AMSI OPTIMISE

A FIVE-DAY SYMPOSIUM INSPIRING INDUSTRY & RESEARCH COLLABORATION

OPTIMISING AUSTRALIA

The Next Industrial Revolution

AMSI's newest flagship research training program aims to unite industry and academia in the name of optimisation.

Industry's response to rapid technology advancement and the resulting data deluge is opening new opportunities for cross-disciplinary university research-industry collaboration. Optimisation and the inclusion of AMSI Optimise in the Institute's flagship event calendar make for an exciting time for mathematics.

Launched in June 2017, the event has provided a much-needed platform for industry-research engagement. Run over five days, the three-day conference and two-day workshop aims to foster discussion and stimulate new ideas and opportunities for collaboration. An expansion of the Institute's Securing Australia's Mathematical Workforce project, the event represents an exciting new chapter in the Institute's long-time funding collaboration with the Commonwealth Department of Education and Training.

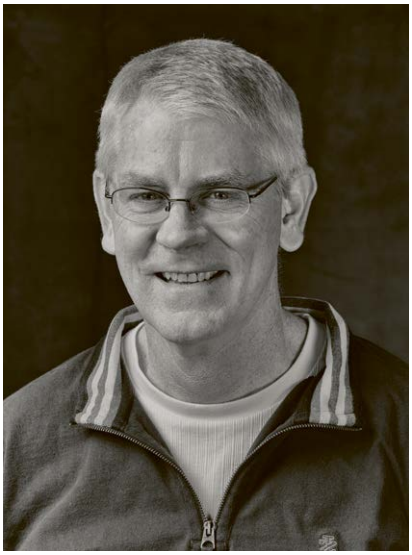
With a strong presence from the Australian and international research communities and industry leaders such as IBM, AGL and Biarri, the launch event explored the application of optimisation to data mining and analytics, strategic planning and operational decision making within the fast-growing energy and transport sectors.

The event has already caught the attention of optimisation stakeholders for its ambitious approach and span of the innovation pipeline, offering a unique chance to explore current applications, future research opportunities and pathways to equip the emerging mathematical workforce for the challenges ahead.

Essential to Australia's future economic competitiveness and security, Optimisation is a critical area for mathematical innovation and AMSI is excited to be helping drive new innovation and secure future capability.

As we prepare for AMSI Optimise 2018, we chat to Professor Stephen Wright and Biarri's Dan Sutherland about optimisation and why Australia needs to be ready for the 4th industrial revolution.

Jointly sponsored by AMSI, the Department of Education and Training, Monash University, Maxima and Optym, AMSI Optimise 2017 was part of the Institute's Securing Australia's Mathematical Workforce project. Other events funded by this project include AMSI Summer School, AMSI BioInfoSummer, AMSI Winter School and the Vacation Research Scholarship Program. For information on AMSI Optimise, visit the website optimise.amsi.org.au.



PHOTOGRAPHY: COURTESY OF THE UNIVERSITY OF WISCONSIN

Optimise keynote speaker Professor Stephen Wright explains how optimisation methods can be applied to the energy sector.

CAN YOU TELL ME A LITTLE ABOUT YOURSELF AND YOUR RESEARCH BACKGROUND?

My research is in algorithms for computational optimisation, and their applications to many areas, including engineering, control, data science, and computational biology.

Optimisation problems arise wherever there is some mathematical model of a situation, and something to be minimised or maximised. In science, the model is often dictated by physical principles, such as the energy associated with the conformation of molecules in a cell; a prediction of the diffraction pattern observed when an x-ray beam is trained on a crystal, or the differential equations that model the dynamics of the atmosphere. Physical principles are the basis of models in engineering applications too, but here we must also model the effects of possible human decisions. An example here is the power flow in an electrical power grid, and how this is affected by changes in demand or by the construction of new capacity in various parts of the grid. In data science, the model is often based on statistical principles, such as when we seek the "most likely" state of an observed system, given the observations that have been made about that system.

I have worked on many applications of this kind. But I also work on more fundamental questions, such as the mathematical properties of the methods that are used to solve these problems – how rapidly they find a solution, how much computation and data movement they require, and so on. I have also worked on software for solving certain key classes of optimisation problems, including linear programming and quadratic programming.

CAN YOU TELL ME A LITTLE ABOUT YOUR RESEARCH AND IN PARTICULAR ITS IMPORTANCE TO ENERGY APPLICATIONS?

Applications of optimisation abound in the energy industry. Take just the electrical power grid, optimisation arises in modelling the flow of power in a grid; in deciding how to design the grid to meet projected demand and make it robust to attacks; in scheduling generators to meet anticipated demands (and possibly respond in a reasonable way to unanticipated demands); in determining the locations of failures in the grid from indirect sensor readings; and in designing well-functioning markets for electrical power. I have worked on several of these problems, which are quite challenging from the point of view of optimisation, in part because they must be solved rapidly in order to be of use to grid operators.

CAN YOU EXPLAIN THE ROLE OF MATHS IN OPTIMISATION, AND THE VALUE FOR INDUSTRY WITH REFERENCE TO ENERGY APPLICATIONS?

Optimisation is a mathematical discipline. It builds on the successes of applied mathematics and statistics, in that these disciplines produce useful mathematical models of physical and information systems that can be used as the basis of optimisation models. Optimisation provides a toolbox of techniques to add features to these mathematical models, which allow the models to be used to make decisions or extract information. Optimisation also provides algorithmic techniques for "solving" the resulting models, obtaining answers that are useful to practitioners.

Energy applications typically involve models with physical and economic components, with many moving parts that interact in complex ways, and many points at which human decisions play a potential role.

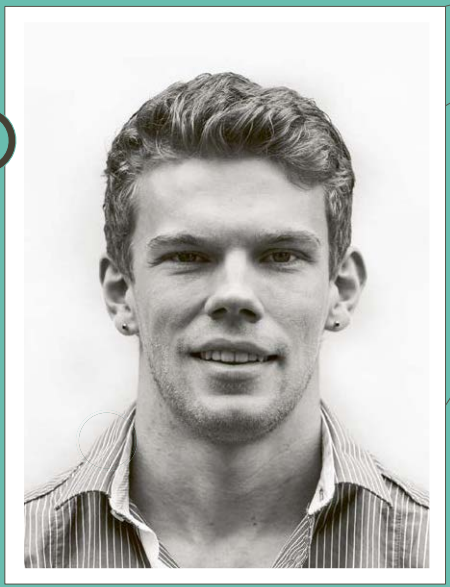
HOW IS THE ENERGY SECTOR LIKELY TO CHANGE IN TERMS OF THE IMPACT OF OPTIMISATION?

Optimisation methods have become highly influential in the research side of the energy sector during the past two decades. In this sector (as in others), engineers and practitioners have become convinced of the usefulness of optimisation as a prism through which to view many of the important problems that arise, and as a source of computational tools for solving these problems. I'm less equipped to say how this influence has propagated into everyday practice, where human factors and other logistical issues arise. For example, in electrical power grids, there are human grid operators that make key decisions regarding shedding load, or regarding bids to supply power to the grid at a certain schedule of prices. In such situations, optimisation tools can play a powerful advisory role, showing the operator the effects of the various decisions they may take and providing them with a "what if" capability.

WHAT RISK DOES AUSTRALIA'S RELATIVELY LOW RATE OF RESEARCH-INDUSTRY COLLABORATION POSE IN TERMS OF HOW WE INNOVATE AND RESPOND TO THE FUTURE?

The optimisation and applied mathematics community in Australia has a great track record in engaging with industry. Several of my colleagues, for example in Newcastle and Brisbane, have been involved in joint projects with the mining and electricity industries, in some cases spanning many years. Such interactions should be encouraged – they help point optimisation researchers toward problem types of practical interest, and thus to guide their fundamental research activities. They can also potentially provide researchers with funding that is sorely lacking the Australian system – funding to support and incentivise students, to support travel to conferences, and to allow them to spend time away from their other academic responsibilities, to engage in the intense, focused intellectual effort that is needed to make significant advances in research. ⇨

Professor Stephen Wright, from the University of Wisconsin, Madison (USA) was one of the keynote speakers at AMSI Optimise in June, delivering two plenary presentations during the week-long event.



Biarri's Energy, Mining and Infrastructure Lead, Dan Sutherland, shares his thoughts on optimisation in the energy, mining and infrastructure sectors.

HOW DOES BIARRI APPLY OPTIMISATION INNOVATION WITHIN ENERGY, MINING & INFRASTRUCTURE (EMI)?

The most frequent way in which we apply our optimisation capability in the EMI sectors is to solve logistics problems. Common examples are FIFO scheduling, maintenance scheduling, transport load consolidation. In addition to the logistics problems common across the three industries, optimisation is also crucial in industry specific problems such as operational mine throughput optimisation, long term mine design and planning and utilities (e.g. water) flow optimisation. The overarching benefits of these optimisations are an increase in safety, productivity and revenue and a decrease in cost and waste.

Recently we have been involved in a number of projects to reduce unnecessary driving and increase efficiency in onshore LNG projects. These focus around the scheduling and prioritisation of work to create an overall reduction in the travel required to do this work while considering constraints such as worker skills and work interactions. In addition to optimisation a key aspect of this work centres around identifying the opportunities for optimisation and where a business process change can unlock further optimisation capability. This has demonstrated an overall decrease of as much as 30 per cent in driving time and distance. The flow on effects of decreasing driving time and distance are increased productivity and increased safety which is a particularly large consideration in these industries.

Biarri has also been involved in underground mining throughput optimisation by optimising the scheduling of loaders and trucks to work in synergy. This has demonstrated an increase in productivity and ultimately revenue through the mine. A long-term customer of Biarri's continually use our water flow model to optimise their capital and operational spend in maintaining and upgrading their water supply network. We're currently undertaking new projects with clients to globally reduce travel and increase efficiency

THE FUTURE IS COMING, THE ONLY THING WE CAN CONTROL IS HOW WE RESPOND TO IT

WHAT WILL WE SEE NEXT? WHAT ARE THE EMERGING CHALLENGES IN EMI OPTIMISATION?

The future is coming, the only thing we can control is how we respond to it. As we move into the 4th Industrial Revolution the Energy, Mining and Infrastructure sectors will need to keep up with the changing environment and new workforce used to this new environment. Being industries with large capital expenditure and costly assets, EMI companies typically make decisions based on long term forecasts and decisions. As the world continues to change at an accelerated rate (it is frequently said that we will see more change in the next 5 years than the previous 30), this will pose a particularly big challenge for the Energy, Mining and Infrastructure sectors.

As we negotiate the changing tides of our world, optimisation and mathematical modelling can provide a framework for data driven decision making for responding to the changing world. Using optimisation for decision making can help change the operating dynamic from "the way it's always been done" to "it's the most efficient way to operate". Having the capability to run scenarios and mathematically model the impact a major shift in environment will make to operations (e.g. a large increase in power demand, or modelling the benefit of drone usage on power line inspection) and establish the most effective response.

I think we'll see a large up take in the use of drone / automated / remote technology. Mines have already started using automated trains, trucks and loaders. The energy sector has already started using drones to inspect assets throughout distributed networks. In the next five years I believe these technologies will become 'table steaks'; they'll be used ubiquitously.

There's also likely to be fundamental shifts in the operating models of some businesses, but what I can't yet tell. All of this will create a confusing environment in which mathematical modelling and optimisation can play a key role in understanding.

WHERE DOES AUSTRALIA'S ENERGY SECTOR LAG IN TERMS OF ITS ENGAGEMENT WITH OPTIMISATION?

The Energy, Mining and Infrastructure sectors are engaging with optimisation as a part of software products or developments. While this is a step in the right direction there is a still a gap in explorative use of optimisation. Collaboration between industry, research and optimisation providers such as Biarri will help to close this gap. However, I see the most important step as the incorporation of mathematics graduates and professionals into these companies to identify and model early opportunities for optimisation (as is done in the financial and meteorological industries).

With the setup of the Australian government growth centres, the industries are well poised to take advantage of research and development opportunities. The Collaborative Project Funds offered by both NERA and METS Ignited (the growth centres for Energy and Mining Equipment, Technology and Services (METS) industries), are already encouraging and providing great opportunity for collaboration between industry, technology providers and research institutions. □

PHOTOGRAPHY: COURTESY OF BIARRI

Biarri is an Australian commercial mathematics company working across a range of industry sectors to assist companies with optimisation and other maths-based problems.