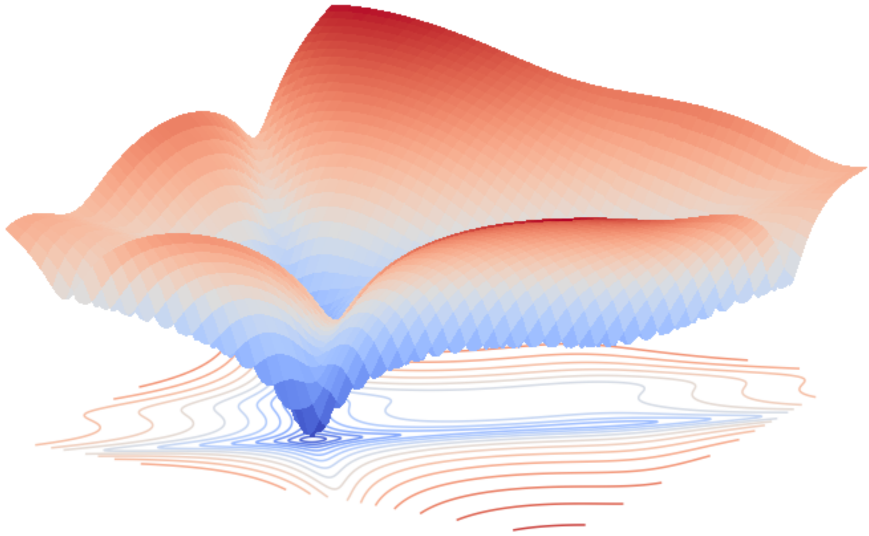

Workshop on Optimisation, Metric Bounds, Approximation and Transversality (WOMBAT)

joint with

Workshop on the Intersections of Computation and Optimisation (WICO)

University of Sydney

11–15 December 2023

Event Sponsors

Discipline of Business Analytics, University of Sydney Business School
School of Mathematics and Statistics, University of Sydney

THE UNIVERSITY OF SYDNEY

Conference Information

We would like to acknowledge and pay respect to the traditional owners of the land on which we meet; the Gadigal people of the Eora Nation. It is upon their ancestral lands that the University of Sydney (Camperdown Campus) is built.

In 2023, the annual Workshop on Optimisation, Metric Bounds, Approximation and Transversality (WOMBAT 2023) will be run in conjunction with the second biennial Workshop on the Intersections of Computation and Optimisation (WICO 2023). Together, these workshops aim to bring together Australian and international researchers interested in all areas of optimisation and computational mathematics.

Location

The workshop will be entirely in-person at the University of Sydney Business School, Abercrombie Building (H70), corner Abercrombie Street and Codrington Street, Darlington NSW 2006. Google maps link.

The University of Sydney's Camperdown/Darlington campus is located in central Sydney. It is accessible by many bus routes, particularly along Parramatta Rd and City Rd/King St. The nearest train station is Redfern, from which you can catch trains to most areas of Sydney.

Room Information

All talks will be held in Room 1050 (Case Study Lecture Theatre) on level 1. If you enter building H70 using the main entrance on Codrington St (where you will see a large spiral staircase), you can find room 1050 by going up the small flight of stairs on the right-hand side. Lift access is also available.

The room has HDMI and USD-C ports to connect to projectors, or you can use a USB drive to load a presentation onto the room's desktop computer.

The welcome reception (Monday 5pm) will be in the Refectory on level 5 of the same building (H70).

Tourism information

The nearest shopping and dining strips to the University of Sydney are King St (Newton) and Glebe Point Rd (Glebe). It is a short bus trip from the university to Haymarket/Chinatown or the city.

- Sydney tourism
- Visit New South Wales
- Sydney weather forecast
- Transport NSW (public transport information)
- Sydney Airport transport — the easiest way from the airport is to catch the T8 train to the city to Central Station, then change to a T1/T2/T4/T9 train to Redfern (1 stop) or catch a bus (423/426/428/430) from Pitt St to City Rd (University of Sydney stop).

All Sydney public transport allows you to tap on/off with your credit card or digital wallet (Transport NSW payment information). The TripView Lite app is an excellent (free) way to plan trips on public transport.

Catering

All morning and afternoon teas listed on the program (i.e. no afternoon tea on Wednesday or Friday) are provided. There are many nearby options for lunch, including:

- Abercrombie Terrace (at the main entrance of the H70 building)
- Café Abercrombie, 386 Abercrombie St Darlington (200m walk from H70)
- Ralph's café on boardwalk, behind the university Sports and Fitness centre, corner Codrington St & Maze Crescent South (150m walk from H70)
- Beirut falafel, 254 Abercrombie St Darlington (500m walk from H70)
- Taste baguette, New Law Building (F10A) on Eastern Avenue (500m walk from H70)

as well as numerous other options on King St in Newtown (approx. 10–15 min walk from H70).

Acknowledgements

We would like to thank the University of Sydney's Discipline of Business Analytics and School of Mathematics and Statistics for their financial support. They also provided administrative support, along with the Sydney Mathematical Research Institute (SMRI).

WOMBAT and WICO are events overseen by the Mathematics of Computation and Optimisation (MoCaO) Special Interest Group of the Australian Mathematical Society (AustMS).

Organising Committee

Mareike Dressler (UNSW Sydney)
Nam Ho-Nguyen (University of Sydney)
Quoc Le Gia (UNSW Sydney)
Dmytro Matsypura (University of Sydney)
Lindon Roberts (University of Sydney)

Timetable

	Monday 11th	Tuesday 12th	Wednesday 13th	Thursday 14th	Friday 15th
9am	Registration	Plenary: Georg Stadler	Plenary: Fatma Kilinc-Karzan	Plenary: Ricardo Ruiz-Baier	Plenary: Andrea Raith
	Plenary: Andreas Ernst				
10am		Ian Sloan	Samir Adly	Tomas Lagos	Alexander Gilbert
	Morning tea	Morning tea	Morning tea	Morning tea	Morning tea
11am	Tiangang Cui	Ayesha Sohail	Li Chen	Elizabeth Harris	Anupam Kumar Pandey
	Jordan Shaw-Carmody	Vinesha Peiris	Johnson Phosavanh	Quoc Thong Le Gia	James Nichols
12pm	Open problems	Open problems	Open problems	Open problems	Scott Lindstrom
					Andrew Eberhard
1pm	Lunch	Lunch	Lunch	Lunch	(close at 1pm)
2pm	Lindon Roberts	Nam Ho-Nguyen	Guoyin Li	Tamanna Yadav	
	Vera Roshchina	Bethany Caldwell	Lien Nguyen	Yingkun Huang	
3pm	Discussion	Discussion	Ponpot Jartnillaphand	Discussion	
	Afternoon tea	Afternoon tea	(close at 3.30pm)	Afternoon tea	
4pm	Sandy Spiers	Daniel Uteda		Hongzhi Liao	
	Felipe Atenas	Minh Dao		Saeid Kazemzadeh	
5pm	Welcome reception				

All talks will be held in Room 1050 (Case Study Lecture Theatre) of the Abercrombie Building (H70), and all times listed are AEDT (UTC+11). The welcome reception will be held in the Refectory on level 5 of building H70.

Plenary Talks

Public transport network optimisation

Andreas Ernst
Monash University

Indonesia is working hard to increase its living standards and create economic growth by building new infrastructure. A new railway line is being constructed in South Sulawesi, a province of Indonesia. How can the province get the most benefit out of this infrastructure? They are keen to build a public transport network, but a single rail line does not make a whole transport system. The problem of creating the best transport network, can be formulated as a large-scale, non-linear mixed integer program. It includes combinatorial network design constraints and a logistic function to model the competitiveness of the public transport compared to private vehicles. This talk will discuss the modelling compromises and computational approaches that have been used to tackle the challenging optimisation problem.

Optimization-based estimation of tail probabilities in complex systems with uncertainty

Georg Stadler
New York University

Estimation of tail probabilities in systems that involve uncertain parameters or random forcing is important when these unlikely events have severe consequences. Examples of such events are hurricanes, energy grid blackouts or failure of engineered systems. I will discuss a connection between extreme event probability estimation and constrained optimization that is established by large deviation theory. The approach leads to a practical method to estimate small probabilities, and an interesting class of challenging, large-scale constrained optimization problems.

New Perspectives on Deriving Compact Extended Formulations for Optimization Problems with Indicator Variables

Fatma Kılınç-Karzan
Carnegie Mellon University

Applications in statistics and data sciences require modeling an inherit sparsity as well as structural relationships among variables and often lead to NP-Hard nonconvex problems. Sparsity and structural relations in such problems are usually modeled by introducing indicator (binary) variables associated with the original continuous variables and enforcing complementarity relations between them. We consider optimization problems with convex objective functions of the continuous variables and arbitrary constraints on their associated indicators, and study the resulting conic mixed-binary sets with complementarity restrictions. For such sets, by studying the recessive directions and also utilizing perspective functions, we provide a practical framework to derive compact, ideal, and conic-representable extended formulations. The size of our extended formulation depends on the "rank" of the function and the presence of sign restrictions. Moreover, our techniques highlight that the complexity of the convex hull characterizations of these conic mixed-binary sets with complementarity restrictions hinges solely on the complexity of the convex hull characterization of a set defined by only the indicator variables. This then enables us to take advantage of the extensive research on convex hull descriptions of binary sets and related sophisticated optimization software. In addition, our results unify and generalize previous results established for special cases, e.g., perspective reformulation for separable functions, non-separable rank-one functions, or low-rank quadratic functions optimized over domains with combinatorial constraints on indicator variables and possibly sign constraints on continuous variables. On the computational side, we illustrate the effectiveness of our approach on sparse structured logistic regression problems.

This is joint work with Soroosh Shafieezadeh-Abadeh.

Robust mixed finite element methods for the Biot-Stokes interfacial coupling

Ricardo Ruiz-Baier
Monash University

I will discuss discretisations for a fluid-poroelasticity interaction model. A five-field finite element scheme solves for Stokes velocity-pressure and Biot displacement-total pressure-fluid pressure. One of the distinctive features of the formulation is that its stability is established robustly in all material parameters. We propose robust preconditioners for this perturbed saddle-point problem using operators in weighted fractional spaces at the interface. The performance is corroborated by several test cases.

Problem decomposition in biobjective optimisation

Andrea Raith
University of Auckland

Decomposition techniques for optimisation problems have significantly improved the ability to solve problems of ever-increasing complexity and problem size by decomposing a complex optimisation problem into related smaller ones. The premise of a decomposition technique is to omit parts of the problem that are unlikely to influence the final solution, and iteratively include, as needed, the parts which will have an impact. Many real-world problems are formulated with two or more objectives and solving such multiobjective optimisation problems means identifying sets of so-called efficient solutions representing available trade-offs. Building on a biobjective (parametric) version of the well-known simplex algorithm for biobjective linear programmes, different decomposition approaches are presented here. One approach, also known as column generation, is to omit some or all variables (corresponding to columns of the constraint matrix) from the original optimisation problem and then iteratively re-introduce them into the problem. An alternative approach, known as Benders decomposition, separates decision variables into different stages and related optimisation problems, and then dynamically adds constraints into the first-stage formulation to capture the full problem. We present theoretical developments and algorithms that adapt these ideas into decomposition techniques for BLPs. We will also briefly discuss a so-called math-heuristic approach that combines exact optimisation concepts with a neighbourhood search heuristic that can be used instead of an exact column generation approach to solve challenging biobjective (mixed) integer problems.

Contributed Talks

Scalable conditional transport maps using tensor trains

Tiangang Cui
University of Sydney

We present a novel offline-online method to mitigate the computational burden of characterizing posterior random variables in statistical learning. In the offline phase, the proposed method learns the joint law of the parameter and the observable random variables in the tensor-train (TT) format. In the online phase, the resulting conditional transport can generate the posterior random variables given newly observed data in real time. Compared with normalizing flow techniques, the proposed method relies on function approximation and is equipped with a thorough performance analysis. The function approximation perspective also allows us to extend the capability of transport maps in challenging problems with high-dimensional observations and high-dimensional parameters using gradient-based dimension reduction. We demonstrate the efficiency of the proposed method on various statistical learning tasks in ordinary differential equations (ODEs) and partial differential equations (PDEs).

Optimising error estimators in the Reaction-Diffusion-Convection problem using an AFEM approach

Jordan Shaw-Carmody
University of Newcastle

The Adaptive Finite Element Method (AFEM) is a variation of the Finite Element Method (FEM), adapted so that the elements to be refined are chosen according to their estimated error. Each element in the mesh of the domain has its estimated error calculated at every iteration of the AFEM loop until an acceptable tolerance for the error has been reached. Here we demonstrate that the error estimator can use the same local projection operator as that present in the stabilisation term of the Reaction-Diffusion-Convection problem. The proposed local projection operator uses biorthogonal functions so that the matrix to be inverted is diagonal and therefore more efficient. The transition layers within the problem are found and refined more efficiently using AFEM than when using normal uniform refinement implemented with FEM.

Expected decrease for derivative-free algorithms using random subspaces

Lindon Roberts
University of Sydney

When optimising functions that are black-box, noisy and/or computationally expensive, it may be impractical to get gradient information, requiring the use of derivative-free optimisation (DFO) algorithms.

Compared to traditional nonlinear optimisation methods, DFO methods are typically not as scalable (in terms of number of decision variables). However, recent DFO approaches based on iterative steps in randomly drawn subspaces has shown promise as a way of improving scalability. In this talk, I will outline these approaches, and a novel average-case analysis that demonstrates why lower dimensional subspaces typically perform well (even though this is not guaranteed by existing theory).

This is joint work with Warren Hare (UBC) and Clément Royer (Université Paris-Dauphine PSL).

Face-relative interior of convex sets

Vera Roshchina
UNSW Sydney

The talk covers a new notion of face relative interior for convex sets in topological real vector spaces. Face relative interior is grounded in the facial structure, and may capture the geometry of convex sets in topological vector spaces better than other generalisations of relative interior. We show that the face relative interior partitions convex sets into face relative interiors of their closure-equivalent faces (different to the partition generated by intrinsic cores), establish the conditions for nonemptiness of this new notion, compare the face relative interior with other concepts of convex interior and prove basic calculus rules.

This is based on joint work with Dr Reinier Díaz Millán (Deakin University).

Kernel method for parametric PDE with doubled convergence rate

Ian Sloan
UNSW Sydney

This talk, based on joint work with Frances Kuo and Vesa Kaarnioja, describes a periodic kernel method based on lattice points. It has a doubled rate of convergence compared to previously known estimates. With the use of “serendipitous” weight parameters the cost grows linearly with respect to both dimension and number of lattice points.

Proximal splitting methods through the lenses of Moreau-type envelopes

Felipe Atenas
University of Melbourne

In the context of convex optimization, the proximal point algorithm was devised to solve minimization problems, by regularizing the objective function using quadratic terms. This regularization results in the so-called Moreau envelope, a function that can be seen as a smoothing of the function, since under mild regularity assumptions, the envelope enjoys nice continuity and differentiability properties. The smoothness of the envelope can be exploited through the following relationship: one proximal point iteration on the original function corresponds to a gradient descent step applied to the envelope. Hence, methods of proximal type can be understood using one of the simplest methods in differentiable optimization. In this talk, we will discuss smoothing functions resembling the Moreau envelope, tailored for two splitting methods: the forward-backward and the Douglas-Rachford methods. We will explore smoothness properties of such envelopes beyond convexity, and how they relate to convergence properties of these methods. We will also address the issue of avoidance of saddle points, and how these methods converge to local minimizers when randomly initialized.

Machine Learning and Optimal Control Problems Interface

Ayesha Sohail
University of Sydney

Optimisation is a challenging field of research, with applications in the fields of business, engineering, biology and many more. It is difficult to solve the complex problems of optimisation, in higher dimensional spaces. The target can be achieved subject to lengthy calculations and deep knowledge of possible constraints. With the advancement in the field of machine learning and data science, the optimal control problems can be improved by developing an interface.

During this presentation, we will discuss some numerical examples where the complexity can be managed with the aid of smart programming tools.

Kolmogorov-Arnold representation theorem

Vinesha Peiris
Curtin University

Even though the Kolmogorov-Arnold representation theorem (KA theorem) has been very well known since 1957, nobody is fully aware of how this function representation works. Therefore, this has been an unsolved problem for many decades. Constructing the representation is as significant as KA theorem itself, particularly, in practical problems. Some modified versions of this theorem have similar structures as neural networks which are the building blocks of Artificial Intelligence, but these interpretations have been highly arguable for several years. In this talk, we walk through the history of the KA theorem, its relation to neural networks and recent developments in this area.

Projection-Free Methods for Solving Convex Bilevel Optimization Problems

Nam Ho-Nguyen
University of Sydney

When faced with multiple minima of an “inner-level” convex optimization problem, the convex bilevel optimization problem selects an optimal solution which also minimizes an auxiliary “outer-level” convex objective of interest. Bilevel optimization requires a different approach compared to single-level optimization problems since the set of minimizers for the inner-level objective is not given explicitly. In this paper, we propose new projection-free methods for convex bilevel optimization which require only a linear optimization oracle over the base domain. We provide convergence guarantees for both inner- and outer-level objectives that hold under our proposed projection-free methods. In particular, we highlight how our guarantees are affected by the presence or absence of an optimal dual solution. Lastly, we conduct numerical experiments that demonstrate the performance of the proposed methods.

Douglas–Rachford Algorithm for Control- and State-Constrained Optimal Control Problems

Bethany Caldwell
University of South Australia

The Douglas–Rachford algorithm has been applied to many optimization problems due to its simplicity and efficiency but the application of this algorithm to optimal control is less common. In this talk we utilize this method to solve state- and control-constrained linear-quadratic optimal control problems. Instead of the traditional approach where we discretize the problem and solve it using large-scale finite-dimensional numerical optimization techniques we split the problem into two subproblems and use projection methods to find a point in the intersection of the solution sets of these two subproblems hence giving the solution to the original problem. In a 2022 preprint we provide numerical results and comparisons for various other projection methods as well as the Douglas–Rachford algorithm.

Cutting Plane Algorithms are Exact for Euclidean Max-Sum Problems

Sandy Spiers
Curtin University

This talk addresses binary quadratic programs in which the objective is defined by a Euclidean distance matrix, subject to a general polyhedral constraint set. This class of nonconcave maximisation problems includes the capacitated, generalised and bi-level diversity problems as special cases. We introduce two exact cutting plane algorithms to solve this class of optimisation problems. The new algorithms remove the need for a concave reformulation, which is known to significantly slow down convergence. We establish exactness of the new algorithms by examining the concavity of the quadratic objective in a given direction, a concept we refer to as directional concavity. Numerical results show that the algorithms outperform other exact methods for benchmark diversity problems (capacitated, generalised and bi-level), and can easily solve problems of up to three thousand variables.

Minimising a Separable Sum Coupled by a Difference of Functions and Linear Constraints

Minh N. Dao
RMIT University

In this work, we develop a splitting algorithm for solving a broad class of linearly constrained composite optimisation problems, whose objective function is the separable sum of possibly non-convex non-smooth functions and a smooth function, coupled by a difference of functions. This structure encapsulates numerous significant non-convex and non-smooth optimisation problems in the current literature including the linearly constrained difference-of-convex problems. Relying on the successive linearisation and alternating direction method of multipliers, the proposed algorithm exhibits the global subsequential convergence to a stationary point of the underlying problem. We also establish the convergence of the full sequence generated by our algorithm under some mild assumptions. The efficiency of the proposed algorithm is tested on a robust principal component analysis problem and a non-convex optimal power flow problem.

Accelerated Dynamics with Dry Friction Via Time Scaling and Averaging of Doubly Nonlinear Evolution Equations

Samir Adly
University of Limoges

In a Hilbert framework, with the aim of convex differentiable optimization, we analyze the long-time behavior of inertial dynamics with dry friction. We rely on the general acceleration method recently developed by Attouch, Bot and Nguyen, which consists of applying the time scaling and then averaging method to a first order in time continuous differential equation.

In our approach, we start from a doubly nonlinear first-order evolution equation involving two potentials: one is the differentiable function f to be minimized, which acts on the state of the system via its gradient, and the other is the dry friction potential $\varphi(x) = r\|x\|$ which acts on the velocity vector via its subdifferential.

We so obtain a second-order in time evolution system involving dry friction, asymptotically vanishing viscous damping (directly related to Nesterov's accelerated gradient method), and a damping driven by the Hessian in the implicit form. The mathematical analysis does not require developing a Lyapunov analysis for inertial systems.

We obtain fast convergence rates for both the system and its dual, which governs the evolution of the gradients, using Riemannian gradient structure.

Robust Actionable Prescriptive Analytics

Li Chen
University of Sydney

We propose a new robust actionable prescriptive analytics framework that leverages past data and side information to minimize a risk-based objective function under distributional ambiguity. Our framework aims to find a policy that directly transforms the side information into implementable decisions. Specifically, we focus on developing actionable response policies that offer the benefits of interpretability and implementability. To address the potential issue of overfitting to empirical data, we adopt a data-driven robust satisficing approach that effectively handles uncertainty. We tackle the computational challenge for linear optimization models with recourse by developing a new tractable safe approximation for robust constraints, accommodating bilinear uncertainty and general norm-based uncertainty sets. Additionally, we introduce a biaffine recourse adaptation to enhance the quality of the approximation. Furthermore, we present a localized robust satisficing model that efficiently solves combinatorial optimization problems with tree-based static policies. Finally, we demonstrate the practical application of our framework through a simulation case study on risk-minimizing portfolio optimization using past returns as side information. We also provide a simulation case study on how the framework can be applied to obtain an interpretable policy for allocating taxis to different demand regions in response to weather information.

An improved algorithm to find the most degree-central shortest path

Johnson Phosavanh
University of Sydney

The degree centrality of a node, defined to be the number of nodes adjacent to it, can be used as a measure of the importance of a node to the structure of a network. This metric can be abstracted to paths in a network, where the degree centrality of a path is defined to be the number of nodes connected to it. In this talk, we reconsider the problem of finding the most degree-central shortest path in a graph. By modifying Dijkstra's algorithm, we provide a more efficient algorithm than the previous algorithm. We conduct a numerical study of our algorithm on synthetic and real-world networks and compare our results to the existing literature.

Frank-Wolfe type methods for nonconvex inequality-constrained problems

Guoyin Li
UNSW Sydney

The Frank-Wolfe method (also known as the conditional gradient method) implements efficient linear optimization oracles for minimizing a smooth function over a compact convex sets. This method and its variants form a prominent class of projection-free first-order methods for solving several important application problems such as matrix completion. In this talk, we extend this method to minimize smooth functions over a possibly nonconvex compact set, which is defined as the level set of a difference-of-convex function that satisfies mild regularity conditions. We will discuss convergence and present some preliminary numerical experiments to illustrate the empirical performance of the proposed algorithm.

Active Support Identification for Finite Max Functions

Daniel Uteda
University of Melbourne

Minimisation of finite max functions is prevalent throughout nonsmooth optimisation. However, the set of functions equal to the maximum, called the support, at the minimiser can be significantly smaller than the original index set. After measuring this desired support, we can thus create a simpler but equivalent problem by discarding a potentially large proportion of functions. This in turn leads to improved convergence rates at the least, and for some problems the information obtained can give rise to an analytic solution. In this talk based on recent work, we begin by describing a simple model to solve the original minimisation problem, which can exploit the first-order information of the functions inside the maximum. We then describe how the support can be measured, without any knowledge of the solution, using several approaches, some of these new and some existing. Time permitting, we will then present some numerical results on the accuracy of these approaches, and how they can be used in a numerical setting to achieve faster convergence rates.

Finite-time nonconvex optimisation using time-varying dynamical systems

Lien T. Nguyen
RMIT University

In this work, we study the finite-time convergence of the time-varying dynamical systems for solving convex and nonconvex optimization problems in different scenarios. We first show the asymptotic convergence of the trajectories of dynamics while only requiring convexity of the objective function. Under the Kurdyka-Łojasiewicz (KL) exponent of the objective function, we establish the finite-time convergence of searching trajectories to the optima from any initial points. Making use of the Moreau envelope, we adapt our finite-time convergent algorithm to solve weakly convex nonsmooth optimization problems. In addition, we unify and extend the contemporary results on the KL exponent of the Moreau envelope of weakly convex functions. A dynamical system is also introduced to find a fixed point of a nonexpansive operator in finite time and fixed time under additional regularity properties. We then apply it to address the composite optimisation problems with finite-time and fixed-time convergence.

Parallel Machine Scheduling with Flexible Resources and Shift Consideration

Ponpot Jartnillaphand
Curtin University

This talk presents a challenging problem related to team formations, team assignments, and job schedules. The presented problem incorporates shift consideration into the static Unspecified Parallel Machine Flexible Resource Scheduling (UPMFRS) problem. In the literature, teams are simplified as machines that perform jobs throughout the day without any breaks. However, these teams cannot work continuously within a day, as they require breaks between shifts. Therefore, we involve shift considerations where teams are not allowed to perform jobs in consecutive shifts. We consider flexible workers, capable of performing any job, who are distributed among different teams in different shifts to undertake various tasks. The number of teams in each shift is treated as a decision variable. The duration of each job is defined by the number of workers in a team assigned to it. The objective function is to minimise the makespan, which represents the overall schedule completion time while adhering to precedence constraints. An integer linear programming model is formulated for the proposed problem, which is difficult to solve on a large scale. Therefore, we address the dimensionality challenge by developing data-preprocessing techniques and a bilinear branch-and-check algorithm that utilises bilinear valid inequalities to accelerate convergence. The numerical results indicate that our algorithm is more efficient than the IBM CPLEX standard branch-and-cuts.

Robust multi-period wildfire fuel treatment planning

Tomas Lagos
University of Sydney

Wildfires pose grave risks to human life, health, and infrastructure. To address these challenges, proactive fuel treatment strategies are crucial before each fire season. However, managing fuel treatment resources becomes problematic due to species protection and forest maturity considerations. Furthermore, inherent inaccuracies of fuel load accumulation models introduce uncertainties from approximations and parameter calibration. We extend previous work and introduce a robust modeling approach for devising multi-year treatment strategies. Our robust mixed-integer optimization model incorporates worst-case scenarios of fuel growth and treatment effects, offering adjustable uncertainty levels. Our scalability study on random instances shows that the difficulty to solve the problem is mainly driven by long time horizons with a small treatment budget (5% of locations treatment budget). From our real-life application in south-east Australia, we derive several practical insights, such as the value and the cost of the robust solutions and the structure of the solution depending on different optimization objectives.

This is joint work with Nam Ho-Nguyen (University of Sydney), Dmytro Matsypura (University of Sydney) and Oleg Prokopyev (University of Zurich).

Preprocessing Algorithm for the Minimum Volume Covering Ellipsoid Problem

Elizabeth Harris
University of Newcastle

We want to compute the ε-approximate minimum volume covering ellipsoid (MVCE) for a set of n points in $\mathbb{R}^d$. Inspired by the elimination strategy of Harman and Pronzato, we propose a preprocessing algorithm which iteratively deletes interior points of the MVCE. We show that our algorithm outputs a subset containing the boundary points of the MVCE, that is, the MVCE of the subset is identical to the

MVCE of the full dataset. Our algorithm works well when there are many points with very small leverage score. In fact, if the leverage scores follow a power law decay, we can show an upper bound on the number of remaining points. We then demonstrate the performance of our algorithm on synthetic datasets.

QMC/Galerkin finite element methods for linear elasticity equations with uncertainties

Quoc Thong Le Gia
UNSW Sydney

We explore a linear inhomogeneous elasticity equation with random Lamé parameters. The latter are parameterized by a countably infinite number of terms in separated expansions. The main aim of this work is to estimate expected values (considered as an infinite dimensional integral on the parametric space corresponding to the random coefficients) of linear functionals acting on the solution of the elasticity equation. To achieve this, the expansions of the random parameters are truncated, a high-order quasi-Monte Carlo (QMC) is combined with a sparse grid approach to approximate the high dimensional integral, and a Galerkin finite element method (FEM) is introduced to approximate the solution of the elasticity equation over the physical domain. The error estimates from (1) truncating the infinite expansion, (2) the Galerkin FEM, and (3) the QMC sparse grid quadrature rule are all studied. For this purpose, we show certain required regularity properties of the continuous solution with respect to both the parametric and physical variables. To achieve our theoretical regularity and convergence results, some reasonable assumptions on the expansions of the random coefficients are imposed. Finally, some numerical results are delivered.

This is a joint work with J. Dick, K. Mustapha and T. Tran (UNSW Sydney)

Optimality and duality results for interval-valued semi-infinite programs with vanishing constraints

Tamanna Yadav
Indian Institute of Technology, Roorkee

An optimization model having finite number of variables with infinite number of constraints is called a semi-infinite optimization problem. Extensive research is being conducted in this direction, not only due to its remarkable structural features but also because of its various applications in engineering, production, marketing, finance, and management. In this work, we focus on a non-smooth semi-infinite optimization model having vanishing constraints. This work presents various findings, starting with the development of necessary and sufficient optimality conditions for the optimization model. Further, Wolfe's and Mond-Weir type dual models are formulated for the considered semi-infinite optimization problem, and weak, strong and converse duality results are established.

Semi-Definite Program Reformulation for Distributionally Robust Optimisation, with Applications in Newsvendor Problems

Yingkun Huang
University of New South Wales

Moment problems find the worst-case probability measure from a class of distributions governed by expectation inequality constraints. Unfortunately, evaluating a multi-dimensional integral for the expectations and searching through the infinite-dimensional space of probability distributions is computationally hard. Motivated by the Newsvendor problem, we convert a class of moment problems with difference-of-convex sums-of-squares polynomials into a semi-definite program using optimisation duality theory. In particular, we show how an optimal probability measure is obtained for a subclass of moment problems by solving a single SDP. Further, we present exact SDP reformulations for distributionally robust optimization (DRO) problems with losses quantified by the considered class of moment problems. Finally, as an application, we derive exact SDP relaxation results for a generalized Newsvendor problems.

Douglas–Rachford is the best projection method

Hongzhi Liao
UNSW Sydney

We prove that the Douglas–Rachford method applied to two closed convex cones in the Euclidean plane converges in finitely many steps if and only if the set of fixed points of the Douglas–Rachford operator is nontrivial. We analyze this special case using circle dynamics.

We also construct explicit examples for a broad family of projection methods for which the set of fixed points of the relevant projection method operator is nontrivial, but the convergence is not finite. This three-parametric family is well known in the projection method literature and includes both the Douglas–Rachford method and the classic method of alternating projections.

Even though our setting is fairly elementary, this work contributes in a new way to the body of theoretical research justifying the superior performance of the Douglas–Rachford method compared to other techniques. Moreover, our result leads to a neat sufficient condition for finite convergence of the Douglas–Rachford method in the locally polyhedral case on the plane, unifying and expanding several special cases available in the literature.

Reducing computation cost of evolutionary optimization algorithms in structural engineering applications

Saeid Kazemzadeh
Atilim University

In the past few decades, evolutionary optimization methods have been extensively employed for optimum design of steel skeletal structures. In spite of the advantageous features of evolutionary optimization algorithms, excessive computational of these algorithms in structural engineering applications can be stated as a main shortcoming. To overcome this difficulty, different approaches have been proposed and successfully applied in the literature of structural optimization. This study aims to outline the recent advancements in reducing the computation cost of evolutionary optimization algorithms in structural engineering applications. More specifically, recently developed evolutionary optimization techniques for handling challenging design examples of steel skeletal structures with numerous design variables are elaborated and discussed. Finally, the role of engineering design optimization competitions to provide useful platforms for benchmarking evolutionary optimization algorithms is emphasized.

Density estimation in uncertainty quantification using quasi-Monte Carlo methods with preintegration

Alexander Gilbert
UNSW Sydney

Quasi-Monte Carlo (QMC) methods have previously shown great success in tackling difficult high-dimensional problems that often occur in uncertainty quantification. However, a key limitation is that they are limited to approximating only the expected value of the quantity of interest. One of the main reasons for this limitation are the smoothness requirements, such as requiring square-integrable mixed first derivatives. In this talk, we present a method for approximating the cumulative distribution function (cdf) and probability density function (pdf) of a quantity of interest coming from the solution of an elliptic PDE with lognormal random coefficients. The key idea is to formulate the cdf (and pdf) as an expected value, or equivalently, a high-dimensional integral, which can then be efficiently approximated by a QMC method. Typically QMC methods struggle to efficiently approximate the cdf because of a lack of smoothness in the integrand, which for a cdf is an indicator function. We overcome this by using an initial preintegration step to smooth out the integrand. Preintegration, also known as conditional expectation, is a method for smoothing a discontinuous function by integrating with respect to a single specially chosen variable. The result is a function in one dimension less that is now smooth (under appropriate assumptions of course). We will outline the QMC with preintegration method for approximating the cdf and pdf for lognormal PDEs, then present an error analysis and numerical results.

Detection of swallowing disorders in oesophagus through a catheter: A study through a mathematical model

Anupam Kumar Pandey
Indian Institute of Technology (BHU), Varanasi

We constructed a mathematical model of the oesophagus that is being catheterized to examine the accurate diagnosis of a sliding hiatus hernia. Even in many healthy persons, this particular oesophageal swallowing disorder goes unrecognized. In this, the diaphragm allows the upper portion of the stomach to block the oesophagus, causing it to swell. Obesity, improper diets, and sleeping positions after eating a lot are the main signs and symptoms. We presented our findings for the two-layered Newtonian fluid analytically. We discussed about the outcomes of the catheter's broadening and the increase in the dilation parameter. The two layers' mass conservations are considered properly. It has been noted that when a patient has swallowing disorders, catheterization has a substantial impact. By expanding the size of the catheter, the pressure increases with the axial length of the oesophagus. The flow rate experiences the same thing. The results for the interface between the two layers are discussed by solving the fourth-order algebraic equations. With the increase in viscosity, the peripheral layer got thinner. Most importantly, our findings suggest that the pressure requirement is less when the oesophageal tube diverges more at the lower oesophageal sphincter. It is also suggested that the feeding of the patient requires proper attention because the stimuli of the secondary peristalsis come into play. With the exception of the sliding hiatus hernia in the oesophagus, this study offers a novel concept of diagnostics in the realm of biomedical sciences.

Community detection with entropic regularisation

James Nichols
Australian National University

Detecting community structure in graphs is a common task in a variety of scientific and commercial settings. A correlation matrix can be considered an adjacency matrix of a weighted graph, and in the biological sciences the increasing use of high-throughput assays generate large quantities of correlated genomic data. Efficiently finding the correlative clusters is of paramount importance.

We re-examine an old approach that looks to sort the graph with an optimal permutation on the rows and columns of the adjacency matrix. We use an objective function that penalises off-diagonal components in the permuted adjacency matrix. Effectively this is a re-labelling of the nodes in such a manner as to make neighbouring nodes maximally connected.

Sorting a graph adjacency matrix boils down to a type of quadratic assignment problem, known to be equivalent to the travelling salesman problem and hence NP-hard. We propose a method of solving this optimisation with an entropically regularised version of the Frank-Wolfe algorithm. Each linearised and entropically regularised step in the Frank-Wolfe algorithm can then solved with the Sinkhorn method The Sinkhorn method has been re-popularised recently in the computational optimal transport literature, and has some history of being used in relation to quadratic assignment problems, however our approach is new and allows some theoretical demonstrations of convergence.

This approach delivers a scalable method that permutes the rows and columns of a matrix, making the matrix *maximally diagonal*. It allows us to do quick community detection, and further results in a permuted matrix that is amenable to a hierarchical (H-)matrix representation.

On tight error bounds for conic optimisation

Scott B. Lindstrom
Curtin University

Conic-linear programming allows researchers to tackle many important problems. Popular programs such as Mosek, Alfonso, Hypatia, and CVX solve problems with conic-linear methods. Such software packages provide users with so-called “backward error bounds”, which may not be useful accuracy guarantees. After Joss Sturm found “forward” error bounds (i.e. useful guarantees) for the second order cone, 23 years passed before forward error bounds were found for any other cones on the Mosek conic modeling wheel. I will describe the framework that we built for obtaining such guarantees, a framework we used to find forward error bounds for several new classes of cones in short succession. This talk is based on joint work with Bruno Lourenço (ISM), Ying Lin, and Ting-Kei Pong (both The Hong Kong Polytechnic University).

Progressive Hedging for Stochastic Integer Programming — Advances in Theory and Practice

Andrew Eberhard
RMIT University

Motivated by recent literature demonstrating the surprising effectiveness of the heuristic application of progressive hedging (PH) to stochastic mixed-integer programming (SMIP) problems, we provide theoretical support for the inclusion of integer variables, bridging the gap between theory and practice where optimal or at least feasible convergence is observed. We provide an analysis of a modified PH algorithm from a different viewpoint, drawing on the interleaving of (split) proximal-point methods (including PH), Gauss-Seidel methods, and the utilisation of variational analysis tools. Through this analysis, we show that under mild conditions, convergence to a feasible solution should be expected. A practical implementation of a modified PH is discussed and we demonstrate its convergent behaviour in computational experiments.

Open Problems

Title TBC

Anupam Kumar Pandey
Indian Institute of Technology (BHU), Varanasi

Details TBC

Lyapunov Functions for ADMM and Douglas–Rachford

Scott B. Lindstrom
Curtin University

Operator splitting methods are known to have duality-like relationships. For example, when Alternating Direction Method of Multipliers (ADMM) minimizes $f + g$, Douglas–Rachford algorithm (DRA) minimises $f^* + g^*$. The two objectives are related to one another through a duality-inducing operation: Fenchel Conjugation. Recently, Lyapunov functions have been used to describe the convergence behaviour of these algorithms.

Question: given a Lyapunov function that describes ADMM, can we define a duality-inducing operation that sends that function to a Lyapunov function that describes the behaviour of Douglas–Rachford?

Efficient descriptions of convex sets with prescribed facial structure

Vera Roshchina
UNSW Sydney

For any finite set of nonnegative integers, there exists a closed convex set whose faces have precisely these dimensions. Such sets can be constructed in many ways, for instance, from Minkowski sums of Euclidean balls (see Roshchina, Sang and Yost "Compact convex sets with prescribed facial dimensions"). I would like to talk about the efficiency of such representations and to formulate several questions about constructing convex sets with faces of prescribed dimensions using appropriately defined minimal representations.

Participants

Alexander Gilbert (UNSW Sydney)
Andrea Raith (University of Auckland)
Andreas Ernst (Monash University)
Andrew Eberhard (RMIT University)
Anupam Kumar Pandey (Indian Institute of Technology (BHU), Varanasi)
Ava Vahedi (UNSW Sydney)
Ayesha Sohail (University of Sydney)
Bethany Caldwell (University of South Australia)
Blair Butler (UNSW Sydney)
Daniel Uteda (University of Melbourne)
Dingxuan Zhou (University of Sydney)
Dmytro Matsypura (University of Sydney)
Elham Shadkam (UNSW Sydney)
Elizabeth Harris (University of Newcastle)
Fatma Kilinc-Karzan (Carnegie Mellon University)
Felipe Atenas (University of Melbourne)
Georg Stadler (New York University)
Guoyin Li (UNSW Sydney)
Hongfei Qiao (University of Sydney)
Hongzhi Liao (UNSW Sydney)
Ian Hugh Sloan (UNSW Sydney)
Ilknur Tulunay (UNSW Sydney)
Iryna Khodos (Curtin University)
James Foster (CSIRO)
James Nichols (Australian National University)
Jessica Leung (Monash University)
Joe Gurr (UNSW Sydney)
Johnson Phosavanh (University of Sydney)
Jordan Shaw-Carmody (University of Newcastle)
Li Chen (University of Sydney)
Lien Nguyen (RMIT University)
Lindon Roberts (University of Sydney)
Lisa Aoki Hillas (University of Auckland)
Mareike Dressler (UNSW Sydney)
Maryam Salem Alatawi (University of Tabuk)
Minh Dao (RMIT University)
Muge Tekin (Rotterdam School of Management)
Nam Ho-Nguyen (University of Sydney)
Nathan Lee (UNSW Sydney)
Ponpot Jartnillaphand (Curtin University)
Qi Wang (UNSW Sydney)
Qing Li (Shijiazhuang Traditional Chinese Hospital)
Quoc Thong Le Gia (UNSW Sydney)
Ricardo Ruiz-Baier (Monash University)
Ryan Tran (UNSW Sydney)
Saeid Kazemzadeh (Atilim University)
Salman Ahmad (Chinese University of Hong Kong)
Samir Adly (University of Limoges)
Sandy Spiers (Curtin University)
Scott Lindstrom (Curtin University)
Seyed Mohammad Khalili (UNSW Sydney)
Soheil Davari (Univeristy of Bath)
Steven McCaw (UNSW Sydney)
Tabish Ali Rather (Swinburne University of Technology)
Tamanna Yadav (Indian Institute of Technology Roorkee)
Tiangang Cui (University of Sydney)
Tjiu Ginny Yee Ni (University of Sydney)
Tomas Lagos (University of Sydney)
Vera Roshchina (UNSW Sydney)
Vinesha Peiris (Curtin University)
Wei Zhang (Tsinghua University)
Yingkun Huang (UNSW Sydney)
Yiwei Wu (Hong Kong Polytechnic University)