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Biennial Research Report 2019–2021

Research in the School of Electrical and Information Engineering

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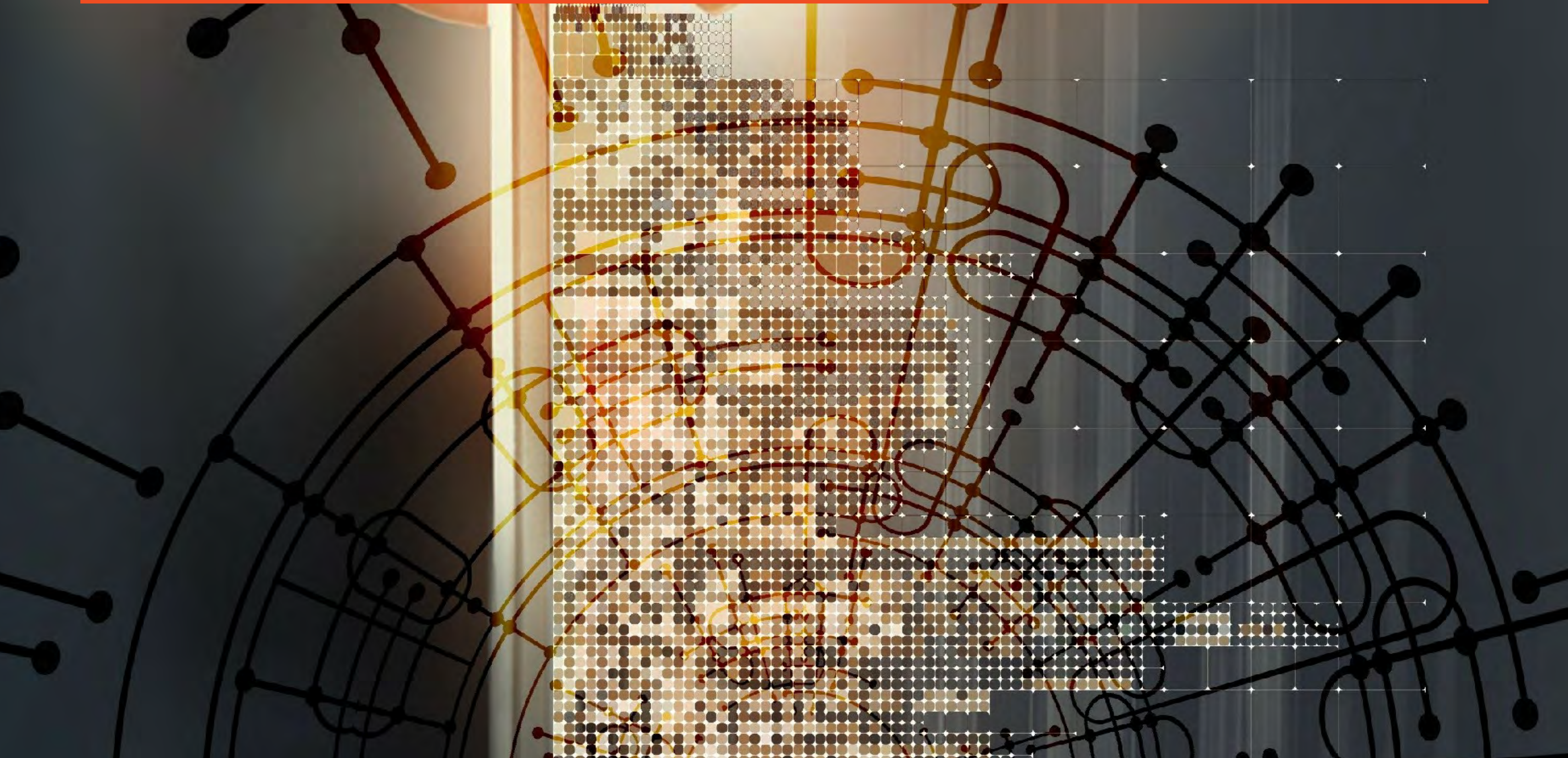


“Together we are finding sustainable solutions to create a better future"

Contents

Our vision

To be the leading school in the field of electrical and information engineering in Australia, among the best in the world, and to be recognised as such by our peers, students, and external partners.

We will achieve this through our innovative teaching and research for the digital transformation of the world; our strengths in energy networks, wireless communications and networking, computer hardware and software, AI, photonics, and our strong industry links.

Message from the Head of School

Collaborating in our digital world

Over the past two years the adoption of digital technologies has taken a giant and unforeseen leap forward due to the COVID 19 pandemic. Governments, industry and consumers alike quickly embraced digital channels to communicate and provide services.

Over time our researchers have contributed to the design and ongoing development of these now commonly used digital platforms. And it was these very platforms that largely allowed us to continue our research and meet the ever-growing demand for research engineers with skills in AI, data processing, computer hardware, photonics and smart grids.

We were able to continue our quest to find sustainable and reliable solutions that will meet future needs for smart, clean energy cities, instant wireless communications, virtual healthcare and advanced manufacturing techniques.

As a result, the School's research productivity remained high as did its success in securing Australian Research Council discovery and linkage grants. Our expertise was recognised internationally with several of the school's researchers named among the world's most influential.

I am delighted to also report that we remained ranked as one of the best universities in Australia and the world for electrical, computer, photonics and telecommunications engineering.

I thank each of our industry partners for their strong and ongoing support. By working closely with our industry partners we believe we can thoroughly understand the needs and trends of industry and how our research can support the broader community to achieve its goals.

Finally, I would like to thank the School's academics, researchers and staff for their tenacity and dedication throughout what can be seen by many as a challenging time.Together we have remained focused, committed to finding solutions that are sustainable and flexible for a rapidly changing world.

Professor Jian Guo (Joe) Zhu

Our research excellence

Our work is guided by the pursuit of excellence and genuine engagement.

It is underpinned by values of courage and creativity, respect and integrity, inclusion and diversity, and openness.

The School of Electrical and Information Engineering is dedicated to finding solutions to the issues facing the power, communications and healthcare sectors. Our researchers are undertaking cutting-edge research in collaboration with industry partners across a wide range of related sub-disciplines. Our current work is future focused in areas such as energy networks, wireless and telecommunications engineering, computer, software and photonics engineering.

With an annual research budget in excess of $3 million and more than 50 researchers, we host the largest research program within the University of Sydney's Faculty of Engineering. Our efforts divided into the following four core discipline areas:

- **Computer and software engineering**
- **Photonics engineering**
- **Power engineering**
- **Telecommunications and the Internet of Things**

Our global reach

Whether face-to-face or via an online platform we are committed to creating and enhancing our international research network. We will continue to work with tertiary institutions, industry and governments across the globe.

As we participate on the global stage we are also working closely with our Australian counterparts to find solutions to current and future challenges.

Asia Pacific Region

23

Europe

3

United Kingdom

8

USA and Canada

10

Australia

8

Regions where we are collaborating

Our research leaders

Professor Jian Guo (Joe) Zhu
Head of School and Centre for Future Energy director

Professor Joe Zhu, a specialist in clean energy, joined the University of Sydney as Head of the School of Electrical and Information Engineering in 2018.

Professor Philip Leong
Deputy Head of School and Computer Engineering director

Professor Philip Leong is recognised internationally for his pioneering work in using FPGA to solve otherwise intractable computing problems.

Associate Professor Craig Jin
Computing and Audio Research Laboratory head

Associate Professor Craig Jin is recognised worldwide as a leader in recording, generation, and perception of spatial audio.

Professor Robert Minasian
Fibre-optics and Photonics Laboratory director

Professor Robert Minasian is acknowledged internationally as an authority in the field of photonic signal processing.

Professor Xiaoke Yi
Sensing, Communications and Security director

Professor Xiaoke Yi, was a QEII fellow and she has been recognised as one of Australia's most innovative engineers for her work in microwave photonic nanocircuits.

Associate Professor Gregor Verbic
Centre for Future Energy Networks director

Associate Professor Gregor Verbic is recognised for his expertise in power system operation, stability and control, and electricity markets.

Professor Dong Xu
Chair in Computer Engineering

Professor Dong Xu is recognised for his work in computer vision, multimedia, machine learning and biomedical image analysis. His group has developed new machine learning methods and intelligent systems for a broad range of vision and big data analytics related applications.

Associate Professor Luping Zhou
ARC DECRA Fellow

Dr Luping Zhou is a senior researcher recognised for her work developing medical imaging applications with machine learning and computer vision techniques for computer-assisted diagnosis.

Associate Professor Wanli Ouyang
ARC Future Fellow

Associate Professor Wanli Ouyang is a young leader in machine learning. His research interests include deep learning and its application to computer vision and pattern recognition, and image and video processing.

Professor Branka Vucetic
The Centre of Iot and Telecommunications director, ARC Laureate Fellow

Professor Branka Vucetic is an internationally recognised expert in coding theory and its applications in wireless engineering. Her work aims to develop theoretical frameworks and design principles for wireless communications

Professor Abbas Jamalipour
Wireless Networking Laboratory director

Professor Abbas Jamalipour is a professor of Ubiquitous Mobile Networking and author of the first book on Wireless IP.

Professor Yonghui Li
Wireless Engineering Laboratory director

Professor Yonghui Li is a wireless telecommunications expert specialising in wireless communications, internet of things and machine to machine communications.

Our highlights - Honours and awards

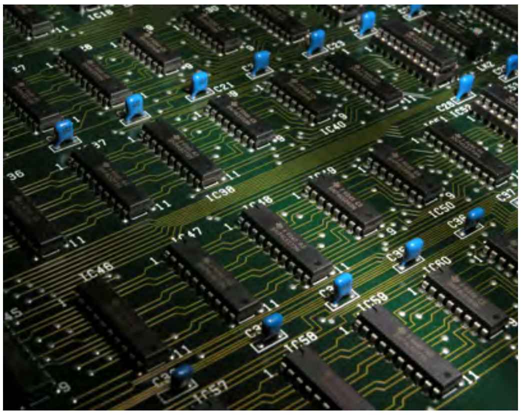
Creating a digital, sustainable and healthier future

Stanford study shows
A study conducted by Stanford University recognised ten of our researchers as among the world's most-cited (top 1.3%, approximately 100K top researchers). Looking at several indicators, the study analyzed data, covering ~7 million scientists in 22 major fields ranging from chemistry to engineering to economics and business. Those named included Professors David Hill, Branka Vucetic, Robert Minasian, Abbas Jamalipour, Yonghui Li, Dong Xu, Weidong Xiao, Jianguo Zhu, Wanli Ouyang, and Philip Leong.

Australia’s top fifty
Dr David Boland whose work is aimed at achieving faster and more energy efficient computing was name in *The Australian* as one of the nation’s top 50 engineering and computer science researchers. His research seeks to develop tools to create efficient hardware accelerators.

Patenting our inventions
Professor Xiaoke Yi and Dr Shijie Song were granted an United States patent for their landmark invention relating to optical RF spectrum analysers and methods for analysing an input RF signal. The work supports the ever-increasing demand for information and communication systems that can process high-frequency and wideband signals at lightning speed.

Honours and awards



Advancing the Internet of Things

Honoured for their contributions to advancing the frontiers of science, engineering and technology research colleagues Professors Branka Vucetic and Yonghui Li were listed among the 2020 winners and listed in the AI2000 Most Influential Scholar Awards for their “outstanding technical achievements with lasting impacts and contributions” to the field of Internet of Things between 2009 and 2019.

Powering on

Professor (Emeritus) David Hill was awarded the 2021 IEEE PES Prabha S. Kundur Power System Award. This prestigious award recognises outstanding contributions to the understanding and control of the dynamics of the power system. Professor Hill’s research has focussed on what many people call 'smart grids' - power systems with embedded 'intelligence'. His work aims to make the energy grid more automated and efficient, and sustainable.

Funding supports collaboration

Energy efficiency is an important component of efforts to supply affordable, reliable, and green electric power, and demand response technologies have emerged as an essential tool for both energy utilities and end-users. Our researchers working within the Australia-China Joint Research Centre for Energy Informatics and Demand Response Technologies received funding to support vital work on finding new technological solutions for efficient and reliable energy supply.

Eye on the prize

Associate Professor Wanli Ouyang was awarded the Outstanding Young Author Award of the IEEE CAS Society. Associate Professor Ouyang's research into computer vision, pattern recognition and image processing aims to simulate in computers how humans perceive our environment, for a wide range of applications. The objective of this work is to mimic the human brain's capacity to perceive and understand what we see.

Our highlights - Research projects

Computer and Software Engineering

Learning from web data

The Automatic Video Annotation by Learning from Web Data project is contributing to the computer vision and machine learning communities. A prototype system can be used by individuals to search personal videos using textual queries. The system could also be applicable to video surveillance applications, enhancing Australia's homeland security.

Our ARC funded project is studying next-generation video annotation technologies. New domain adaptation schemes and frameworks are being studied to improve video annotation performance by learning from a massive amount of web images and videos.

Object recognition

Reliable object recognition systems are critical to technologies such as intelligent transportation systems (ITS) in driverless cars. The AUSLearn: AUtomated Sample Learning for Object Recognition project is developing new algorithms for computers to learn to recognise objects. This will improve the accuracy of technologies such as ITS.

The new algorithms will benefit a wide range of applications, for example to effectively use car crash training samples for accurately identifying potential road crashes in transport.

Influential Scholar

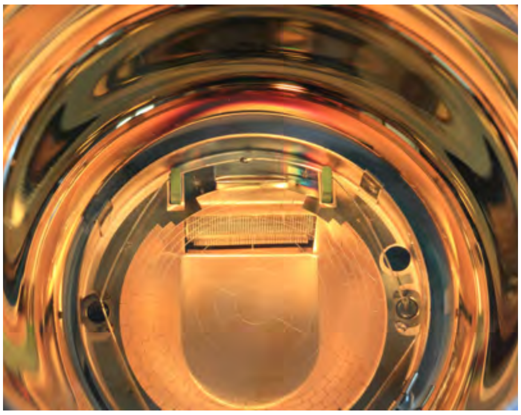
Associate Professor Wanli Ouyang was awarded the AI 2000 Most Influential Scholars Honorable Mention in the field of computer vision. He is one of only three Australian researchers nominated on the list. According to SciVal, Ouyang's "Field-weighted citation impact (FWCI)" and "citations per paper" are ranked as top-10 in the world for the publications in 2016-2021 in his research area.

Power

Modelling and analysis of renewable energy grid

This project aims at designing energy management solutions for a precinct embedded network considering several energy carriers, including electricity, gas, heat and hydrogen. It works with energy technology manufacturers, network service providers, technology providers, and energy retailers and market operators to design solutions that will pave the way for the operation of embedded networks in a carbon constraint environment. The project is funded by Mitsubishi Heavy Industries, a globally leading energy technology manufacturer.

Research projects



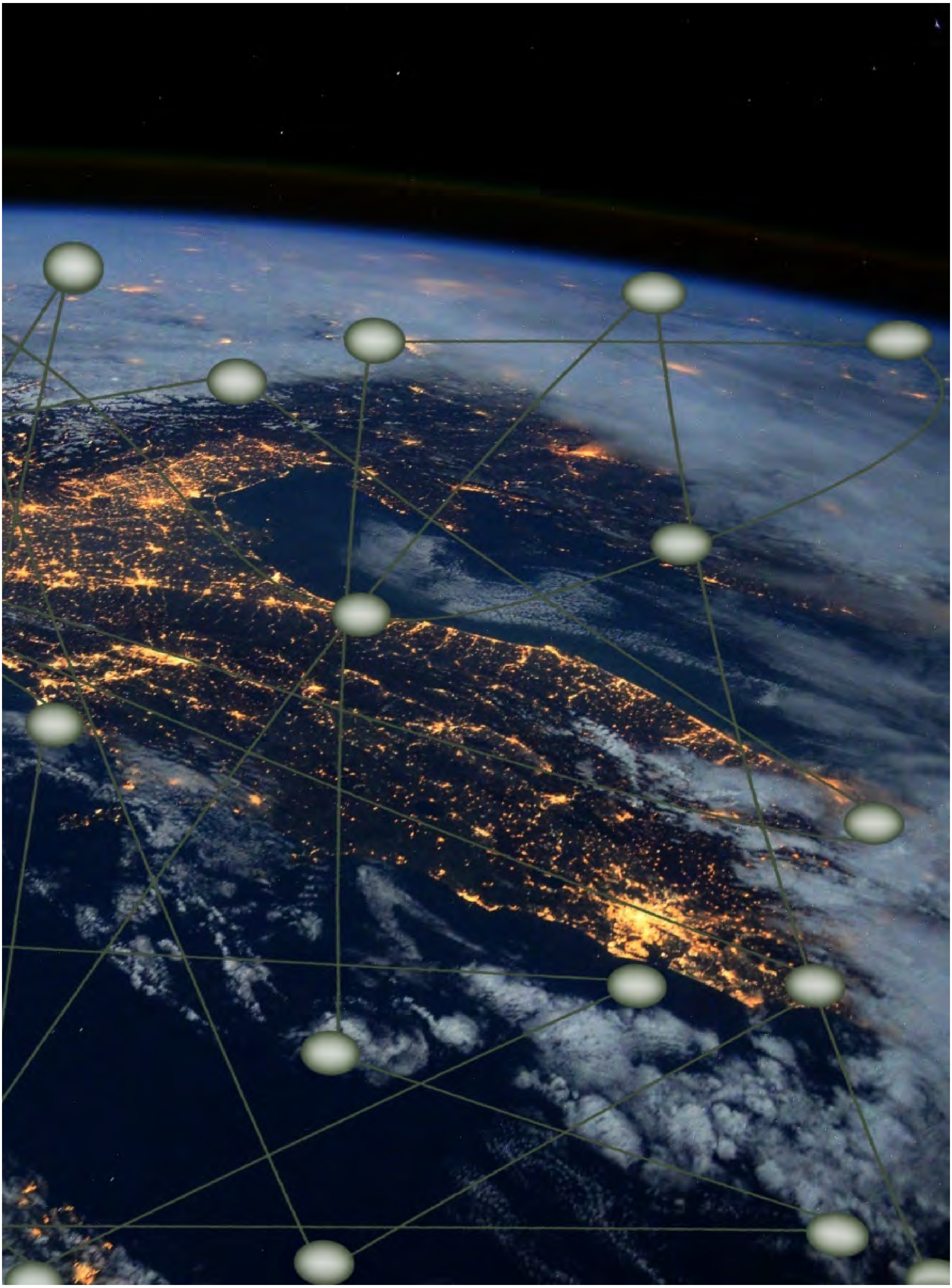
Photonics

Microwave photonics and photonic integration for advanced sensing
This project leverages breakthroughs in microwave photonics and integrated photonics for advanced sensing with wide range of applications in Internet of Things and healthcare. It develops compact and cost-effective micro-resonator sensors for unmanned aerial vehicle (UAV) applications in harsh environment, high-performance magnetic field sensor and high-density magnetic field sensing array with scalability. Outcomes herald disruptive, compact on-chip sensing techniques for reliable, high-resolution, low-noise and real-time sensing.

National Interest Test Statement
Capitalising on advancements in microwave photonics and photonic integration this project is developing innovative frontier technologies for advanced sensing. The proposed compact and high performance sensors will lead to breakthroughs in integrated sensors which will bring significant national benefits in environmental monitoring, disaster management, internet of things and healthcare diagnostics. This project will strengthen the development of end-user driven sensing devices and systems, and increase Australia's opportunities in the fourth industrial revolution.

Telecommunications and IoT

Smart Material Recovery Facility (SMRF) Curby Soft Plastics Project
Together with our software colleagues we are developing a template for upgrading existing Material Recovery Facilities (MRFs) to Smart Material Recovery Facilities (SMRFs) by introducing Internet of Things (IoT) automation and trial it in an existing MRF, aiming to increase post-consumer soft plastics recycling by 80 times 2018 levels delivering process engineered feedstock integrated with industry. It will address the waste export ban and contribute to Australia's transition to a circular economy. SMRFs utilise the CurbCycle Solution for household segregation and collection of soft plastics. It enhances existing recycling infrastructure that may be used to lift recycling rates on other materials



More about our research

Computer and software engineering
Our project highlights

Dr David Boland whose work is aimed at achieving faster and more energy efficient computing was named as one of Australia's top 50 computer scientists.

"I study the computer algorithms used to solve problems across many domains, including scientific computing, machine learning and optical communications".

The personal computers available today operate on a range of software but do not have the flexibility to use all available hardware.

"I consider how to design fully customised hardware solutions to these problems. In doing this, I focus on how to perform as little computation as necessary, while still obtaining results as accurate as those produced by the original algorithm used in the software. This helps to maximise energy efficiency. I also look at how to do as much parallel computation as possible, in order to maximise performance.

“The technology to support this exists: we can already create application-specific integrated circuits, and we can use field-programmable gate arrays on which custom hardware designs can be programmed after manufacturing. However, designing customised hardware architectures is challenging, so is currently restricted to experts. I’m interested in making this performance more widely accessible.

“My research to date has largely focused on accelerating common computational kernels and basic arithmetic structures. I’m currently working on creating custom hardware accelerators for machine learning within the context of analysing wireless communication systems.

“High-performance and energy-efficient computation is also critical for the development and widespread use of novel technologies such as artificial intelligence, which could transform society. The challenge is to develop design techniques that are of benefit both now and in the future.”

Computer and software engineering

Computer and software engineering – our multidisciplinary group has four key strands of research covering computer engineering, computing and audio research, image processing, and software engineering.

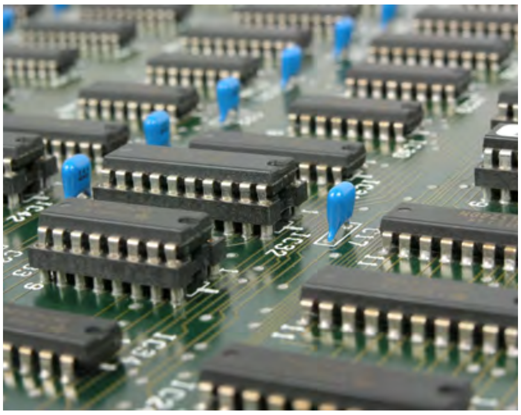
"*Our research and data set contribute to the development of novel hardware and software techniques used to solve computationally intensive problems," Professor Dong Xu*

Distributed aUtonomous Spectrum managemenT (DUST)
A cooperative research centre project, DUST is being undertaken on behalf of the Department of Defence. Led by Consunet Pty Ltd, and including a multi-university team of researchers from RMIT University, the Universities of Melbourne and Sydney and DST, DUST aims to develop and demonstrate near real-time autonomous spectrum management to deliver cost savings for Australian Defence and commerce.

Automatic video annotation by learning from web data
This ARC Future Fellowship project is studying next-generation video annotation technologies to automatically tag raw videos using a huge set of semantic concepts. It investigates new domain adaptation schemes and frameworks to substantially improve video annotation performance. The resulting prototype system could be used by people worldwide to search their personal videos using textual queries. The system is also applicable to video surveillance applications, which can enhance Australia's homeland security.

AUSLearn: AUtomated Sample Learning for Object Recognition rate
Reliable object recognition systems are critical to technologies such as intelligent transportation systems (ITS) in driverless cars. This recently ARC funded project will develop new algorithms for computers to learn to recognise objects, which will improve the accuracy of technologies such as ITS. The outcomes of this project can be applied to many industries, especially the transport innovation sector that is projected by Austrade to `explode in value to more than $16 billion ... by 2025'.

Computer and software engineering



Translating AI networks to support clinical excellence in neuro diseases

Software–generated 'artificial neural networks' have demonstrated a remarkable capacity for (generic) image recognition, with error rates of only 1–2%. This project will build a hybrid AI learning ecosystem that links researchers and industry specialist from Sydney Neuroimaging Analysis Centre, with health provider networks including IMED Radiology and clinical Neurology partners to generate clinically–relevant biomarkers of disease progression of the common, disabling neurological condition, multiple sclerosis.

Personalised learning for per-pixel prediction tasks in image analysis

AI-assisted image segmentation and synthesis are very challenging and usually require pixel-level labelling (per-pixel prediction) that is costly to obtain. The small number of labels makes it difficult to train an "optimal" unified model for varied data as conventional methods did. Our researchers aim to develop a new paradigm "personalised learning" to tackle this problem, where each image could be dealt with a model tailored to individual characteristics.

Edge-accelerated deep learning

Implementing deep learning applications usually requires a large amount of collected data and powerful computing resources. Without properly addressing the provision of computing, the wider application of deep learning in practice will seriously be hindered. This ARC funded project will build an edge computing system for effective deployment and efficient execution of deep learning applications in the large-scale distributed environment.

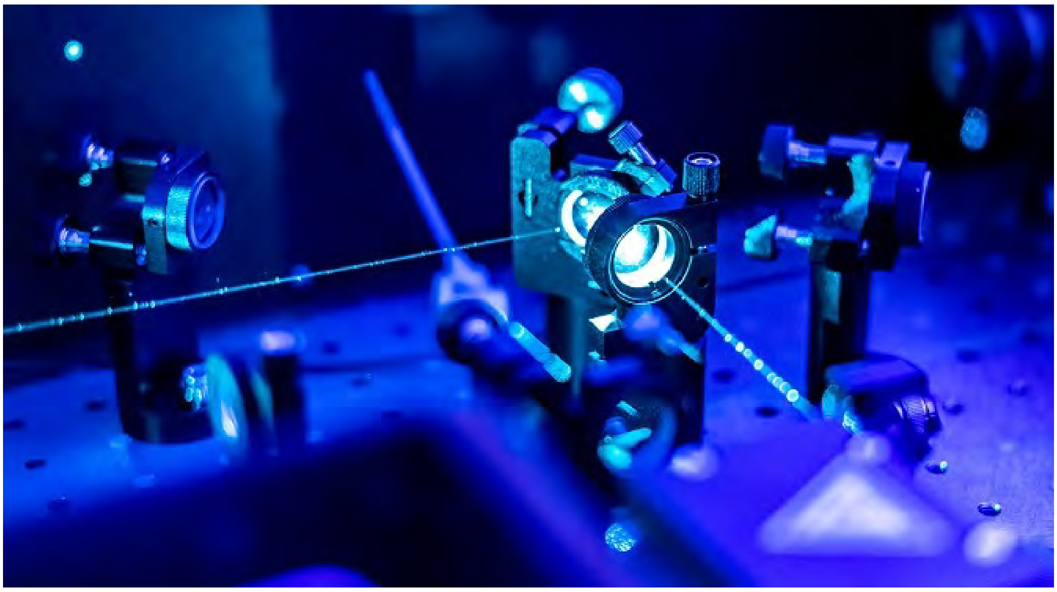
Project Aria

Aria is a breakthrough bionic device that helps people who are blind, and vision impaired overcome the barriers of the sight-centric world. We have been working with the Sydney based start-up to test acoustic signal processing, spatial audio, machine learning, ultrasound and electrical impedance tomography. ARIA is scheduled to begin pre-clinical trials in Australia in 2022.

Individualisation for 3D audio

The project aim is to allow the general listener to enjoy high-fidelity 3D sound over headphones. Such 3D audio is importance when inter-personal communication requires situational awareness such as in search and rescue, fire-fighting, and air traffic control. To achieve this, the project aims to address one of the toughest problems in audio signal processing: deriving high-fidelity 3D audio headphone filters from photos and/or 3D scans of ears.

Photonics engineering
Our project highlights



Our researchers have been working with Thales Australia on developing integrated optical phased arrays for light detection and ranging (LIDAR).

"Key outcomes of this research program will enable its use across a host of new commercial and personalised automation applications." Professor Xiaoke Yi

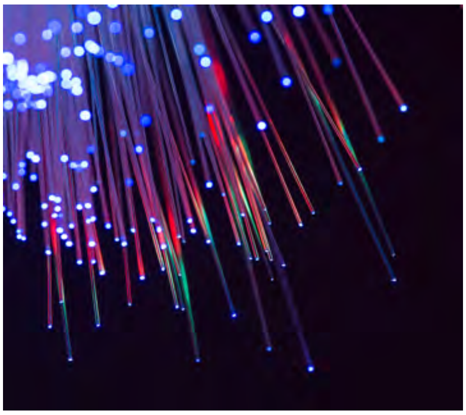
Supported by an Australian Research Council Linkage Project grant, we have partnered with Thales Australia to develop new integrated optical phased arrays for light detection and ranging (LIDAR). This technology could be applied to secure communications and autonomous vehicles, growing the automation and sensing systems market sector, as well as increasing Australian national security.

Conventional LIDAR systems rely on a mechanical system for beam-steering, which is a major constraint because it imposes limitations on the scan rate, while also substantially degrading reliability, and increasing system cost and maintenance.

"The project is focused on exploiting integrated photonic advancements to develop innovative technologies to realise chip scale optical beamforming for light detection and ranging with low power consumption and high resolution," said Professor Yi.

We have successfully fabricated a prototype multi-element optical phased array structure and have experimentally demonstrated its capabilities for beam scanning with a narrow beamwidth. We have demonstrated optimised optical waveguides for dense photonic integration and high feasibility for scale-up fabrication. Key outcomes of this research program will enable its use across a host of new commercial and personalised automation applications.

Photonics engineering



Photonics engineering – our researchers specialise in advanced optical techniques for information systems and currently focus on areas such as microwave photonics, integrated photonic circuits, photonic signal processing, LIDAR, non-invasive biosensing technologies, nonlinear optical phenomena, photonic crystal fibres for Terahertz applications, Bragg grating solutions, optoelectronic sensing technology, and optically-controlled phased array

"Our Fibre-optics and photonics engineering is recognised as one of the world's leading research groups in photonic signal processing and microwave photonics." Professor Robert Minasian.

Microwave photonics and photonic integration for advanced sensing

This project leverages breakthroughs in microwave photonics and integrated photonics for advanced sensing with wide range of applications in Internet of Things and healthcare. It is developing compact and cost-effective micro-resonator sensors for unmanned aerial vehicle (UAV) applications in harsh environment, high-performance magnetic field sensor and high-density magnetic field sensing array with scalability. The project's researchers aim to deliver, compact on-chip sensing techniques for reliable, high-resolution, low-noise and real-time sensing.

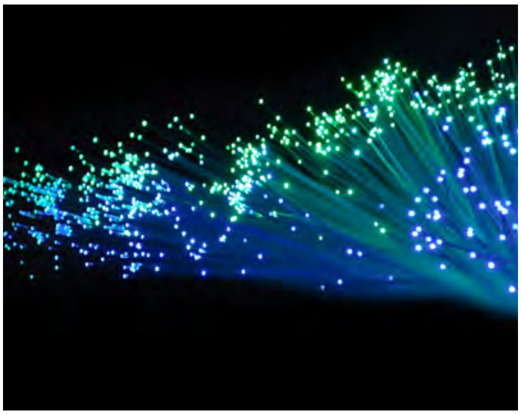
Integrated microwave photonics

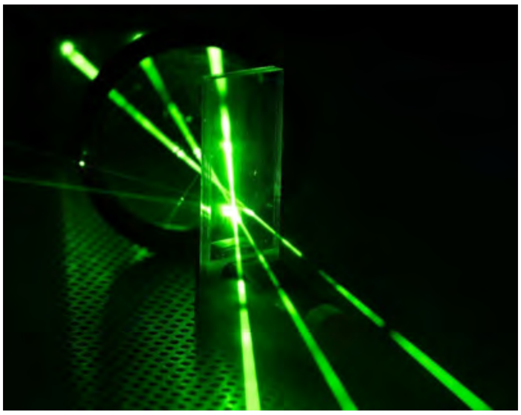
Our researchers have been developing photonic integration technologies that enable microwave photonic functions on a chip. Integration platforms such as InP, Silicon on Insulator (SOI), and Silicon Nitride (Si3N4-SiO2) have now reached the required degree of maturity to be considered as viable options for the implementation of MWP functions. This will enable us to explore the potential capability enhancements that the broadband signal transmission, receiving and processing characteristics of photonics can provide.

Photonic signal processing

New photonic signal processing structures that can manipulate broadband signals is the focus of this research. Our team is exploring techniques to make the processors adaptive and tunable so that the characteristics can be controlled for information processing.

Photonics engineering





Optical signal processing is expected to effectively handle high-speed, broadband signals in advanced optical communications systems and information processing.

Improving optoelectronic sensing technology

To meet the increasing demand for real-time monitoring and detection in biomedical, environmental and industrial applications we are developing photonic-based highly sensitive and robust optoelectronic sensors. The sensors we developed could be used for hazard detection, health and fitness monitoring, and biomarker discovery.

Nonliner fibre optics

Our project team is continuing its fundamental research in nonlinear optical phenomena. Our work has included the analysis and characterisation of the formation and dynamics of Bragg grating solitons in various structures such as nonuniform and coupled Bragg gratings and photonic crystals, dispersion managed solitons, nonlinear pulse propagation in periodic media, and solitons in dual-core optical waveguides.

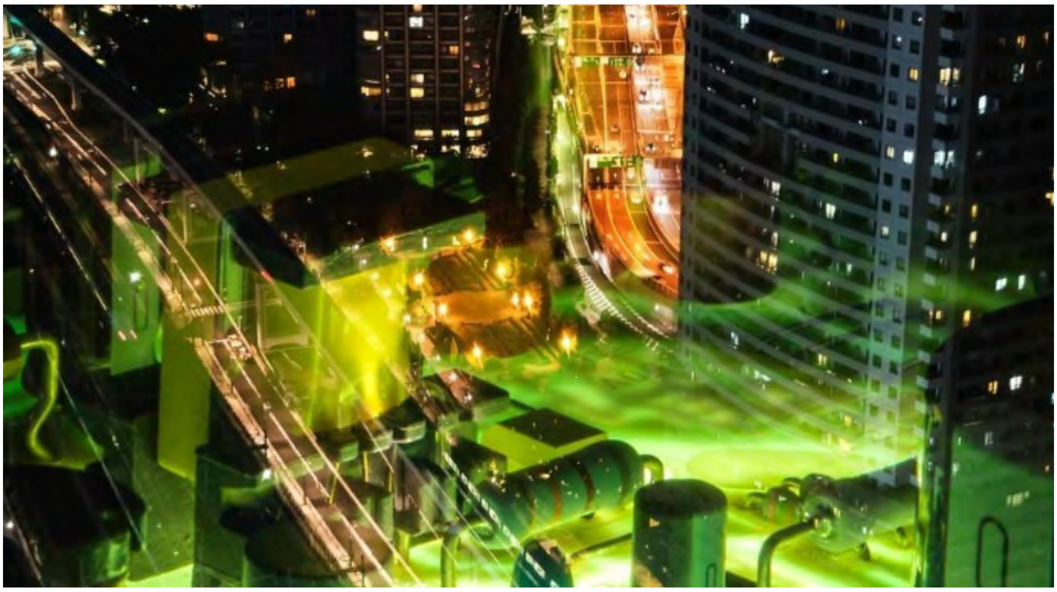
Optically-controlled phased arrays

We have been creating new architectures of optical phased arrays that realise high capacity phased array antennas that can generate high- resolution steerable beams and which can operate with wide bandwidth. Our new architecture uses wavelength mapping to the array elements and partitioning concepts. Future radar and communication systems will require phased array antennas that can achieve true-time delay beam-forming and can synthesise a large number of beams.

Part of the ACTION

Next generation global telecommunication platforms and emerging massive take-up applications in radar, communications and space industries requires new technologies to address the current limitations of electronics for massive capacity and connectivity. Microwave photonics combines RF and photonics is the best positioned technology to carry out this convergence. Our team is working within The European Network for High Performance Integrated Microwave Photonics (EUIMWP) Action group. ACTION brings together groups from academia, industry and transnational organisations with complementary competences and on a global scale including photonic integrated circuits and microwave photonics experts, microwave system application designers and end-users to fully develop the synergies required by this new paradigm.

Power engineering
Our project highlights



We are contributing to the digital power revolution working with industry providers to investigate the challenges, opportunities and technologies.

“The digital transformation is the final piece of the puzzle when it comes to the large-scale adoption of renewable energy.” Professor Jian Guo (Joe) Zhu

Australia is at the forefront of the uptake of distributed energy resources (DER). According to the Australian Energy Market Operator (AEMO), power supply will consist mostly of renewable energy sources by 2040, with more than 20 percent coming from small-scale DER.

A large-scale rollout of IoT technology – will would manage and connect millions of devices and sources of information – will be central to the digital power revolution, according to our "Power" team, who are working alongside the School’s IoT specialists and industry partners. The group has been investigating virtual power plants, the current digital energy systems landscape, and a regulatory framework. According to Professor Joe Zhu “Digitising the energy market through IoT and AI technologies is central to building a secure, clean and efficient future.”

Colleague, Associate Professor Gregor Verbic said the move toward virtual power plants is leading to a behavioural shift, with traditional energy consumers becoming “prosumers”, who both generate and sell energy.

“In traditional energy grids, customers were simply energy consumers, and energy flow was one way from generation to load. Advances in rooftop solar and smart metering technology have enabled consumers to increasingly generate and sell energy, becoming prosumers, and resulting in two-way energy and information flow. This trend is set to increase substantially.
AGL’s virtual power plant in South Australia – which coordinates energy from 1,000 batteries that store solar-generated power – is a successful example of virtual power plant technology that supports further renewables penetration by providing grid-stabilising services.”

The group’s work aims to generate further collaborations as Australia seeks to find effective solutions for integration of distributed energy resources.

Power engineering

Centre for Future Energy Networks - We carry out internationally-recognised research in the fields of energy and power networks and intelligent grid technologies towards the development of future electrical power grids.

"Our research is reshaping electricity networks to fit the special conditions and challenges within Australia." Professor Jian Guo (Joe) Zhu

Breaking performance limits

This Breaking Performance Limits of Solar Inverters for a Sustainable Future project aims to tackle the performance challenges of micro-inverters by developing a novel power-conversion architecture, a unified design framework, and a new control theory. The intended research outcome will be a new range of ultra-high-performance micro-inverters. This will promote greater solar uptake and maintain Australia's leadership in the development of disruptive solar power generation technology.

Global hydrogen economy

The ARC Training Centre for The Global Hydrogen Economy aims to transform Australia into a hydrogen powerhouse by building enabling capacity in hydrogen innovation in a short timeframe. This innovative, five-year program which is lead by the University of NSW will generate new technologies and equip a future workforce of industry-focused engineers with advanced skills for development and scaling-up of hydrogen generation and transport. Benefits include the export of hydrogen fuel and advanced technologies, job creation and a lower emissions domestic energy industry.

A unified framework

This Unified Framework for Resource Management in Edge-Cloud Data Centres project aims to investigate and provide solutions for the realisation of seemingly integrated Edge Data Centres (EDCs) with cloud environments. Using theoretical and system development approaches, the project expects to generate new knowledge for managing the resources of an EDC ecosystem. The outcome of this project includes practical solutions through building novel mathematical frameworks and resource management objectives accompanied by system implementations.

Power engineering

Transforming microgrid to virtual power plant

This Transforming Microgrid to Virtual Power Plant – ICT Frameworks, Tools, Control project aims to enhance large scale renewable penetrations to national power grid by advancing control, optimisation, and ancillary services of Virtual Power Plants (VPPs), considering different disruptive events including the recent South Australian blackouts. This project expects to create new control, frame communication architecture, develop plug and play type IoT enabled grid interfacing inverter, and optimise resource management for distributed VPPs.

A legal framework for resilient electricity infrastructure in Australia

Our researchers have been developing a legal and governance framework to enhance the resilience of Australia's electricity infrastructure. The project has been addressing both the integration of smart technologies and disaster risk reduction measures in the electricity system. The framework is expected to help provide significant economic, social and environmental benefits to Australia.

A new energy research centre

A new research centre, the Australia-China Joint Research Centre for Energy Informatics and Demand Response Technologies, was provided funding from the Australian Government as part of the Australia-China Science and Research Fund Joint Research Centres to fund research into making energy supply more efficient and reliable.

The new centre follows on from almost a decade of collaboration between the University of Sydney and the Tianjin University researchers on energy solutions.

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Telecommunication and IoT
Our project highlights

Working with industry partners our researchers are developing unique robotic technology to aid plastic recycling

“Not only does our project divert household soft plastics from going to landfill; we’re also creating a sustainable supply chain that takes rubbish from households to end markets,” said Associate Professor Wanli Ouyang.

Between 2018 and 2019, Australia generated 2.5 million tonnes of plastic waste, which included soft plastics: only 9 percent was sent to recycling while 84 percent went to landfill.

We aim to drastically switch those percentages by developing a solution that allows for most soft plastic waste being recycled," said Professor Yonghui Li.

Current recycling methods rely on the manual sorting of soft plastics, an often repetitive and unsafe task.

Working alongside industry partners as part of a federal government Cooperative Research Centre Project grant, our researchers are developing a unique method to increase recycling of soft plastics – by creating a smart, automated robotic system that uses and AI to sort recyclable waste.

“The recycling robotic automation system will use artificial intelligence and computer vision to learn how to identify different forms of recycling waste, effectively learning how to ‘see’ and ‘sort’ waste, to create separate waste streams and maintain soft plastics’ purity so they can be recycled,” said Professor Branka Vucetic.

Professor Li adds “Soft plastics are a big contributor to landfill and have long been a challenge for the circular economy and waste management sector, as they have lacked an adequate and safe sorting method. Using the latest IoT techniques, we have created a custom robot to solve this issues."

The system will be integrated into IQ Renew’s material recovery facility as part of CurbCycle’s Soft Plastic Recovery program, an Australian initiative that involves the household collection of recyclables that are segregated into bags prior to placing them into their kerbside recycling bin.

Telecommunications and IoT
Our project highlights

Our research covers a broad range of research initiatives related to telecommunications engineering, with our key research focusing on the areas of wireless engineering, wireless networking and the Internet of Things.

"Our industry-supported research in the field of the Internet of Things focuses on the next generation of wireless communications and networking." Professor Branka Vucetic.

Large scale critical applications

Moving from the state-of-the-art small pilot projects to a global Industrial Internet requires wireless systems with consistent high reliability, low latency and massive connectivity. In this Wireless Cellular Connectivity for Large Scale Critical Applications project we are developing new communication-theoretic principles and technologies for wireless networks meeting the demands of critical industrial and infrastructure applications in the Industrial Internet era.

Information-theoretic secure communications via caching

Working with University of Newcastle this project aims to address the cybersecurity problem of securing telecommunication networks to prevent data leakage. To circumvent current risks, the project team has proposed a new information security approach using information cached at devices to camouflage data. The project aims to future-proof secure communication systems against large-scale quantum computers, which threaten current encryption approaches. This should ensure that data transmitted over communication networks can never be revealed to interceptors or hackers, even in public WiFi.

Short code design for mission critical communications

This project aims to develop the fundamental science to enable transmission and channel coding technologies, which will be essential for building and rolling out of future ultra-reliable and low latency wireless networks. Reliable and low latency communications are central to the development of the next generation mobile communications and many emerging critical applications. The project is expected to provide the foundations and tools for transforming, modernising and safeguarding Australia's national critical infrastructure.

Telecommunications and IoT

Wireless cellular connectivity for Large scale critical applications

A vision of the Industrial Internet is emerging, in which equipment, machine, and industrial robots are interconnected to each other and to the cloud, allowing remote control of industrial processes and critical infrastructure, to intelligently optimise their behaviour with minimal human intervention. Moving from the state-of-the-art small pilot projects to a global Industrial Internet requires wireless systems with consistent high reliability, low latency and massive connectivity. In this project we are developing new communication-theoretic principles and technologies for wireless networks meeting the demands of critical industrial and infrastructure applications in the Industrial Internet era.

Cross-layer Design for Ultra-reliable Low-latency Communications

This project aims to develop fundamental theories and practical technologies for ultra-reliable low-latency communications (URLLC) are one of the grand challenges in 5G cellular networks. Due to the dynamic nature of wireless networks, existing approaches dividing networks into multiple layers cannot guarantee a hard deadline with high reliability. The outcomes of the project will be cross-layer models for characterising the end-to-end performance, a prediction and communication co-design framework for improving the delay-reliability trade-off, and an online architecture for implementing model-based algorithms in real networks.

Long-range WiFi project

Our researchers are developing a safe and cost-effective technology that could be a wireless internet game changer for industry, agriculture and other applications – developing a long-range WiFi system that transmits signals to hard-to-reach places while maintaining high data rates. Supported by a $800,000 NSW Physical Sciences Fund, the system is being created for mission-critical applications in underground mines that require remote monitoring of workers and control of sensitive mining equipment, with signals extending as far as several kilometers underground. The Centre's long-range WiFi has been designed for ultra-low latency and high data rates, which allow wireless signals to travel over a long range of more than 1km and carry more data without dropping out or experiencing lag. The technology is an innovative solution that achieves both long-range communication and high data transmission, with an algorithm implemented on commercial WiFi chips. The long-range WiFi could also help places such as airports, shopping centres, university campuses, and large industrial settings. Australian company, Roobuck, will manufacture a low-cost, ready-to-use WiFi device which is expected to available in two years' time.

Telecommunications and IoT

Software-defined UAV-enabled heterogeneous network: Delay-oriented resource management and UAV placement

Wireless network operators have been motivated to harness UAV base stations (BS) as compared with a fixed ground BS, an UAV BS features low cost, high mobility, easy deployment, strong communication link, and flexible control. In this project we perform resource management and UAV 3D positioning for an UAV-enabled heterogeneous network. The network architecture spans macro BS, micro BS, and a WiFi access point (AP) in a software-defined ecosystem.

Traffic-steering framework for SDN-based cellular networks

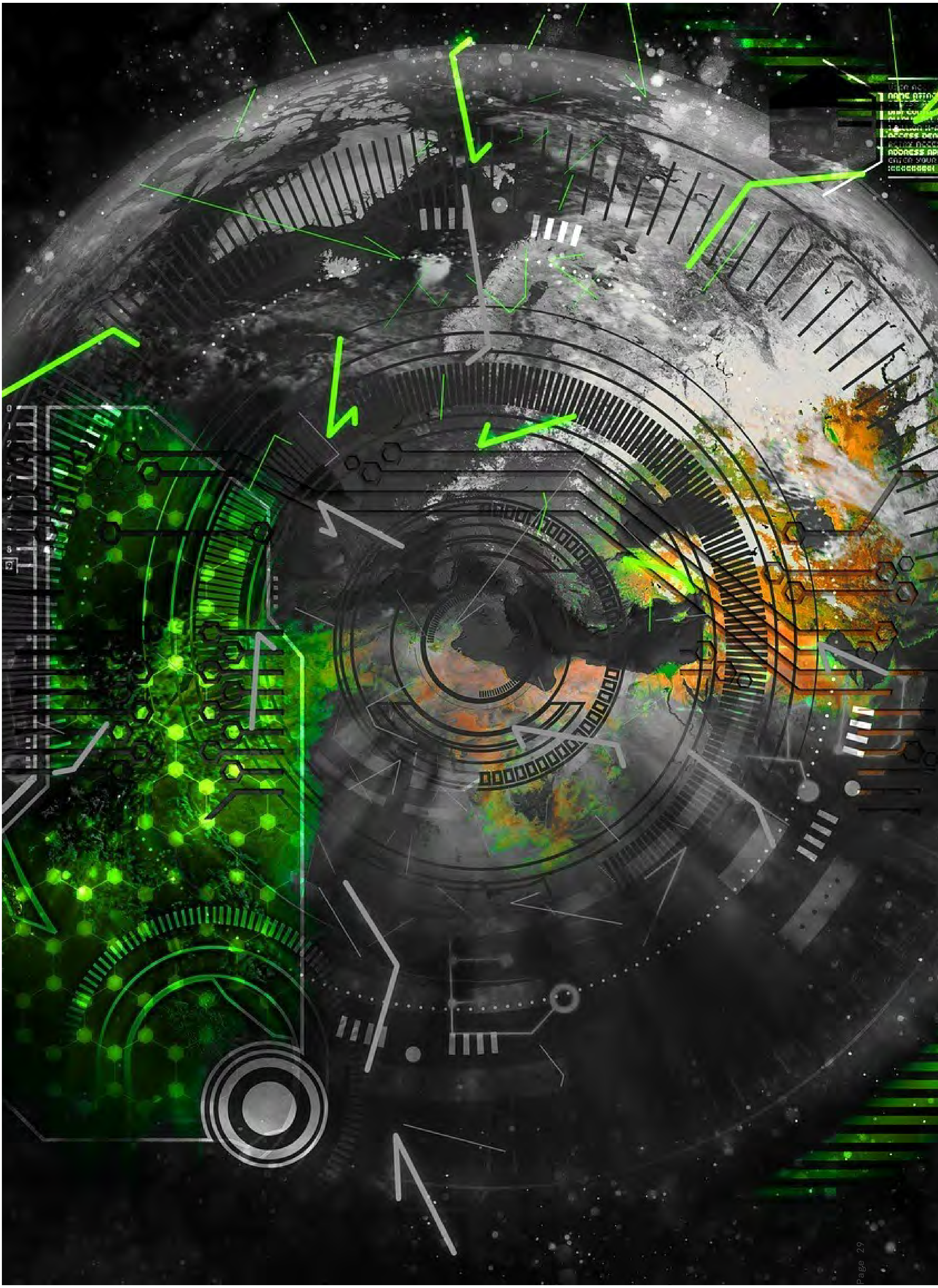
The aim of this project is to develop a universal traffic steering framework for the next generation software defined networking (SND) based cellular network. The framework will consider the current user condition and demand as well as the candidate network's status. With the help of SDN a feeback mechanism will be introduced in order to make real-time dynamic decisions for steering the traffic.

Co-operative content caching for future mobile networks

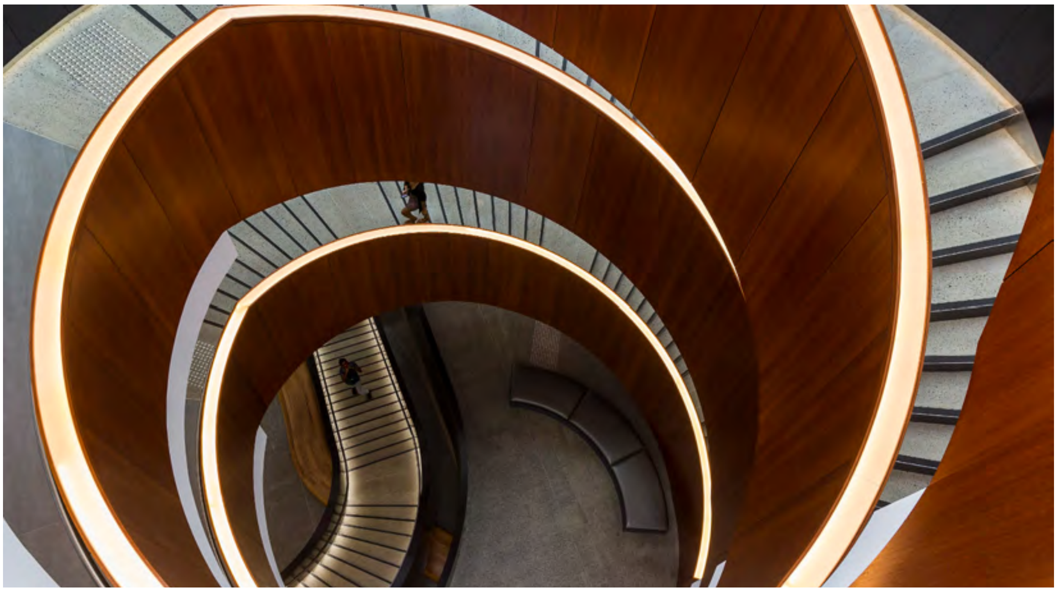
The increased interest in traffic-intensive applications like high definition video, augmented reality, wearable devices and 3D visualisation is expected to result in a higher growth in network traffic. This has shifted researchers towards cooperative content caching in mobile networks, its services and efficient cache placement. In a cache enabled device-to-device underlaid cellular network, we aim to formulate cooperation-based caching that will further exploit the limited storage capacity and result in a more efficient wireless resource utilisation.

Research on reliability-based decoding algorithms

6G research is in its infancy. The stringent requirements in 6G URLLC bring new challenges to the physical layer design. One of the important development directions is the theoretical study of encoding and decoding mechanisms. It is necessary to develop high-rate and low-delay channel coding techniques under complex time-varying channels for various situations where 6G is ubiquitous. This project aims to develop optimized finite-length-coded multiple access schemes that enable extremely high reliability in the non-orthogonal multiple access (NOMA) scenarios with multiple access schemes with two and three users.



Working with industry



Our ongoing cross-disciplinary research collaborations with international industry partners in the energy, environment, health and technologies sectors have let to engagement with tertiary and industry partners across the global. We are dedicated to continuing these strong industry links to ensure our research and teaching remain relevant to real-world demands.

Our partners include:
ABB
Airbus
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“Many of our researchers have been recognised as among the most influential in their field of expertise.”

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Associate Professor

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Ms Rita Wong

Senior Administration Officer

Ms Brooklyn Sulaeman

Administration Officer

Ms Ping Zhang (until January 2021)

IT Operations and Liaison Manager

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Dr Thomas Huang

Dr Peter Jones

Building Attendant

Mr Danny Phillips

About the University of Sydney

The University of Sydney is one of the world's top research universities and a member of the prestigious Group of Eight network of Australia's leading universities. We teach more than 50,000 bright minds, with 10,000 international students from more than 145 countries

We've taught six prime ministers, two Nobel laureates, three astronauts, 110 Rhodes scholars and one Pulitzer Prize winner. Our partners join an inspiring network of leading academics, distinguished graduates and alumni.

Since 1850, the University of Sydney has led the way in setting new directions for society. Leadership has always been at the core of the University of Sydney's values.

Our aim is to make lives better – not just by producing leaders, but through equipping our people with leadership qualities so they can meaningfully serve all of our communities at every level.

The cross-disciplinary nature of our faculties allows us to offer the widest range of academic programs of any Australian university.

Key facts

- year of foundation: 1850
- student enrolments: 73,000 *
- academic staff: 3465*
- named as one of the world's leading institutions making a positive impact on society, placing second in the world and first in Australia in the 2020 Times Higher Education Impact rankings.
- number of alumni worldwide: 270,000
- 110 Rhodes Scholars
- Chancellor: Belinda Hutchinson AC
- Vice-Chancellor and Principal: Professor Mark Scott

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