presentation I will discuss a new Julia package unifying competition ratings methods. Julia is ideal for this task as it provides (i) high-performance computations and efficient memory use, (ii) a large variety of supporting packages for statistical modelling and stochastic simulation, and (iii) a sophisticated type system that allows us to create a unifying framework for diverse methods. And I will describe using the package to understand this one particular aspect of the Marvel films.

Yoni Nazarathy *email: y.nazarathy@uq.edu.au*
Title: Simulation with the Julia language

Abstract
In this talk we introduce the Julia programming language and illustrate a few simple examples where it is used for simulation of stochastic models. This includes, discrete event simulation, simulation of systems with additive noise, simulation of systems controlled via reinforcement learning and simulation of continuous time Markov chains using the Doob-Gillespie algorithm. The purpose of the talk is to illustrate to the audience how Julia may be practically used, allowing both ease of programming and fast running times.

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