ENGINEERING RESEARCH PROJECTS – SUMMER 23-24

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AERO2023-24/2 - Simultaneous Aerial Object Detection, Localisation and Classification for Airspace Management Using AI and Computer Vision

AERO2023-24/3 - Propulsion system testing for a long-range electric vertical take-off and landing aircraft

BIOMEDICAL ENGINEERING PROJECTS

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BME2023-24/2 - Systems integration, simulation, and testing of an electric propulsion pulsed plasma thruster for low earth orbit satellites

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AERONAUTICAL ENGINEERING PROJECTS

AERO2023-24/1 Construction of a Jabiru J400 X-Plane Aircraft Model for the AMME Flight Simulator Facility
Supervisors: Associate Prof Nicholas Lawson; Dr KC Wong and Zi Wang

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
AMME has recently commissioned a new flight simulator facility, based on the Eight360 untethered VR simulator. The simulator visual and aircraft model interface is X-Plane 11. AMME also operates a Jabiru J400 test aircraft, based at Bankstown airport. The aspiration of the Aeronautical Engineering group is to link teaching and research activities between the aircraft and the simulator.

There is currently an X-Plane model available for the Jabiru J160 aircraft. This project requires the student to convert the J160 model into the J400 model, using existing data, including a detailed CAD model of the aircraft is already available. Implementation of the J400 will allow a significant increase in both research and teaching activity in AMME around these facilities. The student will have access to the Eight360 VR flight simulator facilities and demonstrate the final J400 model in the VR simulation at the end of the project.

X-Plane Jabiru J160 model

Eight360 Flight Sim

Requirement to be on campus: Yes *dependent on government’s health advice.

AERO2023-24/2 Simultaneous Aerial Object Detection, Localisation and Classification for Airspace Management Using AI and Computer Vision
Supervisors: Dr Zihao Wang, David Williams (SiNAB Pty Ltd), Dr KC Wong

Eligibility: WAM > 75; knowledge and/or experience in OpenCV and Python is preferred
Project Description:
Knowing what is in the sky is essential in many situations, especially in the emerging Urban Air Mobility (UAM) market, where it is proposed that multiple autonomous aircraft carry passengers and cargo in dynamic and crowded airspace. Small flying objects such as photography drones can pose a fatal threat to autonomous aircraft without sufficient collision warning. This project aims to build an aerial target detection system using computer vision to detect, localise and classify any aerial object in the local airspace. The research will build upon our experience using ground-based cameras to detect and localise commercial aircraft. The student will focus on the training of machine learning based computer vision packages such as YOLOv5 to classify a range of aerial objects and have access to the source code and camera system from our prior study. The student will also have the opportunity to work closely with an external industry advisor from SiNAB Pty Ltd to work on a prototype, and optimally achieve a field demonstration of the concept.

Fig 1: Illustration of the proposed aerial target detection model using an aircraft example.

Requirement to be on campus: Yes *dependent on government’s health advice.

AERO2023-24/3 Propulsion system testing for a long-range electric vertical take-off and landing aircraft
Supervisor: A/Prof. Dries Verstraete

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Drones can dramatically improve rural healthcare delivery and services, and medical drones are increasingly used globally. However, existing medical drones have a range of less than 200 km, less than half of what is needed to assist substantially in Australia. A fuel-cell-powered drone could provide the required coverage to enable real innovation in rural healthcare whilst being environmentally friendly if its propulsion system is efficient, reliable, and light.

This project will assist in developing a light and efficient propulsion system for an electric vertical take-off and landing (eVTOL) medical drone. Participants will test electric motors, electronic speed controllers, and propellers to determine the best propulsion system for a 25-kg fixed-wing eVTOL drone and its sub-scale 7 kg demonstrator. An efficient computational model will be developed to allow full mission simulation of the aircraft.

Requirement to be on campus: Yes *dependent on government’s health advice.
BIOMEDICAL ENGINEERING PROJECTS

BME2023-24/1 Study electrochemical properties of annealed plasma coatings for biosensor applications

Supervisors: Dr Clara Tran, Dr Kosta Tsoutas and Professor Marcela Bilek

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Plasma Activated Coating (PAC) is a perfect interface for biomolecule attachment through covalent bonds, thanks to its embedded radicals. Excitingly, recent discoveries involving thermal and photo annealing technologies have unlocked the potential to significantly increase the electrical conductivity of PAC, positioning it as the ideal material for cutting-edge electrochemical biosensors.

In this research project, we will delve into the electrochemical properties of PAC after annealing with various techniques and explore its electrical response once recognition biomolecules are immobilized on the coatings.

Joining this project, you will gain hands-on experience in utilizing state-of-the-art techniques such as plasma deposition, annealing, cyclic voltammetry, and electrochemical impedance spectroscopy. These skills will not only enrich your scientific knowledge but also equip you with expertise in nanotechnology and bio-sensing applications.

Requirement to be on campus: Yes *dependent on government’s health advice.

BME2023-24/2 Systems integration, simulation, and testing and of an electric propulsion pulsed plasma thruster for low earth orbit satellites

Supervisors: Dr Kostadinos Tsoutas, Mr Julian Whichello, Professor Marcela Bilek

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Pulsed plasma thrusters (PPT) are a class of electric propulsion engines being developed for satellite station keeping. The operating principle involves a high voltage electric discharge which ionises a solid metal fuel source into a plasma. The plasma acts as a conductive bridge between the electrodes, which induces a Lorentz force, accelerating the plasma slug down the rails to provide thrust.

This project will involve the integration and simulation of a coaxial rail-type thruster and associated power and control component parts into a 3U set of modules suitable for a very low Earth orbit satellite.

This project is best suited to a student with strong understanding of aerospace system requirements. The student will be introduced to rail-type thrusters, both at the theoretical and practical levels with hands-on experience. A background in electrical engineering and experience with simulation is desirable.

Requirement to be on campus: Yes *dependent on government’s health advice.

BME2023-24/3 Plasma Diagnostics for Cathodic Arc Systems

Supervisors: Dr Kostadinos Tsoutas, Professor Marcela Bilek

Eligibility: This project is best suited for students with an interest in engineering chemistry and physics or have a strong electrical engineering background.
**Project Description:**
Cathodic arcs (CA) are low-voltage, high-current plasma systems used in thin film coating deposition and satellite propulsion. The operational mechanism of CA’s revolves around cathode spots, regions of high-density plasma. As the fundamental mechanisms that generate these cathode spots are not fully understood, this project aims to use plasma diagnostic techniques to probe the nature of the electrical and chemical processes that take place during CA discharge.
In this project, students will have the opportunity to learn about plasma technology and carry out analytical diagnostics on a range of CA systems. Students will get hands on experience with industrial plasma systems and engineering problem solving.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

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**BME2023-24/4 Plasma polymerized nanoparticles shelf life for biomedical applications**

**Supervisors:** Professor Marcela Bilek, Seyedeh Khadijeh Alavi

**Eligibility:** Ideally 3rd year of Engineering with lab working experiences and a good knowledge in chemistry. Having experiences in working with solutions and nanoparticles would be beneficial. Time management skill is essential.

**Project Description:**
Plasma synthesised carbon-based polymer nanoparticles have recently been shown to have the capacity for linker-free immobilisation of biomolecules on their surface. Polymer nanoparticles have also show promise in drug delivery applications due to their ability to be made pH sensitive and reactive to their environment. While their potential for diverse biomedical uses is significant, a major step in bringing this technology to the public lies in establishing optimal storage conditions to maintain the required properties throughout storage. Particularly for drug and gene delivery applications, these nanoparticles may need to endure long-distance transportation or extended periods of storage prior to use. Therefore, the creation and optimisation of storage protocols are of great importance in streamlining the commercialization process of this novel nanoparticle technology.

This project is mainly focus on characterizing of plasma polymerized nanoparticles and potentially, depending on the time budget of the project, investigating their ability for biomolecules conjugations over time. Additionally, you may be involved in the nanoparticle production process as well.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

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**BME2023-24/5 Metal-Organic Framework Membranes for Enhanced Antibacterial Efficacy and Selective Ion Filtration in Water Purification**

**Supervisors:** Dr Borui Liu, Prof Antonio Tricoli

**Eligibility:**
- Research passion: Demonstrated deep interest and commitment to scientific inquiry.
- Pursuit of HDR studies: Clear ambition to pursue a PhD and higher academic research career.
- Relevant background: Enrolment in biomedical or materials engineering.

**Project Description:**
This project aims to revolutionize water purification technology, focusing on the development of efficient and cost-effective solutions using ultrathin metal-organic framework (MOF) membranes. This proposal, blending biomedical and material engineering, offers a unique research platform for Biomedical Engineering students.
Current purification processes, contributing significantly to energy use and carbon emissions, contradict the ‘net zero’ target. To address this, we propose a solution involving the synthesis of two-dimensional nanocomposite materials and manufacturing membranes with nano and sub-nano ionic channels.

The MOF membranes exhibit high ion selectivity, outstanding flux performance, and low material usage. Their application in water treatment provides antibacterial functionality and selective ion filtration, improving water quality and battling bacterial contamination.

This project, aimed at addressing global water resource challenges, also aspires to publish findings in high-impact journals, thus enhancing prospects for securing potential funding. It effectively merges academic enrichment and skill development, paving the way for significant scientific breakthroughs.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**CHEMICAL AND BIOMOLECULAR ENGINEERING PROJECTS**

**CBE2023-24/1 Computer modelling of destruction of the forever chemical**

**Supervisor:** Adj Prof David F Fletcher, Assoc. Prof John Kavanagh

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
There has been much recent media interest in PFAS, dubbed the forever chemical, because of its extreme stability and toxic nature. Used in Teflon, waterproofing and fire-fighting foams because of its hydrophobicity, it has unfortunately contaminated large regions of groundwater. We are part of a team that has developed a novel destruction process using a bubble column for concentration and a cold plasma to break the chemical down. We have large amounts of experimental data and are also developing simulation models based on Computational Fluid Dynamics (CFD).

We are seeking an intern to help perform this simulation work. The successful applicant will have an interest in mathematical modelling, a willingness to assist in running simulations in **Ansys Fluent** and developing post-processing code in Python. A knowledge of Python programming would be an advantage but if you know Matlab you will pick it up very easily.

**Requirement to be on campus:** Yes, for most of the time but can work remotely occasionally as agreed with the supervisor/s.

**CBE2023-24/2 Material development, manufacturing, and in vitro testing of a bioinspired polymeric heart valve replacement**

**Supervisors:** Dr Sina Naficy and Dr Aeryne Lee

**Eligibility:**
1. Passionate about learning new skills and researching.
2. Keen interest in developing biomedical solutions for real life problems.
3. Experience in laboratory work.
4. At the very least, in the penultimate year of their undergraduate degree.

**Project Description:**
The end goal of this research project is to develop a heart valve replacement that performs better than current treatments, in hopes to improve clinical patient outcomes for those suffering from cardiac diseases.
Candidates will be involved in testing materials from a portfolio of polymers for use in manufacturing of polymer-based heart valve prototypes. They will also be involved in the fabrication of these prototypes as well as testing them using specialised equipment – all of which they can learn great skills from for the future.
This research project is currently in the developmental stages before animal testing, and those who are passionate about learning and are hard-working will be strongly considered for this role.
If you are interested in working with a supportive team and becoming one step closer to developing a solution for a real-life problem that could save millions of lives in the future, please apply!

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**CBE2023-24/3 Electrochemical CO2 capture from ocean water**

**Supervisor:** Dr. Fengwang Li

**Eligibility:** Chemistry, chemical engineering, or materials science & engineering background

**Project Description:**
This project seeks to explore technologies to focus on the capture process of removing carbon dioxide from oceanwater. Direct ocean capture (DOC) is one method of capturing dispersed CO2. DOC also has the potential for offshore deployment that offers a variety of useful potential benefits such as reducing competition for useful land, allowing access to oceanic CO2 storage sites currently only reachable by pipeline, and producing valuable CO2 streams offshore for a number of potential uses, including as a feedstock for fuel and chemical synthesis. Finally, DOC represents a direct reversal of ocean acidification caused by anthropogenic CO2 emissions. This Project will focus on the development of robust, energy efficient, and low-cost strategies for direct removal of CO2 from oceanwater and other natural waters by addressing challenges and opportunities specifically found in operation in an oceanic environment.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**CBE2023/4 Making alcohols out of thin air**

**Supervisor:** Dr. Fengwang Li

**Eligibility:** Chemistry, chemical engineering, or materials science & engineering background.

**Project Description:**
Ethanol is a widely used liquid fuel and fuel additive. However, the combustion of ethanol produces carbon dioxide (CO2), which is a greenhouse gas causing global warming and climate change. Why not converting CO2 back to ethanol for re-use so that we can form a closed carbon cycle? This project aims to discovery catalyst materials that can drive the conversion of CO2 to ethanol using electricity as a power input and can work at room temperature and ambient pressure. New materials synthesis, characterisation, electrochemical test, and product analysis with various analytical equipment will be expected from this project.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**CBE2023-24/5 Biofuels and biochemicals from biomass: advancing net-zero chemicals and fuels production**

**Supervisor:** Associate Professor Alejandro Montoya

**Eligibility:** Student studying Chemical Engineering degree
**Project Description:**
Platform chemicals are essential building blocks for various industrial applications and have significant potential as renewable alternatives to petrochemicals and petroleum. The project aims to establish a sustainable and eco-friendly process for producing platform chemicals from biomass, creating a pathway to establish sustainable chemical industries, enabling circular economy, and reducing greenhouse gas emissions.
This project offers students with invaluable opportunities for skill development, such as problem-solving, analytical thinking, communication, teamwork, and time management, which are highly valuable in academic and professional settings. Furthermore, it offers students an opportunity to expose themselves to cutting-edge research technologies, allowing them to get a better understanding of current trend and innovations in their field.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

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**CBE2023-24/6 Portable biosensor for monitoring Health conditions**

**Supervisors:** Dr. Syamak Farajikhah, Dr. Sepehr Talebian, Prof. Fariba Dehghani, Dr Jacopo Giaretta

**Eligibility:** Previous laboratory experience is advantageous

**Project Description:**
This project aims to develop a robust biosensor for rapid diagnosis of life-threatening diseases such as cardiac arrest and cancer. Cardiovascular and cancer diseases are leading causes of death globally. These diseases also have a massive socioeconomic impact on societies. Early diagnosis is a key factor for better treatment plan, increasing the survival rate and reducing the risk of disability.
The candidate will join a highly active and supportive multidisciplinary team of entrepreneurs and experts in engineering, science and clinician working towards solving real-world issues. We are seeking to hire highly motivated, creative, and passionate researchers with a background in medical science, materials engineering, or chemistry ready to join our team to tackle the grand challenges for developing these diagnostic devices to promote human wellbeing. The candidate will acquire various skills in electrochemistry, engineering, additive manufacturing, wireless system design and various analytical techniques.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

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**CBE2023-24/7 Improving a New Spray Dryer Design using CFD and Experimental Testing**

**Supervisor:** Prof. Tim Langrish

**Eligibility:** 2nd or 3rd year chemical engineering

**Project Description:**
This project will improve a new spray dryer design using Computational Fluid Dynamics and experimental testing. The project will use our understanding of fluid and particle mechanics to continue developing the design of an already-existing pilot-scale spray dryer to minimize the deposition rate of particles on the walls of the spray dryer. Applications include the development of future food materials through advanced food engineering and the production of new particles of Metal Organic Frameworks for Direct Carbon Capture of carbon dioxide. An interest in fluid and particle mechanics and experimental testing would be very helpful for this project.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*
CBE2023-24/8 Design of Metal-organic Framework based biocatalysis

Supervisor: Dr. Weibin Liang and Prof. Jun Huang

Eligibility: 1. Some background in Chemical engineering, chemistry, catalysis or equivalent
2. The ability to work well with others in a team
3. Excellent oral and written communication skills

Project Description:
Biocatalysis presents a significant opportunity in chemical manufacturing, due to its efficiency, selectivity, and environmental sustainability. However, the activity of many biocatalysts is compromised, or extinguished, when exposed to thermal, pH, and/or chemical stressors. This is largely due to the structural fragility of biocatalyst (e.g. enzymes) in artificial conditions. This project aims to stabilize biocatalyst in/or metal-organic frameworks (MOFs), generating a stable MOF biocatalyst with high reaction –activity and chemo-selectivity in catalysing reaction of industrial importance. This project involves the synthesis, characterization, and catalytic application of biocatalyst immobilized in/on metal-organic frameworks (MOFs). The student will assist in the synthesis and characterization of the MOF biocatalyst, as well as testing the catalytic performance of the materials.

Requirement to be on campus: Yes *dependent on government’s health advice.

CBE2023-24/9 Repurposing mine tailings to concrete

Supervisor: A/Prof. Marjorie Valix

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Mine tailings pose environmental liability and reclamation costs associated with the long-term storage of tailings. The management of tailings. Solid tailings are generated as residues after mineral concentration and after the value metals are extracted. This project will examine the potential utilisation of tailings as a replacement for concrete components specifically fine aggregates, supplementary cementitious materials (SCMs) in mortar or concrete, and in the production of cement clinker.

Requirement to be on campus: Yes *dependent on government’s health advice.

CBE2023-24/10 Parametric Optimization Studies of Bioinspired Heart Valve Geometry through Computer-Aided Design

Supervisors: Dr Xinying Liu and Adj. Prof. David F Fletcher

Eligibility:
1. Have a strong interest in research and strong problem-solving skills.
2. The capability of using any CAD software (Creo, AutoCAD, SOLIDWORKS, Fusion 360) is preferred.

Project Description:
This research project aims to optimize the geometry of bioinspired heart valves using Computer-Aided Design (CAD) techniques and parametric optimization. Inspired by natural heart valve structures, the study focuses on developing polymeric heart valves with geometry defined by equations, mimicking the efficiency and functionality of biological valves. By employing CAD software and mathematical optimization methods, this research seeks to enhance the design of heart valve replacements, potentially leading to improved patient outcomes and long-term durability.
Requirement to be on campus: Yes *dependent on government’s health advice.

CBE2023-24/11 Flexible sensor for medical diagnosis and monitoring food quality and safety
Supervisors: Dr. Syamak Farajikhah, Prof. Fariba Dehghani

Eligibility: Previous laboratory experience is advantageous

Project Description:
This project aims to develop simple and flexible devices that can be easily incorporated in food packaging for detecting life threatening contamination in food products to reduce the risk of food outbreaks that each year threaten health of millions of people worldwide. It can also be used for rapid and non-invasive diagnosis of some health issues such as kidney diseases. Candidates will join our highly supportive and multidisciplinary team with various expertise in engineering, science and clinicians who are working towards solving real-world issues. We are seeking to hire highly motivated and creative researchers with the background in engineering, medical science, or chemistry with the desire to join our team to develop such devices that tackle grand challenges in early detection of a disease or monitoring food quality and safety to promote human wellbeing. The candidate will acquire skills in additive manufacturing, electrochemistry, and several different analytical techniques.

Requirement to be on campus: Yes *dependent on government’s health advice.

CBE2023-24/12 Plasma-Based Advanced Oxidation Process for Wastewater Treatment
Supervisors: Professor PJ Cullen, Dr Behdad Soltani

Eligibility:
1. Attend the office/lab consistently and demonstrate responsibility regarding work schedules and deadlines.
2. Show genuine interest in research and approach tasks with enthusiasm.

Project Description:
Wastewater treatment is essential to protect the environment and human health from the harmful effects of pollutants. However, some organic contaminants, such as pharmaceuticals, pesticides, and industrial chemicals, are resistant to traditional treatment processes like biological treatment and physical-chemical methods. Advanced oxidation processes, including plasma based AOP, have shown great potential in degrading recalcitrant organic compounds by generating highly reactive species that can break down complex molecules into harmless by-products.

1. Conduct a comprehensive review of existing literature and studies on plasma based AOP for wastewater treatment. Identify and prioritize target pollutants and contaminants prevalent in the local wastewater to focus on during the project.

2. Investigate and optimise operational parameters, such as gas composition, flow rate, treatment time, and input power, to maximize contaminant degradation efficiency, to understand their impact on pollutant removal.

Requirement to be on campus: Yes *dependent on government’s health advice.
CIVIL ENGINEERING PROJECTS

CIVIL2023-24/1 Structural application of recycled fibre reinforced polymer (rFRP) composites

Supervisor: Dr. Ali Hadigheh

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Carbon fibre reinforced polymer (CFRP) composites are being increasingly used in lightweight structures due to their unique combination of high strength and low weight. These superior properties promoted high usage growth rates observed in aerospace, defence, construction, automotive and renewable energy. This research will aim to produce recycled composites for structural applications.

Requirement to be on campus: Yes *dependent on government’s health advice.

CIVIL2023-24/2 Engineered living materials for a sustainable future

Supervisor: Dr. Ali Hadigheh

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Most of our production and consumption patterns are following a linear economy resulting in exploitation of non-renewable resources and generation of a large amount of waste. The project will aim to develop innovative bio-inspired and sustainable living materials for applications in the building industry, and waste management and upcycling. The project will address the UN’s Sustainable Development Goals on increasing resource efficiency and reducing waste for sustaining natural resources and environments.

Requirement to be on campus: No

CIVIL2023-24/3 BIM and Digital Twin for Developing Convergence Technologies as Future of Digital Construction

Supervisor: Dr. Faham Tahmasebinina

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
The construction industry is slow to adopt new technologies. The implementation of digital technologies and remote operations using robots were considered farfetched affairs and unbelievable approaches. However, the effect of COVID-19 on clients and construction companies put high pressure on construction managers to seek digital solutions and justified the need for remote operating or distant controlling technologies. This paper aims to investigate the state of play in construction technology implementation and presents a roadmap for developing and implementing required technologies for the construction industry. The COVID-19 disruption required new methods of working safely and remotely and coincided with the advent of advanced automation and autonomous technologies. This paper aims to identify gaps and 11 disruptive technologies that may lead to upheaval and transformation of the construction sector, perhaps in this decade. A road map for technology implementation can be helpful in developing business strategies at the organizational level as a theoretical measure, and it can facilitate the technology implementation process at the industry level as a practical
measure. The roadmap can be used as a framework for policymakers to set industry or company strategies for the next 10 years (2030).

Requirement to be on campus: No

**ELECTRICAL AND INFORMATION ENGINEERING PROJECTS**

**EIE2023-24/1** Grid connected solar inverter control  
**Supervisor:** Dr. S. Sathiakumar  
**Eligibility:** Able to work with power electronics and microcontrollers

**Project Description:**  
Grid connected inverters are usually employed to utilize the renewable energy resources like solar, wind, tidal energy etc. by converting them to electrical energy and then injecting into the power grid. The renewable energy is converted first to DC power and then use the power inverter to convert to AC power.  
The control of inverter is done with Pulse Width Modulation (PWM) technology using a micro-processor. The microprocessor systems like **Arduino, Raspberry PI, ESP32** etc., currently available in the market are very powerful and can easily be programmed to generate PWM pulses for driving the inverter and at the same time provide user interface for monitoring and control purpose over internet.  
The project is to develop the required user interface to control and monitor the grid connected inverter by programming any of the microprocessor system.

Requirement to be on campus: Yes *dependent on government’s health advice.

**EIE2023-24/2** AI-based long- and short-term electricity price prediction for profitable community battery operation  
**Supervisors:** Prof. Jian Guo ZHU  
**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**  
Community batteries play a significant role in improving the integration of renewable distributed energy resources in regional community electricity distribution networks. For the effective and economically viable operation of community batteries, it is essential to accurately predict the day-ahead and short-term (5 min to an hour) electricity prices. While the historical and current electricity prices can be downloaded from the AEMO website, this project focuses on developing AI-based prediction tools.

Requirement to be on campus: Yes *dependent on government’s health advice.

**EIE2023-24/3** FPGA-based Quantum-classical Interface  
**Supervisors:** Prof. Philip Leong and Rich Radamacher  
**Eligibility:** Experience in digital systems design and embedded systems.

**Project Description:**  
In trapped-ion quantum information processing, qubit state measurements are integral, typically involving photon collection from state-dependent fluorescence and classification. Electron Multiplying Charge-Coupled Device (EMCCD) cameras are well suited to classify large ion chains, as they allow for real-time collection of photons with 2D resolution. We have
developed an EMCCD interface that incorporates a deep neural network (DNN) to achieve higher accuracy than conventional thresholding techniques. It is implemented in a field-programmable gate array (FPGA) to accelerate the DNN and achieve low latency. This project involves making improvements to our existing system and characterising the performance advantage over conventional techniques. It will be done in collaboration with Dr Tingrei Tan from the Quantum Control Laboratory (QCL) in Physics and Mr Binglei Lou (PhD candidate in the Computer Engineering Lab).

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**EIE2023-24/4 Augmented Reality (AR) mobile APP development for wayfinding**

**Supervisors:** Dr. Zihuai Lin, Dr. Callum Parker, Nathan Moore (Western Sydney LHD), Dr. Audrey P Wang

**Eligibility:** The students participating in this project should have good knowledge on smartphone APP development. Programming skills are essential. The students with average marks above 75 are preferred.

**Project Description:**
This project is to develop an Internet of Things network and platform architecture suitable for the Westmead Precinct consisting of location sensors, people counting sensors and an interactive way-finding app e.g. an augmented reality (AR) mobile app. The design of the proposed platform and data processing architecture will aim to future-proof IoT network capabilities to allow more connected devices including environmental sensors to be incorporated such as temperature, humidity, and air quality. The project is based on a multi-sensor data fusion artificial intelligence algorithm, which can geolocate compatible smartphones inside buildings. This algorithm achieves higher accuracy by leveraging pre-existing information of the environment (Bluetooth, WiFi…) combined with sensors that allow inferring the movement of the user (compass, gyroscope, accelerometer, barometer…). The information can be fed into the indoor wayfinding and navigation solution to guide hospital visitors to always find the most suitable route to their destination, based on their stated preference.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**EIE2023-24/5 Machine/deep learning assisted signal processing for advanced sensors**

**Supervisors:** Prof Xiaoke Yi, Associate Prof Luping Zhou, Dr Liwei Li

**Eligibility:** Year 3/4/5 or Master students studying Electrical engineering, Mechatronics, Computer engineering, Software engineering or Computer science

**Project Description:**
The state-of-the-art sensing technology is rapidly growing and will play a critical role in the near future. For instance, smart phones, which play a significant role in our daily life, have a fingerprint identity sensor that makes it easy for us to access the device, and they also use an ambient brightness sensor to adjust the display brightness, etc.

The project is to deliver the superior, advanced sensing platforms assisted by machine/deep learning to address the important challenges across a diverse range of applications in various fields, particularly in lab-on-chips, Internet of Things, broadband communications, and biomedical applications. The internship project focuses on electrical circuits design and data processing as well as machine learning and software programming. The aim is to realize ultra-sensitive, high resolution and extreme-range sensing.

The intern will closely work with a research team including PhD students and postdoctoral research associates. Innovative signal processing and design in both hardware and software will be carried out during the project.

**Requirement to be on campus:** Yes *dependent on government’s health advice.
EIE2023-24/6 Electro-optic modulators for broadband communications

Supervisors: Prof Xiaoke Yi, Dr Liwei Li

Eligibility: Year 3/4/5 or Master students studying Electrical engineering, mechatronics, computer engineering, software engineering or computer science

Project Description:
Electro-optic modulators encode electrical signals onto an optical carrier. They are essential for the operation of global communication systems and data centers for artificial intelligence, broadband networks, and high-performance computing. The project focuses on the development of an ultra-wideband electro-optic modulator. Addressing the challenges associated with achieving a large modulation bandwidth entails reducing microwave attenuation and realizing velocity and impedance matching. It is also essential to optimize the modulation electrode and optical waveguide jointly. The project will advance signal modulation techniques, paving the way for enhanced optical communication and modulation capabilities.

Requirement to be on campus: Yes *dependent on government’s health advice.

EIE2023-24/7 New camera to unlock the unseen

Supervisor: Prof Xiaoke Yi

Eligibility: Year 3/4/5 or Master student studying Electrical engineering, mechatronics, computer engineering, software engineering or computer science

Project Description:
In the pursuit of enhancing imaging technology to new heights, the project aims at developing a new camera that embodies compactness, an expansive field of view, and low power consumption. Leveraging the latest advancements in photonic technology, the primary focus lies in the design and testing of the camera for high performance optical imaging. The intern will work with a collaborative team, comprising PhD students and research associates in this project.

Requirement to be on campus: Yes *dependent on government’s health advice.

EIE2023-24/8 Towards End-to-End Learning for 6G Wireless Air-Interface

Supervisor: Dr Wibowo Hardjawana

Eligibility: Fundamental knowledge in wireless communications and deep learning and Phython programming. C programming is desirable.

Project Description:
Each generation of cellular communication systems is marked by a defining disruptive technology of its time, such as orthogonal frequency division multiplexing (OFDM) for 4G or Massive multiple-input multiple-output (MIMO) for 5G. Since artificial intelligence (AI) is the defining technology of our time, it is natural to ask what role it could play for 6G. The goal of the project is to demonstrate a 6G vision of a new air interface and end-to-end learning PHY, which is partially designed by AI to enable optimised end-to-end communication schemes for any hardware, radio environment, and application. The project will leverage our current telecommunication research at the Centre of Excellence in IoT and Telecommunications.

Requirement to be on campus: No
**EIE2023-24/9 Distributed AI on Embedded Systems**  
**Supervisor:** Dr. David Boland  

**Eligibility:** Experience with machine learning. Knowledge of hardware design beneficial

**Project Description:**  
The use of machine learning (ML) across an increasing number of application domains continues to grow. Similarly, we are seeing an increasing number of digital devices throughout society. Embedded devices nowadays have substantial processing capability — but not sufficient to handle the latest ML algorithms. Instead, simplified networks are often deployed on these devices, but these typically come with reduced accuracy.  
In this project, you will explore how to combine input from multiple embedded devices with independent sensors to produce a more accurate output. Since the embedded devices will have different sensors or different viewpoints, they should be able to outperform any single device.  
The ML algorithms you create will perform some local processing before sharing this with other devices to make final decisions. This means the algorithms must be simple enough to be implemented on embedded hardware, and as such, some hardware design experience is desirable.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

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**EIE2023-24/10 Nanophotonic passive cooling canopies**  
**Supervisor:** Dr. Alex Song

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**  
With nanostructured fabrics, a canopy can not only shade you from the sun but also cool you down. We will develop such a canopy and optimize its performance in this project. At a fundamental level, such canopies use nanostructures to control the incident solar radiation and the infrared thermal radiation from itself and the surroundings. Here, we will use advanced computational algorithms to simulate and design such canopies, as well as fabricate and test them in our campus environment. This interdisciplinary research project embodies optics, thermal physics, materials science, and architecture. Students with curious minds are welcome to apply.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

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**EIE2023-24/11 Fragility in topological nanophotonic structures**  
**Supervisor:** Dr. Alex Song

**Eligibility:**
- WAM>75
- Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.
- Basic knowledge of electromagnetics and solid-state physics

**Project Description:**  
The 2016 Nobel Prize in Physics has further invigorated the enthusiasm for topological phases of matter over the past two decades. In the field of nanophononics, the emergence of non-trivial topology holds great promise for the development of robust photonic devices, including large lasers, quantum emitters, and quantum interconnects. However, recent studies have yielded surprising results: in photonic structures, non-trivial topological indices like Chern
numbers and Z2 may not confer the anticipated robustness against deformations and defects. Although this fragility might be interpreted as symmetry breaking in certain scenarios, a comprehensive investigation and categorization of disorder are currently lacking. Considering this, our objective is to conduct a systematic study of various types of disorder in topological photonic structures to comprehend the reasons behind their evasion of topological protection. Through these studies, we aim to propose genuinely fault-tolerant structures suitable for real-world applications.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**EIE2023-24/12 A Digital Twin System for Autonomous Driving and Smart Manufacturing**

**Supervisor:** Dr Dong Yuan

**Eligibility:** Good programming skill. Familiar with UE5 and C++ are preferrable.

**Project Description:**
Wireless technology as the backbone of mobile applications has become essential in our daily lives. However, signal fluctuations caused by the unpredictable nature of factors such as moving crowds and improvised events in wireless and mobile applications amplify the complexity of their comprehensive evaluation across diverse real-world environments. To address these challenges, we developed a digital twin system with learning-based calibration and ray-tracing based real-time wireless propagation simulation capabilities for WMAs. The system can learn the latent state of the environment from real data for high-precision calibration and accurately simulate wireless systems in realistic 3D environment. The candidate will work on the applications of this system, e.g., autonomous driving and smart manufacturing, which will use measurement of wireless signals for training AI models.

**Requirement to be on campus:** No

**EIE2023-24/13 Efficient Deep Learning Inference with Edge Computing**

**Supervisor:** Dr. Dong Yuan

**Eligibility:** WAM>75 and Familiar with PyTorch; programming with Python and C++

**Project Description:**
Recent advances in deep neural networks (DNNs) have substantially improve the accuracy and speed of video analytics. The maturity of cloud computing, equipped with powerful hardware like GPU, becomes a typical choice for such kind of computation intensive DNN tasks. One obstacle, however, is the large amount of data volume of video streams. For example, a self-driving car can generate up to 750 megabytes of sensed data per second, but the average uplink rate of 4G, fastest existing solution, is only 5.85 Mb/s. To avoid the effects of network delay and put the computing at the proximity of data sources, edge computing emerges. Nevertheless, edge computer itself is limited by its computing capacity and energy constraints, which cannot fully replace cloud computing. This project will investigate the efficient parallel algorithms for DNN inference tasks on the edge server that equipped with GPUs.

**Requirement to be on campus:** No

**EIE2023-24/14 Detecting and Mitigating Signal Jitter-Based Power Analysis Attacks**

**Supervisors:** Prof. Sri Parameswaran/ Dr Darshana Jayasinghe

**Eligibility:** Verilog/ VHDL, oscilloscope measurement knowledge.

**Project Description:**
Recent research showed that signal jitter can be used to deduce secret keys from Advanced Encryption Standard (AES) circuits. AES algorithm is widely used to encrypt data and credit/debit cards. In this project, we aim to detect signal jitter and identify when power consumption information is presented in signal jitter. We will also test whether filtering jitter can be used as a countermeasure to prevent such attacks.

How do we do it? - We will implement an experimental setup on an FPGA board and perform a jitter-based power analysis attacks (we have most of the source code). Using an oscilloscope, we will analyse signal jitter when the signal has random jitter vs. when it contains power side-channel information. Finally, we will investigate filtering jitter from the signal as a possible countermeasure and test the efficacy of mitigating such attacks.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**EIE2023-24/15 Covert Data Channels using Signal Jitter on FPGAs**

**Supervisors:** Prof. Sri Parameswaran/Dr Darshana Jayasinghe

**Eligibility:** VHDL or Verilog knowledge.

**Project Description:**
Recent research [1] showed signal jitter can reveal power consumption side-channel information. When circuits are operated on FPGAs, the signal jitter is induced due to the power consumption of other circuits running parallel.

In this project, we aim to deploy the FPGA signal jitter to transmit and receive secret data (covert data). Covert channels use different properties such as message delays, temperature differences and operating frequencies to transmit data secretly between isolated entities. Such covert data transmission channels create security vulnerabilities in cloud FPGA services, such as Amazon EC2 F1.

How We do it? - We will develop an FPGA hardware program to generate and measure signal jitter to create a novel covert data system and evaluate data transmit rates. Then, we will integrate the developed covert data transmission system into an HDMI controller to demonstrate a practical security vulnerability.


**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**EIE2023-24/16 Testing on AI-based systems**

**Supervisors:** Dr. Huaming Chen

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Deep learning (DL) has become a new paradigm for solving many real-world problems due to its astonishing performance in different domains such as image analysis, natural language processing and system security. However, DL has also shown latent vulnerabilities leading to different kinds of “errors” which makes it challenging to develop robust DL software. Sometimes, it may involve the hardware-software codesign issue.

Therefore, to improve the reliability of DL software, it is crucial to have a systematic understanding and exploration for the techniques of automatically testing the robustness of trained DL software. In this project, we will work on the topic to test the trained DL software against various errors and ensure that it meets the required quality standards.

**Requirement to be on campus:** No
Enabling accurate indoor localization on Commercial Off-the-Shelf (COTS) devices

**Supervisors:** Prof. Yonghui Li; Prof. Branka Vucetic; Dr. Yunkai Hu

**Eligibility:**
1. Programming skill (e.g., Python, MATLAB and Java preferred).
2. Fundamental knowledge of signal processing, wireless communication, and machine learning.
3. Problem-solving and teamwork skill.

**Project Description:**
Exploiting WiFi signals for indoor localization has been an active topic due to the wide deployment of WiFi infrastructure. However, existing ranging-based methods can achieve meter-level accuracy with strong line-of-sight (LoS) paths. In the scenarios without LoS path, the wireless signals suffer from deep fading, multi-path effects, and packet losses, and thus resulting in low localization accuracy.

This project aims to develop a high-accuracy indoor localization system based on existing WiFi infrastructure and mobile devices. Signal fusion algorithms and machine/deep learning approaches will be heavily used. Students are encouraged to come to campus for experiments.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

Vital Sign monitor and gesture recognition based on WiFi channel state information

**Supervisors:** Prof. Yonghui Li; Prof. Branka Vucetic; Dr. Yunkai Hu

**Eligibility:**
1. students need strong knowledge on wireless and RF propagation knowledges.
2. students need strong background on machine learning and mathematical.

**Project Description:**
Indoor human sensing, recognition and detection are key enablers of building smart environments. Compared with traditional vision-based and wearable sensor-based solutions, WiFi-based approaches have advantage of providing contactless and wireless solutions. The project aims to develop a WiFi sensing system to monitor human vital sign and gesture recognition based on channel state information.

**Requirement to be on campus:** Yes *dependent on government’s health advice

Neural Network Aided Adaptive Error-Control Coding

**Supervisors:** Dr. Vera Miloslavskaya, Prof. Branka Vucetic

**Eligibility:** Experience in software development (Python or C++), machine learning, and English (reading, listening, speaking and writing)

**Project Description:**
Error-control coding is the key enabling technology for reliable data transmission. Polar codes have been adopted in the 5G standard. Beyond 5G and 6G systems need a highly adaptive polar coding scheme that closely adapts to various channel conditions and satisfies KPI requirements such as reliability, throughput, and latency. A flexible channel code structure with high error correction capability is needed to achieve high reliability in multi-user interference scenarios. Adaptivity means the opportunity to produce codes with diverse characteristics and select a proper code for given requirements on the FER performance, decoding latency, and computational complexity. To accurately predict the FER performance of polar codes, this project will build a framework that integrates the coding theory and machine learning. This framework will be based on a neural network that receives essential code features as input.
MECHANICAL ENGINEERING PROJECTS

MECH2023-24/1 Fluid Mechanics of Inhaled Pharmaceutical Aerosols
Supervisor: Agisilaos Kourmatzis

Eligibility: Strong interest in fluid mechanics. Strong skills in Matlab preferred. WAM>80. Must be at least in Year 3 of degree.

Project Description:
The use of intranasal drug delivery as a means of effective self-vaccination has a lot of interest, but so many questions remain with regards to how aerosol is transported through the human nasal channels and what the mechanisms of drug transport are once the drug has made contact with human tissue. Similar questions persist in our understanding of more traditional inhaler devices. These inhalers are not only used for treatment of common respiratory diseases such as asthma and COPD, but also for delivery of inhaled antibiotics. At the core of controlling the efficacy of these delivery systems, is a need to understand the turbulent fluid mechanics of droplets in complex geometries. In this project you will work on either experimental work, computational modelling, or in the design of new devices, to improve our ability to deliver drugs for specific applications.

Requirement to be on campus: Yes *dependent on government’s health advice.

MECH2023-24/2 Three-phase turbulent fluid mechanics
Supervisor: Dr Agisilaos Kourmatzis

Eligibility: Strong interest in fluid mechanics. Strong skills in Matlab preferred. WAM>80. Must be at least in Year 3 of degree.

Project Description:
One of the most complex fields in turbulent flows is that of 3-phase, or gas-liquid-solid flows. Despite how critical understanding these flows is to our everyday lives, from food production to pollutant control and pharmaceuticals, the physics of these flows remains poorly understood. This results in high inefficiency and waste in a range of industrial systems because our ability to physically model the underlying mechanisms is too rudimentary. In this project, you will work on developing a new 3-phase flow experiment and make use of a new integrated optical coherence tomography and particle imaging method to make the first steps towards helping us understanding this critically important field. Depending on interest, the project may also involve computational fluid dynamics.

Requirement to be on campus: Yes *dependent on government’s health advice.

MECH2023-24/3 Developing aluminium superalloys through nanoscale phase engineering by metal 3D printing
Supervisors: Prof. Simon Ringer & Dr. Suqin Zhu

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Heat-resistant metallic alloys, or superalloys, are essential for our industries and everyday life. They must meet high-performance requirements for working at elevated temperatures, limiting
the material options to Ni, Co, Fe or Ti-based alloys which are either expensive or heavy. To meet modern industry’s emission-reduction and sustainability requirements, it is necessary to develop lightweight and cost-effective heat-resistant alloys that complement the current alloy systems. Aluminium (Al) is the second most used metal, lightweight and infinitely recyclable. However, Al alloys have relatively poor heat resistance and are typically used below 150 °C.

Additive manufacturing (AM), also known as 3D printing, has emerged as a disruptive technology in the last decade to produce geometrically complex and lighter metallic products with exceptional microstructure and properties. This project will explore the feasibility of developing Al-based superalloys using AM via phase transformations that create nanoscale heterogeneity to achieve heat resistance at 200-400 °C.

Requirement to be on campus: Yes *dependent on government’s health advice.

MECH2023-24/4 Combustion of Green Fuels (Hydrogen and its derivatives)
Supervisors: Prof. Assaad Masri, Dr Matthew Dunn and Andrew Mcfarlane

Eligibility: Open to final-year students only with HWAM>75

Project Description:
Combustion will remain central to the process of decarbonization particularly in power generation, heavy duty transport and high-temperature process industries. The project will investigate fundamental issues associated with the turbulent combustion of green fuels (also referred to as power-fuels, or electro-fuels such as hydrogen and its derivatives).

Requirement to be on campus: Yes *dependent on government’s health advice.

MECH2023-24/5 Buoyant fires and their suppression by enhanced chemicals
Supervisors: Prof Assaad Masri, Dr Agi Kourmatzis, Vinny Gupta

Eligibility: Open to final year student with WAM>75

Project Description:
The project aims at investigating the structure and stability of buoyant flames which simulate compartment fires. The suppression of such fires by water mist enhanced with chemicals is also studied. The challenge here is the dynamics of the spray droplets and access to the reaction zone for maximum effectiveness.

Requirement to be on campus: Yes *dependent on government’s health advice.

MECH2023-24/6 Legoing atoms on supercomputers: point defects and impurities in advanced alloys
Supervisors: Prof. Simon Ringer; Dr Carl Cui

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application

Project Description:
Computational simulation is a valuable approach often likened to “theoretical experiments on (super)computers”. It is one of the few enabling methodologies that can significantly reduce development cycle times and costs in the material sciences. With continuous advancements in algorithms and computational power, this methodology has played a pivotal role in expediting the design, processing and performance optimisation of technologically important materials and devices.

In the realm of alloy mechanics, it has long been known that point defects and impurities play a crucial role in affecting mechanical properties – some are vital, and some are fatal.
However, much of the current understanding relies on semi-empirical rules, limiting direct applicability to new alloy designs. By performing accurate first principles (without experimental or empirical parameters) atomistic simulation based on density functional theory, this project aims to delve into the fundamental behaviour (including the distribution, interaction, and diffusion) of defects and impurities in various technologically important alloys, such as titanium and nickel. The successful applicant will have access to powerful national computational facilitates, enabling robust and comprehensive simulations. The outcome of this project will provide valuable insights that can inform knowledge-based, rational design for advanced alloys, contributing to the advancement of materials science.

**MECH2023-24/7 Mining rare-earth elements at the atomic level**

**Supervisors:** Prof. Simon Ringer; Dr Carl Cui

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Computational simulation has emerged as a pivotal tool, expediting the design, processing and performance optimisation of materials and devices, making it increasingly vital in contemporary research.

Of particular interest are the rare-earth (RE) elements and their alloys, renowned for their peculiar properties, which hold significant promise for applications in high-tech industries and diverse manufactured products. In steel alloys, RE elements play a crucial role by eliminating impurities (such as oxygen and sulphur) and forming alloy solutions with iron. However, the underlying microscopic mechanism governing these processes remains inadequately understood. Based on the predictive first principle (no experimental or empirical parameter) density functional theory, this computational project seeks to unravel two fundamental aspects: (1) the behaviour of RE elements in iron, and (2) the interaction between RE elements and different impurities (including boron, phosphine and sulphur) in the iron (both bcc and fcc) matrix.

The successful applicant will have access to state-of-the-art national computational facilities. This project offers a great opportunity to gain fundamental knowledge of materials engineering, particularly in the emerging domain of next-generation steel research. The insights garnered from this endeavour will contribute valuable information for the advancement of next-generation steel, opening new frontiers for exploration in materials science.

**Requirement to be on campus:** No

**MECH2023/8 Additive manufacturing and mechanical behaviour of high-performance multiple-principal element alloys**

**Supervisor:** Dr. Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**
Over millennia, the basic alloying strategy of adding small amounts of secondary atoms into a primary element has remained unchanged, limiting the total number of alloys and thus the reachable properties. The recently developed multiple-principal element alloys (MPE) alloys, can essentially address this shortfall, presenting a multitude of new opportunities for materials properties due to the vast compositional space previously inaccessible. It has been revealed
that the exceptional properties and functionalities of MPE alloys originate from their compositional heterogeneities at the atomic level. In this project, we will apply the advanced manufacturing methods to enable the nanostructure engineering of MPE alloys, aiming to intelligently integrate multilevel chemical and structural heterogeneities, from sub-nanoscale and up, into the MPE alloys towards the superior combinations of properties that are beyond current benchmark ranges. By delicately tailoring the parameters, the local chemical composition and nanostructures can be regulated to enable the rapid construction of complex heterogeneities from the bottom-up manner. This project will open a new avenue for engineer the multiscale microstructure/chemical heterogeneities to design next-generation, high-performance, and sustainable alloys.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**MECH2023-24/9 Making Strong Alloys Ductile and Hydrogen-Tolerant through Engineering hierarchical heterogeneous Nanostructures**

**Supervisor:** Dr. Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**
High-performance alloys are the backbone of decarbonising innovations in manufacturing, infrastructure, energy, and transportation. There is an accelerated demand for high-strength materials to produce lighter, more-reliable structural components. Stronger alloys will substantially improve mechanical and energy efficiencies, which can benefit our economy and environment directly. However, high-strength materials typically have low ductility and are more vulnerable to fracture. Furthermore, they are also susceptible to hydrogen embrittlement (HE) in many service environments for renewable energy applications such as hydrogen transportation and the bearings of wind turbines. Hydrogen-induced embrittlement can lead to unpredictable and catastrophic failures at relatively low applied stresses. These critical shortcomings cause serious safety concerns but cannot be readily addressed by traditional materials development approaches that generally render materials property trade-offs between strength and ductility/HE resistance.

Gradient structures are an emerging material-design paradigm inspired by nature that has great potential to overcome these alloy design trade-offs. This project aims to develop an innovative design strategy of gradient segregation engineering (GSE) to produce high-performance alloys by synergistically introducing a chemical gradient via grain boundary (GB) segregation and a physical gradient by nanostructure control. The novel GSE will entail a synergy of multiscale strengthening mechanisms that offer an exceptional strength-ductility combination and simultaneously enable the hierarchical HE-resisting mechanisms to notably enhance the hydrogen tolerance.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**MECH2023-24/10 Architecting high-performance Metal-Ceramic Composites by advanced manufacturing**

**Supervisor:** Dr. Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**
Materials come with characteristic combinations of mechanical properties. For example, ceramics have high stiffness but break easily; metals have high strength and ductility but limited ability to deform elastically. A vital requirement for all structural materials is that they possess an exceptional combination of stiffness, strength, ductility, and damage tolerance.
However, these characteristics cannot currently be obtained simultaneously. Although materials with different combinations of attributes can be designed by forming composites of different materials, it is still scientifically and technologically challenging to harvest desirable combination of properties.

To address these issues, in this project, we will propose a multidesign strategy, which encompasses the deliberate modulation of the phase constitution and architecture of metal-ceramic interpenetrating-phase composites that can be enabled by the combination of advanced manufacturing techniques. The newly designed materials will push the boundaries of materials properties beyond current benchmark ranges.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**MECH2023-24/11 Play with small-scale metals: new insights into micro-plasticity**

**Supervisors:** Dr. Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**

The past two decades have witnessed a rapid increase in demand for micro/nano devices and components, such as micro/nano-electromechanical systems (MEMS)/(NEMS) sensors, micro-engines, connectors, micro-pumps, and medical implants, to push the boundary of property and functionality for many evolving technologies. This essential requirement for device miniaturisation promotes an unprecedented advancement in manufacturing techniques and processes, empowering us to fabricate these small structures at micrometer, submicrometer, and even nanometer scales. During practical application and service, these novel systems would ineluctably suffer from external loading and large deformation. Therefore, their robustness and reliability rely primarily on the mechanical performance of small-sized materials.

However, when the external geometric sizes of materials are diminished into the micro/nanoscale, their mechanical responses are profoundly distinct from those of bulk counterparts. Comprehensively exploring the mechanical behaviour of the micro-/nano-sized materials is not only significant scientifically to furnish principal insights into their deformation physics to enrich the theory of crystal plasticity, but also crucial technologically to empower us to exert control over the design and development of cutting-edge MEME/NEMS with predictable, reliable, and reproducible performances.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**MECH2023-24/12 Mechanical behaviour of high-performance and sustainable steels**

**Supervisors:** Dr. Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**

As the backbone of decarbonizing innovations in key sectors such as energy, infrastructure, transportation, and safety, high-performance structural steels are urgently required to address the significant economic, energy-efficient, and environmental challenges. Stronger, tougher steels are always needed to reduce weight and improve safety in transportation, enhance architectural flexibility in construction, and improve performance in heavy machinery. Adjusting steel composition with the addition of an increasing number of elements is the general approach to achieving desirable properties. Such a strategy requires more energy for alloys production, entails materials development more resource-dependent, and makes materials
recycling more difficult, imposing negative impacts on the long-term sustainability of advanced steel.

Recently, we developed several advanced steels with superior mechanical properties and compositional constraints using efficient manufacturing method. Timely exploiting the knowledge of the mechanical behaviour of these advanced steels is important both scientifically, for the in-depth comprehension of their deformation behaviour, and technologically, for assessing their service utilities in safety-critical structural components and providing mechanistic strategies for future steel design.

**Requirement to be on campus:** Yes *dependent on government's health advice.

### MECH2023-24/13 Real-time anomaly detection in additive manufacturing processes using artificial intelligence

**Supervisors:** Dr. Xianghai An; Prof. Gwénaëlle Proust, A/Prof. Zhiyong Wang

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This summer project has the option to be combined with an honours project.

**Project Description:**

Additive manufacturing (AM) is revolutionizing manufacturing processes to build 3D parts by progressively adding thin layers of materials guided by digital models, enabling the fabrication of innovative structures, complex shapes, and customised parts. However, various anomalies commonly occur during manufacturing due to the improper settings of process parameters, and residual and thermal stresses. Insufficient quality assurance will create material waste, increase production time and prevent AM adoption in advanced fields that require quality-assured high-performance parts.

Current non-destructive defect detection techniques are post-production analysis that largely depends on the operator’s experience, making the identification of defects inaccurate and inconsistent. To assess the printing condition and product quality efficiently and accurately, in-situ monitoring systems for detecting defects are highly needed. Although novel image processing methods demonstrate promising progress in real-time anomaly detection, they mainly depend on specific problems and cannot identify different types of defects simultaneously. It has increasingly realised that machine learning (ML) methods hold great promise in overcoming these problems as they could analyze underlying patterns and features within datasets. In this project, we will establish imaging systems for in-situ monitoring of the fabrication process and develop new ML algorithms for solving multiple real-time anomaly detection problems with high accuracy.

**Requirement to be on campus:** Yes *dependent on government's health advice.

### MECH2023-24/14 Improving mechanical properties of metallic materials via combined compositional and structural heterogeneities

**Supervisor:** Prof. Xiaozhou Liao

**Eligibility:** WAM>80

**Project Description:**

Strength and ductility are among the most important mechanical properties of materials. Materials with high strength and high ductility are desirable for many structural applications. However, achieving both high strength and excellent ductility in structural materials poses significant challenge because they often exhibit a trade-off relationship. Significant worldwide efforts have been made looking for solutions to overcome the trade-off. One promising approach is to introduce combined structural and compositional gradients. This project aims to explore how different gradient structures affect deformation behaviour and mechanical properties. Combined compositional and structural gradients will be introduced using additive manufacturing and surface mechanical treatment. The digital image correlation technique will
be incorporated during tensile mechanical property testing. Electron microscopy will be used for microstructural characterisation. Through this research, we seek to gain valuable insights into how such gradient structures can potentially enhance materials' performance.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**MECH2023-24/15 Exploring the Effect of Mechanical Loading on HfO2-Based Ferroelectric Microstructure**  
**Supervisors:** Prof. Xiaozhou Liao and Dr. Ying Liu

**Eligibility:** WAM>80

**Project Description:**  
Ferroelectrics have a wide range of applications in fields including information and communication technologies, medical imaging, and energy harvesting. HfO$_2$-based ferroelectrics show promise for future electronic device applications such as non-volatile memories and neuromorphic computing due to their compatibility with silicon technology and stable ferroelectric properties at the nanoscale. To predict their nanoscale properties and performance, it is crucial to understand how external stimuli affect their microstructures, including different phases, strain, and electric field distribution. This project aims to investigate the impact of external mechanical loading on the microstructure of HfO$_2$-based ferroelectric single crystals. Advanced transmission electron microscopy techniques will be used to capture atomic resolution images, which will then be analysed using Python-based coding methods. The analysis will yield precise measurements of strain, strain gradient, phase distribution, and local electric field. These quantitative findings will provide valuable insights into how mechanical loading affects the microstructure of the crystals.

**Requirement to be on campus:** Yes *dependent on government’s health advice.

**MECH2023-24/16 High-resolution imaging to evaluate the dynamic interaction between pharmaceutical solids and liquid**  
**Supervisors:** Dr. Agisilaos Kourmatzis and Dr. Taye Mekonnen

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**  
Understanding the dynamic behaviour of solid-liquid interactions is vital across various industries, including inks, paints, food, and pharmaceuticals, as it directly impacts the dispersion and dissolution characteristics of the solid forms. The primary objective of this project is to assess the real-time kinetics of interactions between pharmaceutical tablets or powder bed and liquids using Optical Coherence Tomography (OCT) with high temporal and spatial resolutions. The technique entails bringing the solid form in contact with liquid and employing OCT imaging to continuously capture high-resolution cross-sectional images of the evolving internal structure of the wetted material. These time-series OCT images will be analysed to facilitate a quantitative assessment of the liquid’s penetration and spreading within the solid form. Such real-time OCT monitoring offers a non-destructive and time-efficient way to study the wettability and internal dynamics of pharmaceutical solid forms, thus providing valuable information for optimizing formulations and improving drug delivery systems.

**Requirement to be on campus:** Yes *dependent on government’s health advice.
MECHATRONIC ENGINEERING PROJECTS

MECHATRON2023-24/1 Data Augmentation for Semantic Segmentation for autonomous Vehicles
Supervisor: Dr. Stewart Worrall; Dr. Julie Stephany Berrio Perez; Dr. Mao Shan

Eligibility: Programming Skills: Basics in Computer Vision and ML

Project Description:
The main objective of this project is to enhance data augmentation for semantic segmentation in images, specifically for autonomous driving applications. The project involves applying cutting-edge machine learning techniques to modify the appearance of locally annotated images into various domains. One of the core tasks is image translation, which entails training a machine learning model to transform an image from one domain to another. For instance, this could involve converting a daytime image to a night-time or rainy condition image. By performing such data augmentation, the project aims to create a more robust and diverse dataset, which can improve the performance and generalization capabilities of semantic segmentation models used in autonomous driving scenarios. This augmentation process will expose the models to different environmental conditions, preparing them to handle various real-world situations effectively.

Requirement to be on campus: Yes *dependent on government's health advice.

MECHATRON2023-24/2 3D Digital Twins from Autonomous Vehicles data
Supervisors: Dr. Stewart Worrall; Dr. Julie Stephany Berrio Perez; Dr. Mao Shan

Eligibility: Programming Skills: Python or C++, basic knowledge of robotics

Project Description:
The project aims to advance digital twins for Autonomous Vehicles (AVs) by harnessing combined capabilities, facilities, and equipment. Students will be able to gather data, process it, and create an accurate model of the environment. Data collection includes various perception sensor data, such as lidar, inertial units, cameras, and GPS localisation. Experienced researchers specialising in robotics and sensor fusion will mentor the students. Their guidance will assist in developing scalable digital twin models that represent the physical features of the local environment. Applying state-of-the-art techniques will be central to overcoming perception, localisation, and 3D reconstruction challenges. In addition to the technical aspects, the project will incorporate virtual reality (VR) to effectively communicate the research's potential and showcase the project’s results. Ultimately, the models, algorithms, and tools developed during the internship will be publicly available.

Requirement to be on campus: Yes *dependent on government's health advice.

MECHATRON2023-24/3 Active Monocular Depth Estimation
Supervisors: Donald Dansereau, Danish Khan

Eligibility: Strong programming skills. An interest in one or more of image processing, optics, camera calibration, and computer vision. Experience with machine learning would be an asset

Project Description:
Working with researchers at the Australian Centre for Field Robotics, this project will develop novel sensing technologies to enable robots to operate in new domains. Monocular depth estimation is estimating the depth of objects in a scene using a single camera. It has critical applications in robotics, augmented reality, and autonomous driving. You will work on the depth estimation problem using light patterns as an additional cue. A calibrated camera-projector system is assumed where a projector projects light-coded...
patterns, and a camera captures the deformed patterns. The deformed light pattern can be fed into a deep-learning model to estimate the depth map of the scene. The deep learning model will be trained using a dataset of images, and corresponding depth maps to learn the mapping between the input image and its depth.
You can also contribute to synthetic dataset generation. We will model a virtual camera-projector 3D sensing system to render the ground truth data for deep learning training.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**MECHATRON2023-24/4 Privacy-Preserving Robotic Vision**
**Supervisor:** Dr. Donald Dansereau

**Eligibility:** Experience with one or more of imaging, image processing and/or computer vision Knowledge of optics and/or analogue electronics would be an asset; Strong programming skills in Matlab, Python or C++ would be an asset.

**Project Description:**
What does your robotic vacuum cleaner see, and who else has access to those images? In homes, hospitals, and secure industrial sites, the uptake of autonomous robots is limited by privacy concerns.
Working with researchers at the Australian Centre for Field Robotics, this project will develop novel sensing technologies to enable robots to visually understand their environments without capturing privacy-revealing images.
Building on existing work in the group, you will construct and control the first opto-electronic hardware prototype of an inherently privacy-preserving robotic vision system.
Depending on interest and ability, there is also scope to advance the algorithms behind the hardware, making sense of the novel computational imaging device to allow robots to intelligently understand their environments.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*

**MECHATRON2023-24/5 Visual Satellite Docking and Repair**
**Supervisor:** Dr. Donald Dansereau

**Eligibility:** An interest in one or more of image processing, optics, camera calibration, and computer vision; Strong programming skills

**Project Description:**
The escalating proliferation of defunct satellites and other space debris represents a growing threat to crucial spaceborne technologies, including communication infrastructure and astronomical instruments. To help deal with this problem we are developing technologies that will allow us to dock with and repair satellites in orbit.
Working with researchers at the Australian Centre for Field Robotics, this project will develop a physical surrogate environment for developing satellite docking and repair technologies.
This project will continue existing work on construction of a scaled physical model that emulates the visual scenario of docking with a satellite in orbit, and novel imaging technologies capable of handling the space environment. Depending on ability and interest, there are opportunities to work on physical model construction, illumination characterisation and engineering, and camera development and characterisation including development of perception algorithms and novel cameras.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*
MECHATRON2023-24/6 Human-Machine Collaborative Deep Learning of Complex 3D Sensor Data

Supervisor: Dr. Mitch Bryson

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
Three-dimensional sensor data (e.g. LiDAR, photogrammetry point clouds) are used extensively to measure complex environments in applications such as infrastructure inspection and environmental management. State-of-the-art approaches to interpreting this data are based on machine learning techniques in which deep neural networks which are trained for performing complex tasks. These techniques perform well in environments for which they are trained, but often fail to interpret data in new environments or novel scenarios.

This research project will focus on developing approaches to 3D data analysis in novel/unseen environments based on human-machine teaming. This involves both a human expert and a machine-learnt/AI model working collaboratively, for example through a virtual-reality interface, to analyse complex 3D datasets in new situations. Approaches will be developed including interactive segmentation and active learning which combine the complimentary abilities of a human expert’s adaptability to new scenarios with the precision and throughput offered by machine learning and AI.

Requirement to be on campus: No