Australian Government
Australian Research Council

EI 2018 ENGAGEMENT AND IMPACT

Engagement and Impact 2018

Curtin University

CUT01 (ST) - Impact

Overview

Title

(Title of the impact study)

LNG vessel scheduling: On time and under budget - how optimization creates efficiency

Unit of Assessment

01 - Mathematical Sciences

Additional FoR codes

(Identify up to two additional two-digit FoRs that relate to the overall content of the impact study.)

09 - Engineering
08 - Information and Computing Sciences

Socio-Economic Objective (SEO) Codes

(Choose from the list of two-digit SEO codes that are relevant to the impact study.)

84 - Mineral Resources (excl. Energy Resources)
89 - Information and Communication Services
97 - Expanding Knowledge

Australian and New Zealand Standard Industrial Classification (ANZSIC) Codes

(Choose from the list of two-digit ANZSIC codes that are relevant to the impact study.)

10 - Exploration and Other Mining Support Services

Keywords

(List up to 10 keywords related to the impact described in Part A.)

computational mathematics

optimisation

maintenance scheduling

operations planning

Sensitivities

Commercially sensitive

Culturally sensitive

Sensitivities description

(Please describe any sensitivities in relation to the impact study that need to be considered, including any particular instructions for ARC staff or assessors, or for the impact study to be made publicly available after EI 2018.)

Aboriginal and Torres Strait Islander research flag

(Is this impact study associated with Aboriginal and Torres Strait Islander content?
NOTE - institutions may identify impact studies where the impact, associated research and/or approach to impact relates to Aboriginal and Torres Strait Islander peoples, nations, communities, language, place, culture and knowledges and/or is undertaken with Aboriginal and Torres Strait Islander peoples, nations, and/or communities.)

No

Science and Research Priorities

(Does this impact study fall within one or more of the Science and Research Priorities?)

No

Impact

Summary of the impact

(Briefly describe the specific impact in simple, clear English. This will enable the general community to understand the impact of the research.)

Professor Ryan Loxton led a team of researchers from Curtin's School of Electrical Engineering to develop novel algorithms and modelling tools for tasks beyond the scope of commercially available optimisation software and push the limitations of optimization capabilities of existing computing hardware. The team's modelling techniques delivered efficiencies, supported expansion, and boosted the bottom line for the resources sector. Loxton's expertise in computational mathematics underpins his design and use of quantitative methods for optimising systems and processes. Two applications of the algorithms and tools are in optimizing the scheduling and sequencing of vessel fleets for Woodside, and optimizing plant maintenance shutdowns for engineering services company Linkforce Engineering.

Beneficiaries

(List up to 10 beneficiaries related to the impact study)

Woodside Energy

Linkforce

Countries in which the impact occurred

(Search the list of countries and add as many as relate to the location of the impact)

Australia

Details of the impact

(Provide a narrative that clearly outlines the research impact. The narrative should explain the relationship between the associated research and the impact. It should also identify the contribution the research has made beyond academia, including:
- who or what has benefitted from the results of the research (this should identify relevant research end-users, or beneficiaries from industry, the community, government, wider public etc.)
- the nature or type of impact and how the research made a social, economic, cultural, and/or environmental impact
- the extent of the impact (with specific references to appropriate evidence, such as cost-benefit-analysis, quantity of those affected, reported benefits etc.)
- the dates and time period in which the impact occurred.

NOTE - the narrative must describe only impact that has occurred within the reference period, and must not make aspirational claims.)

Researchers in Curtin's School of Electrical Engineering, Computing and Mathematics, led by ARC Future Fellow Professor Ryan Loxton, have a strong focus on developing new mathematical techniques to optimise complex processes in a wide range of applications such as mining, oil and gas, agriculture, and industrial process control. In several Australian industries, the team's modelling techniques deliver efficiencies, support expansion, and increase cost efficiencies.

Professor Loxton's emphasis on fostering university-industry engagement has facilitated collaboration between mathematicians and engineers to improve the efficiency of complex industry processes. Most of the research end-users are in the key Australian export industries of mining, energy, and agriculture. Loxton explains why university-industry engagement is essential: "Australian industries operate in a complex global market; they must modernise their processes and cut inefficiency by exploiting the massive big-data sets now available. But the more realistic the model, the more challenging it is to solve. Hence the need for smart algorithms – mathematics is

the key to unlocking these massive-scale optimisation problems."

Professor Loxton's expertise in is the design and use of quantitative methods for optimising systems and processes. With key colleagues in mathematical sciences, Dr Elham Mardaneh and Dr Qun Lin, Professor Loxton developed novel algorithms and modelling tools for tasks that were beyond the scope of commercially available optimisation software.

In 2015, the Marine division of Australia's largest independent oil and gas company, Woodside, was looking to minimise operating costs for their North West Shelf and Exmouth assets. The company had a number of offshore oil and gas facilities, comprising platforms as well as floating production, storage and offloading units, each needing regular visits from vessels that deliver essential cargo and assist the transfer of oil to tankers. The challenge was in scheduling and sequencing the support vessels' visits to each facility.
Loxton describes the task: "Vessel scheduling involves specific operational constraints, such as vessel speeds and capacities, as well as the cargo demands of each facility. In this case, other factors include which vessels have the required equipment, the facility's closing time and night-time loading restrictions. This is a large-scale problem with millions of variables and constraints. Finding an optimal schedule manually is almost impossible – which is why we design custom mathematical models that can search efficiently through the possibilities."

Collaboration between Woodside and Loxton saw improvements in vessel utilisation and field planning. For Woodside, their initial research collaboration with Loxton (the first of several) led to a significant improvement in vessel utilisation and field planning, delivering a saving of around 20 per cent annually in vessel charter costs across the company's North West coast facilities. Further demonstrating the project's success, the method was described in several papers published in optimisation and engineering journals, two co-authored with Woodside personnel.

In a 2014-15 project with Western Australian engineering services company Linkforce, Professor Loxton's expertise was recruited for research on optimally scheduling mine plant shutdowns. Once again, the task was to develop and apply customised models to the scheduling process which included a multitude of factors ranging from the availability of personnel to plant activity inter-relationships, which the algorithms would take just seconds to run. The result was the capability to fast-track mine plant maintenance and minimise downtime – an advance in best practice that not only boosted the plant's bottom line, but also reduced the environmental footprint of its maintenance activities.
The work for Linkforce was developed through a collaborative research endeavour with Linkforce staff embedded within the project and working side by side with Curtin researchers. The partnership was brokered by the consulting firm Alternate Futures, headed by former Rio Tinto executive Denise Goldsworthy. The team worked together to ensure the algorithms and software met the needs of Linkforce as a competitive service provider, as well as optimizing for best outcomes for plant operators. The team took into account in their design factors such as activity workflow, plant access restrictions, safety regulations, and availability of personnel and equipment.

The algorithms developed through the partnership took seconds to run, replacing the previously time-consuming manual process to schedule plant shutdowns. The optimized schedules were also 10% shorter than the manually-created schedules, reducing plant downtime as well by as much as eight hours on an average shutdown.

This work received coverage in: Create, the official magazine of Engineers Australia which has a membership of over 100,000 professionals at every level and across all fields of practice; Trunkline, which is the official magazine for Woodside personnel; WA Business News, which has over 350,000 page impressions, the majority of membership comprising of non-academic professionals; and Science Network WA (now Particle) powered by the not-for-profit organisation SciTech, that aims to connect the Western Australian community with the world of STEM (science, technology, engineering and mathematics).

Although the Curtin team's expertise has focused primarily on real-world applications, it is important to acknowledge the fundamental research that underpins the industry impact. Much of this has been supported by the Australian Research Council, through a Postdoctoral Fellowship awarded to Loxton in 2011, followed by an ARC Discovery Project grant.

Associated research

(Briefly describe the research that led to the impact presented for the UoA. The research must meet the definition of research in Section 1.9 of the EI 2018 Submission Guidelines. The description should include details of:
- what was researched
- when the research occurred

- who conducted the research and what is the association with the institution)

The research group engaged in collaborative, interdisciplinary research with international universities and Australian resource companies. The research expertise built through these projects underpinned the development of the novel algorithms.

Supported by Curtin, Loxton collaborated successfully with researchers at Central South University, Harbin Institute of Technology, and Zhejiang University (all top universities in China) on the optimization of aquaculture harvesting operations, industrial evaporation/purification processes, and micro-robot manipulation via electromagnetic fields. This preliminary research collaboration has led to several papers in high-quality international journals.

The 2013-2016 ARC Linkage project with Woodside Energy explored the potential for using mobile computing technologies in liquefied natural gas plant construction. The research aimed at transforming construction processes through the development of a novel mobile computing approach for improving productivity through enhanced information access. Novel optimization methods were developed to improve efficiency and streamline operations.

FoR of associated research

(Up to three two-digit FoRs that best describe the associated research)

01 - Mathematical Sciences
08 - Information and Computing Sciences
09 - Engineering

References (up to 10 references, 350 characters per reference)

(This section should include a list of up to 10 of the most relevant research outputs associated with the impact)

Mardaneh, E., Lin, Q., & Loxton, R. (2016). A heuristic algorithm for optimal fleet composition with vehicle routing considerations. Optimization Methods and Software, 31(2), 272-289. doi:10.1080/10556788.2015.1062890

Gong, Z., Loxton, R., Yu, C., & Teo, K. L. (2016). Dynamic optimization for robust path planning of horizontal oil wells. Applied Mathematics and Computation, 274, 711-725. doi:10.1016/j.amc.2015.11.038

Chen, T., Xu, C., Lin, Q., Loxton, R., & Teo, K. (2015). Water hammer mitigation via PDE-constrained optimization. Control Engineering Practice, 45, 54-63. Retrieved from http://dx.doi.org/10.1016/j.conengprac.2015.08.008

Chen, T., Ren, Z., Xu, C., & Loxton, R. (2015). Optimal boundary control for water hammer suppression in fluid transmission pipelines. Computers and Mathematics with Applications, 69(4), 275-290.

Sun, Y., Aw, G., Loxton, R., & Teo, K. L. (2014). An optimal machine maintenance problem with probabilistic state constraints. Information Sciences, 281, 386-398. doi:10.1016/j.ins.2014.05.051

Loxton, R., Lin, Q., & Teo, K. L. (2013). Minimizing control variation in nonlinear optimal control. Automatica, 49,

2652-2664. doi:10.1016/j.automatica.2013.05.027

An, Y., Xu, C., Lin, Q., Loxton, R., & Teo, K. L. (2013). Path Planning for Underactuated Dubins Micro-robots Using Switching Control. In Proceedings of the 2013 10th IEEE International Conference on Control and Automation (ICCA 2013) (pp. 1403-1408). China: IEEE. doi:10.1109/ICCA.2013.6565059

Blanchard, E. A., Loxton, R., & Rehbock, V. (2013). A computational algorithm for a class of non-smooth optimal control problems arising in aquaculture operations. Applied Mathematics and Computations, 219(16), 8738-8746. doi:10.1016/j.amc.2013.02.070

Loxton, R., Lin, Q., & Teo, K. L. (2012). A stochastic fleet composition problem. Computers and Operations Research, 39(12), 3177-3184. doi:10.1016/j.cor.2012.04.004

Loxton, R., & Lin, Q. (2011). Optimal Fleet Composition via Dynamic Programming and Golden Section Search. Journal of Industrial and management optimization, 7(4), 875-890. doi:10.3934/jimo.2011.7.875

Additional impact indicator information

Additional impact indicator information

(Provide information about any indicators not captured above that are relevant to the impact study, for example return on investment, jobs created, improvements in quality of life years (QALYs). Additional indicators should be quantitative in nature and include:
- name of indicator (100 characters)
- data for indicator (200 characters)
- brief description of indicator and how it is calculated (300 characters).)