
THE UNIVERSITY
of ADELAIDE
Annual Report
2019
AUSTRALIAN
INSTITUTE FOR
MACHINE LEARNING
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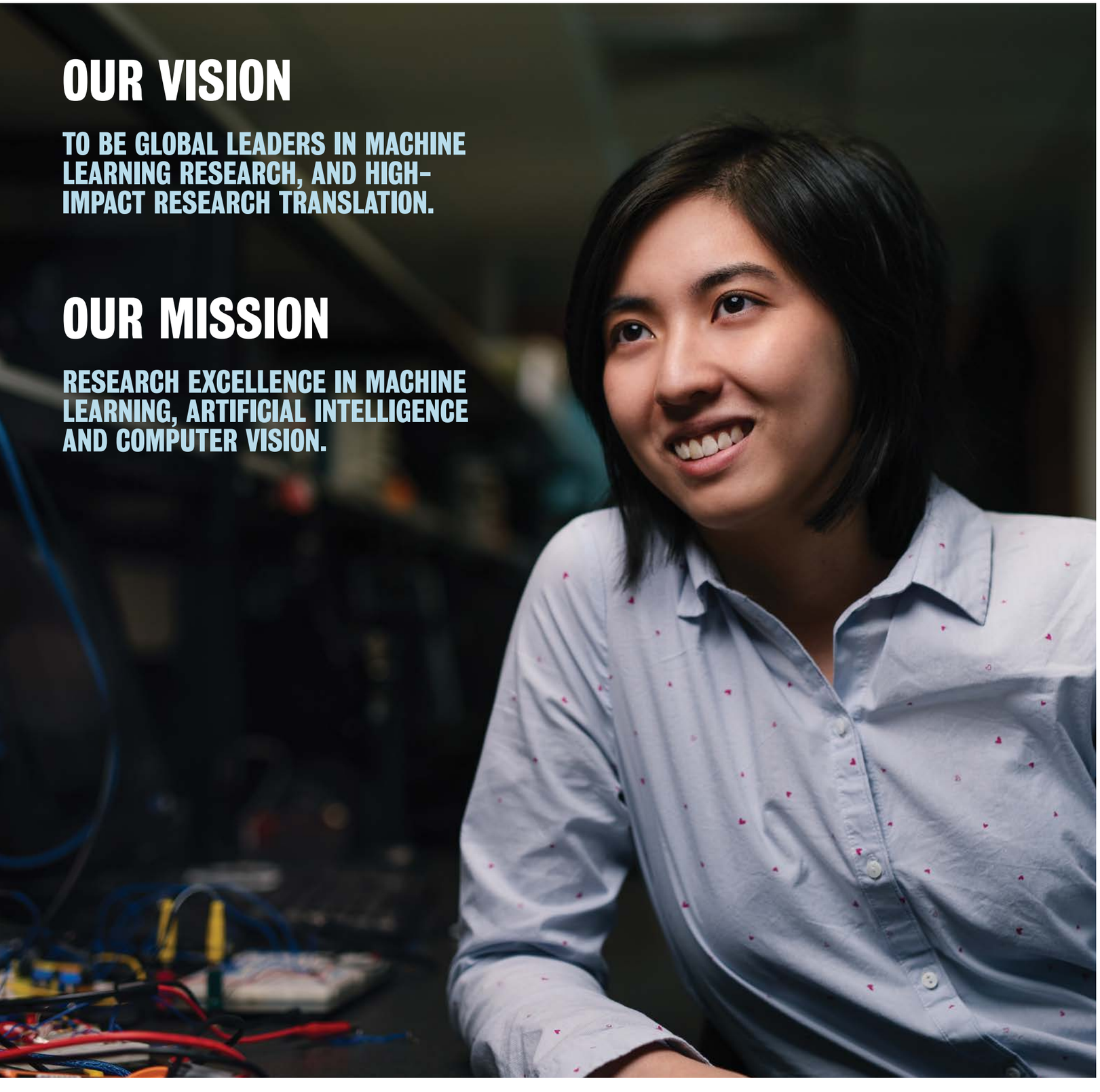


OUR VISION

TO BE GLOBAL LEADERS IN MACHINE LEARNING RESEARCH, AND HIGH-IMPACT RESEARCH TRANSLATION.

OUR MISSION

RESEARCH EXCELLENCE IN MACHINE LEARNING, ARTIFICIAL INTELLIGENCE AND COMPUTER VISION.

RANKED IN THE TOP 3 OF GLOBAL RESEARCH ORGANISATIONS FOR COMPUTER VISION

01

RANKED NUMBER ONE IN AI AND MACHINE LEARNING IN AUSTRALIA.

THE LARGEST MACHINE LEARNING GROUP IN THE COUNTRY

ABOUT THE INSTITUTE

The Australian Institute for Machine Learning (AIML) is Australia's first university-based institute dedicated to research in machine learning.

AIML launched in early 2018 with co-investment from the South Australian Government and the University of Adelaide.

Built on the success of the Australian Centre for Visual Technologies, AIML has taken high-impact applied research to another level, becoming a world-leader in applying machine learning methodologies.

With over 120 researchers, AIML is the largest University-based research group in machine learning in Australia. Our impact partners include experts in many fields including agriculture, space, medicine, transport defense, cybersecurity and advanced manufacturing.

Machine learning underpins the business models of the largest corporations and has the potential to deliver great social, economic and environmental benefits.

Our Institute makes an important national and international contribution to pushing the boundaries of what machine learning can do, and how that can be applied to almost every aspect of our lives.

At AIML we collaborate with world-leading companies to develop high-tech products and solutions to everyday problems.

THE FUTURE OF WORK IS AI

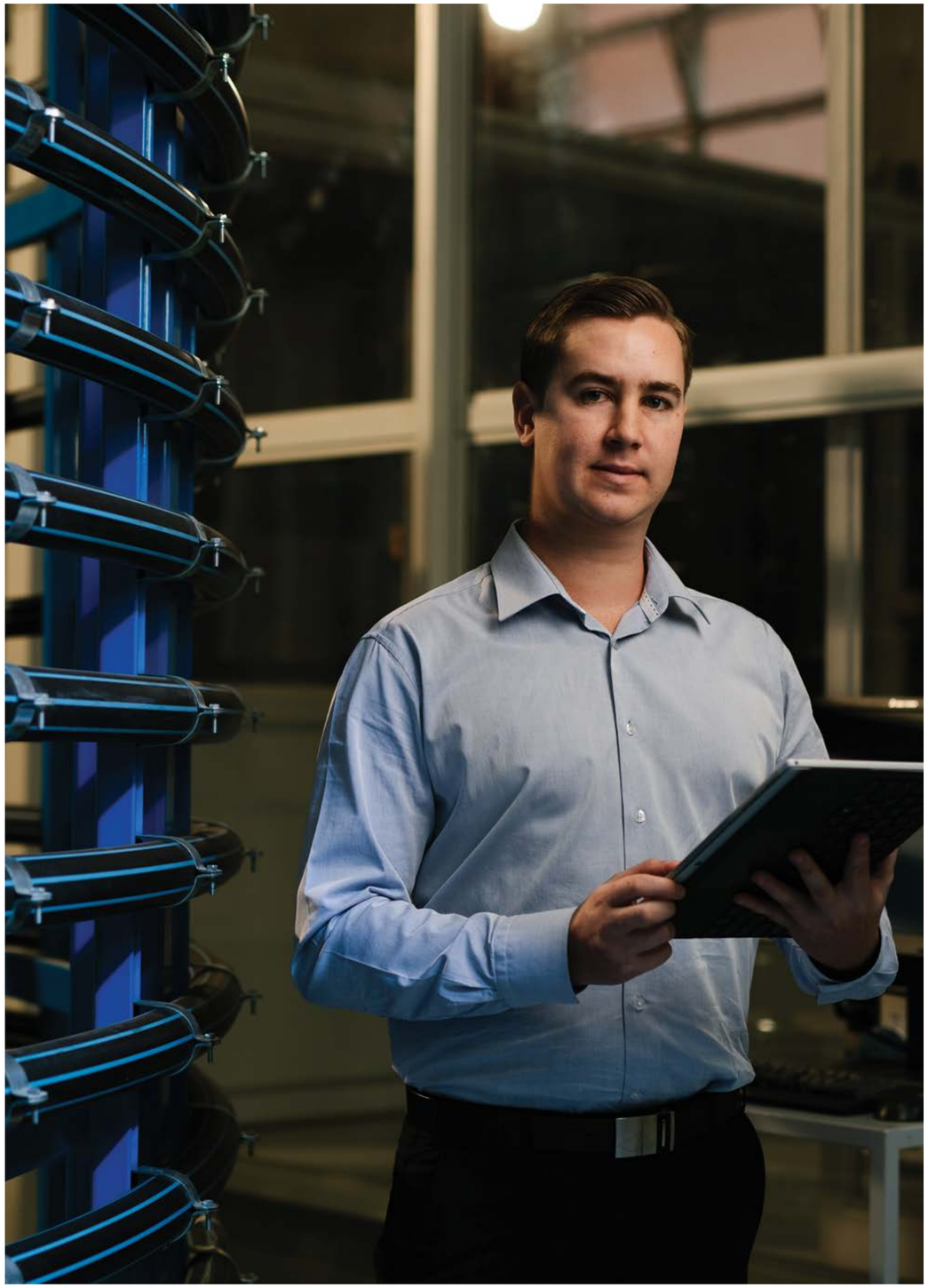
The LinkedIN 2020 Emerging Jobs Report says AI has arrived.

"All of Australia's top five emerging jobs feature automation or Artificial Intelligence (AI) skills."

"AI is spreading to all organisational areas, from IT to finance and marketing. AI may not be fully integrated into everything yet, but the trajectory is clear."

Top five emerging jobs

01	02	03	04	05
Artificial Intelligence specialist	Cybersecurity specialist	Marketing Automation Specialist	Robotics Engineer	Site Reliability Engineer



AIML capabilities

- Machine learning
- Deep learning
- Image captioning
- Medical imaging
- Object recognition
- Parameter estimation
- Robust fitting
- Segmentation
- Video surveillance
- Augmented reality
- 3D modelling
- Tracking
- Visual question answering.

AIML's strategies

Recruit and retain high calibre people

AIML has built a reputation as a highperforming research group because we have talented staff and students. Our standards for recruitment are very high, and we are able to promote a fantastic work environment. This continues to strengthen the international reputation of the group.

High quality research

AIML is ranked in the top four in the world on many metrics because of our commitment to high quality research, and research translation. Visibly achieving high-quality research in an extremely competitive field is critical to our ability to attract the top staff, students, and commercial partners.

Research impact

AIML's history of high-impact pure and applied research is critical to our credibility, and thus to our continued success. Our reputation has been developed through decades of world-class research, and collaboration across a variety of fields.

AIML's key actions

- Collaborate with world-leading researchers and companies to develop high-impact products and solutions
- Identify and exploit new opportunities for high-impact research and research translation
- Raise the profile of South Australia and the University of Adelaide as a focus for high quality research
- Identify and attract high-quality staff and students to grow AIML's research capacity.

AIML THEMES

MACHINE LEARNING THEORY

Advancing the mathematical fundamentals of the field.

ROBOTIC VISION

Enabling machines that see.

VISION AND LANGUAGE METHODS

Enabling natural language interactions with systems that exploit visual information.

TRUSTED AUTONOMOUS SYSTEMS

Developing machines that cooperate actively with humans.

MEDICAL MACHINE LEARNING

Applying machine learning methods to problems in Health and Medicine.

ADVANCED REASONING AND LEARNING

Enabling higher-level analysis and ongoing learning in machine learning methods.

AIML CHAIR & DIRECTOR REPORTS

PROFESSOR ANTON MIDDELBERG
REPORT OF THE DEPUTY VICE-CHANCELLOR (RESEARCH) AND ADVISORY BOARD CHAIR

The 21st Century is a time of considerable change. Artificial intelligence is beginning to have a major impact on our lives and has huge growth potential.

The Australian Institute for Machine Learning (AIML) leads the way as Australia's first university-based research body dedicated to machine learning and is the largest machine learning group in Australia.

A joint initiative of the South Australian Government and the University of Adelaide, AIML launched early in 2018. Built on the success of the Australian Centre for Visual Technologies, AIML has taken high-impact applied research to another level, becoming a world-leader in applying machine learning methodologies to diverse priority areas including space, agriculture and medical health.

AIML has grown from strength to strength in 2019. Highlights include moving into our new state of the art premises at Lot14; securing contracts with diverse industry partners including Lockheed Martin, the Australian Institute of Sport and Wine Australian as well as supporting AIML students graduate with postgraduate degrees.

AIML aligns with the University of Adelaide's *Strategic Plan, Future Making*, which is designed to help realise our purpose as a catalyst of knowledge creation and innovation, an engine of social advancement and an active participant in the local, national and global economies.

AIML is also strongly engaged with the University of Adelaide's five pillars of the Strategic Plan:

1. Connected to the Global World of Ideas: We are partnering with companies thinking strategically about artificial intelligence.
2. A Magnet for Talent: AIML hosts top-performing researchers from all over the world, helping to extend our global reach.
3. Research that Shapes the Future: Artificial intelligence is a key to the future, and we want Adelaide to be on the front foot. An institute dedicated to advancing machine learning ticks this box.
4. A 21st Century Education for Growing Community of Learners: AIML is providing our bright young minds with opportunities to stay in South Australia to study and pursue a career in emerging technologies.
5. The Beating Heart of Adelaide: AIML has already become a catalyst to bring companies and people into South Australia and to generate significant economic activity.

I hope you enjoy learning about the many AIML highlights from this 2019 annual report.

PROFESSOR ANTON VAN DEN HENGEL
DIRECTOR'S REPORT

AIML's world-class, interdisciplinary research provides South Australia and the nation with significant social, economic, educational and environment benefits.

We are Australia's largest, and one of the world's best research groups in artificial intelligence, computer vision and machine learning.

AIML was built on the core of a strong existing research group, the Australian Centre for Visual Technologies (ACVT). The ACVT started with 5 people in 2007, and had grown to over 120 members in 2019.

The research capability and reputation of AIML continues to grow.

Proud moments have included: 18 papers accepted to CVPR19; winning global awards such as 1st in visual question answering Challenge 2.0; and celebrating ARC DECRA, Future Fellowship and Discovery successes with the team.

Thanks to the ongoing transformative funding from the South Australian State Government, 2019 has seen AIML: assist SA SMEs to integrate and adopt machine learning within their businesses; develop an executive education course to introduce executives to machine learning; and build new partnerships across SA innovation neighborhoods including Adelaide BioMed City, Waite, Roseworthy and the Loxton Research Site.

As part of our role as a national leader in the field, AIML has partnership with the MIT SA living Laboratory, hosted a 2019 summit of key research leaders in machine learning, and participated in a national summit on AI in Canberra to discuss implementation of the national AI roadmap.

The above inevitably represents a small fraction of the work carried out by an amazing team. It has been a privilege to be a part of it.

ADVISORY BOARD MEMBERS

Professor Mike Brooks

Provost, University of Adelaide (Board Chair until October 2019)

After announcing that the Australian Institute for Machine Learning was to be established, we were inundated with enquiries from companies, government and research institutions about how to partner with us. Australia needed an institute for machine learning, and we gave it to them.

Professor Anton Middelberg

Deputy Vice-Chancellor (Research) (Board Chair from October 2019)

AIML has grown its productive links with industry and governments throughout 2019, while also building outreach to schools and the next generation of AI researchers. We expect 2020 will see projects into new fields including health and agriculture.

Professor Anton van den Hengel

Director AIML

We have seen incredible growth in our capability, research income, and visibility. It's particularly gratifying to see that so many of the existing and new staff have driven these results.

Dr Tony Lindsay

Director, STELaRLab, Lockheed Martin Australia (Science, Technology, Engineering Leadership and Research Laboratory)

It's wonderful for a new institute to secure a major contract. AIML's three-year strategic partnership agreement with Lockheed Martin, with significant cash and in-kind investment from LM, is just that. We'll work together to advance machine learning techniques in intentional machines.

Ms Lusia Guthrie

Independent Business Consultant; Chair, BioMelbourne Network; Chair, Medicines Manufacturing Innovation Centre

One of the keys to AIML's success is going to be in how well it brings innovative ideas and products to global markets. The Board will assist researchers wherever possible, from forming strategic partnerships with important companies and governments, to concept and product development.

Mr Adam Reid

Chief Executive, Department for Innovation and Skills

AIML was established with the help of a $7.1 million funding agreement with the State Government. AIML's focus on skills development, defence industry engagement, government efficiency, and SME and global R&D will drive improvements in productivity that underpin sustainable economic growth in South Australia.

Developing talent in rapidly advancing technology domains, including machine learning, is critical to ensure that South Australia is a destination for technology based businesses that can solve globally relevant problems and build successful businesses in South Australia.

AIML's collaborative research partnerships with defence companies will address the priority needs of the defence industry and contribute to Australia's necessary industrial capabilities. This will continue to build on South Australia's long history of success in defence research, underpinned by strong education and industry partnerships.

AIML delivers an innovative model for effective research collaboration between the University, industry, start-ups and government.

RESEARCH THEMES

The core of machine learning is the development of systems that are able to learn by example. This is important for a range of tasks, but particularly for those that humans have difficulty in specifying algorithmically.

Our focus at AIML is to develop fundamental new methods and technologies in machine learning. Our research can be broken down into 6 major themes.

RESEARCH PROGRAM & THEME LEADERS

Machine Learning Theory

Advancing the mathematical fundamentals of the field.

Professor Chunhua Shen

Trusted Autonomous Systems

Developing machines that cooperate actively with humans.

Professor Anton van den Hengel

Robotic Vision

Enabling machines that see.

Professor Ian Reid

Medical Machine Learning

Applying machine learning methods to problems in Health and Medicine.

Professor Gustavo Carneiro

Vision and Language Methods

Enabling natural language interactions with systems that exploit visual information.

Dr Qi Wu

Advanced Reasoning and Learning

Enabling higher-level analysis and ongoing learning in machine learning methods.

Professor Javen Shi

MACHINE LEARNING THEORY

Advancing the mathematical fundamentals of the field

Machine learning continues to be a fascinating field of research. At its most basic, it is the science of getting computers to act and learn over time without being explicitly programmed, but its areas of research and application are exploding.

What can machines learn?

After teaching computers what to do with examples of data and information, machines can learn to:

- detect disease and other medical problems
- operate machinery and drive cars
- recognize faces and groups of people
- predict retail buying trends and socioeconomic patterns.

And much more!

Research strengths at AIML

A particular strength of researchers at AIML is our ability to teach computers using only weakly labelled data. Our researchers are making major contributions in four key aspects of machine learning theory:

- **Deep learning**, by advancing the mathematical tools that underpin the training of computers to perform humanlike tasks
- **Systems optimisation**, by developing the theory, algorithms and tools that can predict environmental factors such as electricity prices and the weather, which are constantly changing
- **Robust statistics**, by developing procedures to analyse data to make sure that information from machines remains informative and efficient
- **Probabilistic graphic models**, by improving the way that machines model complex relationships among variables, to improve the reliability of the inferences they make.

Theme leader
Professor Chunhua Shen

TACKLING TRAFFIC CONGESTION IN SPACE

Professor Tat-Jun Chin
Director of Machine Learning for Space Engineering

Thousands of man-made objects orbit the Earth, including satellites, space installations, space debris and junk.

One or two operating satellites are lost in space crashes each year, as more nations and commercial companies develop space programs.

There is an increasing need to monitor space traffic, to try to prevent collisions and damage to trillions of dollars worth of technological investments.

Dr Tat-Jun Chin leads a multidisciplinary research team, working in collaboration with industry to develop a space-based surveillance system.

They aim to deploy satellites that use optical sensors to detect objects in space, increasing the capability and utility of space situational awareness.

The team won a global challenge hosted by the European Space Agency.

They used a unique combination of machine learning and 3D vision algorithms to determine the most accurate orientation of an object in space, edging out 50 competitors from some of the world's most prestigious universities and space technology companies.

"Figuring out the orientation of an object is a long-term study problem in computer vision and AI," Dr Chin says.

"If you want to program a robotic arm to make coffee, you need to figure the orientation of the object with respect to the robot; we are now applying those techniques in space."

Our team's research forms an important component of the growing local space industry.

It could be the foundation for new technologies to remove space debris, or to refurbish and prolong the life of ageing space assets and prevent them adding to space pollution.

It could even facilitate development of space depots; jumping off points for distant space travel.

All these exciting possibilities begin with space traffic management.

ROBOTIC VISION

Enabling machines that can see.

Theme leader
Professor Ian Reid

When machines have the ability to see, their capabilities grow substantially. Using one or more video cameras, they are able to collect visual data to understand the physical world.

Why pursue vision for machines?

As humans, we rely heavily on our vision to perform all sorts of tasks, including to see where we're going, who is in a room, and the emotions of faces. If we could enable machines to see as well as – or better than – we do, this would open up amazing possibilities.

Research strengths at AIML

Here are three key areas of robotic vision we focus on:

- **Visual simultaneous localisation and mapping (SLAM).** This technology uses a 3D vision camera to determine the position and orientation of the machine, while mapping the unknown surrounding environment. It enables field robots, drones and autonomous vehicles to navigate independently. The technology is not reliant on satellite information, but is able to accurately measure the physical world.
- **Semantic vision.** It's one thing to collect vision data, but how can we be sure that machines can make sense of it? Semantic vision is the field of processing the often huge amount of data in a way that produces meaningful, understandable information.
- **Vision and language**

Australian Centre for Robotic Vision

AIML is a founding partner of the ACRV, which carries out breakthrough science and technology under four research objectives: robust vision, vision and action, semantic vision, and algorithms and architecture.

CASE STUDY
ROBOTIC VISION

OBJECTIVELY MAPPING THE FUTURE

Kejie Li PhD student with Prof Ian Reid

We tend to take for granted how we navigate the three dimensional world we inhabit, because our brains rapidly process messages sent by our senses and just as quickly tell our bodies what to do in response.

Equipping robots with similar navigational skills has been a research challenge for some time. It starts with a camera transmitting visual images to enable Simultaneous Localisation and Mapping (SLAM).

Building robots with consistently reliable SLAM skills would be a great leap forward in robotic vision.

PhD student Kejie Li has been working towards this leap through object-oriented SLAM, which enables robots to recognise objects in context.

Traditional SLAM can only reconstruct an environment using low-level geometry based representations, such as data points on a 3D grid (3D point cloud).

Kejie says that although such representations can indicate where items might be occupied in the 3D space, they fail to provide the descriptive information used by people to recognise and utilise a specific object. For example: this is a chair, I could sit in it, walk around it, perhaps move it. This description helps create a more accurate map.

"Unlike traditional SLAM systems, the mapping of our object-level SLAM is based on objects with semantic meaning," Kejie says.

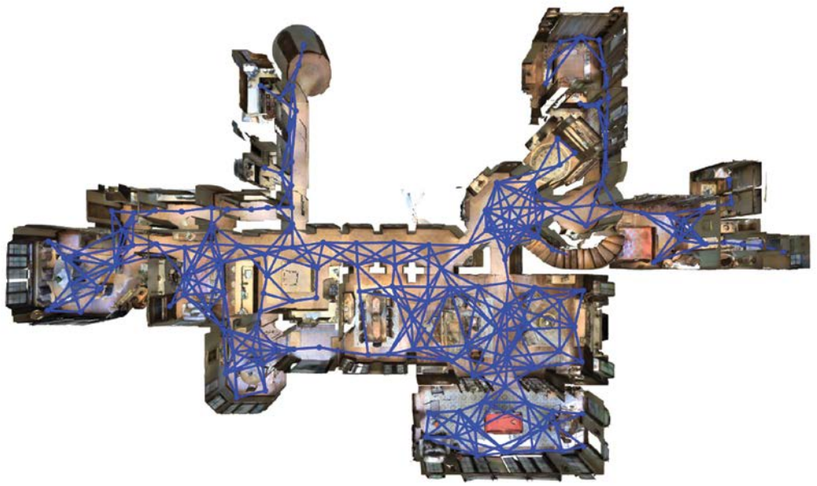
"In particular, in order to reconstruct 3D object shapes from partial observations, we train a deep neural network to 'hallucinate' the full 3D shape of an object given only a few images, or even just one image."

Placing the reconstructed objects in the 3D space would enable a robot to 'see' what and where the objects are.

Kejie says we are likely to see many virtual reality devices entering our daily lives and that representing the environment via object-level mapping would help them to understand and navigate their surroundings in the same way that people do.

The research has a long way to go, but his team is helping to map the way forward.

FUNDING: ARC CENTRE OF EXCELLENCE FOR ROBOTIC VISION



Theme leader
Dr Qi Wu

VISION AND LANGUAGE METHODS

Enabling natural language interactions with systems that exploit visual information

Recognising cats and dogs is now an easy task for a computer. The next frontier? Computers that understand natural (human) language and vision (images) in order to answer questions.

Teaching with data

Machine learning starts with making each system learn from data; we do not hard code. A big challenge can be having access to enough data. Fortunately, AIML has huge data sets from partners, in which we have the question, the image and the correct answer. These are standardised data sets. Each VQA system can be individualised to suit a particular task, from assisting with medical treatment plans, to assisting people who are vision impaired.

Research strengths at AIML

Our two major areas of focus are:

- **Dialogue**. How can we make VQA useful in real life? When people converse with each other, they don't ask just one short question; there is to-ing and fro-ing and ongoing interaction. A useful VQA system will need to keep track of what is being asked, know how to follow up, and maybe ask questions back to the person to clarify. To date, systems are only good at this when they have been heavily trained.
- **Data retrieval.** How can we enable VQA systems to retrieve information as it is needed? Let's say the system receives a question about zebras, but it doesn't know what a zebra is. We want it to be able to find out by itself.

BRING ME A CUSHION

Dr Qi Wu Director of Vision and Language Methods

CASE STUDY
VISION AND LANGUAGE

A reverie is a state of being pleasantly lost in one's thoughts, a daydream.

Having a home robot that can see, talk and actually help around the house may seem the stuff of daydreams, but Dr Qi Wu leads a project to make such dreams a reality.

Remote Embodied Visual Expression in Real Indoor Environments (REVERIE) aims to advance real-world vision and language research.

The challenge is to get a robot to complete a task by following precise instructions, including directions, descriptions and locations.

"You can ask a 10-year-old child to bring you a cushion, and there is a good chance that they will succeed, even in an unfamiliar environment," Qi says.

"While the probability that a robot will achieve the same task is significantly lower.

"Children have a wealth of knowledge learned from similar environments that they can easily apply, including that cushions may be found on couches, that couches inhabit lounge rooms, and that lounge rooms are often accessed through hallways."

Children are also able to interpret natural language instructions and associate them with the visual world.

Qi's research addresses robots' lack of these capabilities, to stretch the limits of their domain of application.

His team plans to equip robots with real-world visual navigation skills and natural language understanding, to be able to follow concise and practical instructions.

Their Matterport 3D simulator uses a 3D image of a real house to extend and test the range of tasks a robot may perform in a real indoor environment.

To be able to ask a robot to bring a cushion, or dust a light fitting, or clean up a room would not be child's play, but indeed a dream come true.

TRUSTED AUTONOMOUS SYSTEMS

Machines that work cooperatively with humans.

Trusted autonomous systems are reliable and independent. They do not need to be operated by humans, but they work alongside humans, and may communicate, cooperate and negotiate with us or other autonomous systems to achieve goals.

The road to independence

In the beginning, machines were under full human control. Then we created supervised systems (for example, automated sewing machines), and then automatic systems (such as car assembly robots). Autonomous systems are the final step. They can operate without any human intervention at all.

How can they be trusted?

The 'trusted' part is the most challenging. Trusted autonomous systems are often being applied in situations where there are big consequences for failing, such as driverless cars and robotic defence technologies. So we need to make sure they are fully reliable with very low probability for error.

Research strengths at AIML

Three key areas we focus on at AIML are:

- developing autonomous systems that are aware of the uncertain environment and can perform complex tasks successfully
- theoretical and practical research to develop systems capable of making transparent and explainable decisions, asking questions when uncertain about decisions or the surrounding environment, and understanding their interactions with the world and applying reasoning to their surrounds
- progress towards intelligently controlled autonomous vehicles.

Theme leader
Professor Anton van den Hengel

CASE STUDY
TRUSTED AUTONOMOUS SYSTEMS

BUILDING TRUST THROUGH Q&A

Dr Damien Teney Postdoctoral Fellow

Uncertainty is the driver of research. To find out what we don't know, to build our reservoirs of knowledge and to learn who, where, what, when, why and, most importantly, how – we ask questions.

Autonomous systems are becoming an everyday part of more and more diverse industries. It is important that the people working with them find them trustworthy and reliable, so as to have confidence in the outcomes.

Senior Researcher Damien Teney has been working with Dr Qi Wu and Dr Ehsan Ebbasnejad on developing trusted autonomous systems that function reliably in a complex environment and work collaboratively with people to solve problems.

To do this the autonomous systems need to be aware of uncertainty, ask questions to resolve that uncertainty and provide clear and explainable decisions in response.

This would mean they understand their interaction with the world and are capable of applying reason to a situation.

The primary technology developed in this field has been in what is called visual dialogue, which enables an ongoing conversation about an image or other visual information.

Damien says his team's research enables questions to be asked proactively, so it's not always left to people to drive a conversation and the autonomous system to just respond.

"This can fill in the 'unknown unkowns' by supplying questions we may not have realised needed asking and therefore help to find answers we didn't necessarily know we were looking for."

These conversations aim for a specific outcome, cutting out pointless chat and speeding up a result.

It is a significant step towards achieving the goal of real active collaboration between people and the autonomous systems they work with.

CASE STUDY
MEDICAL MACHINE LEARNING

BUILDING CONFIDENCE IN CANCER DIAGNOSIS

Professor Gustavo Carneiro, Director of Medical Machine Learning

Early diagnosis is the first step in successful cancer treatment and medical imaging has become intrinsic to the diagnostic process.

Professor Gustavo Carneiro's research team has been using AI to boost diagnostic screening for potentially deadly bowel and rectal cancer.

Polyps are abnormal growths that look like small bumps in the colon; some are benign but others may grow into cancer and need to be biopsied or removed.

Some are already cancerous and will need surgery, chemotherapy or radiotherapy to stop the spread.

It's very difficult to determine during an examination which kind are present and only a few experts are able to do that.

Gustavo's research team used more than 1000 images of polyps found during colonoscopies to teach an AI program to identify differences and report level of certainty around the identification process.

Identifying and treating bowel cancer is quicker and more effective when doctors can diagnose it during a colonoscopy, rather than having to wait for further tests.

Real-time diagnosis assists the endoscopist to make decisions: leave it alone, biopsy or remove.

This will fast track treatment, decrease patient risk and reduce costs thanks to faster treatment and a reduction in colonoscopy related complications.

"Our target is that this system will be as accurate as an experienced endoscopist in the detection and classification of polyps," Gustavo says.

The research has been very positive, offering the hope of moving the computer-assisted diagnostic system to clinical trials in the next few years.

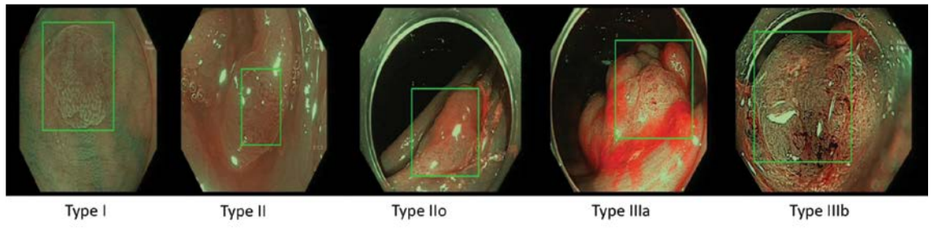
Translating research findings into use by medical experts will be a big step forward for machine learning in health.

Theme leader
Professor Gustavo Carneiro

MEDICAL MACHINE LEARNING

Applying machine learning methods to problems in Health and Medicine.

With more data available in the healthcare sector than ever, the AIML is seizing the opportunity to make significant progress in clinical diagnosis and prognosis through data analysis. Using machine learning techniques, computers can analyse large datasets, potentially including billions or trillions of data points, and learn to detect illness sooner and with higher success rates leading to a healthier society.



Improving patient understanding

One key area of research has been improving clinical decision making and patient understanding. Typically, if a patient has follow-up questions after a diagnosis, they are either required to make another appointment, causing delays and increased costs, or resort to search engines and get general and potentially inaccurate advice. Using Artificial Intelligence, patient oriented interfaces can be developed to provide meaningful and bespoke information to improve patient wellbeing.

Research strengths at AIML

AIML has partnered with world leading medical research institutions and together are we working on solving issues that have real impact on healthcare.

We are currently focusing on the following areas:

- applying machine learning to cardiology, cancer (colorectal and breast cancer), obstetrics and gynaecology, orthopaedics (arthroscopy, hip replacement), neurology (transient ischaemic attack, stroke, vascular dementia), and public health
- improving clinician certainty through machine learning methods to provide a 'second opinion'
- increasing patient awareness and experience through improving accessibility to approachable and bespoke information.

CASE STUDY
ADVANCED REASONING AND LEARNING

GOING DEEP FOR MINERAL TREASURE

Professor Javen Shi Director of Advanced Reasoning and Learning

Prominent Hill, in South Australia's far north, has been a rich source of minerals for almost 20 years. Keen to extend the life of this resource, mine operator OZ Minerals created a crowd-sourcing competition to pinpoint potential exploration sites.

The OZ Minerals Explorer Challenge took place over three months, involving more than 1000 participants from 62 countries.

They dug through more than six terabytes of public and private exploration data to identify mineral deposits and find new ways to access them.

There was a $1 million prize pool on offer as well as the prestige of leading the way for the local mining industry.

Professor Javen Shi led a team from AIML and the University's Institute of Mineral and Energy Resources on the treasure hunt, in collaboration with industry experts in minerals exploration and geoscientific modelling.

His DeepSightX consortium exploited multi-disciplinary skills at the intersection of artificial intelligence and geoscience to analyse the exploration data sets.

AIML provided machine learning techniques and engineering support, while the Geoscience team members contributed an understanding of the exploration process, industry best practice and true domain expertise.

"The team developed a drilling exploration plan that took advantage of the overwhelming data available, while being justifiable from a geoscientific perspective," Javen says.

"We achieved this by integrating the latest concepts from mineral systems modelling, with recent breakthroughs in deep learning – artificial neural networks and algorithms inspired by the human brain that learn from large amounts of data – and computer vision."

The result was a world-class predictive modelling capability, which confidently recommended a series of drilling targets and enabled feedback of more data to further develop the model and AI targeting.

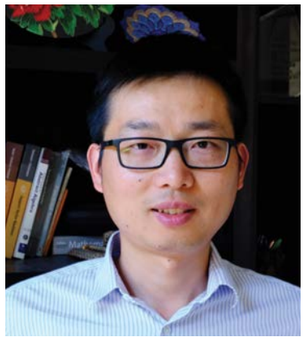
The DeepSightX team took out second place in the OZ Minerals Explorer Challenge, winning a $200,000 prize.

The results of the international challenge offer the potential to revitalise mineral exploration and discovery in South Australia.

Javen's team was proud to further the cause of integrating AI into the mining industry and plans to expand and commercialise its work.

"The competition was a prelude for DeepSightX and we look forward to the exciting journey ahead," Javen says.

The DeepSightX team has embraced the opportunity to develop deep learning to improve mineral exploration and help uncover the treasure in our own backyard.



Theme leader
Professor Javen Shi

ADVANCED REASONING AND LEARNING

Enabling higher-level analysis and ongoing learning in machine learning methods

Recognising patterns in complex datasets is at the heart of machine learning. With the efficiency improvements made possible by innovation in this field, algorithms that can interpret and learn from data from any industry are key.

AI that makes sense

With artificially intelligent systems being used to inform decisions in the public and private sectors, it is crucial that the solution provided can be understood and justified by humans. Researchers at the AIML are designing AIs that make decisions using logic and reason, not simply magic.

Industry independence

Machine learning has the potential to deliver substantial improvements in nearly every industry. With research into advanced learning, models are capable of drawing conclusions from complex relationships between variables based on potentially trillions of data points. Needless to say, this level of analysis has previously been inaccessible by humans.

Research strengths at AIML

Two key areas we are focusing on are:

- advancing machine learning through research into core theory in optimisation and deep learning and developing algorithms that allow for analysis beyond today's capability,
- developing systems that unlock the real-world potential of AI and can be applied directly to industry challenges.

CASE STUDY
VISUAL
ODOMETRY

WORKING ALL THE ANGLES FOR BETTER VISION

Huangying Zhan, PhD student with Professor Ian Reid

Visual odometry analyses camera images to determine the position and orientation of a robot, so it can localise itself.

An on board sensor, often a single camera, tracks visual landmarks for navigation, in the same way that people rely heavily on their vision to get around.

With rapid advancement in mobile robotics and industrial automation it has become an increasingly important area of research – resulting in innovative and helpful tools from robo-vacuum cleaners to the Mars Rover.

Working with Professor Ian Reid, Huangying has been advancing visual odometry by integrating traditional geometric methods and newer deep learning methods of measurement
and analysis.

They are trying to overcome a longstanding problem in computer vision when using a single camera, called Monocular Visual Odometry.

"We try to revisit the basics of visual odometry, using geometry-based methods, and draw the best from a learning approach and a geometric approach to solve the problem in
a simple but effective way,"
Huangying says.

Huangying has built a system called DF-VO that uses a deep optical flow network to establish good correspondences between images.

These are used for geometry-based approaches to estimate the camera motion.

Huangying says the system is state-of-the-art for monocular VO.

"More interestingly he has shown that the deep networks can be fine-tuned online, so this is a step towards an online learning system that can get better and better at a specific task just by 'watching video'."

A lot of computer vision tasks rely heavily on pure deep learning, but Huangying says it's important not to abandon traditional methods that still have a lot to contribute to building simple yet effective and robust systems.

The ultimate aim is to create lifelong learning systems that enable robots to continually improve how they operate in the world.

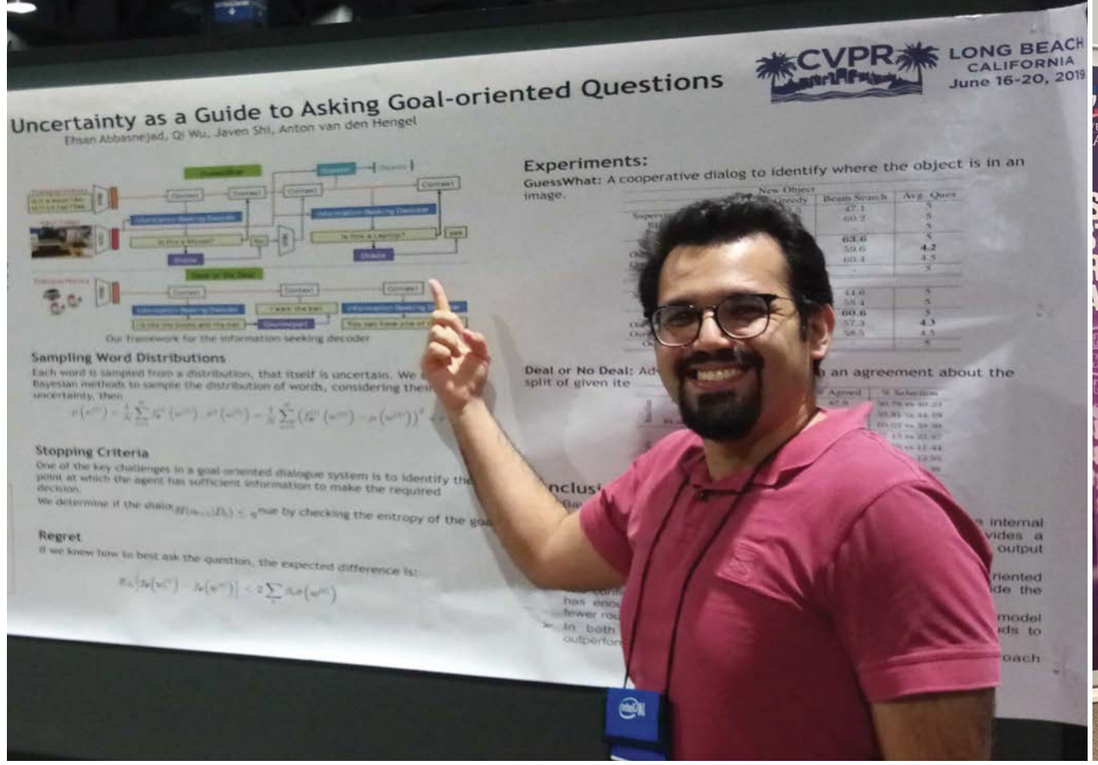
FUNDING: ARC AUSTRALIAN CENTRE OF EXCELLENCE FOR ROBOTIC VISION

AIML @ LOT FOURTEEN

In December 2019, AIML officially moved its operations over to Lot 14 to take residence in the former Women's Health Centre building.

With the heritage listed building being over 80 years old, the 2,400 square metre premises was modernised to facilitate cutting-edge, state-of-the-art research.

CONFERENCE HIGHLIGHTS



SA Regional Development Conference

Innovation Along the Value Chain was the theme of this conference held in Tailem Bend in May, where Dr Paul Dalby presented "The Future of Artificial Intelligence in the Food Industry".

ICRA 2019

The International Conference on Robotics and Automation was held in Montreal in May. PhD Graduate Mehdi Hosseinzadeh spoke on the fundamental problem of Simultaneous Localization and Mapping and presented a way to improve map quality without requiring additional hardware in mobile robotics at the 2nd International Workshop on Lines, Planes and Manhattan Models for 3-D Mapping.

CVPR2019

The conference on Computer Vision and Pattern Recognition was held in June in Long Beach, California. AIML representatives who presented papers included Dr Hui Li, Dr Ehsan Abbasnejad and Dr Damien Teney. The AIML had 18 publications accepted in total.

KDD 2019

Anchorage in Alaska hosted the KDD conference on Knowledge Discovery and Data Mining in August. Guansong Pang, Professor Anton van den Hengel and Professor Chunhua Shen's paper on Deep Anomaly Detection with Deviation Networks was accepted for oral presentation.

BMVC 2019

AIML was well represented at the 30th British Machine Vision Conference, held in Cardiff in September. Papers from Professor Ian Reid and PhD students Jiawang Bian, Kejie Li, Ravi Garg and Ming Cai were accepted.

AI for Business Summit

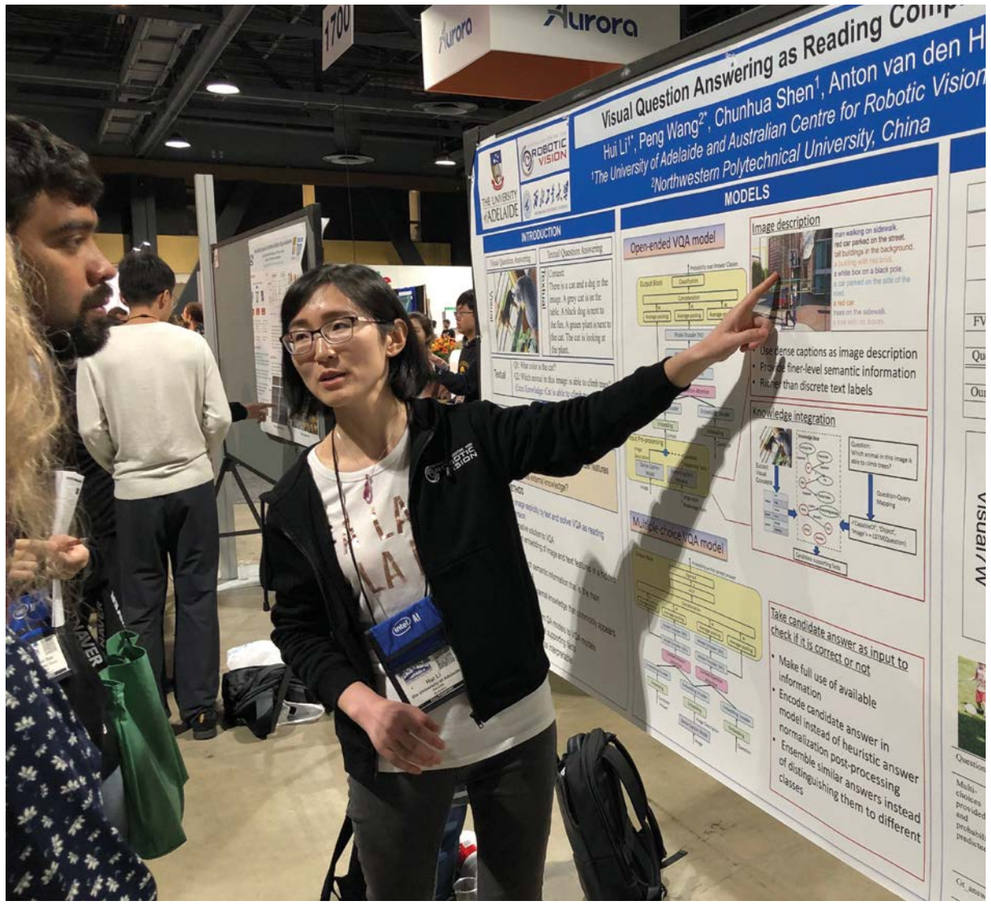
AIML was strongly represented in Sydney in September, with Professor Ian Reid presenting on how Computer Vision, Robotics and AI interrelate and what the future looks like for robotics; and Dr Paul Dalby providing insight on the uptake of AI in business and government on an interdisciplinary panel.

IMARC 2019

The International Mining and Resources Conference was held in Melbourne in October. Dr Zygmunt Szpak delivered the METS Technology workshop on data analytics and machine learning, and how to prepare businesses for to take advantage of the new technologies.

NeuroEng 2019

Professor Mark Jenkinson presented on Big Data MRI at the 12th Australasian Workshop on Computational Neuroscience and Neural Engineering in Adelaide in November.



AIML IN THE COMMUNITY – CAPACITY BUILDING

Austmine 2019

Austmine 2019

In May Dr Zygmunt Szpak ran "Machine learning: what does that actually mean for a METS business?", a workshop teaching industry professionals from the Mining Equipment, Technology and Services (METS) sector about the benefits of machine learning and AI at the Austmine conference in.

Bringing AI to the state libraries

A new partnership between AIML and the City of Adelaide delivered a series of Tech Talks on the present and future possibilities of AI.

Academics from AIML and the broader University spoke to diverse audiences on topics ranging from AIs impact in fashion, health and agriculture, the positive implications of AI on the future job markets; and improvements for diversity in both the AI workforce and data sets.

Strong Women in Future Technologies (SWIFT)

Designed and hosted by AIML, the inaugural SWIFT program engaged students between the ages of 8 to 13 years old who identify as female or non-binary. On Friday the 20th of September, two SWIFT Student Workshops were hosted: for competition winners and a parent/caregiver; and a teacher/educator focus group. It was pleasing to see representation across both regional and metropolitan South Australia.

The aim of SWIFT was to uncover the current understanding of artificial intelligence and machine learning study and career pathways, and the barriers holding young women and gender-diverse persons back from taking up these options. Topics also included understanding unconscious and implicit bias, the imperative for these students to contribute to current and future technologies, and the personal skills required to be successful.

Future Thinkers

Professor Anton van den Hengel was the keynote speaker in November at the third Future Thinkers event in Adelaide for 2019, "Are Robots Taking Our Jobs?" He joined a panel discussion featuring Dr Michelle Perugini and Adrian Fahey from SAGE Group.

Women in Maths Day

To celebrate International Women in Mathematics Day, AIML partnered with other communities at The University of Adelaide to run the first Women in Maths Day SA Conference on Monday 13th May 2019. This event recognised the value and importance of diversity within the field of AI research.

Machine Learning for Executives

Developed and delivered by AIML researcher Dr Zygmunt Szpak in partnership with Executive Education at the University of Adelaide. This course was designed as an introduction for executives wanting insight into machine learning (ML) with a focus of identifying ways AI and ML could support their businesses.

Smarter Regions CRC

AIML held an introductory workshop for potential partners in the Smarter Regions Cooperative Research Centre in Adelaide in October, with a follow-up event in Port Pirie in November.

Bringign AI to the state libraries

The workshops outlined the opportunities and threats posed by AI to regional Australia and invited organisations to indicate specific projects for co-investment.

ETIG working group

The Artificial Intelligence Emerging Technology Interest Group (ETIG) was launched at the Adelaide Oval on the 6th of June with a presentation by Dr Zygmunt Szpak, introducing the series of eight planned workshops and seminars. Delivered in partnership with the Department of Trade, Tourism and Investment (DTTI), the program had a focus on the application and implementation of AI technologies in business and industry.

With members from over 75 unique companies in attendance, the events pragmatically explored data management, licensing, big data analytics and business strategy. AIML worked with key stakeholders, including but not limited to, IBM, Saab and the Department of Energy and Mining to make the events a success

.

An important objective of this series was to spawn collaborative projects between members of the group. Four such projects were formed, ranging from automated production processes for Bickford's Australia, to smart probes for advanced sensing and tomography in partnership with MiniProbes and Meat and Livestock Australia.

Strategic alliances were also cultivated between AIML and AiLab, Adiona, Brainframe and Consillium Technology to enhance consulting and industry expertise.

A highlight of the series was having data specialist, speaker and author, Ellen Broad present "Responsible AI in Practice: Openness & Transparency". She discussed the ideas of ethical, transparent and accountable AI systems; concepts that are of mounting importance as the technology becomes increasingly commonplace.

This collaboration with industry highlighted the increasing rate of digital innovation in South Australia and further cemented AIML as the foundation for that growth.

AWARDS AND PRIZES

Global Space Challenge winners

The Pose Estimation Challenge asked competitors for accurate estimation of distance and orientation (pose) of a spacecraft from its synthetic and real images, captured using computer graphics and a robotic testbed.

The knowledge developed through this competition can be directly applied to Space Situational Awareness (SSA) problems, which is a priority area for the Australian Space Agency due to the increasing concerns surrounding space debris.

Professor Tat-Jun Chin and Dr Bo Chen won a global space challenge run by the European Space Agency, beating teams from a range of prominent universities.

Digital Culture win at Govhack 2019

Congratulations to Team **Artificially Intelligent** including AIML researchers Yasir Latif, Sam Bahrami, Boris Repasky, Mahdi Kazemi and Thomas Rowntree for first place in the Digital Culture category for their work training two machine learning models using two specific data sets.

The first model applied a concept called neural style transfer to current images and historical photos from the History Trust of South Australia's photographic collection. It allowed the style of one image to be transferred to another image, enabling reproduction of any photographic style regardless of the age of the photo.

The second model used a series of old colonist photographs from the State Library of South Australia collection, allowing the user to identify the colonist photograph that most closely resembled themselves. This was achieved using facial similarity detection, a neural network that they trained to find the most similar face.

The aim of the competition was to increase public engagement with the history of South Australia. The team created a physical demonstration where you could walk in front of a camera and in real-time have your colonial doppelganger created which proved to be very engaging.

First Place at Volkswagen Logistics Innovation Day in Shanghai

This global event showcases the latest technologies in automobile manufacturing. Golden Prize (first place) was awarded to Professor Javen Shi and his team, which includes PhD student Mahdi Kazemi Moghaddam for their work in demonstrating how artificial intelligence can improve vehicle manufacturing.

Javen and Mahdi received their first place for the development of a digital factory. This consisted of a dashboard that could monitor and manage the processes taking place on the factory floor, showing performance metrics of systems and ultimately leading to increases in efficiency and safety.

CORE: Chris Wallace Award for Outstanding Research in computer security and computer architecture

Awarded to Dr Yuval Yarom for his for his internationally significant recent work on hardware vulnerabilities. This is the most prestigious award in Australia for Computer Science research and given on a yearly basis for a notable breakthrough or a contribution of particular significance to the field.

STEM Initiative

Ali Anderson and AIML won the award for Best Industry STEM Initiative at the Electronics Industry Excellence Awards.

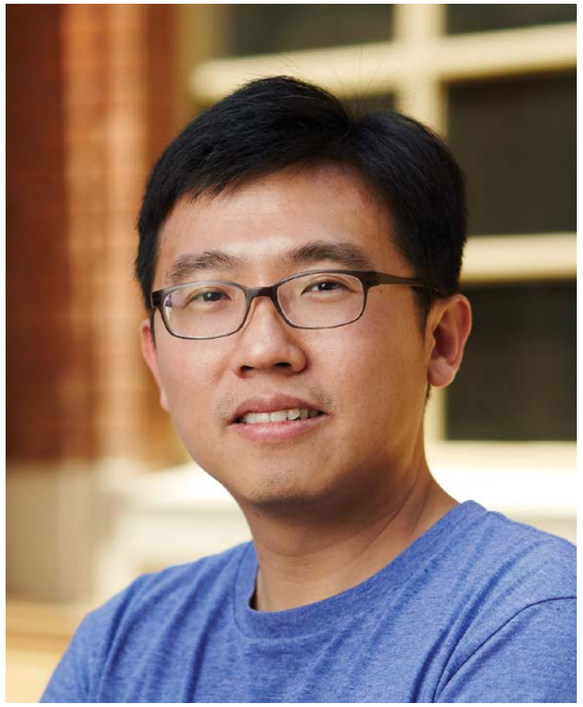
Fellowship Success

AAS JG Russell Award

Dr Qi Wu towards his DECRA to develop an Artificial Intelligence agent that communicates with humans on the basis of visual input, and can complete a sequence of actions in environments by combining computer vision, natural language processing and reinforcement learning.

ARC Future Fellowship

Professor Gustavo Carneiro to continue working on the development of computer vision and machine learning techniques in the area of medical image analysis problems. The Future Fellowship is given to outstanding mid-career researchers to enable them to undertake high quality research in areas of national and international benefit, and to conduct this research in Australia.



ARC DECRA

Dr Yuval Yarom for his project on Microarchitectural attacks and JavaScript: threats and defences. Expected outcomes of this project include novel techniques for protecting web browsers and cloud servers to prevent them from inadvertent leaks of private or sensitive information in an effort to enhance cybersecurity.

ARC Discovery Grants:

- Professor Tat-Jun Chin
- Professor Chunhua Shen
- Professor Ian Reid
- Dr Seyed Hamid Rezatofighi

Postgraduate Scholarships

Congratulations to:

- **Lockheed Martin Honours Scholarship** to Clint Gamlin for his work in machine learning deployment on Field Programmable Gate Arrays;
- **Lockheed Martin PhD Top-up Scholarship** to Jordan Yeoman who is investigating new machine learning techniques in the area of reinforcement learning
- **Google PhD Fellowship** to Zhi Tian, supervised by Professor Chunhua Shen, was awarded a Google PhD Fellowship in Machine Perception.

FACEBOOK INTERNSHIP
KEJIE LI GETS A SLAMMING START IN SEATTLE

PhD student Kejie Li's work on Simultaneous Localisation and Mapping (SLAM) gained him a six-month internship with Facebook Reality Lab in Seattle, starting in September 2019.

There he worked on an object-based mapping system, known as FroDO, with a paper to be published in Computer Vision and Pattern Recognition 2020.

Kejie says his time working with industry has taught him about improving research efficiency by focusing on daily deliverables and quickly building on ideas that flow from that focus.

He has also learned to look beyond quantitative evaluation, important as that is, by keeping in mind that the ultimate goal is to make something work in real life.

A highlight of Kejie's Facebook odyssey has been working with 'rock stars' of his field, including Steven Lovegrove and Richard Newcomben and his inspiring mentor Julian Straub.

While breakfast at the Facebook café provides an awesome start to the research day, Kejie says that nothing beats Australian coffee!

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