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AEROSPACE ENGINEERING PROJECTS

AERO2020/1 Advanced Methods for Computations of Reacting Compressible Flows
Supervisor: A/Prof Ben Thornber
Eligibility: WAM>75
Project Description:
This project will focus on the advancement of numerical methods to solve compressible reacting flow problem, with a particularly focus on turbulent flows and detonations. The candidate should be passionate about numerical methods, fluid mechanics and reacting flows and keen to work at a research level. It aligns with existing projects in high speed propulsion within the group.
Requirement to be on campus: No

AERO2020/2 Advanced Methods for Computations of Wind Turbine Aerodynamics
Supervisor: A/Prof Ben Thornber
Eligibility: WAM>75
Project Description:
This project will focus on the advancement of numerical methods to solve for the unsteady aerodynamic flow past a wind turbine, using a newly developed computational fluid dynamics method. The overall goal would be a real time high fidelity tool – a world first.
Requirement to be on campus: No

AERO2020/3 Failure strength of quasi isotropic composite laminates
Supervisor: Prof Liyong Tong
Eligibility:WAM >79; knowledge and/or experience in experiments; familiar with finite element analysis software, e.g. NASTRAN, ANSYS.
Project Description:
Quasi isotropic composite laminates with unidirectional prepregs in zero, forty-five, negative forty-five and ninety degrees have been used as black metal with high specific stiffness and strength. The fibre contents and orientations play an important role in both stiffness and strength. In this project, the role of fibre distribution across the thickness direction will be investigated experimentally and numerically. In the experimental part, a number of quasi isotropic laminate specimens with different number of plies and different ply thickness will be tested. This will enable us to develop an understanding on the influence of ply orientation and geometries on failure strength and behaviour of quasi isotropic laminates with and without notches. In the numerical part, three dimensional finite element analyses will be conducted to develop an understanding on the role of fibre distribution in the thickness direction on the interlaminar stresses and failure loads. The experiments will be conducted on campus, whereas the numerical part can be conducted off campus.
Requirement to be on campus: No/Yes (dependent on government’s health advice)

AERO2020/4 Development of A Satellite Simulation Platform
Supervisors: Dr. Xiaofeng Wu and Dr. Youngho Eun
Eligibility Criteria: Senior Space Engineering students will be preferred.
Project Description:
At AMME, we are developing a new concept for hardware-in-loop simulation using the satellite simulator (hardware) and virtual reality (software). For this research internship
program, we are seeking potential students with skills in mechanical structures, embedded systems, propulsion, dynamics and control to develop and test the satellite simulator. The simulator will be levitated by an air cushion, which minimizes the friction and allows the simulator to move freely on a 2m by 3m granite bench. The simulator will also equip with a 5DoF air-bearing table to emulate the micro-gravity environment in orbit. We are aiming to develop two such simulators to demonstrate missions that require cooperative control like formation flying, docking, in-orbit servicing and so on. The preference will be given to students who are willing to continue this research for the honour theses / higher degree research, in which innovative research will be carried on using the platform.

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

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**BIOMEDICAL ENGINEERING PROJECTS**

**BME2020/1 Development of a fat-muscle multilineage cultured meat product**

**Supervisor:** Prof Hala Zreiqat

**Eligibility Criteria:** 3rd year (Desired); Cell culture training, competent with software MATLAB.

**Project Description:**
Cultured meats have transformative potential to substitute meat products and alleviate their hugely significant and extremely damaging effects on our planet. We have developed 3D printing technology able to fabricate high-resolution, complex three-dimensional structures capable of supporting growth of multilineage tissues constructs from single-cell-sources.

Applying this technology to develop a cultured meat product addresses the major limitation of current meat products: they lack flavour and texture, as a result from their single cell source, and scaffold/culture methods that are unable to support simultaneous fat-muscle growth. This project will use 3D printer technology to fabricate cultured meat scaffolds that support multilineage fat-muscle integration addressing this limitation.

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

**BME2020/2 Microfluidic biochip fabrication and haemodynamic analysis with micron resolution particle image velocimetry (mPIV) for blood clotting**

**Supervisors:** Dr Lining Arnold Ju (ARC DECRA, NSW Tall Poppy of the Year), NHF Future Leader, Sir Zelman Cowen Investigator

**Eligibility Criteria:** Capability of using two or more of ImageJ, Micro Manager, AutoCAD, Cell Sens, Labview, ANSYS, MATLAB, SOLIDWORKS, Comsol, Abaqus and other CFD or Microscope controller 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:**
Excessive clotting (thrombosis) leads to the cardiovascular diseases such as heart attack and stroke—the No.1 world-wide killer, killing one Australian every 12 minutes. It has long been recognized that platelets play a central role in thrombosis and are unique in their ability to form stable adhesive interactions under conditions of rapid blood flow. We have recently discovered a new ‘biomechanical’ prothrombotic mechanism that highlights the remarkable platelet sensitivity to the shear stress gradients of blood flow disturbance. Importantly, we found that the current anti-thrombotic drugs such as Aspirin, Plavix® or Brillinta®, have limited effect against this biomechanical thrombosis.
To address this pressing need, we are developing simple-to-use, high-throughput and highly informative microfluidic biochips using soft lithography in corporation with USYD research and prototype foundry (RPF) cleanroom, to understand sequences of molecular events underlying biomechanical thrombosis (mechanobiology). We are also developing micron resolution particle image velocimetry (µPIV) to correlate the haemodynamic parameters with thrombotic phenotypes, utilising the cutting-edge Olympus FV3000 confocal system with deep collaboration with Olympus engineering team. Besides, the high speed, back illuminated Kinetix Scientific CMOS (sCMOS) camera platform is established for particle tracking, delivering the fastest speed and the largest field of view with the most balanced pixel size and near perfect 95% quantum efficiency. We are assembling a team of bioengineers and clinicians at the newly launched Biomedical Engineering School and Sydney Manufacturing Hub. Candidates are expected to maintain collaborations with Olympus professional microscope team and RPF soft lithography cleanroom, bridge the research results to the optimisation of microfluidics design (AutoCAD) and fabrication (soft lithography). The anticipated outcome could translate into point-of-care tools that facilitate physicians’ decisions on diagnosis, follow disease progression, optimise treatment courses, or even deploy on ambulance to improve patient care.

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

**BME2020/3 Computational fluid dynamics simulation and 3D imaging reconstruction for blood clotting, vasculature and microfluidics**

**Supervisors:** Dr Lining Arnold Ju (ARC DECRA, NSW Tall Poppy of the Year, NHF Future Leader, Sir Zelman Cowen Investigator)

**Eligibility Criteria:** The capability of using two or more of ANASYS, Comsol, Labview, AutoCAD, MATLAB, 3D-max, PRO-E, SolidWorks, ZEMAX 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.

**Project Description:**

Excessive clotting (thrombosis) leads to the cardiovascular diseases such as heart attack and stroke—the No.1 world-wide killer, killing one Australian every 12 minutes. It has long been recognized that platelets play a central role in thrombosis and are unique in their ability to form stable adhesive interactions under conditions of rapid blood flow. We have recently...
discovered a new ‘biomechanical’ prothrombotic mechanism that highlights the remarkable platelet sensitivity to the shear stress gradients of blood flow disturbance. Importantly, we found that the current anti-thrombotic drugs such as Aspirin, Plavix® or Brilinta®, have limited effect against this biomechanical thrombosis.

To address this pressing need, we are developing high resolution vessel and clots imaging and extraction approaches to replicate the complicated physiological structures (3D reconstruction), and computational fluid dynamics (CFD) simulation to correlate the haemodynamic parameters with thrombotic phenotypes. Furthermore, the results could be used for developing microfluidic biochips using soft lithography in corporation with USYD research and prototype foundry (RPF) cleanroom, to understand sequences of molecular events underlying biomechanical thrombosis (mechanobiology). We are assembling a team of bioengineers and clinicians at the newly launched Biomedical Engineering School and Sydney Manufacturing Hub with the cutting-edge Olympus FV3000 confocal system.

Candidates are expected to maintain collaborations with Olympus professional microscope team and RPF 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.

Requirement to be on campus: No

BME2020/4 Instrumenting Biomembrane Force Probe (BFP) biomechanical nanotool that harness cytoskeletal forces to enhance T-cell cancer killing and immunotherapy

Supervisors: Dr Lining Arnold Ju (ARC DECRA, NSW Tall Poppy of the Year, NHF Future Leader, Sir Zelman Cowen Investigator), Dr Peyman Obeidy

Eligibility Criteria: Eligible candidate should be capable of using two or more of these software: Labview, SolidWorks, AutoCAD, MATLAB, 3D-max, PRO-E, ZEMAX. Also have a knowledge of Image processing tools such as ImageJ, Python and 3D illustration tools. Preference is given to applicants who have a strong interest in the biophysical instrumentation and treatment of cancer diseases.

Project Description:
Nobel Prize in Medicine & Physiology 2018 was awarded for Cancer Immunotherapy—development of T cells with optimised response of killing cancer. However, there is a major challenge in the field that activated T-cells produced in immunotherapy can also kill normal cells causing adverse-side-effect or death.
Recent studies showed that T cells utilise mechanical force distinguishes between 'self'- or cancer cell-based as well as for their activation. Such mechanobiology is elusive at molecular level due to the technical difficulties and lack of biomechanical nanotools. Ju lab aims to integrate its own invention of cutting-edge BFP technology (Nature Communications 2014, 2018; eLife 2016) with 4D confocal/super-resolution microscopies (Nature Materials 2019) to capture the T-cell cancer killing moments, visualise the molecular behaviours at the T-cell/Tumour cell interface and examine the regulatory role of T-cell cytoskeletal force. On the translation side, Ju Lab ‘BFP’ technology has been used to evaluate clinically approved PD-1 drugs (Nivolumab, Pembrolizumab and Camrelizumab) (Nano Letters 2020). This project outcome will generate computerised and automated data/image processing towards cancer immunotherapeutic drug screening.

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

BME2020/5 Digital Single-Molecule Biophysics: Molecular Dynamics simulation and Bioinformatics analysis for COVID-19 viral protein dynamics

**Supervisors:** Dr Lining Arnold Ju (ARC DECRA, NSW Tall Poppy of the Year, NHF Future Leader, Sir Zelman Cowen Investigator)

**Eligibility Criteria:** Capability of using two or more of VMD, NAMD, PyMol, AutoDock, Labview, GROMACS, MATLAB, AMBER, CHARMM, TINKER, OpenMM and other Molecular Dynamics simulation software; Candidates with experience with High Performance Computer and passion to contribute to the research of COVID-19 are preferred and have priority.

**Project Description:**
Since the first reports of Coronavirus disease 19 (COVID-19) from December 2019, it rapidly spread in humans and spilled to over 200 countries within 3 months and caused a significant impact to global health and economy. The virus, SARS-CoV-2 infects host cells via its spike protein(S) receptor-binding domain (RBD) binding to human angiotensin-converting enzyme 2 (ACE2). We have recently discovered that artificial ACE2 mutant provides higher simulated affinity to S protein. Therefore, our idea is to block the viral binding to ACE2 with designer drugs has the potential to inhibit the coronavirus from entering human cells. Importantly, we believe that blocking strategies of the virus–host should be tailored to virus mutations by various country sources and passing generations.
In order to contribute to the drug screening process, we are developing a supercomputer based *in silico* simulated approach to select high-affinity candidates for experiments, using the USYD High-Performance-Computer (HPC) Molecular Dynamics (MD) platform. We are also developing protein-protein docking and bioinformatics studies on viral genome sequence alignment and amino acid translation using newly established local High-end PCs at School of Biomedical Engineering. Overseas collaborations are ongoing with Penn State Uni, USA and Zhejiang Uni, China. Statistic tools such as MAFFT (Multiple Alignment using Fast Fourier Transform) will be implemented on alignment of different sequences against the binding section of SARS-CoV from worldwide database.

We are targeting talents with interests and background in computational biology, GitHub programming and high-performance computing. Please send us your application if you are interested in computational biology, molecular simulations and bioinformatics.

**Requirement to be on campus:** No

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**BME2020/6 Optical artefact correction for wearable electronic brain-sensing**

**Supervisor:** Dr Omid Kavehei

**Eligibility Criteria:** Basic experience in electronic circuits and systems and previously done at least breadboard level circuit implementation.

**Project Description:**
Improved artefact removal plays a crucial role in the efficacy of biomedical signal processing is conducted with variety of techniques such as deep learning signal processing, in this project we employ an optical correction system for artefact recorded on electroencephalogram (EEG) signals that are electronically recorded.

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

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**BME2020/7 Sleep enhancement for newborn babies**

**Supervisor:** Dr Omid Kavehei

**Eligibility Criteria:** Interested and have fundamental experience in programming.

**Project Description:**
This project aims to develop a proof-of-concept sleep enhancement device for newborn babies and accompanying business plan. New evidence suggests disrupted sleep impairs healthy brain development in newborn babies, yet most newborns in hospital remain chronically sleep deprived. Pharmaceutical methods of enhancing sleep have terrible side-effects and nonpharmacological methods typically have little effects.
Like adults, newborn sleep consists of distinct “stages” characterised by different brain activity. The two key sleep stages in newborns are called active sleep and quiet sleep. Active sleep (AS) is essential for the growth of the nervous system and similar to rapid eye movement (or REM sleep) in adults. Quiet sleep (QS) promotes the replenishment of energy reserves and is analogous to deep sleep in adults. The defining feature of deep sleep (and QS in newborns) is a type of brainwave called “slow-waves” which can be measured using surface EEG sensors placed on the head. Abnormal slow-waves are common in preterm and critically ill newborns and thought to be associated with impaired brain development.

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

**BME2020/8 High definition neurostimulation for enhancing brain health**

**Supervisor:** Dr Omid Kavehei

**Eligibility Criteria:** Interested and have fundamental experience in programming and basic electronic hardware design experience.

**Project Description:**
Transcranial electrical stimulation (tES) or neurostimulation has rapidly gained popularity within clinical research due to its ability to treat a variety of disorders by gently stimulating different brain regions to enhance neuroplasticity. The number of clinical trials using tDCS and exponentially increased since 2010 and is beginning to be adopted within clinical practice. This project will focus on developing a headset capable of delivering each of those treatments through a single design. This “universal” approach to neurostimulation is a critical step to creating a platform technology, which will allow researchers to discover high-impact treatments and clinicians to deliver them. One promising application for this technology is cognitive enhancement, as recent research has shown that neurostimulation can reverse memory loss in older adults if the current is personalised to the participant’s unique brain structure and activity.

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

**BME2020/9 Matching White Matter Axon Tracts across Individuals**

**Supervisor:** Jinglei Lv, Fernando Calamante

**Eligibility Criteria:** Programming skills with C++, Matlab or Python are desired.

**Project Description:**
With diffusion MRI, we are able to trace the axon fibers in the brain white matter. Although a certain level of variability exists, we still believe that there are a substantial amount of fiber bundles/tracts that are common across subjects. Thus, matching the fiber bundles across subjects could help us understand the common architecture of white matter in the human brain. The correspondence realized by the tract matching is beneficial for any tract-based statistics, e.g., functional connectivity on tract. This project answers an important question of human brain mapping. Research on this topic could benefit cognitive neuroscience and help understand the white matter brain pathology of certain diseases.

https://github.com/ohbm/hackathon2020/issues/204

**Requirement to be on campus:** No
BME2020/10 Game development to enable Voice recordings for children with cerebral palsy and dysarthria

**Supervisor:** Dr. Petra Karlsson, Prof. Alistair McEwan

**Eligibility Criteria:** Programming experience and game design desirable

**Project Description:**
Communication is at the very heart of who we are as people. However, for 50% of children with cerebral palsy (CP), using speech to talk to their family and friends is difficult or impossible. For many, their challenges producing speech, described as dysarthria, often masks their capability to understand speech. For those with moderate to severe dysarthria, their speech is especially difficult to understand. Children with CP often rely on technology solutions, which translate composed text or symbols to speech, and frequently access this technology via a single switch. Single switch use usually requires the child to scan through a hierarchy of command menus to arrive at the target function. This can be a slow and arduous process. On average, a child with CP’s communication rate, using available communication technologies, is 10 words per minute compared to 150-200 words per minute for those children who can speak. With artificial intelligence such as machine learning and natural language processing becoming more widely used, voice recognition and video analysis for children with CP needs to be explored. Speech recognition to control assistive technology is not new. However, commercially available recognition algorithms e.g. Siri, Alexa, breakdown even when dysarthria is mild. To address this challenge a few research databases with <20 adult voices with CP have been established, but none, that we are aware of, for children under the age of 16.

**Aim:** To develop an engaging platform or app that can collect and store voice recordings from children aged 8 and older with cerebral palsy remotely.

**Objectives:**
1. Develop a game with several levels that engages the child to read “The Caterpillar” text.
2. Identify how to optimise the recordings – what minimal technology will be required for remote recording and to enable future voice analysis.

“The Caterpillar”

Do you like amusement parks? Well, I sure do. To amuse myself, I went twice last spring. My most MEMORABLE moment was riding on the Caterpillar, which is a gigantic rollercoaster high above the ground. When I saw how high the Caterpillar rose into the bright blue sky I knew it was for me. After waiting in line for thirty minutes, I made it to the front where the man measured my height to see if I was tall enough. I gave the man my coins, asked for change, and jumped on the cart. Tick, tick, tick, the Caterpillar climbed slowly up the tracks. It went SO high I could see the parking lot. Boy was I SCARED! I thought to myself, “There’s no turning back now.” People were so scared they screamed as we swiftly zoomed fast, fast, and faster along the tracks. As quickly as it started, the Caterpillar came to a stop. Unfortunately, it was time to pack the car and drive home. That night I dreamt of the wild ride on the Caterpillar. Taking a trip to the amusement park and riding on the Caterpillar was my MOST memorable moment ever!

**Requirement to be on campus:** No

BME2020/11 Biomechanical-neural model and simulated robots

**Supervisor:** Prof. Alistair McEwan

**Eligibility Criteria:** Physics, engineering and coding. Some background or interest in biology.

**Project Description:**
Cerebral Palsy is the most common physical disability of childhood that leads to lifelong implications for families and society. The cause is complex and often unknown but relates to a brain injury or malformation. Early intervention (as young as possible) and intense therapy has been shown to benefit and promote neuroplasticity. Biomechanical models such as OpenSim [https://simtk.org/projects/opensim](https://simtk.org/projects/opensim) are used in adults to best inform therapy and in some cases have been modified with neural parameters for spinal cord injury or stroke. Simulated robots appear to use strategies we see in humans to learn to walk.
Could biomechanical-neural models of infants be used to develop therapies such as soft exoskeletons? Ideally, we are looking for something where neural parameters could be changed to simulate neurodevelopment in cerebral palsy. This could link into the work going on around spinal cord stimulation in cerebral palsy.

**Requirement to be on campus:** No

**BME2020/12 Reconstruction algorithms for preclinical PET/MR imaging**

**Supervisor:** Georgios Angelis, Fernando Calamante

**Eligibility Criteria:** Advance programming skills (C/C++ and/or Matlab)

**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 a number of sources pertaining to data acquisition and image reconstruction. Incorporation of high-resolution MR information within iterative PET image reconstruction algorithms can substantially improve image quality.

In this project, a custom MR-guided PET image reconstruction algorithm will be developed dedicated to a preclinical PET/MR scanner located at the Brain and Mind Centre, aiming to improve resolution and/or noise of the reconstructed images. The quality and quantitative accuracy of the reconstructed images will be assessed with experimental phantom (and potentially animal) data acquired on the scanner, as well as against images reconstructed with the manufacturer’s software.

**Requirement to be on campus:** No

**BME2020/13 Effect of white matter fibre architecture on human cortical MRI properties using Track Weighted Imaging**

**Supervisor:** Tonima Ali, Fernando Calamante

**Eligibility Criteria:** Basic programming skill

**Project Description:**
A whole-brain fibre-tracking dataset (tractogram) generated from diffusion MRI provides valuable insight on white matter architecture, and can be exploited by track-weighted imaging (TWI) for brain mapping. TWI can incorporate various MRI contrasts to assess specific properties of brain with super resolution. Much is yet to be known about the inter-play between white matter and grey matter, and TWI provides a powerful framework to address that.

This study will focus on evaluating the influence of white matter fibre architecture on the patterns of MRI properties in the brain cortex. It will use retrospective diffusion MRI data from healthy subjects and tractograms with millions of streamlines throughout the brain. MRI parameters sensitive to tissue architecture will be studied using TWI, and those will then be projected on the cortex. Finally, the correspondence between the resulting various cortical patterns will be evaluated and compared to known patterns (e.g. myelin-related patterns).

**Requirement to be on campus:** Yes

**BME2020/14 Rapid prototyping of medical Personal Protective Equipment (N95 transparent face masks) to improve healthcare communication during a medical emergency**

**Supervisor:** Anna Paradowska, Luke Gordon

**Eligibility Criteria:**
- CAD modelling (Solidworks or similar) ability
- 3D printing ability
- Basic knowledge of medical sciences and medical regulatory standards
- Knowledge of recycling of plastics and biodegradable materials

**Project Description:**
COVID-19 has already set a global precedent that will alter the approach countries take to supplying Personal Protective Equipment (PPE) for their medical frontline. PPE is the primary controllable risk factor protecting healthcare workers (HCWs) from illness, which in turn governs a country’s capacity to respond to a global medical emergency. Illness amongst HCWs has crippled our global medical response to COVID-19 by creating an unbreakable cycle which reduces our global capacity to test, diagnose, treat and greatly exacerbates...
civilian infection rates as a result. In order to reduce HCW infection rates in a novel disease context, PPE must adapt quickly to new information of transmission routes and be in domestic supply.

Students will work to rapidly prototype transparent & reusable N95 face masks, in collaboration with Royal Prince Alfred Hospital, to improve communication amongst clinicians and their patients (especially those patients reliant on lip-reading and facial presentation) and healthcare teams.

**Requirement to be on campus:** Yes

### CHEMICAL AND BIOMOLECULAR ENGINEERING PROJECTS

**CBE2020/1 Production of alcohols from carbon dioxide**

**Supervisor:** Dr Fengwang Li

**Eligibility Criteria:** Experience in the following subjects would be advantageous: Chemistry, Chemical Engineering, Materials Science and Technology.

**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.

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

**CBE2020/2 Can we make money from carbon dioxide?**

**Supervisor:** Dr Fengwang Li

**Eligibility Criteria:** Experience in the following subjects would be advantageous: Chemical Engineering, Computer Science, or Mathematics.

**Project Description:**
Carbon dioxide (CO2) is a greenhouse gas causing global warming and climate change. What can we do to deal with the CO2 challenge? Instead of letting it go or burying it underground to let our descendant deal with it, scientists are developing various techniques to capture, store, and utilise CO2. But which way can make the most use of CO2, i.e., can we make money from dealing with CO2? This project will compare the economic aspects of emerging CO2 techniques. The project aims to provide – by doing technoeconomic assessment – a guide to which ways the future CO2 technique should go.

**Requirement to be on campus:** No

**CBE2020/3 Techno-economic assessment of aqueous zinc-ion batteries and capacitors for energy storage applications**

**Supervisor:** Yuan Chen

**Eligibility Criteria:** Year 2-4 students with basic chemistry lab experiences before are preferred.

**Project Description:**
Zinc-ion batteries and hybrid electrochemical capacitors use zinc ions (Zn²⁺) as the charge carriers. It was first reported in 2011, using manages dioxide as a host for Zn²⁺. They show good energy storage capacity and reversibility. Companies in Canada and the USA are commercializing zinc-ion based energy storage technologies. Based on a comprehensive patent and literature survey and our research results, this project will carry out a techno-economic assessment of aqueous zinc-ion batteries and capacitors for different energy storage applications, including electric vehicles, grid-scale energy storage, and wearable devices. The advantages and disadvantages of aqueous zinc-ion batteries and capacitors will be evaluated. Critical technical challenges for their commercialization will be identified.
Requirement to be on campus: Yes (dependent on government’s health advice)

CBE2020/4 Carbon catalysts for energy conversion applications – a techno-economic assessment

Supervisor: Yuan Chen

Eligibility Criteria: Year 2-4 students with necessary chemistry lab experiences before are preferred.

Project Description:
Several critical energy conversion applications, such as hydrogen fuel cells, metal-air batteries, and hydrogen production by water splitting, all require efficient catalysts. Current catalysts, based on noble metals, such as platinum, are expensive and non-sustainable. Recent scientific research has reported carbon catalysts with superior catalytic performance. However, their industrial usages are still limited. Based on a comprehensive patent and literature survey and our research results, this project will carry out a techno-economic assessment of practical applications of carbon catalysts in fuel cells and water electrolyzers. The advantages and disadvantages of carbon catalysts will be evaluated. Critical technical challenges for their commercialization will be identified.

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

CBE2020/5 Designing and simulating novel materials for heart valves

Supervisors: Prof. David F Fletcher, Dr. Sina Naficy

Eligibility Criteria: Interest in materials and simulation. Experience with Ansys Mechanical would be beneficial but not essential.

Project Description:
A multi-faceted research team is developing implantable heart valved conduits that can be used in cardiac surgery and grow with a child avoiding multiple surgical interventions. To mimic the biological performance of natural heart, the artificial valved conduits will be made of multiple materials with hierarchical architectures. Given their complexity, it is necessary to predict artificial conduits’ properties computationally. Thereby, this summer project aims to numerically model the mechanical behaviour of these complex constructs. The participant will learn about material design and modelling. Complex multi-layer materials will be constructed computationally, and their properties modelled using Ansys FEA software. Simulated results will be compared with experimental results obtained from mechanical testing of 3D printed test samples. Once validated, the model will be used to correlate the mechanical behaviour of conduits with their 3D geometry and material attributes to explore a wide range of design ideas in a highly efficient manner.

Requirement to be on campus: No

CBE2020/6 Data mining and analysis of microfiltration and ultrafiltration membrane performance: permeability and selectivity trade-off trend

Supervisors: Dr David Wang and Dr Jia Ding

Eligibility Criteria: Literature review research skill and 3rd/4th year chemical engineering students are suitable.

Project Description:
Literature on the MF/UF membrane permeability and selectivity relationship is virtually non-existent, despite the overcrowded empirical data have been reported for various types of pollutant models. This project will systematically mine the existing literature data on MF/UF membrane performance and correlate with the membrane pore size and surface wettability to uncover detail insight into this trade-off relationship that are critical to the research and development applications of all new and commercially-available MF/UF membranes.

Required to be on campus: No
CBE2020/7 Structural-property criteria of intermediate layer development for thin-film gas separation membranes

**Supervisors:** Dr David Wang and Dr Jia Ding

**Eligibility Criteria:** Literature review research skill and 3rd/4th year chemical engineering students are suitable.

**Project Description:**
Intermediate layer is an important requirement for the production of an extremely thin and smooth, defect-free membrane for gas separation. It is critical to ascertain high-quality intermediate layer to support the separation top-layer to obtain superior membrane gas flux and selectivity. Despite much research advancement has been made to control the top-layer membrane pore size to solve structural and performance issues, the technology transfer of thin-film gas separation membranes is continued to be hindered by the challenges of controlling the topology and structural integrity of the underlying layer. This project will critically review the intermediate layer development in the literature and propose new requirement criteria for microporous membranes for gas separation applications.

**Required to be on campus:** No

CBE2020/8 Stretch goals for the cost of CO₂ Capture, Transport and Storage

**Supervisors:** Dr Gustavo A Fimbres Weihs, Prof Dianne Wiley

**Eligibility Criteria:**
- Essential: Some background in chemical or process engineering or equivalent
- Strong mathematical and data analysis skills
- The ability to work well with others in a team
- Excellent oral and written communication skills

- Desirable:
  - Experience in performing Techno-Economic Analyses
  - Ability to gather and interpret information from a range of sources

**Project Description:**
CO₂ capture and storage (CCS) is an important greenhouse gas mitigation technology. The investment in low emissions technology is a key priority on the road to recovery from COVID-19 in Australia. As such, setting economic stretch goals for priority low emissions technologies can help accelerate the competitiveness of such technologies. This project aims to analyse recently reported cost data for all the components of the CCS chain, particularly for emerging and viable technologies, and use these data to estimate the expected current costs for CCS in the Australian context. Furthermore, technology learning curves will be employed to provide educated estimates of the future costs of each of those components by 2040, thus assisting in proposing achievable stretch goals for CCS in Australia.

**Requirement to be on campus:** No

CBE2020/9 Smart linings for Pipe and Infrastructure

**Supervisor:** Marjorie Valix

**Eligibility Criteria:**
- Excellent academic aptitude, WAM >75
- Strong analytical and STEM skills
- Excellent technical writing and presentation skills
- Strong problem solving skills and the ability to use initiative

**Project Description:**
The work will support current research, testing and experiments being conducted as part of the “Smart linings for Pipe and Infrastructure”, which is funded by the Cooperative Research Centre Projects (CRCP).

This will include field, accelerated corrosion testing of specialty concrete including geopolymers and calcium aluminate cement concrete and assessment of micro- and macroproperties of the concrete. The results will be used to develop smart water infrastructure design and advanced asset management tools.

**Requirement to be on campus:** *dependent on government's health advice*
CIVIL ENGINEERING PROJECTS

CIVIL2020/1 Service life prediction of infrastructures with machine learning
Supervisor: Ali Hadigheh
Eligibility Criteria: Basic knowledge of programming.
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

CIVIL2020/2 Structural application of recycled fibre reinforced polymer (rFRP) composites
Supervisor: Ali Hadigheh
Eligibility Criteria: Basic knowledge about composite materials
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: No

CIVIL2020/3 3D printing technologies for development of innovative solutions in the construction industry
Supervisor: Daniel-dias-da-Costa
Eligibility Criteria: WAM>75
Project Description:
This project will explore different possibilities of using 3D printing technologies for enhancing the construction industry. The candidate will have the freedom to propose and explore new concepts and ideas, for example, based on auxetic materials to achieve enhanced performance. Interestingly, auxetic materials are capable of increasing their size/volume when loaded in compression, which is an unexpected and instrumental behaviour for high-end structural applications. This project will include a literature review on recent advancements and the exploration of ideas through computational mechanics, and possibly small testing.
Requirement to be on campus: No

CIVIL2020/4 Strengthening of composite cementitious materials using carbon polymers
Supervisor: Daniel-dias-da-Costa
Eligibility Criteria: WAM>75
Project Description:
Many existing structures are approaching the end of their service life. As such, innovative solutions are being sought to upgrade them for further use. This may require the development of strengthening techniques, for example based on CFRPs, that can quickly establish the required strength and serviceability conditions. This project will explore the advanced optimisation algorithms with the state-of-the-art computational modelling tools to optimise the constitutive models and achieve the best possible performance of structures.
Requirement to be on campus: No

CIVIL2020/5 Development of phononic crystals and metamaterials
Supervisor: Daniel-dias-da-Costa
Eligibility Criteria: WAM>75

Project Description:
This project will explore the use of metamaterials and phononic structures for civil engineering applications. These engineered materials have been successfully used for many different applications, ranging from energy harvesting to the protection of buildings and cities by capturing/filtering the propagation of seismic waves. The candidate will study those materials and develop new ideas for possible applications. The project could include the development of advanced computational models, as well as small tests as proof of concept.

Requirement to be on campus: No

CIVIL2020/6 Building neighbourhoods for healthy kids
Supervisor: Emily Moylan

Eligibility Criteria: Previous experience or willingness to learn regression modelling.

Project Description:
Recent population growth in Australian cities has caused an increase in demand for educational infrastructure. In many places, playground space has been forsaken for demountable classrooms that can adjust to rapidly changing enrolments. Previous research and commentary have raised concerns about the reduction in play space and impacts on the students’ health. However, the rapid growth in enrolment is often accompanied by local built environment impacts from population growth such as increased traffic volumes and loss of green space.

This project looks at how attributes of the built environment impact the way that students travel to and from school, how they participate in active play and key health indicators related to diet and physical skills. It will include the gathering and processing of data about the built environment around schools in New South Wales. Expected findings will contribute to policy recommendations for urban planning, educational infrastructure, and travel behaviour.

Requirement to be on campus: No

CIVIL2020/7 Demand prediction in E-hailing services
Supervisor: Mohsen Ramezani

Eligibility Criteria: Computer programming (preferably Matlab and/or Python); Knowledge of data analysis; Interested students should contact mohsen.ramezani@sydney.edu.au before applying.

Project Description:
E-hailing companies (e.g. Uber, Didi) provide disruptive mobility services that act as a two-sided market, enabling self-scheduling contractors (drivers) to be matched with travel requests of passengers. Predicting the travel demand is essential to enable proactive operational solutions for the e-hailing platforms. Recent advances in data analytics and artificial intelligence such as deep learning methods can be used for demand prediction of e-hailing services in cities. This project tries to develop new methods to cluster the city into different neighbourhoods and predict the time-series of e-hailing travel demands based on real-world data.

Requirement to be on campus: No

CIVIL2020/8 Bio-Reinforcement of Soil
Supervisor: Guien Miao

Eligibility Criteria: WAM>75

Project Description:
Traditional soil slope reinforcement methods (such as steel-mesh, concrete and rock-wall) are expensive, harmful to the environment and are often aesthetically unsatisfactory. In response to this, bio-reinforcement of soil slopes has increasingly become popular. This project will involve simulating the reinforcement behaviour of plants in soil to compare with existing experimental data and improve our understanding of how plant roots reinforce soil.

Requirement to be on campus: No
CIVIL2020/9 Sustainability of University air travel

Supervisor: Emily Moylan
Eligibility Criteria: WAM>75

Project Description:
Air travel, particularly overseas, is often seen as an essential aspect of University business, but recent commentary has highlighted the heavy personal, financial and environmental burden of these activities. Virtualisation of meetings spurred by the Covid-19 pandemic has shifted the way that individuals and organisations view the necessity of face-to-face interactions. In the 2020 Sustainability Strategy, the University of Sydney has set targets for a 20% reduction in the number of kilometres flown on University business by 2025. This project attempts to collect baseline evidence from the University about how much air travel is undertaken and why. The candidate will bring together up-to-date research on the costs and benefits of air travel with context from locally collected data. The project is an opportunity to collaborate with interested parties across the University of Sydney and draw conclusions with potential relevance to other institutions or industries.

Requirement to be on campus: No

ELECTRICAL AND INFORMATION ENGINEERING PROJECTS

Telecommunications Engineering

EIE2020/1 Deep learning for Wireless Communications in Industrial 4.0
Supervisors: Prof. Yonghui Li

Eligibility:
- Bachelor degree in Telecommunications, electrical engineering, and related areas
- Outstanding transcript or publication record (Top 5%)
- Familiar with Python (PyTorch, Tensorflow, or Keras) and Matlab
- Research experience in wireless communications or deep learning (preferred)

Project Description:
The fifth generation (5G) wireless communication systems should provide real-time, reliable, and safe connections for Industrial Internet-of-Things (IIoT) in the era of Industrial 4.0 – the 4th industrial revolution. Such an ambitious goal brings unprecedented challenges to 5G system design. Existing approaches to communication system design rely on the theoretical models and ideal assumptions, which may not hold in different vertical industries of 5G, such as autonomous vehicles, industrial robots, augmented realities, etc. To handle the model mismatch, wireless networks should be intelligent to adjust themselves in dynamic environments, explore unknown optimal policies, and transfer domain knowledge to practical systems.

We propose to integrate domain knowledge into deep learning for wireless network design. However, the combinations are not straightforward. The scalability, transference, and learning efficiency remain as the bottlenecks. To handle these issues, we will investigate how to apply graph neural networks, transfer learning, and knowledge-assisted deep learning.

Requirement to be on Campus: No

EIE2020/2 Wireless Localization
Supervisor: Yonghui Li

Eligibility: Open to third or fourth year undergraduate or postgraduate students.

Project Description:
With the rapid deployment of Internet of Things (IoT), location-based services becoming more popular in various application scenarios like augmented reality (AR), health care monitoring, personnel tracking and inventory control in industry automation. The student will involve in the design and development of ultra-high accuracy wireless localization system with cutting edge artificial intelligent (AI) and multiple antenna technology in mmWave.

Requirement to be on Campus: Yes
EIE2020/3 WiFi Localization
Supervisors: Yonghui Li, Yifan Gu, Zhanwei Hou
Eligibility: Basic knowledge of Linux Operating System, Basic knowledge of C++ and Python, Basic knowledge of WiFi mechanism

Project Description:
The project targets on wireless indoor positioning systems (IPS) for various applications such as campus-wide localization, targeted advertisement in supermarkets, and shopping mall navigations. Commercial off-the-shelf WiFi devices are used for the wireless interface in the designed IPS. Students will be focusing on the implementation of the IPS in terms of hardware modification and software algorithm realisation.

Requirement to be on campus: Yes

EIE2020/4 AI-Based Robotics
Supervisors: Wanchun Liu and Yonghui Li
Eligibility: Familiar with Python or Matlab

Project Description:
In the project, we will work on developing AI-based computer vision and robot control methods to make robot arms intelligently complete different real-world tasks, such as pick-and-place in warehouse automation and waste sorting in waste management centres.

Requirement to be on campus: Yes

EIE2020/5 Preventing Security and Privacy Attacks in IoT Communication Systems
Supervisors: Dr. Phee Yeoh, Dr Wibowo Hardjawana and Prof. Branka Vucetic
Eligibility: Matlab and C programming skills. Good understanding of Internet-of-Things and Telecommunications.

Project Description:
The security and privacy of wireless data transmissions are major challenges in large-scale distributed Internet-of-things (IoT) systems. This project will design and evaluate novel lightweight algorithms to prevent attacks in the physical and networking layers. We will also consider the use of advanced theoretical models using machine learning and distributed blockchains to improve the reliability and latency of IoT communication systems.

Requirement to be on campus: Yes

EIE2020/6 Theoretical Analysis of Communication-Efficient Federated Learning
Supervisor: Mahyar Shirvanimoghaddam
Eligibility: Solid background in mathematics and machine learning with good programming skills

Project Description:
Current machine-learning techniques are complex which inhibit their deployment on many devices due to restricted memory and computational power. This project aims at designing simple learning tools to enable on-the-device analytics via federated learning. In federated learning, each device performs local learning and send only the model parameters to the edge device. The edge device will aggregate the local model parameters and send it back to the devices. A few rounds of message exchange are required to achieve convergence. Most current work in this area assume perfect communication channels between the devices and edge node, which is not realistic. In this project, we consider wireless channel between the nodes and model the convergence of the federated learning under noisy channel conditions. We will also devise novel algorithms to guarantee convergence in presence of channel impairments.

Requirement to be on campus: Dependent on government’s health advice

EIE2020/7 Development of a Farm IoT and a Digital Twin model for Animal Monitoring and Caring
Supervisors: Prof. Branka Vucetic, Dr. Zihuai Lin, Dr. Cameron Clark
Eligibility: UG or PG students having proficient programming skills at Python, matlab, C/C++ and in-depth knowledge on IoT, Wireless Communications, AI and signal processing.

Project Description:

Background
Digital Twins are virtual, digital equivalents to physical objects. They are real-time and remotely connected to the real objects and provide rich representations of the objects and its context. More specifically, a Digital Twin can be defined as 'a digital representation of an object, with a unique identification, that can be trusted, possesses the property of integrity, is timely available, and can be used for the intended purpose. The interaction between real/physical and digital/virtual objects is an essential concept behind the Internet of Things (IoT).

Problem Statement:
In this project, we will develop i) a farm IoT system for remotely monitoring cattle’s health which can also provide location services that track and trace the movements of the cows showing the free-grazing time per animal; ii) based on the collected sensing data and/or existing sensor derived data, we will develop an AI based digital twin model for cattle caring that can provide multiple behavior detection and predictions including animal physiological cycles, health analysis and also provide a forward looking prediction of the next cycle start dates.

Requirement to be on campus: No

EIE2020/8 Design and Implementation of WiFi Rate Control and Scheduling Protocols for IoT Applications

Supervisors: Dr. Wibowo Hardjawana, Dr. Yifan Gu, Dr. Rana Abbas

Eligibility: Background in wireless communications, Proficient in C programming

Project description:
IoT applications can be divided into 2 main categories: massive machine type communications (mMTC) with low energy constraints, requiring best effort services, and ultra-low latency ultra-high reliability communications (uRLLC) with strict delay requirements.

This project aims at the design and implementation of novel rate control and scheduling protocols for IoT applications communicating over WiFi, mainly, WiFi HaLoW (low energy) for mMTC and WiFi-RT (real-time) for uRLLC. The project involves learning the different state-of-the-art rate control and scheduling protocols in WiFi, in theory and in code.

We will use software emulators such as NS3 to evaluate these protocols against the new protocols to be designed. This project can also be extended to hardware, where the designed protocols will be implemented and evaluated on WiFi chips using raspberry pis.

Requirement to be on campus: No

EIE2020/9 Design and Implementation of 5G Network Slicing to support multiple services for multiple vertical industries

Supervisor: Dr. Wibowo Hardjawana

Eligibility: Background in wireless communications, Proficient in C programming

Project description:
Two-tier wireless networks that combines of state-of-art wireless cellular networks (e.g., 5G) and WiFi (e.g., 802.11ah/x) have been proposed to support deployment of advanced internet-of-thing networks such as virtual power plants and industrial automation. Network Slicing has been proposed as an approach to divide the resources in wireless network infrastructure into isolated logical slices which are defined following the requirements and features of the applications. In this project, we would like students to participate in the development of relevant network slicing brokers, signal processing techniques and a virtual network function instantiated inside a Software Defined Network (SDN) controller by using network simulators for our research. These modules are used to make logical slices for the wireless cellular networks and WiFi subject to respective Quality of Service restrictions.

Requirement to be on campus: No
EIE2020/10 Caching techniques in integrated wireless cellular networks

**Supervisor:** Professor Abbas Jamalipour

**Eligibility:** The student must have good understanding of data communications networks and digital communications. Experience in C++ programming and Matlab is desirable.

**Project description:**
The increased interest in the use of traffic-intensive applications such as High Definition (HD) video, augmented reality, wearable devices, and 3-D visualization is expected to result in a higher growth in network traffic. Such a higher-fold traffic growth requires a major paradigm shift in the implementation of upcoming 5G technology so that the user requests can be accommodated at the core network without causing bottleneck. Emerging mobile content caching techniques can efficiently relieve overloaded network traffic by caching popular contents at intermediate nodes and user devices. Its efficacy however lies in intelligent caching of popular files.

For high cache hit probability, popular files should be cached in users nearby base stations. However, the storage space is limited and, as a result, content selection for caching must be performed. In the scenario in which caching nodes are densely deployed and hold close topological associations, these strategies will lead to content redundancy if each node does not share its caching information. Therefore, exploiting cooperation between caching nodes is indispensable in mobile caching systems. When considering content caching in D2D networks, the caching strategy design becomes more rigorous, not only because the storage capacity in the user devices is very small but also because the cached contents should be very specific and related to nearby user request patterns.

**Requirement to be on campus:** Yes

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EIE2020/11 UAV-assisted wireless communications for public safety applications

**Supervisor:** Professor Abbas Jamalipour

**Eligibility:** The student must have good understanding of data communications networks and digital communications. Experience in C++ programming and Matlab is desirable.

**Project Description:**
In recent years, the usage of unmanned aerial vehicles (UAVs), also known as drones, has skyrocketed in a wide selection of applications due to mainly their low cost, small size, and high manoeuvrability. For instance, the wireless communication field is approaching the realization of the integrated UAV and conventional ground network for further improved communication performance. Thus, a UAV, acting as a communication platform, can coexist with different conventional ground serving nodes, such as WiFi access point (AP) and cellular base station (BS). This is because the UAV-enabled communication is a promising technology, enjoying numerous traits such as the ability of on-demand deployment and the high likelihood of strong line-of-sight (LoS) communication links. However, this coexistence poses significant challenges on the communication performance of both the UAV and the ground nodes. Thereby, it is necessary to optimize the position or trajectory of the UAV as well as the power and spectrum allocation of the entire network to ensure harmonious coexistence. This research studies the optimization of the UAV-enabled communication in various coexistence scenarios and applications.

**Requirement to be on campus:** Yes

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EIE2020/12 Delay and Energy Constraints Fog-IoT Wireless Networks

**Supervisor:** Professor Abbas Jamalipour

**Eligibility:** The student must have good understanding of data communications networks and digital communications. Experience in C++ programming and Matlab is desirable

**Project Description:**
Introduction of fog computing in Internet of Things (IoT) networks is envisioned as a promising improvement in IoT networks. The new generation of IoT networks, also known as Fog-IoT networks, could significantly improve the efficiency of these networks in terms of providing different quality of service (QoS) and quality of transmission (QoT) requirements. The traditional IoT networks suffer from several deficiencies, which the two most important ones are
large delay and the hyper-energy consumption of terminal nodes (TNs) due to the long distance between TNs and the cloud servers. Here we apply fog layer, which is closer to IoT layer than the cloud layer, in the traditional IoT networks.

In this project, you will work on development of an algorithm to maximize the network transaction throughput under different QoS and QoT constraints, such as energy efficiency, processing delay, bandwidth requirements, and load balancing. In the new techniques, it is desirable that there exists a load balancing among all FNs, in terms of number of processed tasks, which can almost provide the energy consumption fairness among FNs as well. Higher level of energy consumption balancing needs also to be satisfied among FNs.

**Requirement to be on campus:** Yes

**Computer Engineering Projects**

**EIE2020/13 Optimising hardware for Machine Learning on the Edge through the use of variable precision**

**Supervisor:** Dr. David Boland

**Eligibility:**
- Bachelor Degree in Electrical Engineering
- Outstanding transcript (WAM>75)
- Either:
  - Confidence with hardware design (VHDL/Verilog/High-level synthesis) or embedded systems.
  - Experience training machine learning algorithms
  - Research experience with publication record in electrical engineering (preferred)

**Project Description:**
Recently, machine learning techniques are being used across an increasing range of application domains. Examples include driverless cars, surveillance, radio signal analysis and medical uses such as cancer detection. However, to enhance their capability on the edge, for example on a drone, there is a continual drive for faster and lower power implementations. One important research direction has been the development of low precision machine learning algorithms, and modification of computer architectures to support this. For example, modern GPUs and CPUs are increasingly supporting new custom number systems for machine learning. This project aims to extend this by exploring how to optimise machine learning algorithms to use variable precision at run-time: high precision when needed for accuracy, and low precision elsewhere because it is faster. This project will also explore the development of novel computer architectures to support this.

Ideally this project will be tackled by a team of students combining machine learning and hardware design experience. You will test your developments on a range of benchmark applications to demonstrate its advantages over existing solutions.

**Requirement to be on campus:** No

**EIE2020/14 Enhancing machine learning architectures on the edge through the use of variable precision**

**Supervisor:** Dr David Boland

**Eligibility:**
- Bachelor Degree in Electrical Engineering
- Outstanding transcript (WAM>75)
- Either:
  - Confidence with hardware design (VHDL/Verilog/High-level synthesis) or embedded systems.
  - Experience training machine learning algorithms
• Research experience with publication record in electrical engineering (preferred)

**Project Description:**
Recently, machine learning techniques are being used across an increasing range of application domains. Examples include driverless cars, surveillance, radio signal analysis and medical uses such as cancer detection. However, to enhance their capability on the edge, for example on a drone, there is a continual drive for faster and lower power implementations. One important research direction has been the development of low precision machine learning algorithms, and modification of computer architectures to support this. For example, modern GPUs and CPUs are increasingly supporting new custom number systems for machine learning. This project aims to extend this by exploring how to optimise machine learning algorithms to use variable precision at run-time: high precision when needed for accuracy, and low precision elsewhere because it is faster. This project will also explore the development of novel computer architectures to support this.

Ideally this project will be tackled by a team of students combining machine learning and hardware design experience. You will test your developments on a range of benchmark applications to demonstrate its advantages over existing solutions.

**Requirement to be on campus:** No

EIE2020/15 Project ARIA

**Supervisor:** Craig Jin

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

**Project Description:**
Project ARIA ([www.projectaria.com](http://www.projectaria.com)) aims to assist the blind with spatial audio and haptics. This is especially important during the Covid19 epidemic as the non-sighted have special difficulties with the 1.5 m distancing rule. In this project, students will assist with software development to support the system in which we are employing the Unity game engine for simulations. We will experiment with various protocols to better understand how audio (spatialised or otherwise) and haptics may be used to help guide non-sighted or partially sighted persons.

**Requirement to be on campus:** No

EIE2020/16 Personalised 3D Audio

**Supervisor:** Craig Jin

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

**Project Description:**
This project explores personalised 3D audio using the iPhone and the unity game engine. We are designing and developing a system that takes video images (including depth data via the 'TrueDepth' system) of the ear and provides 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

**Power Engineering Projects**

EIE2020/17 Energy management system for a carpark of electrical vehicles

**Supervisor:** Prof Jian Guo Zhu

**Eligibility:**
- Bachelor degree in electrical engineering
- Outstanding transcript (WAM>75)
• Good knowledge of MATLAB/Simulink
• Research experience with publication record in electrical engineering (preferred)

**Project Description:**
Electrical vehicles (EVs) are becoming popular due to their high energy efficiency and environment friendliness. When a great number of EVs are parked in a carpark, meeting their charging demands can be challenging. However, an aggregation of EVs represents a valuable energy storage system that can provide effective support to the grid to improve the reliability, stability, electricity quality and efficiency. Through this support, an EV carpark should be able to derive certain financial benefits that compensate the electricity bill, and in turn reduce the parking fees of EVs, if managed properly.

This project aims to develop an energy management system for an EV carpark consisting of EV chargers, battery bank, and distributed generators. By optimal coordination of power flows inside carpark, and between carpark and grid versus the electricity cost, the system should be able to provide high quality cost effective charging services to EVs, feed active and/or reactive power to the grid when there is a demand, and generate financial profits, simultaneously.

**Requirement to be on campus:** No

**EIE2020/18 Peer-to-peer energy trading in a prosumer microgrid**
**Supervisors:** A/ Prof Gregor Verbic
**Eligibility:** At least a D average (WAM>75). Good knowledge of Python.

**Project Description:**
The project will develop an energy trading platform for peer-to-peer (P2P) power exchange among prosumers in a microgrid. Each prosumer will be equipped with an energy management system (EMS), implemented on a hardware prototype of a residential building with a range of distributed energy resources, including a PV-battery system and flexible loads. The EMS will be cast as an optimisation problem aiming to minimise electricity cost for the owner. It will be modelled in Python and run on a single-board computer (Raspberry Pi). The EMS will communicate with the battery inverter over a Modbus protocol. Several prosumers will be connected via a mobile network to form a prosumer microgrid where they will trade energy in a P2P market. The P2P market will use a continuous double auction for market clearing, with bids and offers stored in a distributed ledger. The auctioneer will be implemented as an autonomous software agent.

**Requirement to be on campus:** Yes

**Artificial Intelligence and Software Engineering Projects**

**EIE2020/19 Automatic generation of radiology reports**
**Supervisor:** Luping Zhou

**Eligibility:**
• Have basic knowledge in machine learning, especially in deep learning
• Have good programming skills in pytorch and tensorflow
• Have experience in writing deep learning models

**Project Description:**
Radiology has become an essential part in modern health care. The large number of radiological examinations has posed challenges to the workload, precision and efficiency of radiological diagnosis. Recently, with the development of deep learning techniques, increasing efforts have been reported to automatically generate reports from radiological images. However, such research is still in its early stage. Most models are not shared and are evaluated in different ways. This project aims to conduct an experimental study to implement and compare the state-of-the-art models in medical report generation on benchmark datasets. This could establish baselines for model evaluation, and facilitate the advancement of research in this field.
Requirement to be on campus: No

EIE2020/20 Trade-Off Between Accuracy and Resilience in Lateral Dynamics Estimation in Autonomous Ground Vehicles Subject to Attacks

**Supervisors:** Teng Joon Lim / Eman Mousavinejad

**Eligibility:**
- Student in the stream of electrical engineering, mechatronics engineering, or other relevant discipline.
- Demonstrated knowledge in the areas of signal processing, control systems, and optimization problems.
- Programming experience in MATLAB and YALMIP.
- Excellent background in mathematics and demonstrated understanding of matrix algebra.

**Project Description:**
Autonomous ground vehicles (AGVs) are equipped with several sensors in order to enhance their lateral stability, driving comfort, and passenger’s safety. These sensors may be prone to attacks which can deteriorate vehicle stability performance or even result in serious accidents. Therefore, it is of significance to design a secure estimation technique which not only can estimate the vehicle’s lateral dynamics state, i.e., yaw rate and sideslip angle, with high accuracy but is also resilient against certain attacks in the presence of unknown-but-bounded (UBB) measurement noise. Hence, the first aim of this project is to analyse the trade-off between accuracy and resiliency of a possible set-membership estimation technique. An effective detection mechanism should also be developed to identify the occurrence of such attacks, which serves as the second aim of this project. The research intern will be expected to:
2. Formulate the vehicle lateral dynamics in a state-space framework considering UBB measurement noise.
3. Design and develop a resilient set-membership estimation method and a detection algorithm.
4. Simulate the mathematical derivations with MATLAB through using Ellipsoidal toolbox and YALMIP.
5. Write a comprehensive project report which may lead to an article for possible conference and/or journal publications.

Requirement to be on campus: No

EIE2020/21 Silicon photonic sensors for biomarker detection

**Supervisor:** Prof Xiaoke Yi

**Eligibility:** Year 3/4 or Master students in Engineering and Science; Candidates from year 2 with strong academic record or hands-on lab capabilities are also encouraged to apply.

**Project Description:**
There is an increasing demand for non-invasive monitoring and early-detection of the diseases. In this project, we use novel sensors to diagnose biomarkers noninvasively offering significant advantages, such as pain-free, contact-free, high-selectivity and improved resolution. The project is a multidisciplinary project cross engineering, science and medicine with a close engagement with industry. The aim is to utilize cross-disciplinary knowledge in engineering and science to develop high performance sensors for biomarker detection with the applications in medical devices. This project includes four research scopes (1) sensor design (2) prototype testing, (3) prototype optimization (4) data analysis based on machine learning (deep learning and artificial intelligence).

Candidates who wish to work in any of the disciplines including electrical engineering, chemistry, chemical engineering, mechatronic engineering, biomedical engineering and computer engineering are encouraged to apply.

Requirement to be on campus: Yes

EIE2020/22 Photonic signal processor breaking the limits of electronics

**Supervisor:** Prof Xiaoke Yi; Liwei Li
Eligibility: Year 3/4 or Master students in Engineering and Science;

Project Description:
The rolling out of the internet of things which seeks to connect and integrate billions of devices together, and the increasing need for intelligent systems continually demand more bandwidth, higher speed signal processing. Direct signal processing in optical domain has the potential to realize orders of magnitude increase in instantaneous bandwidth, and a very high sampling frequency ability (over THz in comparison to around GHz with electronic technology), which lead to diverse applications for tackling problems of processing wideband signals, and for providing essential interference immunity. This project focuses on light weight, small size and low power consumption integrated photonic circuits for signal processing which applications in data centres, neurophotronics, quantum information processing and Lidar for self-driving cars.

Requirement to be on campus: Yes

MECHANICAL ENGINEERING PROJECTS

MECH2020/1  The complex behaviour of turbulent two-phase flows
Supervisor: Dr. Agisilaos Kourmatzis

Eligibility: No specific requirements

Project Description:
From modifying the behaviour of a turbulent flow using electric fields, to understanding how extreme aerodynamic conditions influence the behaviour of fuel sprays, we work on a broad range of problems seeking to improve our understanding of highly turbulent two-phase flows.

This type of flow is the norm in most industrial applications related to thermal energy conversion or propulsion and understanding it is absolutely critical towards our ability to improve uptake of renewable or synthetic fuels for a sustainable future.

The precise nature of the project can be tuned to the student’s interest however would involve either experimental work or computational modelling of a particular problem as a means to expose you to this complex, but very exciting field.

Requirement to be on campus: Yes

MECH2020/2 Developing new laser-based technologies for visualizing drug delivery
Supervisor: Dr. Agisilaos Kourmatzis

Eligibility: Strong results in fluid dynamics. Proficient in MATLAB.

Project Description:
Working in close collaboration with a leading industry partner in the US, and with researchers from the School of Pharmacy, you will join a multi-disciplinary team looking to improve the current technologies used to characterize pharmaceutical aerosols for oral inhalation drug delivery. You will engage in either experimental, modelling, or design work.

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

MECH2020/3 Developing a coughing or sneezing machine
Supervisors: Dr. Agisilaos Kourmatzis & Prof. Assaad R. Masri

Eligibility: Web development and programming, Statistics and statistical analysis, systems analysis & design.

Project Description:
COVID-19 has demonstrated the importance of two-phase flows and aerosol spreading. We have known for a long time that understanding spray flows and aerosols is crucial towards predicting the spread of pathogens. Previous work by our group has focused on understanding spray formation from a variety of problems using our state of the art experimental facility. Despite progress, the literature demonstrates how little we know about the dynamics of a human expiratory event, whether that be coughing, sneezing, or talking. You will be responsible for designing a new machine which will replicate the conditions of a human cough or sneeze, hence enabling us to make fast progress in understanding how droplets
spread from these types of scenarios. This machine will be used to generate data to improve our ability to predict the spread of pathogens.

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

**MECH2020/4 Designing the next generation of inhaler devices**

**Supervisors:** Dr. Agisilaos Kourmatzis & Dr. Gajendra Singh

**Eligibility:** Strong results in fluid dynamics. Proficient in MATLAB. Proficient in 3D modelling. Keen on innovation and product development.

**Project Description:**
You will join a large research team working on designing the next generation of inhaler devices using a merging of fundamental fluid mechanics principles with applied pharmaceutics. You will learn about some of the issues with existing inhaler technology and come up with ideas to improve our understanding of how inhalers work and how to design them. Depending on progress, you may even be able to design and fabricate a device, and integrate an inhaler system with replicas of the human upper airway or lungs.

**Requirement to be on campus:** Yes

**MECH2020/5 Mechanical testing sample prepared by laser ablation**

**Supervisor:** Prof. Simon Ringer & Dr. Zibin Chen

**Eligibility:** Have basic knowledge in material science and engineering

**Project Description:**
Additive manufacturing (3D printing) has been a hot topic in the globe owning to its benefit on improving material efficiency, resource efficiency, part flexibility, and production flexibility. Mechanical properties are essential index for achieving best 3D printing parts among different methods.

To measure the mechanical properties, especially requiring combined information on microstructure evolution, ambient temperature and deformation information, small dog-bone shape sample is necessary. However, it is time consuming and not cost-efficient for using traditional way (e.g. wire electrical discharge machining) for the sample preparation. By using ultra-short pulse laser ablation tool, the sample with required dimension and surface polished can be achieved.

This project involves using a laser ablation tool located in the Sydney Microscopy and Microanalysis to prepare tensile test sample with required dimension. The candidate needs to learn and engage in using the tool and fine tune the parameters for fully filling the experimental requirement.

**Requirement to be on campus:** Yes

**MECH2020/6 Neural networks for efficient computation of chemical reactions in combustors**

**Supervisor:** Matthew Cleary

**Eligibility:** The project would suit a 2nd or 3rd year student with excellent skills in mathematics, computational engineering and coding.

**Project Description:**
Computational modelling of combustors is widely used in the design stage to improve combustor efficiency and reduce emissions. As fuels become more complex the cost of computing the rates of chemical reactions is growing exponentially. This is especially the case when attempting to calculate the rates of potent pollutants such as micron-sized particulate matter. The cost is limiting the affordability of computational studies.

Modern data science, in particular neural networks, offer a solution to this problem. This summer research project will involve selection of the most viable neural network method for computing combustion reactions, followed by implementation into an in-house code and testing for a range of fuel types.

**Requirement to be on campus:** No
MECH2020/7 Synthesis of materials using flame spray pyrolysis
Supervisor: Assaad Masri
Eligibility: First Class Honours level 1
Project Description:
This project involves the use of flame spray pyrolysis (FSP) to synthesize a range of functional materials such as sensors and other useful products. The FSP processes lead to the formation of particles of different sizes and shapes depending on the initial chemical blended with the liquid fuel. Two challenges for FSP are in producing a high quality spray that undergoes a fast liquid-to-gas conversion, and in having the ability to control the subsequent material synthesis process. The project will investigate these issues using a new rig that has just been installed in the combustion laboratory.
Requirement to be on campus: No

MECH2020/8 Effect of cyclic rapid heating and cooling processes on the cellular dislocation structure in metal plates produced by additive manufacturing
Supervisors: Prof. Xiaozhou Liao and Prof. Simon Ringer
Eligibility: WAM > 80%
Project Description:
Additive manufacturing (AM) will play a critical role in factories of the future because of its many advantages including the ability of producing complicated structures as single pieces without the need to weld or attach individual components together. During AM processes, materials experience cyclic rapid heating–cooling at rates that are orders of magnitude faster than those observed in conventional processes, which affects significantly the structures and consequently the mechanical properties of the materials. This project aims to explore how the number of cyclic heating–cooling processes affects the formation of detailed microstructural features including dislocation cells and local mechanical properties. The evolution of microstructures along the build direction of thick metal plates produced by AM will be investigated using electron microscopy. Local mechanical properties will be tested using nanoindentation.
Requirement to be on campus: Yes

MECH2020/9 Understanding point defects and impurities in advanced alloys from first principles atomistic simulation
Supervisors: Simon Ringer, Carl Cui
Eligibility: Student must have a WAM of 75 or higher to be considered and have completed at least 12 credit points towards their undergraduate studies.
Project Description:
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. Vast experimental efforts have led to rich knowledge of the processing-microstructure-property linkages. 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 behaviour (including the distribution, interaction and diffusion) of defects and impurities in various technologically important alloys, such as Aluminium and Nickel. The outcome will be useful for rational design of advanced alloys.
Requirement to be on campus: Yes

MECH2020/10 Exploring the 3D microstructure of additively manufactured ceramics
Supervisors: Simon Ringer, Andrew Breen and Hangsheng Chen
Eligibility: Student must have a WAM of 75 or higher to be considered and have completed at least 12 credit points towards their undergraduate studies.
Project Description:
The University of Sydney has recently acquired a Lithoz Cerafab ceramic 3D printer housed in the new Sydney Manufacturing Hub (SMH). The printer can fabricate high value ceramic components with complicated geometries more efficiently than with conventional fabrication methods and is finding application in numerous fields including biomedical e.g. dental implants. Understanding how the processing parameters influence the resulting microstructure and mechanical properties is very important. Microstructural characterisation using a variety of microscopy techniques, such as electron back scattered diffraction (EBSD) and atom probe tomography (APT) are powerful contributors to this process.

The student/s will be participating in this exciting project by analysing 3D EBSD and APT data taken from printed ceramic components. These complementary techniques enable unprecedented insight into the 3D grain structure, crystallographic texture and chemistry which strongly influence mechanical behaviour and will help guide our efforts towards improved property performance of 3D printed ceramics.

Requirement to be on campus: Yes

MECH2020/11 Architecting superior lattice materials enabled by additive manufacturing

Supervisors: Dr Xianghai An

Eligibility: High achievement in a relevant undergraduate engineering degree (a WAM of 80 or above). This summer project has the option to be combined with an honours project.

Project Description:
Architected materials that consist of periodic arrangements of nodes and struts (‘unit cells’) are lightweight and can exhibit combinations of properties that do not occur in conventional solids. Inspired by natural structures and advanced materials structures, we can achieve excellent combination of lightweight, high strength, high stiffness and good damage tolerance. However, there are four key questions: 1) what is the optimum unit cells? 2) How should the size of the cell vary spatially? 3) What are the optimal cell parameters? 4) How best should the cell be integrated with the larger form? Answering these questions cannot only progress the development of architected materials, but also enrich their applications in lightweight structures, energy absorption, metamaterials, thermal management and bioscaffolds.

Although advanced manufacturing process provide a tremendous opportunity to fabricate materials with precisely defined architectures, it is still challenging to fully leverage these capabilities for the optimisation of the materials structures. In this project, we try to apply the combined approach of finite element modelling, machine learning and additive manufacturing to design novel cellular architectures for high-performance materials.
Figure Bringing mechanical design to the material level. Engineering and architectural principles can now be applied at the material scale. (Annu. Rev. Mater. Res. 2016. 46:187–210)

Requirement to be on campus: No
MECHATRONICS ENGINEERING PROJECTS

MECHATRON2020/1 Space Robotics: In-orbit docking and servicing demonstrator
Supervisors: Mitch Bryson, Donald Dansereau, Viorela Ila

Eligibility: Depending on area of interest: Mechanical prototyping, experience working with robotic arms and imaging systems, and image processing in Matlab, Python or C++ would be an asset.

Project Description:
Part of the Australian Centre for Field Robotics Space Robotics initiative, this project will develop a ground-based demonstrator for in-orbit docking and servicing of satellite systems. You will develop hardware analogues for the mechanical and visual challenges associated with this problem. Depending on interest and ability, the work will involve mechanical prototyping, design and configuration of illumination and imaging systems, and working with robotic manipulators for motion simulation.

As part of this project you will have the opportunity to work with the ACFR’s state-of-the-art robotics and manufacturing facilities.

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

MECHATRON2020/2 Machine Learning and Virtual Reality interface for 3D LiDAR Point clouds
Supervisor: Dr Mitch Bryson

Eligibility:
Desired Skills include
- Strong programming skills: experience in C, C++, Python and/or Java
- Experience or interest in working with pointcloud data or machine learning
- Experience or interest in 3D graphics and or Virtual Reality

Project Description:
The Australian Centre for Field Robotics (ACFR) is involved in several projects with Australian and New Zealand plantation forestry industry partners that seek to develop new sensing and software tools for improving resource inventory. During forest inventory, high-resolution airborne laser scanning is used to build large scale 3D pointcloud maps which can used to measure trees and other canopy properties. This project would focus on the development of machine learning algorithms that are designed to automatically detect and segment trees for analysis. These algorithms would be designed to connect to a virtual reality interface that allows a user to make canopy and tree measurements, segment tree profiles and provide training data to the automated algorithms.

Requirement to be on campus: No

MECHATRON2020/3 3D Point Cloud Segmentation of Small Objects
Supervisors: Viorela Ila and Tejaswi Digumarti/Donald Dansereau

Eligibility:
Required Skills: Matlab, C++
Desired Skills: Computer Vision, Maths

Project Description:
The goal of this project is to develop methods for 3D point cloud segmentation of small objects in the scene. The scene reconstruction will be achieved using RGB-D cameras and/or novels sensors. Many solutions exist for large-scale point cloud segmentation, but the problem becomes challenging in the case where the objects of interest are small or very thin. In this case, point cloud density augmentation is required. Accurate 3D point cloud segmentation can have a variety of applications in robotics in particular in agriculture robotics and robot manipulation.

Requirement to be on campus: No

**Supervisor:** Viorela Ila and Tejaswi Digumarti

**Eligibility:**
- **Required Skills:** Python programming
- **Desired Skills:** TensorFlow, PyTorch or similar deep learning frameworks; Knowledge about optical flow

**Project Description:**
Modelling and understanding the environment the intelligent agents operate in is crucial to their autonomy. Motion estimation is a key component for many robotic tasks such as navigation and path planning in dynamic environment and simultaneous localization and tracking of multiple objects. In the case of autonomous driving, pedestrians or cyclists crossing unexpectedly, lane-splitting motorcyclists, merging trucks and traffic jams are situations where perception and modelling of rapid changes in the environment are imperative.

This thesis will focus on implementing a convolutional neural network architecture that learns to predict motion of each pixels in an image given a pair of consecutive images. Deep convolutional neural network (DCNN) based approaches have significantly improved the state-of-art in both semantic segmentation and motion estimation.

**Requirement to be on campus:** No

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MECHATRON2020/5 Active 3D Reconstruction Using the UR5e Robotic Arm

**Supervisor:** Viorela Ila

**Eligibility:**
- **Required Skills:** Matlab and/or C++ and/or Python
- **Desired Skills:** Maths, Computer Vision

**Project Description:**
The purpose of this project is to develop an incremental and rapid system for model building and 3D reconstruction from image sequences captured from a camera, whose position is under robot control. The idea is to combine machine learning and geometric scene understanding techniques in order to improve the performance compared with traditional techniques. This includes the active vision task of planning camera trajectories through which the shape of the object is most efficiently captured.

The topic of the project belongs generally to the area of ``view planning'' in which, given a present partial model of a scene, the motion of the camera best suited to obtain more information to improve the model is chosen.

**Requirement to be on campus:** No

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MECHATRON2020/6 Underwater Localization Based on 4 GPS Buoys

**Supervisor:** Viorela Ila

**Eligibility:**
- **Required Skills:** Matlab, C++
- **Desired Skills:** Maths, Signal processing

**Project Description:**
The accurate estimation of the pose and velocity of an autonomous underwater vehicle (AUV) is critical to ensure the repeatability and validity of scientific data that is captured during underwater AUV exploration. Unfortunately, underwater is a GPS denied environment, therefore AUV’s are equipped with different positioning sensors such as Doppler velocity logs (DVL) or acoustic transponders like long baseline system (LBL) and ultra-short baseline system (USBL). Although these methods can provide accurate pose estimation, they are very expensive and not easy to be integrated or deployed in many cases, especially for low-cos missions.

This thesis will focus on implementing a localization system based on 4 floating buoys equipped with GPS receivers and acoustic transducers. The objective is to design the AUV localization algorithm for a system where the GPS buoys are arranged in a rigid structure and floating freely on the surface of the water.
MECHATRON2020/7 FPGA-Accelerated On-Camera 3D Vision

**Supervisor:** Donald Dansereau

**Eligibility:** Experience developing embedded systems using FPGAs; Image processing in Matlab, Python or C++ would be an asset

**Project Description:**
We are helping robots make sense of the world by giving them new kinds of eyes. In this work you will work with emerging time-of-flight and light field cameras with embedded FPGA-based processors capable of performing complex perception tasks on-camera.

The work involves understanding time-of-flight and light field processing algorithms, and adapting and implementing them for on-camera operation.

Applications for this technology are in low-latency vision in challenging conditions, including all-weather autonomous driving and underwater survey. There will be opportunities to work with the robotic optical imaging lab and underwater test tank facilities.

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

MECHATRON2020/8 3D Hyperspectral Sensing

**Supervisor:** Donald Dansereau, Viorela Ila

**Eligibility:** Image processing in Matlab, Python or C++; Experience with ROS, robotic arms, and knowledge of optics would be an asset.

**Project Description:**
Hyperspectral sensing gives us rich information about the health of forests, crops, and reefs. Our group is developing a unique 3D hyperspectral camera that simultaneously measures 3D shape and spectral signatures of objects.

In this work you will characterise and build software for making 3D hyperspectral models using this new camera. The will involve devising and running experiments in the robotic optical imaging lab, and developing software tools to handle the new forms of information delivered by the device. This work will deliver some of the world’s first 3D hyperspectral point cloud measurements for plant-scale objects.

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

MECHATRON2020/9 Machine Learning of Robot Control Systems

**Supervisor:** Ian Manchester

**Eligibility:** A strong understanding of control systems fundamentals (e.g. AMME3500). Experience with machine learning algorithms is desirable but not essential.

**Project Description:**
Robots are being developed that perform surgery, drive us to work, and collaborate with people to build things. There have recently been many exciting control approaches proposed based on machine learning, specifically reinforcement learning. But these methods can be brittle and can fail in unexpected ways. This research project addresses how we harness the power of machine learning for robot control, while ensuring safety and stability at all times. In particular, you will research (via simulation and experiment) the way that recent advances here at Sydney University in robust recurrent neural networks can be used to learn and optimize high-performance control systems for advanced robotic systems.

**Requirement to be on campus:** No

MECHATRON2020/10 Marine Robotics

**Supervisor:** Prof. Stefan B. Williams, Dr. Oscar Pizarro, Dr. Hao Wu, Dr. Lachlan Toohey

**Eligibility:** Students should have a strong background in programming, robotics and/or mechatronic design. Prior experience working with machine learning tools will be considered an asset.
Project description:
We have a number of projects related to our marine robotics program:

- Develop a model predictive controller for an AUV to build local maps of seafloor obstacles and explore high level planning methods like Behaviour Trees that can be used for an AUV to navigate in the littoral environment. This work will access navigation sensor data collected from AUVs and utilise underwater simulators to model and test the controllers;

- Calculate target direction of a Lagrangian float from a hydrophone array, implement real-time navigation when the array is on a moving surface vessel and post-process the trajectory using depth and speed data from the float, and bathymetry maps;

- Develop and train a supervised/unsupervised machine learning model to automatically detect and identify marine life forms or classify benthic habitat cover using underwater imagery data collected by AUVs around Australia.

We will work with successful students to further develop project topics.

Requirement to be on campus: No