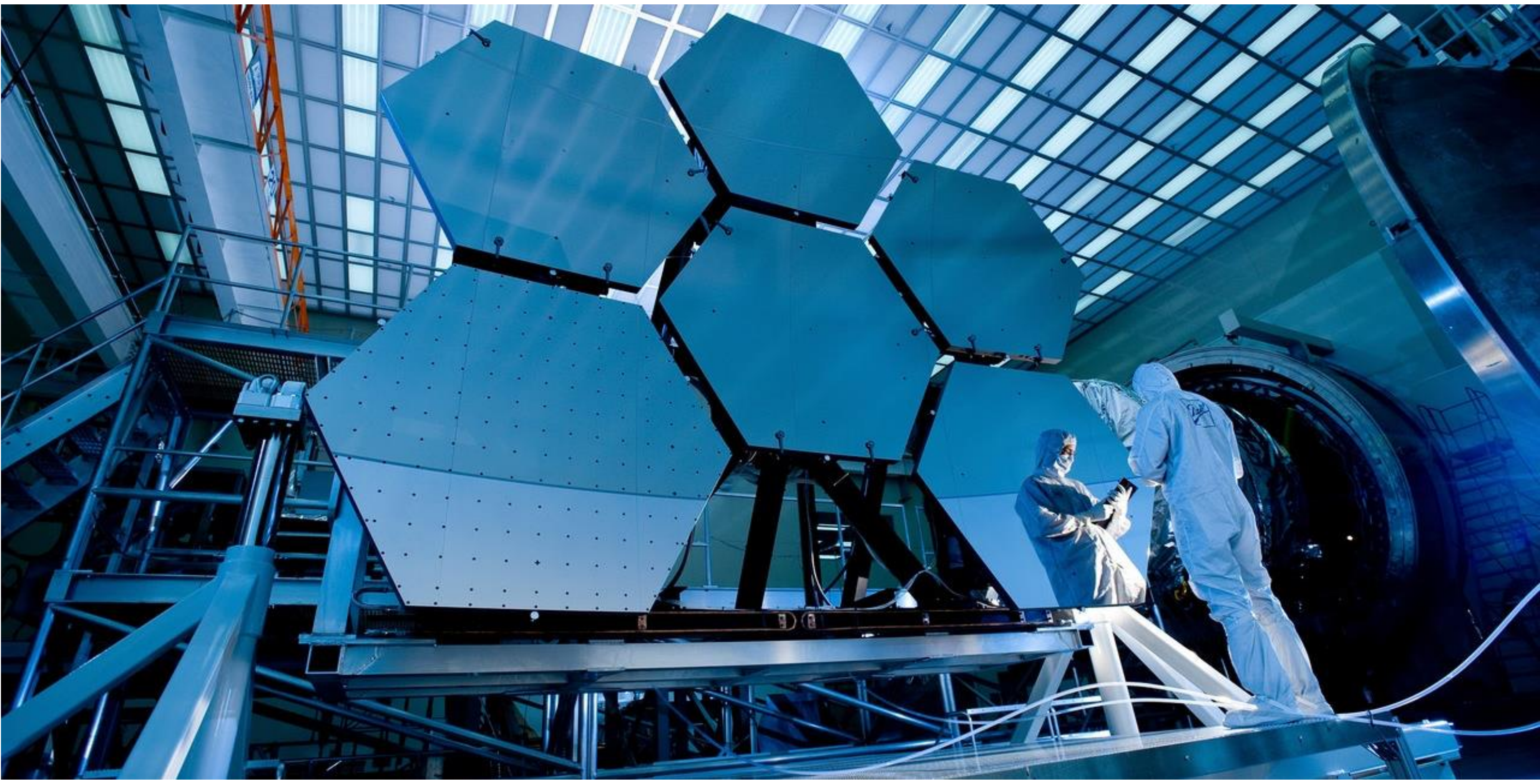
FACULTY OF ENGINEERING

Engineering Vacation Research Internship Program



ENGINEERING RESEARCH PROJECTS – WINTER 2023

THE UNIVERSITY OF SYDNEY

FACULTY OF ENGINEERING

AERONAUTICAL ENGINEERING PROJECTS

AERO2023/1 Design of an Aerodynamic Model of a Reusable Space Vehicle Propulsion and Rocket System

Supervisor: Associate Prof Nicholas Lawson

Eligibility: CAD design, aerodynamics and computational fluid dynamics experience from their undergraduate studies.

Project Description:
This project is aimed at the aerodynamics of reusable rocket geometries, such as being developed for SpaceX Falcon 9. In these vehicles, the rocket must transition to a vertical landing, using deployable landing legs and other propulsion systems. During the transition, there are complex interactions between the main body and components of the landing system, giving non-linear force and moment characteristics, which are difficult to predict using just theoretical or numerical methods.
This project aims to design, a scaled, generic, first stage geometry, suitable for testing in the University of Sydney 4x3 foot low speed wind tunnel. The model design will need to incorporate a jet driven by compressed air, to attempt to simulate the key aerodynamic interactions between the body and rear region of the model. This work is expected to be extended into a student thesis project, which will then test the model on a force balance in the wind tunnel.
This work will also have advisory input from DLR in Germany and the student will be expected to present their design at the end of the project to DLR.

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

AERO2023/2 Automatic Commercial Aircraft Image Capturing and Labelling for Computer Vision Training Using Gimballed Cameras

Supervisors: Dr Zihao Wang, David Williams (SiNAB Pty Ltd), Dr KC Wong

Eligibility:

1. WAM > 75
2. Basic knowledge of Python programming is preferred.
3. Strong communication skills are essential.

Project Description:
Collecting and labelling images is an essential process for building datasets for training computer vision algorithms, however, manually tagging accurate and specific details in an image is a tedious and time-consuming task. In our prior study, we successfully developed a networked camera system that can automatically detect, localise, and classify commercial aircraft approaching an airport runway, using a combination of background subtraction methods, probability mapping, and YOLOv5. We propose to develop an automatic system for gathering fully labelled aircraft imagery at scale, using a long focal length Pan-Tilt-Zoom camera. This system shall be autonomously operated using publicly available information sources, including ADS-B and the existing optical aircraft detector. The student will have access to the networked camera system and the MATLAB source code to develop the proposed system. The student will have the opportunity to work closely with an external industry advisor from SiNAB Pty Ltd to construct a simple prototype of the gimballed camera and achieve proof of concept in field trials at the end of the project, optimally demonstrating an

improvement in the performance of the optical detection system after it is re-trained using the automatically collected data.

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

AERO2023/3 Design and testing of 3D-printed leech-like biomimetic soft pneumatic robots

Supervisors: Prof Liyong Tong and Yifu Lu

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 the design of soft actuators, biomimetic design methods are applied to achieve motions that mimic biology, e.g., fishes or worms. For example, soft worm-like robots are widely studied, for which the peristalsis of worms is mimicked via longitudinal extensions and contractions for crawling or climbing. Leeches are another mollusc, which have been only considered in very few studies of biomimetic soft robots. Unlike worms, leeches have two suction cups at the two ends of their bodies to apply anchoring forces during crawling, and they crawl via bending rather than peristalsis.
This project aims to design, prototype, and test leech-like soft pneumatic robots for crawling and steering locomotion. Our present design can generate bending and achieve crawling in a straight line. The major focus of the project is the design of twisting modules, and the control of the simultaneous bending and twisting to mimic the steering/turning of leeches.

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

BIOMEDICAL ENGINEERING PROJECTS

BME2023/1 Wetware built from mechanical meta-materials

Supervisors: Prof Hala Zreiqat and Dr Peter Newman

Eligibility: 3rd / 4th year student

Project Description:
Wetware, is a computer system built from biological tissues. The term is often used in contrast to hardware (such as computer chips) and software (such as computer programs) in the field of computer science.
This project looks to use 3D nano printing (multiphoton lithography - Nano scribe) to define the connectivity of neurons – thereby defining computation networks.

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

BME2023/2 Synthesis and development of fluorescent nanoparticles for iron Ion sensing in living cells

Supervisors: Prof Hala Zreiqat and Dr Pooria Lesani

Eligibility: 3rd / 4th year student

Project Description:
The project focuses on the development of novel fluorescent nanoparticles, known as carbon dots (CDs), for biosensing applications.

CDs are a type of fluorescent nanomaterial with a particle size in the range of 2-10 nm [1]. Due to their excellent tuneable optical properties, two-photon absorption, non-toxicity, and good biocompatibility, they are widely used in biological applications [2].
In this project, the CDs will be synthesised through our novel developed hydrothermal method [3]. The photophysical, physicochemical, and biological properties of the CDs will be optimised through our developed protocol [4], to make them suitable for biosensing applications. The developed CDs will be characterised by various analysis methods available at Sydney Uni. The produced CDs will be used as accurate sensors for the detection of iron ions in living cells by exploiting their fluorescence properties.

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

BME2023/3 Reconstructing Natural Image from Brain Activity

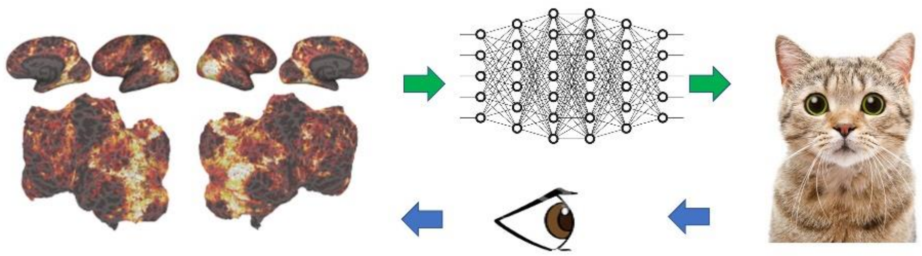
Supervisors: Dr Jinglei Lv, Associate Prof Zhiyong Wang, Prof Fernando Calamante

Eligibility:

1. Necessary skills with programming. Python programming is preferable.
2. Necessary knowledge and experience with deep learning.
3. Self-motivation, curiosity about research and passion to succeed.

Project Description:

The ability to decode neural activity patterns associated with visual perception is a major goal in the field of neuroscience. Recent advances in machine learning and neuroimaging techniques have shown promising results in reconstructing images from brain activity data. In this project, we propose to develop a deep learning-based approach to reconstruct natural images from functional magnetic resonance imaging (fMRI) data. Specifically, the fMRI data was collected while the participants were viewing 10,000 images. Our aim is to train a neural network to learn the mapping between fMRI data and visual stimuli, allowing us to reconstruct images that match the content of the original visual stimulus. This research helps understand the mechanism of human visual system. It will potentially inspire new directions for artificial intelligence and bionic eyes.



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

BME2023/4 Machine Learning and Artificial Intelligence for melanoma classification: Elevating the classroom knowledge to overcome clinical challenges

Supervisor: Dr Sandhya Clement

Eligibility: Only for students who have currently enrolled (S1 2022)/ previously completed (S1, 2021) BMET5933

Project Description:
Machine Learning (ML) and Artificial Intelligence (AI) are considered to be the potential

candidates for transforming the health care technologies. These technologies present useful pathways to unravel a range of biological questions. Utilizing ML and AI, we can develop smart digital system to increase the efficiency and improve the medical outcomes. The current project aims to develop a practical ML or/and AI model for the binary and multiclass classification of melanoma from a Melanoma Skin Cancer Data set that are publicly available. The project is focussed on educating and training the students to implement the existing classroom-based knowledge to practical research experience and implementation towards clinical relevance. This project will enable the students to explore the synergies between software development, and clinical diagnostics.
The experience gained during the proposed project will enable the student to appreciate a multidisciplinary approach of answering research-based questions, using powerful ML and AI techniques.

Requirement to be on campus: No

BME2023/5 Exosome-based Therapeutics for Treating Diabetic Retinopathy

Supervisors: Dr. Mahbub Hassan, Prof. Stephanie Watson and Dr. Yogambha Ramaswamy

Eligibility: Basic knowledge of molecular biology

Project Description:

This proposal aims to investigate the potential of exosome-based therapeutics for treating diabetic retinopathy, a major complication of diabetes and leading cause of blindness worldwide. Current treatments have limited efficacy and significant side effects, making exosomes a promising therapeutic approach due to their low immunogenicity and ability to transfer bioactive molecules between cells. The study's primary objective is to evaluate the efficacy of exosome-based therapeutics in inhibiting retinal vascular leakage and neovascularization in diabetic retinopathy. Methods involve isolating exosomes from stem cells or other sources and engineering them to deliver therapeutic agents, such as microRNAs or anti-angiogenic factors. Efficacy will be evaluated using in vitro model of diabetic retinopathy, with transcriptomic and proteomic analysis used to investigate mechanism of action and potential positive outcomes. This study has the potential to revolutionize diabetic retinopathy treatment and develop novel therapies for ocular diseases.

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

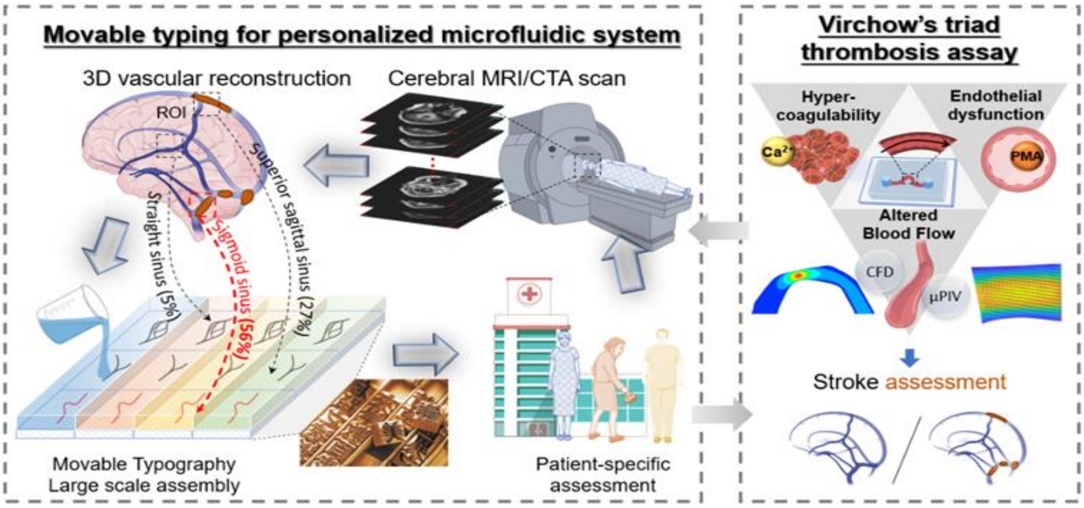
BME2023/6 Novel movable typing for personalised microvasculature-on-chip in large scale: recapitulate patient-specific Virchow's triad and its contribution to thrombosis diseases

Supervisor: Dr Lining Ju

Eligibility: Familiar with SLA 3D printing technology. Capability of using two or more of Labview, Altium, Klayout, ANSYS, SOLIDWORKS, or other design/programming 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.

Project Description:
The success of COVID-19 RATs has underscored the urgent need for rapid and cost-effective biomanufacturing processes, spurring the advancement of point-of-care testing (POCT) technologies. In the context of thrombotic diseases, current patient-specific assessments of thrombosis remain insufficient, constituting a significant healthcare burden in Australia. Our recent high-impact publications illuminate the potential of 3D printing technology for predicting patients' blood clot tendencies before life-threatening events, such as strokes and heart attacks, occur.

To this end, we propose a research project aimed at developing an innovative 3D printing-based technology, Biochip Movable Typing, to facilitate personalised blood clotting analysis. This project will concentrate on creating a POCT device capable of providing tailored blood clotting assessments for various thrombotic conditions. The successful completion of this project is expected to give rise to a burgeoning biomanufacturing industry, offering personalised solutions to cater to the diverse clinical requirements associated with blood clotting disorders.



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

BME2023/7 Excimer Laser System Development

Supervisors: Prof Gregg Suanning and Matthew Kolibac

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 involve the design and commissioning of an excimer laser system. The bionics lab located on level 4 of J13 possesses an uncommissioned 193nm excimer laser, with no safety shielding, nor an x-y system for engraving specific geometries. The goal of this project would be to:

1. design and construct a laser safety enclosure.
2. setup and program a motorised x-y stage system, that can use input CAD files to engrave specific geometries.
3. commissioning and initial testing of the excimer laser system on various materials.

The resulting system will be highly valuable in further USYD bionics research. It will provide an excellent method of silicon ablation, which will allow the engineers and researchers of the bionics lab the ability to precisely manufacture silicon components for projects such as the bionic eye. This project will also open new research projects with silicon ablation.

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

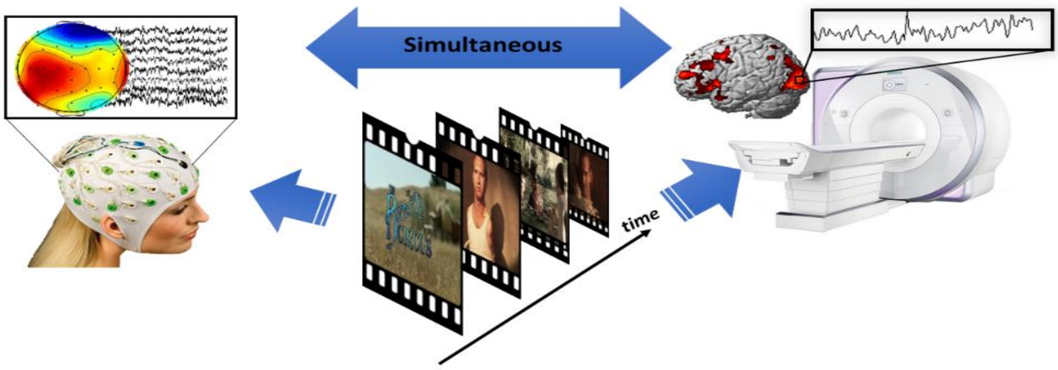
BME2023/8 Read the mind with simultaneous EEG-fMRI

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

Eligibility:

1. Basic skills with programming.
2. Necessary knowledge about medical image and signal processing.
3. 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: Yes **dependent on government's health advice.*

CHEMICAL AND BIOMOLECULAR ENGINEERING PROJECTS

CBE2023/1 Fabrication and Testing of Artificial Heart Valves

Supervisor: Sina Naficy

Eligibility: Passionate about laboratory research. Passionate about research in the field of biomedical devices. Prior laboratory skills are not necessary but are advantageous

Project Description:
We are a multi-disciplinary, multi-institutional team with partners in the US and Italy, working towards commercialisation of the next generation of heart valve replacements for kids and adults.
In this program, we use a combination of simulation, 3D printing, and surface modification to produce artificial equivalents of human heart valves.
In this specific project, you will work with our passionate "materials development" and "additive manufacturing" team members, assisting them with the fabrication and characterisation of new biomaterials and heart valve prototypes.
During your internship with us will learn how to perform a combination of mechanical testing, surface analysis, and biological testing to determine the suitability of materials for medical applications. You will also gain new skills in additive manufacturing using our state-of-the-art Bioplotter and 4-axis robotic arm printer.
The materials and heart valve prototypes developed with your help will be tested in a preclinical study planned for December 2023.

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

CBE2023/2 Photoenzymatic reaction in enzyme/metal-organic framework composite

Supervisors: Dr. Weibin Liang Prof. Jun Huang

Eligibility:

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

Project Description:
By combining photocatalysis with enzyme catalysis, the photo-enzymatic method can achieve a remarkable conversion capacity that surpasses current catalytic protocols. This project aims to produce pharmaceutical drug components using lipase and a photo-catalytically active MOF (SYD-1). The student's tasks will include synthesizing and characterizing MOF materials and testing their catalytic performance.

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

CBE2023/3 Improving the performance of zinc 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. Rechargeable zinc ion batteries are promising next-generation energy storage devices with inherent safety and low-cost advantages. This project will focus improving the energy density and long-term stability of zinc ion batteries. Students will participate in battery material synthesis, characterization, battery assembly and performance tests.

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

CBE2023/4 Investigation of polymer nanoconfinement effect on PEI membranes for gas separation

Supervisors: Dr David Wang and Mr Yi-Chen Lin

Eligibility: Must achieve WAM 75 or higher. Possess a general understanding and interest for membrane separations.

Project Description:
Organic polymer membranes are widely used for gas separation that operates at low pressures and temperatures, but their performance is usually defined by the empirical trade-off between gas permeability and selectivity. Recently, we reported a novel inorganic/organic polymeric interfacial diffusion membrane, which delivers an extremely high selectivity for gas separation and far exceeded the Robeson boundary. Selective molecular transport proceeded only in the amorphous polymer interface between the alumina support and the polymer crystals, of which is intricately linked with the phenomenon of nanoconfined crystallization. Hence, the ability to control nanoconfined crystallization of polymer is essential for a high-performance gas separation membrane.

In this project, gas separation membranes will be prepared on the Al_2O_3 tubular supports. Calcination conditions will be varied to change the pore size, porosity and interfacial chemistry of the alumina supports. Then polyetherimide polymer will be infiltrated into the supports to create the inorganic/organic polymeric interfacial diffusion membranes. Gas separation tests of the final membranes will be carried out to understand the behaviour of polymer confinement.

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

CBE2023/5 Investigation the effects of surface abrasion and calcination temperature on alumina tubular membranes for microplastic filtration

Supervisor: Dr David Wang

Eligibility: Must achieve WAM 75 or higher. Possess a general understanding and interest for membrane separations.

Project Description:
Microplastic pollution is a significant global concern due to the persistent nature of microplastics and adverse effects to the ecosystems. In this project, an investigation of microplastic filtration will be carried out using bespoked membrane tubes prepared from alumina ceramic materials due to their excellent thermal stability and high mechanical strength. However, fine tuning of membrane pore size and surface properties will be crucial to delivery separation efficiency and membrane stability for long term operation. The project will investigate how membrane fabrication conditions such as surface abrasion and heat treatment affect the alumina membrane structures and chemistry. The water flux, filtration efficiency and membrane fouling will also be evaluated and compared with the commercial alumina tubes and the literature.

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

CBE2023/6 Metal-Organic Frameworks for the Electrochemical Removal of CO_2 from Air

Supervisors: Prof. Deanna D'Alessandro, Dr Marcello Solomon, Dr Eleanor Kearns

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:
By 2100 the concentration of CO_2 in our atmosphere will exceed 570 ppm, contributing to a 1.9 ^{o}C temperature increase. Development of Negative Emissions Technologies can address this challenge by permanently removing and storing CO_2 emissions. Current CO_2 capture technologies exploit the chemical reaction between amines and CO_2 for capture; however, liberation of the CO_2 for storage requires elevated temperatures and has a high energy penalty.

Redox chemistry can be used to activate chemical moieties (quinones, disulphides, bipyridines) towards CO_2 removal.

Metal-Organic Frameworks (MOFs) are a porous class of materials with tuneable structures. Their high surface areas make them ideal for CO_2 separation from air.

This project involves the incorporation of redox-active ligands into MOFs and the design of a direct air capture device. This will exploit their high surface area and large pore volumes to increase the efficiency of CO_2 separation.

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

CBE2023/7 Digital modelling support for replacement heart valve design and testing

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

Eligibility:

1. Have a strong interest in research and strong problem-solving skills.
2. The capability of using any CAD software (AutoCAD, SOLIDWORKS, Fusion 360) or programming languages (Matlab, Python, C/C++) is preferred.

Project Description:
We are dedicated to advancing the modern treatment of valvular heart disease by innovating the next-generation heart valve replacements that comprehensively meet the physiological demands of the cardiovascular system. This technology is projected to reduce the burden of a range of valvular heart diseases, ranging from children to adult populations.

This project involves the use of digital modelling for improving the heart valve design. You will be working closely with the computational and experimental teams, assisting in designing the heart valve prototypes and testing their performance through modelling.

More details of the project can be found on our website: https://polymeric-heart-valve-eng.sydney.edu.au/

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

CIVIL ENGINEERING PROJECTS

CIVIL2023/1 BIM and Digital Twin for Developing Convergence Technologies as Future of Digital Construction

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

Requirement to be on campus: No

CIVIL2023/2 Designing Lightweight Stadium Roofing Structures Based on Advanced Analysis Methods

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 current structural engineering practical standards are unable to offer a universal structural design standard for long-spanning lightweight stadium roofing structures. As such, the design procedure of a particular stadium roof is not replicable to another. This research aims to present a novel design procedure for lightweight stadium roofing structures considering the Lakhwiya stadium the Optus Stadium and the CommBank Stadium as experimental cases. Using the finite element analysis (FEA) software Strand7, the cases will be modelled and analysed. Varying load cases and combinations such as ultimate strength (ULS) and serviceability limit states (SLS) based on the Australian Standard AS1170.0:2002 will be calculated and subsequently applied. Linear static analysis will then be undertaken where critical members will be identified within the model. Based on this, preliminary member sizing and design feasibility checks will be conducted in order to ensure structural stability and compliance to the Australian Steel Structure code AS4100:2020. A linear buckling analysis is also conducted based on the selected sizes from the initial stage to determine critical loads. Advanced analysis including non-linear buckling computation is comprehensively managed. Some of the crucial parameters such as maximum displacement, maximum/minimum principal stresses, critical buckling loads, as well as load factors are examined. The main novelty of this study is to determine a clear road map to design stadium roofing systems subjected to a combination of different types of the loading.

Requirement to be on campus: No

CIVIL2023/3 Structural application of recycled fibre reinforced polymer (rFRP) composites'

Supervisor: Dr Ali Hadigheh

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

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

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

CIVIL2023/4 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

CIVIL2023/5 Corrosion in reinforced concrete structures

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. Corrosion of reinforcement is one of the main deteriorating mechanisms in reinforced concrete (RC) structures. In addition, 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 innovative methods and machine learning methods for automated condition assessment and evaluation of reinforced concrete infrastructure.

Requirement to be on campus: No

CIVIL2023/6 Wind loads on large-scale solar (LSS) farms

Supervisor: Dr Kapil Chauhan

Eligibility: Knowledge of fluid mechanics, CIVL3612 or equivalent, MATLAB competency Basic statistics of mean, variance, correlation, etc.

Project Description:
Net-zero capabilities of the Australian energy market heavily relies on future investment in large-scale solar (LSS) farms that reach GW capacity. Solar farms are exposed to extreme weather conditions. Particularly, panels with solar tracking are highly susceptible to failure because of wind. Hence it is necessary to investigate the effect of wind on LSS through a systematic study. This project is designed to establish such test capabilities in the school of civil engineering.

The experimental project requires acquiring data in the Boundary Layer Wind Tunnel. Models of solar panels are instrumented with pressure taps and installed in an array, representing a large-scale solar farm. Pressure measurements are acquired under different conditions of wind and spatial configurations of the panels. The measurements provide an estimate of loads and can be further analysed to examine dynamic variations. The results will help design of structurally robust LSS and optimisation of spatial arrangements.

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

CIVIL2023/7 Microaccess, active travel and the built environment

Supervisor: Dr Emily Moylan

Eligibility: This work will involve some elements of data collection which requires you to be in Sydney and willing to navigate around the city. Skills with Python, GIS and regression modelling are desirable but not required.

Project Description:

Qualitative feedback indicates that active travellers (walkers and cyclists) are highly aware of microscale attributes of the built environment that impact their journeys. This might include the presence of curb cuts, tree canopy cover or obstructive street furniture. Previous work has demonstrated that access to major activity centres such as train stations and education infrastructure is limited by the number of access points (doors or gates) that are available.

This project builds on a larger body of work looking at built environment impacts on active travel to school in New South Wales. Until now, the project has focused on catchment areas around primary and secondary schools to assess the suitability of active travel. The intern(s) will undertake data collection and analysis to enrich the work with microaccess attributes such as gate access, bicycle parking facilities, and types of pedestrian crossings.

As well as the supervisor, you will be working with Dr Jennifer Kent from the School of Architecture Design and Planning and PhD student Laya Hossein Rashidi.

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

ELECTRICAL AND INFORMATION ENGINEERING PROJECTS

EIE2023/1 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 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*

EIE2023/2 Circuits design and signal processing for advanced sensors

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

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

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

The project is to deliver the superior, advanced sensing platforms 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 projec

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

EIE2023/3 Testing of high-speed integrated *photonics* devices

Supervisors: Prof Xiaoke Yi, Dr Liwei Li

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

EIE2023/4 Enhancing renewable hosting capacity of a distribution network via energy storage

Supervisor: Dr Cuo Zhang

Eligibility: Solid knowledge of power system analysis and control, and established skills of mathematical 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 control methods of integrated energy storage system, this project aims to develop a battery system planning method to enhance renewable hosting capacity of a distribution network.
Mathematical models of distribution network operation and advanced control methods of battery systems will be developed first. Then, a new planning model of battery systems to maximize the renewable hosting capacity with full consideration of uncertain network operating conditions will be proposed in this project. Finally, comprehensive numerical simulations will be conducted to validate the model and enhancement efficiency.

Requirement to be on campus: No

EIE2023/5 Novel Approaches for Quantitative Group Testing

Supervisor: Dr Mahyar Shirvanimoghaddam

Eligibility: Solid understanding of Information and Coding Theory. Experience in Machine Learning Techniques is desirable.

Project Description:
Quantitative group testing (QGT) is a method of combining samples from multiple individuals and conducting a single test on the resulting mixture or pool to accurately identify positive cases in a population. This method has been applied in various fields, including DNA screening, quality control, and managing viral epidemics such as COVID-19. The design of optimal pooling strategies or testing plans remains a challenge in QGT, with the need for continued

research to develop innovative and efficient pooling designs. There are two approaches to the design of pooling in QGT: adaptive and non-adaptive. Non-adaptive pooling designs all pools simultaneously, while adaptive pooling involves designing each pool based on the outcomes of previous testing. While adaptive pooling may require fewer tests, non-adaptive algorithms are more practical in most applications. There is a need for fundamental breakthroughs in the design of poolings and reconstruction algorithms to enable the full potential of group testing approaches to be realized, thereby significantly enhancing testing efficacy in a variety of settings and applications. The project aims to design simple yet effective QGT algorithms that meet the theoretical lower bound by utilizing expertise in information and coding theory to develop fundamentally better and simpler pooling strategies, paired with simple reconstruction algorithms.

Requirement to be on campus: No

EIE2023/6 Testing on AI-based Systems

Supervisors: Dr. Huaming Chen; Dr. Jason Xue (CSIRO)

Eligibility: GPA > 70

Project Description:
Deep learning (DL) has become a new paradigm for solving many real-world problems due to its astonishing performance in different domains such as image analysis, natural language processing and system security. However, DL has also shown latent vulnerabilities leading to different kinds of "errors" which makes it challenging to develop robust DL software. Sometimes, it may involve the hardware-software codesign issue.
Therefore, to improve the reliability of DL software, it is crucial to have a systematic understanding and exploration for the techniques of automatically testing the robustness of trained DL software. In this project, we will work on the topic to test the trained DL software against various errors and ensure that it meets the required quality standards.

Requirement to be on campus: No

EIE2023/7 Development of Open-Source O-RAN 5G Wireless Communication Test-bed

Supervisor: Dr Wibowo Hardjawana

Eligibility: Completed 3rd-year electrical engineering with WAM ≥ 75. Strong background in wireless communication systems and programming skills in C/C++

Project Description:
The O-RAN Alliance is a global effort to increase the openness and functionality of fully operational 5G base stations. The latest standard mandates the division of signal processing in O-RAN-compliant 5G base stations into two levels - the lower-level Control Unit (CU) and the higher-level Distributed Unit (DU). The DU is responsible for most of the real-time signal processing, while the CU handles the remaining signal processing functions.
In this project, students will leverage the existing research work at the Centre of Telecommunications and IoT to develop a 5G communication infrastructure test bed. Their first task will be to create their own 5G cellular networks using open-source 5G communications stacks and software-defined radio (SDR) kits, including base stations and core gateways. Afterwards, the students will focus on enabling functional splitting for the base station.
The ultimate objective of this project is to develop an end-to-end O-RAN 5G communication demonstration using the infrastructure created by the students.

Requirement to be on campus: No

EIE2023/8 Development of Open-Source Radio Access Network Simulator for 5/6G Wireless Communication Networks

Supervisor: Dr Wibowo Hardjawana

Eligibility: Completed 3rd-year electrical engineering with WAM ≥ 75, a strong background in wireless communication systems and programming skills in C/C++

Project Description:
The O-RAN Alliance is a global initiative for greater openness in next-generation virtualised radio access networks (vRANs) and 6G networks. To manage radio resources using AI, the Open RAN Alliance has proposed the Radio Intelligence Controller (RIC) framework as the new standard. However, conducting large-scale system analysis for commercial deployment poses a significant challenge due to the need for a large amount of hardware during the testing process. The student will be working on a project to develop an open-source simulation platform that combines O-RAN-compliant RIC with fully functional 5G stacks. The developed platform will enable large-scale system analysis for multiple scenarios and applications (multimedia streaming, web browsing, wireless virtual reality, etc.) without excessive hardware requirements. The student will also develop key performance metrics to analyse system performance.

Requirement to be on campus: No

EIE2023/9 Towards AI Native Air-Interface for 6G Wireless Networks

Supervisor: Dr Wibowo Hardjawana

Eligibility: Completed 3rd-year electrical engineering with WAM ≥ 75. Strong background in wireless communication systems and programming skills in Python

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 project aims to demonstrate a 6G vision of a new air interface in which AI replaces the standard signal processing blocks to enable optimised communication schemes for any hardware, radio environment, and application. The project will leverage our current telecommunication research at the Centre of Excellence in IoT and Telecommunications.

Requirement to be on campus: No

EIE2023/10 Artificial Intelligence based Error-Control Coding

Supervisors: Dr. Vera Miloslavskaya, Prof. Branka Vucetic

Eligibility: Experience in software development (Python or C++), artificial intelligence, and English (reading, listening, speaking, and writing)

Project Description:
Error-control coding is the key enabling technology for reliable data transmission. The fifth generation (5G) of mobile networks employs such error-control codes as the low-density parity-check (LDPC) and polar codes, while 3G and 4G rely on the turbo codes. Advanced error-control coding techniques ought to be developed to meet the stringent requirements of 6G. In this project, a student will have the opportunity to optimise error-control codes using artificial intelligence (AI) techniques. Compared to the conventional code structure, the AI-based solution is more flexible and expected to provide codes with a better performance-complexity trade-off.

Requirement to be on campus: No

EIE2023/11 A robust and accurate indoor localization using learning-based fusion of Wi-Fi RTT and RSSI

Supervisor: Prof Yonghui Li

Eligibility:

1. Programming skill (e.g., JAVA, Python, Matlab)
2. Fundamental of machine learning and signal processing knowledge
3. Fundamental of wireless and network knowledge
4. Problem solving skills
5. Strong teamwork skills

Project Description:
This project aims to develop a high-precision indoor localization system (ILS) based on Wi-Fi round trip time (RTT) and smartphone inertial measurement unit (IMU) fusion algorithm. Students need to be familiar with Java, Python or HTML languages. Students are encouraged to come to campus to do experiment and data collection.

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

EIE2023/12 Reinforcement learning based path planning of an industrial robot arm

Supervisors: Prof. Yonghui Li, Dr. Subhan Khan

Eligibility: Must have experience with Python, Pytorch, tensorflow, RL

Project Description:
In this project, you will be working on reinforcement learning (RL) based path planning of a robot arm (ABB IRB 120). First, a comprehensive literature review will be carried out on the existing techniques, and then a simulated environment will be considered to test the RL-based path planner. Furthermore, there will be an opportunity to test the planner with a real robot in the lab. Finally, it is expected to document the findings by comparing it with the existing or related works.

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

EIE2023/13 AI-based detection of materials of masonry construction

Supervisors: Prof. Yonghui Li, Dr. Subhan Khan

Eligibility: Must have experience with Python, Pytorch, tensorflow, AI

Project Description:
In this project, you will be working on AI-based solution to classify and detect materials of masonry construction. First, a comprehensive literature will be carried out on existing open-source datasets available for object detection in construction, while ensuring to use cutting-edge AI techniques. Furthermore, we will consider a simulated autonomous vehicle or bulldozer, which will have a camera to detect these objects. In addition, the smart perception system must accurately detect and label the materials of construction. Finally, the proposed AI-technique will be compared with existing related-works to document the findings.

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

EIE2023/14 Cyber Security Risk in Distributed Energy

Supervisor: Glenn Platt

Eligibility: Must achieve WAM 75 or higher. Possess a general understanding and interest for membrane separations.

Project Description:
All over the world, large numbers of "distributed energy" devices such as batteries, solar systems, or controlled loads (pool pumps, air conditioners, etc) are appearing. These are essentially "Internet of Things" (IoT) type devices yet are also a significant electrical load.

The cyber-security risks associated with IoT devices are fairly well understood. What is less understood are the risks that IoT devices, through their cyber security weaknesses, could pose to the electricity system.

This project will investigate what level or risk a large number of IoT distributed energy devices could pose to electricity system operation.

There are a variety of ways this project could proceed. These include:

- Theory research into what is known on this topic
- Electrical networks simulation to try to determine risk thresholds
- Penetration testing of actual devices if appropriate hardware can be located

Requirement to be on campus: No

EIE2023/15 Data Mining for Emissions Estimation

Supervisor: Glenn Platt

Eligibility: Must achieve WAM 75 or higher. Possess a general understanding and interest for membrane separations.

Project Description:
Reporting of emissions is a key part of improving sustainability. Calculating the emissions from an industrial facility can take a long time, and cost a lot- it usually involves installation of measurement equipment, detailed logging of materials, etc. This project will research how emissions could be estimated based on publicly available emissions information, or other sources of data (such as satellite information). Through the automated mining of publicly available emissions data, can we estimate the emissions from a facility without needing expensive measurement equipment?

The project is likely to involve building of software.

Requirement to be on campus: No

EIE2023/16 Diseases detection and classification using machine learning

Supervisors: Dr. Subhan Khan, Prof. Branka Vucetic, Prof. Yonghui Li

Eligibility: Python, deep learning, pytorch, tensorflow

Project Description:
In this project, detection and classification of various diseases or abnormalities in medical images, such as cancer, fractures, or brain lesions will be carried out by using deep learning techniques, which can lead to more accurate diagnoses and improved patient outcomes. First, a detailed literature review will be performed to compare the existing medical imaging techniques in the deep learning contexts. Furthermore, opens source Keras or related datasets

will be used to train the disease detection algorithm, for instance, consisting of normal and tumorous brain MRI images. Finally, we will compare existing U-Net architecture with classical deep learning techniques.

Requirement to be on campus: No

EIE2023/17 Language Understanding and Multimodal Interaction in Robotics

Supervisors: Dr. Subhan Khan, Prof. Branka Vucetic, Prof. Yonghui Li

Eligibility: Python, NLP, deep learning, pytorch, tensorflow

Project Description:
In this project, we will develop algorithms that enable robots to understand natural language in the context of their environment, integrating other sensory inputs (e.g. vision, touch) to provide richer contextual information. Furthermore, we will combine natural language understanding with multimodal information, which robots can interpret and respond to human instruction more accurately and adapt their behaviour to different scenarios. In addition, we will explore techniques like multimodal fusion and deep learning-based approaches to combine multiple input modalities. Finally, this project will contribute to the development of intelligent robots that can better understand and interact with their surroundings, ultimately enhancing the potential for effective collaboration between humans and robots.

Requirement to be on campus: No

EIE2023/18 Proving Green Energy

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:
In energy markets around the world there is a strong desire for 100% renewable or "green" electricity. Yet today electricity systems typically have a mixture of renewable and fossil-fuel generated electricity flowing in them. This project will investigate ways to prove the source of electricity to a particular load, and/or trace the flow of electricity in a network. The project could be entirely theoretical, or it could also include a practical component, where the student builds a software dashboard for a particular load, that shows in real-time the provenance of the electricity being consumed.

The project is likely to involve desktop analysis, and/or building of software.

Requirement to be on campus: No

EIE2023/19 Investigating Cipher Algorithms Vulnerable to On-chip Voltage Sensor Attacks

Supervisors: Prof Sri Parameswaran and Darshana Jayasinghe

Eligibility: Familiar with VHDL/Verilog programming

Project Description:
Background:
On-chip voltage sensors demonstrated revealing secret keys from Advanced Encryption Standard (AES). Hackers place a hardware design (an on-chip sensor) and measure power consumptions of Field Programmable Gate Arrays (FPGAs). Today, FPGAs are used in many places. E.g., Air Bus A380 contains over 300 FPGAs. So far only AES has been vulnerable

(demonstrated an attack). Such attacks have not been demonstrated on other cipher algorithms (Present, BLOWFish, Simon and Spek etc..).

What we are doing:
In this project, you will investigate block ciphers other than AES which are vulnerable to on-chip sensor-based attacks.

We have developed on-chip voltage sensors on FPGAs in our lab. You (we will guide) will read from on-chip sensors with other block ciphers (Present, BLOWFish, Simon and Spek) and carry out attacks to reveal secret keys.

Deliverables: GitHub repository of experimental setup and comparisons (graphs and tables) about attack success.

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

EIE2023/20 On-chip Voltage Sensor-based Attacks using Machine Learning Framework

Supervisors: Prof Sri Parameswaran and Darshana Jayasinghe

Eligibility: Familiar with Verilog/ VHDL and fundamentals of FPGAs

Project Description:
Background:

On-chip voltage sensors demonstrated revealing secret keys from Advanced Encryption Standard (AES). Hackers place a hardware design (an on-chip sensor) and measure power consumptions of Field Programmable Gate Arrays (FPGAs). Today, FPGAs are used in many places. E.g., Air Bus A380 contains over 300 FPGAs for signal processing. Therefore, the threat is immense. Currently, these sensors use correlation coefficient (we use the Pearson correlation coefficient) or mutual information algorithms to process the attacks to reveal AES keys.

What you will do:

In this project, you will use machine learning models (CNNs and MLPs) to process on-chip sensor data and reveal AES keys.

How: We have developed on-chip voltage sensors on FPGAs in our lab. You (we will guide) will read from on-chip sensors and train machine learning models to perform attacks quicker with higher accuracies.

Deliverables: GitHub repository and documents about how to use the framework.

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

EIE2023/21 Developing an interactive nanopore raw signal visualizing tool kit

Supervisors: Prof Sri Parameswaran, Hiruna Samarakoon and Hasindu Gamaarachchi,

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:
Oxford Nanopore Technologies (ONT) is a popular third-generation DNA sequencing platform that is known for its ability to produce long reads. The sequencer outputs current signals that need to be mapped (basecalled) to DNA bases (A, C, T, G). Currently, there is no interactive software available to visualize these current signals. Developing such a tool would be highly beneficial to the nanopore community. This project requires strong programming skills in Python as well as problem-solving skills. As the student develops new features to our basic prototype software, they will gradually learn how to apply fundamental software engineering principles to build a stable software.

Objective 1: Replace the Bokeh plotting library with Plotly in an existing Python visualization software to make the experience more interactive.

Objective 2: Implement new features in the software that are useful for the bioinformatics community.

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

EIE2023/22 Nanophotonic passive cooling canopies

Supervisor: Dr Alex Song

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

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

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

MECHANICAL ENGINEERING PROJECTS

MECH2023/1 Characterization of switching dynamics in a potassium tantalate niobate (KTN) crystal

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:

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 **dependent on government's health advice.*

MECH2023/2 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*

MECH2023/3 Buoyant fires and their suppression by enhanced chemicals

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

Eligibility: This is open to final-year students only with HWAM>75.

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

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

MECH2023/4 Combustion of Green Fuels (Hydrogen and its derivatives)

Supervisors: Prof Assaad Masri, Matthew Dunn and Andrew Mcfarlane

Eligibility: This is open to final-year students only with HWAM>75

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

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

MECH2023/5 Three-phase turbulent fluid mechanics

Supervisor: Dr Agisilaos Kourmatzis

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

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

Requirement to be on campus: No

MECH2023/6 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*

MECH2023/7 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*

MECH2023/8 Making Strong Alloys Ductile and Hydrogen-Tolerant through Engineering hierarchical heterogeneous Nanostructures

Supervisor: Dr. Xianghai An

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

Project Description:
High-performance alloys are the backbone of decarbonising innovations in manufacturing, infrastructure, energy, and transportation. There is an accelerated demand for high-strength materials to produce lighter, more-reliable structural components. Stronger alloys will substantially improve mechanical and energy efficiencies, which can benefit our economy and environment directly. However, high-strength materials typically have low ductility and are more vulnerable to fracture. Furthermore, they are also susceptible to hydrogen embrittlement (HE) in many service environments for renewable energy applications such as hydrogen transportation and the bearings of wind turbines. Hydrogen-induced embrittlement can lead to unpredictable and catastrophic failures at relatively low applied stresses. These critical shortcomings cause serious safety concerns but cannot be readily addressed by traditional materials development approaches that generally render materials property trade-offs between strength and ductility/HE resistance.
Gradient structures are an emerging material-design paradigm inspired by nature that has great potential to overcome these alloy design trade-offs. This project aims to develop an innovative design strategy of gradient segregation engineering (GSE) to produce high-performance alloys by synergistically introducing a chemical gradient via grain boundary (GB) segregation and a physical gradient by nanostructure control. The novel GSE will entail a synergy of multiscale strengthening mechanisms that offer an exceptional strength-ductility combination and simultaneously enable the hierarchical HE-resisting mechanisms to notably enhance the hydrogen tolerance.

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

MECH2023/9 Architecting Superior Composites by advanced manufacturing

Supervisor: Dr. Xianghai An

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

Project Description:
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*

MECH2023/10 High speed remote sensing system for turbulence measurements on the Great Barrier Reef

Supervisor: Dr Nicholas Williamson

Eligibility: General programming skills. A strong interest in fluid mechanics.

Project Description:
This project aims to develop and test a high-speed sensor and data acquisition platform for remote measurement of turbulent flow and oxygen transport in the Great Barrier reef and inland rivers. The motivation is to understand the physical environment and better understand the impacts of climate change. Existing instrumentation systems are less accurate and at lower speed than what is required to make these world first measurements. The system would be built and tested in the AMME Environmental Fluid Mechanics laboratory. The work would involve integration of high-speed thermistors through a raspberry pi together with a high-speed camera and/or a high speed acoustic doppler current profiler. The project will involve a number of elements including coding (python), mechanical design, internal cooling system design, drawing and design of support frame. The work would be supported by a knowledgeable instrumentation officer and our research group including a PhD student, post-doc and honours students.

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

MECH2023/11 Characterizing optical properties of inhalation drug powders in Optical Coherence Tomography imaging

Supervisors: Dr. Agisilaos Kourmatzis and Dr. Taye Mekonnen

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

Project Description:
Optical coherence tomography (OCT) is a high-resolution and non-destructive imaging modality that has gained considerable attention in pharmaceutical applications such as quantitative evaluation of tablet coatings and *in-vitro* drug powder deposition. OCT relies on the backscattered light from sample microstructures, and hence, its imaging performance is significantly affected by the optical properties, mainly the refractive index and attenuation coefficient, of the sample. The attenuation coefficient, which characterizes the optical amplitude decay as a function of depth, limits the imaging depth of the drug powder deposition. Furthermore, the achievable imaging contrast, e.g., the ability to discern active pharmaceutical ingredients from carriers in powder blend, is determined by the difference in the refractive indices of the constituents. The aim of this study is, therefore, to characterize the optical properties of different inhalation drug powders and their associated physical properties including the morphology, size, and density of agglomerated drug powder.

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

MECH2023/12 Exploring the Effect of Mechanical Loading on HfO_2-Based Ferroelectric Microstructure

Supervisors: Professor Xiaozhou Liao and Dr. Ying Liu

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:

Ferroelectrics find wide-ranging applications in fields including information and communication technologies, medical imaging, and energy harvesting. HfO_2-based ferroelectrics show promise for future electronic device applications such as non-volatile memories and neuromorphic computing due to their compatibility with silicon technology and stable ferroelectric properties at the nanoscale. To predict their nanoscale properties and performance, it is crucial to understand how external stimuli affect the microstructures of these materials, including different phases, strain, and electric field distribution.
This project aims to investigate the impact of external mechanical loading on the microstructure of HfO_2-based ferroelectric single crystals. We will use advanced transmission electron microscopy techniques to capture atomic resolution images, which will then be analysed using Python-based coding methods. Our analysis will extract precise measurements of strain, strain gradient, phase distribution, and local electric field to obtain quantitative information on the effects of mechanical loading on the crystals' microstructure.

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

MECH2023/13 Optimization of dry-powder inhaler devices for improved treatment of asthma and pulmonary disorders

Supervisors: Dr Agisilaos Kourmatzis, Liam Milton-McGurk

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 you will investigate the flow through a range of commercial dry-powder inhaler devices integrated with realistic human upper airway models with the goal of improving pulmonary drug delivery.

Different inhaler devices will be considered, and the effect of transient versus steady inhalation profiles. The influence of such factors on key features of the flow associated with effective drug delivery will be investigated.

The research will predominantly use computational fluid dynamics (CFD) with a discrete phase model (DPM) in ANSYS to investigate the flow, with the potential for some lab-based experimental work.

The project is suitable for students from AMME and BME and is part of a larger research program aimed towards improving the design of inhaler devices.

Requirement to be on campus: No/optional **dependent on government's health advice*

MECHATRONIC ENGINEERING PROJECTS

MECHATRON2023/1 Surrogate Orbital Environment for Visual Satellite Docking

Supervisor: Dr Donald Dansereau

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

Project Description:
Working with researchers at the Australian Centre for Field Robotics, this project will develop a physical surrogate environment for visual satellite docking.

Docking with a disabled satellite entails dealing with hard shadows, bright highlights, complex albedo from the earth, and potentially large relative velocities. Dealing with these in visual docking requires us to develop novel imaging technologies.

This project will develop a scaled physical model that emulates the visual scenario of docking with a satellite in orbit. Depending on ability and interest, there are opportunities to work on physical model construction, illumination characterisation and engineering, and camera characterisation including development of perception algorithms for novel cameras.

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

MECHATRON2023/2 Active Monocular Depth Estimation

Supervisors: Danish Khan, Dr Donald Dansereau

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

Project Description:
Working with researchers at the Australian Centre for Field Robotics, this project will develop novel sensing technologies to enable robots to operate in new domains.

Monocular depth estimation is estimating the depth of objects in a scene using a single camera. It has critical applications in robotics, augmented reality, and autonomous driving.

You will work on the depth estimation problem using light patterns as an additional cue. A calibrated camera-projector system is assumed where a projector projects light-coded patterns, and a camera captures the deformed patterns. The deformed light pattern can be fed into a deep-learning model to estimate the depth map of the scene. The deep learning model will be trained using a dataset of images, and corresponding depth maps to learn the mapping between the input image and its depth.

You can also contribute to synthetic dataset generation. We will model a virtual camera-projector 3D sensing system to render the ground truth data for deep learning training.

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

MECHATRON2023/3 Edge computing for robotic inspection

Supervisor: Dr Viorela Ila

Eligibility: C,C++ Programming, some basic knowledge in Computer Vision and/or Robotics

Project Description:
Edge computing is an emerging technology that uses on-premise hardware and software to process and analyse data near the edge of the network. By delivering the processing power of the server directly to robotic platforms, we can optimize the way the data is collected in a robotic inspection mission.
NVIDIA Jetson AGX ORIN Developer Module is the world's leading platform for autonomous machines and other embedded applications. Jetson is compatible with the same AI software and cloud-native workflows used across other NVIDIA platforms and delivers the power-efficient performance need in many AI and robotic applications.
The scope of this project is to develop AI and robotics algorithms for object detection, mapping and localization that can run in real-time on an embedded platform. The students will acquire knowledge about robotics, real-time sensor data processing, parallel and embedded computing. They will have the flexibility to "play" with several sensing modalities and implement and test their algorithm or application of choice.

Requirement to be on campus: No

MECHATRON2023/4 Motion segmentation in the open world

Supervisor: Dr Viorela Ila

Eligibility: C,C++, Python Programming, some basic knowledge in Computer Vision and/or Robotics, Deep Learning

Project Description:
Motion Segmentation is the task of identifying the independently moving objects in the video (sequence of images) and separating them from the background.

Great number of researchers focused on this segmentation problem, however, performances of most of the existing algorithms is still fall far behind human perception or cannot achieve real-time performance.

This project will evaluate latest motion segmentation techniques and will research the use of geometric constraints alongside appearance cues in order to achieve object motion segmentation and tracking in open world.

Requirement to be on campus: No