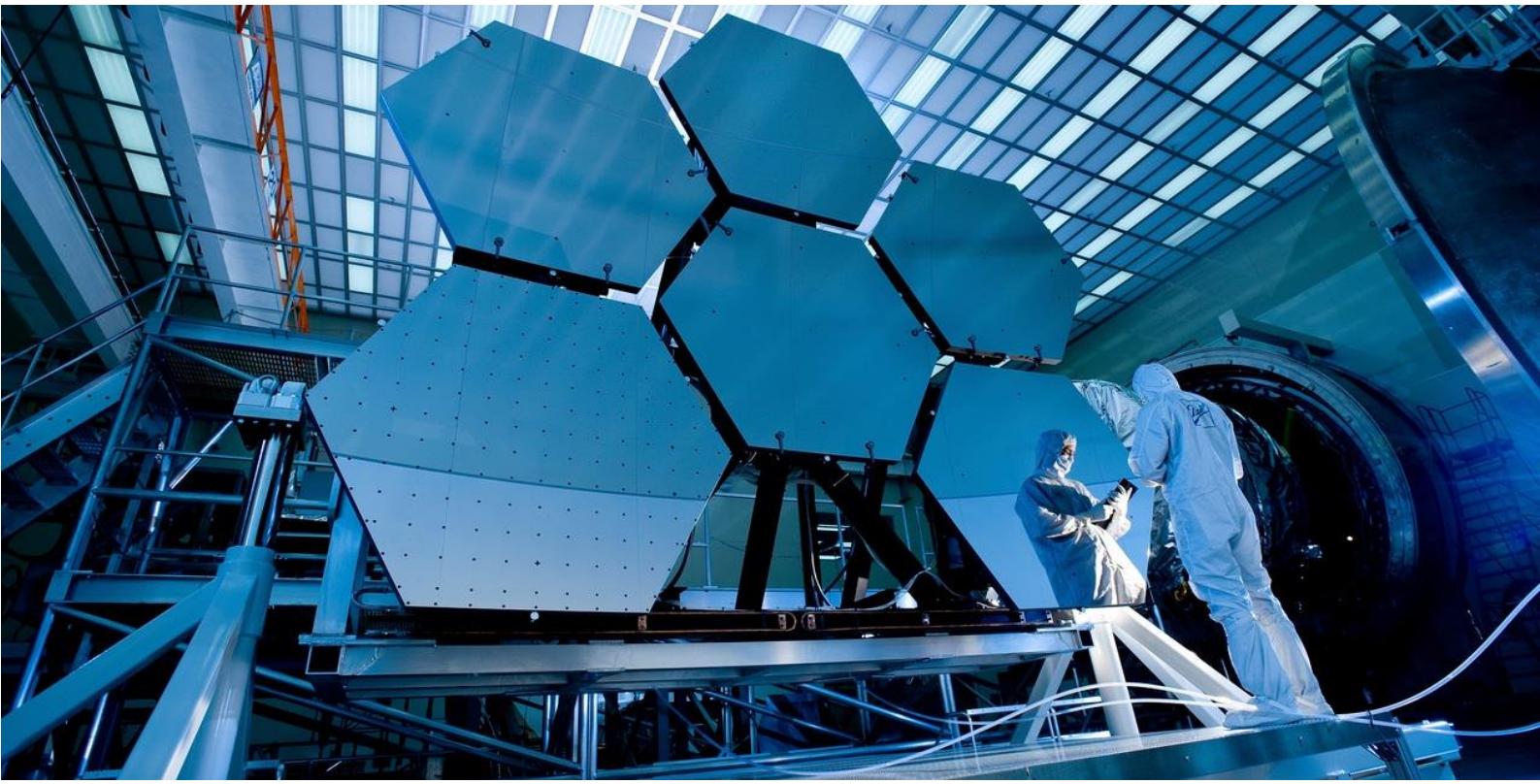
THE UNIVERSITY OF SYDNEY

FACULTY OF ENGINEERING

Engineering Vacation Research Internship Program



ENGINEERING RESEARCH PROJECTS - SUMMER 2022-23

AERONAUTICAL ENGINEERING PROJECTS

AERO2022-23/1 Probability Map Based Aerial Target Detection and Localisation Using Networked Cameras

Supervisors: Dr Zihao Wang and A/Prof K C Wong

Eligibility: WAM>75; Experienced in MATLAB; Basic knowledge in Linux is preferred; Strong communication skills are essential.

Project Description:
Aerial target detection and localisation is an important capability in many industries, such as providing early detection of rogue small Unmanned Aerial Systems (UASs) in sensitive airspace, and localising pest birds near aerodromes or farms so that bird control measures can be deployed before the birds can cause any damage. The project aims to extend the capabilities of a networked optical sensor system prototype developed in a related study. The prototype consists of multiple webcams that are placed around the airspace of interest. The webcams are each paired with a single-board-computer that processes the video stream using computer vision. A central computer processes the detection results into GPS coordinates using a probability map-based algorithm inspired by trilateration. The student will have access to the prototype system and the MATLAB source code developed by the supervisors. A field trial of the improved prototype is required at the end of the project.

Requirement to be on campus: No

AERO2022-23/2 Computational Fluid Dynamics analysis of Metal-Organic Framework cartridges for Direct Air Capture

Supervisors: Dr Michael Groom and Nicholas Lawson

Eligibility: Experience with CFD and related numerical methods is desirable but not compulsory.

Project Description:
This project addresses the urgent need to remove historical emissions of carbon dioxide from the atmosphere using innovative Metal-Organic Framework (MOF) adsorbents for Direct Air Capture (DAC). Solar-powered adsorption via MOFs provides a carbon neutral and cost-effective option for the extraction of CO2 from the atmosphere.

The student will use Computational Fluid Dynamics (CFD) to analyse the flow through a MOF cartridge and guide improvements in the geometry for various performance metrics such as increased CO2 uptake, kinetics of uptake and heat of adsorption. Commercially available sensors for pressure, temperature and flow rate will be integrated within a prototype DAC module and used to provide data for augmenting the CFD calculations. Various approaches for tuning the CFD simulations to provide better agreement with the measured data will also be explored.

This is an exciting opportunity to work as part of an interdisciplinary collaboration between the School of AMME and the School of Chemistry.

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

AERO2022-23/3 Failure strength of 3D printed interlocked structural connections

Supervisor: Prof Liyong Tong

Eligibility: Students with Distinction (or at least CR) with intension to pursuing PhD.

Project Description:
Structural connections are inevitable in aircraft, automobiles, ships, and building. When two or more structural components are connected, it is desirable that adequate load path should be maintained so to meet the requirements of structural stiffness, strength, and integrity. In this project, we aim to develop effective joining method for two plates with optimally designed interlock and bonding. Additive manufacturing technology will be used to fabricate test specimen of double lap joints with interlocking and bonding in tension. The project involves using 3D printer available in FabLab to fabricate structural parts, using adhesive bonding to prepare the test specimen, and conducting tensile tests to investigate the failure mechanisms and strength. The expected outcome would be an in-depth understanding of the roles of interlocking and bonding in strengthening structural connection.

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

AERO2022-23/4 Design and testing of 3D printed pneumatic soft robots

Supervisor: Prof Liyong Tong and Yifu Lu

Eligibility: Students with Distinction (or at least CR) with an intension of pursuing PhD.

Project Description:
This project is about developing soft robots that are driven by pneumatic pressure differential and can perform simple functions, such as walking, gripping, etc. This project can be broadly split into two parts: design and optimization of soft structures subjected to internal pressure actuation, and prototyping by using 3D printer, and testing and characterization under different internal pressure. The basic movement in the design of soft structure under internal pressure loading is elongation, bending and torsion (or twisting). The question is how to achieve one or a combination of these three motions via designing internal material distribution and simple pressure channel with single pressure variation. Some structural components or soft robots to be considered can be as simple as a beam that can bend and walk like a worm through internal pressure variation.

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

AERO2022-23/5 Navigation and Control for Satellite Close Proximity Operations

Supervisor: Dr Xiaofeng Wu

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:
Design and test mathematical models to support the development of spacecraft flight control algorithms. Students will use MATLAB and Simulink to model real world systems and will be responsible for creating or contributing models of one or more spacecraft subsystems (e.g. spacecraft sensors, actuators, solar arrays, etc).

The project will involve modelling the attitude and orbit control subsystem including actuators, sensors, errors and delays, testing the system and integrating models into the wider suite of simulation algorithms.

From this internship, you will: 1. Learn how mission critical spacecraft control algorithms are developed. 2. Understand the key design tradeoffs which must be made while designing spacecraft subsystems. 3. Learn how subsystems work together to fulfil a spacecraft's mission.

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

BIOMEDICAL ENGINEERING PROJECTS

BME2022-23/1 Automated Audio/Video-Based Lameness Characterisation in Athlete Horses

Supervisors: Dr Andre Kyme and collaborators at TeleMedVet (WA)

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 aim of this project is to develop and validate a deep neural network for audio/video-based equine lameness characterisation. This has the potential to dramatically improve the prediction of catastrophic injuries (e.g. fetlock fracture) in athlete horses. Current methods lack quantification, reliability and efficiency and require overhaul. Augmenting video and audio inputs into a comprehensive machine learning model is extremely novel, and nothing like this exists for gait analysis in horses. A neural network-based approach has many advantages – but there are also many unanswered research questions. The Winter program will tackle these questions.

This project is in collaboration with our imaging and veterinary partners at TeleMedVET, Perth, WA. The end goal is to develop a viable product that can be deployed throughout the athlete horse industry for game-changing injury prevention. The project will suit a student with an interest and strength in deep learning and its application to biomedical engineering.

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

BME2022-23/2 Proof of concept of lactate detection using electrochemical biosensor

Supervisors: Dr Clara Tran and Prof Alistair McEwan

Eligibility: Wet lab experience, electrical biosensing knowledge desired.

Project Description:
Lactate is a product of anaerobic energy production in the body. Continuous monitoring lactate is of great interest for sport medicine and clinical care, in particular fetal monitoring with brain signals (EEG) would have great impact on pregnancy outcomes. In this project, we will investigate the immobilisation of lactate oxidase on plasma treated gold electrode and the performance of this immobilized enzyme for lactate and electrical biosignal detection. Students will have an opportunity to learn diversified techniques such as plasma deposition, enzyme immobilisation and colorimetric assay as well as electrochemical sensing. Wet lab experience is required.

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

BME2022-23/3 Mechanobiological study of protein-protein interaction of von Willebrand Factor (vWF) and platelet glycoprotein Ib alpha (GPIbα) using flow Molecular Dynamics simulation to understand hemophilia and thrombosis

Supervisors: Dr Lining Ju and Dr Chandreyee Das

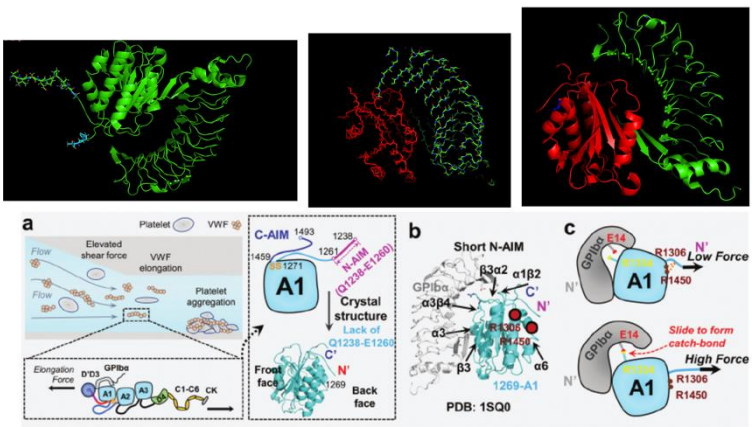
Eligibility:

- The capability of using two or more of Pymol, VMD, GROMACS, ANASYS, Comsol, Linux scripts, MATLAB, and other software.
- Preference is given to applicants who have a strong interest in researching and programming.
- The anticipated outcome could translate into the structural explanation of haemophilia inherited deficiency and assist the development of the novel 'mechanodrugs'.

Project Description:

The von Willebrand factor (VWF) is a multimeric plasma protein that mediates platelet adhesion and hence plays an important role in hemostasis and thrombosis. It senses and responds to the hemodynamic forces and interacts with the circulatory system to form a balanced condition and thus mediate conditions of hemophilia and thrombosis. It is quite well-known that the A1 domain of VWF is activated by tensile forces, and it binds to glycoprotein Ib alpha (GPIbα) to form platelet plugs. The study of the exact mechanism of the binding of the two proteins VWF and GPIbα is still in its initial stage.

With the help of molecular dynamics simulation tools of Pymol, GROMACS and other computational fluid dynamics softwares like ANSYS and COMSOL, we shall evaluate the mechanism of mechanobiological interaction of the two proteins VWF and GPIbα.



Requirement to be on campus: On-campus students will be preferred

BME2022-23/4 A high-throughput cell avidity measuring platform for targeted therapy and immunotherapy

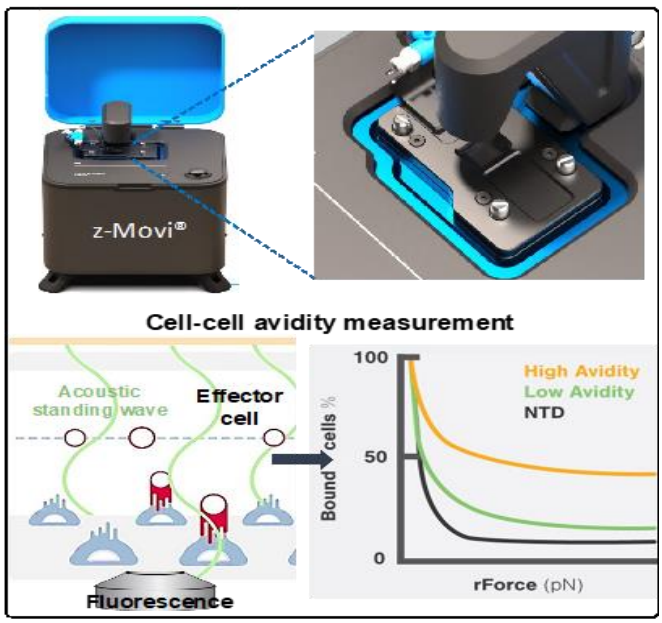
Supervisors: Dr Lining Ju and Dr Yao Wang

Eligibility:

- Candidates with experiences in conducting cell culture work in a PC2 lab,
- Having capability of using Micro Manager, GraphPad Prism are preferred.
- Preference is also given to applicants who have a strong interest in the research and treatment of cancer.

Project Description:
Cancer cells interact with non-cancerous host cells, including endothelial cells (angiogenesis), fibroblasts (invasion) and immune cells (immune response), as well as extracellular matrix proteins present in the tumour microenvironment (TME). Targeting the cell-TME communication represents an effective way to treat cancer, such as the emerging CAR T-cell immunotherapy for individual patients. However, the existing techniques are either limited by the throughput, or their time frames of cell handling without causing any damage to the cell viability. The recent integration of microfluidic devices and piezoelectric ceramic by LUMICKs, Netherland leads to a commercial product 'z-Movi®', which non-invasively applies acoustic forces within the piconewton range to the cells and track the live position of cells in a 3D plane.

In this project by partnering with LUMICKs, we aim to establish a novel high-throughput cell avidity screening platform using the emerging z-Movi technology for the discovery of new therapeutics with anti-metastatic or anti-angiogenic properties, as well as engineered immune cells for immunotherapy. We will characterize the drug impact on the interactions between tumourcells with CAR T-cells, endothelial cells, fibroblasts and ECM proteins.



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

BME2022-23/5 Rheological analysis and micron resolution particle image velocimetry for blood clotting

Supervisors: Dr Lining Ju and Dr San Seint Aye (PhD Deakin)

Eligibility:

- The capability of using two or more of ImageJ, Micro Manager, ANASYS, Comsol, Labview, AutoCAD, MATLAB, and other software;
- Preference given to applicants who have a strong interest in the research and treatment of cardiovascular and cerebrovascular diseases such as heart attack and stroke.
- Candidates are expected to maintain collaborations with Olympus professional microscope team and research and prototype foundry soft lithography cleanroom, bridge the research results to the optimisation of microfluidics design (AutoCAD) and fabrication (soft lithography).

- The anticipated outcome could translate into precision medicine that facilitate physicians' decisions on diagnosis, follow disease progression, optimise treatment courses, or even bridge dependent medication strategies for individuals.

Project Description:
Thromboembolism, which is complication of thrombus/blood clot formation, is the most common cause of hospital death as it can lead to stroke or heart attack. Thrombosis occurs in dynamic blood flow conditions in which platelets are key ingredients and they have adhesive interaction with fibrin. Thrombus alone does not grow large enough to completely occlude vessels. Haemodynamic force also decides onset and propagation of the thrombus.

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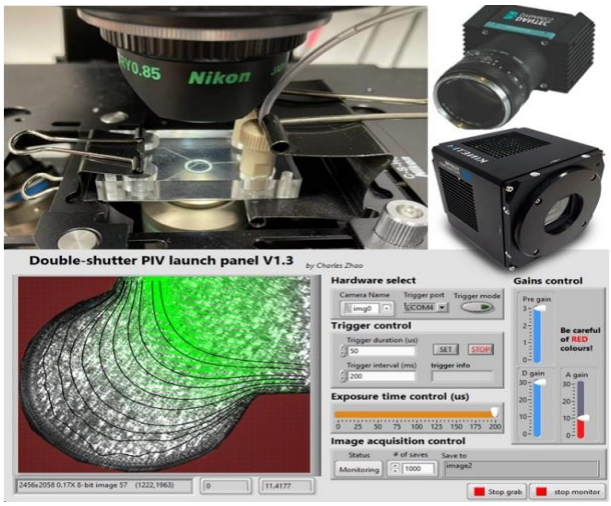
To analyse ex-vivo blood clotting process, we are developing 'micron resolutionparticle image velocimetry (μPIV)' techniquesto correlate the haemodynamic parameters with thrombotic phenotypes. To effectively correlate them, rheological profile of bloodclots during thrombosis can also be established by 'Rheometer'; it can measure viscosity of blood under shear gradient caused by blood flow disturbance, kinetic assembly of growing thrombus, rigidity of final stable clot and stability/deformation of the fibrous network. The findings could be used for micro vessel on chip development.



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

BME2022-23/6 Performance Evaluation of Denoising Algorithms for PET/MR Imaging

Supervisors: Dr Georgios Angelis and Dr Yaser Gholami

Eligibility: Advanced programming skills (C/C++, Matlab, Python). Good mathematical background on linear algebra.

Project Description:
Simultaneous PET/MR imaging allows the acquisition of functional and anatomical tomographic information at the same space and point in time. However, the quality of PET images is affected by lower spatial resolution and higher statistical noise, compared to their MR counterparts, due to several sources pertaining to data acquisition and image reconstruction.

In this project, the performance of several image denoising algorithms, such as Total Variation, Non-Local Means and Block-matching with 3D filtering, will be evaluated. The **hyper-**parameters of each denoising method will be optimised for several clinically relevant noise levels and activity distributions. The quality and quantitative accuracy of the denoised reconstructed images will be assessed using simulated digital data, as well as a set of clinical [18F]FDG PET/MR brain data.

This project is an exciting primer to medical image processing and analysis.

Requirement to be on campus: No

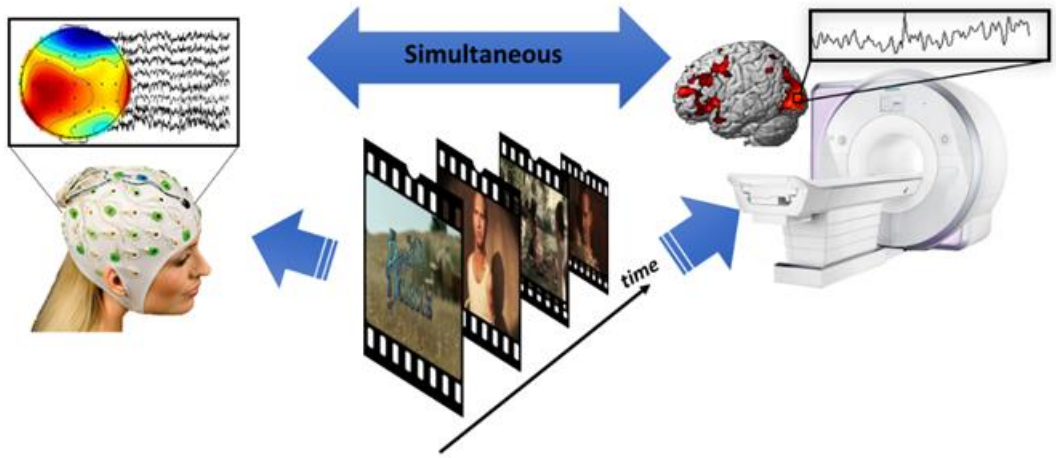
BME2022-23/7 Read the mind with simultaneous EEG-fMRI

Supervisors: Dr. Jinglei Lv, A/Prof. Mayuresh Korgaonkar, Prof. Fernando Calamante

Eligibility:

- Basic skills with programming.
- Basic knowledge about medical image.
- Self-motivation, curiosity about research and passion to succeed.

Project Description:
We are so close to reading the mind with the modern neuroimaging technology. The electroencephalogram (EEG) records the electrical activity of billions of neurons while the functional magnetic resonance imaging (MRI) reflects the blood oxygen consumption because of neuronal firing. Now at our lab, we have the hardware setup to record both signal modalities simultaneously. We can record the brain activity during resting state as well as with cognitive tasks, even movie watching. The concurrent activity recording from both EEG and fMRI helps us not only understand how the brain works and how the mind is generated, but also suggests potential biomarkers for psychiatric disorders, such as Depression, Bipolar and Schizophrenia. It demands smart engineering to decode faithful signals among massive noise in this advanced setting. In this project, you will work with both biomedical scientists and neuroscientists to develop a pipeline of experiment design, data collection and data processing with simultaneous EEG and fMRI. Together with T1w and Diffusion MRI imaging, you would explore the possibility of finding the signal sources and signal pathways in the human brain.



Requirement to be on campus: No

BME2022-23/8 Decoding Human Brain Dynamic Activity with Deep Learning

Supervisors: Dr Mariano Cabezas and Dr Jinglei Lv, Dr Tim Wang and Prof Fernando Calamante

Eligibility:

- Basic skills with programming. Python programming is preferable.
- basic knowledge about medical image.
- Self-motivation, curiosity about research and passion to succeed.

Project Description:
The human brain is a complex dynamic system with still many unknowns when it comes to its functional behaviour. However, functional MRI provides a means to record brain activity

signals. The signal at a given time point can then be used to define a brain state. That begs an interesting research question, i.e., whether one brain state can predict following states. This biological question can be formulated as an auto-regression problem in machine learning. Recent deep learning techniques, specifically transformers, can learn patterns from high dimensional time series and can model the sequential relationship between states (also known as tokens). We aim to develop a transformer-based method to explore this research question. Furthermore, we could use this model trained on healthy brains to model the brain states of patients with pathology. Afterwards, the measured prediction error could be employed to find anomaly regions related to a specific disease. The Human Brain Connectome dataset will be used for model training and validation while patient data from OASIS, ADNI or PPMI will be used for the disease research part and to compare to healthy controls.

Requirement to be on campus: No

BME2022-23/9 Plasma Catalysis for Gas Conversion Applications
Supervisors: Prof Marcela Bilek, Seyaedah Khadijeh Alavi

Eligibility: Ideally 3rd year of Engineering with design and prototyping experience. A good knowledge of chemistry and electromagnetism would be beneficial, time management and problem-solving skills are essential.

Project Description:
Plasma technology is a promising power-to-X technology that would enable the use of renewable electricity in a flexible way for chemical processes that create fuels, which do not emit greenhouse gases, and value-added chemicals. In this regard there is an increasing interest in using plasma for gas conversion applications. A plasma discharge is created by applying electrical energy to a gas. It is very reactive environment due to the presence of various type of atoms and molecules, electrons, ions, excited species and radicals. However, for the same reason it cannot be selective on its own in the production of targeted compounds. The plasma catalysis can combine the high reactivity of plasma with the selectivity of catalyst and for this reason it is gaining increasing interest for gas conversion. In this project you will investigate the catalysts use in different plasma reactors for gas conversion to be able to suggest an effective design for the reactor with catalyst.

Requirement to be on campus: No

BME2022-23/10 Rapid detection of pathogenic bacteria

Supervisors: Professor Ken-Tye Yong and Dr. Xiaochen (Morning) Liu

Eligibility:

- Ability to conduct independent research activities.
- Excellent oral and written communication skills.
- Knowledge of/willingness to conduct wet-lab synthesis.
- Knowledge of/willingness to conduct microbial culture.
- Basic knowledge of optics, chemistry or nanomaterials.
- Willingness of continuing as an honours project.

Project Description:
Pathogenic bacteria caused productivity loss is amounted to approximately more than US$95 millions annually in the middle- to low-income countries. It is projected that premature death due to foodborne illnesses contribute approximately 420,000 cases of the total annual deaths worldwide. The full extent of the burden and cost of unsafe food is currently still unknown but its impact on global health, trade and development is likely to be profound. The surveillance and prevention of food risk and biological terrorism are of central importance all over the world. Therefore, food safety and public health become a global mission and need worldwide cooperation. In this project, we will build an optical microfiber sensor for straightforward sensing of common pathogenic bacteria such as *Escherichia coli*. The vision of this project is to develop a rapid, user-friendly, and low-cost detection method for pathogenic bacteria. Continuation as an honours project is encouraged.

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

CHEMICAL AND BIOMOLECULAR ENGINEERING PROJECTS

CBE2022-23/1 Simulation support for replacement heart valve design and testing

Supervisor: Adj. Prof. David F Fletcher

Eligibility: You should have an interest in mathematics and the ability to program in Python would be a huge plus.

Project Description:
We are developing a new heart valve, that can grow with children as they mature, using novel materials and a bio-inspired design. This involves a collaboration between a wide range of clinical, materials and engineering specialist. Novel to this project is the embedding of simulation within the design team, where models are developed by computational specialists and then "rolled out" to the team. In this project you will work with the computational team leader assisting in the development of models and implementation of new physics.

If you are interested in the experimental side or just want to see where the data are coming from there is the possibility of being involved in data acquisition from novel experiments being performed by the team.

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

CBE2022-23/2 Evaluating polymeric heart valve replacement prototypes against computational modelling using a pulse duplicator

Supervisor: Dr Sina Naficy

Eligibility: You should be passionate about experimental work and be able to think critically. We value creativity and innovation.

Project Description:
We are developing a new artificial heart valve, using novel materials and bio-inspired designs. To achieve our goal, we have put together a multi-disciplinary team of clinical, engineering, and computational modelling specialists based in Australia and the US. To test the feasibility of our novel designs for heart valve prototypes, we first utilise computational modelling. The selected candidate designs must then be evaluated using an advanced equipment (a.k.a. pulse duplicator) that mimics heart's flow/pressure outputs.

In this project you will work on the evaluation side of this task. Briefly, you will make heart valve prototypes alongside our team members, and then test their performance in the pulse duplicator. The output of pulse duplicator will be then compared with our computational modelling data.

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

CBE2022-23/3 Making alcohols out of thin air

Supervisor: Dr Fengwang Li

Eligibility: Background knowledge in chemistry, chemical engineering, environmental science, or materials science.

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*

CBE2022-23/4 Plasma-assisted ammonia electrosynthesis

Supervisor: Dr Fengwang Li

Eligibility: Background knowledge in chemistry, chemical engineering, environmental science, or materials science.

Project Description:
Ammonia is conventionally regarded as a fertiliser but has received increasing attention as a new fuel and a hydrogen carrier in the era of hydrogen economy. Ammonia synthesis from nitrogen in the air and water using renewable electricity as energy input is a promising approach to replacement of traditional H-B process, which accounts for 2% global carbon emission. However, nitrogen is extremely stable due to triple N-N bond. This project aims to use cold plasma to active nitrogen to its excited state, which eases the energy barrier for the following electrochemical conversion to ammonia with nanomaterials as catalysts. New materials synthesis, characterisation, electrochemical test, and product analysis will be expected from this project.

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

CBE2022-23/5 Using protein condensates for RNA delivery

Supervisor: Dr.Yi Shen

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:
RNA therapy has become an emerging medical tool for many health challenges, including vaccination for COVID. Proteins and peptides can undergo a liquid-liquid phase separation forming condensates. Recent studies state therapeutic molecules can be recruited within biomolecular condensates and act as payload and carrier, respectively, to treat disease. In this project we will use microfluidic and optical techniques to load the condensates with RNA and deliver them to specific location in cells.

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

CBE2022-23/6 Using protein self-assembly for bioplastic generation

Supervisor: Dr. Yi Shen

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:
Biomaterials derived from natural components, such as proteins, have been widely explored in many applications for their excellent biocompatibility and degradability. In particular, protein-based microgels has great potential to be engineered as an alternative to synthetic microplastic in food, personal care and cosmetic applications. However, the bottleneck of the development of protein-based microgels has always lied in the poor stability and high cost of the synthesis methods. Taking advantage of protein phase behaviour, microgels with high stability and low cost can be generated. In this project, functional proteins and peptides will be screened and investigated as building blocks of the new biomaterials through their phase behaviour.

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

CBE2022-23/7 Enhancing green hydrogen production by magnetic field-assisted electrochemical water splitting

Supervisor: Dr Li Wei

Eligibility: This project requires a senior undergraduate student or MPE student with basic chemistry, and preferably electrochemistry and physical chemistry knowledge. Experience in the lab or related to research is a bonus.

Project Description:
Electricity converted from renewable sources can facilitate the electrochemical water splitting reaction to produce green hydrogen (H_2) fuels. Cost-effective and high-performance electrocatalysts are critical in the process. While the H_2O splitting process involves the multiple-electron transfer between the H_2O molecule and the catalyst, regulating the electron spin can effectively boost the catalytic activity.

This project will utilise a local magnetic field to control the catalyst electron spin states and investigate the effectiveness of the spin-state regulation on the catalytic water splitting performance. Two catalyst systems, single-atom catalysts and metal oxide-based catalysts will

be studied. You will examine and interpret the catalyst properties and correlate them to the observed electrochemical performance difference. Opportunities for theoretical mechanism study are also available, depending on the progress of the project.

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

CBE2022-23/8 Optimising solid-state electrolyte in a hydrogen peroxide electrolyser

Supervisor: Dr Li Wei

Eligibility: This project requires a senior undergraduate or MPE student with basic chemical engineering knowledge. Students with electrochemistry knowledge and experience in the lab or related to research will be preferred.

Project Description:
Hydrogen peroxide (H_2O_2) is an essential chemical with a wide range of applications. Its production is currently dominated by energy and emission-intensive anthraquinone-redox process. Alternatively, green H_2O_2 can be produced by the oxygen reduction reaction from an electrolyser driven by renewable electricity. We have previously demonstrated the production of pure H_2O_2 solution directly from an electrolyser. A solid-state electrolyte composed of polymer beads with proton conductivity is one of the key components in this electrolyser. Its key properties, including size, porosity, and proton capacity, may substantially influence the electrolyser operating conditions and performance.

This project will focus on the optimisation of these parameters by using a series of polymer beads with varied properties. You will assemble electrolysers using these polymer beads and collect their H2O2 production performance. This work will acquire vital information for electrolyser design and operation optimisation.

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

CBE2022-23/9 Improving capacity and stability of graphic carbon electrodes for dual-ion batteries

Supervisor: Prof Yuan Chen

Eligibility: Year 3 or year 4 students with chemical engineering, chemistry or material background are preferred.

Project Description:
Batteries are essential in our daily life. They are expected to become more critical in helping us achieve carbon neutrality in the middle of this century for powering electric vehicles and storing electricity generated from renewable sources. However, current dominant lithium-ion batteries are not sustainable. We need more environmentally sustainable and cheaper alternatives. Our team has recently demonstrated that graphitic carbon materials produced from catalytic methane decomposition can serve as efficient electrodes for an emerging type of new battery, dual-ion batteries, which are safer and cheaper. However, the energy storage capacity and stability are still inferior to lithium-ion batteries. In this project, students in the research internship will work with our team to modify graphitic carbon materials to improve their energy storage performance in dual-ion batteries. Students will learn how to prepare battery materials, fabricate electrodes, assemble coin cell batteries and carry out electrochemical tests of assembled batteries.

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

CBE2022-23/10 Novel defect-engineered catalysts for simultaneous solar-driven chlorine and hydrogen evolution from seawater

Supervisors: Prof. Jun Huang, Dr. Rui Tang

Eligibility: To be eligible, the candidate should

- have basic knowledge background in either of the following: chemistry, chemical engineering, material engineering, and biomedical engineering.
- passion for pursuing research in renewable energy.

Project Description:

Over the past decade, various water splitting approaches have been developed to produce clean Hydrogen fuels. However, current water splitting techniques heavily relays on the limited freshwater. However, freshwater only takes up 2.53 % of the total water resources, with the rest being all brine water, which contains a high concentration of NaCl (0.6 M). When using brine water to produce Hydrogen, many oxidative chlorine species would be generated simultaneously, which is also an important chemical feedstock. In this regard, developing a high-efficient catalyst that could stably work in seawater is of great importance.

This project aims to design a high-performance defect-engineered catalyst for solar-driven seawater splitting to produce Hydrogen and chlorine simultaneously. Through the defect-engineering method, the activity and product selectivity of the catalyst will be investigated.

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

CBE2022-23/11Anti-biofouling strategies for osmotic membrane processes

Supervisors: Dr Gustavo Fimbres Weihs and Dr Anne Mai-Prochnow

Eligibility:

Essential:

- Background in chemical or process engineering, chemistry, microbiology or equivalent
- Strong data analysis skills
- The ability to work well with others in a team
- Excellent oral and written communication skills

Desirable:

- Experience in microbiological culturing techniques
- Experience with experimental laboratory work
- Experience with LabView programming
- Ability to gather and interpret information from a range of sources

Project Description:

Clean water is vital for good health and sanitation. It is fundamental to agriculture, and it is a key resource in many industrial processes. Membrane processes, particularly osmosis-based processes (such as reverse osmosis (RO) and forward osmosis (FO)) are critical technology to achieve the goal of a stable, sustainable supply of clean water. However, membranes are easily fouled by inorganic, organic substances, and biofouling. Biofouling is very difficult to mitigate, as microorganisms cannot be eliminated completely by pre-treatment. This project investigates several anti-biofouling strategies, such as incorporating iron nanoparticles and cold plasma treatment. It involves the characterisation of modified clean and fouled membranes as well as their flux performance. The students will assist in the setup of an accelerated biofouling experimental apparatus, collection and analysis of membrane and water samples, and in determining the presence and quantity of microorganisms in the samples via microbiological cultures, with the aim to determine the potential for industrial use of the anti-biofouling strategies developed.

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

CBE2022-23/12 Designing ultrafiltration, bioreactive membranes for microplastic removal

Supervisors: Dr David Wang and Dr Anne Mai-Prochnow

Eligibility: Essential

- Background in chemical or process engineering, chemistry, microbiology or equivalent
- Excellent oral and written communication skills
- Experience with experimental laboratory work

Project Description:
Microplastic (MP) pollution is a significant global concern due to the persistent nature of MPs and adverse effects to ecosystems. This project will design and develop bioreactive film on ultrafiltration membrane using *Pseudomonas fluorescence* as the bioreactive film to degrade and metabolize synthetic plastics and polyvinyl fluoride as the hydrophobic UF membrane materials to control phase porosity. Expected outcomes will include high water permeability, excellent MP rejection rate and removal through biodegradation as well as membrane biofilm performance stability.

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

CBE2022-23/13 Investigating Cobalt-Cerium Silica catalyst for the degradation of antibiotics (TCH)

Supervisors: Dr David Wang and Hashim Jalil Khan

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:
Presence of organic contaminants in wastewater poses a serious threat to the human health. Different techniques have been applied in the past to treat wastewater. However, these techniques have a low efficiency for the removal of contaminants. Recently, advanced oxidation process (AOP) has gained a lot of attention as the process has shown high efficiency. Membrane technologies have also shown excellent results for the removal of large molecules from wastewater. Amongst the different membrane types, catalytic membranes have great potential for the treatment of wastewater. In this project, bimetallic catalysts will be synthesized that will use the advanced oxidation process phenomenon for the degradation of organic contaminants specifically focusing on antibiotics. This project will also involve combining the advanced oxidation process with the catalytic membranes to enhance the wastewater treatment for the removal of different antibiotics that are present in the wastewater.

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

CBE2022-23/14 Life-cycle analysis of concrete mixtures using machine learning and artificial intelligence tools

Supervisors: Prof Ali Abbas and A/Prof Daniel Dias-da-Costa

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 are currently many possibilities for achieving more sustainable cementitious materials. These can include environmentally friendly materials and incorporate the use of waste to impact our society positively. The challenging aspects, however, relate to the quantification of the life cycle of these new materials, which can include numerous interactions through the lifetime of the material and structure. This project will explore the use of computational tools for the life-cycle analysis of a given concrete mixture. This will include a literature review on

recent advancements and the exploration of ideas through modelling. The skills developed by the candidate could become an essential asset for future postgraduate studies or even a PhD.

Requirement to be on campus: No

CIVIL ENGINEERING PROJECTS

CIVIL2022-23/1 Physics-informed deep learning approaches for fluid dynamics modelling

Supervisors: Prof Chengwang Lei and A/Prof Zhiyong Wang

Eligibility:

- UG Students in their 3rd year or higher, or PG students
- Strong interest in fluid dynamics, programming Skills (Python) and Math Skills
- Students with knowledge of computational fluid dynamics are preferred.

Project Description:
Understanding the complex dynamics of fluid motion is important for applications in a wide range of sectors, such as climate, agriculture, environment, health and medicine, and computer animation. Recently, deep learning has shown a great promising as an effective and efficient alternative for conventional resource-intensive computational approaches.

This project aims to investigate physics-informed deep learning approaches to simulate and model fluid dynamics. Students will gain comprehensive inter-disciplinary knowledge in deep learning and fluid dynamics.

Requirement to be on campus: No

CIVIL2022-23/2 Communicating Climate Change Impact Scenarios using Serious Games

Supervisor: Dr Aaron Opdyke

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:
Climate change poses a significant threat to global development – impacts that are expected to disproportionately impact low- and middle-income countries. For local decision-makers in these contexts, understanding the tangible expected impacts of climate change within their communities can be challenging. Serious games are simulations or activities that create a purposeful learning environment. This research will develop and test a serious game activity to expose local governments in the Philippines to climate change models in a more engaging format. This tool will introduce decision trade-offs when considering current and projected flood hazards under climate change.

Requirement to be on campus: No

CIVIL2022-23/3 Causal Loop Diagramming for Climate Change Systems

Supervisor: Emily Nabong and Dr Aaron Opdyke

Eligibility: Preference will be given to applicants who have completed CIVL2010 (Environmental Engineering), an equivalent unit of study at another Australian university, or have previous experience with system dynamics.

Project Description:
Climate change is a wicked global problem that that will require complex problem solving to combat. There is a need to understand how current and proposed policy interventions will

affect society and future generations. This research will model current climate change interventions (e.g. the 2022 Australian Climate Change bill) to map interdependencies affecting infrastructure using a system dynamics approach (stock & flow and causal loop diagramming). The models generated from this project will further our understanding of best practices for long-term climate resiliency.

Requirement to be on campus: No

CIVIL2022-23/4 Mapping crop water stress and yield loss

Supervisors: A/Prof Federico Maggi, Fiona Tang University of New England, Armidale
Francesco Tubiello, Food and Agriculture Organization of the United Nations, Rome

Eligibility: Basic knowledge of or willingness to learn hydrology and soil sciences; Good knowledge of MATLAB. Current knowledge of or willingness to learn high-performance computing (HPC) methods, Intermediate level of programming skills.

Project Description:
We have recently released a comprehensive dataset of monthly dynamics of soil moisture in the root zone and water table depth globally georeferenced at 0.25-degree resolution from 1970 to 2014 (SOIL-WATERGRIDSv1, Guglielmo et al., 2021, https://zenodo.org/record/4997453). These data are essential for investigating the state of soil water and trends related to climate change.

For this project, we will couple SOIL-WATERGRIDSv1 to a new dataset of individual crop mapping (CROPGRIDSv1) released by the Food and Agriculture Organization of the United Nations to quantify the occurrence of water stress in 10 major crops globally over about 40-year time scale and estimate patterns in yield changes related to shifts in climate. We will therefore identify geographic regions where agriculture production may concentrate losses or, in contrast, where it may increase due to improved state of soil water.

The project will involve large data analysis and elaboration, data visualization, use of diverse coding capabilities in the Matlab environment.

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

CIVIL2022-23/5 LiDAR as a moving sensor

Supervisor: Dr Mohsen Ramezani

Eligibility: Programming skills

Project Description:
A major research agenda is to further investigate disruptive technologies of autonomous vehicles (AVs). Most particularly, instead of looking at building AVs, we could leverage on their capabilities to build up on the sensor data for traffic state estimation and other smart city applications. LiDARs are among the most widely deployed sensors on AVs for perception purposes. The sensor itself can collect 3D cloud maps of objects 360 degrees. However, it is required to convert the 3D map into objects (identifications and classification) and consequently tracking them (trajectory building). This project would capitalize on data analytics and machine learning methods.

The sensor could be fused with other sensors such as camera, GPS, GNSS, etc. for simultaneous localization and mapping (SLAM) applications. The project requires working with sensor, installation, and programming skills. Highly motivated students are encouraged to contact mohsen.ramezani@sydney.edu.au prior to submission.

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

CIVIL2022-23/6 Advanced Structural Analysis of Innovative Steel–Glass Structures with respect to the Architectural Design

Supervisor: Dr. Faham Tahmasebinia

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:
Steel–glass composite frames are advantageous compared with traditional steel frames. The combined use of steel and glass diversifies the structural design. Compared with traditional steel structures with straight members, the irregular shapes of glass–steel structures allow designers to express their design concepts in more artistic ways, which improves the aesthetic value of the designed structure.

In this research, the loading performance of the glass spindle torus in different cases will be investigated using two numerical modelling packages, Strand7 and ABAQUS. The research methodology will be exhibited high applicability on other case studies. With these two powerful finite element modelling tools, the loading performance of other structures can also be captured by developing new structural models.

The most effective thickness and size of the stiffener to prevent local buckling will be explored. Finally, structural performance of the designed structure under serviceability limit state with vertical supports configured in the central opening will be comprehensively investigated.

Requirement to be on campus: No

CIVIL2022-23/7 A new concept to design combined support under dynamic loading using numerical modelling

Supervisor: Dr. Faham Tahmasebinia

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:
A rock burst is an uncontrolled failure that releases a massive amount of kinetic energy, inducing excessive displacement of rock mass. Combined support to controlling rock dynamic failures is an essential part of the rock burst management. In the design of rock support, it is essential to consider not only the capacity of the individual elements but also their compatibility with each other and their interactions. This research is aimed to develop a novel full-scale numerical procedure to evaluate the behaviour of individual support elements and their interactions under dynamic loads using Finite Element Commercial Package ABAQUS/Explicit. A mutual interaction relationship between two indicators, namely Cable/Rock Bolt Dissipated Energy and the Steel Mesh Dissipated Energy is also developed, and an interaction diagram will be provided. The proposed design concept can be used for the selection of an appropriate support system for coal burst management.

Requirement to be on campus: No

CIVIL2022-23/8 Implementation of BIM energy analysis and Monte Carlo simulation for estimating building energy performance based on regression approach: A case study

Supervisor: Dr. Faham Tahmasebinia

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 energy performance prediction of buildings plays a significant role in the design phases. Theoretical analysis and statistical analysis are typically carried out to predict energy consumption. However, due to the complexity of the building characteristics, precise energy performance can hardly be predicted in the early design stage. This study considers both building information modelling (BIM) and statistical approaches, including several regression models for the prediction purpose. This research also highlights a number of findings of energy modelling related to building energy performance simulation software, particularly Autodesk Green Building Studio. In this research, the geometric models were created using Autodesk Revit. Based on the energy simulation conducted by Autodesk Green Building Studio (GBS), the energy properties of number of prototype and case study models will be determined. The GBS simulation will be carried out using DOE 2.2 engine. Some key parameters will be demonstrated used in BIM, including building type, location, building area, analysis year, floor-to-ceiling height, floor construction, wall construction, and ceiling construction. The Monte Carlo simulation method will be performed to predict precise energy consumption.

Requirement to be on campus: No

CIVIL2022-23/9 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.
There is a possible pathway toward a PhD with full scholarship.

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

CIVIL2022-23/10 Engineered living materials for a sustainable future

Supervisors: Dr Ali Hadigheh, Dr Anusha Withana, Dr Anastasia Globa, Dr Phillip Gough

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 majority 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

CIVIL2022-23/11 Augmented reality for supporting design and visualisation of buildings and bridges

Supervisor: A/Prof Daniel Dias-da-Costa

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:
Exploration of new tools for the support of advanced teaching and design experience. These could include BIM in combination with augmented reality. A strong curiosity and interest in learning coding/computational skills would be recommended. This project is at the forefront of technology and could provide a competitive edge for a recent graduate.

Requirement to be on campus: No

CIVIL2022-23/12 Development of an extended finite element method for simulation failure analysis of materials and structures

Supervisor: A/Prof Daniel Dias-da-Costa

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:
This project is at the forefront of the computational mechanics of fracture propagation and failure analysis. The accurate simulation of fracture is of interest to many fields of research and industry design. This includes civil engineering applications and medical and mechanical, as long as there are brittle materials where fracture can develop and/or interfaces between materials along which fractures can develop. The interested candidate will develop new modelling skills and develop a small code to simulate the interfacial crack stresses in a benchmark problem. If successful, this project could serve as a pilot for developing a publication in an international journal with the team members. The skills developed by the candidate could become an essential asset for future postgraduate studies or even a PhD.

Requirement to be on campus: No

CIVIL2022-23/13 Advanced design of tensegrity and ribbon cable supported structures

Supervisor: A/Prof Daniel Dias-da-Costa

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:
This project will explore new designs for possible application in bridges. This could include the development of a computational model and design of a bridge involving tensegrity modules and/or a stress ribbon cable-supported bridge. The latter type of bridge explores the behaviour of the materials to achieve slender and impressive designs. For example, one can refer to the Three 'Ribbon' Bike & Pedestrian Bridges For NYC. A strong curiosity and interest in learning would be recommended. This project is at the forefront of technology and could provide a competitive edge for someone who would like to experience research with the aim of postgraduate studies and research.

Requirement to be on campus: No

CIVIL2022-23/14 Design and modelling of self-healing concrete

Supervisors: A/Prof Daniel Dias-da-Costa and Prof Luming Shen

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:
Developing self-healing concrete based on bacteria opens numerous possibilities for achieving long-lasting structures. Structures can potentially heal and seal damages from service conditions, therefore enabling much more efficient and economical use of materials. Most research, however, has been mainly experimental, and proper design models are still lacking. This project will include a literature review on recent advancements and the exploration of ideas through computational mechanics for modelling. The skills developed by the candidate could become an essential asset for future postgraduate studies or even a PhD.

Requirement to be on campus: No

CIVIL2022-23/15 Design of concrete mixtures with machine learning and artificial intelligence tools

Supervisors: A/Prof Daniel Dias-da-Costa and Prof Luming Shen

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 design of concrete mixtures is often done by empirical methods. With the numerous possibilities now available to achieve greener and more sustainable concrete and cementitious materials, attaining the desired properties can become challenging. Not only the materials used will vary depending on their source (e.g., waste materials), but also there can be unforeseen interactions among them that impact durability and performance. This project will explore the use of computational tools for designing and quantifying the optimal performance of a concrete mixture. This project will include a literature review on recent advancements and the exploration of ideas through modelling. The skills developed by the candidate could become an essential asset for future postgraduate studies or even a PhD.

Requirement to be on campus: No

CIVIL2022-23/16 3D printing of wood plastic composites

Supervisors: Prof Gwenaelle Proust and A/Prof Sandra Loschke

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:
This is an integrated project to scale up additive manufacturing (3D printing) of wood-plastic composites for use in civil engineering/architectural applications. Different sub-projects can be carried out and therefore several students can be working on this project.

- Optimisation of composition of the wood-plastic composites for additive manufacturing
- Customised printing instructions appropriate for the stress-strain profile of the target object
- Gradient-based design of components to take advantage of bespoke printing while optimizing for performance and aesthetic considerations.

For this project the student will join the team of the Sydney Manufacturing Hub and be able to become familiar with advanced manufacturing technology.

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

CIVIL2022-23/17 Characterisation of the mechanical performance of high-resolution printed polymers

Supervisor: Prof Gwenaelle Proust

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 Sydney Manufacturing hub just acquired two new high resolution polymer resin 3D printers. The student working on this project will compare the mechanical performance of coupons produced by these two machines by performing:

- Design of coupons on solid work
- Printing of coupons using the two 3D printers
- Mechanical testing (tension, compression, 3-point bending)
- Fracture characterisation (Charpy test)
- Surface finish characterisation

For this project the student will join the team of the Sydney Manufacturing Hub and be able to become familiar with advanced manufacturing technology.

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

CIVIL2022-23/18 Service life prediction of infrastructures with machine learning

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:
Structures are subject to gradual and progressive deterioration over time, and are likewise prone to damage due to accident, misuse or extreme natural events. The on-going requirement for more structurally sound infrastructures has driven the introduction and development of advanced machine learning methods for structural health monitoring. This project aims to use machine learning methods for automated condition assessment and evaluation of infrastructure.

Requirement to be on campus: No

ELECTRICAL AND INFORMATION ENGINEERING PROJECTS

EIE2022-23/1 Real-time Machine Learning on FPGAs

Supervisor: Prof Philip Leong

Eligibility: Experience in machine learning and FPGA design.

Project Description:
This project involves supplementing the HLS4ML (https://fastmachinelearning.org/hls4ml/) library with a new type of arithmetic, block minifloats (http://phwl.org/assets/papers/bm_iclr21.pdf) which have been developed in our lab. The resulting library will be suitable for doing real-time FPGA-based inference, with block minifloats offering improvements in performance and accuracy over conventional techniques.

Requirement to be on campus: No

EIE2022-23/2 Self-contained desalination systems for agriculture

Supervisor: Glenn Platt

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:
Salinity of rivers, underground aquifers and other water resources is a huge challenge for Australia's agriculture industry.

Whilst well-known technologies exist for the desalination of water, they are not designed for the unique demands of the agriculture sector. An agricultural desalination solution needs to be self-contained (likely using its own energy supply), capable of delivering large volumes of water, and low maintenance.

This project is focused on designing and modelling a water desalination solution suitable for agricultural purposes. It will involve two core components- selection of a desalination technology and modelling its performance, and theoretical design of a self-contained energy system for supporting desalination operation.

The project may involve a mix of electrical and chemical engineering skills and could be supported by both Schools.

This topic is of great interest to Australia's agricultural industry, and industry partners are also available to provide data and practical support.

Requirement to be on campus: No

EIE2022-23/3 New LIDAR techniques for wind data

Supervisor: Glenn Platt

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:
Collection of reliable high-quality data on the wind resource is key to the viability of large wind generation projects. Modern wind data systems are based on LIDAR technology, which mounted at surface level, can measure wind speeds hundreds of metres into the air.

LIDAR technology works well, but current LIDAR sensors for wind speed measurement are very expensive, large and use a lot of energy.

This project will investigate new approaches to LIDAR measurement of wind data, that may be smaller, cheaper, or use less energy. Particular inspiration may be drawn from the hardware now available for autonomous vehicles, where small low-power LIDAR modules are now becoming almost commonplace.

The project is likely to involve both hardware investigations as well as signal analysis research, to investigate the feasibility of (for example) using autonomous vehicle sensors for wind measurement purposes.

The availability of better wind data sensors is a major interest for Australian industry, and industry partners are also available to provide information and practical support.

Requirement to be on Campus: No

EIE2022-23/4 Self-powered underwater acoustic sensor

Supervisor: Glenn Platt

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:
Underwater sensors are of growing importance for environmental, industry and defence sensing applications. The underwater environment is very challenging for sensor deployment, with challenges ranging from operation in an acoustically noisy environment, to getting energy to sensors, to managing biofouling.

This project is based around performing a feasibility study for the development of a self-contained underwater acoustic sensor. Such a sensor should be self-powering and will perform a level of acoustic analysis on board. The project will need to include consideration of:

- Acoustic sensing technology
- Underwater self-power technology options
- Communications method suitable for underwater operation

This project is likely to consider the latest in embedded computing, energy harvesting and low-power communications technologies.

The self-powering (energy harvesting) component of the project could include collaboration with the School of Aerospace, Mechanical and Mechatronic Engineering.

This topic is of great interest to Australian industry, and industry partners are also available to provide data and practical support.

Requirement to be on campus: No

EIE2022-23/5 Power buffering for electric vehicle charging

Supervisor: Glenn Platt

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:
Electric vehicle (EV) chargers can now operate at charge levels over 300kW, which, whilst offering great benefits to the EV owner, can provide very significant strain on the electricity grid. Locations with multiple high-power EV chargers are likely to be challenged in providing sufficient power capacity to charge those vehicles all at once.

This project will investigate the design of an EV charge-management system, that can act as a buffer for the high-power demands of a multiple-vehicle EV charging system. Such a solution is likely to include a mix of energy storage and charge management algorithms and will need to consider the latest industry EV-charging standards.

The project will include consideration of available hardware, the economics of such a solution, and modelling of control algorithms used in a real-world system. The successful student may also have the opportunity to consider non-technical aspects, including business models for a company that would own or operate such hardware.

Requirement to be on campus: No

EIE2022-23/6 Data-driven optimal power flow of an islanded microgrid with high renewable penetration

Supervisor: Dr Cuo Zhang

Eligibility: Solid knowledge of power system analysis and control, and established skills of Matlab or Python programming. Self-motivation in investigating optimisation theory and machine learning algorithms.

Project Description:
Islanded microgrids, where electric power is generated for local loads, are highly promising for remote islands and rural areas. Microturbines with droop control functions are generally used to keep secure operation of an islanded microgrid. Existing optimal power flow (OPF) models can minimize the microturbine operating cost and network power loss, while keeping system frequency and bus voltages within secure operating ranges. However, it is time-consuming to efficiently solve an islanded microgrid OPF problem, especially under uncertainties of high renewable power generation.

Machine learning methods have high capability of online fast computation, and they have been increasingly applied to the power engineering area. This project will apply and modify a deep reinforcement learning method to solve the mentioned problem, thus achieving data driven OPF of an islanded microgrid while addressing the renewable uncertainties. Practical network operating conditions and use of batteries can be further considered in the data driven OPF model.

Requirement to be on campus: No

EIE2022-23/7 Enhancement method for renewable hosting capacity of an active distribution network

Supervisor: Dr Cuo Zhang

Eligibility: Solid knowledge of power system analysis and control, and established skills of mathematic modelling and Matlab programming. Self-motivation in investigating optimization theory.

Project Description:
Hosting capacity of a network is defined as the maximum power generation allowed to be connected without any network operating constraint violation. As the renewable power generation has been increasingly penetrating distribution networks, it is imperative to assess and enhance the hosting capacity for renewable. With advanced operation techniques of active distribution network, such as community battery management and volt/var control, this project aims to develop a new hosting capacity enhancement method.

Mathematical models of distribution network and advanced operation techniques will be developed first. Then, a new optimisation model of active distribution network operation to maximize the renewable hosting capacity with full consideration of uncertain operating conditions will be proposed in this project. Finally, comprehensive numerical simulations will be done to validate the model and enhancement efficiency.

Requirement to be on campus: No

EIE2022-23/8 Exploiting Wi-Fi channel state information for human gesture reconstruction and biometric signal monitoring

Supervisor: Dr Yonghui Li

Eligibility: You will need strong wireless background. It is preferable you have completed some of these courses: ELEC5507, ELEC5508, ELEC5510, ELEC5514, etc.

Project Description:
Wi-Fi is a critical technology that enables smart home services connectivity. Apart from its primary use for communication, the Wi-Fi signal has now been widely leveraged for various sensing tasks, such as gesture recognition and fall detection, due to its sensitivity to environmental dynamics. Building a smart home based on Wi-Fi sensing is cost-effective, non-invasive, and convenient. In this project, we will build a Wi-Fi sensing system based on Wi-Fi 6 (802.11ax), mainly in health monitoring, gesture recognition, contextual information acquisition, and authentication.

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

EIE2022-23/9 Machine learning in wireless networked control for Industrial Internet of Things

Supervisors: Dr Wanchun Liu and Prof. Yonghui Li

Eligibility: Background in mathematics, telecommunications, or control; Python programming. Experience in machine learning frameworks, TensorFlow, PyTorch or Matlab.

Project Description:
Different from the 1st to the 5th generation (5G) of cellular communications, which are communications performance-focused, a primary driver behind 6G is the imminent deployment of Connected Robotics and Autonomous Systems (CRAS). To make CRAS come true, advanced wireless networked control technology needs to be developed. In particular, communications and control codesign will be a crucial research topic. This project will develop a novel deep reinforcement learning-based algorithm for communications and control codesign to achieve high-performance networked control.

Requirement to be on campus: No

EIE2022-23/10 Wireless human-machine collaboration

Supervisors: Dr Wanchun Liu and Prof. Yonghui Li

Eligibility: Background in telecommunications, control, robotics, or software engineering. Experience in Python programming; Experience in machine learning frameworks, TensorFlow, PyTorch or Matlab.

Project Description:
Wireless human-machine collaboration (HMC) will play a central role in a wide range of applications in the incoming industrial revolution that need humans to connect and collaborate with many machines remotely in real-time for completing a common goal. This requires seamless integrating of wireless human-control loop and automated-control loop. The project aims to establish the mathematical model of wireless HMC, optimise the system for achieving the best performance for control task completion, and develop a wireless HMC prototype

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

EIE2022-23/11 Neural-Network-Assisted 5G Decoder Design

Supervisors: Prof. Yonghui Li, Dr. Chentao Yue

Eligibility: Basic knowledge of Python and Matlab

Project Description:
In networks beyond 5G, universal decoders are preferred due to their capacity to handle flexible error control coding schemes. However, the design of low-complexity practical universal decoders is still an open challenge.

The objective of this project is to design a low-complexity universal decoder using deep neural network (DNN) and ordered-statistics decoding (OSD) techniques. OSD is a universal decoding algorithm that achieves the maximum-likelihood decoding performance for any linear block codes. Nevertheless, in the literature, the complexity of OSD has not been fully optimized, especially by exploiting code structures.

This project will utilize DNN techniques to enhance the error-correction and complexity performance of OSD. Supervised learning will be applied to train the OSD decoder parameters for various code structures and channel conditions. The success of this project will demonstrate the potential of OSD as a 5G universal decoder and yield publishable results.

Requirement to be on campus: No

EIE2022-23/12 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: up to 2 students are required for this project. The students participating in this project should have good knowledge on smart phone 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*

EIE2022-23/13 Data driven National Electricity Market studies

Supervisor: A/Prof Jin Ma
Eligibility: Must have strong skills in managing the database and python programming. Knowledge in machine learning/artificial intelligence is a plus.

Project Description:
Australian National Electricity Market has gone through more than two decades since its inception in 1998. Large amounts of market operation data have been accumulated and there

is a need to evaluate the market performance based on real operation data. This project aims to use machine learning approaches to analyze the NEM price data in both the energy wholesale market and the ancillary service market; as well as the generation and demand data to find the underlying patterns of the market operation. Classification and regression methods will be applied to statistically model the market dynamic properties.

Requirement to be on campus: No

EIE2022-23/14 Distribution network state estimation

Supervisor: A/Prof Jin Ma

Eligibility: Background in power engineering and studied courses on distribution power system before. Knowledge in power system simulation software and in state estimation of power system are a plus.

Project Description:
Different from the transmission network, the distribution network has more irregular network configuration and diversity in terms of load connections, which causes low visibility of the distribution network. Many Distribution network service providers in Australia have no circuit model for their distribution network and limited measurement points in the distribution network. This project aims to develop preliminary algorithms on using the measurements to estimate the voltages of distribution network nodes and the power flow in the distribution lines. The impacts of measurement point deployments on the distribution network state estimation will also be investigated.

Requirement to be on campus: No

EIE2022-23/15 Efficient Deep Learning Inference with Edge Computing

Supervisor: Dr Dong Yuan

Eligibility: WAM>75 Skills: Familiar with PyTorch; programming with Python or 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 Mbps. In order 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

EIE2022-23/16 Towards an effective battery management in IoT

Supervisors: Dr. Huaming Chen and Dr. Reza Behi (Metasense)

Eligibility: WAM>80

Project Description:
While traditional energy consumption has been revolutionised with new energy resources, it is expected to reduce the impact for environments. Thus, more and more rechargeable batteries, i.e., the lithium batteries, have become a key role being widely used in many fields.

Particularly, with its characteristics of small size, long life, and high efficiency, we have witnessed its application in IoT devices in many safety-critical domains, such as autonomous driving. In this project, together with Metasense as the industry partner, we will harness the state-of-the-art artificial intelligence techniques to tackle the battery life prediction challenge. The aging of batteries can lead to various degrees of machine damage and accidents. Thus, providing effective and intelligent analysis of the life and health status of batteries envisions an effective battery management and allows the system to be maintained safely. In the meantime, it largely boosts the battery performance and enhance the energy consumption efficiency.

Requirement to be on campus: No

EIE2022-23/17 Towards AI Native Air-Interface for 6G Wireless Networks

Supervisor: Dr Wibowo Hardjawana

Eligibility: Strong WAM and strong experience in Python and DNN tools and wireless communication networks

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 PHY which is partially designed by AI to enable optimized communication schemes for any hardware, radio environment, and application. The project will leverage on our current telecommunication research at Centre of Excellence in IoT and Telecommunications.

Requirement to be on campus: No

EIE2022-23/18 Radio Intelligence Controller for O-RAN Alliance based 5G NR Networks

Supervisor: Dr Wibowo Hardjawana

Eligibility: Strong WAM and experience in Python, Keras, Tensorflow and Matlab and knowledge of DNN.

Project Description:
The O-RAN Alliance is a worldwide effort to reach new levels of openness in next-generation virtualized radio access networks (vRANs) and 6G networks. Radio Intelligence Controller (RIC) framework has been proposed by Open RAN Alliance as the new standard to implement AI or Machine Learning with various control loops, characterise by latency requirements (near-real-time, real-time and non-real-time). This project will develop AI controlled RIC for a chosen control loop by using a combination of Matlab, Python, Keras and/or Tensorflow and their corresponding interfaces.

Requirement to be on campus: No

EIE2022-23/19 On-orbit demonstration of integrated photonic circuits

Supervisor: Prof Xiaoke Yi

Eligibility: Year 3/4/5 or Master students studying electrical engineering, computer engineering, space engineering, mechanical engineering, software engineering, mechatronic engineering, or computer science.

Project Description:

This project will take new photonic integration technology to the harshest environment for materials and circuitry: Space. We will focus on designing, testing, and packaging new photonic integrated circuits for space related applications. The intern will work alongside experts in a multidisciplinary team and industry, while making key contributions to an on-orbit demonstration.

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

EIE2022-23/20 Circuits design and signal processing for advanced sensors

Supervisor: Prof Xiaoke Yi, Dr Liwei Li and A/Prof Luping Zhou

Eligibility: Year 3/4/5 or Master students studying electrical engineering, computer engineering, space engineering, mechanical engineering, mechatronic 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 that arise with cutting-edge solutions to address the important challenges across a diverse range of applications in various fields, particularly in lab-on-chips, Internet of Things, aerospace, 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*

EIE2022-23/21 Testing of high-speed integrated photonics devices

Supervisors: Prof Xiaoke Yi, Dr Ping Ma, Dr Liwei Li

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

Project Description:
The convergence of photonics and CMOS electronics empowers photonic integrated circuits to meet the ever-increasing demand for data throughput in information systems.
The project is focused on chip-scale testing of photonic integrated circuits and related data processing.

The aim is to achieve high performance and cost-effective chips permitted by the integration via CMOS compatible fabrication.

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

EIE2022-23/22 Project ARIA

Supervisor: A/Prof Craig Jin

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:
Project ARIA (www.projectaria.com) aims to assist the blind with auditory sensory augmentation (AR/VR) with smart glasses. In this project, students will help design/conduct auditory sensory augmentation experiments exploring the use of sound to convey the shape of objects and to assist with spatial navigation.

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

EIE2022-23/23 Avatar and 3D Audio iPhone App

Supervisor: A/Prof Craig Jin

Eligibility: Some understanding of iPhone software development and audio signal processing will be helpful.

Project Description:
This project explores developing and refining an iPhone app to capture an avatar and 3D audio filters. We are designing and developing a system that takes video images (including depth data via the 'TrueDepth' system) of the ear and provides an avatar and customised 3D audio filters for the listener. The listener can then trial these 3D audio filters using the iPhone as a virtual window to another world simulated using the Unity game engine.

Requirement to be on campus: No

EIE2022-23/24 Machine Learning based Design of Non-Linear Error-Control Codes

Supervisors: Dr. Vera Miloslavskaya, Prof. Branka Vucetic

Eligibility: Machine learning skills, software development skills (Python or C++), good English skills (reading, listening, speaking, and writing).

Project Description:
Error-control coding is one of the key enabling technologies for reliable data transmission. The fifth generation (5G) of mobile networks employs such linear error-control codes as the low-density parity-check (LDPC) and polar codes, while 3G and 4G rely on the turbo codes. Advanced error-coding techniques are ought to be developed to meet the stringent requirements of 6G. In this project, a student will have the opportunity to generate non-linear polar codes using machine learning (ML) techniques. Specifically, neural networks should be used to produce efficient frozen bit expressions for polar codes. Compared to polar codes with the conventional linear frozen bit expressions, the neural network-based solution is more flexible and expected to provide codes with better error-correction capability.

Requirement to be on campus: No

MECHANICAL ENGINEERING PROJECTS

MECH2022-23/1 The fluid mechanics of marine cloud brightening: An approach to reduce coral bleaching on the great barrier reef

Supervisor: Dr Agisilaos Kourmatzis

Eligibility: Have completed at least 2.5 years of full-time study & HWAM>80

Project Description:
Marine Cloud Brightening has been proposed as a method to prevent coral bleaching (https://www.savingthegreatbarrierreef.org/cooling-the-reef). In order to achieve this, it is necessary to generate very small droplets at very high flow-rates, and it is unclear what

technology would be best suited for this. You will work with us in researching available nozzle technologies as well as assisting in developing optically accessible nozzle systems to help us better understand the most efficient way to generate the aerosols we need. This is a very ambitious multi-phase fluid mechanics project.
Note: if you do not meet the eligibility requirements below but have at least an HWAM>75 and are still interested in doing research then please email agisilaos.kourmatzis@sydney.edu.au with your CV and academic transcript.

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

MECH2022-23/2 Multiphase turbulent fluid mechanics

Supervisor: Dr Agisilaos Kourmatzis

Eligibility: Have completed at least 2.5 years of full-time study & have a weighted average mark (WAM)>80. Students with WAM<80 (but greater than 75) will still be considered if they have exceptional relevant work or research experience.

Project Description:
One of the most complex fields in turbulent flows is that of multiphase, particularly 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 and drug delivery 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. One will be focused on an energy application and the other will be focused on a biomedical application. Please specify your preference in your cover page.
Note: if you do not meet the eligibility requirements below but have at least an HWAM>75 and are still interested in doing research then please email agisilaos.kourmatzis@sydney.edu.au with your CV and academic transcript.

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

MECH2022-23/3 Microstructural evolution along the build direction of a 316L stainless steel fabricated by laser powder-bed fusion

Supervisors: Prof. Xiaozhou Liao and Mr. Hao Wang

Eligibility: WAM > 80. If possible, linked to the student's honours project.

Project Description:
Additive manufacturing (AM) offers distinct advantages over conventional manufacturing, including design freedom, near net or net shape production, efficient use of materials, and short lead times. AM of metallic materials using techniques like laser powder-bed fusion consists of cyclic rapid thermal loadings and different layers in the as-built component experience different thermal histories. These result in complex stress and thermal gyrations and therefore lead to microstructural heterogeneity along the build direction that significantly affects local and global mechanical properties of the component produced by AM. Investigation of the microstructural evolution of AM components is therefore critical for us to understand how printing parameters affect mechanical properties of AM components. In this project, we will choose 316L stainless steel as the model material due to its simple single-phase structure and sensitivity to thermal history. Laser powder-bed fusion will be used for AM and electron microscopy will be used for microstructural characterisation.

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

MECH2022-23/4 Mechanical behaviour of high-performance and sustainable steels

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:
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 weigh 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*

MECH2022-23/5 Nanostructure engineering of multiple-principal element alloys via electrodeposition

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 electrodeposition 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 electrodeposition 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 up 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*

MECH2022-23/6 Play with small-scale metals: new insights into micro-plasticity

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:
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*

MECH2022-23/7 Characterization of switching dynamics in a potassium tantalate niobate (KTN) crystal

Supervisors: A/Prof. Niels Quack; Shashank Gupta

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:
Integrated photonics in thin films is an active area of research that advances rapidly, promising many exciting opportunities due to its ultra-fast speed and low power consumption. This project aims at investigating and understanding the switching dynamics in a potassium tantalate niobate (KTN) crystal. The student will first study the material properties of KTN crystals. The student will then design, assemble, and characterize an electro-optical test setup, and perform the electro-optical characterization of a KTN crystal.

Requirement to be on campus: Yes*. Project requires on-site requirement, as this involves experimental work. **dependent on government's health advice*

MECH2022-23/8 Legoing atoms on supercomputers: point defects and impurities in advanced alloys

Supervisors: Prof Simon Ringer and Dr Carl Cui

Eligibility: Student must have a WAM of 75 or higher to be considered and have completed at least 96 credit points towards their undergraduate studies.

Project Description:
Computational simulation is often described as "performing theoretical experiments on (super)computers". It is one of the few enabling methodologies that can reduce development cycle times and costs in the material sciences. Coupled with significant algorithm development

and computational power upgradation, it has made major advances in accelerating the design, processing and performance optimisation of technologically important materials and devices.

It has long been known that point defects and impurities play a crucial role in affecting the mechanical properties in alloys – some are vital, some are fatal. However, much of the understanding of the defects and impurities in alloys is based on semi-empirical rules and is hard to be directly applicable for new alloy design. By performing accurate first principles (without experimental or empirical parameters) atomistic simulation based on density functional theory, this project aims to explore 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 the access to the powerful national computational facilitates. The outcome will be useful for knowledge-based rational design of advanced alloys.

Requirement to be on campus: No

MECH2022-23/9 Mining rare-earth elements at the atomic level

Supervisors: Prof Simon Ringer and Dr Carl Cui

Eligibility: Student must have a WAM of 75 or higher to be considered and have completed at least 96 credit points towards their undergraduate studies.

Project Description:
Computational simulation is playing an increasingly important role in accelerating the design, processing and performance optimisation of materials and devices. Rare-earth (RE) elements and their alloys display peculiar properties that are fascinating for the development of materials currently widely used in high-tech industries and manufactured products. In steel alloys, RE elements are used to remove impurities (such as oxygen and sulphur) and dissolve in iron to form an alloy solution. However, the underlying microscopic mechanism remains poorly understood. Based on a predictive first principle (no experimental or empirical parameter) density functional theory, this computational project aims to understand the fundamental aspects of (1) the behaviour of RE elements in iron, and (2) the interaction between RE elements and different impurities (including boron, phosphine and sulphur) in iron.

The successful applicant will have the access to the powerful national computational facilitates. This project will be a great way to get fundamental knowledge of materials engineering and the outcome of this project will provide useful information for the development of next-generation steel, which is an emerging area of research.

Requirement to be on campus: No

MECH2022-23/10 Investigating hydrogen embrittlement in high-strength steels under deformation

Supervisors: Prof. Simon Ringer; Dr. Suqin Zhu

Eligibility: Students must have a WAM of 75 or higher to be considered and have completed at least 96 credit points towards their undergraduate studies.

Project Description:
Hydrogen, as a promising renewable energy source, is gaining extensive interest in research and engineering. Hence, understanding the interaction between hydrogen and materials has become essential for hydrogen production, storage, and transport. Hydrogen build-up in some metallic materials can cause sudden and catastrophic failure, called hydrogen

embrittlement (HE). Even though HE has been recognised for over a century, there is still a lack of understanding of the underlying mechanism, which affects the development of the prevention means.

This project will use cutting-edge atom probe microscopy to investigate hydrogen interaction with carbides and crystal defects in high-strength steels under deformation at an atomic level. We will explore some new experimental designs based on the current techniques developed in our lab to achieve our goal.

Come and join us to tackle this century-old but also new and exciting project!

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

MECH2022-23/11 Revealing the 3D microstructure of a WC-Co cemented carbide

Supervisors: Prof. Simon Ringer; Dr Hansheng Chen

Eligibility: Students must have a WAM of 75 or higher to be considered and have completed at least 96 credit points towards their undergraduate studies

Project Description:
Usually, our understanding of physical metallurgy is based exclusively on 2D experimental observations, though we know that the properties of the materials must be derived from the 3D microstructure. The development of the scanning electron microscope makes it possible to automate serial sectioning and visualising the 3D microstructure. This project will use the cutting-edge scanning electron microscope to reveal the 3D microstructure of a WC-Co cemented carbide. The WC-Co cemented carbide has been used widely in a variety of industrial processes, e.g., mining, drilling tools and metal machining. This work will refresh our understanding of the microstructure of the WC-Co cemented carbide and serves as a prerequisite for quantifying the microstructure-properties relationship.

The dataset was collected. This project will focus on the reconstruction and analysis of the dataset using Dream3D etc. The experience of this project would be beneficial for research or working in other fields, e.g., data science.

Requirement to be on campus: No

MECH2022-23/12 Design of a Micro-Electro-Mechanical Systems (MEMS) Accelerometer

Supervisor: A/Prof Niels Quack

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:
Micro-Electro-Mechanical Systems (MEMS) Accelerometers are widely used systems in automobile, robotics, and consumer electronics. In this project, the student will develop the design of a MEMS accelerometer based on SOI technology that can be fabricated in a simple process flow at the research and prototype foundry at the university of Sydney. The student will learn the basics of microfabrication process flow, perform hands-on finite element modelling, and transfer of the designs into a microfabrication compatible design framework.

Requirement to be on campus: Yes- on-site requirement, as project involves experimental work. **dependent on government's health advice*

MECH2022-23/13 Design & Feasibility Study of a Micro-Opto-Electromechanical Systems Actuator for Integrated Photonics

Supervisors: A/Prof Niels Quack and Sher Ali Nawaz

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:
Micro-Opto-Electromechanical Systems have emerged in the last few decades and their applications can be found in various fields such as video projection systems, laser printing, and optical microscopy. The efficiency of these MOEMS rely on the design and integration of mechanical actuators. In photonic integrated circuits, such actuators can be used for effective mode index tuning by mechanical displacement. In this project, the student will design a piezo-electric MEMS actuator for photonic integrated circuits by Finite Element Analysis and perform feasibility study by evaluating actuator designs and the choice of suitable piezo-electric materials.

Requirement to be on campus: Yes- on-site requirement, as project involves experimental work. **dependent on government's health advice*

MECH2022-23/14 Design Optimization of Silicon Arrayed Waveguide Gratings

Supervisors: A/Prof Niels Quack and Leila Vatandoust

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:
Spectrometers play a paramount role in sensing applications, environmental monitoring, and medical diagnostics. Moreover, in recent years, on-chip spectrometers have attracted intensive research for telecom regarding their high reliability, ultra-compact size, low-cost, low-power consumption, and facile integration with photodetector arrays. Among on-chip spectrometers, using arrayed waveguide gratings (AWGs) as a dispersive element allows for a tightly integrated high-performance selection of spectral components. In this regard, Silicon as a material for photonic platforms enables the usage of a high index contrast and then further miniaturized on-chip spectrometers providing a path to satisfy these requirements. This research project aims to develop optimized designs for silicon photonics' arrayed waveguide gratings (AWGs). The vacation research internship project will introduce the student to the exciting field of integrated photonics, and based on analytical modeling, the student will develop a specific arrayed waveguide grating design that can support 12 individual communication channels with 100GHz channel spacing.

Requirement to be on campus: Yes, as project involves experimental work. **dependent on government's health advice.*

MECH2022-23/15 Developing Atom Probe Tomography for Bone Tissue and Bioceramic Bone Scaffolds

Supervisors: Dr Natalie Holmes and Prof Julie Cairney

Eligibility: Open to 2nd, 3rd and final year students.

Project Description:
Building a comprehensive knowledge of bone tissue structure and composition at the nanoscale has the potential to add to our understanding of biomineralisation in these complex biological tissues, and in turn our understanding of the differences between healthy and diseased states of bone tissue.

The main elements in bone tissue are Ca, C, O, P and Na. Atom probe tomography (APT) reveals elemental composition at nanoscale (atomic) spatial resolution, in three dimensions, and hence is uniquely suited to the study of bone tissue structure on these small scales. Due to the challenges associated with exploring bone structure on the nanoscale, it is only recently that studies revealing its structure have emerged. The first report of applying APT to the study of bone tissue was in 2017, revealing local gradients; Mg trace element detection; and the co-localisation of Na with the inorganic-organic interface of biomineral and collagen fibril domains.

The aim of this summer project is to study the atomic-scale structure of bone tissue and bioceramic bone scaffolds using atom probe tomography. The bioceramic bone scaffolds are synthetic bone substitutes under development for the treatment of critical-sized bone defects, in the animal model phase moving to the clinical trials phase.

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

MECH2022-23/16 Synthesis and Characterisation of Core-shell Nanoparticles for Nanomedicine and Electronics

Supervisors: Dr Natalie Holmes and Prof Julie Cairney

Eligibility: Open to 2nd, 3rd and final year students.

Project Description:
Breakthroughs in materials science and nanotechnology have revolutionised the way we design and build new material systems for targeted applications. Two key areas of interest are colloidal based core-shell nanoparticles for drug delivery and two-component blend nanoparticles for organic electronics. But the synthesis of these complex, nanoscale assemblies require careful measurement of structure at high resolution in order to verify that synthesis strategies are producing suitable nano-morphologies for targeted roles, and there are few microscopy techniques available with the required chemical *and* spatial resolution for the task.

This summer project will focus on developing nanoparticle systems with unique core-shell morphologies for future applications in nanomedicine and electronics, with a strong emphasis on high resolution electron microscopy techniques for characterisation. Drug-loaded nanocarriers will be characterised, these being core-shell nanoparticles comprised of a biodegradable polymer shell (such as lignin) and a drug molecule core. The core-shell structure achieved by the miniemulsion synthesis route. Similarly, core-shell and Janus (biphasic) nanoparticles of two-component organic semiconductor blends will be studied, these materials are used to print the *light absorbing – charge generating* layer of organic electronic devices, for example, solar cells.

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

MECH2022-23/17 Develop high performance polymer composites using additive manufacturing technologies

Supervisor: Dr Li Chang

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:
Over the past few decades, with continuing development and adoption of additive manufacturing (AM), the fabrication of polymer composites has drawn increasing attention from both industrial and academic communities. Despite the advantages of AM with high design flexibilities and low material waste, AM also has drawbacks such as poor surface finishing and voids formation. To enable AM technology for a wider mechanical application, it

is imperative to study and understand the basic process-structure-property relationship of the printed materials.

This project aims to develop new in-situ morning technology (eg. morning the evolution of the surface profile of printed structure) to further understand the important role of printing parameters such as printing temperature, air gap and raster angle in controlling materials structure/properties. The work aims to yield the new science for designing and tailoring polymer composites with desirable properties by 3D printing technology.

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

MECH2022-23/18 Opto-Electro-Mechanical Characterization of Photonic Microsystems

Supervisor: A/Prof Niels Quack

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:
In this project, the student will dive into the exciting world of Micro-Electro-Mechanical Systems (MEMS), with the hands-on characterization of MEMS components in cutting edge Photonic Integrated Circuits (PIC), the optical equivalent of electrical integrated circuits. After an introduction to the key features of the experimental setup, the student will measure and extract key performance metrics of the Photonic MEMS Devices, such as spectral response, optical losses and the electro-mechanical response for a variety of components of a prototype photonic MEMS chip, such as Photonic MEMS Switches and Photonic MEMS Tuneable Filters for Fiber-Optical Telecommunication Systems.

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

MECH2022-23/19 Combustion of Green Fuels (Hydrogen and its derivatives)

Supervisors: Prof Assaad Masri, Matthew Dunn and Andrew Mcfarlane

Eligibility: WAM>75 for final year students.

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*

MECH2022-23/20 Buoyant fires and their suppression by enhanced chemicals

Supervisors: Prof Assaad Masri, Dr Agi Kourmatzis and Vinny Gupta

Eligibility: WAM>75 for final year students

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*

MECHATRONICS ENGINEERING PROJECTS

MECHATRON2022-23/1 Inspection Planning in Partially Observed and Cluttered Environments

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics industry today.

Imagine a scenario where a mobile manipulator is inspecting a cluttered compartment for potential changes, but many parts of the compartment's walls are occluded and can only be inspected after some objects are moved. The challenge is, which objects should be moved, where to move these objects, and from which configurations should the environment be scanned to gain the most useful information in the least amount of time?

To answer the above question, we need seamless integration of rearrangement (of occluding objects) planning with view and motion planning. This integrated problem is novel and the focus of this project.

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

MECHATRON2022-23/2 Inspection Planning of Confined Environment with Multi-Modal Sensors

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics industry today.

Imagine a scenario where inspection of a confined and cluttered environment is conducted by multiple autonomous mobile platforms equipped with sensors of various modalities. Different sensing modalities would provide extra information to other parts of the environment.

The challenge here is fast and scalable coordination planning: Which (subset of) sensing modalities should be used and from which configurations should each sensor take the scan, such that the fused results provide the most information gained for the purpose of the inspection (e.g., change detection).

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

MECHATRON2022-23/3 Inspection Planning of Confined Environment via Human-Robot Teaming

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics industry today.

Imagine a scenario where a mobile manipulator is inspecting a cluttered compartment for potential changes, but many parts of the compartment's walls are occluded and can only be inspected after some objects are moved. Then add a human to monitor and provide high-level command (e.g., where to scan) to teleoperate the autonomous mobile platforms. Given the environment contains many occluded areas, the challenge is how should a robot interpret the potentially inaccurate teleoperator command.

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

MECHATRON2022-23/4 Inspection Planning in Unknown and Potentially Unsafe Environment

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics industry today.

This project focuses on inspection planning of environments when no initial model exists, or the current model has become very different from reality, such as building struts that have undergone structural changes due to flood. The challenge is how to conduct an efficient inspection when places the robot can traverse safely are not fully known.

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

MECHATRON2022-23/5 Large Scale View Planning in Partially Occluded Outdoor Environments

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

In this project, we are interested in information gathering in large outdoor areas where scaling of existing planning algorithms is an issue. The aim is to automatically identify locations from where a scan should be taken to gain the most valuable information with the least cost when:

- The benefit of scanning different parts of the areas is heterogeneous
- Different areas of the environment may be occluded by foliage or cloud, and therefore scanning must be done from specific configurations or from multiple places
- The influence of weather, wind and fuel consumption needs to be considered.

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

MECHATRON2022-23/6 Precision Navigation & Control in Close Proximity to Structures

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

In both aerial and marine domains, mission success may rely on bringing an AUV/UAV close to some structure. This capability could enable contact-based sensing, imaging in turbid conditions, or to enable manipulation, despite the potentially strong and variables currents/winds.

This project is on precision navigation and control in such circumstances, and can include:

- Robust online motion planning for mobile platforms operating in domains with large disturbances
- Fundamental advances in reinforcement learning with safety guarantees
- Control based on high-dimensional data streams (video) and real-time local maps

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

MECHATRON2022-23/7 Mobile Manipulation in Challenging Conditions

Supervisor: Prof Ian Manchester

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

Imagine an AUV/UAV equipped with an on-board manipulator arm. When moving beyond inspection to enable intervention, in both aerial and marine domain, there is a need to jointly control an AUV/UAV and the on-board manipulator arm to achieve the mission's goal.

Projects could include:

- Planning and learning of manipulation actions
- Joint optimisation and control of base/arm motions
- Achieving precision manipulation when subject to significant disturbances.

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

MECHATRON2022-23/8 Low-level sensor reconfiguration as part of the planning process

Supervisor: Dr Donald Dansereau

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:

ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

Robotic planning and control of low-level sensing is presently very limited and does not approach the level of sophistication seen in human camera operators. Jointly planning a trajectory and camera settings like exposure time, aperture and focus settings promises vastly superior sensing. Considering more sophisticated reconfigurable sensors like active plenoptic imaging devices and foveated LiDAR increases both the degree of challenge and opportunity.

Intentional control of reconfigurable sensing can increase signal quality and reduce distractors by measuring more of what's relevant in-context.

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

MECHATRON2022-23/9 Manipulating to see better: sensing for underwater inspection with manipulation / defouling

Supervisor: Dr Donald Dansereau

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

How can we manipulate / interact with objects to gather more useful information? This arises in the underwater domain in the form of surface fouling, and in air in the form of corrosion and vegetation visually taking over surfaces requiring inspection. There is a strong coupling between what the manipulator does and what the robot sees. In a sense, the camera and the manipulator are part of one interface between the robot and the world.

- Designing sensing and manipulation payloads so sensing and manipulation can work together to better achieve sensing, manipulation, and high-level tasks like mapping and change detection.
- Designing manipulation and sensing behaviours that allow these modes to work together.

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

MECHATRON2022-23/10 Computational imaging for up-close imaging

Supervisor: Dr Donald Dansereau

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today. Designing new visual sensors and imaging pipelines for up-close operations.

Moving from mapping to intervention means getting up close to infrastructure, raising challenges because common visual sensing systems have chiefly been designed for use at larger distances. This project will employ the tools of computational imaging to design visual

sensing systems for effective wide-field-of-view up-close imaging associated with manipulation and intervention tasks.

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

MECHATRON2022-23/11 Computational imaging for seeing through turbidity & particulate

Supervisor: Dr Donald Dansereau

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today. Designing new visual sensors and imaging pipelines for working in murky water and particulate

Seeing well underwater is a key challenge for several of our partners. Backscatter and attenuation limit contrast while particulate distracts from important visual content.

While this project is intended to be predominantly concerned with seeing underwater, it could be expanded to include similar in-air issues such as fog, dust rain or snow.

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

MECHATRON2022-23/12 Vision-based control and active perception for multiple sensors & manipulators

Supervisor: Dr Donald Dansereau

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

Controlling more than one manipulator at a time poses new challenges best overcome by tightly integrating vision and control. This project will address key challenges in underwater intervention tasks by developing visual approaches to dextrous underwater manipulation for ROV and AUV systems, with a focus on scene reconstruction, semantic understanding, and vision-enabled intervention. Such visual methods are not only necessary to achieve fully autonomous manipulation in subsea environments but can also support more effective piloted operations and facilitate safer, more reliable, and faster task execution.

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

MECHATRON2022-23/13 Sensor auto-calibration and integration using implicit representations and unsupervised learning

Supervisor: Dr Donald Dansereau

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:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

Automatically learning to use sensors for modularity and maintainability. Developing and maintaining modular and flexible platforms is at the heart of many of our partners' businesses. This work will develop the tools required to allow sensors to be swapped in/out of a system such that the robotic platform exercises the sensors and autonomously learns to interpret them, with no supervision or manual intervention.

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

MECHATRON2022-23/14 Underwater robot relocalisation for change detection

Supervisor: Dr Viorela Ila

Eligibility: Image processing, Machine learning

Project Description:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

This project will investigate methods for consistent underwater mapping across different survey scans. The project will focus on how to derive features suitable for visual odometry and persistent re-registration across different survey scans. Of particular interest are learnt features that avoid hand-coding heuristics for each application domain. The method should be able to accurately overlay identical parts of different survey scans.

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

MECHATRON2022-23/15 Change detection and modelling

Supervisor: Dr Viorela Ila

Eligibility: Machine learning, image processing

Project Description:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

When interpreting the evolution of a virtual model (e.g. virtual representation of an asset) over time, it is important to understand the semantic timeline of relevant changes. Semantic understanding of changes requires the algorithm to distinguish for example between incidental changes (e.g., parked car) and expected changes (e.g., building modifications) or between long-term changes (e.g., tree growth) and step changes (e.g., solar installation).

This project will investigate methods to model changes at scale using available survey data (e.g. images, laser scans, etc.). The model should be able to understand the nature of the changes over time and create representation of the scene's semantic timelines (e.g. how the model evolves in time).

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

MECHATRON2022-23/16 Semantic spatio-temporal representations
Supervisor: Dr Viorela Ila

Eligibility: Machine learning, Python programming

Project Description:
ARIAM Hub is an Australian Research Council research hub within the Australian Centre for Field Robotics at the University of Sydney. Our research themes address real-world problems in the robotics sector today.

Implicit representations such as Neural Radiance Fields (NeRF) are a recent development that allows storing information about scenes within the weights of a neural network such that renderings of the scene can be reconstructed by the network.

This project will investigate methods for using implicit representation for storing geometry and semantics. Subsequently, the output that can be queried should no longer be a photorealistic rendering but instead recover the high-level features that were used at creation time. We will also investigate adding the time component to the scene representation.

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