Australian Government
Australian Research Council

EI 2018 ENGAGEMENT AND IMPACT

Engagement and Impact 2018

The University of Sydney

SYD09 (ST) - Impact

Overview

Title

(Title of the impact study)

Robotics and intelligent systems: Transforming the mining and stevedoring industries

Unit of Assessment

09 - Engineering

Additional FoR codes

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

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)
88 - Transport

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.)

08 - Metal Ore Mining
09 - Non-Metallic Mineral Mining and Quarrying
46 - Road Transport
49 - Air and Space Transport
52 - Transport Support Services
53 - Warehousing and Storage Services

Keywords

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

Simultaneous localisation and mapping (SLAM)

Autonomous control

Autonomous optimisation

Autonomous data fusion

Intelligent systems

Autonomous vehicles

Robotic navigation

Robotics

Sensitivities

Commercially sensitive

No

Culturally sensitive

No

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?)

Yes

Science and Research Priority	**Practical Research Challenge**
Resources	Technologies to optimise yield through effective and efficient resource extraction, processing and waste management.
Transport	Improved logistics, modelling and regulation: urban design, autonomous vehicles, electrified transport, sensor technologies, real time data and spatial analysis.

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.)

The Australian Centre for Field Robotics' (ACFR) research is instrumental in the development of automation technologies for Rio Tinto (mining) and Patrick Stevedores. Rio Tinto's 3D mine visualisation software has been installed in over 75% of their Australian open-cut mines, while Patrick Stevedores automated straddle carriers (AutoStrads) are operating in Sydney and Brisbane ports.

Based at the University of Sydney, the ACFR is one of the largest robotics and autonomous systems research institutes in the world, developing intelligent systems operating 24/7 in outdoor environments with precision, productivity, and flexibility. Industries are increasingly turning to these solutions to manage safety, increase operational efficiency and cost effectiveness in a variety of settings.

Beneficiaries

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

Patrick Stevedores

Employees of the Port of Brisbane and Port of Botany

Rio Tinto

Energy intensive industries

Countries in which the impact occurred

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

England
United States of America
France
Australia
Chile
Indonesia

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.)

Many industry sectors are turning to robotic automation to build operational efficiencies, increase profitability and decrease the environmental impact of operations. Based at the Faculty of Engineering and Information Technologies at University of Sydney, the ACFR has been instrumental in conducting world-leading research and developing breakthrough technologies in autonomous and intelligent robots, and systems for use in outdoor environments.

ACFR develop robotic devices and intelligent systems that can operate 24/7 in outdoor environments. These devices can perceive and understand their environment, make informed decisions about any actions required and then carry out those actions, all without direct human input.

Energy intensive industries, such as stevedoring (loading and unloading ships) and mining have collaborated with the ACFR seeking a step change in safety, predictability, precision and efficiency. ACFR researchers have collaborated nationally and internationally with leading industry partners, resulting in substantial impact through the uptake of their research outcomes.

ACFR research has been instrumental in the development of automation technologies for Patrick Stevedores and Rio Tinto (mining). These technologies contributed to these companies maintaining their international competitiveness by improving operational productivity and efficiency resulting in reduced energy usage.

The development and implementation of automated straddle carriers (AutoStrads) at the Ports of Botany and Brisbane are the result of a partnership between ACFR and Patrick formed in 2002. AutoStrads are unmanned machines controlled by centrally operated software that move containers around container terminals, using radar based navigation. The AutoStrad technology was introduced at Port of Brisbane in 2014 where 35 AutoStrads were installed and at Port Botany (Sydney) in 2015 where 44 AutoStrads were installed.

The AutoStrads operate unmanned 24 hours per day, 7 days per week, eliminating human error and increasing workplace safety. The technology introduces process driven, predictable reliability which directly lowers operational costs, and improves flexibility.

The technology developed by ACFR has resulted in significant savings in maintenance and fuel costs at both ports, which handle more than 5500 ships and 40 million tons of cargo per year.

In 2014, the Port of Brisbane handled more than 1M containers. Patricks has estimated a labour cost per-lift saving of more than $30 per container compared to its non-automated ports as a result of the introduction of this new technology.These efficiencies resulted in a 90% reduction in time lost, and lower pollution rates due to reduced machine idling. Electricity savings of up to $1M have been achieved due to the radar based navigation system manoeuvring containers. The AutoStrad usage has resulted in an overall fuel efficiency saving of 65% compared to manned vehicles.

In 2015, Patrick Port Botany was the world's second fully automated AutoStrad terminal, handling more than 2million containers. Patrick reported annual savings of over $40M in 2016, which included a reduction in operational time lost and reduced administration costs due to the successful automation of the terminal.

Patrick's AutoStrad terminals have become some of the safest in the world since introducing the autonomous technology developed by the ACFR. "We went 12 months without a single lost time injury among our 160 employees," said Matt Hollamby, manager of the Port of Brisbane.

The AutoStrad technology informs the 'AutoStrad terminal' concept owned by Kalmar which was introduced to the European market at the TOC Europe exhibition in 2015.

The Rio Tinto Centre for Mine Automation (RTCMA) was established at University of Sydney in 2007. It advanced mine automation and developed the mine of the future for Rio Tinto, with the focus on new autonomous drill technology and imaging. The key outcomes of this research are the RTVi 3D visualisation technology (RTVi) and the Mine Automation System (MAS). The RTVi provides the front end for MAS, where more than 1000 users across Rio Tinto evaluate and compare mine information in real time.

The RTVis delivers real-time 3D models of ore deposits located well beneath the earth's surface. The pin point accurate mapping ensures efficiency of mining activities by ensuring the focus is on the extraction of high quality ore, significantly reducing waste and operation costs. The RTVis feed into the MAS, where users compare and evaluate mine information, including the grade of the material and how much can be extracted per hour. This has impacted team members in local and remote facilities who are able to make faster, more informed decisions resulting in more accurate drilling and blasting; reduced explosive use; better waste classification; and efficiencies achieved because trucks carried more ore and less waste to the refinery.

In 2016, RTVis were deployed in over 75% of Rio Tinto's open-cut Australian mines, boosting productivity and lowering costs. General Manager, Mining, Automation and Analytics, Rio Tinto, Alastair Mathias, said: "The mine automation system that the University has put together for us, and which we continue to build on, puts us years ahead of our competitors and provides us a platform for the future."

In 2016, the RTVis technology enabled the Hope Downs mine in the Pilbara region of Western Australia to improve the way drill patterns are tailored to ground conditions. In six weeks, costs of each pattern by around 13%, which saved $150,000. John McGagh, former Head of Innovation at Rio Tinto, said: "… tomorrow's mines will rely on remote monitoring and control, with employees running the mines from cities thousands of kilometres away. With the input of the best academic minds we are already making this a reality. We remotely manage the automated operation of our iron ore mines in Pilbara region from our offices in Perth."

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)

From 1997 the ACFR has undertaken fundamental and applied research that encompasses the development of new theories and methods in the field of robotics and intelligent autonomous systems. The team identified human safety, operational efficiency and cost effectiveness as major and growing concerns in the mining industry and large-scale stevedoring operations.

ACFR have aimed research and development of autonomous robotic systems directly at these issues, where it continues to have industrial, social and environmental impacts.

Research includes
1.Perception and navigation system technologies and algorithms. Specifically, the development of statistical data fusion techniques that provide the autonomous platform with real time situational awareness;
2.Machine learning techniques, which provide the autonomous platform with the ability to adapt to its environment, specifically focussing on algorithmic approaches to detecting and classifying features in the environment, as well as better control strategies;
3.Real-time optimisation algorithms developed from mathematical optimisation approaches. These provide robotic platforms and intelligent software system to operate in real time and make informed decisions;
4.Sensing systems, in particular the development of novel sensors that can operate 24/7 in all weather conditions. Research was done to build efficiencies in high through-put industries to maintain globally competitiveness.

FoR of associated research

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

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)

1. T. Lupton and S. Sukkarieh, "Visual-Inertial-Aided Navigation for High-Dynamic Motion in Built Environments Without Initial Conditions," IEEE Transactions on Robotics, vol. 28, no. 1, pp. 61–76, Feb. 2012.

2. B. Douillard et al., "On the segmentation of 3D LIDAR point clouds," in 2011 IEEE International Conference on Robotics and Automation, 2011, pp. 2798–2805.

3. K. Yang and S. Sukkarieh, "An Analytical Continuous-Curvature Path-Smoothing Algorithm," IEEE Transactions on Robotics, vol. 26, no. 3, pp. 561–568, Jun. 2010.

4. S. Vasudevan, F. Ramos, E. Nettleton, and H. DurrantWhyte, “Gaussian process modeling of large-scale terrain,” Journal of Field Robotics, vol. 26, no. 10, pp. 812–840, 2009.

5. M. JohnsonRoberson, O. Pizarro, S. B. Williams, and I. Mahon, “Generation and visualization of large-scale three-dimensional reconstructions from underwater robotic surveys,” Journal of Field Robotics, vol. 27, no. 1, pp. 21–51, 2009.

6. M. F. Huber, T. Bailey, H. Durrant-Whyte, and U. D. Hanebeck, “On entropy approximation for Gaussian mixture random vectors,” in 2008 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems, 2008, pp. 181–188.

7. T. Bailey and H. Durrant-Whyte, “Simultaneous localization and mapping (SLAM): part II,” IEEE Robotics Automation Magazine, vol. 13, no. 3, pp. 108–117, Sep. 2006.

8. H. Durrant-Whyte and T. Bailey, “Simultaneous localization and mapping: part I,” IEEE Robotics Automation Magazine, vol. 13, no. 2, pp. 99–110, Jun. 2006.

9. J. Kim and S. Sukkarieh, “Autonomous airborne navigation in unknown terrain environments,” IEEE Transactions on Aerospace and Electronic Systems, vol. 40, no. 3, pp. 1031–1045, Jul. 2004.

10. J. E. Guivant, F. R. Masson, and E. M. Nebot, “Simultaneous localization and map building using natural features and absolute information,” Robotics and Autonomous Systems, vol. 40, no. 2, pp. 79–90, Aug. 2002.

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).)